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สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

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ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

SELECTION OF THE OPTIMUM OFFSET INK SET FOR COLOUR DIGITAL IMAGE REPRODUCTION BY GAMUT MATCHING

Miss Pattamas Sukkaew

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

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งานวิจัยจำนวนมากประสบความสำเร็จในการศึกษาเกี่ยวกับการเทียบสีระหว่างภาพต้นฉบับและภาพที่ผลิตได้ในหลายด้าน คุณภาพสีของภาพต้นฉบับ เช่นภาพเขียน ภาพถ่าย ไม่สามารถที่จะผลิตได้ด้วยกระบวนการพิมพ์เพียงแค่หมึกสี่สีเท่านั้น และการแก้ปัญหาด้วยการใช้กระบวนการหมึกพิมพ์แบบคุณภาพสูง (high-fidelity colour printing) นั้นยังไม่เพียงพอนอกจากนั้นการเพิ่มหมึกพิมพ์เข้าไปในกระบวนการพิมพ์ฮาร์ฟโทนยังมีข้อจำกัดดังนั้นงานวิจัยนี้จึงแนะนำวิธีในการคัดเลือกหมึกพิมพ์และจำนวนของหมึกพิมพ์โดยการเทียบเคียงขอบเขตสีของชุดหมึกให้ใกล้เคียงกับขอบเขตสีของต้นฉบับมากที่สุด โดยจะมีการสร้างฐานข้อมูลของกระบวนการหมึกพิมพ์สี่สี 3 ชุดและ หมึกพิมพ์สีพิเศษ 21 สี ซึ่งพิมพ์บนกระดาษอาร์ตมัน โดยฐานข้อมูลนี้จะประกอบด้วยสมบัติทางทัศนศาสตร์ของหมึกพิมพ์ ซึ่งคำนวณมาจากการใช้ทฤษฎีคูเบลคา-มังค์ชนิดสองตัวแปรโดยใช้โปรแกรม Microsoft Excel นอกจากนั้นยังใช้โปรแกรมนี้เป็นเครื่องมือในการหาขอบเขตสีของชุดหมึกพิมพ์ต่างๆ สูตรถูกกำหนดให้ใช้จำนวนของหมึกพิมพ์ในการหาขอบเขตสีดังนี้ 5, 6, 7, 9 และ 10 สี ภาพมาตรฐานดิจิทัลที่ใช้ในงานวิจัยนี้เป็นของ SHIPP ซึ่งค่าสี R, G, และ B ของทุกพิกเซลในภาพต้นฉบับจะถูกอ่าน จากนั้นนำมาแปลงเป็นค่าสี XYZ และ ค่าสี CIEL*a*b* ต่อไปโดยการใช้โปรแกรม MATLAB โดยวิธีที่ใช้ในการแปลงนั้น จะเป็นของภาพมาตรฐาน SHIPP เกณฑ์ที่ใช้ในการพิจารณาชุดหมึกที่เหมาะสมกับภาพสีดิจิทัลของต้นฉบับนั้นใช้ 2 วิธี คือการพิจารณาปริมาตรของขอบเขตสีและ พิจารณาจากขนาดและรูปร่างของขอบเขตสีของชุดหมึกใดที่ใกล้เคียงกับขอบเขตสีของภาพต้นฉบับมากที่สุด การใช้เครื่องมือนั้นพบว่า ขอบเขตสีของภาพมาตรฐานบางภาพสามารถถูกครอบคลุมโดยขอบเขตสีของชุดขบวนการหมึกพิมพ์เพียง 4 สี อย่างไรก็ตามบางภาพที่มีสีสันมากจะต้องการหมึกพิมพ์มากกว่า 4 สี ดังนั้นสามารถใช้เครื่องมือที่พัฒนานำมาหาชุดหมึกที่เหมาะสมกับภาพสีต้นฉบับดิจิทัลได้

ภาควิชา วิทยาศาสตร์ทางภาพถ่ายและเทคโนโลยีทางการพิมพ์	ลายมือชื่อนิสิต..
สาขาวิชา เทคโนโลยีทางภาพ	ลายมือชื่ออาจารย์ที่ปรึกษา..............................
ปีการศึกษา 2545	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม........................

4472360223 : MAJOR IMAGING TECHNOLOGY

KEY WORD: COLOUR GAMUT / KUBELKA-MUNK THEORY / ABSORPTION COEFFICIENTS / SCATTERING COEFFICIENTS / OPTICAL PROPERTIES

PATTAMAS SUKKAEW : SELECTION OF THE OPTIMUM OFFSET INK SET FOR COLOUR DIGITAL IMAGE REPRODUCTION BY GAMUT MATCHING. THESIS ADVISOR : PICHAYADA KATEMAKE, Ph.D., THESIS COADVISOR : ASSISTANT PROFESSOR MICHELE POZZI, Ph.D., 192 pp. ISBN 974-17-2768-2.

A number of researchers have carried out the research on matching the colour of the original to the printed output for many years in various aspects. A quantity of original painted with artistic colours, and several photos with colour produced by dye, cannot be matched with only four-colour process ink. This difficulty has been solved to a certain extent by using High-Fidelity colour printing. Nevertheless, not many coloured inks are added for halftone printing at present. This research was concerned about the introduction of a method of selection of custom inks in any combination and number provided the shape and size of the colour gamut that was similar to the original. Calibration prints of three sets of four-colour process inks and twenty-one special inks were prepared on glossy paper so as to determine their optical properties using the two-constant method of Kubelka-Munk theory. The spreadsheet tools were used to calculate the optical properties and to obtain colour gamuts for any combination of inks. The numbers of inks in the formulations used to determine the colour gamut were five, six, seven, nine and ten. The digital originals employed were the SHIPP standard digital images. The RGB colour values of all pixels of the digital orginal were read and recorded using the MATLAB code. They were converted to XYZ tristimulus values and CIEL*a*b* coordinates using an appropriate conversion method for SHIPP images. Two criteria for selecting the optimum ink in order to match the colour gamut of the colour digital image reproduction were the gamut volume as well as the size and the shape of the inks selected. By using the tool developed, it showed that the gamut of some of the SHIPP digital images can be covered using four-colour process ink. However, the colour gamut of the colourful SHIPP image needed more than four-colour inks to cover it. The ink-set that is suitable for an image can be investigated using the tools developed.

Department Photographic Science and Printing Technology Student's signature…………………………….

Field of study Imaging Technology Advisor's signature……………………………….

Academic year 2002 Co-advisor's signature…………………………….

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CHAPTER 1

INTRODUCTION

The offset printing using four-process colours has played an important role in the printing industry for a long time. Since the reproduced colour gamut could only produce the prints with limited satisfaction, every aspect of the technology for four colour halftone printing including devices, substrates, and software has been continually developed. However, the brilliant colours in the original, which could be recorded with the drum scanner, could not be reproduced by the use of the four-process colour printing. This is because of the limitations of the process-colour inks which have a deficiency in absorbing the light spectrum.

For more than 30 years, the halftone printing with more than four colours has been developed in order to expand the printing colour gamut. There are six and seven colour printings, which could provide a wide colour gamut. This results in saturated colour and colourful prints, which is suitable for the printing of packaging, annual reports, and advertisement.

Although halftone printing with more than four colours can produce high quality colour prints, it may not be necessary when the original image has a limited colour gamut. The most important thing is that the chosen custom inks be suitable for the colours of the original image. Printing with four or three colours also could produce high quality colour prints.

Besides the expansion of the printing colour gamut, the matching of colour between an original and a reproduction is an important topic in this research. Colour management has been used for the printing industry in Thailand. However, colour management needs expertise and a great number of factors need to be controlled. In addition, co-operation among co-workers is necessary for success in the use of Colour management system (CMS). Therefore, an alternative method of matching the colour of the original to the colour of the reproduction will be developed.

The development of this method involves determination of the optical properties of 4 sets of lithographic inks by using the Kubelka-Munk equation to predict the printing colour gamut. The printable gamuts obtained from different colour ink-sets are not the same since each ink has its own reflectance that is unique. This results in different ink-sets producing different colour gamuts.

This research develops a method/system/software/technique/etc. to guide in the selection of the custom inks that suits the prints. This could enable the system to produce the highest colour quality job and consume the least amount of inks. A database of the offset inks was developed. By using it together with the tools for simulating the colour gamut of the selected custom inks, the desired colour gamut, which corresponds to the colour of the original image, can be achieved.

1.1 Objectives

1. To obtain a spreadsheet tool for the selection of the optimum ink-set.

2. To explore the possibility of further developing the spreadsheet into a commercial package.

1.2 Scope of the Research

In this research the method of colour gamut matching of the original to the combinations of inks was proposed. The ink calibration of all ink-sets will be carried out to determine the optical properties of a number of ink-sets. The spreadsheet tool used to calculate the absorption and the scattering coefficients will be improved so it can be used more easily and therefore be more suitable for use in industry. The optical properties obtained from the relationship between the absorption coefficient and the concentration are then used to obtain the colour gamuts for any combination of inks. The original mentioned in this research is a colour digital image. The colour values of every pixel that compose the image will be read and recorded using the MATLAB code. The three-dimensional colour gamut of the original will be represented in CIELAB colour space. Finally the gamut of the digital image file will be optimized to fit in the colour gamut ink-set. The factors that will be considered for colour matching are lightness, chroma and hue.

1.3 Content of the Thesis

This thesis studies the method of selecting custom inks in any combination and number to provide a gamut of the same size as the original. This thesis consists of 5 chapters: Chapter 1 is an introduction of this thesis. Chapter 2 gives the explanation of theoretical considerations such as an optical model for a semi-transparent layer, transformation from RGB to XYZ, and CIE Lab colour space. Chapter 3 describes the experimental apparatus, materials and experimental techniques. Chapter 4 gives the results of ink calibrations. The spreadsheet applications for the calculation of the optical properties, and colour gamut of combination of inks is shown and explained. Finally, the results are concluded in Chapter 5 along with some suggestions.

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CHAPTER 2

THEORETICAL CONSIDERATION AND LITERATURE REVIEWS

2.1 Theoretical Consideration

2.1.1 Application of Kubelka-Munk Theory to Semitransparent Layers

The Kubelka–Munk theory can be used for colour prediction, calibration of the optical properties of materials and applying gloss correction equations to the colour prediction and it deals with the determination of the reflectance of an opaque layer, R_∞ and the derivation of the absorption coefficient K and scattering coefficient S of semitransparent layers.

2.1.1.1 Calculation of the K and S Coefficients of Semitransparent Layers.

The Kubelka-Munk colour model is a mathematical model used to describe the reflectance. The model considers the absorption and scattering that occurs in a coloured sample of fixed thickness, and is applied on a wavelength by wavelength basis throughout the visible region of the electromagnetic spectrum. The reflectance of the sample at each wavelength depends on four factors: an absorption spectrum (K), a scattering spectrum (S), the sample thickness (X), and the reflectance spectrum of the substrate or backing (R_g). The model considers the illuminating light to be collimated, and the light penetrating the sample is considered to be scattered. While the light can be scattered in any direction, the model considers two net fluxes: straight up and straight down.

The Kubelka–Munk theory does provide a solution and it can be developed by first establishing the optical properties of a layer in isolation (**Figure 2.1**) and then determining the effect when a substrate is placed beneath the layer.

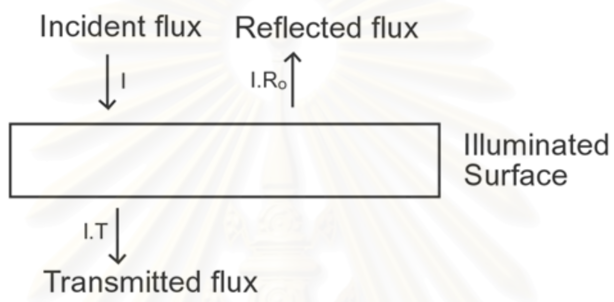

Figure 2.1 The reflection and transmittance of an isolated layer [1].

The optical properties of an isolated layer can be described by the reflectance (R_o), transmittance (T) and absorbance (A) of energy as defined below.

$$R_o = \frac{\text{energy flux reflected by the layer}}{\text{energy flux incident on the layer}}$$

$$T = \frac{\text{energy flux transmitted throught the layer}}{\text{energy incident on the layer}}$$

and

$$A = 1 - R_o - T$$

One of the most common uses of pigments is in generating the colour of printing inks. Printed layers are usually semitransparent and the light reflected from the printed surface often includes light directly scattered from the pigments in the ink layer as well as light that has been transmitted through the layer, reflected by the substrate and transmitted back out of the system (**Figure 2.2**) [1]

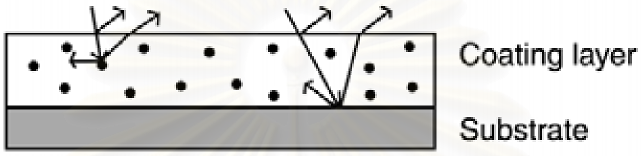

Figure 2.2 Light reflection by a semi-transparent layer [1].

These optical interactions can be modelled by the Kubelka–Munk theory that is able to predict the total fraction of light reflected over all directions by the surface. The well–known theory that is commonly used for investigating the optical properties of a semitransparent ink layer before and after being applied on the substrate is the Kubelka-Munk theory [2]. The Kubelka-Munk equation has been reviewed and applied to printed substrates. The Nobbs' reviews [3] described the approach to determine R_∞ and to derive the K and S coefficients.

In order to determine the properties of coating on substrate, two more reflectance values need to be defined.[4,5]

$$R_g = \frac{\text{energy flux reflected by the substrate}}{\text{energy flux incident on the substrate}}$$

$$R = \frac{\text{energy flux refrected by the system}}{\text{energy flux incident on the system}}$$

The Kubelka-Munk theory is used to solve the radiation transfer problem by considering the interaction of light with the material in terms of two fluxes of energy: the incident flux I and the reflected flux J. Let us suppose the printed layer is applied on the substrate which is separated into two isolated layers.

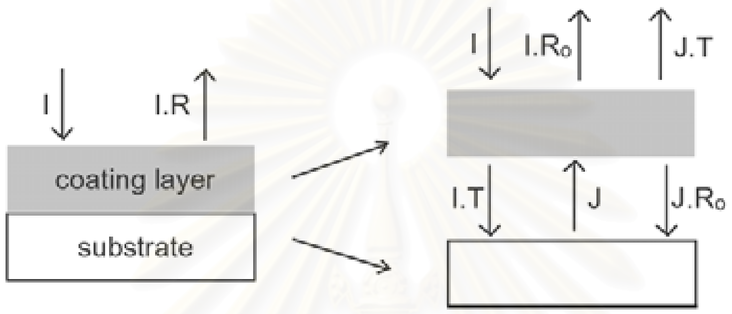

Figure 2.3 Imaginary splitting of the coating from a substrate to form an isolated layer[4,5].

Flux I : is incident on the top surface.

I. R_o : is reflected from the ink layer.

I.T : is transmitted through the ink layer.

R_o : is the fraction of incident light reflected by the ink layer.

T : is the fraction of light transmitted through the ink layer.

Flux J : is reflected back from the substrate and is incident on the bottom surface of the ink layer.

J. R_o : is reflected through the ink layer.

J.T : is transmitted through the ink layer.

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From the definition of R it follows that

$$R = \frac{I.R_o + J.T}{I} \qquad \textbf{Eqn.-2.1}$$

The flux J can be related to I via R_g as shown

$$J = (\,I.T + J.\,R_o\,).\,R_g$$

Re-arrangement gives

$$J = \frac{I.T.R_g}{1 - R_o R_g}$$

and substitution for J in **Eqn.-2.1** gives

$$R = R_o + \frac{T^2.R_g}{1 - R_o.R_g} \qquad \textbf{Eqn.-2.2}$$

and

$$R = \frac{\alpha.R_g + \beta.R_\infty}{\alpha + \beta} \qquad \textbf{Eqn.-2.3}$$

where α is a function of the reflectance of the opaque layer (R_∞) and the reflectance of the substrate (R_g).

β is a function of K, S (and D) via the variable Z defined in **Eqn.-2.6.**

$$\alpha = \frac{1 - R_\infty^2}{1 - R_g.R_\infty} \qquad \textbf{Eqn.-2.4}$$

$$\beta = e^{2z} - 1 \qquad \textbf{Eqn.-2.5}$$

$$Z = D\sqrt{K(K + 2S)} \qquad \textbf{Eqn.-2.6}$$

and D is the thickness of the layer

The coefficients K and S of the layer of material then can be calculated from reflectance values by **Eqn.-2.7, 2.8, 2.9** and **2.10** respectively.

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$$\beta = \left[\frac{R_g - R}{R - R_\infty}\right].\left[\frac{1 - R_\infty^2}{1 - R_g R_\infty}\right] \quad \text{Eqn.-2.7}$$

$$Z = 0.5\ln(\beta + 1) \quad \text{Eqn.-2.8}$$

$$K = \frac{Z}{D}\left[\frac{1 - R_\infty}{1 + R_\infty}\right] \quad \text{Eqn.-2.9}$$

$$S = \frac{Z}{D}\left[\frac{2R_\infty}{1 + R_\infty^2}\right] \quad \text{Eqn.-2.10}$$

It is normal practice to define unit layer thickness as the thickness of the calibration print. The value of D is then 1 for the calibration database.

2.1.1.2 Saunderson Correction

Before the Kubelka-Munk model can be applied, a correction has to be made for reflections at the sample surface. The reason is that the kubelka-Munk theory is limited in the sense that it does not take the partial effect at the air to layer bounding into account. Since the transparent coating has a refractive index *n* different from that of air, multiple internal reflections occur as shown in **figure 2.4**.[6]

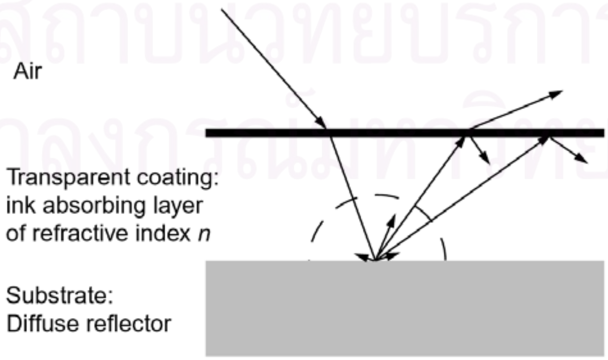

Figure 2.4 Multiple internal reflections caused by the interface between the air and the ink coating.[6].

This phenomenon significantly increases the optical density of the ink-containing layer. This is taken into account by applying the Saunderson correction to the computed spectrum.

The explanation of the derivation of the correction equation can be simplified by considering a diagram of energy flux at the air and coating layer boundary in **Figure 2.5.**[7]

Figure 2.5 Diagram of energy flux at the boundary of air and coating layer[7].

r_e : is the fraction of the incident flux I reflected by the interface.

t_e : is the fraction of the incident flux I transmitted by the interface.

r_i : is the fraction of the incident flux J reflected by the boundary.

t_i : is the fraction of the incident flux J transmitted by the boundary.

The measured reflectance ρ of the layer is the ratio of the total reflected energy flux to the total incident flux:

$$\rho = \frac{r_e I + t_i J}{I} \qquad \text{Eqn-2.11}$$

The flux J is linked to flux I via the true or body reflectance R of the layer.

$$J = R\left(t_e I + r_i J\right) \qquad \text{Eqn.-2.12}$$

Re-arrangement gives **Eqn.-2.13**

$$J=\frac{t_e IR}{1-r_i R} \qquad \textbf{Eqn.-2.13}$$

Substitution of eqn-13 for J in eqn-11 provides the relation between ρ and R. This is the relationship of the measured reflectance ρ and the true reflectance R is expressed by **Eqn.-2.14**

$$\rho = r_e + \frac{t_e t_i R}{1 - r_i R} \qquad \textbf{Eqn.-2.14}$$

The inverse of **Eqn.-2.14** is expressed in **Eqn.-2.15** and is used to obtain the true reflectance.

$$R = \frac{\rho - r_e}{t_e t_i + r_i\left(\rho - r_e\right)} \qquad \textbf{Eqn.-2.15}$$

The Saunderson correction was derived for spectrophotometer measurements made with integrating sphere geometry. In this research the spectrophotometer with integrating sphere geometry is used.

2.1.1.3 Spectrophotometer Measurement Geometrics.[8,9]

Spectrophotometer measurements can differ depending on the geometry of the instrument, i.e., how the sample is illuminated and how the intensity of reflected light is measured. There are two main standard spectrophotometer geometries.

The first pair of geometries are labeled as 45°/ normal and normal/45°, known as bi-directional geometries. The designation corresponds to the illumination/viewing angles. In bi-directional instruments the sample is illuminated at 0°

and the reflected light is measured at 45°, or alternatively the sample is illuminated at 45° and the reflected light is measured at 0°. These are referred to as 0/45 and 45/0 geometries respectively, and the two are considered to be equivalent. All angles are measured relatively to the normal to the sample surface. Bi-directional spectrophotometers exclude any specularly reflected light very effectively because the detector angle is far from the specular angle.

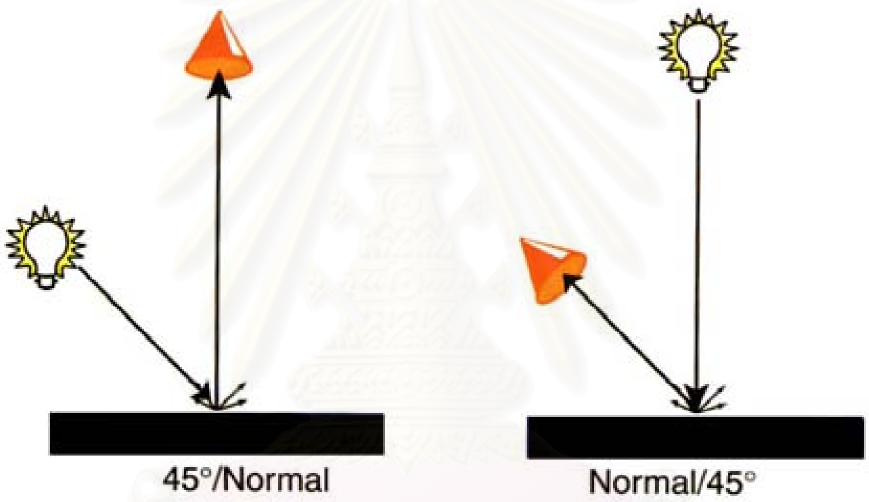

Figure2.6 Simplified diagram of 45/0 , 0/45 measurement geometry [8].

The second pair of geometries is labelled as diffuse/normal and normal/diffuse and refer to the use of integrating spheres. In integrating sphere instruments the sample is diffusely illuminated and the reflected light is measured at 0° (D/0) or alternatively the sample is illuminated at 0° and the reflected light is measured after integrating at all reflected angles (0/D).

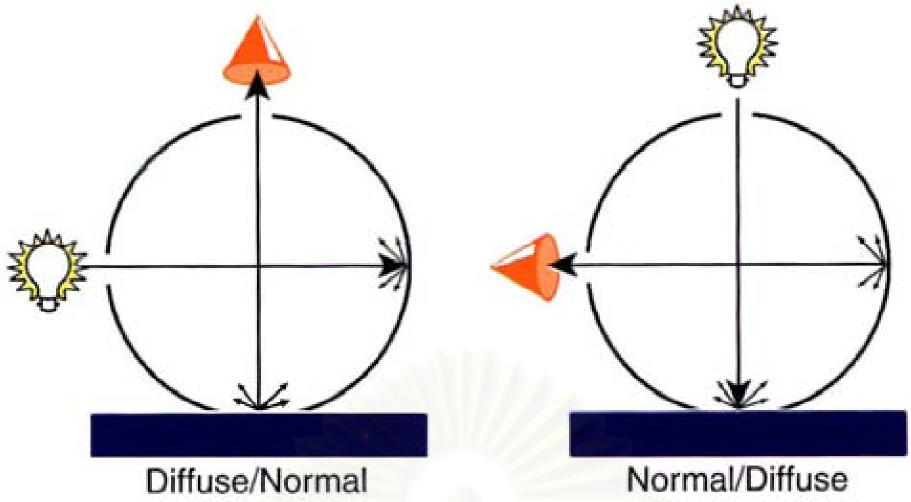

Figure2.7 Simplified diagram of diffuse/0, 0/diffuse measurement geometry [8].

Again these two are considered equivalent. An integrating sphere, which is a hollow sphere coated on the inside with a matte white material, is typically used either to provide the diffuse illumination or to collect the reflected light. There are two different ways in which D/0 or 0/D spectrophotometers can operate, depending on whether the specular component is included (IR) or excluded (XR). IR measurements include the specular component of the reflected light by placing a white cap at the specular reflection point in the integrating sphere, while XR measurements exclude the specular component of the reflection by replacing the white cap with a black one so that the specular reflection is absorbed. In spite of this, D/0-XR cannot completely exclude specularly reflected light unless the specular component is very sharp, because the detector angle is close to the specular angle.

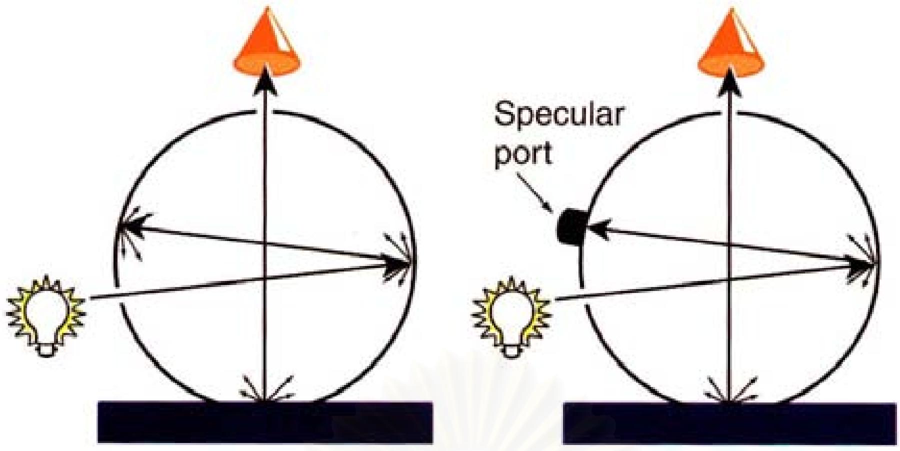

Figure 2.8 The specular reflection of a specimen can be excluded by placing a black trap at the specular port or can be included by placing at that port a plaque with identical properties to those of the sphere's interior [8].

Consequently, the reflected light reaching the detector consists of part or all of the diffusely reflected light and part or all of the specularly reflected light, depending on the spectrophotometer geometry. Incomplete capture of the diffuse component is compensated for by calibrating the spectrophotometer relative to a perfect diffuse reflector, in which case the quantity measured is the reflectance factor. Consequently the difference between measurements made with these spectrophotometer geometries is essentially limited to how much of the specular component is detected. D/0-IR instruments capture virtually all of the specular component and 0/45 instruments capture almost none of it, while D/0-XR instruments lie somewhere between these extremes.

2.1.1.4 Determination of R_∞ for a Semitransparent Layer [10]

R_∞ is the reflectance of an opaque layer of the ink. For many ink systems, it is difficult to obtain a satisfactory opaque layer. Thick layers of ink may take an excessive time to dry and often crack. In addition, because of the limitations of the Kubelka-Munk theory, the value of R_∞ measured from a real opaque layer may not be appropriate for predicting the reflectance of the semi-transparent system. Nevertheless, there is a way that opaque layers are not needed. That is, applying the ink layers on a standard black and white substrate in order to assess their opacity. Assuming that R_w and R_b are the reflectance of the layer over the white substrate and over the black substrate respectively and $R_{g,w}$ and $R_{g,b}$ are the reflectance of the white and black substrates, then the value of β can be obtained by **eqn.-2.16** and **eqn.-2.17**. The value of Z and consequently β are independent of the substrate of the semitransparent layer. Therefore, β_{black} equals β_{white}.

$$\beta_{black} = \left[\frac{R_{g,b} - R_b}{R_b - R_\infty}\right] \cdot \left[\frac{1 - R_\infty^2}{1 - R_{g,b} \cdot R_\infty}\right] \qquad \text{Eqn.-2.16}$$

$$\beta_{white} = \left[\frac{R_{g,w} - R_w}{R_w - R_\infty}\right] \cdot \left[\frac{1 - R_\infty^2}{1 - R_{g,w} \cdot R_\infty}\right] \qquad \text{Eqn.-2.17}$$

Since $\beta_{black} = \beta_{white}$,

$$\left[\frac{R_{g,b} - R_b}{R_b - R_\infty}\right] \cdot \left[\frac{1 - R_\infty^2}{1 - R_{g,b} \cdot R_\infty}\right] = \left[\frac{R_{g,w} - R_w}{R_w - R_\infty}\right] \cdot \left[\frac{1 - R_\infty^2}{1 - R_{g,w} \cdot R_\infty}\right]$$

Then

$$R_\infty = B - \sqrt{B^2 - 1} \qquad \text{Eqn.-2.18}$$

where

$$B = \frac{\left[R_{g,w} - R_{g,b}\right].\left[1 + R_w.R_b\right] - \left[R_w - R_b\right].\left[1 + R_{g,w}.R_{g,b}\right]}{2.\left[R_b,R_{g,w} - R_w,R_{g,b}\right]} \qquad \text{Eqn.-2.19}$$

The ratio ω = K/S can be obtained directly from B (ω = B-1)

2.1.1.5 Concentration Dependence of K and S [11,12].

The value of K depends on the volume concentration of the colorant in the layer, in a manner that is found by producing prints using a series of dilutions of the test ink with a clear diluent. The concentration series is similar to that for opaque layers, more mixtures being prepared at low colorant concentrations than at high concentrations. A typical set is shown in **Table 2.1**. Prints of the same layer thickness are produced and the reflectance spectrum measured. After application of the Saunderson correction, the true reflectance is used to calculate β, and obtain K and S for that concentration.

Coloured ink	Diluent ink	Substrate
2	98	White
5	95	White
10	90	White
20	80	White
30	70	White
50	50	White
70	30	White
100	0	White
100	0	Black

Table 2.1 Typical dilution series for calibration of a printing ink.

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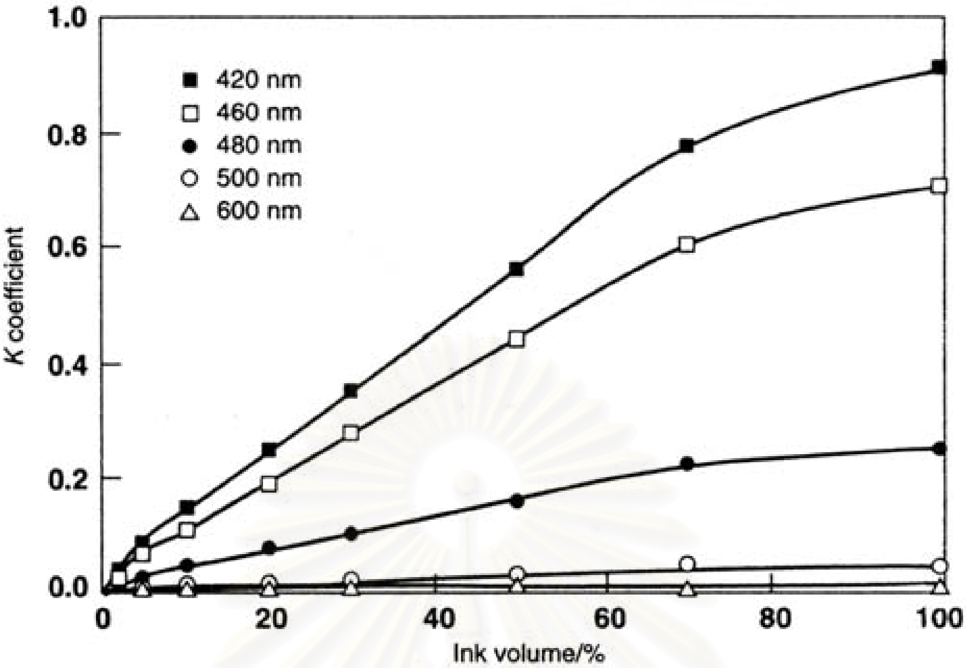

Figure 2.9 Concentration dependence of K for a yellow lithographic ink printed on coated card [11].

Figure 2.9 shows a plot of K against the volume concentration of a yellow lithographic ink in a mixture with clear diluent. Plots at five wavelengths are shown, illustrating a range of absorption strengths. The degree of linearity of the plots is typical for lithographic database, with the on set of saturation indicated by a decrease in slope at high concentrations. The nonlinear dependence of K on C can be characterised by an equation of the general form of Eqn.-2.20.

$$K = a_1C + a_2^{2}+a_3^{3} \qquad \text{Eqn.-2.20}$$

The database will consist of values of the coefficients a_1, a_2, a_3 and ω (K/S, B-1) at each of the measured wavelengths in the spectrum. The coefficients a_1, a_2 and a_3 each wavelength can be obtained by a regression fit of database panels to Eqn.-2.20.

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2.1.2 Standard Digital Image. [13]

2.1.2.1 Standard High Precision Pictures : SHIPP

The significance of high precision standard pictures is self-evident as they facilitate the evaluation of image processing algorithms, the accurate comparison of image output devices, etc.

The set of pictures named SHIPP consists of four full colour natural scenes, each expressed in the three colour space, i.e., XYZ, CIELAB, and Calibrated RGB.

Table 2.2 shown the specifications of the image data for full colour natural scenes composing SHIPP.

No.	Nickname	Pixel (Width x Height)	Colour Space	Data Volume (Mbytes)	Main Subjects	Evaluation Objects
P1	Bride	3072 x 4096	XYZ	75.5	Close-up portrait	Tone reproduction of flesh
			CIELAB/ Calibrated RGB	37.7		
P2	Harbor	4096 x 3072	XYZ	75.5	Fine, regular structures	Image processing technique
			CIELAB/ Calibrated RGB	37.7		
P3	Wool	4096 x 3072	XYZ	75.5	Highly saturated, coloured products	Colour reproduction
			CIELAB/ Calibrated RGB	37.7		
P4	Bottles	3072 x 4096	XYZ	75.5	Lustrous metal products	Reproduction of gray
			CIELAB/ Calibrated RGB	37.7		

Table 2.2 Specification of SHIPP

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The 4 x 5 inches colour transparencies Fujichrome RDP2 film record the four scenes which were scanned with a high precision scanner. **Table 2.3** shown the specifications of the scanner.

Manufacturer, Product Name	Dainippon Screen Co., SG-1000 (modified)
Scanning Aperture	25 microns square
Density Resolution	0.001 at D < 2.5
A/D Conversion	Analogue signals in Density were quantized to 12bits/channel.

Table 2.3 The specifications of the scanner.

By the inverse transform of the film gamma, the acquired density data are converted to integral densities which are proportional to the logarithm of the scene luminance. Then, they are converted to analytical densities, and further to spectral transmission distribution.

By combining the spectral transmission distribution of each pixel thus obtained with the data for D65 CIE standard light source and the colour matching functions in XYZ colour space for 2 degree viewing field, one obtains the XYZ tristimulus values.

2.1.2.1.1 Definition of the Colour Spaces for Calibrated RGB

The standard in practical use for defining the Calibrated RGB colour space is ITU-R BT.709 [14] . The standard is specified as follows;

The colour temperature of the white point: D65.

The colour coordinates of the primaries:

Red x = 0.6400, y = 0.3300

Green x = 0.3000, y = 0.6000

Blue x = 0.1500, y = 0.0600

The conversion matrix combining XYZ tristimulus values (D65) with linear RGB is given by

$$A = \begin{bmatrix} 3.2410 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{bmatrix}$$ **Eqn.-2.21**

Opto-electronic transfer characteristics by **Eqn.-2.22**

If $0.018 \leq V \leq 1.0$

$$V' = 1.099V^{0.45} - 0.099$$ **Eqn.-2.22**

else $0.0 \leq V < 0.018$

$$V' = 4.50V$$ **Eqn.-2.22**

V' are the nonlinear RGB values.

V are the linear RGB values of scenes.

The above specifications are summarized as follows; the Calibrated RGB values are obtained by the opto-electronic transformation defined by **Eqn.-2.22** of the values needed for the colourimetric reproduction of scenes illuminated by a D65 light source by using the primaries defined above.

2.1.2.1.2 Definition of the Colour Spaces for XYZ and CIELAB

Alternatively, the relationship between XYZ tristimulus values and Calibrated RGB values is explained as follows;

The colours expressed in terms of XYZ tristimulus values forming a scene under D65 illumination are precisely reproduced when these XYZ tristimulus values are encoded by ITU-R BT.709 to give the corresponding non-linear RGB values and when they are displayed on a monitor having the D65 white point, based on the 709 primaries, and provided with the inverse characteristics of the 709 opto-electronic transfer characteristics.

SHIPP-XYZ data are regarded as the expression of scenes under D65 illumination. As it is impractical to carry out colourimetric measurements on real scenes, SHIPP takes the position to regard the colour data recorded with the colour reversal photographic film as first approximations of those of the original scene.

SHIPP-CIELAB data can be derived by use of the following equations with these XYZ tristimulus values:

$$L^* = 116\, f(Y/Y_0) - 16$$

$$a^* = 500\{f(X/X_0) - f(Y/Y_0)\} \qquad \text{Eqn.-2.23}$$

$$b^* = 200\{f(Y/Y_0) - f(Z/Z_0)\}$$

If $P/P_0 > 0.008856$

$$f(P/P_0) = \left(P/P_0\right)^{1/3} \qquad \text{Eqn.-2.24}$$

else $P/P_0 \leq 0.008856$

$$7.787(P/P_0)+16/116 \qquad \textbf{Eqn.-2.24}$$

where X_0, Y_0, Z_0 is XYZ tristimulus values of white point, P is X, Y, Z, and P_0 is X_0, Y_0, Z_0.

2.1.2.1.3 SHIPP-Calibrated RGB Data

According to ITU-R BT.709, as XYZ tristimulus values are converted to linear RGB values by **eqn.-2.25**

$$\begin{bmatrix} R_{709} \\ G_{709} \\ B_{709} \end{bmatrix} = A \begin{bmatrix} X/100.0 \\ Y/100.0 \\ Z/100.0 \end{bmatrix} \qquad \textbf{Eqn.-2.25}$$

Then, linear RGB are converted to non-linear RGB via the ITU-R BT.709 opto-electronic transformation

If $0.018 \leq V_{709} \leq 1.0$

$$V_{709}' = 1.099 V_{709}^{0.45} - 0.099 \qquad \textbf{Eqn.-2.26}$$

else $0.0 \leq V_{709} < 0.018$

$$V_{709}' = 4.50 V_{709} \qquad \textbf{Eqn.-2.26}$$

V_{709}' are the nonlinear RGB values.

V_{709} are the linear RGB values of scenes.

R'_{709}, G'_{709} or B'_{709} all range between 0 and 1. SHIPP-Calibrated RGB data, R_{8bit}, G_{8bit} and B_{8bit} are defined as R_{709}', G_{709}', and B_{709}' data each multiplied by 255. They are unsigned and rounded to the nearest integer:

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$$R_{8bit} = 255 \times R_{709}'$$

$$G_{8bit} = 255 \times G_{709}' \qquad \text{Eqn.-2.26}$$

$$B_{8bit} = 255 \times B_{709}'$$

2.1.2.1.4 SHIPP Pictures as Subjective Quality Evaluation Tool.

The following guidelines are given to make an effective use of SHIPP.

Harbour: The thin wires stretching sails, the raw of houses with window, and the roofs with fine structures are all suited for the evaluation of image sharpness. The blue sky area on top can be used for the check of tone jump. Objects with fine structure can also be used to evaluate the registration accuracy of output devices, image deterioration owing to data compression, the existence of jaggies, etc.

Wool: This scene is designed for the evaluation of colour gamut of devices. All the elements composing the scene including the woollen yarn, the colour pencils, the ribbons are highly saturated at various lightness levels, sometimes exceeding the gamut of a system in concern.

Bride: Self-evidently this scene is for the evaluation of skin tone particularly in highlights and shadows. The favourable reproduction of the veil requires a delicate highlight tone, and the hair demands high resolution together with an sample shadow gradation.

Bottles: This scene is suited for the evaluation of tone reproduction of greys as well as of reproduction of lustrous appearances of metallic objects. The grading backdrop can be used to check colour balances at almost neutral areas, and to optimise the reproduction of greys. Conditions for a favourable reproduction of the reflection at metal surfaces and of fruits can also be explored.

2.1.3 The CIE System

The CIE colourimetric system comprises the essential standards and procedures of measurement that are necessary to make colourimetry a useful tool in science and technology. The CIE system is usually employed in connection with instruments for colour measurement. This system has been established by the Commission Internationale de l' Eclairage, the French title of international committee, or International Commission on Illumination in 1931. The CIE system started with the premise developed on the human colour perception process, that stimulus for colour is provided by the proper combination of a source of light, and an observer.[15]

2.1.3.1 Calculation of Tristimulus Values From Spectral Data[16,17].

Tristimulus values are calculated from the emitted spectrum of an object, a CIE standard illuminant, and one of the CIE standard observers. This procedure is illustrated in **Figure 2.10**.

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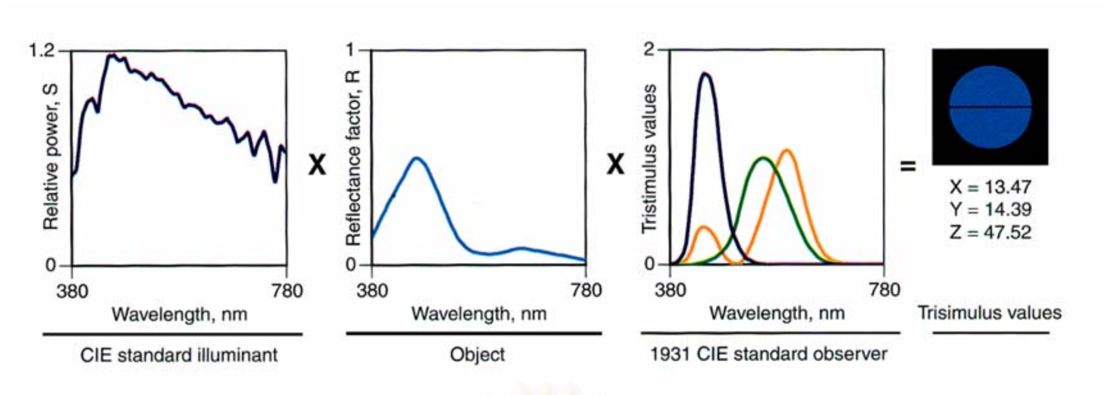

Figure 2.10 The illustrated procedure for calculating the tristrimulus values [16].

The CIE tristimulus values X, Y and Z of a colour are obtained by multiplying together the relative power S_λ of a CIE standard illuminant, the reflectance factor R_λ of the object, and the standard observer functions $\bar{x}_\lambda$, $\bar{y}_\lambda$,or $\bar{z}_\lambda$. The products are summed up for all the wavelengths in the visible spectrum, then their sums are normalized, resulting in the CIE the tristimulus values. The corresponding mathematical equations shown as follows:

$$X = k\sum_{\lambda} S_\lambda R_\lambda \bar{x}_\lambda \Delta\lambda$$

$$Y = k\sum_{\lambda} S_\lambda R_\lambda \bar{y}_\lambda \Delta\lambda \qquad \text{Eqn.-2.27}$$

$$Z = k\sum_{\lambda} S_\lambda R_\lambda \bar{z}_\lambda \Delta\lambda$$

$$k = \frac{100}{\sum_{\lambda} S_\lambda R_\lambda \bar{y}_\lambda \Delta\lambda}$$

where S_λ is a CIE illuminant, R_λ is the object's spectral reflectance factor, $\bar{x}_\lambda$, $\bar{y}_\lambda$,and $\bar{z}_\lambda$ are the CIE standard observer colour-matching functions, Σ_λ represents summation across wavelength, k is a normalizing constant, and $\Delta\lambda$ is the measurement wavelength interval (for objects it is usually either 10 or 20 nm. By definition, CIE colour-matching

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functions are defined from 360 nm to 780 nm in10-nm increments from ASTM [E308] (see Table 1, Appendix A).

2.1.3.2 CIELAB

There are several methods of characterizing a colour, including ***CIE L*a*b*.*** The CIE 1976 space, know as the CIELAB system, is the result of a mathematical transformation of the CIE 1931 system. While seeking, during this transformation, to obtain a space which is uniform is terms of colour differences, one of the other objectives was to develop a much simpler system to interpret, with easier references[17] . The CIELAB space extends the tristimulus colourimetry to three-dimensional space with dimensions that approximately correlate with the perceived lightness, chroma, and hue of a stimulus[18].

The CIE 1976 (L*a*b*) colour space is defined by **Eqn.-28, 29, 30** for tristimulus values normalized to the white that are greater than 0.008856.

$$L^* = 116\,(Y/Yn)^{1/3} - 16 \qquad \textbf{Eqn.-28}$$

$$a^* = 500\,\{(X/Xn)^{1/3} - (Y/Yn)^{1/3}\} \qquad \textbf{Eqn.-29}$$

$$b^* = 200\,\{(Y/Yn)^{1/3} - (Z/Zn)^{1/3}\} \qquad \textbf{Eqn.-30}$$

X,Y,Z are the tristimulus values of the colour stimulus to be defined.

X_n,Y_n,Z_n are the tristimulus values of the reference white.

L* represents lightness

a* approximates redness-greenness

b* approximates yellowness-blueness

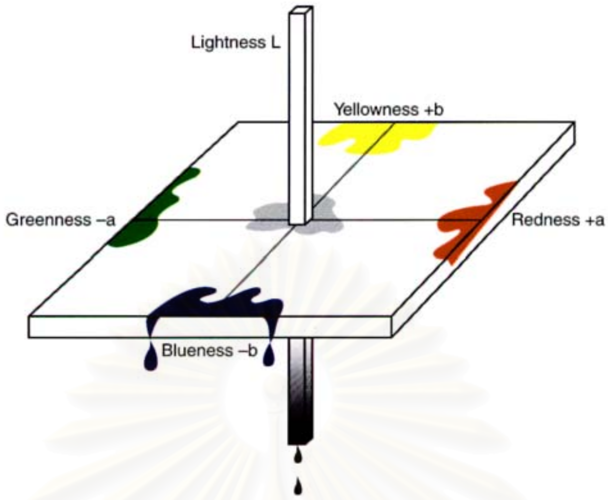

Figure 2.11 The concept of an opponent, rectangular coordinate system using variable L*, a*, and b* to represent lightness, redness-greenness, and yellow-blueness, respectively [19].

2.1.3.3 Colour Difference

Colour differences are measured in the CIELAB. This is expressed in terms of a CIELAB ΔE^*_{ab}, which can be calculated using **Eqn-31**.

$$\Delta E^*_{ab} = [\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}]^{1/2} \qquad \text{Eqn.-31}$$

The lightness difference on the L* axis, expressed by ΔL^*

The red – green color difference on the a* axis, expressed by Δa^*

The yellow – blue color difference on the b* axis, expressed by Δb^* [20]

2.1 Literature Reviews

Optical models for colour prediction have been studied in many reseach works.

Katemake [21] studied the simulation of the colour gamut of offset inks from the prediction of the optical properties of ink by using the Kubelka-Munk equation. The methods used the calibration of the sets of printing inks to determine the optical properties. A spreadsheet that assists in the rapid computation of the optical properties has been developed. Twenty-one colour inks were used for this experiment. The results indicated that an the average of colour difference between the measured reflectance and the calculated reflectance was about 6.

Nobbs[22] reviewed the application of the theory to the prediction of reflectance. The review has the sample calculation of the application of Kubelka-Munk theory to the semi-transparent layer. The approach has been selected from a number of works with the aim of presenting an easily followed argument with the various restricting assumptions clearly stated. A number of authors have compared the predictions of the Kubelka-Munk theory with those of more accurate treatments. These results have been reviewed together with the possible implications for match prediction.

Emmel and Hersh [23, 24, 25] introduced new models and mathematical formulations describing the light scattering and ink spreading phenomena. Their new model is based on model of high quality paper and Saunderson correction, and matrix form of the Kubelka-munk model. The colour difference (ΔE^*_{ab}) between samples printed by two ink-jet printers after use of the new model was 2.1. They also introduced a new spectral colour prediction model for a fluorescent ink printed on paper. The printed paper is modelled by means of three matrices: an interface correction matrix, a matrix exponential modelling the layer which contains the fluorescent ink, and a reflection matrix characterising the substrate. The interface correction matrix allows to take multiple reflections into account by operating the Saunderson correction. These matrices are related to physical properties of ink and paper which must be measured: the transmittance spectra, the quantum yields, the absorption bands and the emission spectra of the fluorescent inks, and the reflection properties of the paper. Their new model can predict the reflection spectra of uniform samples for different ink concentrations and under different illuminants. Using this method they predicted the reflection spectra of 18 uniform samples. The average prediction error is about ΔE^*_{ab} = 2.5 with a maximum of ΔE^*_{Max} = 4.37. Since ink fluorescence is also taken into account, the prediction accuracy in improved by about ΔE^*_{ab} = 17 in comparison with Beer's law for diffuse light.

Tunstall [26] attempted to achieve a balanced outlook regarding two factors that is the accuracy of the practical measurements and the use of a theory that adequately represents the physical phenomena. The success of the colour matching calculation is the result of these two factors. An examination of a series of experimental reflectance values has shown that both the modified Kubelka-Munk Theory and the Saunderson correction are adequate for modern colour matching calculations. The major difficulty is in the practical assessment of absolute reflectance.

Stollnitz et. al.[27] investigated the general problem of reproducing colour images on an offset press using custom inks in any combination and number. While this problem has been explored previously for the case of two inks, there are a number of new mathematical and algorithmic challenges that arise as the number of inks increases. These challenges include more complex gamut mapping strategies, more efficient ink selection strategies, and fast and numerically accurate methods for computing ink separations in situations that may be either over- or under-constrained. In addition, the demands of high-quality colour printing require an accurate physical model of the colours that result from overprinting multiple inks using halftoning, including the effects of trapping, dot gain, and the inter-reflection of light between ink layers. In this paper, they explored these issues related to printing with multiple custom inks, and addressed them with new algorithms and physical models. They presented some printed examples demonstrating the promise of their methods.

Hoffmann [28] attempted to modify the Kubelka-Munk model for xerographic applications. He studied the modelling of the reflectance of multi-layer colour images, as is the case with many xerographic print samples. He apply the colour model with correction parameters to images measured using bi-directional measurement geometry and the variation in toner layer thickness that can occur within a colour sample with the process of xerography. The new model was verified by testing with single and bi-layer toner and hardcopy print images measured using 45/0 measurement geometry. Results show the model to be quite accurate. Colour difference (ΔE^*_{ab}) values between the predictions of the model and measurements on the actual physical samples were used as a means to characterize the accuracy of the model. The average ΔE^*_{ab} for single layer images was found to be 1.8 CIELAB . When testing the model with single and bi-layer hardcopy print images, the average error between the modelled and measured colour was found to be 5.1 CIELAB.

Viggiano and Hoagland [29] studied the selection of ink-sets for six-colour lithographic printing. A computationally and measurement efficient technique for approximating gamut size has been demonstrated. They used two criteria for selecting ink-sets. The first is the volume, in CIELAB space, of an approximation of the gamut. The second is the number of pixels within a digital image whose colours are contained within the approximate gamut. Overprints of two or more colourants are estimated using a spectral model, rather than measured from printed samples. They used the CIELAB colour space, for display, comparison, and analysis.

Guyler[30] introduced three-dimensional convex hulls to construct a geometric solid for visualizing the printing gamut. A computer program can show the overlapping of two such gamuts for improvements or to judge the advantages of one printer over another. A method was demonstrated to compute the true volume of curved surface gamuts in CIELAB colour space. This tools have potential applications in the study of ink/paper interactions, in process ink development, and in lightfastness studies.

Sakamoto and Urabe[31] have presented high precision standard pictures. They characterized pictures that were expressed by 16 bit XYZ data as well as 8 bit CIELAB data and Calibrated RGB data. The set of pictures named SHIPP consists of four full colour natural scenes and a computer-generated chart each expressed in three colour spaces, i.e., XYZ, CIELAB, and Calibrated RGB. The image data are formatted according to TIFF 6.0.

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CHAPTER 3

EXPERIMENT

In this chapter, the materials, equipment and experimental techniques will be explained.

3.1 Materials

3.1.1 Substrates : 120 g/m^2 glossy paper.

3.1.2 Printing Inks and Tint Mediums.

a) Three types of four – colour ink-sets and a special ink-set is displayed in **Table 3.1**

Ink-set	Inks	Serial Number	Density
Geos-GZQRTZ inks	Cyan	NIDV 1637	1
	Magenta	NIDV 1526	1
	Yellow	NIDV 1718	1
	Black	NIOA 7729	1
Fresh & Fast inks	Cyan	*	1
	Magenta	*	1
	Yellow	*	1
	Black	*	1
Hostmann inks	Cyan	*	1
	Magenta	*	1
	Yellow	*	1
	Black	*	1
HIZ-GT inks	Green	Colour Guide	1

Table 3.1 The inks used in the research of principle components.

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Ink-set	Inks	Serial number	Density
	Green 52	10204222	1
	Medium Red 22	10204460	1
	Deep Red 24	10204568	1
	Bronze Red 29	10204220	1
	Reddish yellow 40	10205308	1
	Orange 31	10204550	1
	Orange yellow 42	10111224	1
HIZ-GT Inks	Bronze Red 30	10204221	1
	Process Yellow 47	10203372	1
	Process Magenta 14	10204399	1
	Process Blue 58	10203373	1
	Peacock Blue 56	10204223	1
	Peacock Blue 54	10202518	1
	Ultramarine 603	10202065	1
	Dark Blue 69	10203207	1
	Bronze Blue 61	10203206	1
	Bronze Blue 602	10204489	1
	Violet 68	10203043	1
	Brown 77	10203525	1
	Black 84	10204569	1

Table 3.1 The inks used in the research of principle components (continued).

b) Tint medium

DIC (Dainippon ink & chemicals (Thailand) co.,LTD.) colourless tint medium was used to dilute the coloured inks to the required concentrations.

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3.1.3 Cleaning Solution

White spirit is used in this experiment because it is suitable for conventional lithographic ink.

3.2 Equipment

3.2.1 Print Proofer

a) Ink distribution machine : IGT Reprotest by AE

IGT Reprotest by AE is a part of Print Proofer. It is used to distribute the ink and change the thickness of the printed ink film. There are two major parts: a distributor roller system where ink is applied and the ink receiver roller that is used to transfer an ink layer from the distributor to the substrate. The components of the distributor system are two metal rollers or ink distributors and one polymer roller. These components are rotated by an electric motor, which has a fixed speed. The control of roller pressure during inking up is semi-automatic with the ink receiver roller pressed onto the ink roller by holding both receiver roller shafts. (**Figure 3.1**)

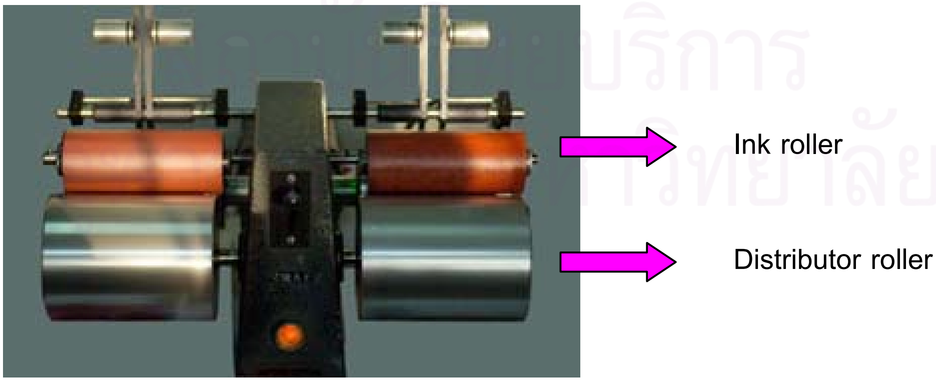

Figure 3.1 IGT Reprotest by AE ink distribution roller system.

b) IGT Printability Tester ATC 2-5

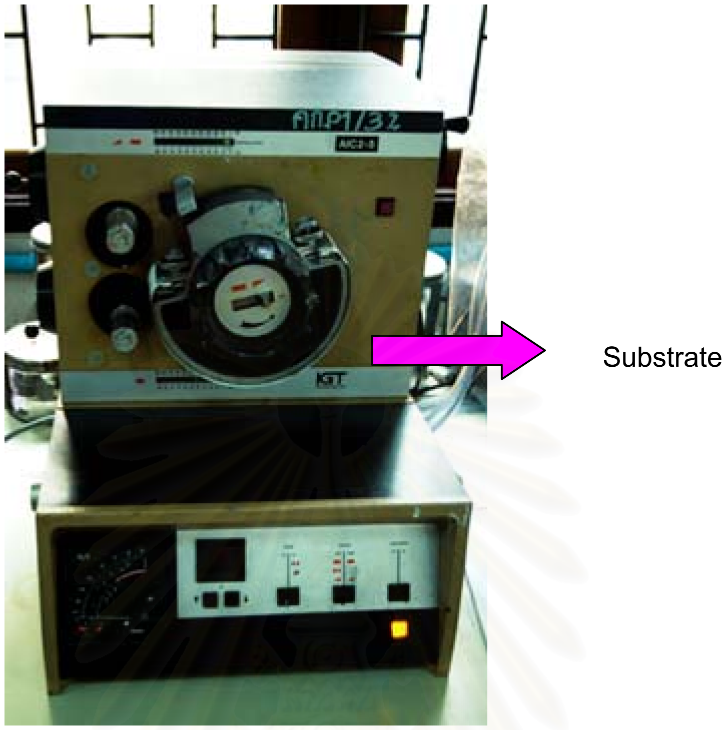

Figure 3.2 IGT Printability Tester ATC 2-5

3.2.2 Spectrophotometer: Gretag Macbeth colour eye 7000A

Specifications : Spectral range : 360 to 750 nm with 10 nm intervals.

: Measurement geometry : Diffuse/ 8 Degree (integrating sphere), dual beam, grating.

: Light source : Single flash pulsed Xenon (D65) with automated UV calibration and control.

: Illumination types : D50, D65, F12 are used in this experiment.

: Standard observer : 2° is used in this experiment.

3.2.3 Weight Measuring Gauge : Mettler AE240

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3.2.4 Software Application

3.2.4.1 Microsoft Excel Spreadsheet

Microsoft Excel spreadsheet was used for creating the K and S analysis tool, and the gamut mapping tool.

3.2.4.2 MATLAB

MATLAB provides a set of high-level graphing routines. These routines implement commonly used techniques for displaying data. It was used to obtain the 3D colour gamut of a digital image and custom combination of inks.

3.3 Experimental Techniques

The procedures of the research can be divided into 4 parts: ink calibration, determination of R_∞, K and S from a semi-transparent layer, the development of a colour gamut of a custom combination of inks, obtaining a colour gamut of a digital image, and gamut matching.

3.3.1 Preparation of Printed Calibration Panels.

1) The coloured ink was mixed and dispersed into a tint medium to produce 7 levels of dilution of the calibration ink in order to prepare prints for a database. The sequence of mixture compositions for the database preparation was chosen as follows:

Ink (%)	Tint Medium (%)
2	98
10	90
20	80
30	70
50	50
75	25
100	0

Table 3.2 The concentration sequence of the ink calibration mixtures.

2) Ink and tint medium was weighed according to the proportions shown in **Table 3.2**.

3) An amount of 0.4 cm^3 of the mixture was applied to the ink distribution roller. The ink is left to distribute uniformly for 2 minutes. Next, the ink was transferred to an ink receiver roller by hand pressing it onto the polymer distribution roller for 2 minutes. After that, the ink receiver roller was set in the IGT Printability tester ATC 2-5 print base where the substrate was already attached tightly to the clamp. Then the ink was transferred to the substrate with a fixed roller pressure to produce a fine ink layer. This is the first panel. The second panel was printed by the same procedure described above, after taking the transferred roller out of the IGT Printability tester ATC 2-5 print base and letting it receive more ink from the ink distribution roller. This was repeated until the third panel was printed.

4) White spirit was used to clean the proofer and its accessories. The proofer was left until it was completely dry before the next mixture was applied.

5) The spectral reflectance measurements were made with the Gretag Macbeth colour eye 7000A spectrophotometer with an average of three readings per measurement.
6) Steps 1 to 5 were repeated until all of the prints for the mixtures shown in **Table 3.2** were completed.

3.3.2 Determination of R_∞, K and S from Semitransparent layers.

The reflectance values of calibration panels for Fresh&Fast (FF) four-colour process cyan is used as a sample. The measured reflectance of the sample prints, that of sample over white, that of sample over black, that of the clear ink over white and R_∞ are presented in **Figure 3.3**. **Figure 3.4** shows the calculated values of K and S plotted against wavelength. **Figure 3.5** shows a flowchart of the determination of R_∞.

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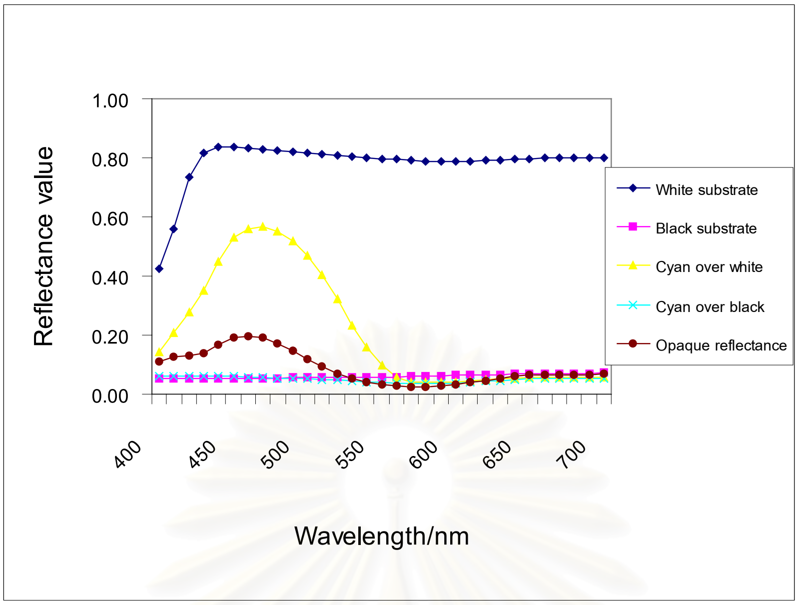

Figure 3.3 Characteristic curves of Fresh & Fast four colour process cyan over white and black card as well as R_{∞} , and that of substrate.

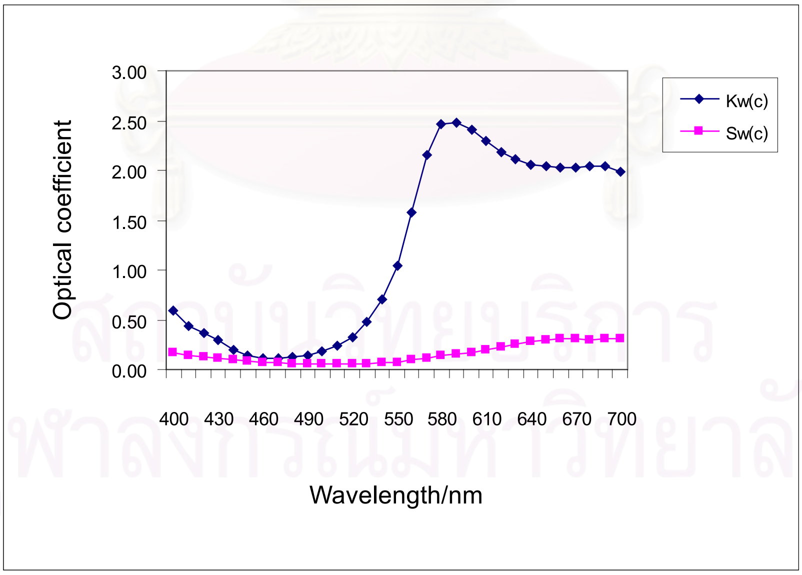

Figure 3.4 Absorption and scattering coefficient of Fresh & Fast colour process cyan.

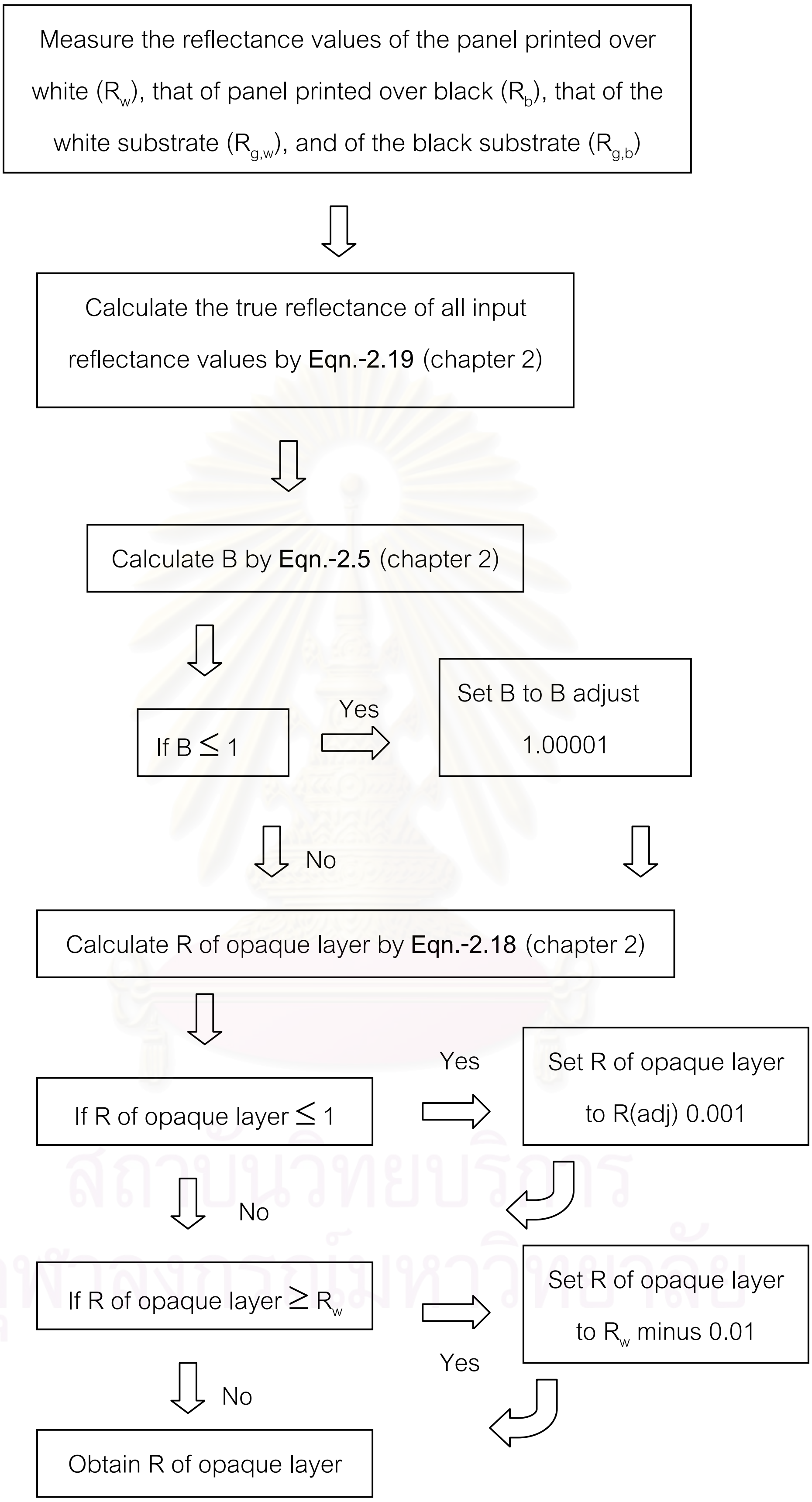

Figure 3.5 Flowchart of the determination of R_∞.

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The calculation of K and S is shown in the simplified flowchart **Figure 3.6**

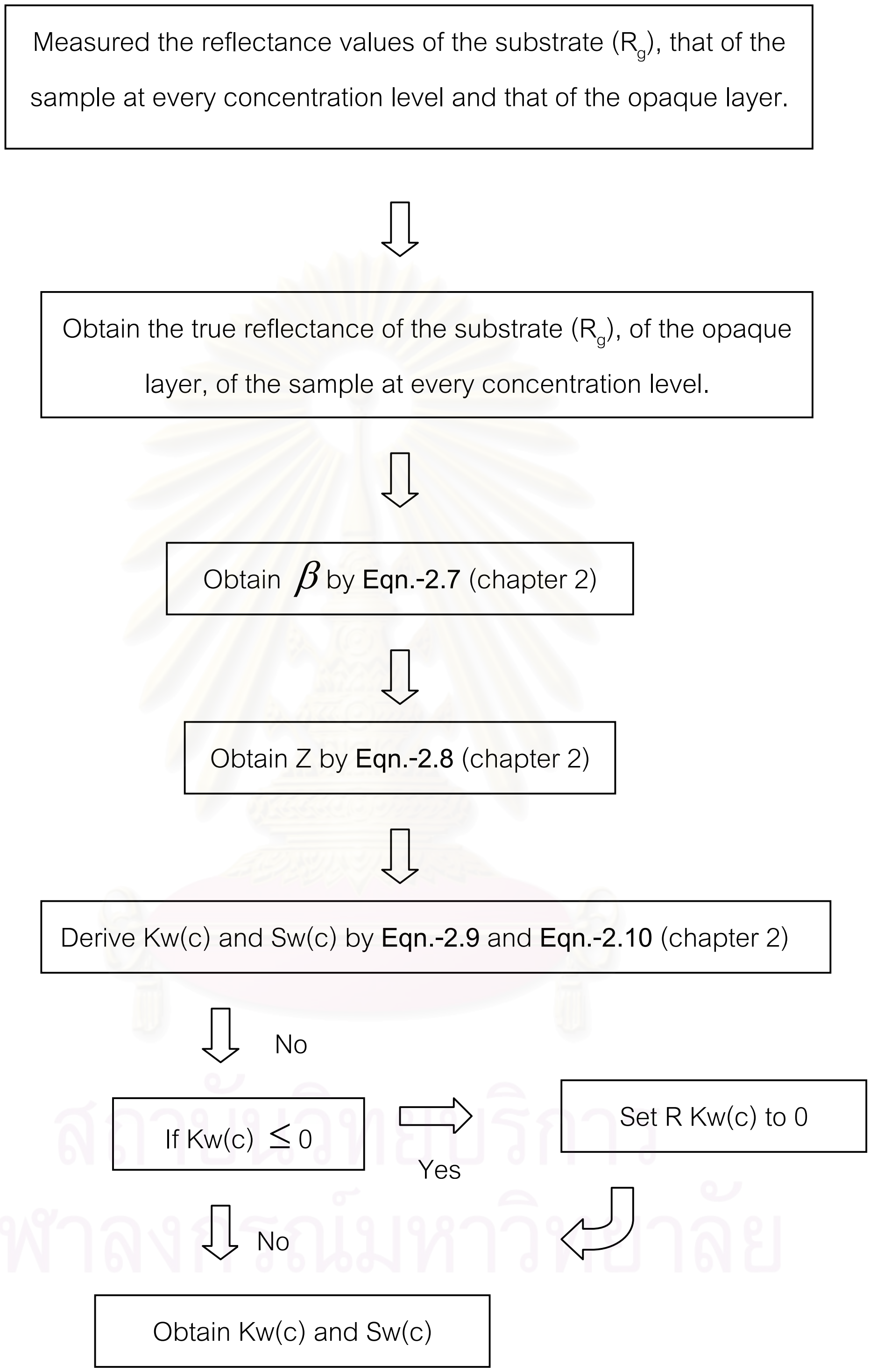

Figure 3.6 Flowchart of the determination of Kw(c) and Sw(c).

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The K value obtained from the print is dependent on the volume concentration of FF four-colour process ink in the mixture with a clear diluent. Figure 3.6 shows a plot of K against ink volume, at eight selected wavelengths.

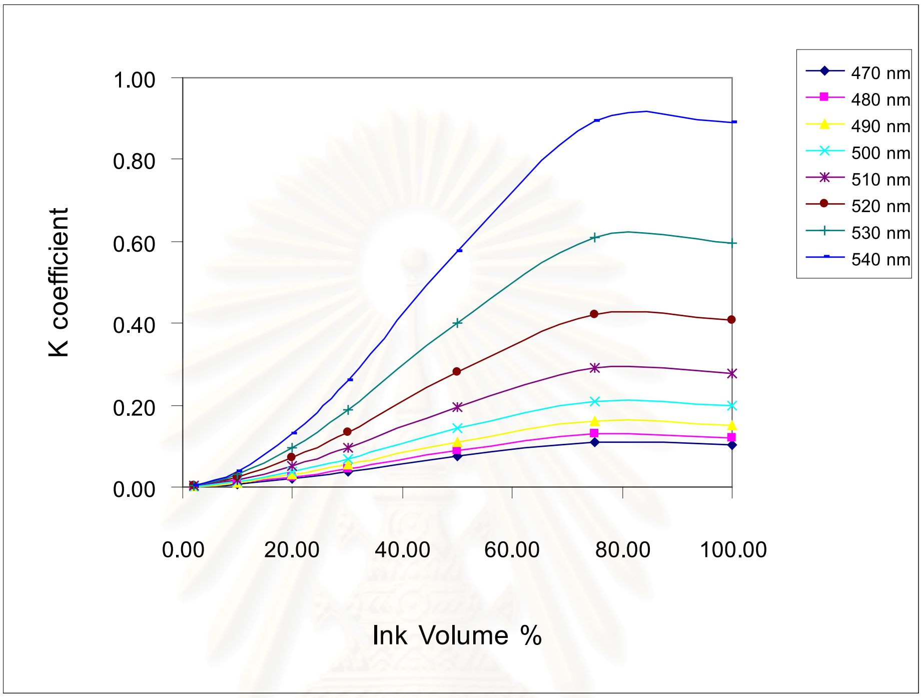

Figure 3.7 Plot of absorption coefficient of prints of Fresh & Fast four – colour process cyan ink mixed with clear ink on glossy paper against coloured ink volume.

For match prediction, the values of K and S derived from Kubelka-Munk theory are not used as a database. The coefficients derived from a least squares method fit of the non-linear dependence of K on C are used instead. Because the calculated coefficients offer a parametric description of the curve which can produce more accurate results than a look-up table because the fit reduces the noise in the original data points. The general form adopted for the non-linear dependence is a cubic approximation, as in Eqn-3.1

$$K = a_1C_1 + a_2C_1^2 + a_3C_1^3 \qquad \text{Eqn-3.1}$$

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The values of the coefficients a_1, a_2, and a_3 at each of the wavelengths in the spectrum are obtained from the least squares method. Microsoft Excel can be used to carry this out by using the LINEST worksheet function: LINEST (set of y-value, set of x-value, const, stat).

With the range of K values at every volume concentrations as the set of y-value and range of every volume concentration C, C^2, C^3 as the set of x-value, the coefficients are obtained.

For colour gamut tool, a prediction equation of a form $K=K_AC'$ is used, where C' is the volume fraction of coloured ink present in the colour prediction formulation. K_A is obtained by using the LINEST worksheet function again with K from **eqn-3.1** set as the y-value and the range of all volume concentrations set as the x-values. Then the scattering coefficient of the print S_A is computed by **Eqn-3.2**.

$$S_A = \frac{K_A}{\omega} \qquad \text{Eqn-3.2}$$

where $\omega = \frac{\left(1-R_\infty\right)^2}{2R_\infty}$

Table 3.3 shows an example of spreadsheet calculation of the coefficients, a_1, a_2, a_3, K and S obtained from the least squares method. a_1, a_2, a_3,and K/S are stored as a database for the colour gamut tool.

Name	Density	C/(mass)	C/(vol)	C/(mass)	C/(vol)	C/(mass)	C/(vol)	C/(mass)	C/(vol)	C/(mass)	C/(vol)
Diluent	1	98	98	90	90	80	80	70	70	50	50
Colour Ink	1	2	2	10	10	20	20	30	30	50	50

Name	Density	C/(mass)	C/(vol)	C/(mass)	C/(vol)
Diluent	1	25	25	0	0
Colour Ink	1	75	75	100	100

Percent volume concentration, %C : C/(vol)

C	0.0200	0.1000	0.2000	0.3000	0.5000	0.7500	1.0000
C^2	0.0004	0.0100	0.0400	0.0900	0.2500	0.5625	1.0000
C^3	0.0000	0.0010	0.0080	0.0270	0.1250	0.4219	1.0000

			B-1			From eqn.-3.1							
a3	a2	a1	K/S	K	K	K	K	K	K	K	slope	K	S
-1.340	1.611	0.246	3.518	0.006	0.039	0.103	0.183	0.358	0.525	0.517	0.006	0.592	0.168
-1.031	1.226	0.190	3.029	0.004	0.030	0.079	0.139	0.273	0.397	0.385	0.004	0.443	0.146
-0.894	1.061	0.154	2.926	0.004	0.025	0.066	0.118	0.231	0.336	0.322	0.004	0.372	0.127
-0.707	0.834	0.124	2.621	0.003	0.020	0.053	0.093	0.182	0.264	0.251	0.003	0.291	0.111
-0.472	0.550	0.093	2.075	0.002	0.014	0.037	0.065	0.125	0.180	0.171	0.002	0.197	0.095
-0.326	0.376	0.068	1.684	0.002	0.010	0.026	0.046	0.087	0.125	0.119	0.001	0.137	0.081
-0.291	0.341	0.053	1.642	0.001	0.008	0.022	0.039	0.075	0.108	0.102	0.001	0.119	0.072
-0.285	0.335	0.047	1.728	0.001	0.008	0.021	0.037	0.072	0.104	0.098	0.001	0.114	0.066
-0.314	0.374	0.044	2.019	0.001	0.008	0.021	0.038	0.076	0.111	0.104	0.001	0.122	0.060
-0.370	0.443	0.048	2.500	0.001	0.009	0.024	0.044	0.089	0.129	0.121	0.001	0.142	0.057
-0.462	0.558	0.054	3.305	0.001	0.011	0.029	0.054	0.109	0.160	0.150	0.002	0.176	0.053
-0.609	0.742	0.066	4.422	0.002	0.013	0.038	0.070	0.142	0.210	0.199	0.002	0.233	0.053
-0.853	1.050	0.081	6.163	0.002	0.018	0.051	0.096	0.197	0.292	0.279	0.003	0.327	0.053
-1.241	1.551	0.097	8.408	0.003	0.024	0.071	0.135	0.281	0.421	0.406	0.005	0.476	0.057
-1.830	2.333	0.092	11.000	0.003	0.031	0.097	0.188	0.401	0.610	0.596	0.007	0.700	0.064
-2.738	3.584	0.044	13.606	0.002	0.038	0.130	0.262	0.576	0.894	0.890	0.010	1.047	0.077
-4.083	5.500	-0.075	16.385	0.001	0.043	0.172	0.362	0.827	1.315	1.342	0.016	1.577	0.096
-5.301	7.327	-0.173	18.498	-0.001	0.051	0.216	0.464	1.083	1.755	1.852	0.022	2.158	0.117
-5.656	7.842	-0.055	18.087	0.002	0.067	0.257	0.537	1.226	1.984	2.132	0.025	2.458	0.136
-5.496	7.503	0.158	16.367	0.006	0.085	0.288	0.574	1.268	2.020	2.165	0.025	2.481	0.152
-4.996	6.662	0.457	14.280	0.012	0.107	0.318	0.602	1.269	1.982	2.122	0.024	2.409	0.169
-4.462	5.765	0.734	11.785	0.017	0.127	0.342	0.619	1.250	1.911	2.037	0.023	2.291	0.194
-4.144	5.215	0.877	9.717	0.020	0.136	0.351	0.621	1.224	1.843	1.948	0.022	2.183	0.225
-3.868	4.794	0.964	8.429	0.021	0.140	0.354	0.616	1.197	1.788	1.890	0.021	2.109	0.250
-3.722	4.589	0.981	7.399	0.021	0.140	0.350	0.607	1.172	1.747	1.848	0.021	2.058	0.278
-3.810	4.755	0.875	6.752	0.019	0.131	0.335	0.588	1.150	1.724	1.820	0.020	2.036	0.302
-3.940	5.022	0.721	6.539	0.016	0.118	0.313	0.562	1.123	1.703	1.802	0.020	2.026	0.310
-4.064	5.252	0.615	6.652	0.014	0.110	0.300	0.547	1.112	1.701	1.803	0.020	2.034	0.306
-4.141	5.336	0.612	6.787	0.014	0.110	0.303	0.552	1.122	1.714	1.807	0.020	2.043	0.301
-3.972	5.058	0.731	6.745	0.017	0.120	0.317	0.567	1.133	1.718	1.817	0.020	2.043	0.303
-3.624	4.459	0.949	6.289	0.021	0.136	0.339	0.588	1.136	1.691	1.784	0.020	1.989	0.316

Table 3.3 Sample calculation of a_1, a_2 and a_3 coefficients, K and S.

3.3.2.1 K and S Analysis Tool

An analysis tool was developed using the Excel spreadsheet application in order to obtain the K and S values from an ink-set database of reflectance values. The key part of the tool consists of two sheets. The first sheet is used for storing the database comprising the reflectance values R_g, R_b, $R_{g,w}$, $R_{g,b}$ and the reflectance spectrum of each ink panel from different concentration levels, R that is used for calculating K and S, R_∞ in the second sheet (See section3.3.2 for the derivation). Obtaining the data for a particular ink from the database was carried out by using the INDEX worksheet function of Microsoft Excel. After determining the R_∞ values, the calculation of K and S by the least squares method is automatically carried out.

3.3.3 Developing the Spreadsheet Tool for the Colour Gamut of a Custom Combination of Inks.

3.3.3.1 The Colour Gamut Tool

The colour gamut tool was developed in order to automatically determine the colour gamut that can be obtained form prints of mixtures of a limited number of inks drawn from the base set. This tool was written with Microsoft Excel spreadsheet and Visual Basic for Application under Microsoft Excel. The tool is divided into four main worksheets. The first sheet carries out the calculations and all control buttons are in this sheet. The second is the plot sheet which shows the plots of the gamut coordinates on chromaticity charts. The third is the database sheet containing the essential optical data values needed, that is K/ S, a_1, a_2, and a_3, and the last sheet contains the tables of amounts of each ink in the test formulations. In the amount sheet, five tables are provided that store the amount of each colorant to be used in a test formulation. The amounts of the inks are varied from 100, 75, 50, 25 and 0 with the condition that the total amount in each recipe is 100. The first table (Table 1 in Appendix B) is set for the mixture of any of 5 inks in the recipe. The second (Table 2 in Appendix B) is set for a mixture of any of 6 inks. The third (Table 3 in the Appendix B) is set for a mixture of any of 7 inks, the fourth is set for 9 inks (Table 4 in the Appendix B) and the last is set for ten inks (Table 5 in the Appendix B). The clear medium can be included in any formulation depending on the needs of the user.

The database sheet contains the values of K/S, a_1, a_2, and a_3 of all inks, which can be used in the recipes. These values are automatically passed to the engine sheet.

The first aim of the engine sheet is to determine the colour of the print of the ink mixtures by determining the reflectance spectrum and the tristimulus values. Therefore, a calculaton of the reflectance spectrum of the semi-transparent layer of the mixture is carried out. Finally the tristimulus values XYZ and CIE L*a*b* coordinates are derived and employed for a gamut plot. The amounts of ink in each test recipe, as mentioned, are stored in the amount sheet. The tool is written to take the amounts of ink specified for each recipe, calculate the CIE L*a*b* and store these values row by row. The steps of calculation can be defined as follows:

1. Select the table corresponding to the number of inks to be used in the formulation from the table list. Each table already contains various amounts for each component in the formulation.

2. Select the inks to be used in the formulation from the database list.

3. Calculate the absorption, K_A (**Eqn.-3.1**) and scattering S_A coefficients (**Eqn.-3.2**) of all inks in the formulation. The amount of inks in the formulation is different and the total amount of inks in the formulation is 100.

4. Calculate the total absorption, K_M and total scattering S_M coefficients by summing the contributions from each component in the formulation at each wavelength in the spectrum (**Eqn.- 3.3**)

$$K_M = K_A C'_1 + K_A C'_1 \ldots K_A C'_n \qquad \text{Eqn.-3.3}$$

$$S_M = S_A C'_1 + S_A C'_1 \ldots S_A C'_n \qquad \text{Eqn.-3.4}$$

5. Calculate the reflectance of the layer R_M which depends on $K_{M,}$ S_M and the reflectance of the substrate R_g via **Eqn.-3.5** derived in Chapter 2 (**Eqn.-2.3**)

$$R_M = \frac{\alpha . R_g + \beta . R_\infty}{\alpha + \beta} \qquad \text{Eqn.-3.5}$$

where α is a function of both the opaque reflectance R_∞ and R_g and given by **Eqn.-2.4** (chapter 2).

when R_∞ is given by **Eqn.-3.6**. (rewritten from **Eqn.-2.15** (chapter 2))

$$R_\infty = 1 + \omega - \left[(1+\omega)^2 - 1 \right]^{1/2} \qquad \text{Eqn.-3.6}$$

where $\omega = K_M / S_M$ Eqn.-3.7

β is a function of both the K_M and S_M values of the layer and the thickness D of the layer relative to that used for the calibration print and given by **Eqn.-2.5** (chapter 2), where Z is defined by **Eqn.-2.6** (chapter 2).

6. Correct the R_M value by taking into account the effect of the coating-to-air interface.
7. Calculate the colour coordinates from the recipe reflectance spectrum.

The flowchart of the calculations is shown in Figure 3.8.

As mentioned before, after the calculation of the tristimulus values and CIE L*a*b* coordinates, these values are stored continuously row by row in the spreadsheet. This part was written using Visual Basic for Application under Microsoft Excel as shown in the following example (all visual basic code developed can be found in Appendix C). Also illustrated in the following example is the code for taking the amount of each colorant from the table to calculate each test recipe one by one.

Visual Basic Code.

```
    Sub Step1()
     MsgBox "Select the Table to define the maximum number of inks
      in the combination to see the gamut then go to step 2"
End Sub

Sub Step2()
     MsgBox "Select Operation 1 if Table 1 is selected or Select
      Operation 2 if Table 2 is selected or Select Operation 3 if
      Table 3 is selected"
End Sub

Sub Operation1()
    Dim R%
    Dim RE% 'new
    Dim RowInd%, dum ' give row as integer
    RowInd = 3 'amount begin in row 2
```

```
    RE = 1000 'new
    R = 101
    Do
      Range(Cells(RowInd, 98), Cells(RowInd, 104)).Copy
      Range("n17").PasteSpecial Paste:=xlAll, Operation:=xlNone, _
                  SkipBlanks:=False, Transpose:=True
      Range(Cells(128, 12), Cells(163, 12)).Copy
      Cells(RE, 2).PasteSpecial Paste:=xlValues, Operation:=xlNone,_
                  SkipBlanks:= False, Transpose:=True
      Range(Cells(101, 9), Cells(109, 9)).Copy
      Cells(R, 17).PasteSpecial Paste:=xlValues, Operation:=xlNone,_
                  SkipBlanks:= False, Transpose:=True
      Range(Cells(113, 9), Cells(121, 9)).Copy
      Cells(R, 26).PasteSpecial Paste:=xlValues, Operation:=xlNone,_
                  SkipBlanks:= False, Transpose:=True
      Range(Cells(102, 6), Cells(104, 6)).Copy
      Cells(R, 35).PasteSpecial Paste:=xlValues, Operation:=xlNone,_
                  SkipBlanks:= False, Transpose:=True

      RowInd = RowInd + 1
      RE = RE + 1
      R = R + 1
      Application.ScreenUpdating = False
      If RowInd > 65000 Then ' a spreadsheet has about 65000 row
        dum = MsgBox("Reached the 65000th row! Help me out!")
        Exit Sub
      End If

    Loop While Cells(RowInd, 105).Value <> 0
    Application.ScreenUpdating = True
    Application.CutCopyMode = False
End Sub
```

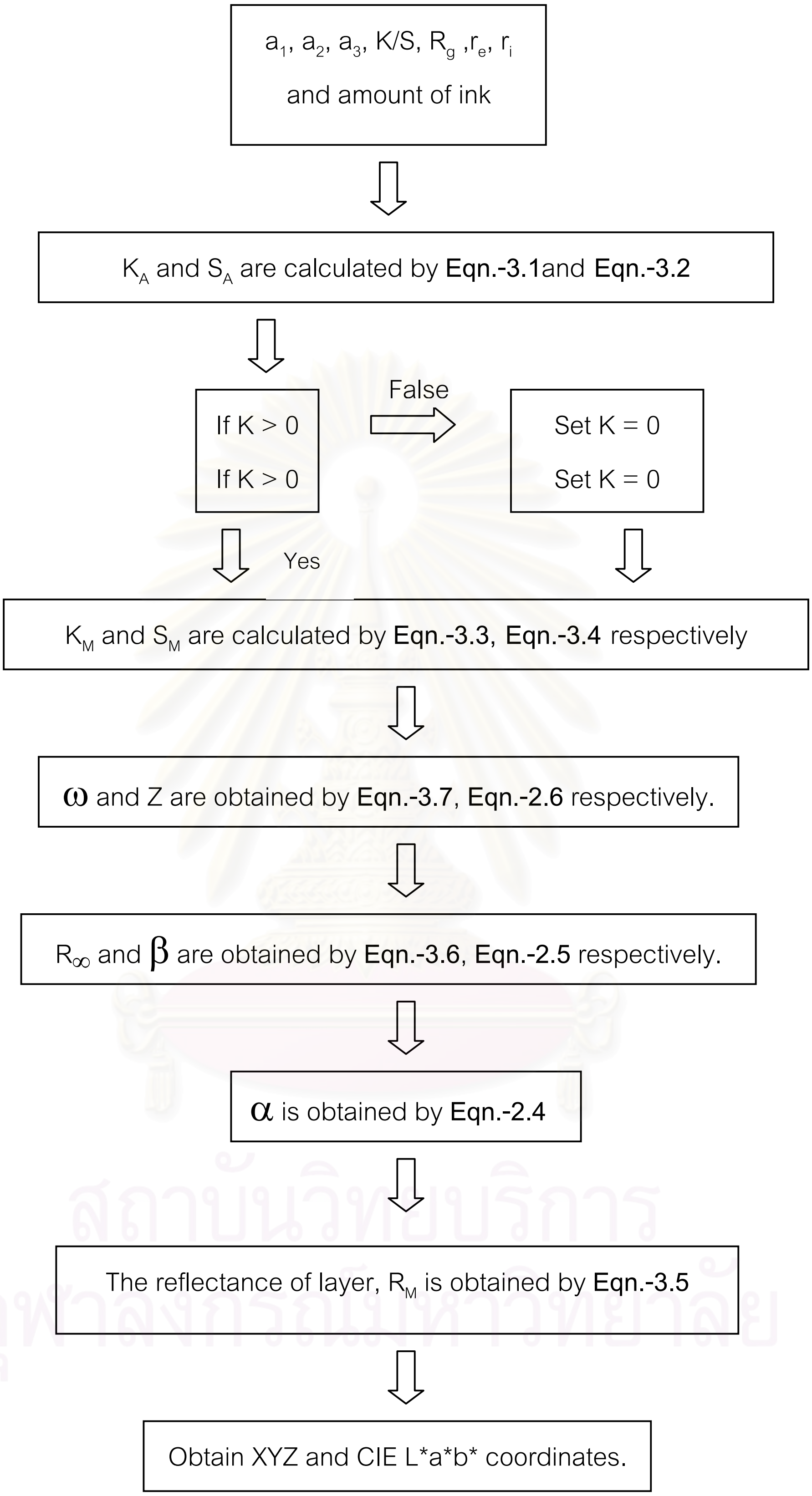

Figure 3.8 Flowchart of the calculation of reflectance spectrum and the tristimulus values from the specified amounts of the components in the formulation.

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3.3.4 Obtaining the Colour Gamut of a Digital Image.

In this experiment, SHIPP Images, standard high precision picture data from IIEEJ (The Institute of Image Electronics Engineers of Japan) is used as the standard digital image. Three images are selected, that is P1rgb (Bride), P3rgb (Wool), P4rgb (bottles).

3.3.4.1 MATLAB Code

The MATLAB code is used to read the RGB values of every pixel of the standard digital image. After that RGB values are transformed to XYZ and CIE L*a*b* coordinates.

The method of conversion from SHIPP-Calibrated RGB to XYZ is shown as follows:

Step1:

$$R'_{709} = R_{8bit\text{-}SHIPP}/255$$

$$G'_{709} = G_{8bit\text{-}SHIPP}/255$$

$$B'_{709} = B_{8bit\text{-}SHIPP}/255$$

$$\text{If } 0.018 \leq V_{709} \leq 1.0$$

Step2:

If $0.0812 \leq R'_{709} \leq 1.0$

$$R_{709} = \left[\left(R'_{709} + 0.099 \right) / 1.099 \right]^{1/0.45}$$

else $0 \leq R'_{709} < 0.0812$

$$R_{709} = R'_{709} / 4.50$$

If $0.0812 \leq G'_{709} \leq 1.0$

$$G_{709} = \left[\left(G'_{709} + 0.099\right)/1.099\right]^{1/0.45}$$

else $0 \leq G'_{709} < 0.0812$

$$G_{709} = G'_{709}/4.50$$

If $0.0812 \leq B'_{709} \leq 1.0$

$$B_{709} = \left[\left(B'_{709} + 0.099\right)/1.099\right]^{1/0.45}$$

else $0 \leq B'_{709} < 0.0812$

$$B_{709} = B'_{709}/4.50$$

Step3:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 100 & 0 & 0 \\ 0 & 100 & 0 \\ 0 & 0 & 100 \end{bmatrix} \begin{bmatrix} 0.4124 & 0.3576 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9505 \end{bmatrix} \begin{bmatrix} R_{709} \\ G_{709} \\ B_{709} \end{bmatrix}$$

3.3.5 Gamut Matching

After obtaining the colour gamut of the combination of inks and of the digital image, they are compared in order to determine the best combination of inks that matches the digital image. The criteria of comparison are as follows.

1. Size and shape of gamut.

The best combination of inks is the one in which boundaries of its colour gamut cover all colour gamuts of the digital image.

2. Gamut volume

The gamut volume program was used for obtaining the gamut volume of the combination of inks and of the digital image. Then the ink combination, having a gamut volume closer to the gamut volume of a digital image, was selected.

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 Ink Calibration Experiments

The aim of the ink calibration experiments was to calibrate all of the ink-sets to determine a database comprising the unit K/S value at each wavelength for each ink. Three coloured process-ink-sets consisting of Geos , Fresh & Fast, Hostmann four-colour process inks and twenty-one special inks of HIZGT were calibrated by the two-constant method. Each of the coloured inks from each set were diluted into 7 concentration levels by using the appropriate tint medium. All inks at each concentration levels were then printed on a black and white substrate. After that, the reflectance values for the printed panels were measured for calculating K and S to form the ink calibration database.

4.1.1 Reflectance Characteristic of Calibration Inks.

The reflectance curves of prints of the Geos four-colour process inks set consisting of cyan, magenta, yellow and black at concentration levels of 100, 75, 50, 30, 20, 10, and 2 percent ink are shown in **Figure 4.1** to **Figure 4.4**. Those of the Fresh & Fast four-colour process inks at the same concentration levels are shown in **Figure 4.5** to **Figure 4.8**. **Figure 4.9** to **Figure 4.12** are plots similar for the Hostmann set of inks.

Finally those of the twenty-one special inks of HIZGT consisting of Green, Green 52, Medium Red 22, Deep Red 24, Bronze Red 29, Reddish yellow 40, Orange 31, Orange yellow 42, Bronze Red 30, Process Yellow 47, Process Magenta 14, Process Blue 58, Peacock Blue 56, Peacock Blue 54, Ultramarine 603, Dark Blue 69, Bronze Blue 61, Bronze Blue 602, Violet 68, Brown 77, Black 84 are shown in **Figure 4.13** to **Figure 4.33**. The reflectance values are given in **Table A**, **B**, **C** and **D** of the **Appendix D** for the HIZGT ink-set, FF ink-set, Hostmann ink-set, and 21 special inks of HIZGT respectively.

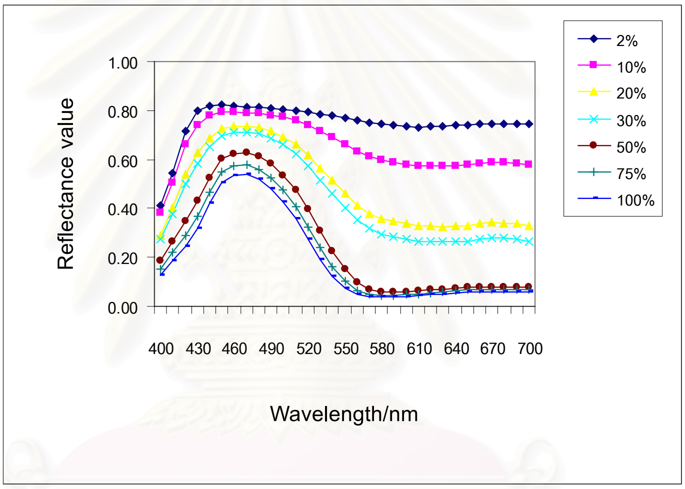

Figure 4.1 Reflectances of Geos four-colour process Cyan at 7concentration levels.

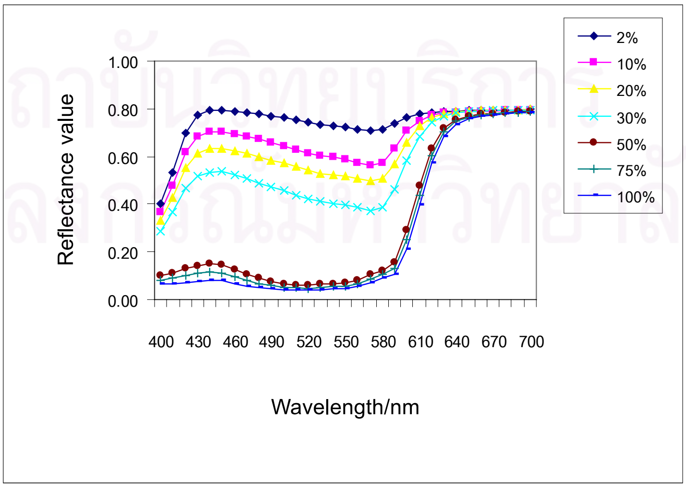

Figure 4.2 Reflectances of Geos four-colour process Magenta at 7concentration levels.

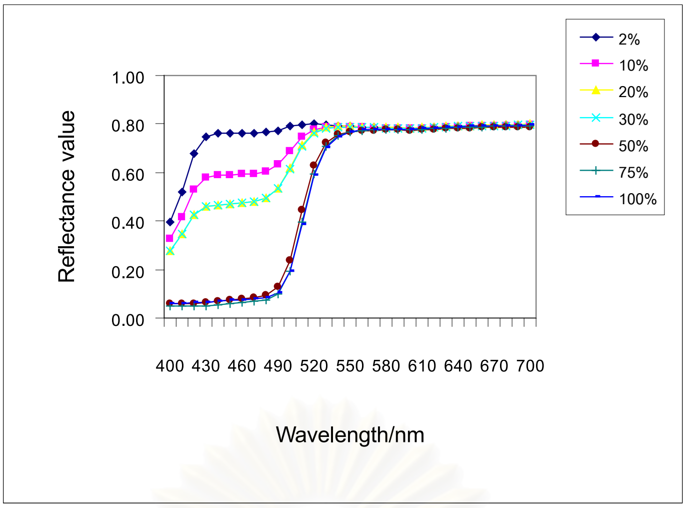

Figure 4.3 Reflectances of Geos four-colour process Yellow at 7concentration levels.

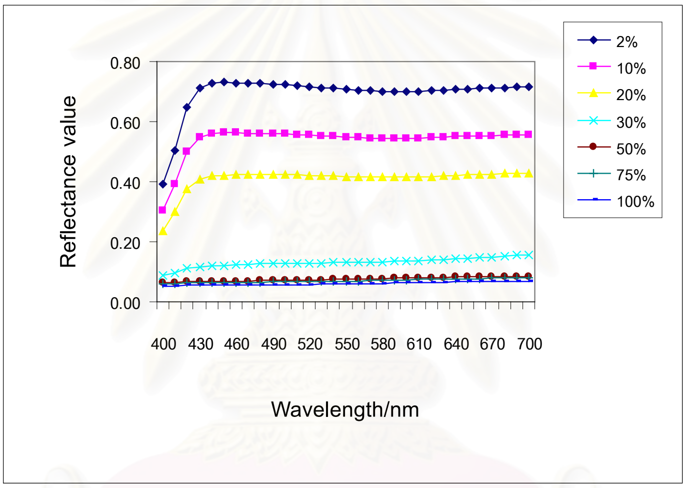

Figure 4.4 Reflectances of Geos four-colour process Black at 7concentration levels.

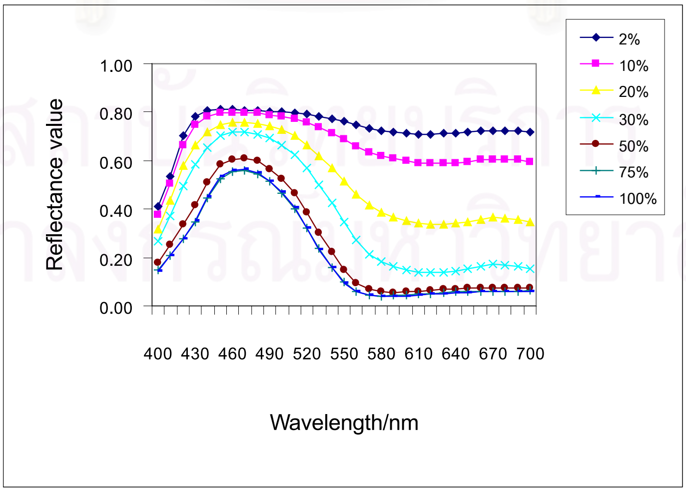

Figure 4.5 Reflectances of FF four-colour process Cyan at 7concentration levels.

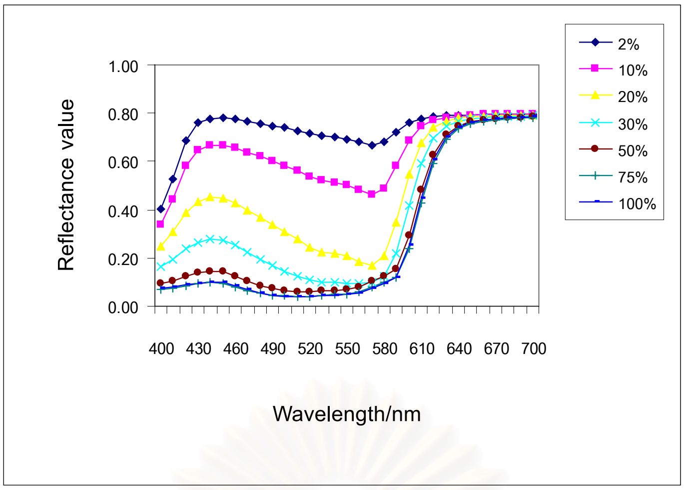

Figure 4.6 Reflectances of FF four-colour process Magenta at 7concentration levels.

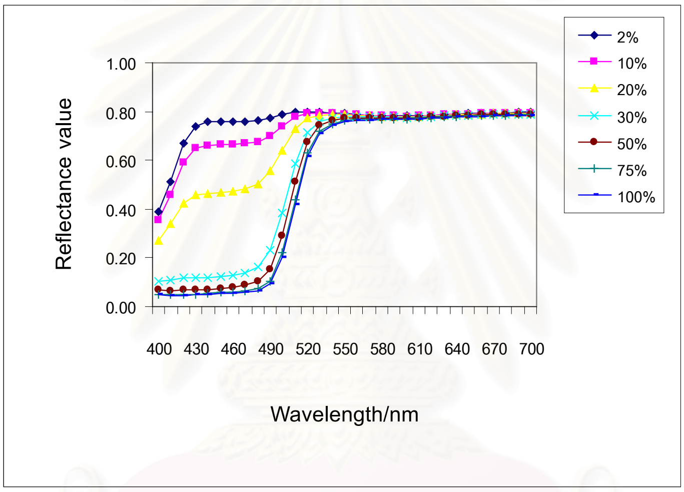

Figure 4.7 Reflectances of FF four-colour process Yellow at 7concentration levels.

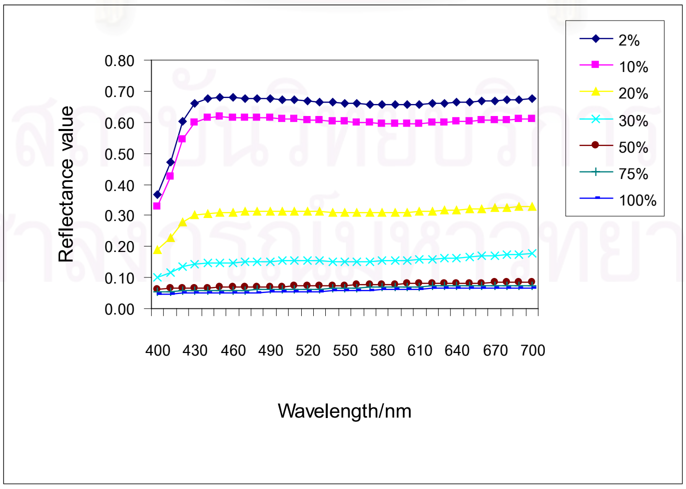

Figure 4.8 Reflectances of FF four-colour process Black at 7concentration levels.

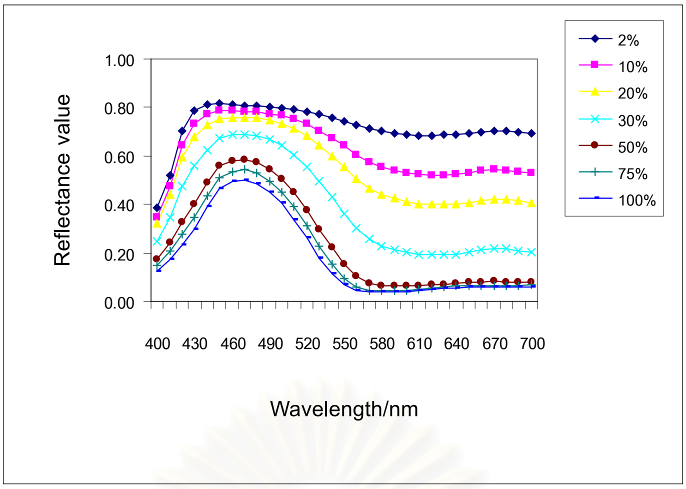

Figure 4.9 Reflectances of Hostmann four-colour process Cyan at 7concentration levels.

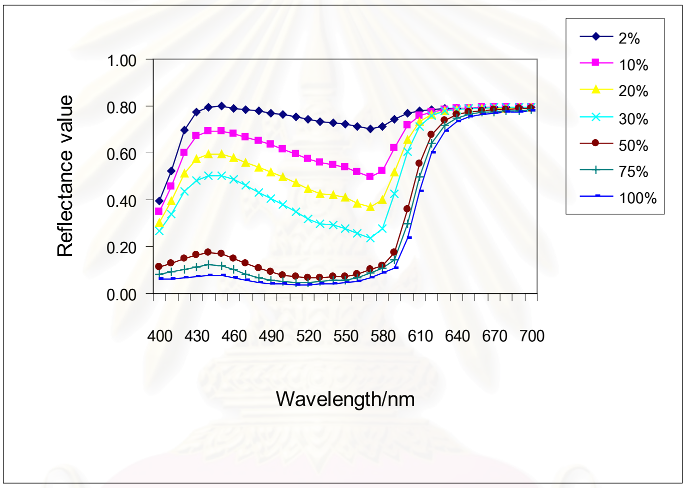

Figure 4.10 Reflectances of Hostmann four-colour process Magenta at 7concentration levels.

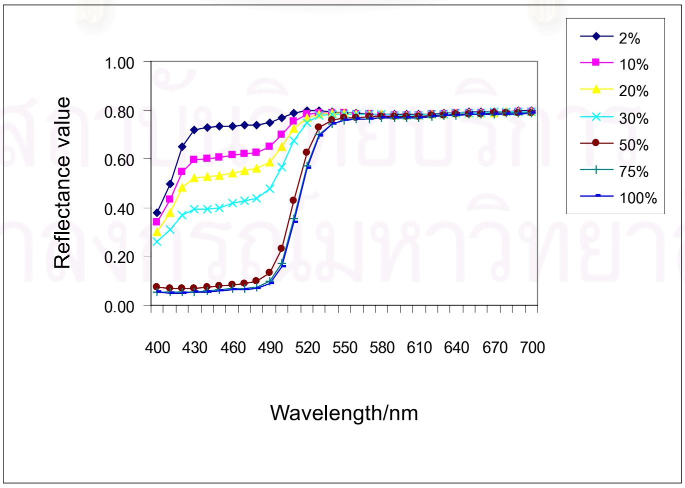

Figure 4.11 Reflectances of Hostmann four-colour process Yellow at 7concentration levels.

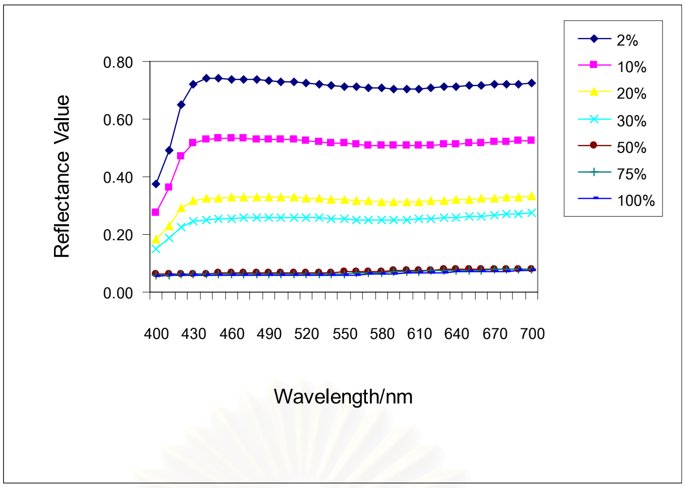

Figure 4.12 Reflectances of Hostmann four-colour process Black at 7concentration levels.

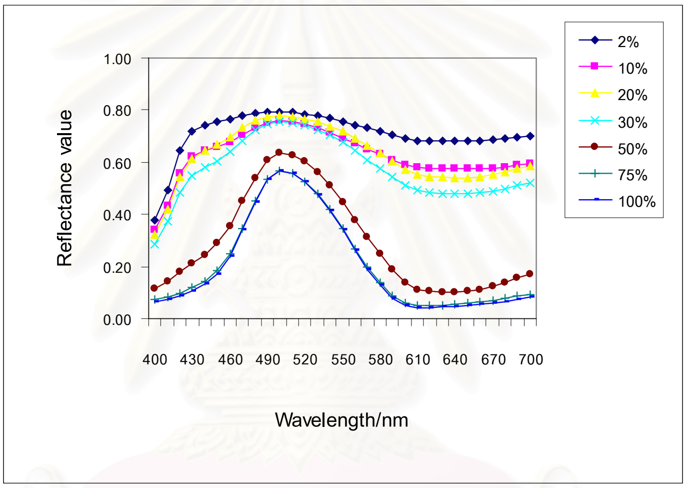

Figure 4.13 Reflectances of HIZGT special ink of Green at 7concentration levels.

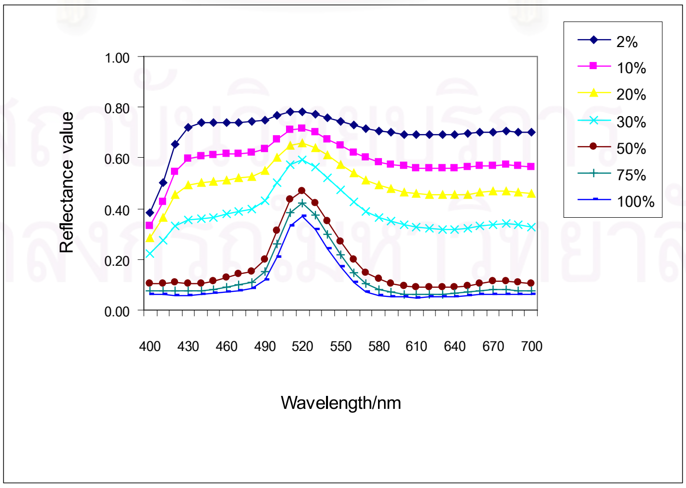

Figure 4.14 Reflectances of HIZGT special ink of Green 52 at 7concentration levels.

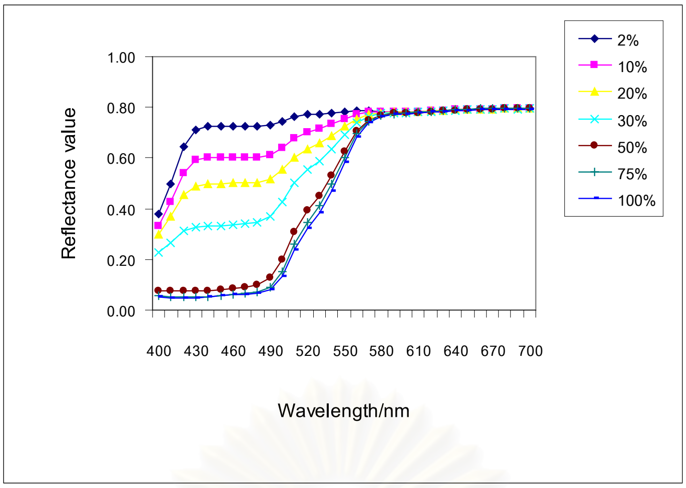

Figure 4.15 Reflectances of HIZGT special ink of Orange Yellow 42 at 7concentration levels.

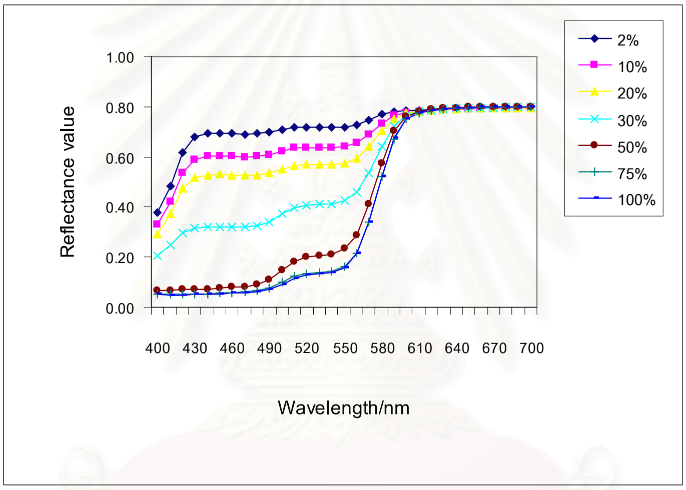

Figure 4.16 Reflectances of HIZGT special ink of Orange 31 at 7concentration levels.

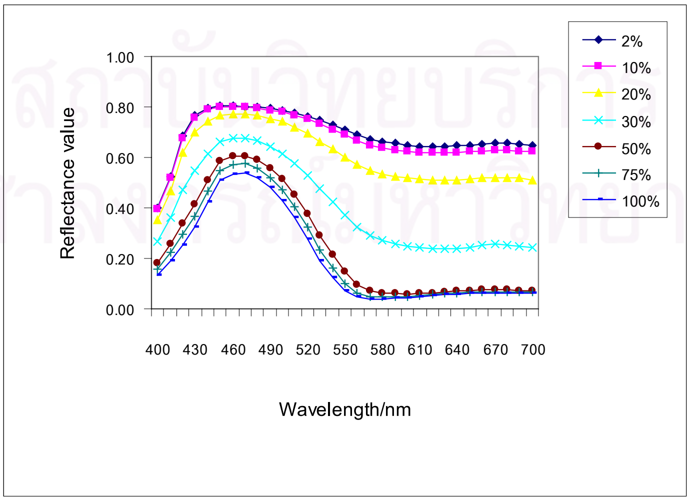

Figure 4.17 Reflectances of HIZGT special ink of Process Blue 58 at 7concentration levels.

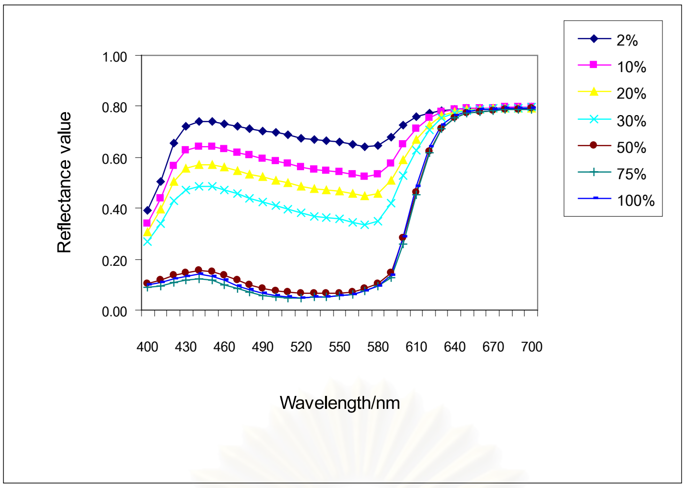

Figure 4.18 Reflectances of HIZGT special ink of Process Magenta 14 at 7concentration levels.

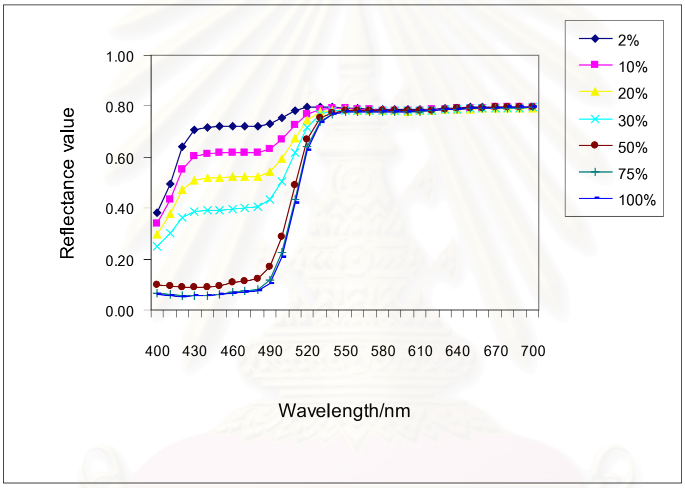

Figure 4.19 Reflectances of HIZGT special ink of Process Yellow 47 at 7concentration levels.

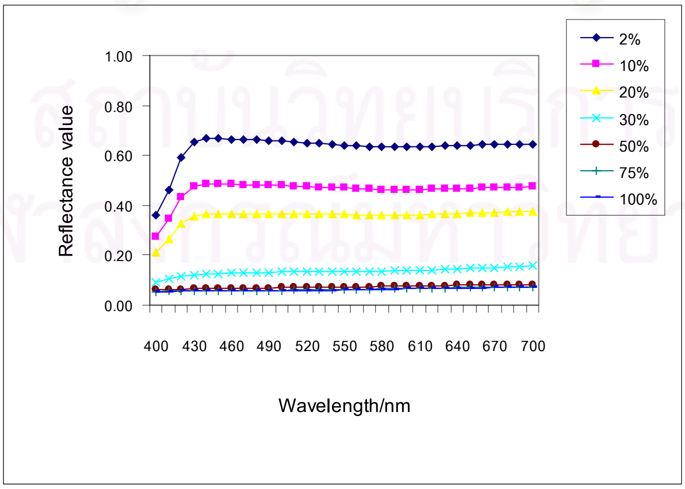

Figure 4.20 Reflectances of HIZGT special ink of Black 84 at 7concentration levels.

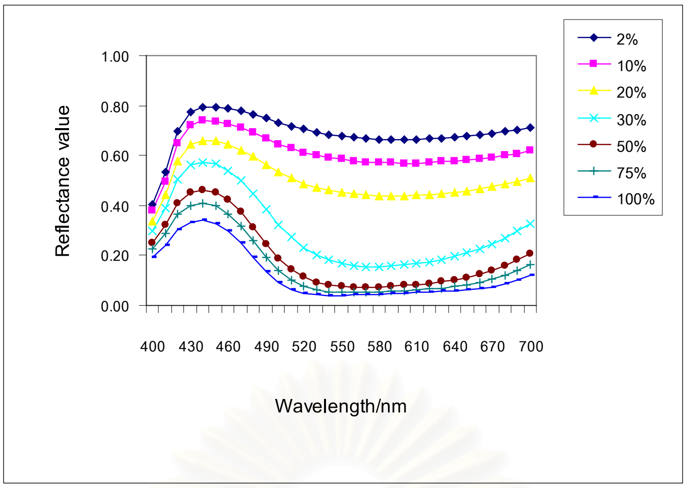

Figure 4.21 Reflectances of HIZGT special ink of Bronze Blue 62 at 7concentration levels.

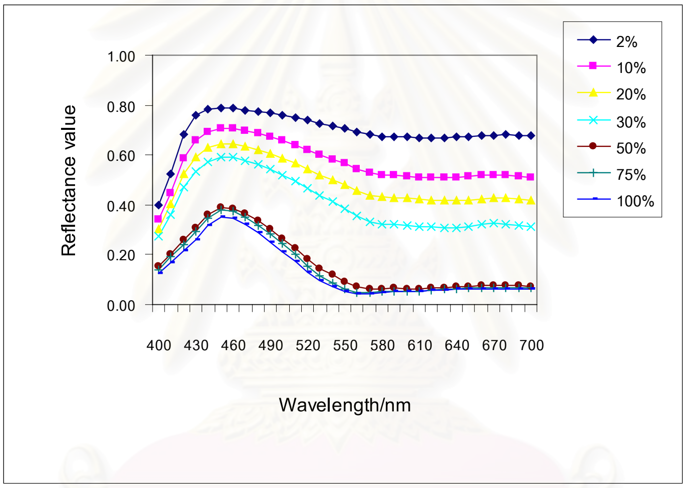

Figure 4.22 Reflectances of HIZGT special ink of Bronze Blue 61 at 7concentration levels.

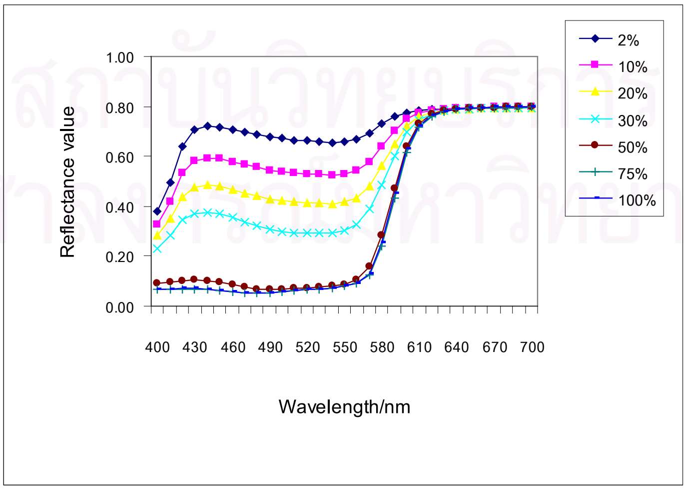

Figure 4.23 Reflectances of HIZGT special ink of Bronze Red 29 at 7concentration levels.

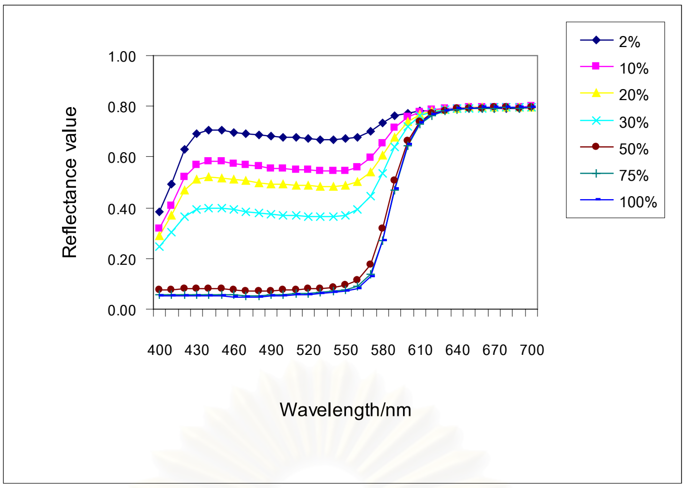

Figure 4.24 Reflectances of HIZGT special ink of Bronze Red 30 at 7concentration levels.

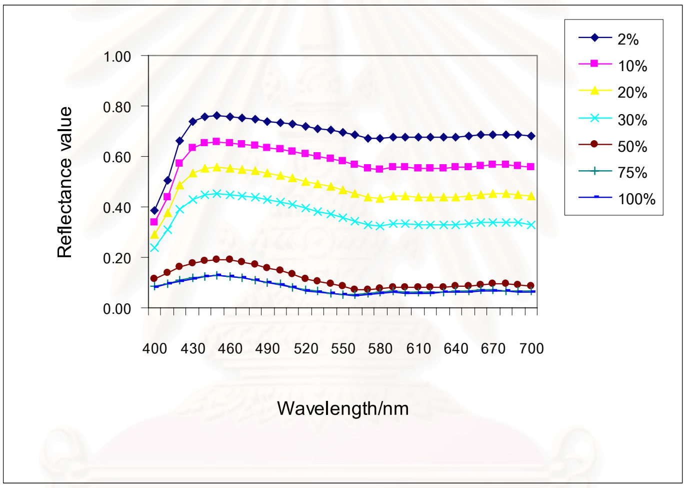

Figure 4.25 Reflectances of HIZGT special ink of Dark Blue 69 at 7concentration levels.

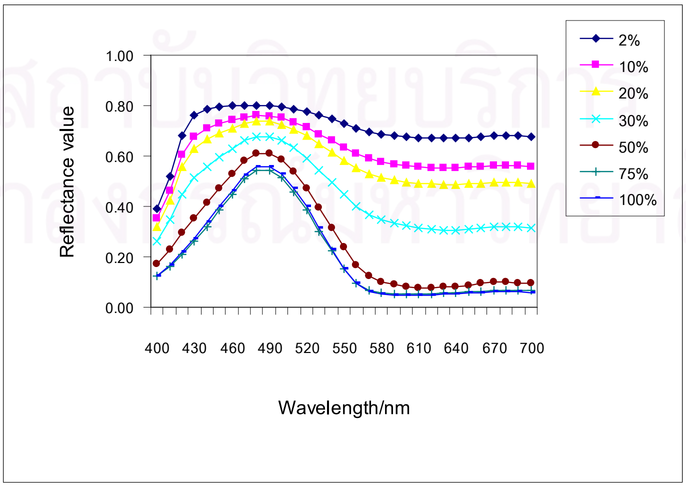

Figure 4.26 Reflectances of HIZGT special ink of Peacock Blue 54 at 7concentration levels.

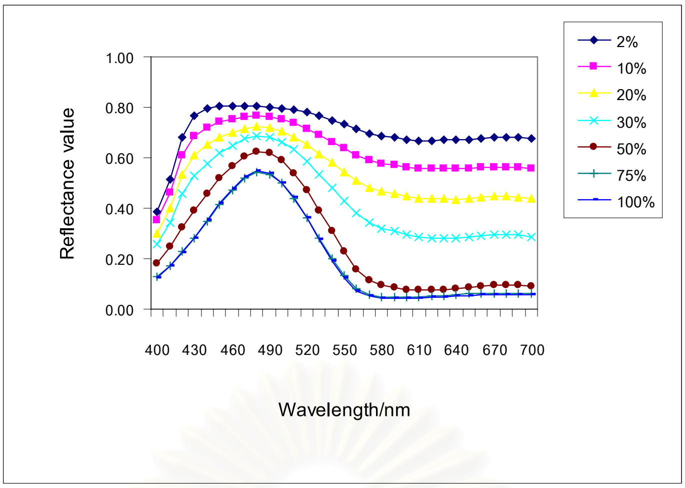

Figure 4.27 Reflectances of HIZGT special ink of Peacock Blue 56 at 7concentration levels.

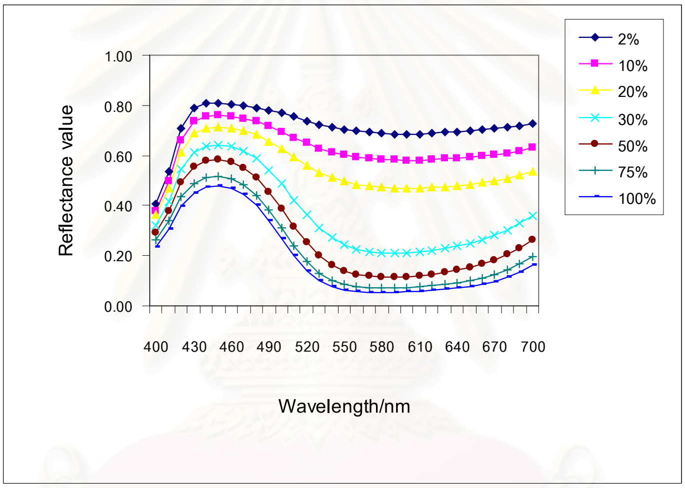

Figure 4.28 Reflectances of HIZGT special ink of Ultramarine 63 at 7concentration levels.

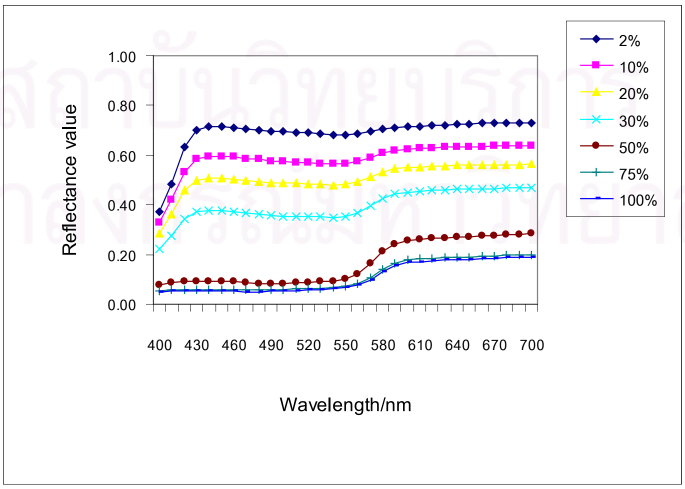

Figure 4.29 Reflectances of HIZGT special ink of Brown 77 at 7concentration levels.

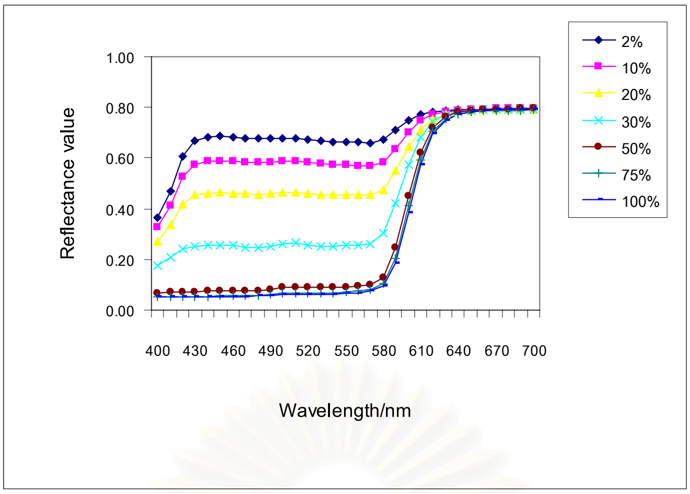

Figure 4.30 Reflectances of HIZGT special ink of Deep Red 24 at 7concentration levels.

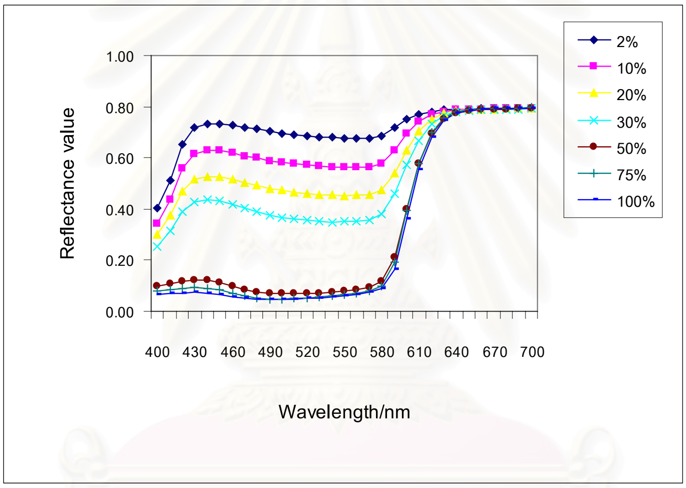

Figure 4.31 Reflectances of HIZGT special ink of Medium Red 22 at 7concentration levels.

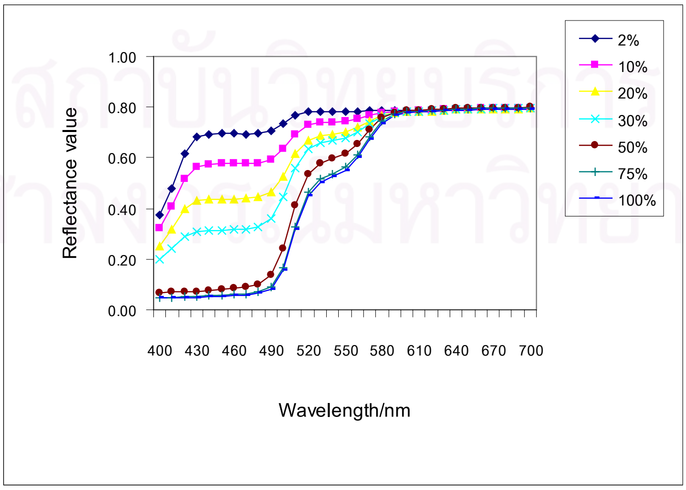

Figure 4.32 Reflectances of HIZGT special ink of Reddish Yellow 40 at 7concentration levels.

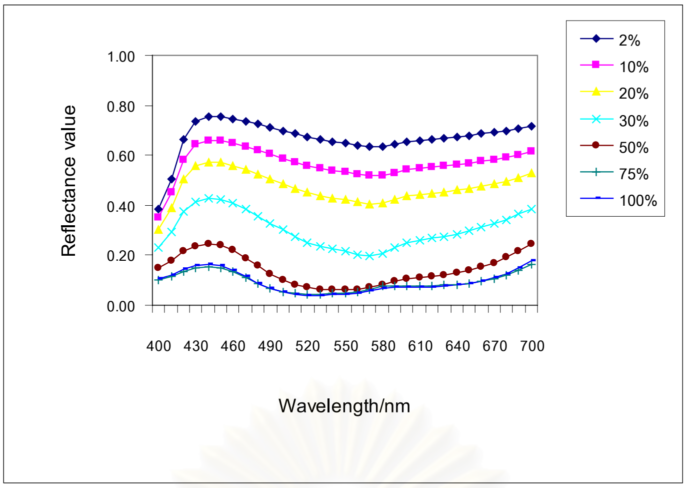

Figure 4.33 Reflectances of HIZGT special ink of Violet 68 at 7concentration levels.

As expected, the results show that the reflectance spectrum of any ink tends to increase when the concentrations of the ink are reduced; for low concentration, the spectrum approaches that of the substrate (white). It is determined that all the printed substrates are lower reflecting than the white substrate, so we can deduce that all the inks are not fluorescent.

The spreadsheet for the determination K and S was developed. The correction coefficients, r_e of 0.025 for print, r_e of 0.040 for substrate, r_i of 0.600 for print, r_i of 0.600 for substrate, t_e of 0.975 for print, t_e of 0.960 for substrate, t_l of 0.400 for print and t_l of 0.400 for subtrate can minimise the colour difference between the predicted spectra and the measured spectra when an integrating sphere instrument was used.

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4.1.2 Application to Ink-sets.

4.1.2.1 Applying the K and S Analysis Tool.

The K and S analysis tool is created with the Excel spreadsheet application. The database sheet consists of the reflectance values of all inks at seven different concentration levels and the reflectance values of the substrate. K and S of each ink are obtained by running the engine worksheet of the analysis tool, this is automatically performed when the corresponding engine from the combo box shown in **Figure 4.34** is selected. Once the coloured ink is chosen, K and S are determined. The K and S and R_∞ of the coloured inks of four ink-sets: Geos ink-set, FF ink-set, Hostmann ink-set and 21 special inks of HIZGT are shown in **Table 4.1**, **4.2**, **4.3** and **4.4** respectively.

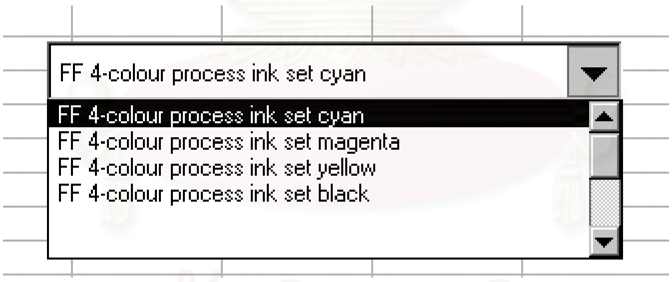

Figure 4.34 Combo box helping the user to select the coloured ink in order to determine K and S.

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	Geos ink-set: cyan			*Geos ink-set: Magenta*			*Geos ink-set: Yellow*			*Geos ink-set: Black*		
Wavelength/ nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.0955	0.6102	0.1424	0.0460	1.2680	0.1282	0.0374	1.6728	0.1350	0.0518	1.6654	0.1921
410	0.1068	0.4605	0.1233	0.0459	1.3036	0.1315	0.0370	1.8062	0.1440	0.0540	1.7565	0.2122
420	0.1088	0.3899	0.1068	0.0453	1.2835	0.1276	0.0371	1.8120	0.1449	0.0566	1.8440	0.2346
430	0.1183	0.3041	0.0926	0.0450	1.2342	0.1218	0.0395	1.7533	0.1503	0.0572	1.8639	0.2398
440	0.1403	0.2018	0.0767	0.0440	1.1869	0.1143	0.0445	1.6818	0.1638	0.0584	1.8708	0.2466
450	0.1637	0.1378	0.0645	0.0422	1.2177	0.1121	0.0512	1.6193	0.1841	0.0589	1.8604	0.2476
460	0.1651	0.1196	0.0567	0.0389	1.3611	0.1146	0.0564	1.5773	0.1997	0.0602	1.8445	0.2516
470	0.1592	0.1158	0.0522	0.0361	1.5800	0.1227	0.0624	1.5236	0.2163	0.0609	1.8353	0.2537
480	0.1420	0.1264	0.0487	0.0332	1.8405	0.1307	0.0711	1.4349	0.2364	0.0614	1.8376	0.2562
490	0.1217	0.1501	0.0474	0.0315	2.1014	0.1409	0.0855	1.1640	0.2380	0.0623	1.8312	0.2595
500	0.0982	0.1896	0.0458	0.0294	2.3360	0.1455	0.1108	0.6387	0.1789	0.0626	1.8274	0.2605
510	0.0783	0.2539	0.0468	0.0277	2.4834	0.1457	0.1700	0.2576	0.1271	0.0625	1.8117	0.2579
520	0.0605	0.3612	0.0495	0.0280	2.4503	0.1454	0.2658	0.0970	0.0956	0.0628	1.8131	0.2595
530	0.0480	0.5345	0.0567	0.0321	2.2792	0.1564	0.3837	0.0388	0.0784	0.0642	1.8100	0.2652
540	0.0388	0.7955	0.0668	0.0358	2.1620	0.1667	0.4892	0.0180	0.0674	0.0661	1.8047	0.2735
550	0.0326	1.1953	0.0832	0.0383	2.0729	0.1716	0.5743	0.0096	0.0607	0.0671	1.7907	0.2761
560	0.0264	1.7661	0.0982	0.0462	1.8436	0.1870	0.6284	0.0060	0.0548	0.0690	1.7853	0.2840
570	0.0225	2.2605	0.1064	0.0779	1.5245	0.2792	0.6683	0.0041	0.0504	0.0705	1.7830	0.2910
580	0.0217	2.3921	0.1087	0.1195	1.3790	0.4252	0.6868	0.0032	0.0449	0.0721	1.7714	0.2966
590	0.0233	2.3555	0.1152	0.1321	1.1651	0.4088	0.7175	0.0024	0.0434	0.0741	1.7659	0.3054
600	0.0261	2.2462	0.1234	0.1519	0.5480	0.2315	0.7318	0.0019	0.0395	0.0762	1.7532	0.3131
610	0.0311	2.1263	0.1409	0.1988	0.2282	0.1414	0.7146	0.0018	0.0319	0.0777	1.7497	0.3196
620	0.0376	2.0050	0.1627	0.2696	0.0941	0.0951	0.6700	0.0019	0.0231	0.0793	1.7489	0.3272
630	0.0438	1.9279	0.1846	0.3531	0.0408	0.0688	0.6227	0.0019	0.0169	0.0811	1.7467	0.3353
640	0.0503	1.8522	0.2064	0.4257	0.0203	0.0523	0.5784	0.0019	0.0121	0.0823	1.7389	0.3399
650	0.0562	1.8102	0.2285	0.4699	0.0121	0.0406	0.5218	0.0017	0.0077	0.0835	1.7333	0.3448
660	0.0591	1.8098	0.2417	0.4894	0.0087	0.0325	0.4388	0.0016	0.0043	0.0849	1.7331	0.3512
670	0.0585	1.8319	0.2418	0.4994	0.0068	0.0273	0.3576	0.0015	0.0027	0.0857	1.7251	0.3539
680	0.0574	1.8508	0.2394	0.5030	0.0057	0.0233	0.2085	0.0015	0.0010	0.0872	1.7264	0.3613
690	0.0569	1.8419	0.2357	0.4978	0.0049	0.0194	0.8932	0.0072	718.05	0.0880	1.7172	0.3632
700	0.0595	1.7853	0.2402	0.4849	0.0043	0.0156	0.8937	0.0064	641.59	0.0886	1.7111	0.3651

Table 4.1 K, S and R_∞ of the Geos four-colour process ink-set.

	FF ink-set: cyan			FF ink-set: Magenta			FF ink-set: Yellow			FF ink-set: Black		
Wavelength /nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.1121	0.5922	0.1683	0.0474	1.1269	0.1178	0.0495	2.0811	0.2279	0.0241	1.4491	0.0734
410	0.1261	0.4428	0.1462	0.0475	1.1498	0.1203	0.0428	2.1966	0.2597	0.0246	1.5350	0.0793
420	0.1295	0.3723	0.1272	0.0466	1.1185	0.1147	0.0425	2.2808	0.2875	0.0231	1.6038	0.0776
430	0.1408	0.2911	0.1111	0.0466	1.0697	0.1096	0.0461	2.2853	0.3166	0.0228	1.6145	0.0772
440	0.1672	0.1970	0.0949	0.0454	1.0241	0.1020	0.0522	2.2513	0.3441	0.0218	1.5983	0.0727
450	0.1933	0.1368	0.0813	0.0434	1.0513	0.0998	0.0601	2.2017	0.3687	0.0212	1.5712	0.0697
460	0.1965	0.1185	0.0722	0.0390	1.1857	0.1002	0.0751	3.0236	0.5310	0.0205	1.5565	0.0667
470	0.1899	0.1136	0.0657	0.0362	1.4048	0.1094	0.0797	2.3951	0.4506	0.0209	1.5377	0.0669
480	0.1704	0.1220	0.0604	0.0324	1.6810	0.1164	0.0863	1.9126	0.3956	0.0206	1.5271	0.0654
490	0.1459	0.1422	0.0569	0.0306	1.9918	0.1296	0.0980	1.1999	0.2892	0.0215	1.5135	0.0680
500	0.1178	0.1764	0.0534	0.0285	2.2936	0.1387	0.1278	0.5538	0.1860	0.0222	1.5073	0.0700
510	0.0930	0.2330	0.0527	0.0271	2.5129	0.1441	0.1998	0.2068	0.1291	0.0247	1.5064	0.0783
520	0.0701	0.3268	0.0530	0.0278	2.4473	0.1441	0.3089	0.0759	0.0981	0.0275	1.5114	0.0878
530	0.0533	0.4763	0.0567	0.0333	2.1983	0.1569	0.4183	0.0325	0.0802	0.0320	1.5238	0.1040
540	0.0417	0.7000	0.0636	0.0382	2.0554	0.1698	0.4932	0.0177	0.0681	0.0374	1.5399	0.1241
550	0.0343	1.0467	0.0769	0.0414	1.9156	0.1728	0.5456	0.0114	0.0603	0.0431	1.5524	0.1462
560	0.0288	1.5767	0.0962	0.0516	1.6278	0.1866	0.5666	0.0087	0.0525	0.0485	1.5699	0.1681
570	0.0257	2.1580	0.1167	0.0855	1.2703	0.2599	0.5788	0.0072	0.0468	0.0529	1.5802	0.1866
580	0.0262	2.4580	0.1359	0.1255	1.1711	0.3842	0.5817	0.0062	0.0413	0.0569	1.5882	0.2033
590	0.0288	2.4815	0.1516	0.1360	0.9949	0.3626	0.5812	0.0055	0.0368	0.0599	1.5929	0.2158
600	0.0328	2.4086	0.1687	0.1595	0.4428	0.2000	0.5750	0.0050	0.0316	0.0624	1.5900	0.2258
610	0.0392	2.2912	0.1944	0.2119	0.1846	0.1260	0.5562	0.0048	0.0271	0.0631	1.5790	0.2271
620	0.0468	2.1834	0.2247	0.2876	0.0786	0.0890	0.5244	0.0046	0.0213	0.0638	1.5666	0.2283
630	0.0532	2.1086	0.2502	0.3720	0.0358	0.0675	0.4968	0.0046	0.0180	0.0642	1.5524	0.2274
640	0.0597	2.0584	0.2782	0.4411	0.0188	0.0531	0.4670	0.0044	0.0143	0.0642	1.5398	0.2256
650	0.0648	2.0358	0.3015	0.4841	0.0117	0.0425	0.4394	0.0041	0.0115	0.0638	1.5235	0.2219
660	0.0666	2.0262	0.3099	0.5061	0.0085	0.0353	0.4052	0.0040	0.0092	0.0631	1.5072	0.2166
670	0.0656	2.0341	0.3058	0.5194	0.0068	0.0305	0.3946	0.0039	0.0083	0.0626	1.4918	0.2124
680	0.0645	2.0430	0.3010	0.5282	0.0056	0.0266	0.3772	0.0037	0.0073	0.0613	1.4715	0.2046
690	0.0648	2.0425	0.3028	0.5248	0.0049	0.0227	0.3484	0.0038	0.0062	0.0599	1.4565	0.1973
700	0.0689	1.9888	0.3162	0.5193	0.0042	0.0189	0.2990	0.0035	0.0043	0.0582	1.4419	0.1894

Table 4.2 K, S and R_∞ of the Fresh and Fast four-colour process ink-set.

	Hostmann ink-set: cyan			*Hostnann ink-set: Magenta*			*Hostmann ink-set: Yellow*			*Hostmann ink-set: Black*		
Wavelength /nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.0991	0.6476	0.1581	0.0497	1.3066	0.1437	0.0493	1.7625	0.1922	0.0643	1.9381	0.3385
410	0.1080	0.4965	0.1348	0.0517	1.3410	0.1543	0.0508	2.1607	0.2439	0.0665	2.0488	0.3704
420	0.1092	0.4265	0.1174	0.0512	1.3101	0.1491	0.0536	2.4051	0.2879	0.0772	12.026	2.1797
430	0.1165	0.3384	0.1010	0.0507	1.2478	0.1405	0.0590	2.4543	0.3269	0.0779	3.9975	0.7328
440	0.1344	0.2339	0.0839	0.0505	1.1966	0.1340	0.0657	2.3904	0.3599	0.0784	3.5311	0.6523
450	0.1520	0.1679	0.0710	0.0494	1.2315	0.1347	0.0745	2.2698	0.3946	0.0792	3.2044	0.5983
460	0.1536	0.1477	0.0633	0.0470	1.3969	0.1446	0.0789	2.1124	0.3928	0.0786	2.9702	0.5498
470	0.1491	0.1422	0.0586	0.0455	1.6764	0.1674	0.0812	2.0026	0.3852	0.0792	2.9630	0.5538
480	0.1353	0.1519	0.0549	0.0437	2.1370	0.2044	0.0881	1.8707	0.3965	0.0784	2.8376	0.5240
490	0.1192	0.1754	0.0539	0.0316	2.2226	0.2116	0.1035	1.4308	0.3684	0.0786	2.7927	0.5168
500	0.1006	0.2155	0.0536	0.0241	2.3031	0.2164	0.1306	0.7828	0.2706	0.0775	2.6836	0.4891
510	0.0832	0.2821	0.0558	0.0200	2.3500	0.2260	0.1908	0.3214	0.1873	0.0770	2.5858	0.4675
520	0.0667	0.3943	0.0604	0.0206	2.3365	0.2372	0.2960	0.1132	0.1353	0.0753	2.4857	0.4377
530	0.0551	0.5777	0.0713	0.0274	2.2720	0.2568	0.4242	0.0411	0.1052	0.0745	2.3546	0.4093
540	0.0464	0.8603	0.0877	0.0333	2.2252	0.2707	0.5124	0.0201	0.0865	0.0738	2.2555	0.3883
550	0.0414	1.3268	0.1197	0.0379	2.1734	0.2797	0.5592	0.0130	0.0748	0.0739	2.1546	0.3714
560	0.0377	2.2250	0.1814	0.0521	2.0451	0.3090	0.5799	0.0100	0.0659	0.0744	2.0642	0.3585
570	0.0206	2.3695	0.1933	0.0901	1.7421	0.3792	0.5948	0.0082	0.0592	0.0753	2.0025	0.3528
580	0.0213	2.4057	0.2179	0.1166	1.3558	0.4050	0.5984	0.0069	0.0516	0.0765	1.9331	0.3467
590	0.0258	2.3824	0.2410	0.1266	1.0565	0.3507	0.6068	0.0059	0.0465	0.0782	1.8834	0.3464
600	0.0325	2.3344	0.2665	0.1550	0.4539	0.1970	0.6069	0.0051	0.0399	0.0809	1.8558	0.3552
610	0.0411	2.2698	0.2930	0.2059	0.1822	0.1190	0.5903	0.0048	0.0337	0.0822	1.8191	0.3548
620	0.0504	2.2078	0.3206	0.2718	0.0764	0.0783	0.5659	0.0045	0.0271	0.0842	1.8019	0.3620
630	0.0582	2.1596	0.3418	0.3408	0.0352	0.0553	0.5409	0.0042	0.0218	0.0861	1.7853	0.3679
640	0.0734	2.5729	0.4401	0.3926	0.0193	0.0411	0.5162	0.0040	0.0176	0.0877	1.7698	0.3732
650	0.0771	2.3689	0.4291	0.4149	0.0129	0.0312	0.4868	0.0037	0.0138	0.0893	1.7627	0.3798
660	0.0785	2.3917	0.4421	0.4175	0.0100	0.0247	0.4669	0.0034	0.0112	0.0909	1.7585	0.3866
670	0.0772	2.4493	0.4438	0.4139	0.0085	0.0205	0.4454	0.0033	0.0096	0.0922	1.7510	0.3918
680	0.0766	2.5247	0.4538	0.4078	0.0074	0.0172	0.4279	0.0032	0.0084	0.0936	1.7513	0.3992
690	0.0776	2.4577	0.4483	0.3874	0.0067	0.0138	0.3947	0.0034	0.0073	0.0943	1.7396	0.3997
700	0.0817	2.2345	0.4329	0.3565	0.0060	0.0103	0.3449	0.0030	0.0049	0.0953	1.7383	0.4048

Table 4.3 K, S and R_∞ of the Hostmann four-colour process ink-set.

	HIZGT Special inks Green			*HIZGT Special inks Green52*			*HIZGT Special inks Orange yellow 42*			*HIZGT Special inks Orange 31*		
Wavelength/ nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.0522	1.3804	0.1605	0.0592	1.4006	0.1874	0.0488	1.8493	0.1996	0.0570	2.3466	0.3009
410	0.0551	1.3221	0.1631	0.0582	1.5368	0.2018	0.0475	2.2324	0.2339	0.0566	2.6204	0.3330
420	0.0566	1.1864	0.1508	0.0561	1.6723	0.2105	0.0463	2.3739	0.2417	0.0564	2.6586	0.3371
430	0.0591	1.0238	0.1366	0.0562	1.7223	0.2175	0.0475	2.2937	0.2404	0.0571	2.5465	0.3273
440	0.0627	0.8553	0.1221	0.0583	1.7144	0.2255	0.0507	2.1505	0.2421	0.0588	2.4517	0.3254
450	0.0682	0.6784	0.1066	0.0623	1.6184	0.2294	0.0566	1.9908	0.2530	0.0609	2.3208	0.3204
460	0.0791	0.4845	0.0904	0.0647	1.4348	0.2121	0.0600	1.8814	0.2556	0.0624	2.2433	0.3183
470	0.0990	0.3108	0.0758	0.0666	1.3096	0.2002	0.0624	1.8089	0.2566	0.0650	2.1400	0.3182
480	0.1221	0.1995	0.0632	0.0699	1.2049	0.1946	0.0676	1.6930	0.2634	0.0707	1.9943	0.3264
490	0.1504	0.1333	0.0556	0.0821	0.8846	0.1724	0.0807	1.3587	0.2595	0.0831	1.6978	0.3355
500	0.1603	0.1112	0.0506	0.1034	0.4973	0.1279	0.0990	0.8308	0.2026	0.0979	1.2888	0.3101
510	0.1520	0.1153	0.0488	0.1296	0.2786	0.0953	0.1234	0.4623	0.1485	0.1062	1.0141	0.2695
520	0.1325	0.1352	0.0476	0.1277	0.2351	0.0790	0.1396	0.3074	0.1160	0.1041	0.9053	0.2350
530	0.1118	0.1695	0.0480	0.1047	0.2924	0.0764	0.1539	0.2283	0.0981	0.1001	0.8641	0.2137
540	0.0919	0.2230	0.0497	0.0833	0.4114	0.0815	0.1838	0.1523	0.0840	0.0994	0.8240	0.2019
550	0.0738	0.3059	0.0526	0.0672	0.6027	0.0931	0.2450	0.0823	0.0707	0.1049	0.7257	0.1900
560	0.0602	0.4273	0.0582	0.0566	0.8996	0.1143	0.3440	0.0368	0.0589	0.1213	0.5356	0.1683
570	0.0509	0.5977	0.0675	0.0498	1.2553	0.1385	0.4587	0.0157	0.0492	0.1633	0.2942	0.1372
580	0.0439	0.8500	0.0816	0.0467	1.5600	0.1604	0.5508	0.0075	0.0408	0.2474	0.1217	0.1063
590	0.0389	1.2544	0.1057	0.0446	1.7633	0.1724	0.6180	0.0041	0.0344	0.3841	0.0414	0.0839
600	0.0340	1.8548	0.1350	0.0432	1.9236	0.1814	0.6554	0.0025	0.0279	0.5616	0.0117	0.0683
610	0.0304	2.2282	0.1442	0.0428	1.9832	0.1855	0.6667	0.0018	0.0217	0.7198	0.0031	0.0574
620	0.0297	2.1884	0.1382	0.0441	1.9426	0.1876	0.6352	0.0017	0.0159	0.8243	0.0006	0.0336
630	0.0307	2.0821	0.1362	0.0459	1.8945	0.1908	0.6158	0.0014	0.0114	0.8915	-0.001	-0.4000
640	0.0320	1.9862	0.1357	0.0481	1.8276	0.1941	0.5833	0.0012	0.0078	0.8931	-0.001	-186.25
650	0.0342	1.8857	0.1382	0.0509	1.7460	0.1975	0.5558	0.0009	0.0051	0.8939	-0.001	-182.22
660	0.0379	1.7649	0.1447	0.0534	1.6467	0.1961	0.5184	0.0007	0.0032	0.8947	-0.001	-177.49
670	0.0433	1.6427	0.1555	0.0543	1.5780	0.1917	0.4861	0.0006	0.0023	0.8948	-0.002	-3.9772
680	0.0471	1.5006	0.1556	0.0542	1.5720	0.1905	0.4576	0.0005	0.0017	0.8950	-0.002	-210.28
690	0.0485	1.3586	0.1457	0.0536	1.6044	0.1920	0.3661	0.0007	0.0012	0.8451	-0.001	-0.0416
700	0.0492	1.2553	0.1367	0.0540	1.6573	0.2000	0.1433	0.0005	0.0002	0.8747	-0.001	-0.1153

Table 4.4 K, S and R_∞ of the HIZGT special inks.

Continued…

	HIZGT Special inks process blue 58			*HIZGT Special inks process magenta 14*			*HIZGT Special inks process yellow 47*			*HIZGT Special inks black 84*		
Wavelength /nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.1038	0.6128	0.1584	0.0522	0.9180	0.1067	0.0502	1.4007	0.1557	1.4007	1.9084	0.2538
410	0.1171	0.4586	0.1377	0.0537	0.9432	0.1131	0.0482	1.7165	0.1825	1.7165	2.0022	0.2760
420	0.1195	0.3877	0.1195	0.0528	0.9286	0.1094	0.0465	1.9217	0.1966	1.9217	2.0297	0.2776
430	0.1300	0.3030	0.1041	0.0529	0.8967	0.1058	0.0477	1.9827	0.2088	1.9827	2.0287	0.2791
440	0.1548	0.2022	0.0876	0.0520	0.8679	0.1004	0.0507	1.9423	0.2184	1.9423	2.0072	0.2775
450	0.1805	0.1384	0.0744	0.0501	0.8954	0.0995	0.0566	1.8278	0.2323	1.8278	1.9741	0.2747
460	0.1814	0.1207	0.0653	0.0461	1.0070	0.1019	0.0603	1.6711	0.2284	1.6711	1.9664	0.2731
470	0.1742	0.1173	0.0599	0.0431	1.1837	0.1113	0.0629	1.5674	0.2244	1.5674	1.9235	0.2679
480	0.1543	0.1280	0.0553	0.0399	1.3972	0.1210	0.0680	1.4457	0.2265	1.4457	1.9065	0.2633
490	0.1321	0.1518	0.0532	0.0385	1.6312	0.1360	0.0823	1.0563	0.2065	1.0563	1.8784	0.2606
500	0.1070	0.1916	0.0514	0.0371	1.8581	0.1489	0.1103	0.5402	0.1505	0.5402	1.8648	0.2579
510	0.0853	0.2574	0.0525	0.0373	2.0835	0.1677	0.1727	0.2038	0.1029	0.2038	1.8420	0.2550
520	0.0652	0.3674	0.0548	0.0386	2.2134	0.1848	0.2892	0.0644	0.0738	0.0644	1.8143	0.2474
530	0.0516	0.5466	0.0627	0.0432	2.1680	0.2045	0.4406	0.0211	0.0594	0.0211	1.8036	0.2489
540	0.0416	0.8173	0.0740	0.0477	2.1052	0.2216	0.5477	0.0096	0.0512	0.0096	1.7779	0.2475
550	0.0350	1.2360	0.0930	0.0515	2.0343	0.2329	0.6156	0.0056	0.0471	0.0056	1.7530	0.2501
560	0.0287	1.8362	0.1117	0.0603	1.8753	0.2559	0.6503	0.0039	0.0418	0.0039	1.7454	0.2571
570	0.0249	2.2849	0.1196	0.0877	1.6199	0.3413	0.6814	0.0029	0.0383	0.0029	1.7306	0.2621
580	0.0244	2.3087	0.1185	0.1211	1.4395	0.4511	0.6947	0.0022	0.0333	0.0022	1.7134	0.2666
590	0.0258	2.2041	0.1201	0.1348	0.9671	0.3484	0.7353	0.0014	0.0301	0.0014	1.7115	0.2776
600	0.0287	2.0875	0.1269	0.1654	0.3983	0.1892	0.7544	0.0011	0.0283	0.0011	1.6941	0.2843
610	0.0334	1.9726	0.1408	0.2253	0.1568	0.1177	0.7549	0.0009	0.0223	0.0009	1.6884	0.2908
620	0.0396	1.8832	0.1618	0.3161	0.0602	0.0814	0.7166	0.0009	0.0169	0.0009	1.6844	0.2986
630	0.0455	1.8229	0.1821	0.4262	0.0241	0.0624	0.6844	0.0008	0.0116	0.0008	1.6853	0.3066
640	0.0520	1.7724	0.2051	0.5273	0.0109	0.0515	0.6560	0.0007	0.0082	0.0007	1.6756	0.3117
650	0.0585	1.7594	0.2323	0.6029	0.0059	0.0451	0.6291	0.0006	0.0055	0.0006	1.6738	0.3165
660	0.0611	1.7672	0.2450	0.6509	0.0039	0.0415	0.6090	0.0004	0.0031	0.0004	1.6661	0.3204
670	0.0602	1.7900	0.2439	0.6776	0.0030	0.0386	0.5607	0.0003	0.0019	0.0003	1.6602	0.3258
680	0.0587	1.8004	0.2387	0.7043	0.0024	0.0393	0.5462	0.0002	0.0009	0.0002	1.6547	0.3299
690	0.0584	1.7872	0.2354	0.6989	0.0023	0.0347	0.3902	0.0002	0.0003	0.0002	1.6451	0.3295
700	0.0612	1.7258	0.2395	0.7042	0.0019	0.0311	0.8949	0.0003	25.4041	0.0003	1.6422	0.3320

Table 4.4 (continued) K, S and R_∞ of the HIZGT special inks.

Continued…

	HIZGT Special inks bronze blue 62			*HIZGT Special inks bronze blue 61*			*HIZGT Special inks bronze red 29*			*HIZGT Special inks bronze red 30*		
Wavelength /nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.0836	0.3135	0.0624	0.0959	0.6527	0.1531	0.0507	1.3152	0.1481	0.0526	1.9180	0.2249
410	0.0876	0.2972	0.0626	0.1033	0.5290	0.1360	0.0506	1.4219	0.1595	0.0536	2.1556	0.2581
420	0.0886	0.2788	0.0595	0.1028	0.4721	0.1206	0.0500	1.4761	0.1636	0.0534	2.2598	0.2694
430	0.0897	0.2663	0.0576	0.1067	0.3996	0.1069	0.0496	1.5101	0.1658	0.0534	2.2806	0.2719
440	0.0893	0.2643	0.0569	0.1155	0.3169	0.0936	0.0486	1.5518	0.1668	0.0537	2.3080	0.2766
450	0.0859	0.2778	0.0571	0.1183	0.2730	0.0830	0.0471	1.6483	0.1711	0.0536	2.3297	0.2789
460	0.0788	0.3150	0.0585	0.1096	0.2788	0.0771	0.0439	1.8161	0.1744	0.0518	2.4259	0.2793
470	0.0709	0.3857	0.0634	0.0987	0.3073	0.0747	0.0422	1.9534	0.1798	0.0509	2.4531	0.2772
480	0.0618	0.5070	0.0711	0.0863	0.3539	0.0731	0.0410	1.9778	0.1763	0.0508	2.3749	0.2676
490	0.0543	0.7007	0.0850	0.0760	0.4166	0.0741	0.0433	1.9166	0.1813	0.0530	2.2296	0.2636
500	0.0481	0.9684	0.1028	0.0664	0.4989	0.0760	0.0479	1.8166	0.1918	0.0560	2.1246	0.2669
510	0.0444	1.3203	0.1283	0.0583	0.6219	0.0818	0.0551	1.7370	0.2144	0.0592	2.0251	0.2710
520	0.0412	1.7614	0.1578	0.0511	0.8091	0.0918	0.0611	1.6851	0.2334	0.0622	1.9816	0.2804
530	0.0395	2.3587	0.2022	0.0455	1.0470	0.1045	0.0678	1.6327	0.2548	0.0659	1.9183	0.2900
540	0.0385	3.5580	0.2959	0.0407	1.3238	0.1171	0.0764	1.5674	0.2807	0.0715	1.8335	0.3040
550	0.0284	2.2050	0.1843	0.0358	1.7310	0.1333	0.0882	1.4885	0.3159	0.0803	1.7060	0.3240
560	0.0393	3.0544	0.2598	0.0312	2.2378	0.1486	0.1011	1.3436	0.3364	0.0924	1.4554	0.3265
570	0.0409	2.5771	0.2289	0.0318	2.2670	0.1538	0.1190	0.9360	0.2871	0.1128	0.9147	0.2622
580	0.0438	2.3294	0.2233	0.0394	2.0652	0.1761	0.1567	0.4476	0.1972	0.1562	0.4115	0.1806
590	0.0460	2.1556	0.2180	0.0418	2.0001	0.1823	0.2292	0.1775	0.1369	0.2351	0.1581	0.1271
600	0.0476	2.0218	0.2121	0.0397	1.9515	0.1680	0.3451	0.0617	0.0993	0.3602	0.0535	0.0941
610	0.0487	1.9182	0.2067	0.0403	1.8795	0.1645	0.4772	0.0222	0.0776	0.5022	0.0188	0.0764
620	0.0504	1.8251	0.2038	0.0437	1.8093	0.1727	0.6028	0.0081	0.0620	0.6289	0.0071	0.0647
630	0.0522	1.7238	0.2004	0.0471	1.7486	0.1815	0.7024	0.0031	0.0486	0.7308	0.0030	0.0603
640	0.0538	1.6209	0.1947	0.0523	1.7044	0.1986	0.7752	0.0010	0.0319	0.8054	0.0014	0.0582
650	0.0553	1.5071	0.1870	0.0577	1.6832	0.2188	0.8264	0.0002	0.0119	0.8627	0.0009	0.0832
660	0.0571	1.3768	0.1770	0.0604	1.6877	0.2311	0.8635	-0.001	-0.0363	0.8941	0.0012	0.3066
670	0.0588	1.2329	0.1636	0.0592	1.6992	0.2272	0.8617	-0.001	-0.0497	0.8592	0.0006	0.0532
680	0.0605	1.0869	0.1490	0.0576	1.7157	0.2227	0.8658	-0.001	-0.0531	0.8591	0.0007	0.0594
690	0.0615	0.9360	0.1308	0.0565	1.7097	0.2171	0.8301	-0.000	-0.0195	0.7845	0.0008	0.0281
700	0.0627	0.7923	0.1130	0.0581	1.6597	0.2175	0.8498	-0.001	-0.0474	0.8139	0.0006	0.0289

Table 4.4 (continued) K, S and R_∞ of the HIZGT special inks.

Continued…

	HIZGT Special inks dark blue 69			*HIZGT Special inks peacock blue 54*			*HIZGT Special inks peacock blue 56*			*HIZGT Special inks ultramarine 63*		
Wavelength /nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.0766	1.1303	0.2030	0.0879	0.6917	0.1461	0.0868	0.6661	0.1387	0.0991	0.2217	0.0541
410	0.0758	1.0666	0.1892	0.0953	0.5778	0.1346	0.0942	0.5432	0.1247	0.1073	0.1993	0.0537
420	0.0740	1.0354	0.1786	0.0978	0.4968	0.1194	0.0964	0.4659	0.1100	0.1120	0.1792	0.0509
430	0.0737	0.9835	0.1689	0.1045	0.4087	0.1065	0.1030	0.3797	0.0972	0.1153	0.1634	0.0481
440	0.0732	0.9246	0.1576	0.1156	0.3158	0.0934	0.1148	0.2864	0.0839	0.1182	0.1532	0.0466
450	0.0718	0.8974	0.1495	0.1286	0.2401	0.0814	0.1290	0.2148	0.0730	0.1162	0.1498	0.0445
460	0.0683	0.9135	0.1437	0.1432	0.1814	0.0708	0.1408	0.1665	0.0635	0.1107	0.1553	0.0434
470	0.0658	0.9553	0.1440	0.1625	0.1346	0.0624	0.1544	0.1307	0.0565	0.1024	0.1733	0.0441
480	0.0614	1.0170	0.1417	0.1701	0.1128	0.0557	0.1547	0.1172	0.0508	0.0906	0.2093	0.0458
490	0.0590	1.0937	0.1456	0.1640	0.1108	0.0520	0.1455	0.1211	0.0483	0.0778	0.2700	0.0494
500	0.0555	1.1901	0.1482	0.1422	0.1288	0.0498	0.1237	0.1439	0.0464	0.0662	0.3654	0.0555
510	0.0527	1.3266	0.1558	0.1168	0.1667	0.0499	0.1020	0.1880	0.0476	0.0578	0.5083	0.0661
520	0.0495	1.5141	0.1660	0.0915	0.2324	0.0515	0.0801	0.2641	0.0500	0.0510	0.7029	0.0797
530	0.0473	1.6960	0.1768	0.0725	0.3370	0.0568	0.0643	0.3866	0.0568	0.0468	0.9425	0.0971
540	0.0453	1.8503	0.1839	0.0582	0.4924	0.0646	0.0528	0.5706	0.0672	0.0445	1.1884	0.1159
550	0.0425	2.0432	0.1895	0.0481	0.7326	0.0777	0.0454	0.8607	0.0858	0.0441	1.4071	0.1358
560	0.0409	2.1976	0.1955	0.0416	1.1028	0.0998	0.0400	1.3187	0.1146	0.0443	1.5755	0.1527
570	0.0472	2.0937	0.2178	0.0375	1.5316	0.1240	0.0358	1.8525	0.1428	0.0450	1.6731	0.1651
580	0.0615	1.9487	0.2722	0.0355	1.8592	0.1420	0.0337	2.2236	0.1603	0.0462	1.7093	0.1738
590	0.0658	1.9114	0.2883	0.0345	2.0398	0.1511	0.0326	2.3243	0.1619	0.0481	1.6911	0.1794
600	0.0619	1.9135	0.2692	0.0346	2.1490	0.1594	0.0321	2.3081	0.1581	0.0499	1.6386	0.1813
610	0.0601	1.9210	0.2615	0.0357	2.1253	0.1633	0.0326	2.1900	0.1525	0.0511	1.5669	0.1777
620	0.0605	1.9014	0.2608	0.0386	2.0492	0.1711	0.0347	2.0609	0.1536	0.0523	1.4847	0.1730
630	0.0616	1.8723	0.2620	0.0420	1.9798	0.1810	0.0372	1.9709	0.1583	0.0537	1.3949	0.1674
640	0.0640	1.8404	0.2686	0.0458	1.9101	0.1920	0.0399	1.8813	0.1630	0.0552	1.2995	0.1606
650	0.0666	1.7974	0.2747	0.0500	1.8449	0.2045	0.0436	1.8189	0.1736	0.0562	1.1967	0.1511
660	0.0678	1.7425	0.2718	0.0535	1.7815	0.2127	0.0469	1.7825	0.1841	0.0574	1.0877	0.1406
670	0.0669	1.7167	0.2639	0.0546	1.7387	0.2122	0.0479	1.7689	0.1868	0.0591	0.9719	0.1297
680	0.0654	1.7336	0.2598	0.0546	1.7318	0.2115	0.0474	1.7735	0.1854	0.0600	0.8542	0.1160
690	0.0647	1.7724	0.2621	0.0544	1.7557	0.2135	0.0467	1.7858	0.1835	0.0612	0.7324	0.1016
700	0.0656	1.7963	0.2697	0.0549	1.7729	0.2178	0.0469	1.7681	0.1824	0.0615	0.6174	0.0862

Table 4.4 (continued) K, S and R_∞ of the HIZGT special inks.

Continued…

	HIZGT Special inks brown 77			*HIZGT Special inks deep red 24*			*HIZGT Special inks medium red 22*			*HIZGT Special inks reddish yellow 40*		
Wavelength /nm	R_∞	K	S	R_∞	K	S	R_∞	K	S	R_∞	K	S
400	0.0495	1.9485	0.2135	0.0528	2.0611	0.2428	0.0462	1.1938	0.1212	0.0468	2.1889	0.2257
410	0.0500	2.0121	0.2230	0.0523	2.2101	0.2574	0.0472	1.2749	0.1325	0.0482	2.5599	0.2725
420	0.0494	2.0597	0.2251	0.0519	2.2482	0.2598	0.0462	1.2984	0.1318	0.0484	2.5022	0.2673
430	0.0494	2.0613	0.2256	0.0519	2.2319	0.2580	0.0456	1.3047	0.1307	0.0506	2.3972	0.2690
440	0.0490	2.0439	0.2216	0.0521	2.1798	0.2527	0.0448	1.3228	0.1300	0.0531	2.2441	0.2656
450	0.0487	2.0345	0.2191	0.0527	2.1387	0.2512	0.0429	1.4127	0.1322	0.0568	2.1314	0.2723
460	0.0466	2.0510	0.2102	0.0519	2.1136	0.2439	0.0397	1.6269	0.1402	0.0598	2.0632	0.2793
470	0.0462	2.0799	0.2111	0.0525	2.0893	0.2445	0.0380	1.9136	0.1569	0.0644	1.9704	0.2901
480	0.0453	2.0570	0.2045	0.0546	2.0250	0.2473	0.0361	2.1549	0.1676	0.0729	1.8324	0.3111
490	0.0471	2.0077	0.2082	0.0606	1.9296	0.2650	0.0363	2.2977	0.1799	0.0922	1.4432	0.3231
500	0.0493	1.9635	0.2141	0.0654	1.8563	0.2780	0.0382	2.2859	0.1886	0.1332	0.7666	0.2718
510	0.0523	1.9192	0.2233	0.0665	1.8260	0.2787	0.0419	2.2155	0.2022	0.2067	0.3308	0.2173
520	0.0542	1.8875	0.2289	0.0644	1.8211	0.2680	0.0455	2.1378	0.2134	0.2636	0.1767	0.1719
530	0.0571	1.8510	0.2379	0.0645	1.8170	0.2680	0.0514	2.0497	0.2344	0.2760	0.1347	0.1419
540	0.0615	1.7928	0.2503	0.0665	1.7736	0.2708	0.0584	1.9648	0.2590	0.2726	0.1194	0.1230
550	0.0685	1.6896	0.2666	0.0696	1.7120	0.2751	0.0667	1.8739	0.2871	0.2777	0.1020	0.1086
560	0.0778	1.4903	0.2726	0.0731	1.6308	0.2777	0.0772	1.7804	0.3228	0.3077	0.0742	0.0953
570	0.0879	1.1466	0.2423	0.0795	1.5216	0.2857	0.0911	1.6572	0.3653	0.3846	0.0402	0.0817
580	0.0945	0.8596	0.1982	0.0939	1.2108	0.2771	0.1093	1.3597	0.3746	0.5110	0.0160	0.0683
590	0.0950	0.7217	0.1674	0.1211	0.5982	0.1876	0.1302	0.6792	0.2337	0.6552	0.0051	0.0563
600	0.0921	0.6675	0.1492	0.1765	0.2213	0.1152	0.1766	0.2504	0.1305	0.7613	0.0015	0.0408
610	0.0885	0.6473	0.1380	0.2607	0.0838	0.0799	0.2514	0.0946	0.0849	0.7842	0.0008	0.0268
620	0.0850	0.6350	0.1290	0.3739	0.0314	0.0598	0.3555	0.0349	0.0598	0.7629	0.0008	0.0214
630	0.0825	0.6259	0.1227	0.4917	0.0125	0.0476	0.4725	0.0131	0.0444	0.7377	0.0009	0.0190
640	0.0802	0.6179	0.1171	0.5814	0.0059	0.0394	0.5699	0.0051	0.0316	0.7121	0.0009	0.0156
650	0.0778	0.6104	0.1118	0.6365	0.0034	0.0328	0.6407	0.0021	0.0205	0.6908	0.0010	0.0140
660	0.0760	0.6034	0.1075	0.6639	0.0024	0.0277	0.6796	0.0009	0.0117	0.6779	0.0009	0.0114
670	0.0747	0.5964	0.1041	0.6649	0.0020	0.0243	0.7045	0.0002	0.0036	0.6570	0.0009	0.0098
680	0.0738	0.5901	0.1015	0.6792	0.0016	0.0215	0.7151	0.0000	0.0000	0.6535	0.0008	0.0088
690	0.0722	0.5838	0.0980	0.6567	0.0017	0.0186	0.6979	0.0000	-0.0003	0.6119	0.0010	0.0081
700	0.0710	0.5774	0.0950	0.6550	0.0014	0.0157	0.7054	-0.001	-0.0047	0.6023	0.0009	0.0069

Table 4.4 (continued) K, S and R_∞ of the HIZGT special inks.

Continued…

	HIZGT Special inks violet 68		
Wavelength/nm	R_∞	K	S
400	0.0566	0.7874	0.1002
410	0.0575	0.7836	0.1015
420	0.0572	0.7564	0.0974
430	0.0568	0.7237	0.0925
440	0.0564	0.7002	0.0887
450	0.0542	0.7208	0.0873
460	0.0499	0.8095	0.0896
470	0.0459	0.9645	0.0973
480	0.0417	1.1892	0.1080
490	0.0385	1.4902	0.1242
500	0.0352	1.8607	0.1408
510	0.0330	2.3253	0.1641
520	0.0311	2.7108	0.1796
530	0.0318	2.6778	0.1816
540	0.0337	2.5186	0.1818
550	0.0358	2.3446	0.1807
560	0.0396	2.0796	0.1786
570	0.0524	1.7423	0.2031
580	0.0738	1.5768	0.2713
590	0.0818	1.6040	0.3112
600	0.0797	1.5922	0.2995
610	0.0764	1.5533	0.2782
620	0.0749	1.5025	0.2629
630	0.0744	1.4365	0.2494
640	0.0745	1.3521	0.2353
650	0.0747	1.2504	0.2181
660	0.0751	1.1347	0.1992
670	0.0759	1.0104	0.1795
680	0.0767	0.8866	0.1596
690	0.0772	0.7617	0.1381
700	0.0777	0.6437	0.1176

Table 4.4 (continued) K, S and R_∞ of the HIZGT special inks.

4.1.2.2 Applying the Gamut Tool.

The optical properties, K and S values, obtained from the K and S analysis tool were used in the gamut tool and stored in a database sheet. The engine sheet is designed to let the user select the number of components and the inks in the formulation. Geos four-colour process inks, Fresh & Fast four-colour process inks, Hostmann four-colour process inks and twenty-one special inks of HIZGT were applied to the gamut tool. The colour gamut of the PANTONE Formula Guide 745XR is used as the standard gamut in order to judge the colour gamut of each ink-set.

When the 'Start Here' button is selected (**Figure 4.35**), the user is invited to select the number of inks in the formulation and go to step 2. By clicking the 'Step 2' button the user is given the instructions for the correct operation of the tool according to the number of inks in the table. Finally, the user can select the inks in the formulation. The "Clear" button must be used to clear the old calculated data before each new calculation begins. By using this tool the numbers of inks and the type of inks can be selected depending on the need of the user.

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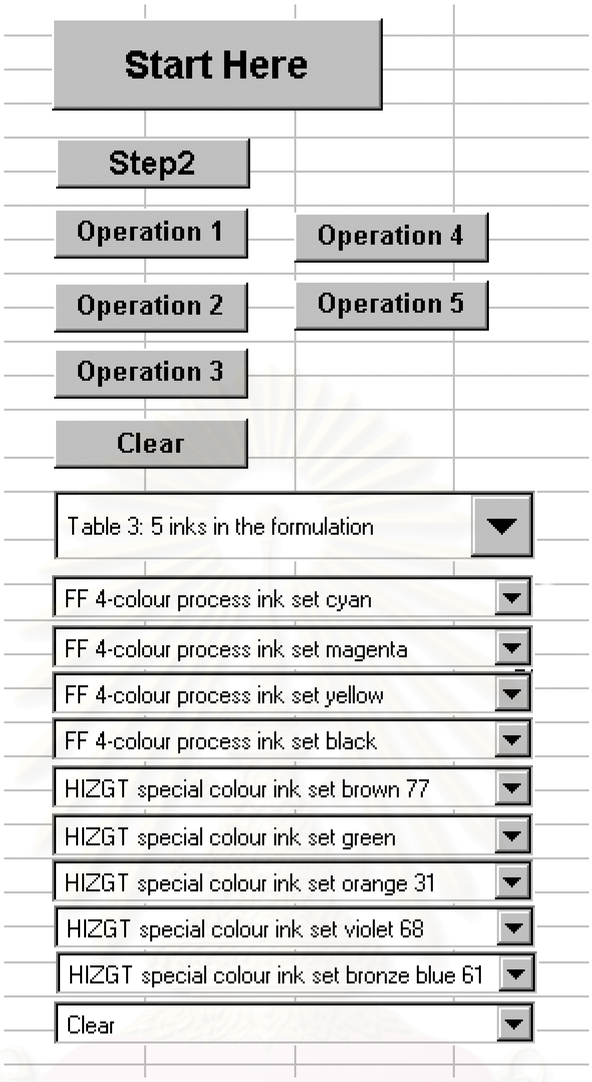

Figure 4.35 The front page of the engine sheet of the gamut tool.

Using the mapping tool, the predicted L*a*b* coordinates of any formulation of ink were computed. In this case, we compared the L*a*b* and the predicted L*a*b* of 100% of single inks. The average colour difference between predicted L*a*b* and measured L*a*b* of the single colours of Geos ink-set, FF ink-set and Hostmann ink-set are 3.86, 4.07 and 4.55 respectively.

Inks	Colour Difference ΔE_{ab}^*
Geos 4-colour process ink-set cyan	3.03
Geos 4-colour process ink-set magenta	4.60
Geos 4-colour process ink-set yellow	4.26
Geos 4-colour process ink-set black	3.56
FF 4-colour process ink-set cyan	2.79
FF 4-colour process ink-set magenta	4.15
FF 4-colour process ink-set yellow	5.58
FF 4-colour process ink-set black	3.75
Hostmann 4-colour process ink-set cyan	3.85
Hostmann 4-colour process ink-set magenta	6.26
Hostmann 4-colour process ink-set yellow	4.65
Hostmann 4-colour process ink-set black	3.46
HIZGT special colour ink-set green	3.65
HIZGT special colour ink-set green 52	5.45
HIZGT special colour ink-set orange yellow 42	4.80
HIZGT special colour ink-set orange 31	4.21
HIZGT special colour ink-set process blue 58	3.01
HIZGT special colour ink-set process magenta 14	3.72
HIZGT special colour ink-set process yellow 47	2.11
HIZGT special colour ink-set black 84	3.47
HIZGT special colour ink-set bronze blue 61	4.06
HIZGT special colour ink-set bronze red 29	4.55
HIZGT special colour ink-set bronze red 30	5.20
HIZGT special colour ink-set dark blue 69	4.04
HIZGT special colour ink-set peacock blue 54	2.95
HIZGT special colour ink-set peacock blue 56	2.96
HIZGT special colour ink-set ultramarine 63	4.27

Table 4.5 Colour difference between predicted L*a*b* and measured L*a*b* of the single colours.

Inks	Colour Difference ΔE_{ab}^*
HIZGT special colour ink-set brown 77	3.84
HIZGT special colour ink-set deep red 24	4.87
HIZGT special colour ink-set medium red 22	4.56
HIZGT special colour ink-set reddish yellow 40	4.83
HIZGT special colour ink-set violet 68	5.68

Table 4.5 Colour difference between predicted L*a*b* and measured L*a*b* of the single colours. (continued).

The average colour difference between predicted L*a*b* and measured L*a*b* of the single colours of Geos ink-set, FF ink-set, Hostmann ink-set and HIZGT special ink-set is 4.13 in CIELAB. It achieved fairly good predictions.

The results of using this tool are shown hereafter. The CIELAB colour system is used to present the difference between the colour gamuts of any combination.

The colour gamuts of the different test ink-sets are displayed together with the gamut of the Pantone book. The L*a*b* colour gamuts of three sets four-colour process inks: Geos, Fresh & Fast and Hostmann are shown in **Figures 4.36** to **4.38**. The prediction L*a*b* coordinates of single inks, mixtures of two inks, mixtures of three inks and mixtures of four inks were obtained by using the two-constant Kubelka-Munk theory.

The FF ink-set and the Hostmann ink-set have high chroma in yellow compared to the Geos ink-set. The chroma difference in yellow between the FF ink-set and the Hostmann ink-set is not considerable. The FF ink-set has the highest chroma in Red compared to the Geos and Hostmann ink-sets, both of which give a similar chroma in red. All three ink-sets give a similar chroma in the Blue region, where the Geos ink-set produces the highest chroma. The FF ink-set produces more saturate green than the Hostmann and the Geos ink-sets. The colour gamut volume of the FF ink-set is 7553 which is the highest value compared to that of the Hostmann and the Geos ink-sets, having a gamut volume of 7217 and of 7109 respectively (**Table 4.6**).

Combination Inks	Gamut Volume
Geos ink-set	7109
FF ink-set	7553
Hostmann ink-set	7217

Table 4.6 Gamut volume of Geos, FF and Hostmann ink-sets.

The combinations of process colour inks of HIZGT special inks were also selected to investigate the colour gamut (**Table 4.7**). The yellow shade was changed from combination to combination.

Set	Combination
1	HIZGT special colour ink-set process blue 58
	HIZGT special colour ink-set process magenta 14
	HIZGT special colour ink-set process yellow 47*
	HIZGT special colour ink-set black 84
2	HIZGT special colour ink-set process blue 58
	HIZGT special colour ink-set process magenta 14
	HIZGT special colour ink-set orange yellow 42*
	HIZGT special colour ink-set black 84

Table 4.7 The combinations of process colour inks of HIZGT special inks.

Set	Combination
3	HIZGT special colour ink-set process blue 58
	HIZGT special colour ink-set process magenta 14
	HIZGT special colour ink-set reddish yellow 40*
	HIZGT special colour ink-set black 84

Table 4.7 The combinations of process colour inks of HIZGT special inks (continued).

The L*a*b* plots in different views of these three combinations are shown in **Figure 4.39** to **Figure 4.41**. The results show that the recipe containing Process Yellow 47 extends the gamut in the yellow-green region. The recipes containing Orange Yellow 42 and Reddish Yellow 40 are similar, both having an extended gamut in the yellow-red region. When the six combinations of ink-set were compared, it was found that FF ink-set gives the largest colour gamut.

In addition, the HIZGT special inks were added to Geos, FF and Hostmann ink-sets to investigate the change of the colour gamut. The combinations of three sets of ink with the HIZGT special inks are shown in **Table 4.8**

Combination Inks
Geos ink-set + Orange 31 + Green
Geos ink-set + Orange 31+ Green 52
FF ink-set + Orange 31 + Green
FF ink-set + Orange 31 + Green 52
Hostmann ink-set + Orange 31 + Green
Hostmann ink-set + Orange 31 + Green 52
Geos ink-set + Orange 31 + Violet 68
FF ink-set + Orange 31 + Violet 68

Table 4.8 The combinations of three sets of inks with the HIZGT special inks.

Combination Inks
Hostmann ink-set + Orange 31 + Violet 68
Geos ink-set + Violet 68 + Green
Geos ink-set + Violet 68 + Green 52
FF ink-set + Violet 68 + Green
FF ink-set + Violet 68 + Green 52
Hostmann ink-set + Violet 68 + Green
Hostmann ink-set + Violet 68 + Green 52
Geos ink-set + Bronze red 30 + Green
Geos ink-set + Deep red 24 + Green
Geos ink-set + Bronze red 30 + Green 52
Geos ink-set + Deep red 24 + Green 52
FF ink-set + Bronze red 30 + Green
FF ink-set + Deep red 24 + Green
FF ink-set + Bronze red 30 + Green 52
FF ink-set + Deep red 24 + Green 52
Hostmann ink-set + Bronze red 30 + Green
Hostmamm ink-set + Deep red 24 + Green
Hostmann ink-set + Bronze red 30 + Green 52
Hostmann ink-set + Deep red 24 + Green 52
Geos ink-set + Bronze red 30 + bronze blue 62
Geos ink-set + Bronze red 30 + Dark blue 69
Geos ink-set + Deep red 24 + Bronze blue 62
Geos ink-set + Deep red 24 + Dark blue 69
FF ink-set + Bronze red 30 + Process blue 58
FF ink-set + Bronze red 30 + Bronze blue 61
FF ink-set + Deep red 24 + Process blue 58
FF ink-set + Deep red 24 + Bronze blue 61
Hostmamm ink-set + Bronze red 30 + Peacock blue 54
Hostmann ink-set + Bronze red 30 + Ultramarine 63
Hostmann ink-set + Deep red 24 + Peacock blue 54

Table 4.8 The combinations of three sets of ink with the HIZGT special inks (continued).

Combination Inks
Hostmann ink-set + Deep red 24 + Ultramarine 63
Geos ink-set + Green + Peacock blue 56
Geos ink-set + Green + Ultramarine 63
Geos ink-set + Green 52 + Peacock blue 56
Geos ink-set + Green 52 + Ultramarine 63
FF ink-set + Green + Bronze blue 62
FF ink-set + Green + dark blue 69
FF ink-set + Green 52 + bronze blue 62
FF ink-set + Green 52 + dark blue 69
Hostmann ink-set + Green + Process blue 58
Hostmann ink-set + Green + Bronze blue 61
Hostmann ink-set + Green 52 + Process blue 58
Hostmann ink-set + Green 52 + Bronze blue 61

Table 4.8 The combinations of three sets of ink with the HIZGT special inks (continued).

The L*a*b* plots in different views are shown in Figures 4.42 to 4.92. It was found that the HIZGT green extends the colour gamut in the green region greatly compared to the HIZGT Green 52. The Bronze red 30 is more effective than the Deep red 24 in extending the gamut in the red-yellow region. The Bronze blue 62 gives higher chroma in blue than Dark blue 69. The Bronze blue 61 extends the gamut in the blue-red region remarkably but it is less saturate in blue compared to the Process blue 58. The Utramarine 63 also extends the gamut in the blue-red region greatly and gives a high saturation in blue compared to Peacock blue 54. The Ultramarine 63 gives a wider colour gamut in blue and blue-red region than Bronze blue 61 does. The Peacock blue 56 and the peacock blue 54 extend the gamut in the green-blue region more than the Bronze blue 62 and the Process blue 58.

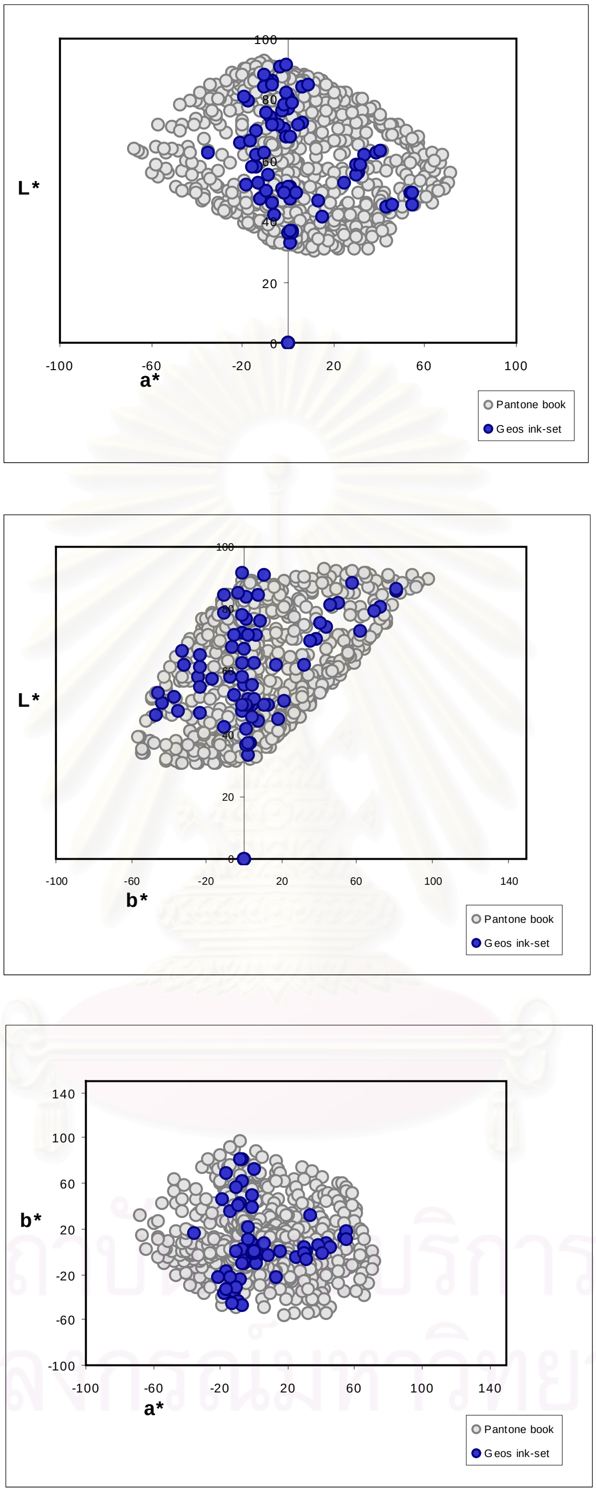

Figure 4.36 The colour gamut of four inks plus clear medium of the Geos ink-set : Geos cyan, Geos magenta, Geos yellow, Geos black, D_{65}/2.

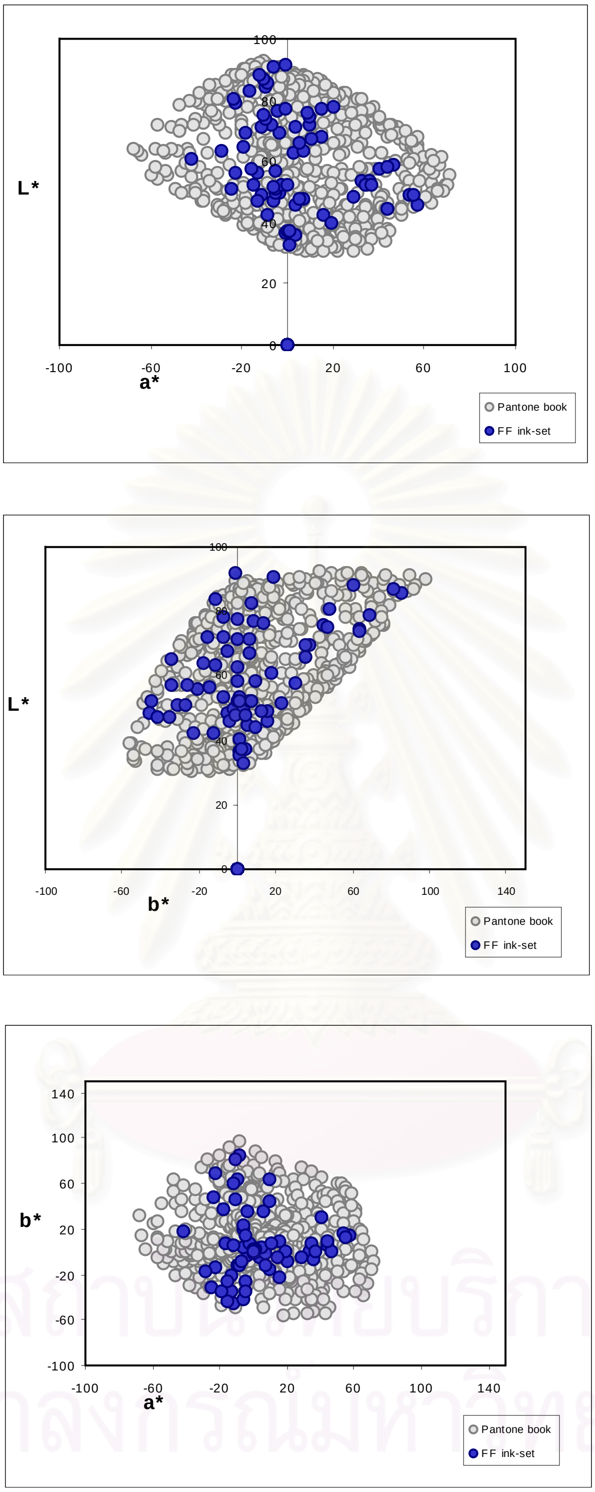

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Figure 4.37 The colour gamut of four inks plus clear medium of the Fresh & Fast ink-set : FF cyan, FF magenta, FF yellow, FF black, D_{65}/2.

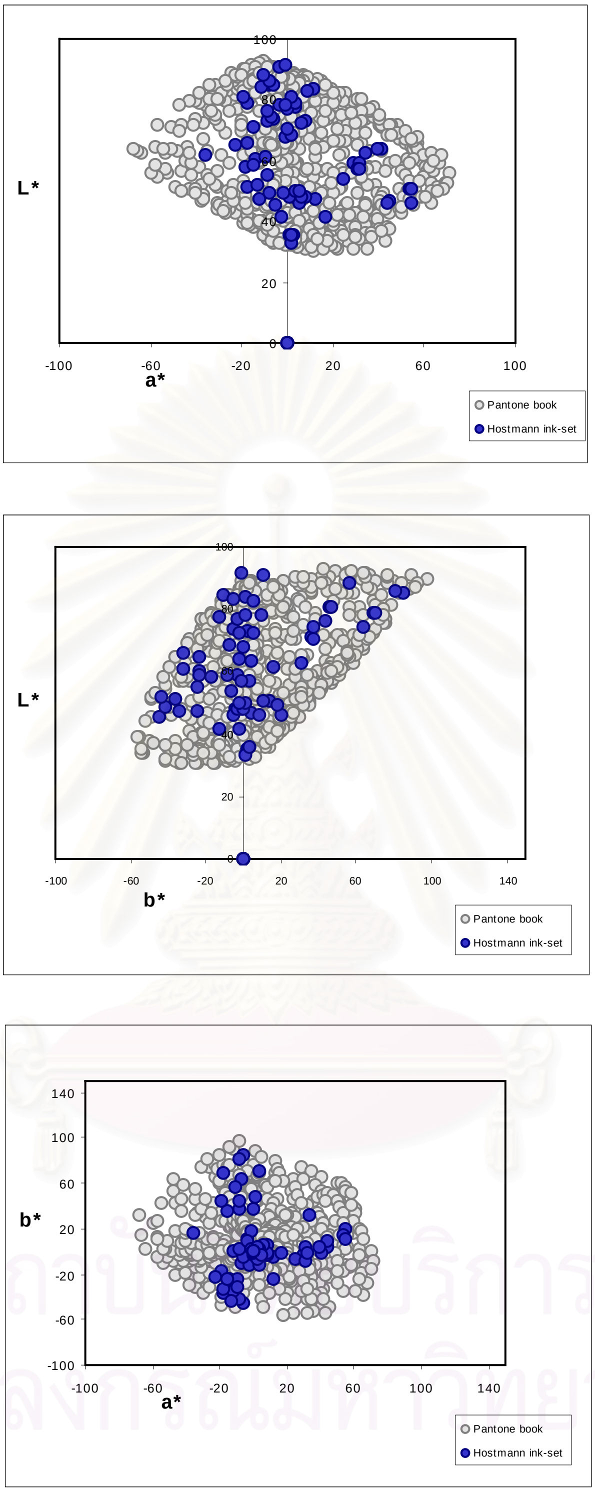

Figure 4.38 The colour gamut of four inks plus clear medium of the Hostmann ink-set : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, $D_{65}/2$.

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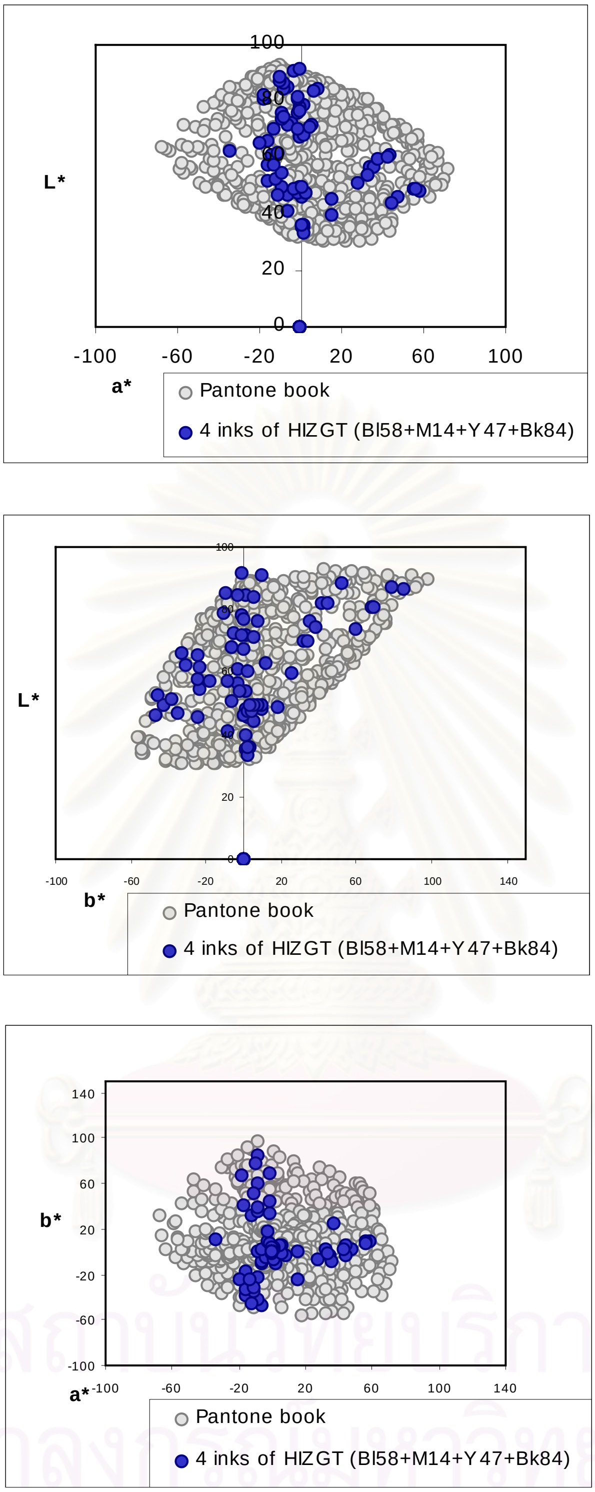

Figure 4.39 The colour gamut of four inks plus clear medium of HIZGT special inks: HIZGT process blue 58, HIZGT process magenta 14, HIZGT process yellow 47, HIZGT black 84, $D_{65}/2$.

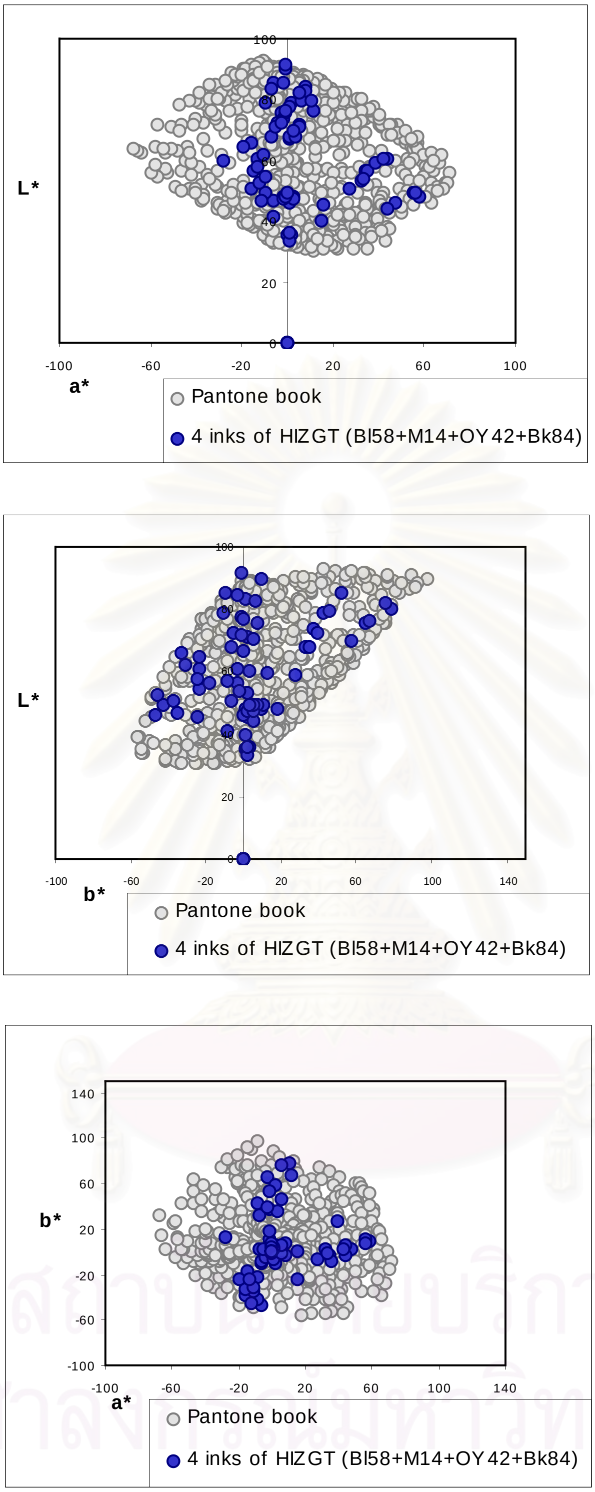

Figure 4.40 The colour gamut of four inks plus clear medium of HIZGT special inks: HIZGT process blue 58, HIZGT process magenta 14, HIZGT orange yellow 42, HIZGT black 84, D_{65}/2.

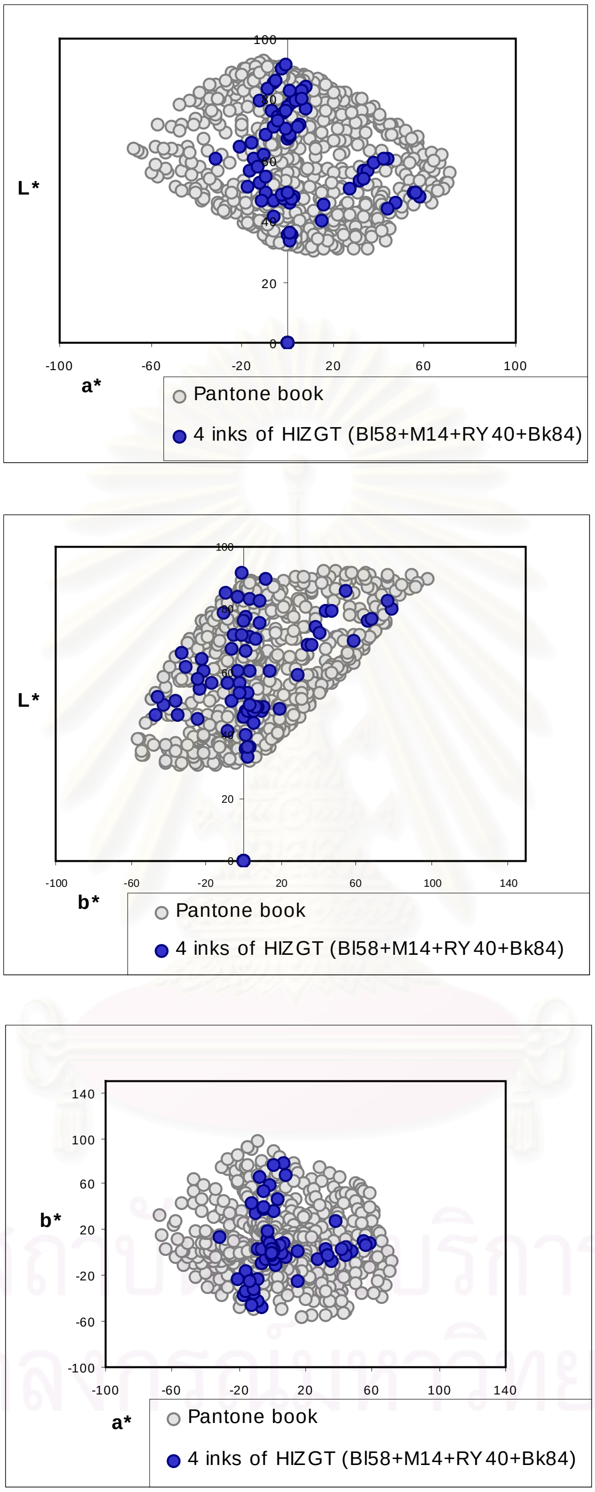

Figure 4.41 The colour gamut of four inks plus clear medium of HIZGT special inks: HIZGT process blue 58, HIZGT process magenta 14, HIZGT reddish yellow 40, HIZGT black 84, D_{65}/2.

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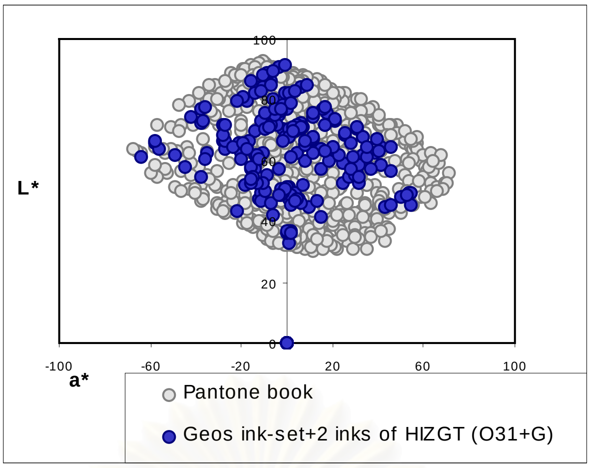

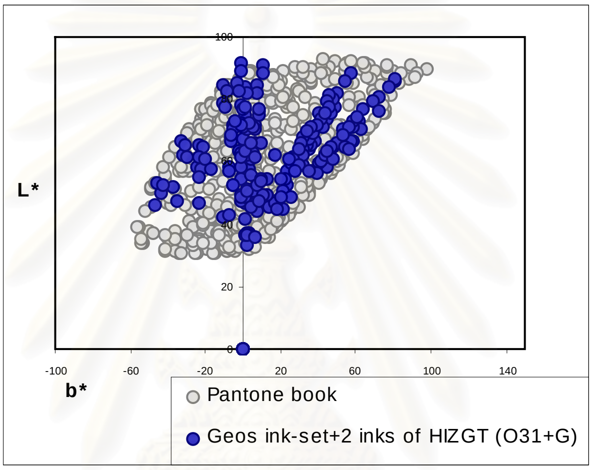

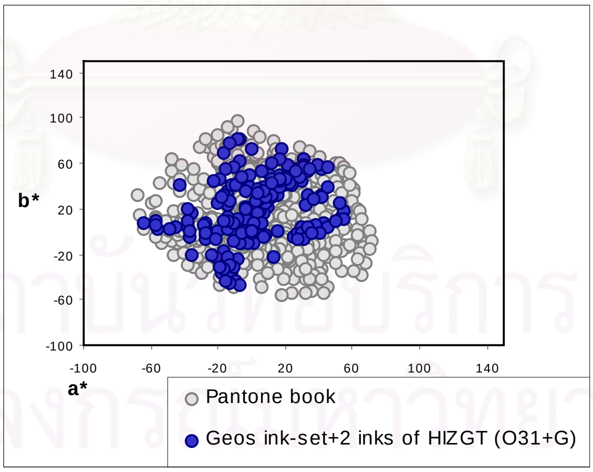

Figure 4.42 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT orange 31, HIZGT green, $D_{65}/2$.

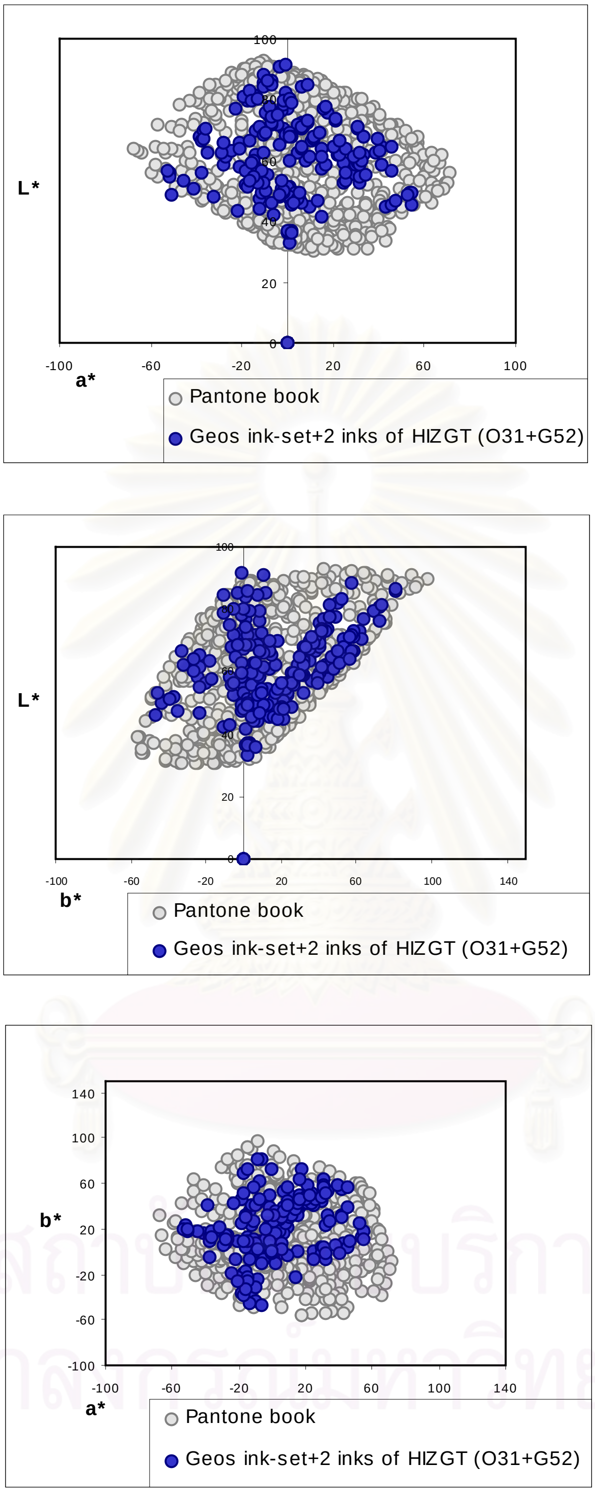

Figure 4.43 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT orange 31, HIZGT green 52, D_{65}/2.

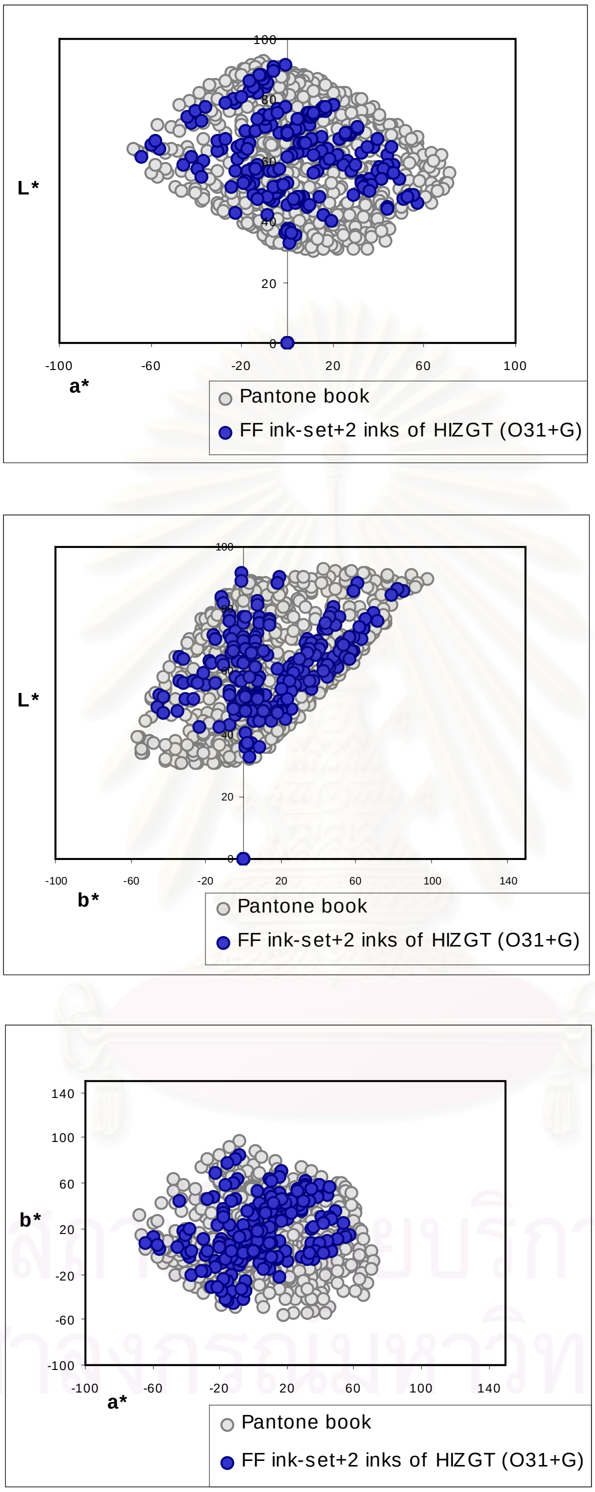

Figure 4.44 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT orange 31, HIZGT green, $D_{65}/2$.

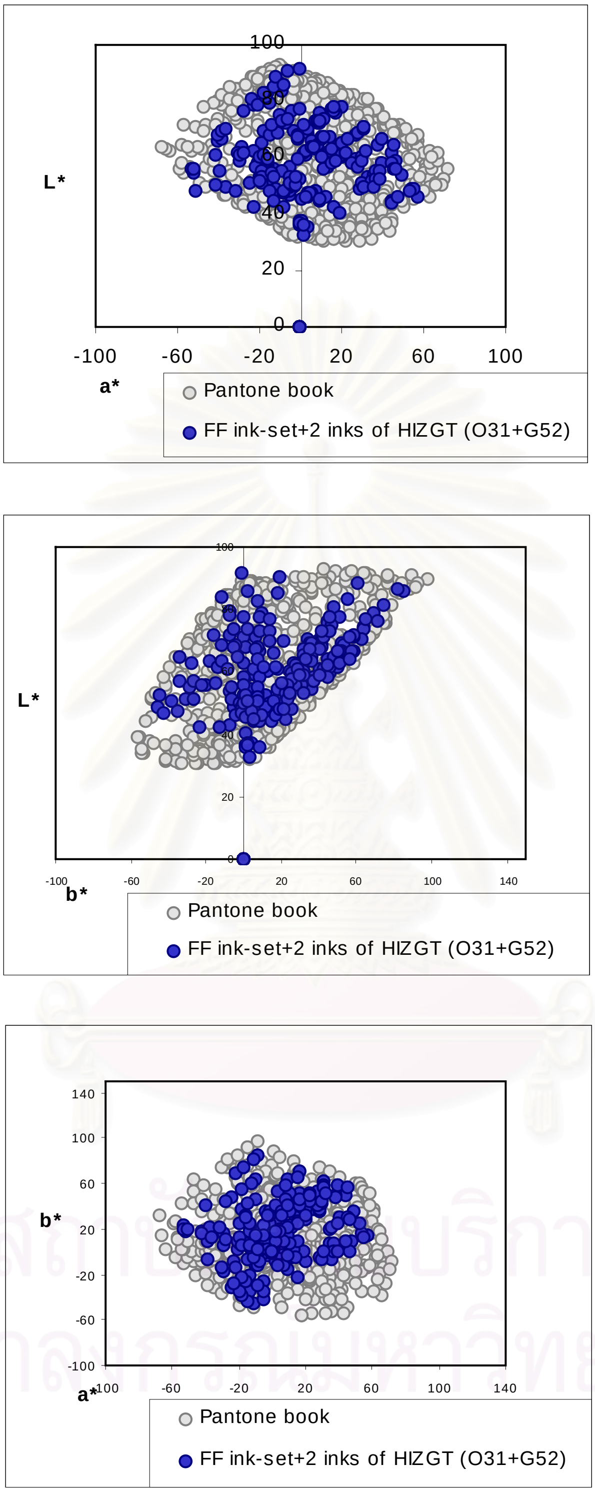

Figure 4.45 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT orange 31, HIZGT green 52, D_{65}/2.

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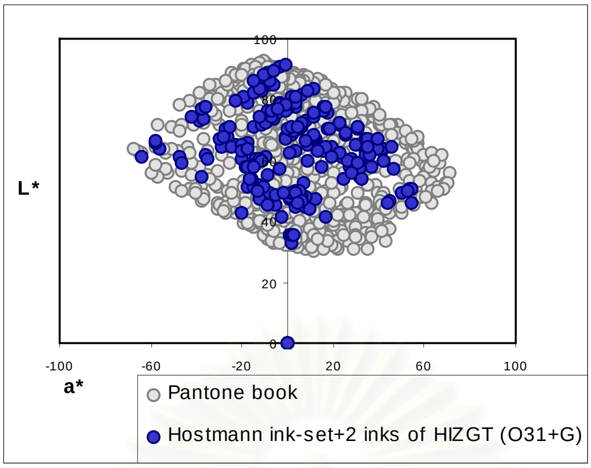
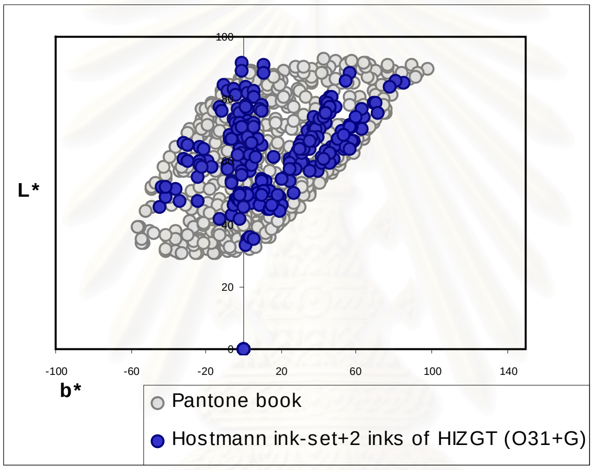




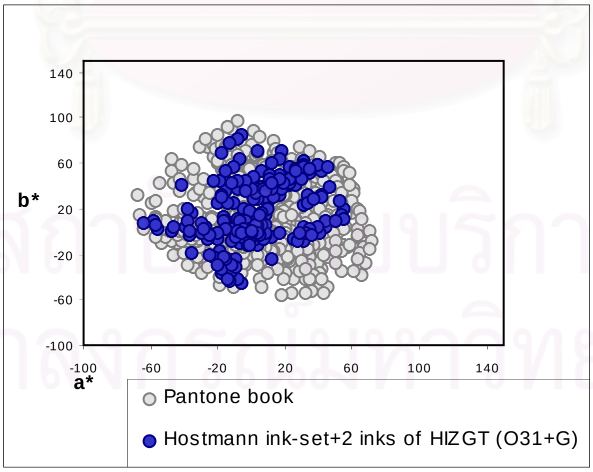


Figure 4.46 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT orange 31, HIZGT green, D_{65}/2.

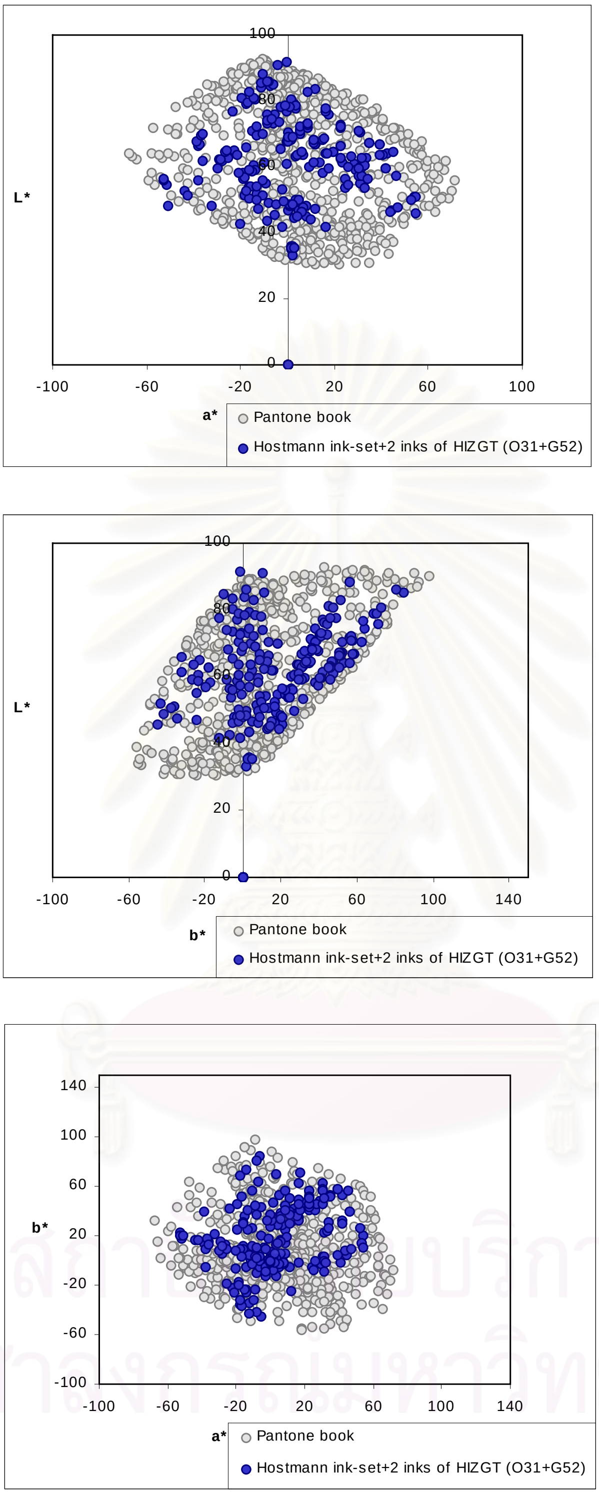


Figure 4.47 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT orange 31, HIZGT green 52, D_{65}/2.

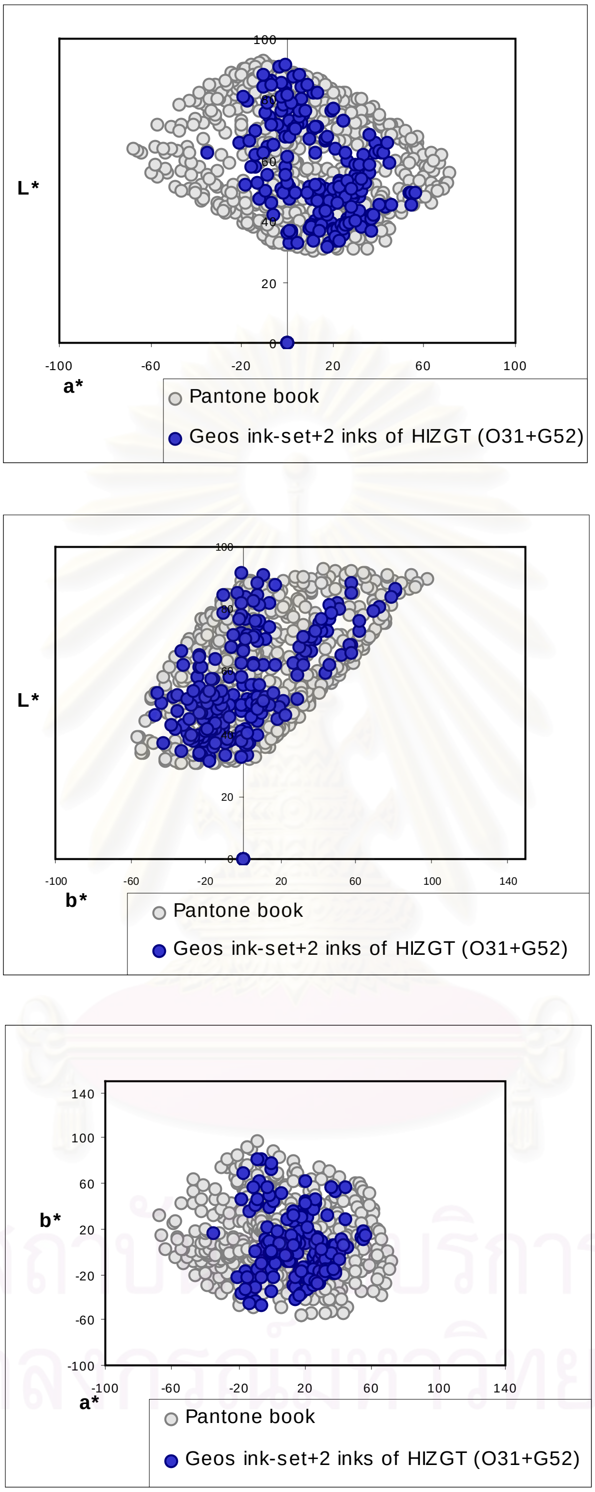
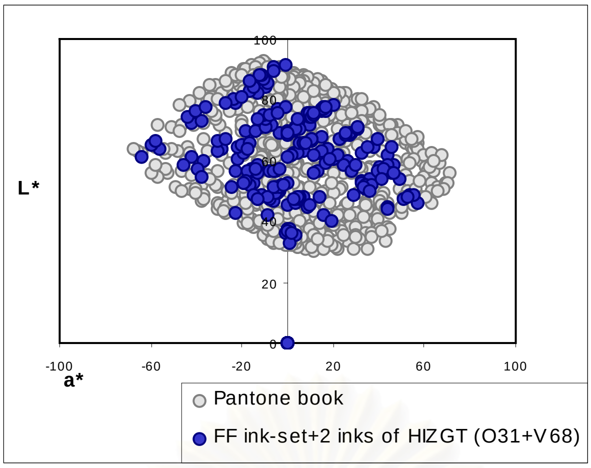
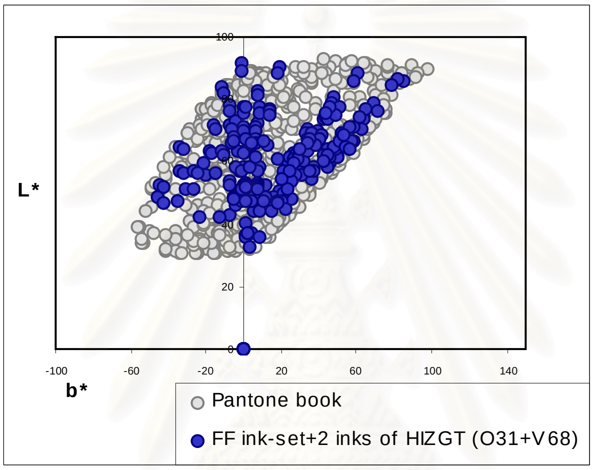


Figure 4.48 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT orange 31, HIZGT violet 68, D_{65}/2.





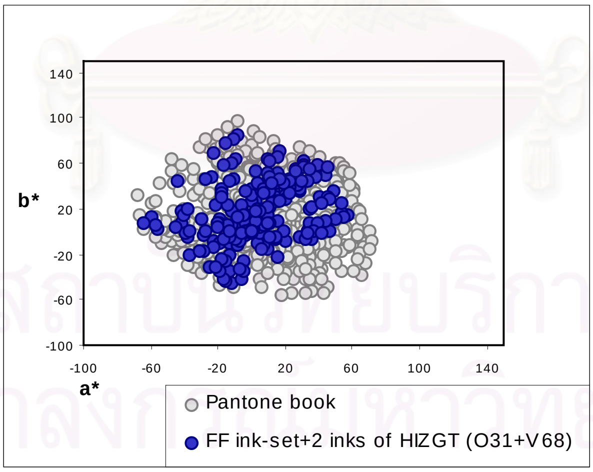


Figure 4.49 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT orange 31, HIZGT violet 68, D_{65}/2.

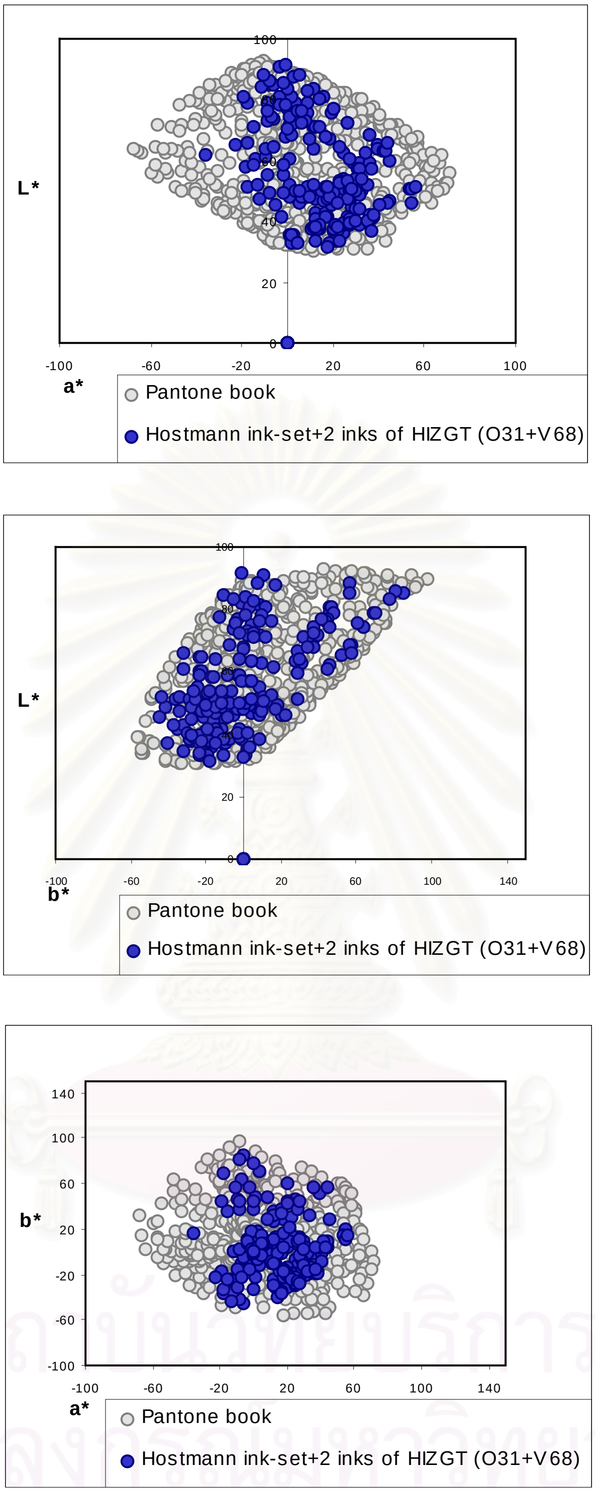


Figure 4.50 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT orange 31, HIZGT violet 68, D_{65}/2.

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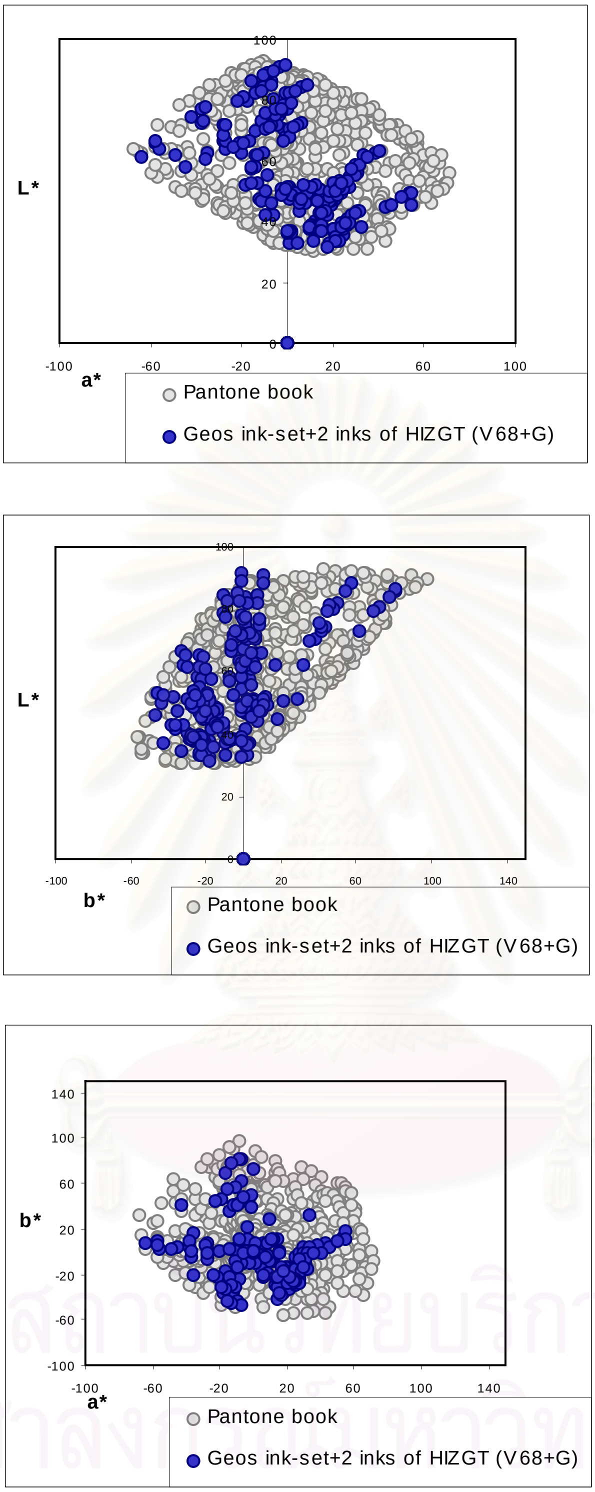

Figure 4.51 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT violet 68, HIZGT green, $D_{65}/2$.

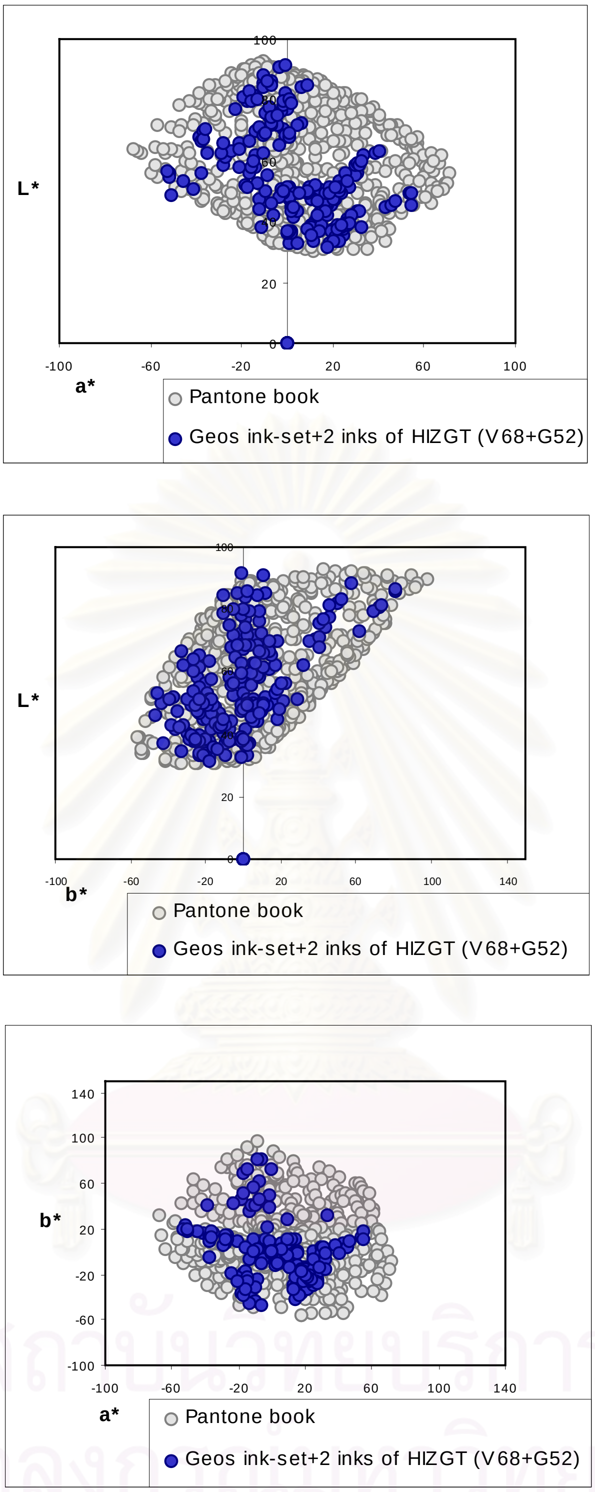

Figure 4.52 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT violet 68, HIZGT green 52, D_{65}/2.

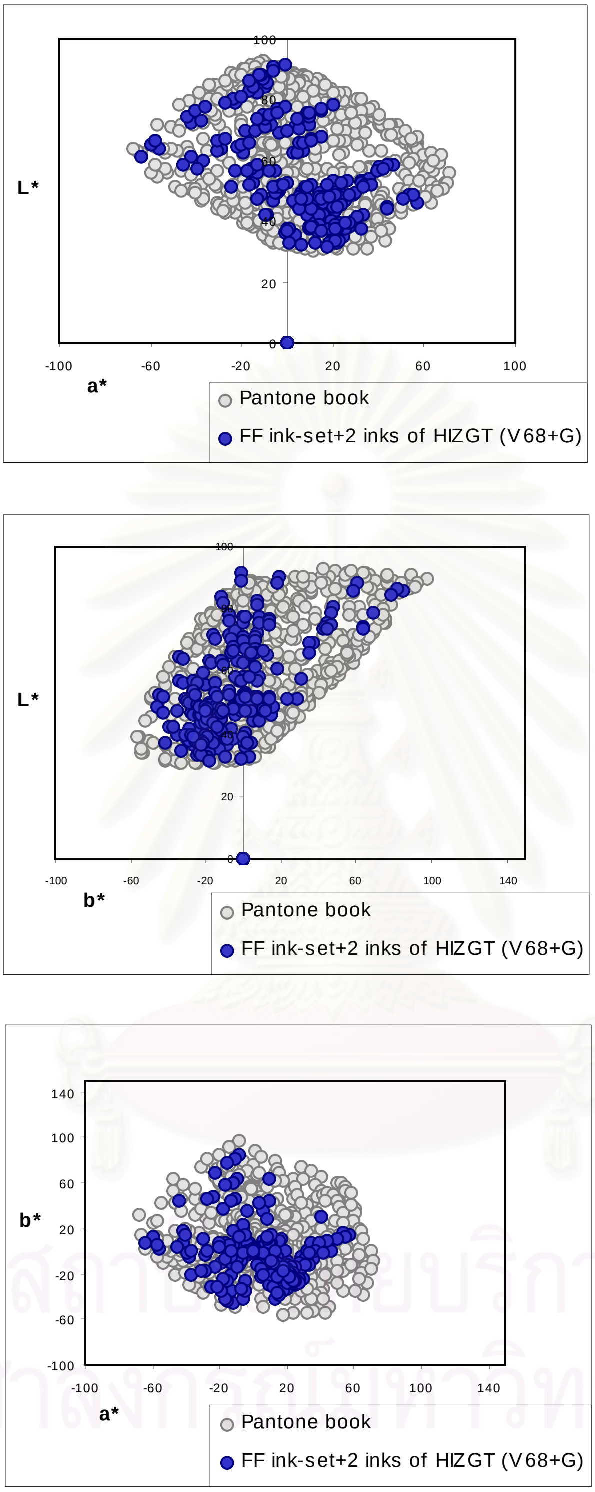

Figure 4.53 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT violet 68, HIZGT green, D_{65}/2.

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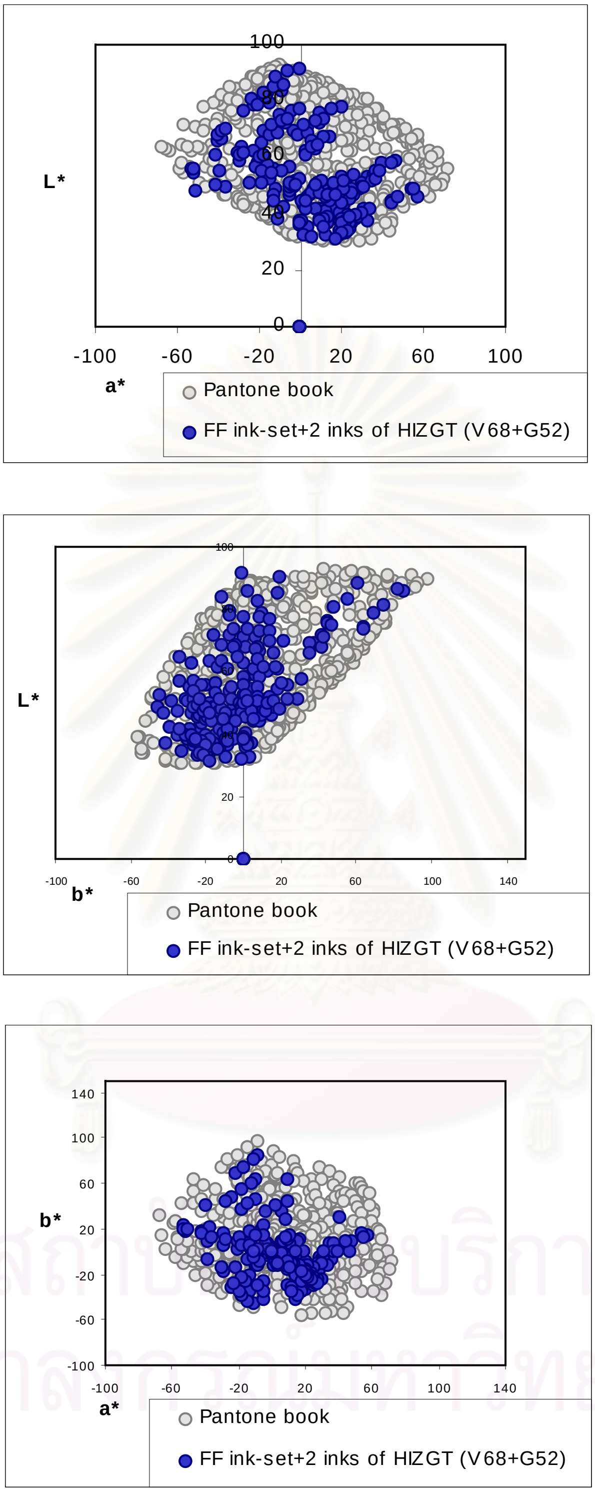

Figure 4.54 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT violet 68, HIZGT green 52, D_{65}/2.

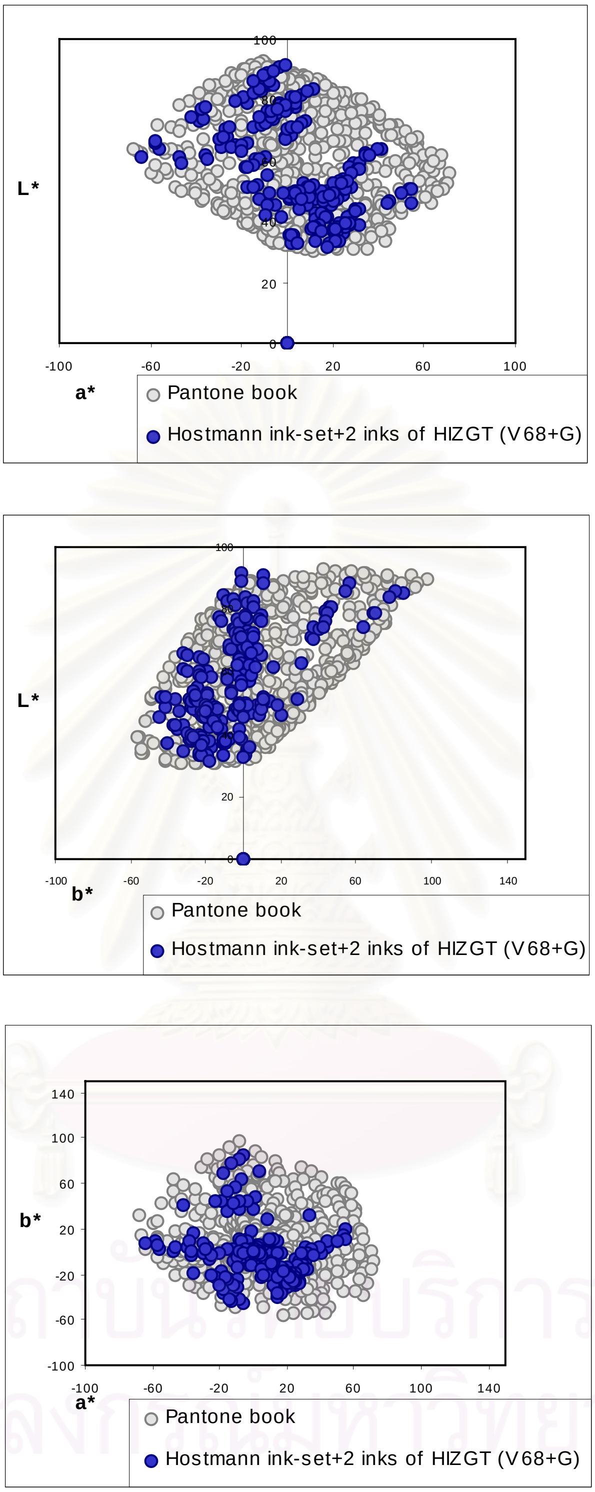

Figure 4.55 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT violet 68, HIZGT green, $D_{65}/2$.

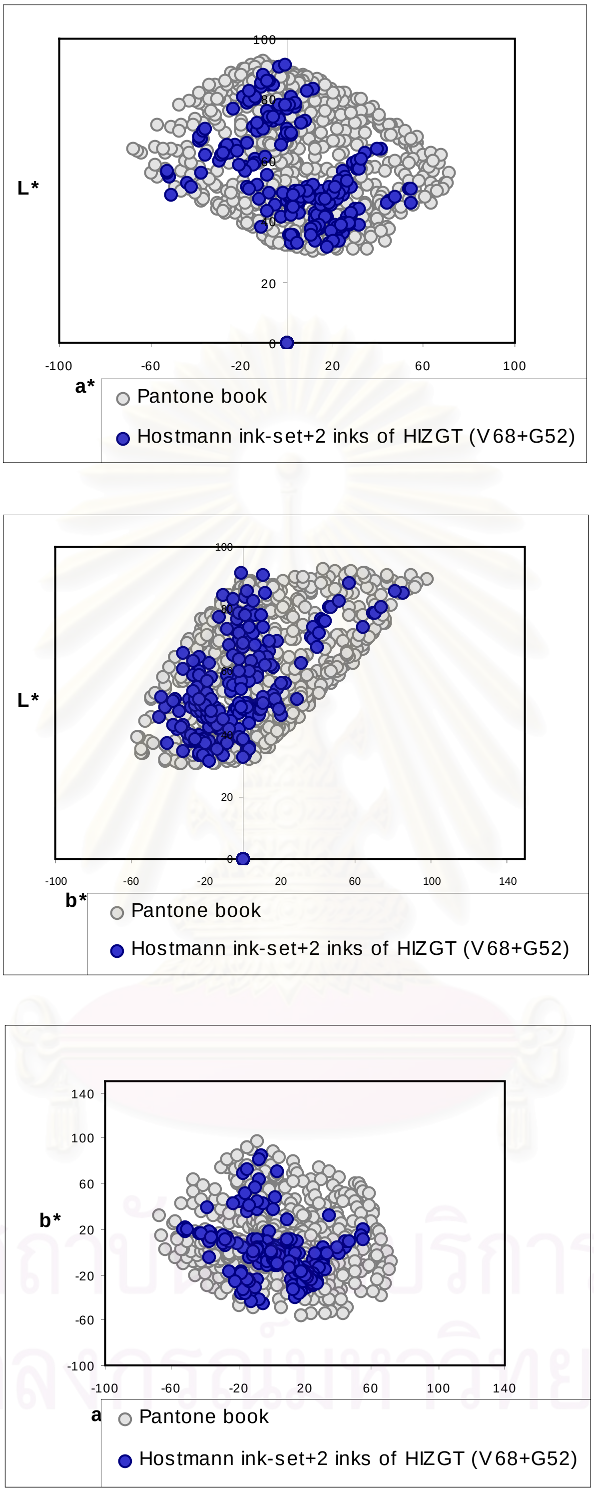

Figure 4.56 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT violet 68, HIZGT green 52, D_{65}/2.

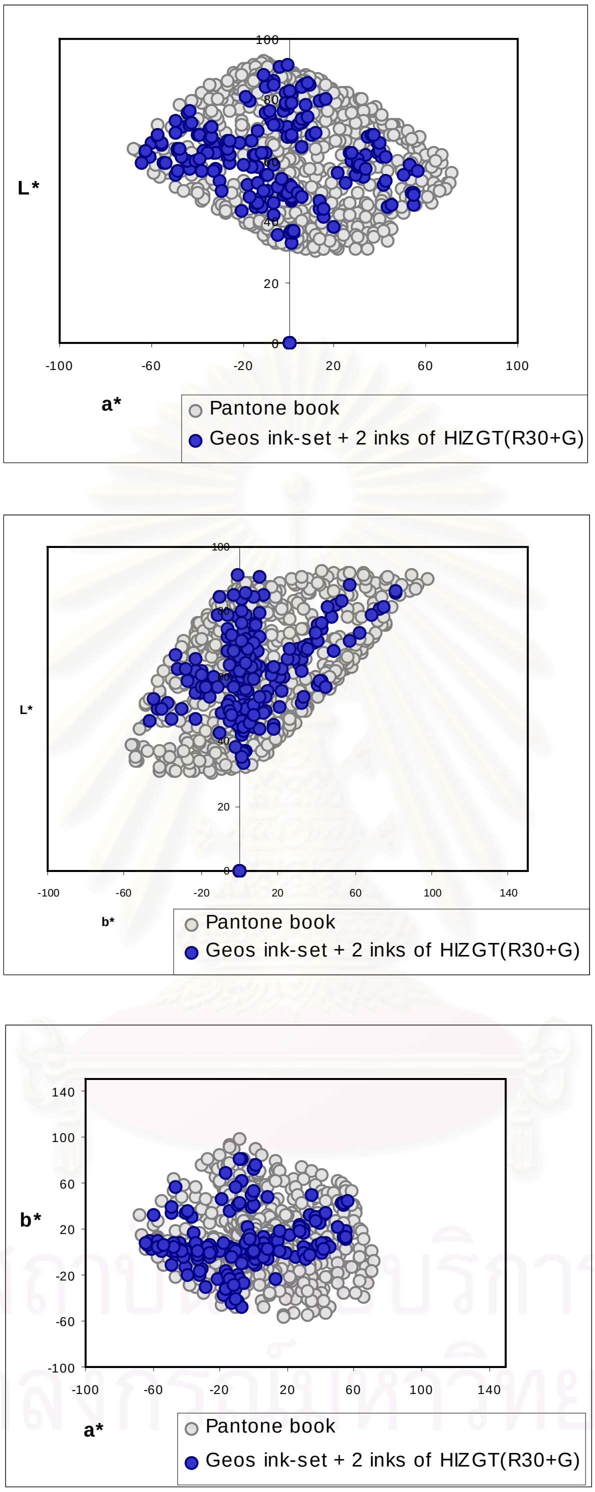

Figure 4.57 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT bronze red 30, HIZGT green, D_{65}/2.

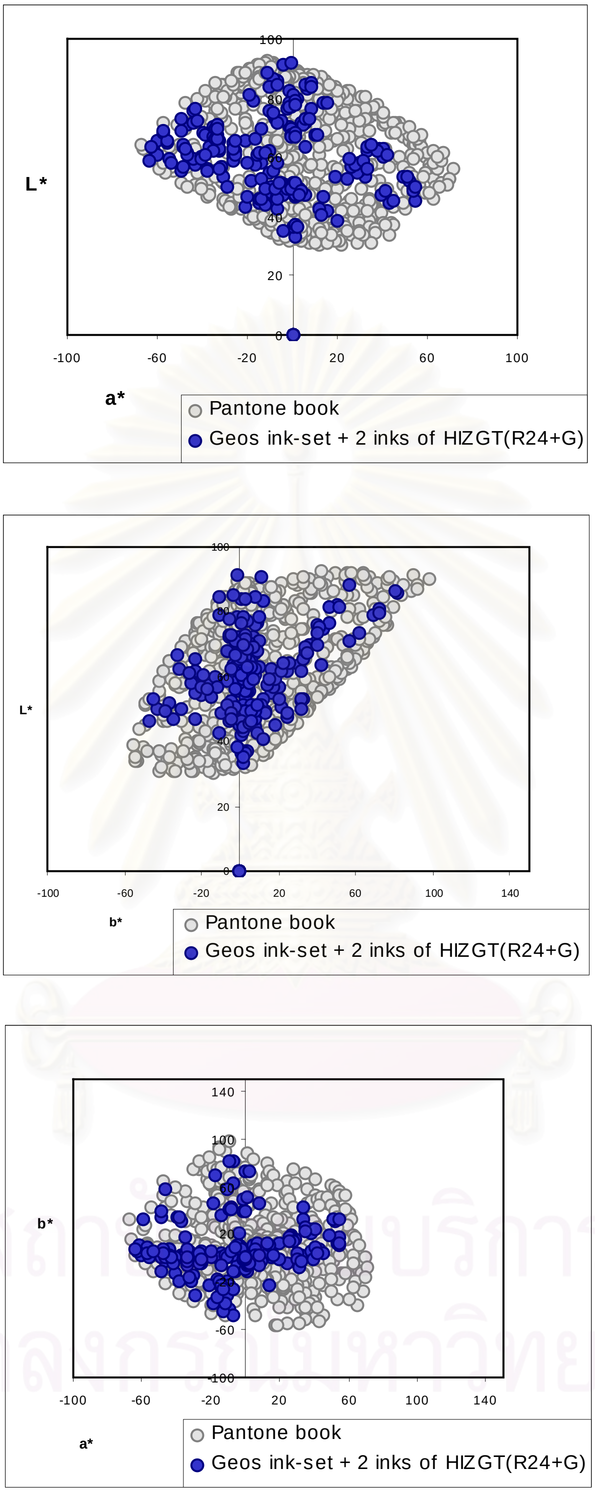

Figure 4.58 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT deep red 24, HIZGT green, D_{65}/2.

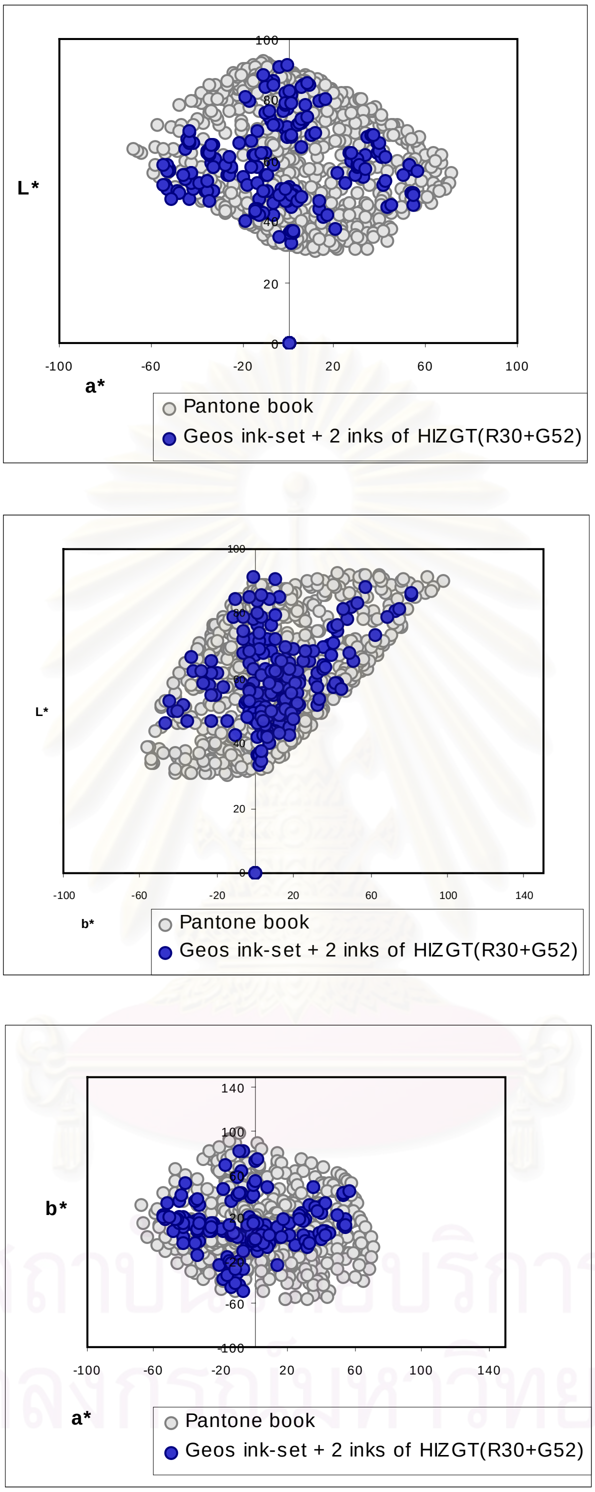

Figure 4.59 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT bronze red 30, HIZGT green 52, D_{65}/2.

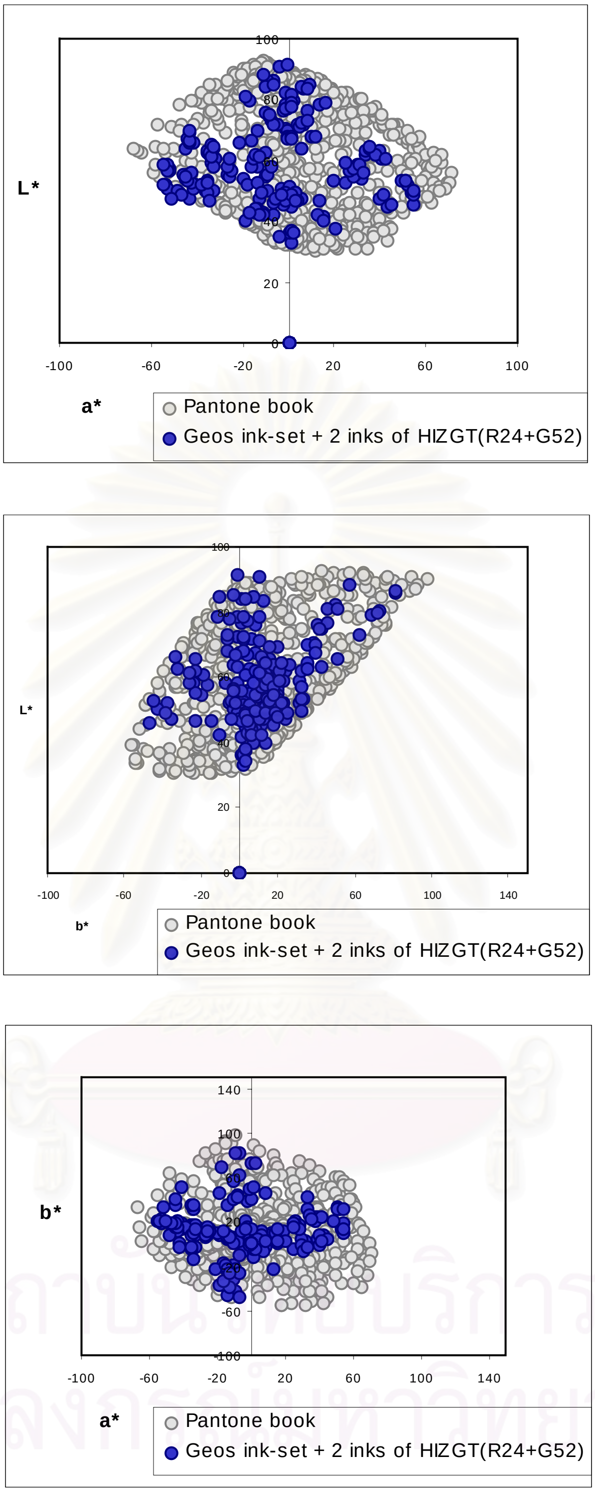

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Figure 4.60 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT deep red 24, HIZGT green 52, $D_{65}/2$.

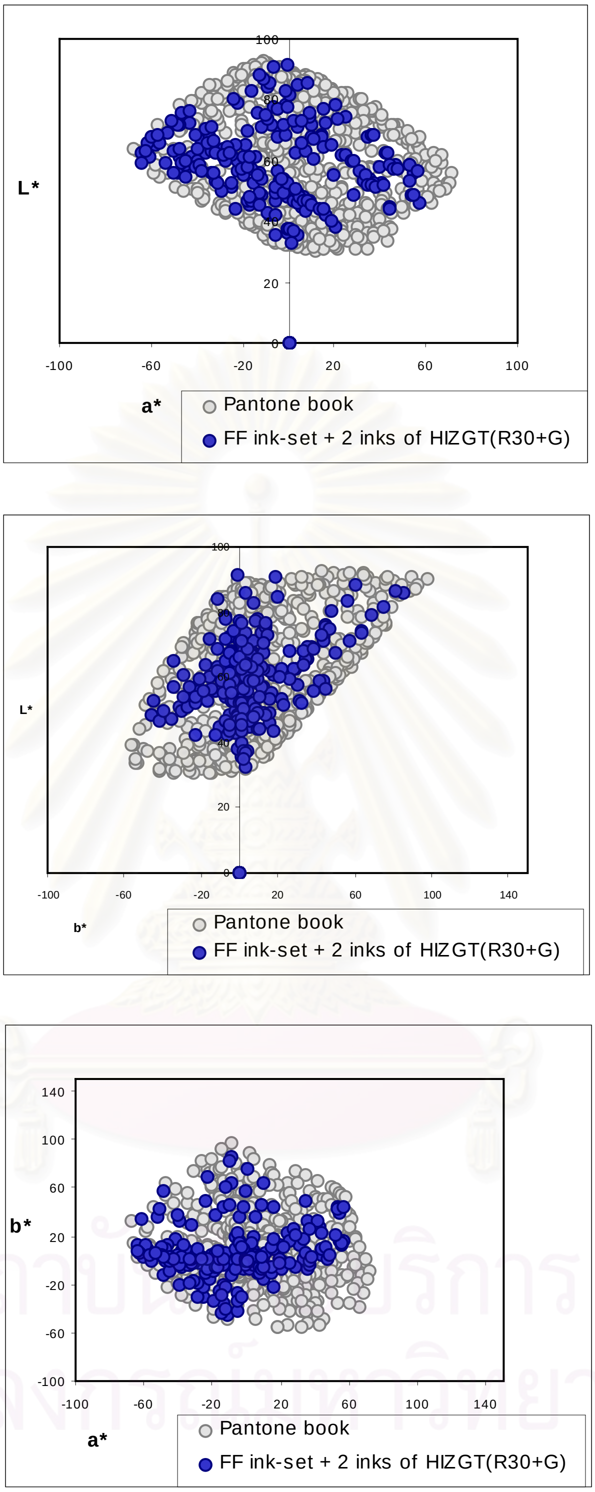

Figure 4.61 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT bronze red 30, HIZGT green, $D_{65}/2$.

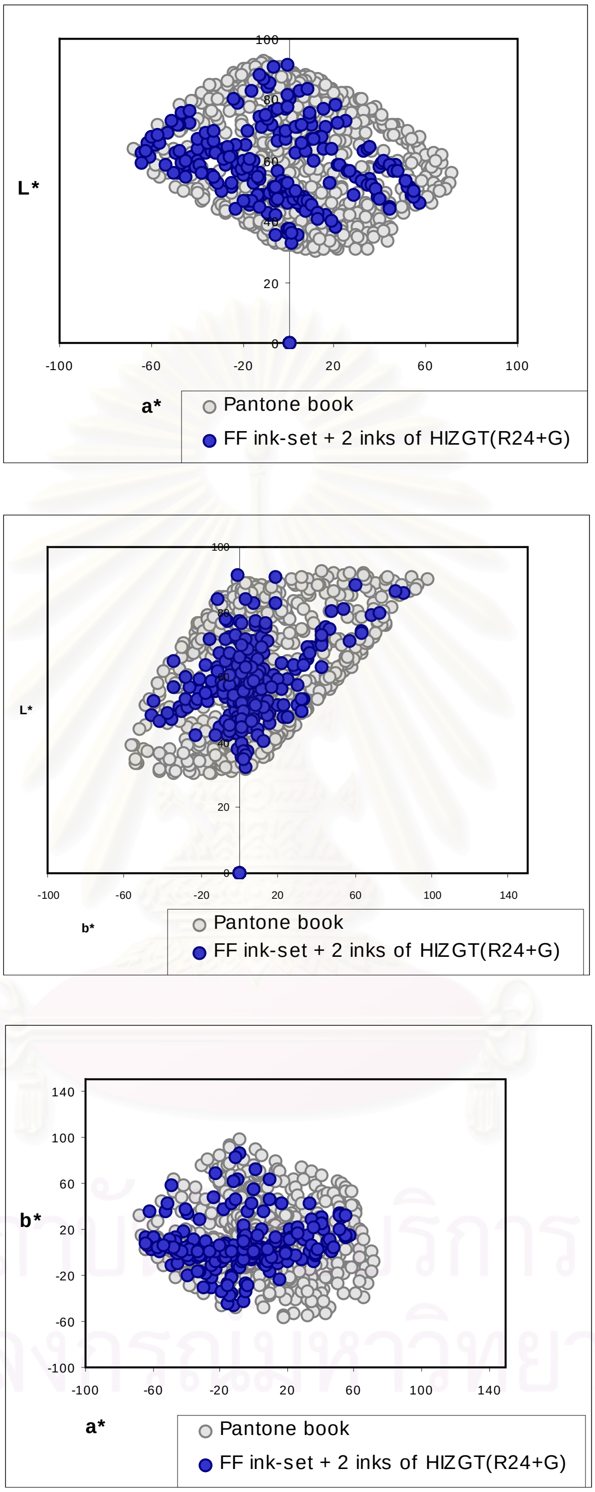

Figure 4.62 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT Deep red 24, HIZGT green, D_{65}/2.

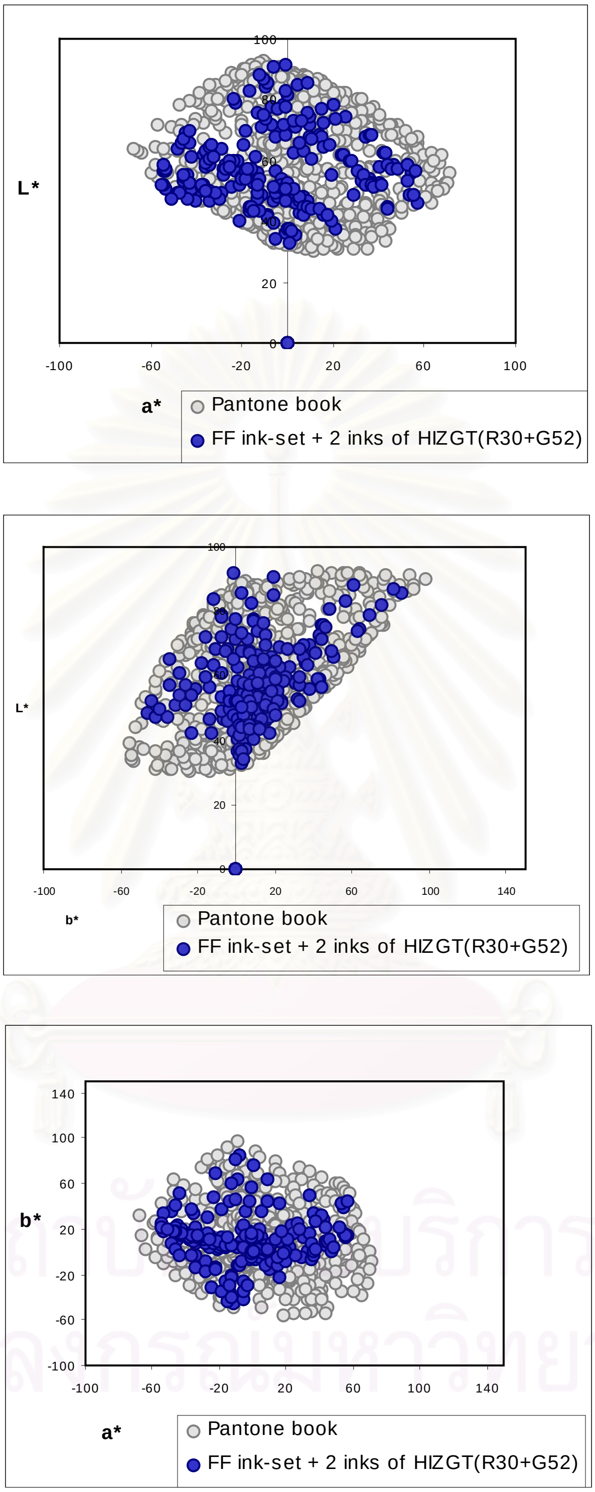

Figure 4.63 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT bronze red 30, HIZGT green 52, D_{65}/2.

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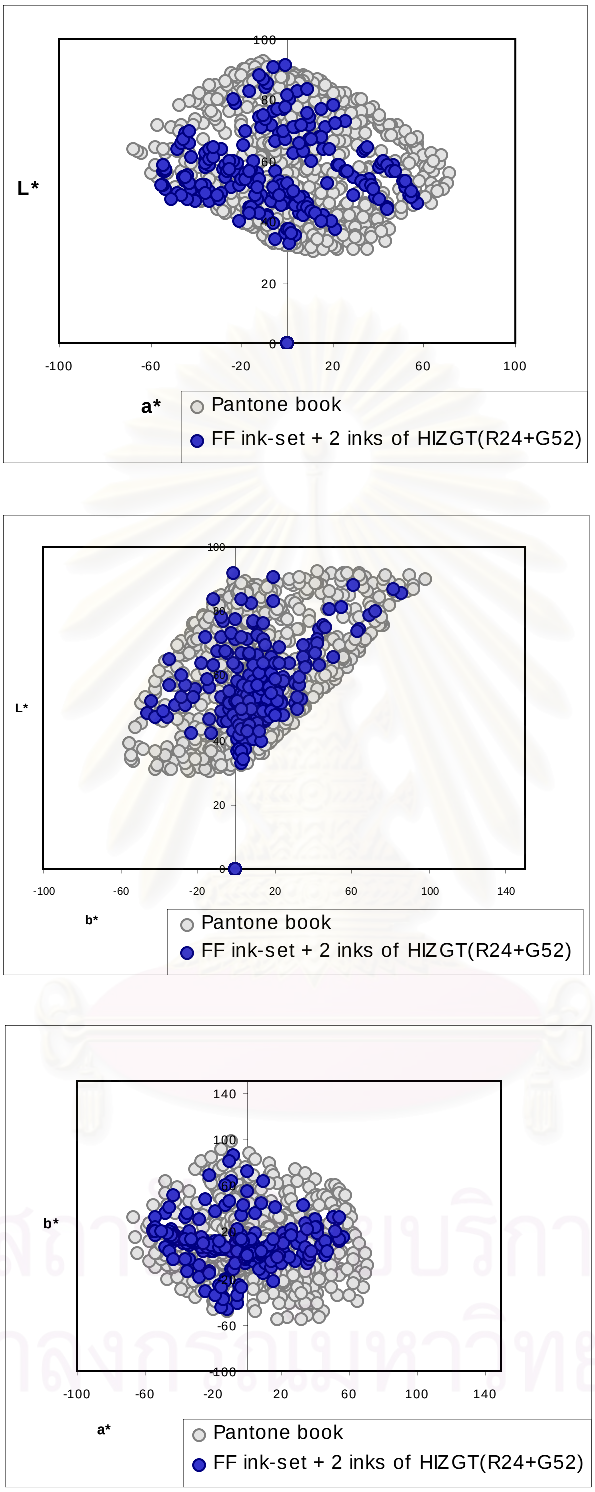

Figure 4.64 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT deep red 24, HIZGT green 52, D_{65}/2.

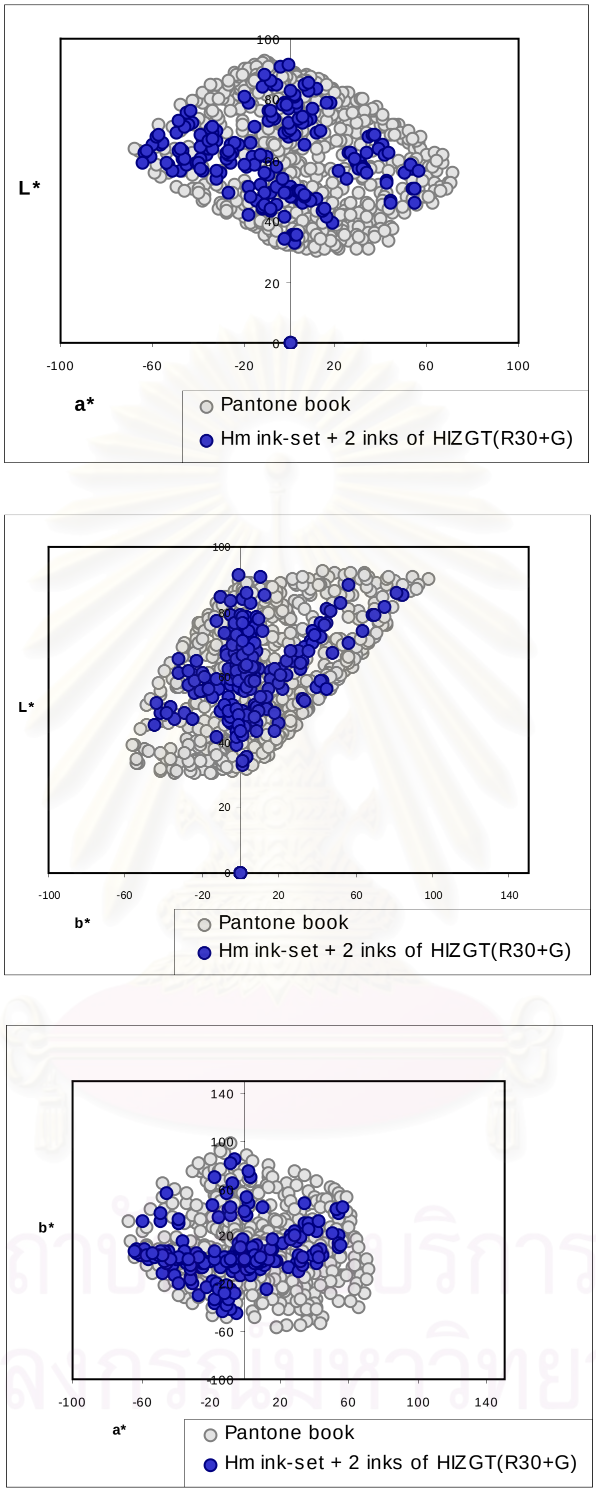

Figure 4.65 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT bronze red 30, HIZGT green, D_{65}/2.

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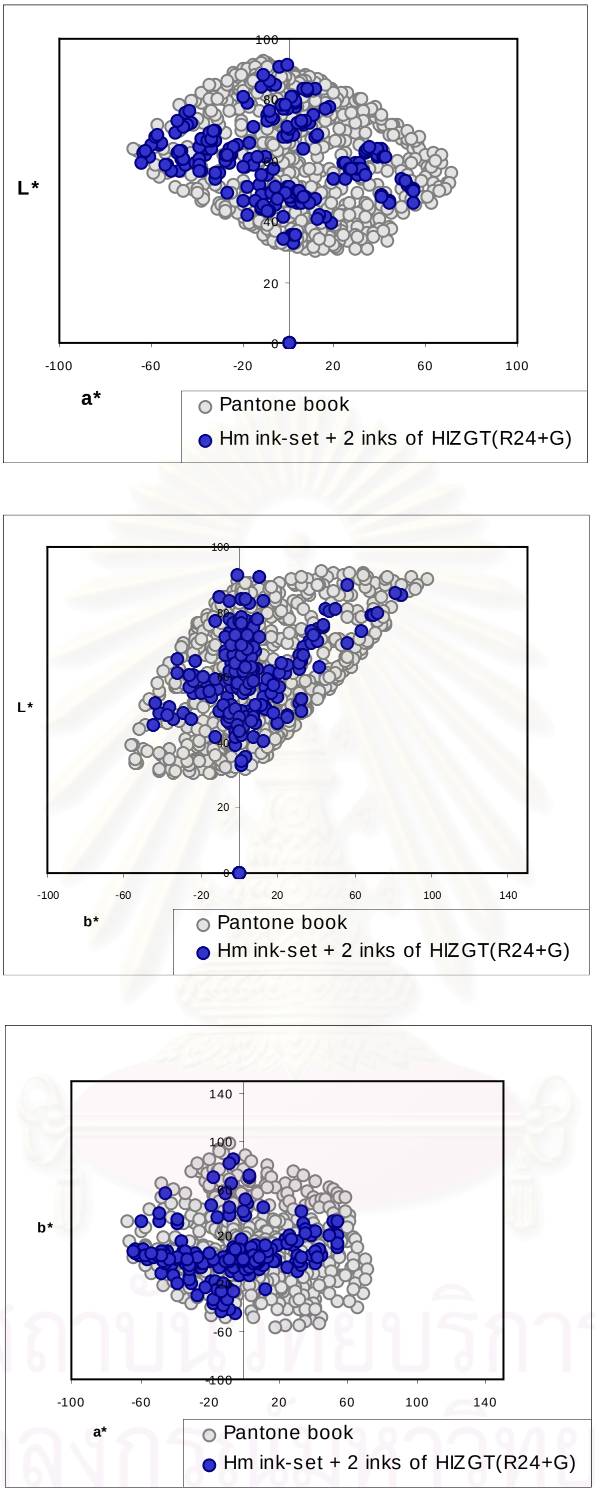

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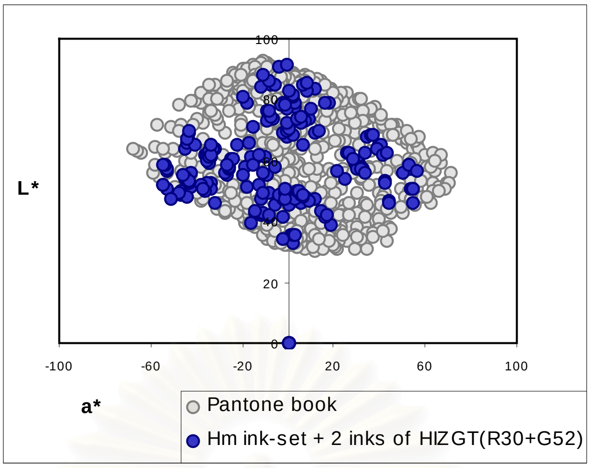
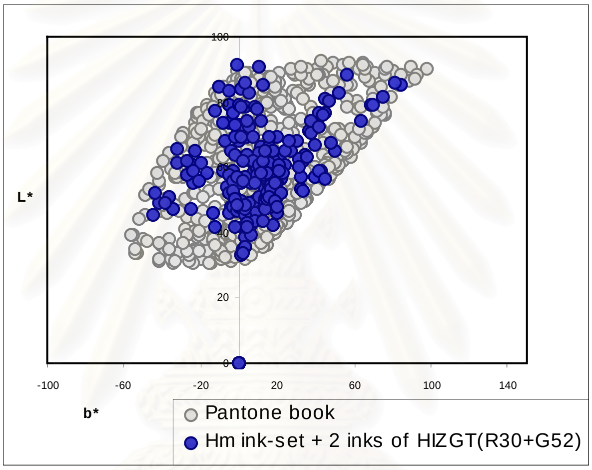
Figure 4.66 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT deep red 24, HIZGT green, $D_{65}/2$.





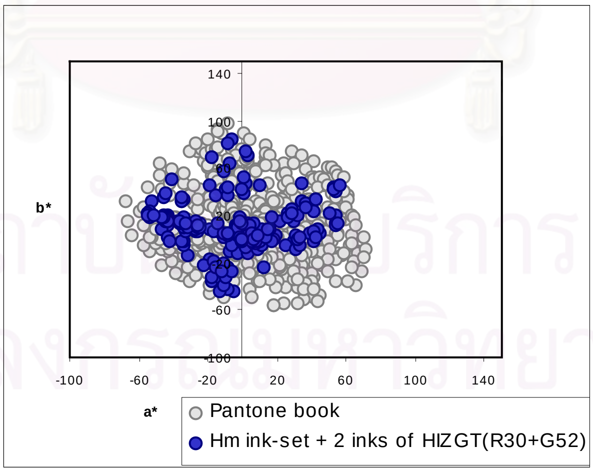


Figure 4.67 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hoatmann black, HIZGT bronze red 30, HIZGT green 52, D_{65}/2.

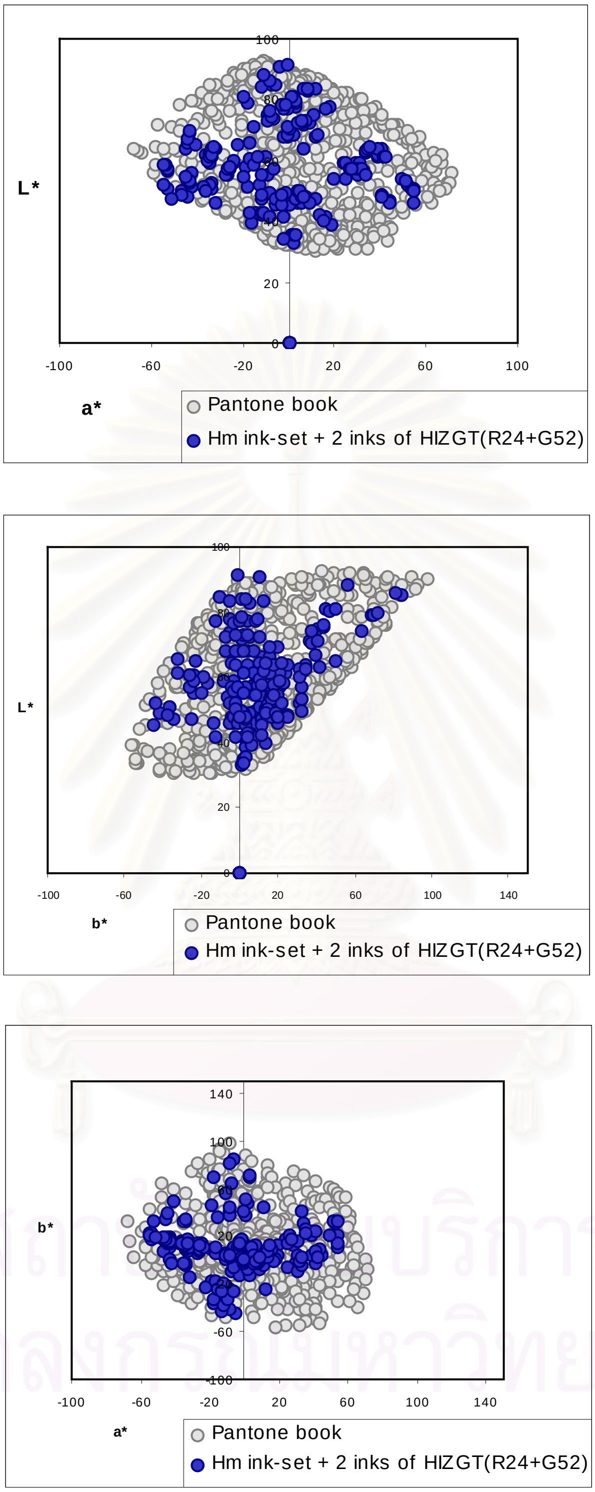


Figure 4.68 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT deep red 24, HIZGT green 52, D_{65}/2.

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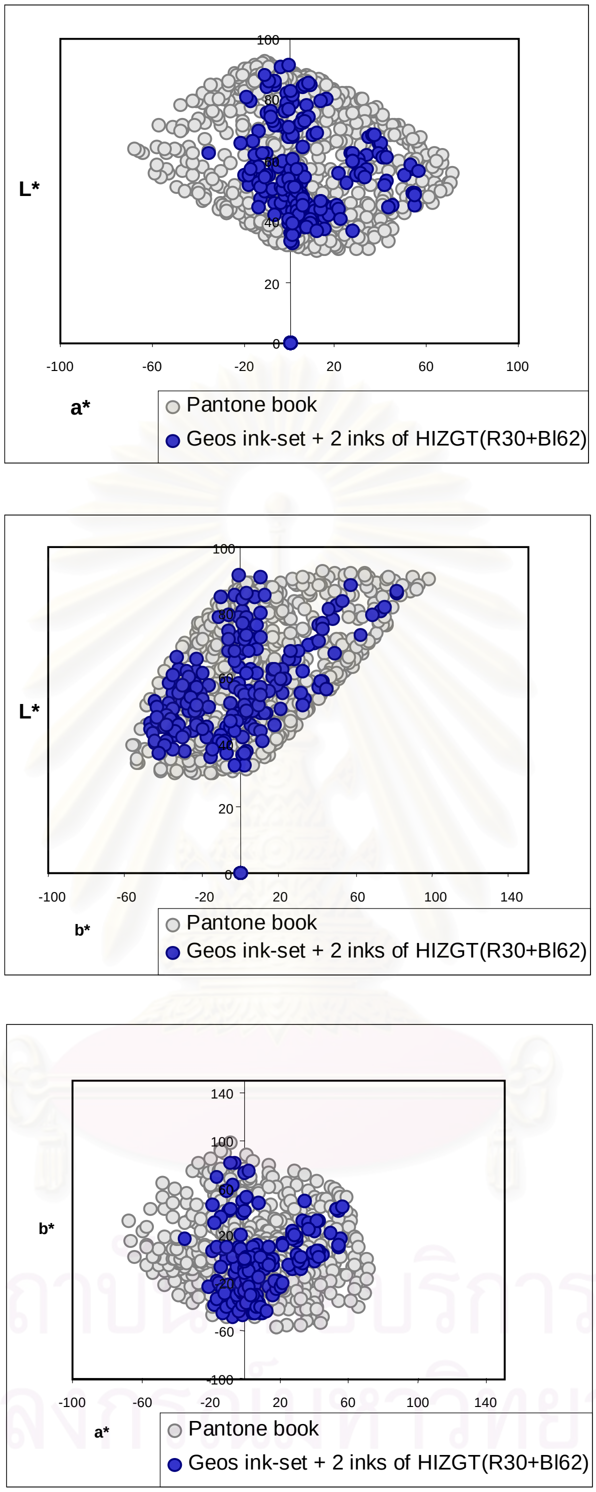


Figure 4.69 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT bronze red 30, HIZGT bronze blue 62, D_{65}/2.

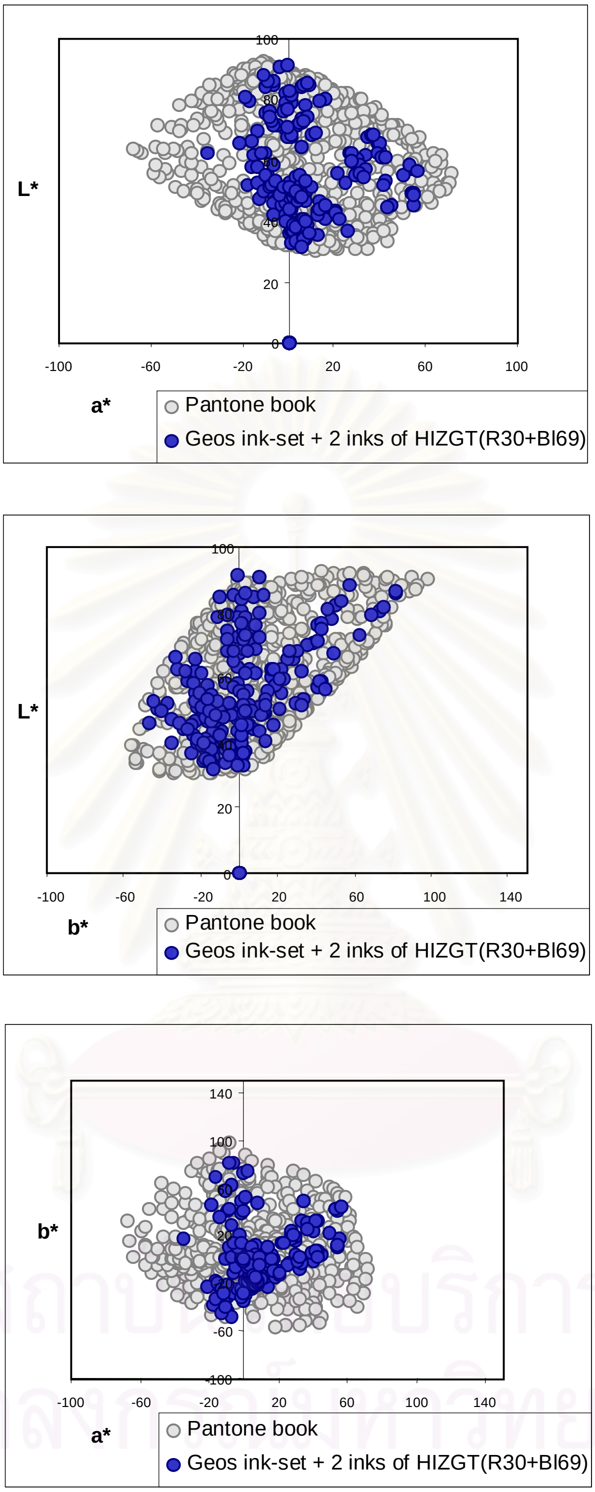
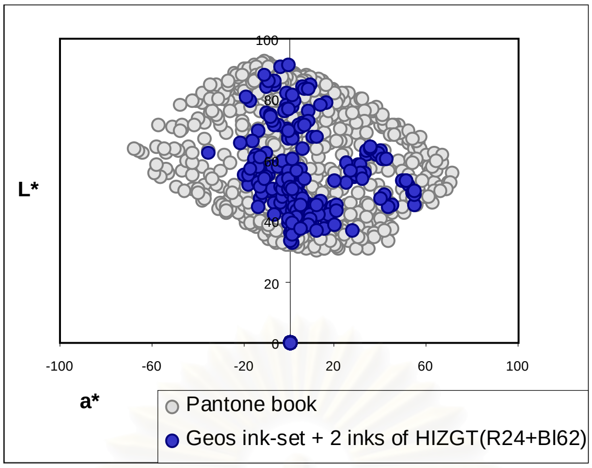
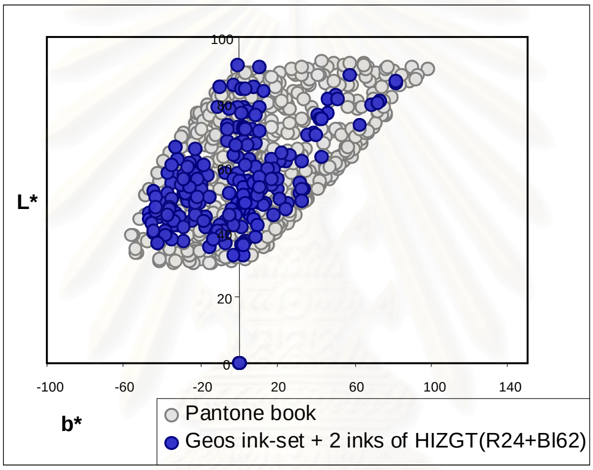


Figure 4.70 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT bronze red 30, HIZGT dark blue 69, $D_{65}/2$.





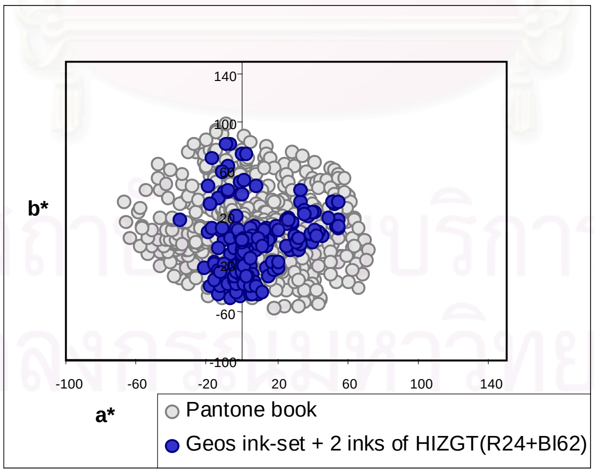


Figure 4.71 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT deep red 24, HIZGT bronze blue 62, $D_{65}/2$.

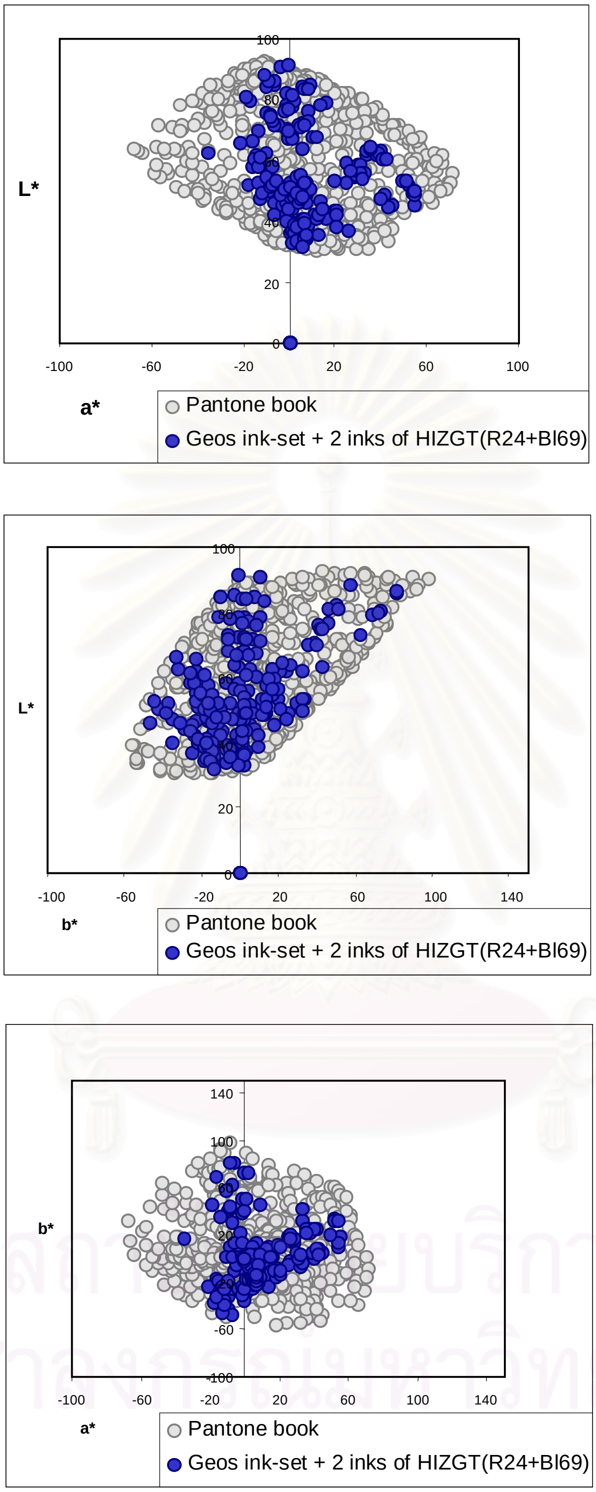
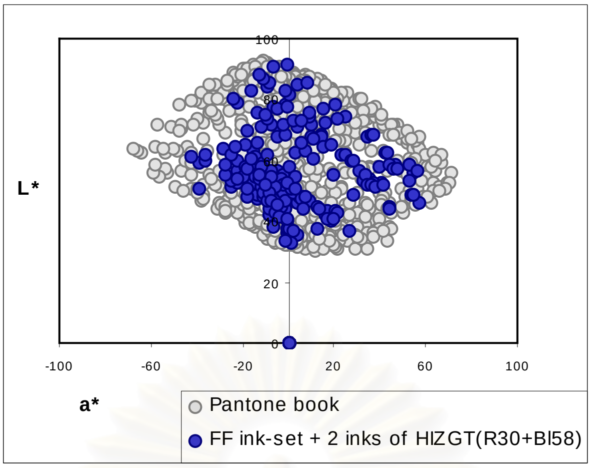
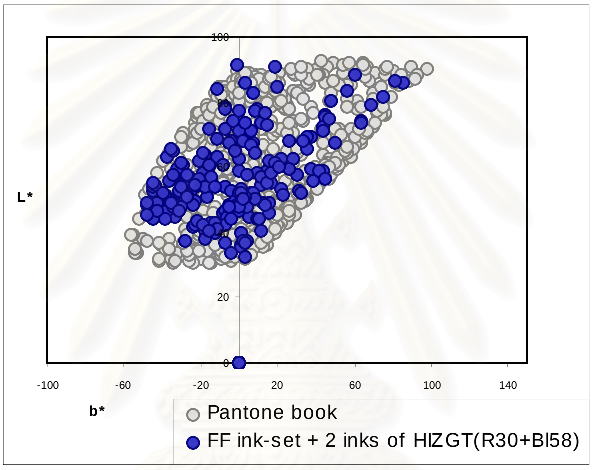


Figure 4.72 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT deep red 24, HIZGT dark blue 69, $D_{65}/2$.





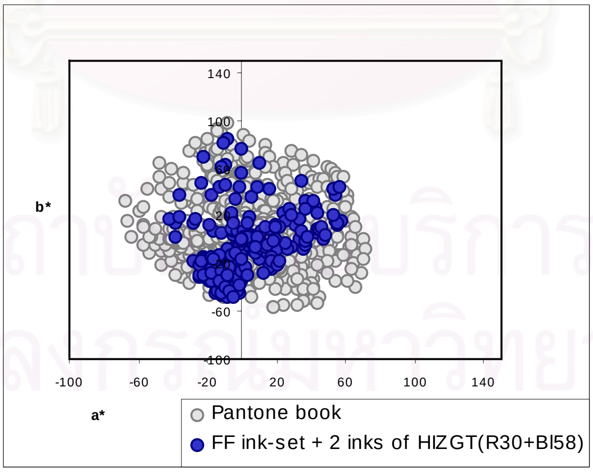


Figure 4.73 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT bronze red 30, HIZGT process blue 58, D_{65}/2.

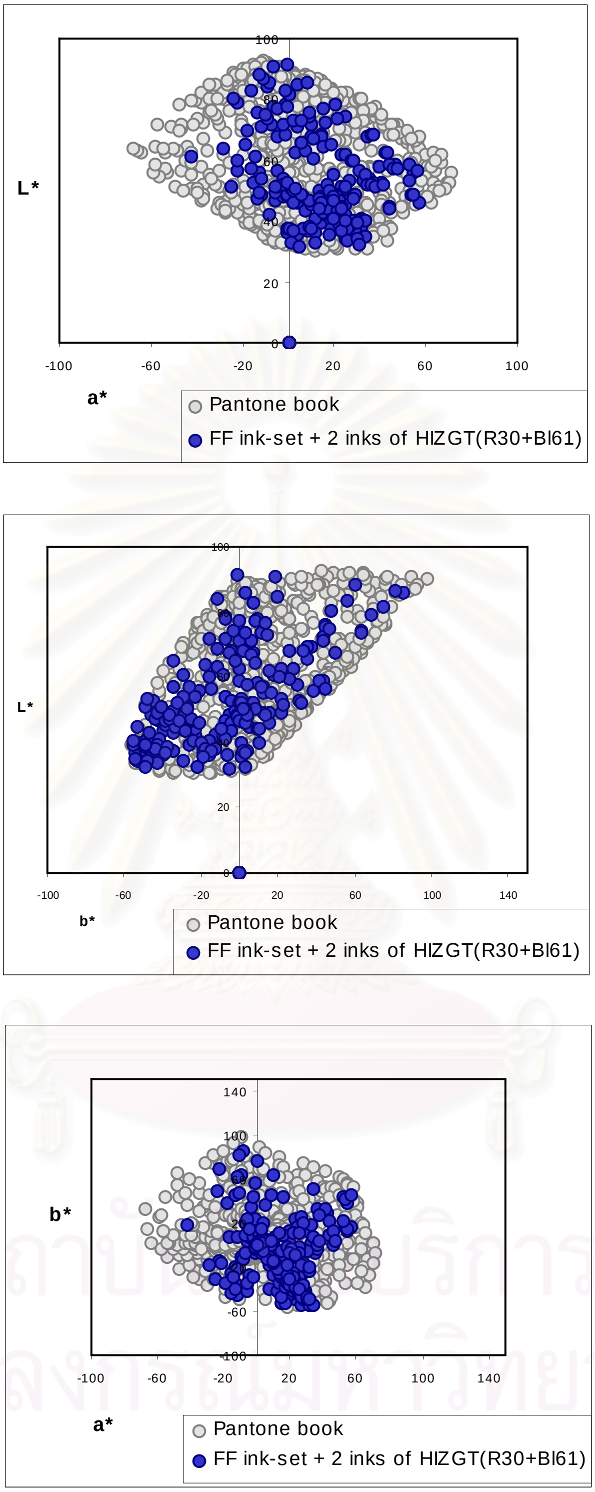


Figure 4.74 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT bronze red 30, HIZGT bronze blue 61, D_{65}/2.

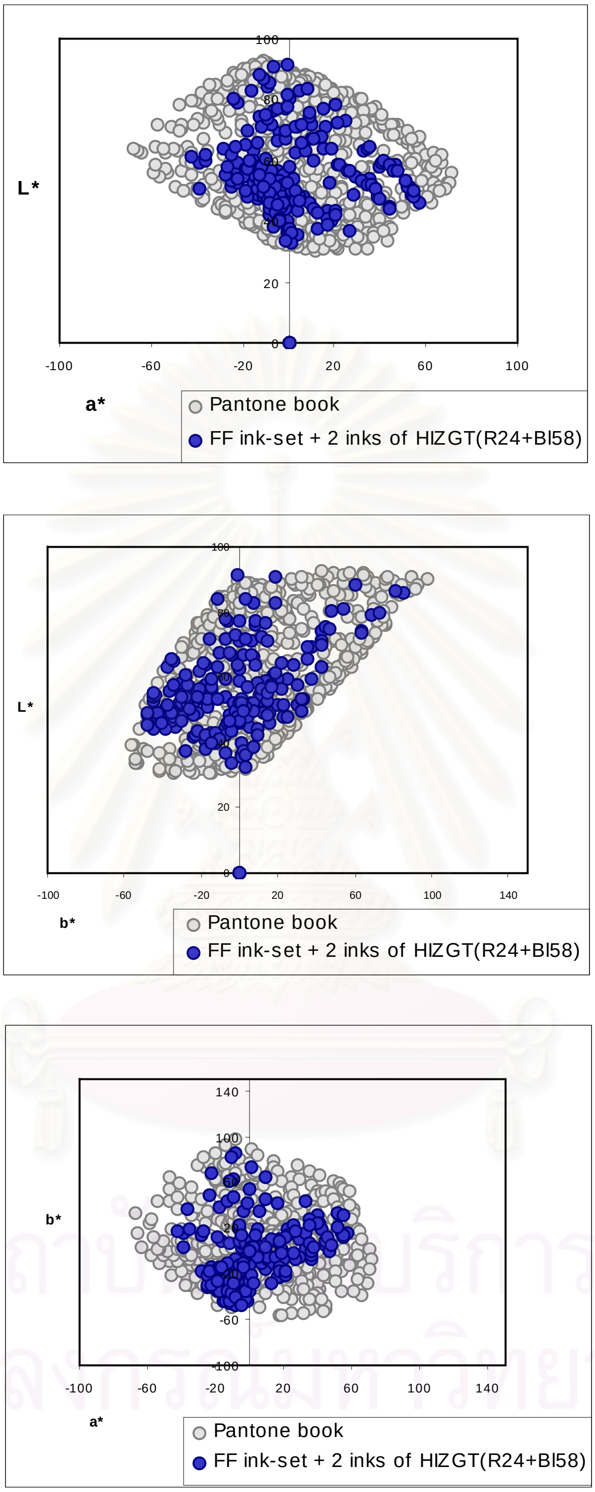


Figure 4.75 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT deep red 24, HIZGT process blue 58, D_{65}/2.

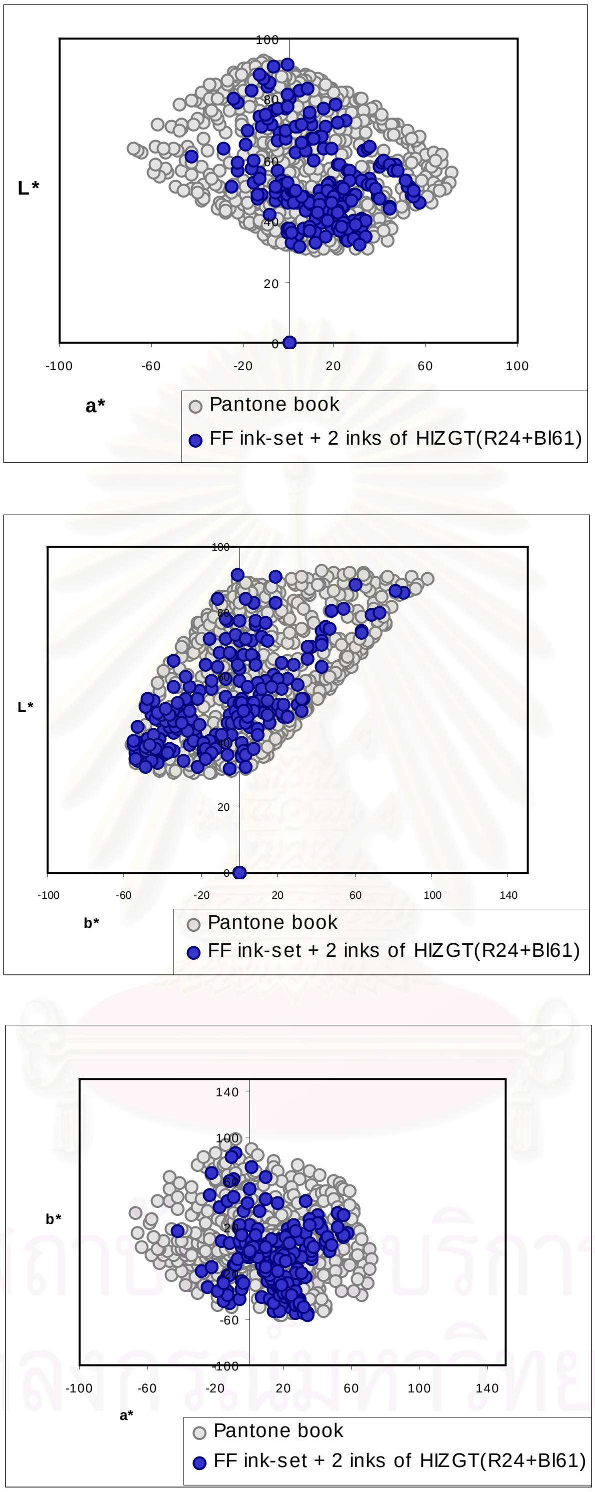


Figure 4.76 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT deep red 24, HIZGT bronze blue 61, $D_{65}/2$.

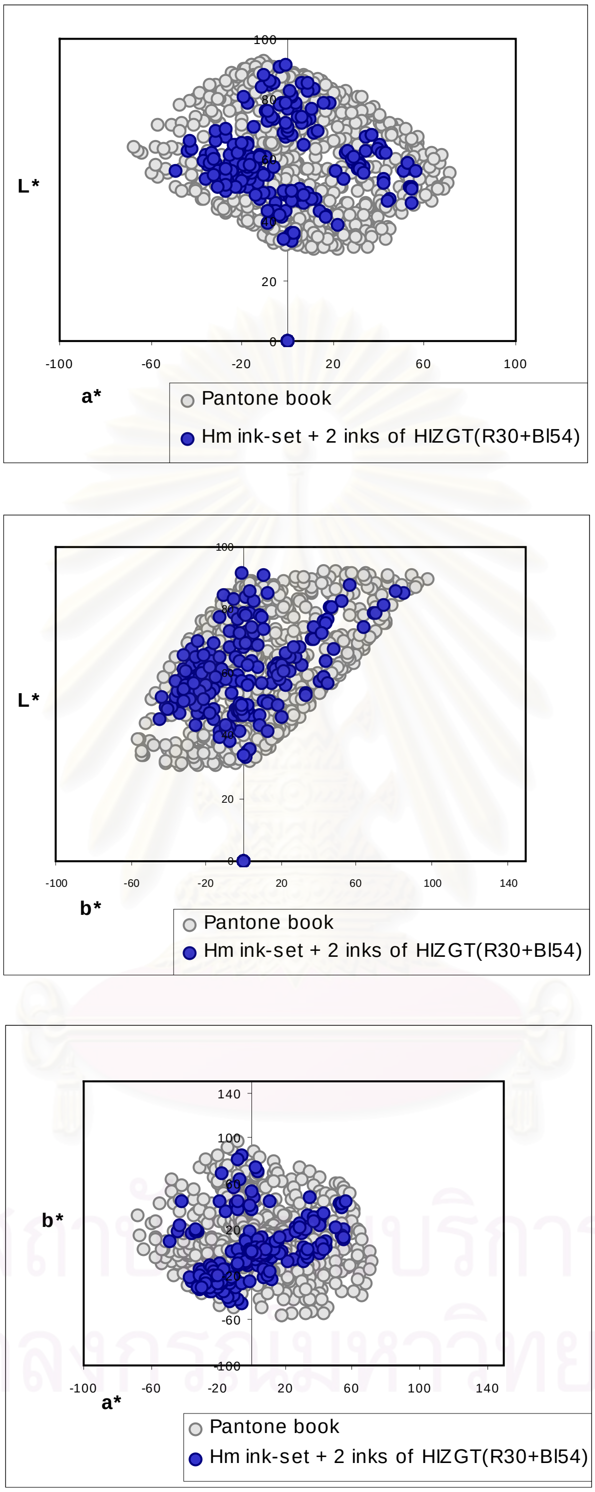
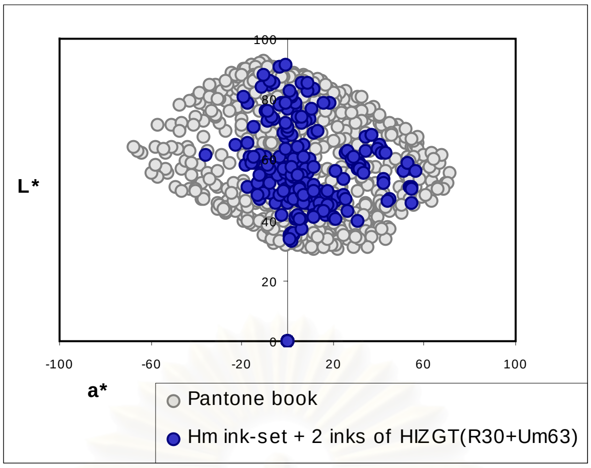
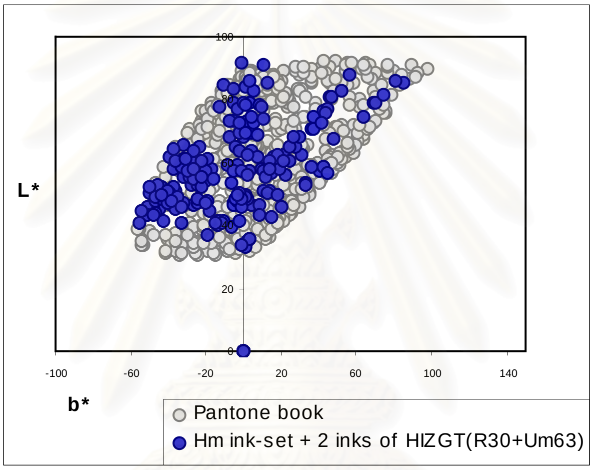


Figure 4.77 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT bronze red 30, HIZGT peacock blue 54, $D_{65}/2$.





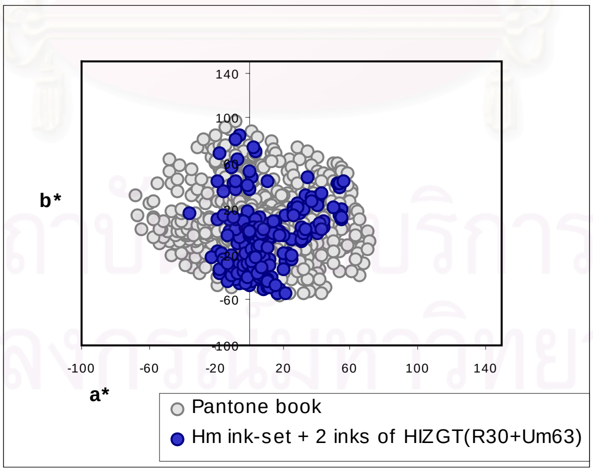


Figure 4.78 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT bronze red 30, HIZGT Ultramarine 63, D_{65}/2.

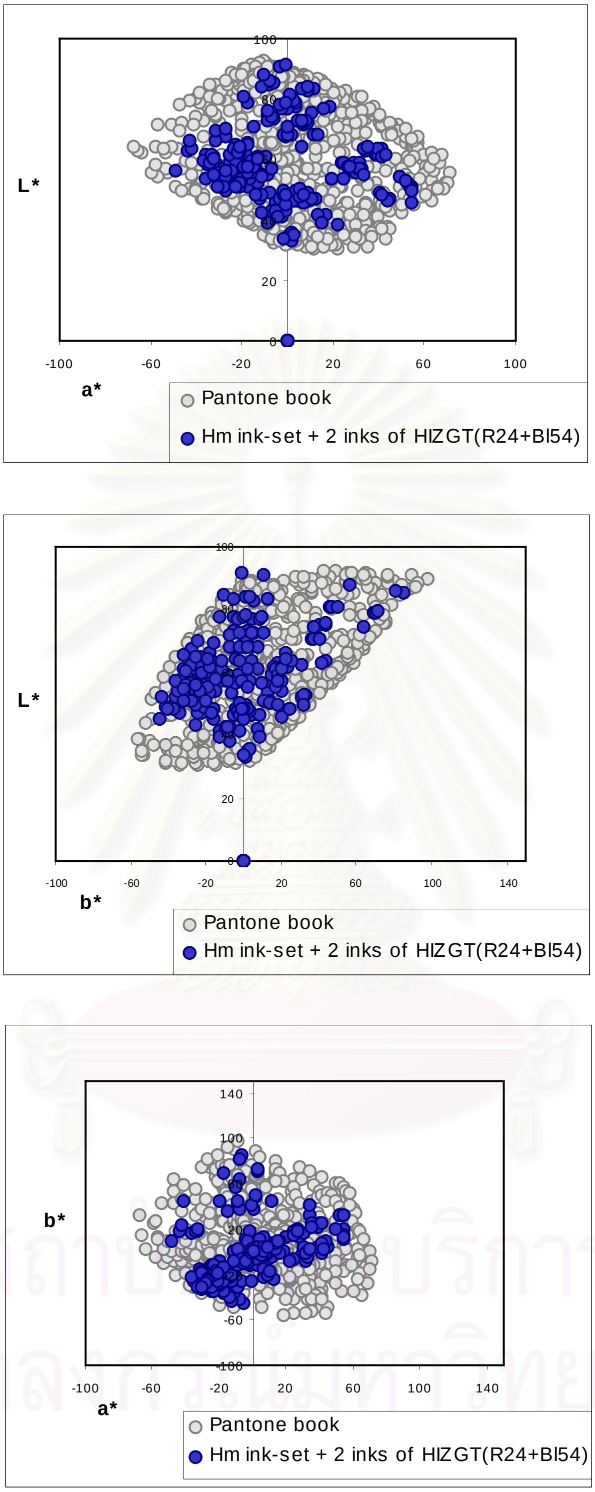


Figure 4.79 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT deep red 24, HIZGT peacock blue 54, D_{65}/2.

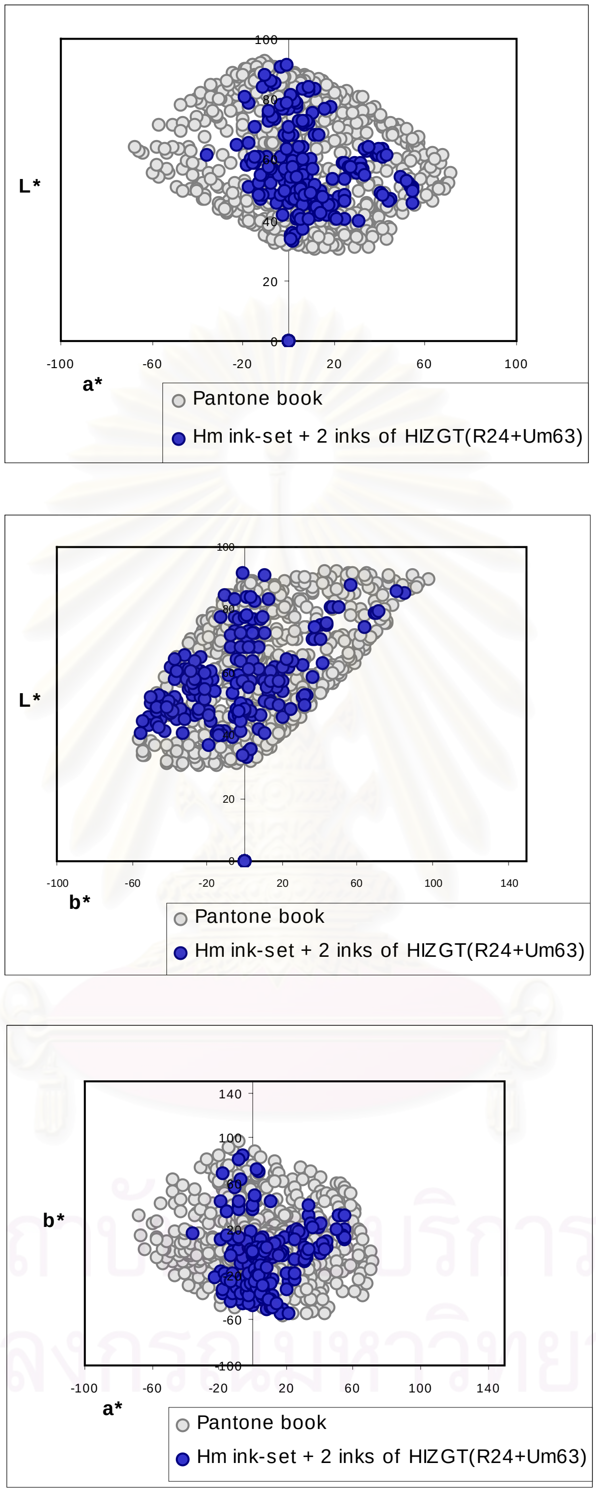


Figure 4.80 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT deep red 24, HIZGT Ultramarine 63, D_{65}/2.

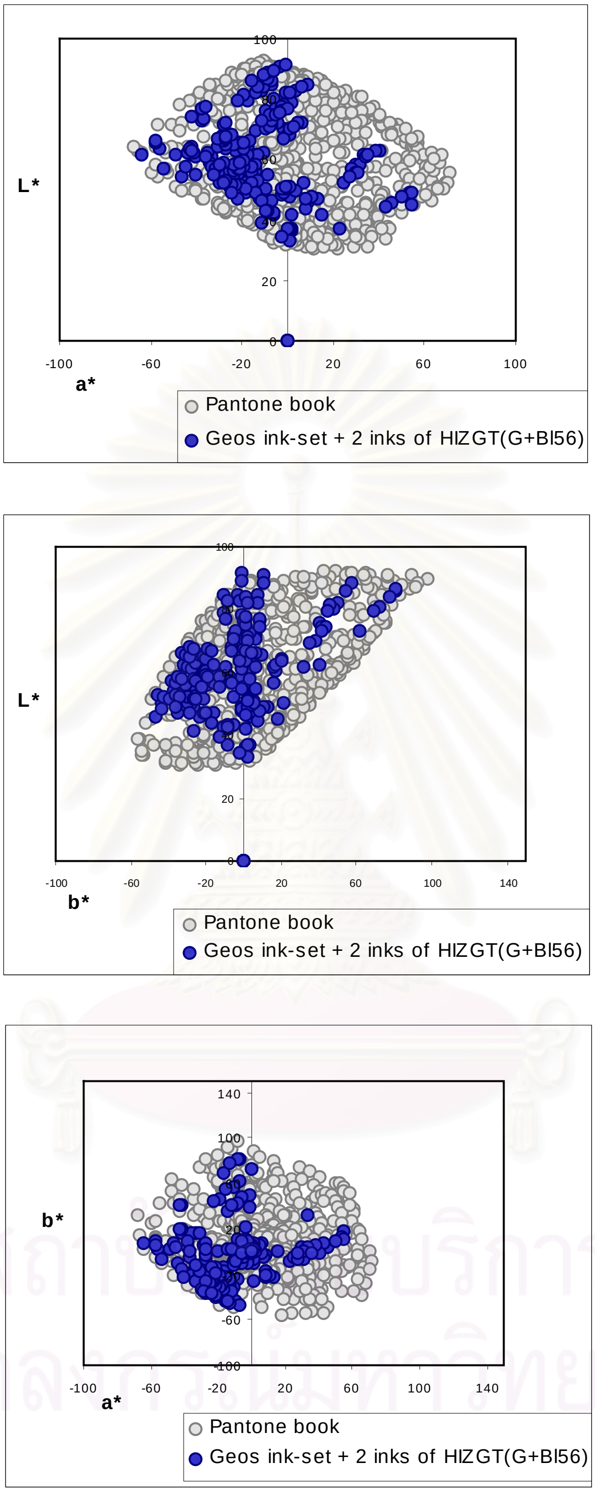


Figure 4.81 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT green, HIZGT peacock blue 56, $D_{65}/2$.

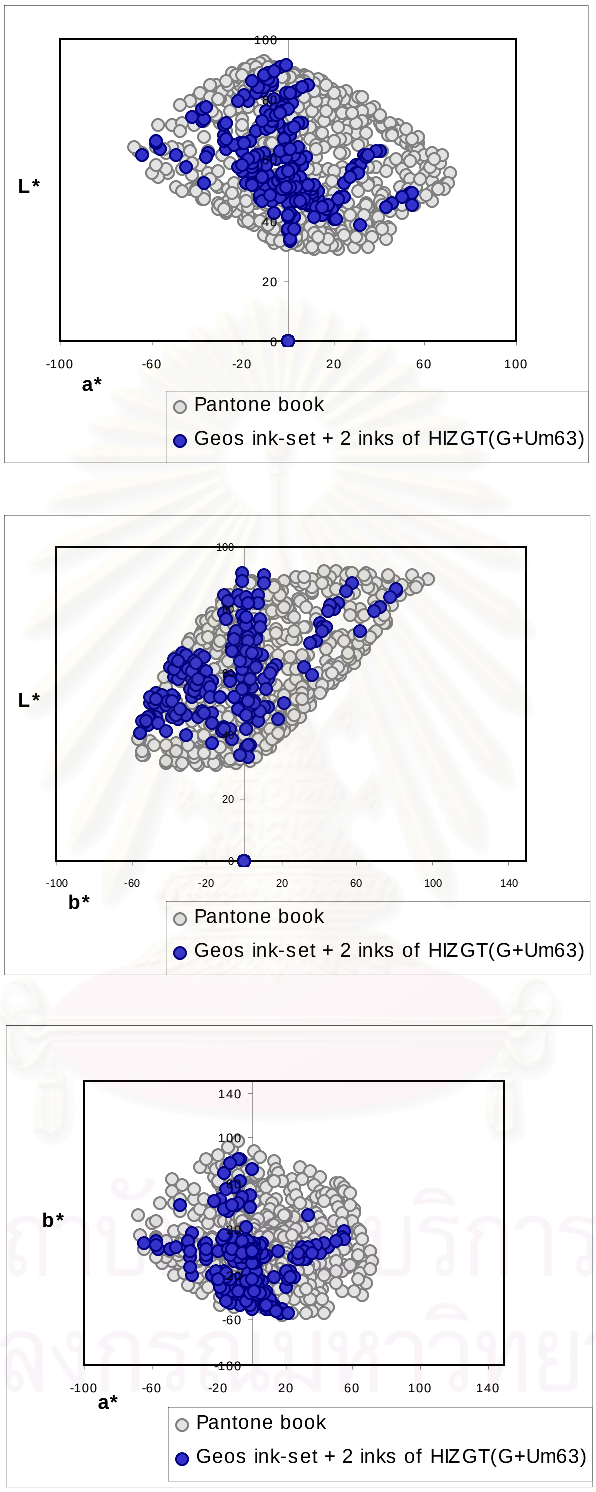


Figure 4.82 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT green, HIZGT Ultramarine 63, D_{65}/2.

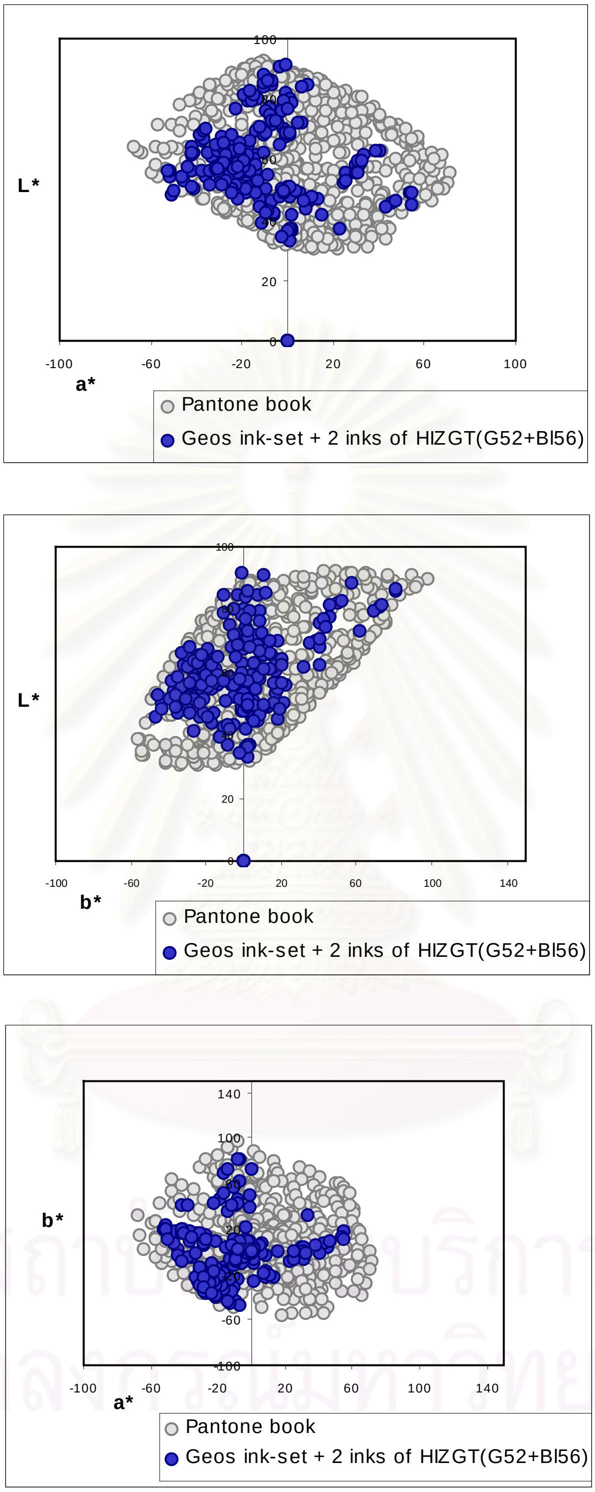


Figure 4.83 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT green 52, HIZGT peacock blue 56, D_{65}/2.

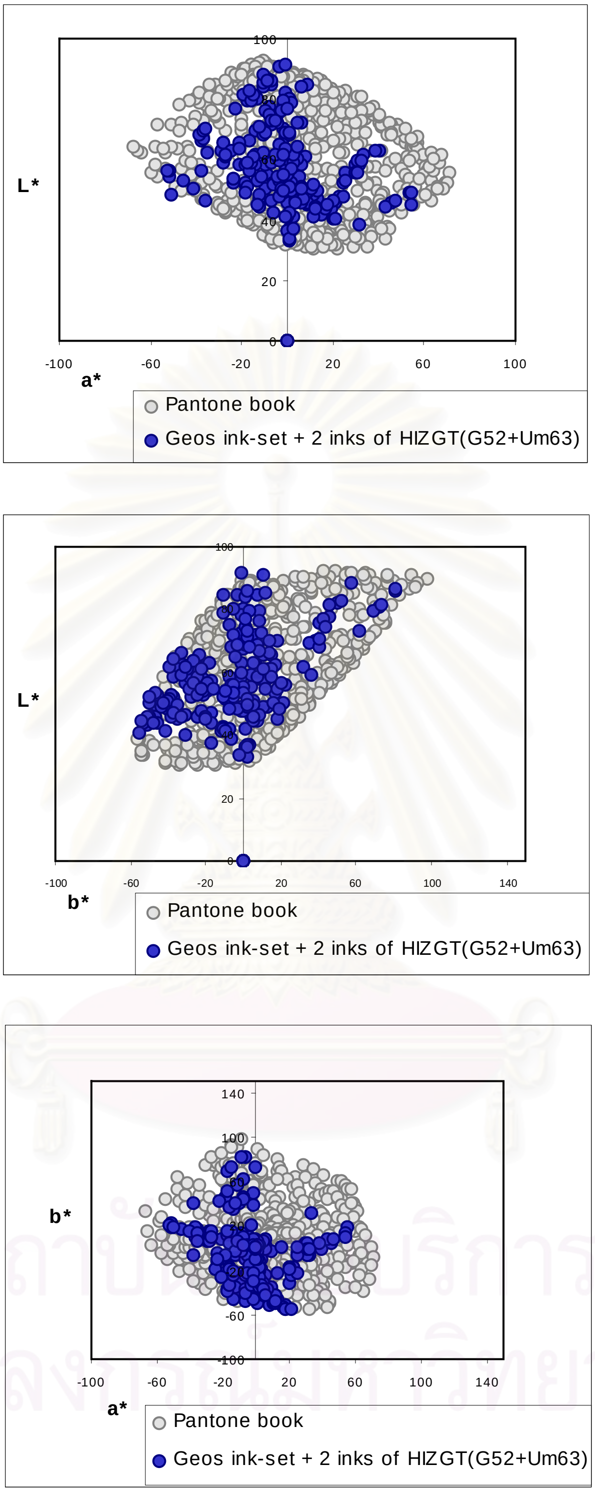


Figure 4.84 The colour gamut of six inks plus clear medium of the Geos ink-set and two inks of HIZGT : Geos cyan, Geos magenta, Geos yellow, Geos black, HIZGT green 52, HIZGT Ultramarine 63, $D_{65}/2$.

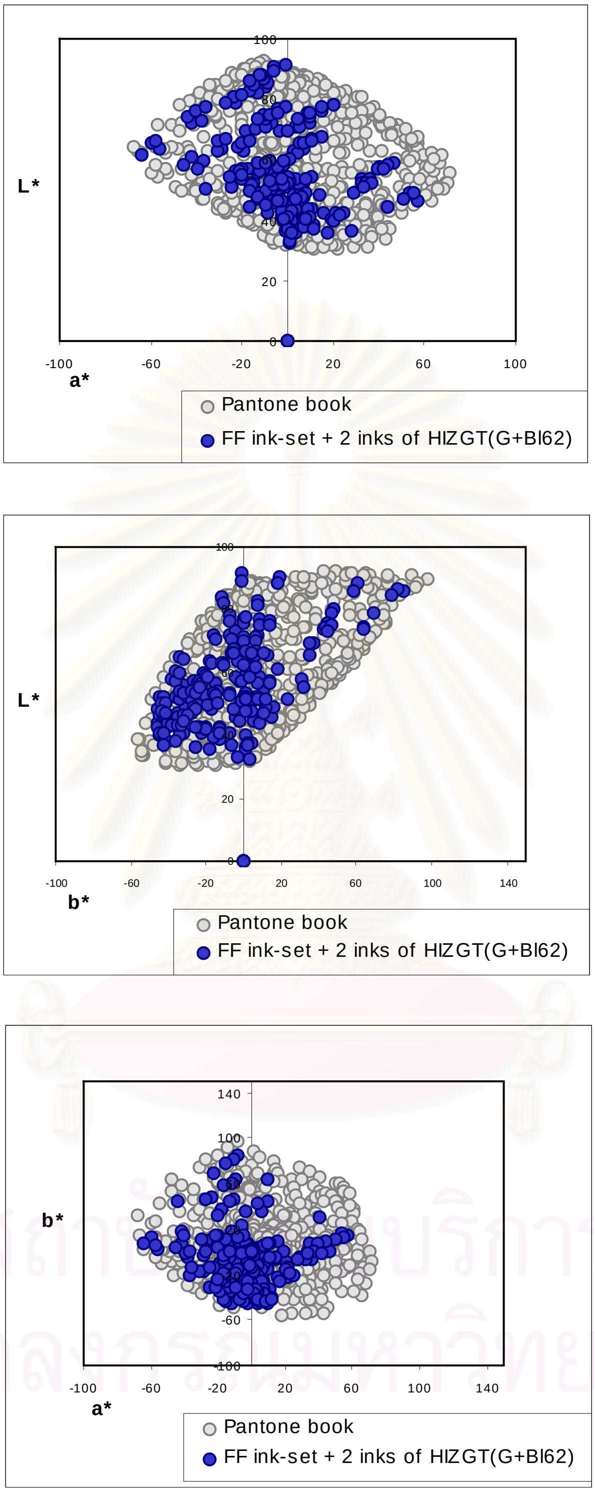


Figure 4.85 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT green, HIZGT bronze blue 62, $D_{65}/2$.

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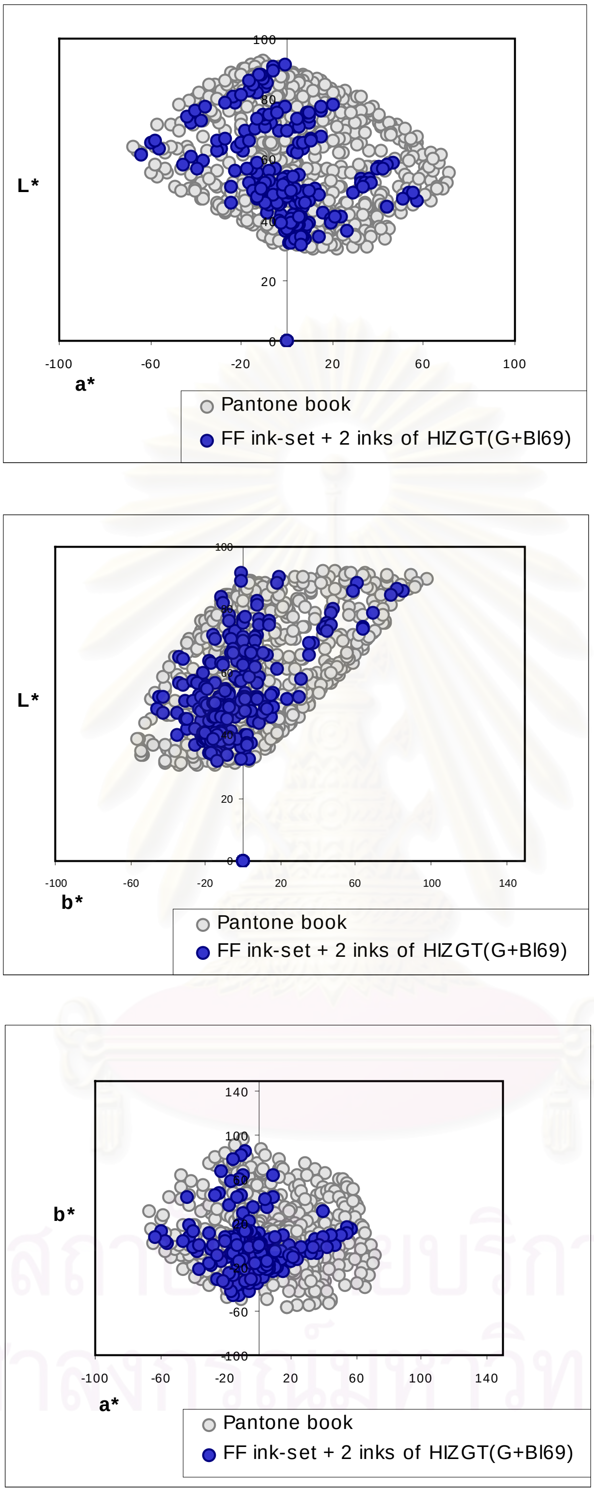

Figure 4.86 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT green, HIZGT dark blue 69, $D_{65}/2$.

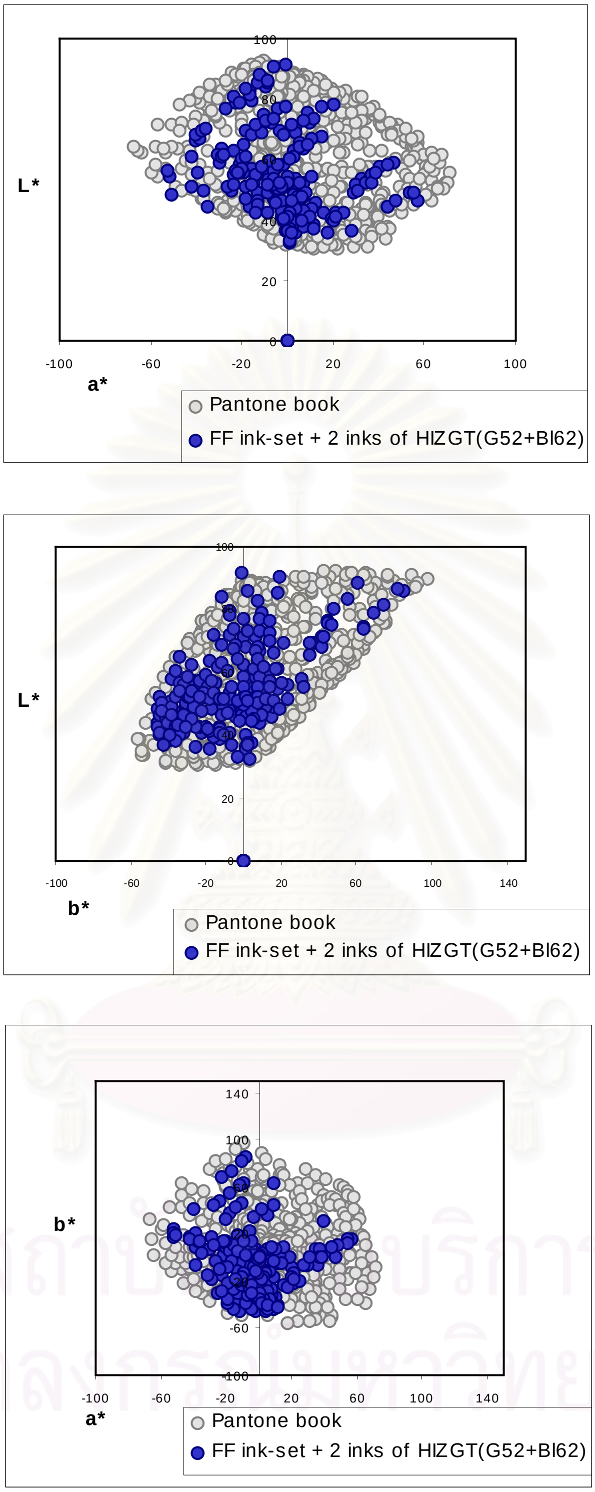

Figure 4.87 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT green 52, HIZGT bronze blue 62, $D_{65}/2$.

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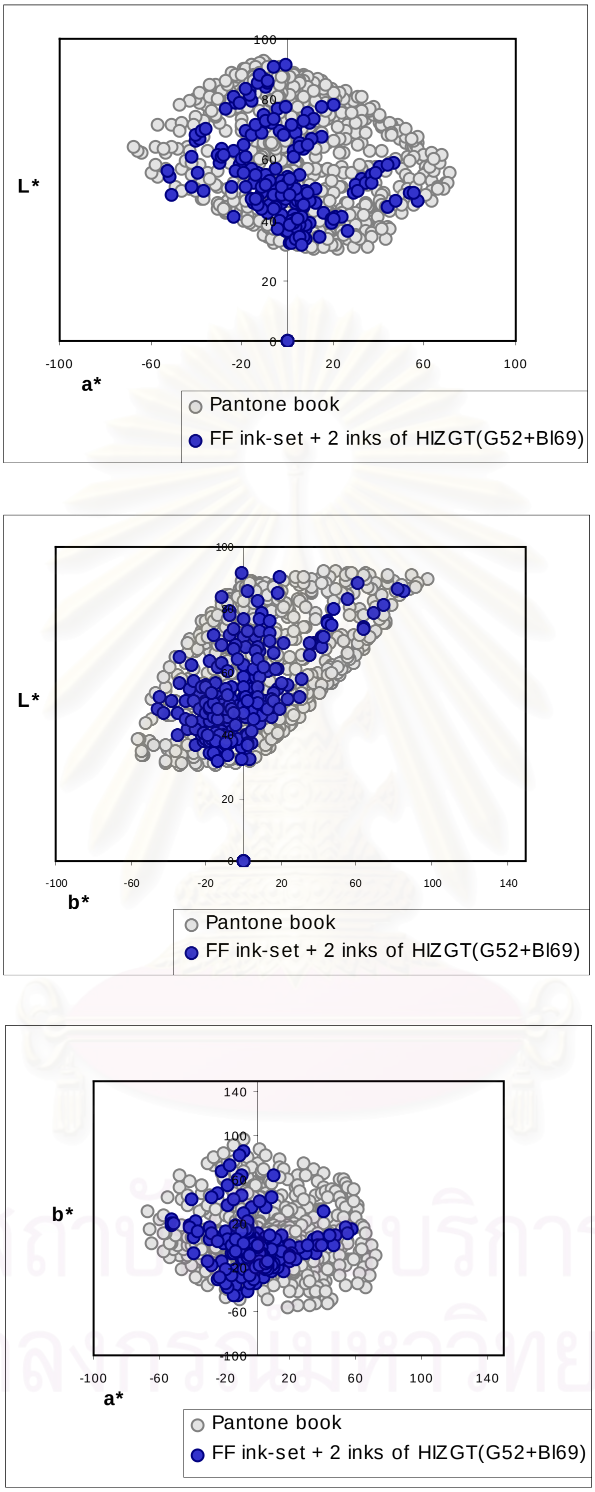

Figure 4.88 The colour gamut of six inks plus clear medium of the Fresh & Fast ink-set and two inks of HIZGT : FF cyan, FF magenta, FF yellow, FF black, HIZGT green 52, HIZGT dark blue 69, $D_{65}/2$.

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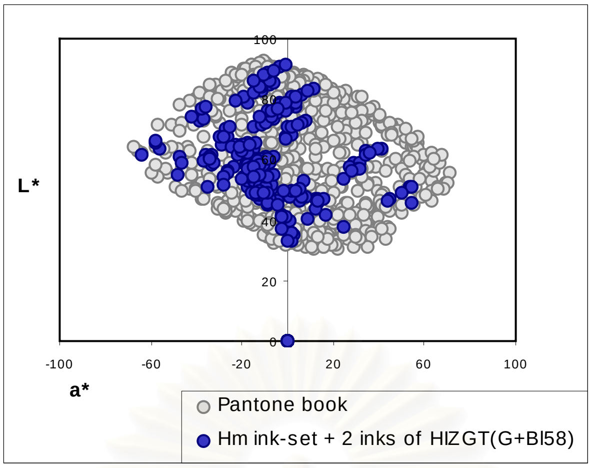
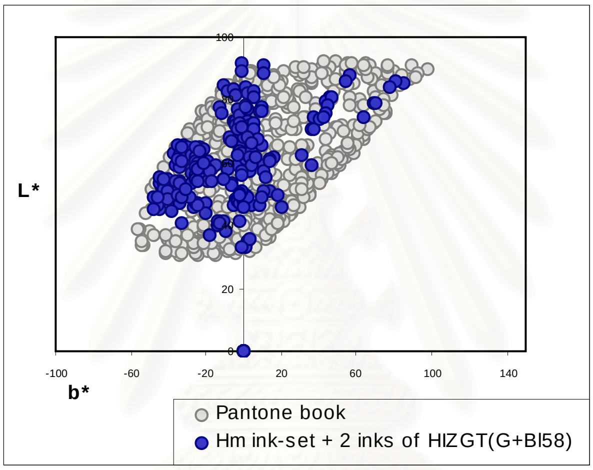




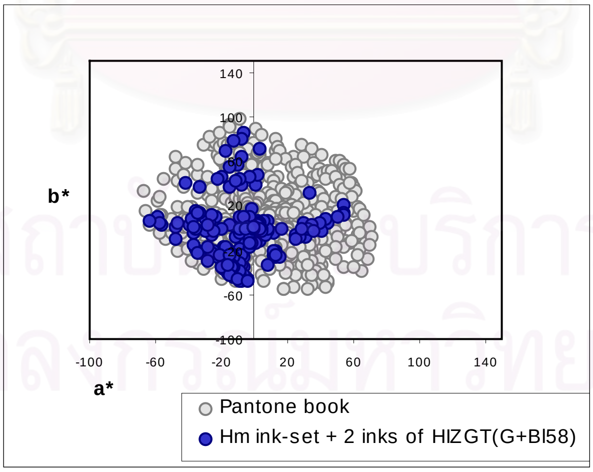
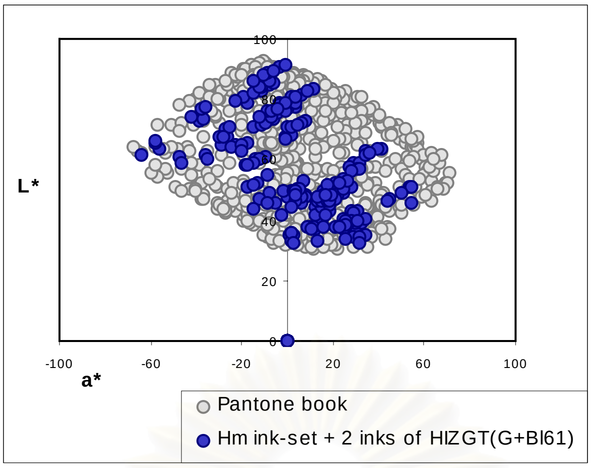
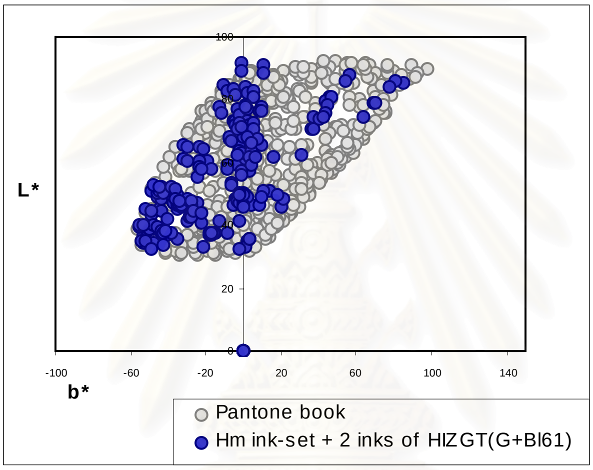


Figure 4.89 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT green, HIZGT process blue 58, D_{65}/2.





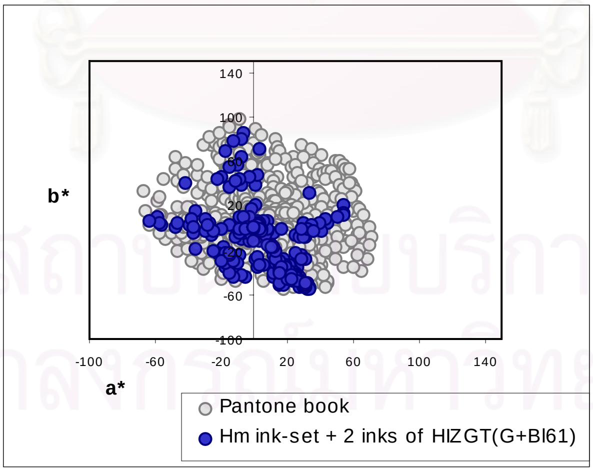
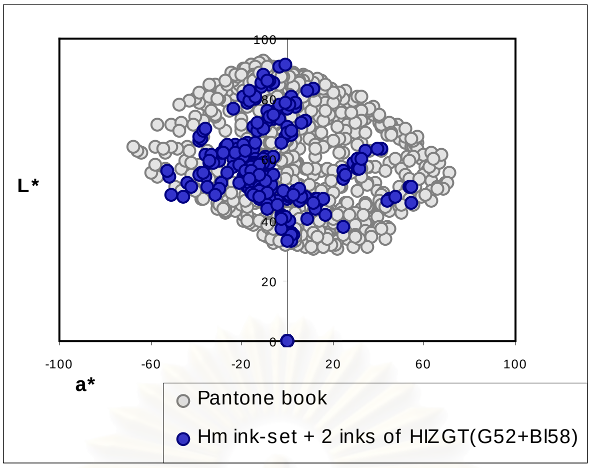
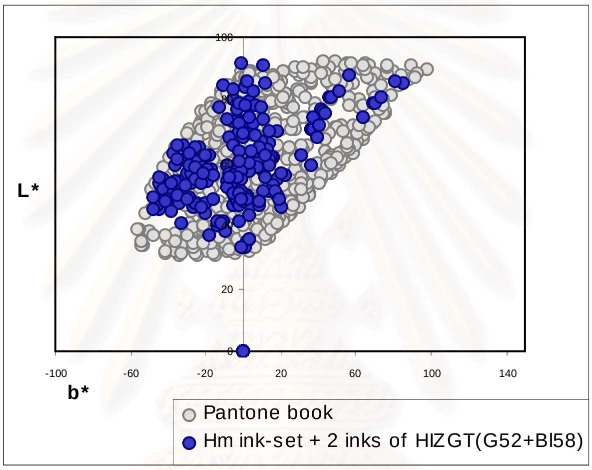


Figure 4.90 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT green, HIZGT bronze blue 61, D_{65}/2.





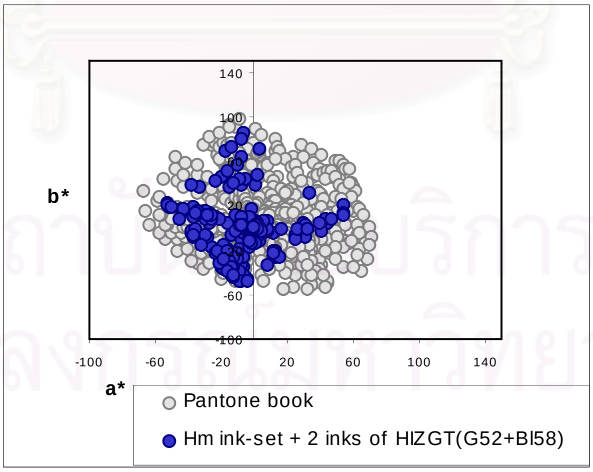
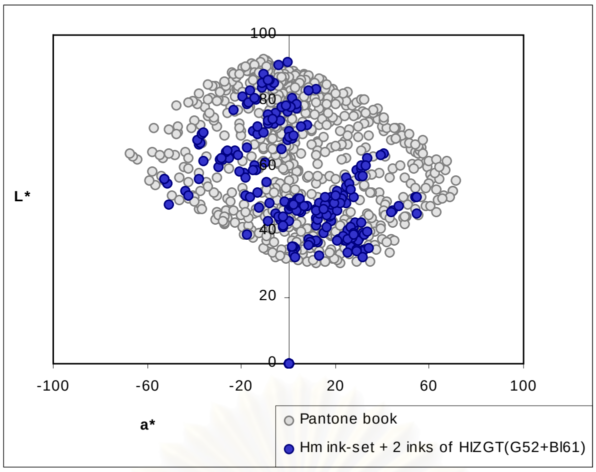
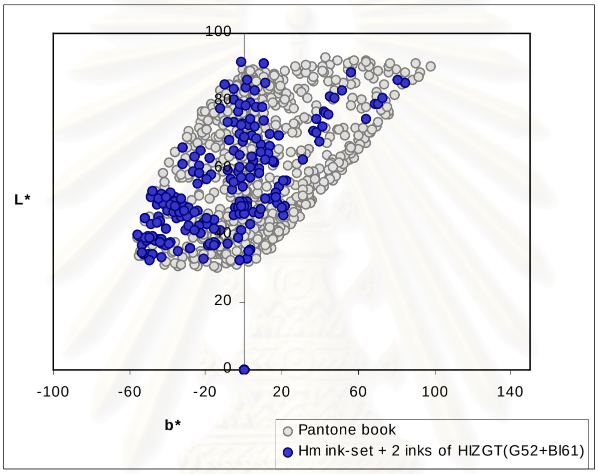


Figure 4.91 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT green 52, HIZGT process blue 58, $D_{65}/2$.





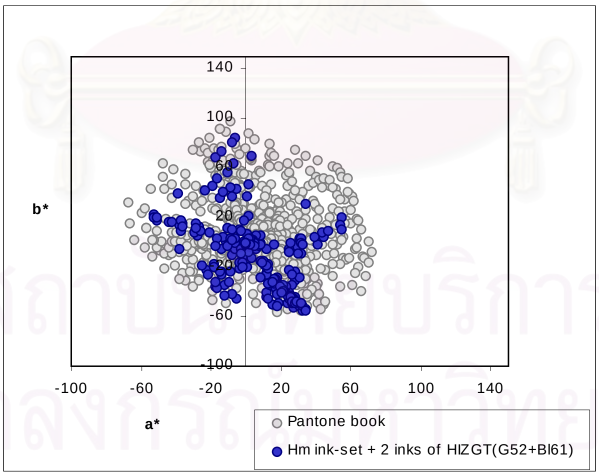


Figure 4.92 The colour gamut of six inks plus clear medium of the Hostmann ink-set and two inks of HIZGT : Hostmann cyan, Hostmann magenta, Hostmann yellow, Hostmann black, HIZGT green 52, HIZGT bronze blue 61, D_{65}/2.

4.2 The Colour Gamut of Digital Images.

Three images, P1rgb (Bride), P3rgb (Wool), and P4rgb (bottles) were used as the standard digital images, they are reproduced in figure 4.93, figure 4.94 and figure 4.95 respectively.

Figure 4.93 P1rgb (Bride) was used as a standard digital image.

Figure 4.94 P3rgb (Wool) was used as a standard digital image.

Figure 4.95 P4rgb (bottles) was used as a standard digital image.

The colour gamuts of the digital images were obtained using the MATLAB software package. An example of MATLAB code used for the Bride picture is shown here.

MATLAB code

```
imm=imread('c:\matlab_poy\Bride.tif');
% Skin is name of image, matlab_poy is folder that containing M-file
and digital image. Bride.tif is name of the digital image.
imshow (imm);
% Imshow is the function that using show the image.
red=imm(:,:,1);
% Red is the red value of each pixel of image.
green=imm(:,:,2);
% Red is the green value of each pixel of image.
blue=imm(:,:,3);
% Red is the blue value of each pixel of image.
R = double(red);
G = double(green);
B = double(blue);
```

```
R_709 = R/255;
G_709 = G/255;
B_709 = B/255;
R709=((sign(R_709-0.0812)+1)/2).*((R_709+.099)/1.099).^(1/.45)+(-
(sign(R_709-0.0812)-1)/2).*(R_709./4.5);
G709=((sign(G_709-0.0812)+1)/2).*((G_709+.099)/1.099).^(1/.45)+(-
(sign(G_709-0.0812)-1)/2).*(G_709./4.5);
B709=((sign(B_709-0.0812)+1)/2).*((B_709+.099)/1.099).^(1/.45)+(-
(sign(B_709-0.0812)-1)/2).*(B_709./4.5);
X1 = (0.4124*R709+0.3576*G709+0.1805*B709);
Y1 = (0.2126*R709+0.7152*G709+0.0722*B709);
Z1 = (0.0193*R709+0.1192*G709+0.9505*B709);
%obtain X',Y',Z'
X = (100*X1+0*Y1+0*Z1);
Y = (0*X1+100*Y1+0*Z1);
Z = (0*X1+0*Y1+100*Z1);
%Obtaining X,Y,Z from the method of conversion from SHIPP-Calibrated
RGB to XYZ.
L65=116*(Y/100).^0.333-16;
a65=500*((X/95.05).^0.333-(Y/100).^0.333);
b65=200*((Y/100).^0.333-(Z/108.88).^0.333);
figure;
plot3(a65,b65,L65,'b.');
axis([-100 140 -100 140 0 100]);
xlabel('a*');
ylabel('b*');
zlabel('L*');
text(0,0,0,'origin');
grid on;
box on;
title('Colour gamut of Shipp Image (P1rgb.tif) under D65/2
observer');
%Plot colour gamut by using CIELAB.
```

The colour gamut of P1rgb (Bride), P3rgb (Wool), and P4rgb (bottles) are shown in **Figures** 4.96 to 4.98.

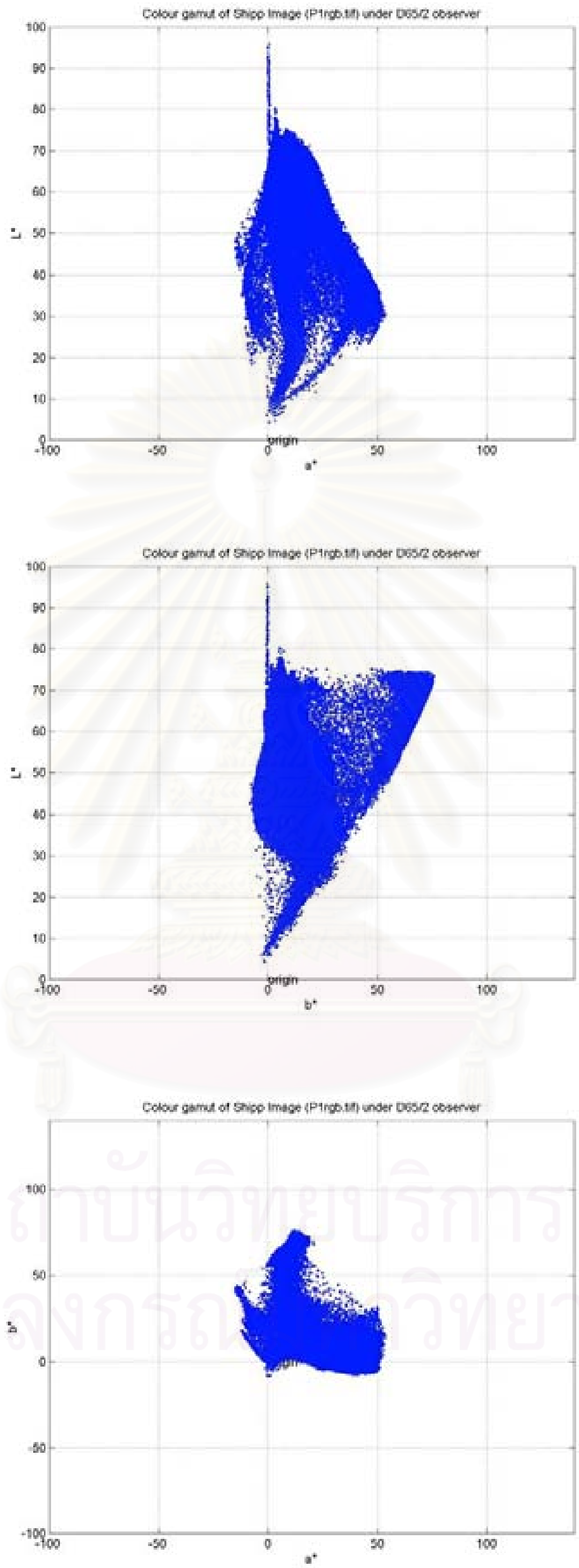


Figure 4.96 The colour gamut of SHIPP image P1rgb (Bride) under D65/2

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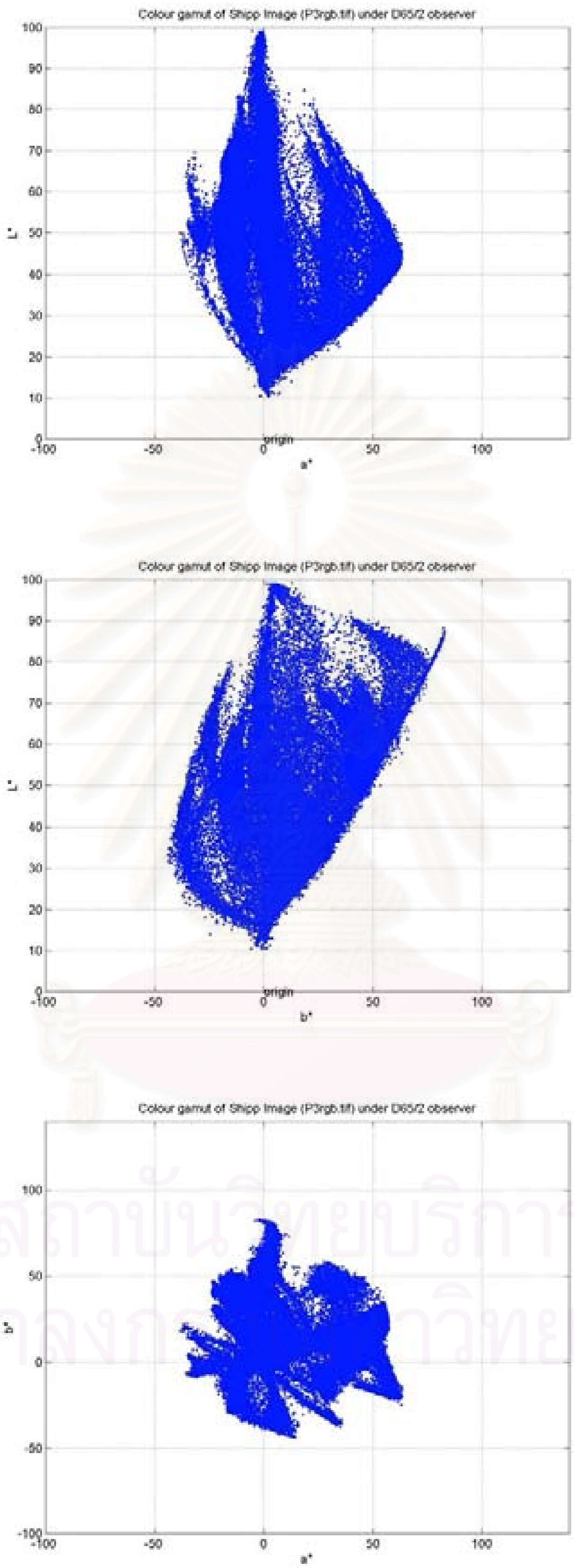

Figure 4.97 The colour gamut of SHIPP image P3rgb (Wool) under D65/2.

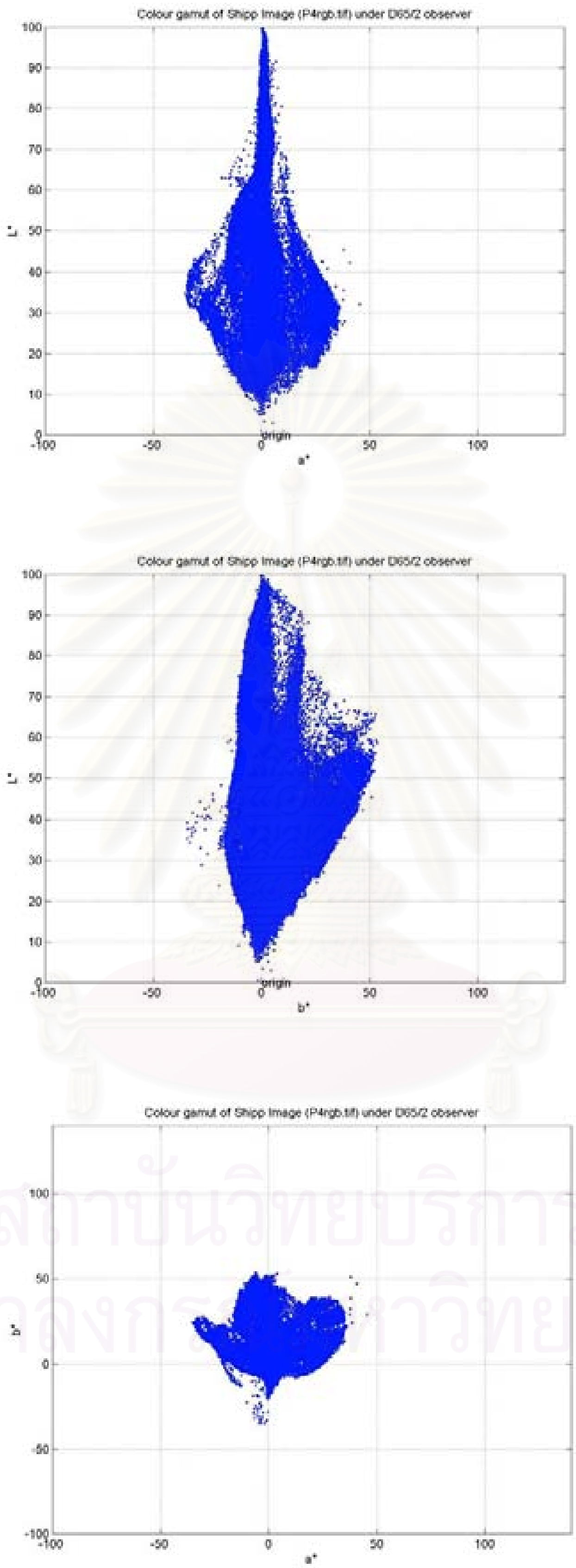

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Figure 4.98 The colour gamut of SHIPP image P4rgb (Bottles) under D65/2.

4.3 Colour Matching.

The representation of the shape of gamut of the digital image compared with the combination inks was determined using the CIE 1976 L*a*b* colour space by the color3D software application. In the Color3D software, the axes can be rotated to any angle but only the bottom view was used to determine the optimum combination inks for digital images. The gamut volumes of the images used Bride, Wool and Bottles are given in **Table 4.9**.

Digital image	Gamut Volume
P1rgb (Bride)	1859
P3rgb (Wool)	8831
P4rgb (Bottles)	1151

Table 4.9 The gamut volumes of the SHIPP images.

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Figures 4.99 to **4.102** show the sample of the selected combinations of ink that is suitable for each one of the digital images considered. **Figure 4.96** shows the comparison of the FF ink-set with the P1rgb (Bride) digital image. The P1rgb image has a large yellow and red area but small green and blue area. The boundary of the four-colour process ink-set can cover the colour of this digital image.

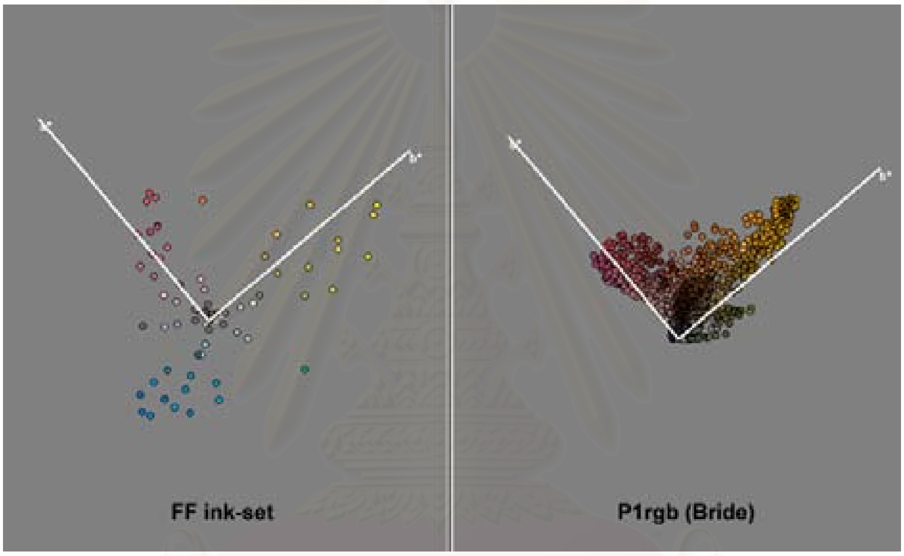

Figure 4.99 The colour gamut of FF ink-set compared to SHIPP image P1rgb (Bride).

Figure 4.100 shows the comparison of the Hostmann ink-set plus five HIZGT special inks consisting of bronze red 30, dark blue 69, reddish yellow 40, green, and violet 68 with P3rgb (Wool) digital image. The P3rgb image has a large gamut which makes it difficult to find the combination of inks that covers it all especially in the pink, violet and dark blue areas. The P3rgb (Wool) image has a larger gamut than any combinations of inks. The Hostmann ink-set plus five HIZGT special inks mentioned above is the best selected combination ink that covers almost all colours of the Wool image.

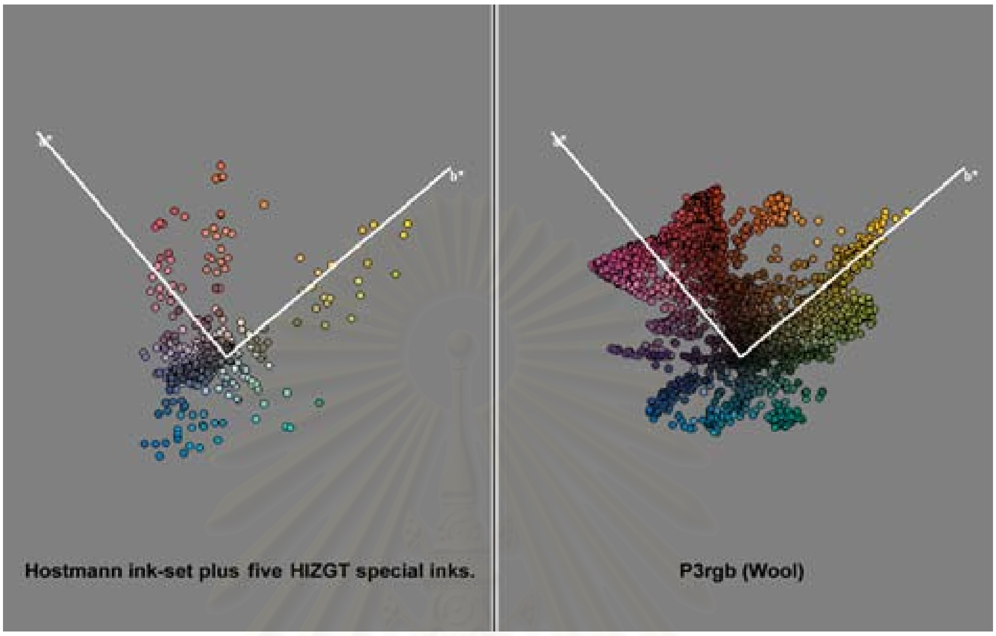

Figure 4.100 The colour gamut of Hostmann ink-set plus five HIZGT special inks consists of bronze red 30, dark blue 69, reddish yellow 40, green, and violet 68 compared to the SHIPP image P3rgb (Wool).

Figure 4.101 shows the comparison of the the FF ink-set plus HIZGT special ink green with the P4rgb (Bottles) digital image. The Bottles image gives large green, yellow and brown areas but small blue and red areas. The FF ink-set plus HIZGT special green ink is the best combination inks that covers all colours of the Bottles image.

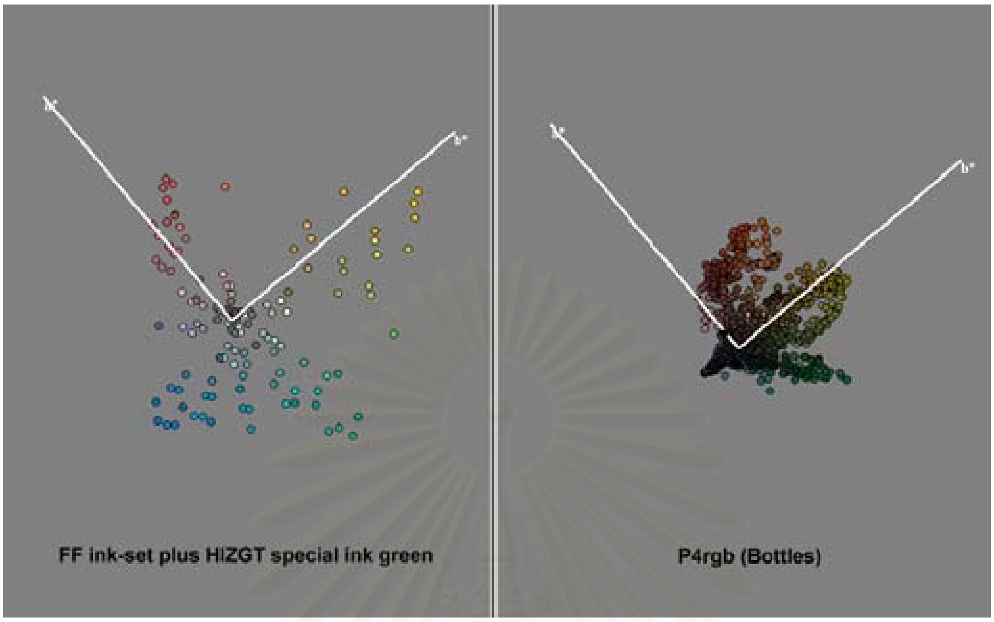

Figure 4.101 The colour gamut of FF ink-set plus HIZGT special ink green compared to SHIPP image P4rgb (Bottles).

CHAPTER 5

CONCLUSIONS AND SUGGESTIONS

Conclusions and suggestions from this research are as follows:

1. The process of calibrating each ink by diluting it into 7 levels using a tint medium had to be accurate because the database produced from the ink calibration prints was then used for creating the gamut mapping tool and may be used for colour matching. Some errors could have occurred e.g., the amount of ink transfered to the substrates may not be the same for every print. However, the ink calibration curves of this research showed a correct reflectance value according to the concentration levels. This was because all steps of the calibration, such as weighting, mixing, printing, cleaning, drying, and measuring, were carried out with great care. The reliability of the database can also be checked by formulating an ink of known concentration, that we would like to check and calculating the colour difference between the formulated colour and the colour of known concentration. If the average colour difference of all coloured inks at different concentrations is approximately 1, then the database is reliable to use (when the colour difference between two samples is less than 1, the human eye cannot perceive the difference of colours).
2. In this thesis, the reflectance values were obtained from spectrophotometer measurements made with integrating sphere geometry. The correction coefficients used for a surface correction of a lithographic layer printed on glossy paper were as

follows: r_e and r_i of print were 0.025 and 0.600 respectively, and r_e and r_i of substrate were 0.040 and 0.600. For further studies, the bi-directional spectrophotometers should be used to investigate the difference of the correction coefficients in the Saunderson model for the lithographic ink layer printed on the glossy substrate. The correction coefficients then can be a guideline for those who use the bi-directional spectrophotometer to obtain the reflectance to be used for the Kubelka-Munk model.

3. The Excel spreadsheet tools including the K and S analysis tool and the gamut mapping tool were created and found to be simple to use with the selection of inks by combo box and the command by the button. Users can investigate the colour gamut of their own combination of inks.
4. This research has developed a simple method for investigating the optimum colour ink based on the use of the gamut mapping tool. Furthermore, a new set of inks can be added without difficulty. However, the user must take a good care of the number of recipes used to map the gamut for each ink-set. For example, if 5 inks are selected, 70 recipes can be made out by varying all inks in the set with the amount of 0 to 100% with 25% increment steps.
5. As expected, the colour gamut of the Pantone book, used as the reference, was found to be the largest. The gamut of Geos four-colour process ink-set and that of the Fresh and Fast four-colour process ink-set and that of Hostmann four-colour process ink-set were similar in shape and area. When the comparisons of the colour gamuts between the ink-sets and the Pantone book were made, it was found that the

yellow and blue area of Pantone's gamut can be covered by any of three ink-sets but it is not so for the red and green areas.

6. While selecting the optimized combination inks for the digital images named "Bride" by shape and area comparison, as well as gamut volume, it was found that any of the three four-colour process ink-sets used in this thesis can match these images. The colour gamut of the digital image named "Wool" was so large that the inks in the database were not sufficient to cover it, especially in the blue-red region. However, the Hostmann ink-set plus five HIZGT special inks consisting of bronze red 30, dark blue 69, reddish yellow 40, green, and violet 68 were the optimized combination inks for this image. The FF ink-set plus HIZGT special green ink were the best combination inks that covers all colours of the "Bottles" image.
7. In this research, the colour gamut of a digital image was obtained using the MATLAB code. The method of obtaining X, Y, Z values and L*, a*, b* values in the MATLAB code written was used especially for the SHIPP standard pictures. If other images are used, the method of obtaining the tristimulus values must be changed according to condition of the image captured. Then the tristimulus values will be encoded to the same standard of the SHIPP pictures. The MATLAB code should be developed further to handle different kinds of image according to the process mentioned above.

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APPENDICES

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APPENDIX A

Colour Matching Functions

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	Illuminant D65			Illuminant D50			Illuminant F11		
Lambda	X	Y	Z	X	Y	Z	X	Y	Z
400	0.131	0.004	0.618	0.076	0.002	0.361	0.055	0.002	0.264
410	0.376	0.010	1.788	0.234	0.006	1.113	0.097	0.003	0.463
420	1.200	0.035	5.765	0.775	0.023	3.723	0.024	-0.004	0.087
430	2.396	0.098	11.698	1.610	0.066	7.862	2.687	0.128	13.218
440	3.418	0.226	17.150	2.453	0.162	12.309	3.952	0.237	19.703
450	3.699	0.417	19.506	2.777	0.313	14.647	1.471	0.177	7.819
460	3.227	0.664	18.520	2.500	0.514	14.346	1.328	0.274	7.620
470	2.149	0.998	14.137	1.717	0.798	11.299	0.723	0.295	4.686
480	1.042	1.501	8.850	0.861	1.239	7.309	0.448	0.803	4.043
490	0.333	2.164	4.856	0.283	1.839	4.128	0.326	1.905	4.458
500	0.045	3.352	2.802	0.040	2.948	2.466	0.020	1.104	1.005
510	0.098	5.129	1.602	0.088	4.632	1.447	0.006	0.499	0.121
520	0.637	7.076	0.791	0.593	6.587	0.736	-0.012	0.244	0.038
530	1.667	8.708	0.420	1.590	8.308	0.401	-0.155	0.163	0.037
540	2.884	9.474	0.202	2.799	9.197	0.196	8.983	26.955	0.483
550	4.250	9.752	0.086	4.207	9.650	0.085	10.520	26.054	0.291
560	5.626	9.419	0.037	5.657	9.471	0.037	0.993	1.348	-0.007
570	6.988	8.722	0.019	7.132	8.902	0.020	1.064	1.283	0.002
580	8.214	7.802	0.014	8.540	8.112	0.015	6.717	6.191	0.011
590	8.730	6.442	0.010	9.255	6.829	0.010	8.697	6.590	0.010
600	9.015	5.351	0.007	9.835	5.838	0.007	6.188	3.669	0.005
610	8.492	4.263	0.003	9.469	4.753	0.004	27.072	13.415	0.009
620	7.050	3.145	0.001	8.009	3.573	0.002	13.847	6.329	0.003
630	5.124	2.113	0.000	5.926	2.443	0.001	4.003	1.614	0.000
640	3.516	1.373	0.000	4.171	1.629	0.000	0.864	0.335	0.000
650	2.167	0.818	0.000	2.609	0.984	0.000	0.541	0.203	0.000
660	1.252	0.463	0.000	1.541	0.570	0.000	0.301	0.111	0.000
670	0.678	0.248	0.000	0.855	0.313	0.000	0.096	0.035	0.000
680	0.341	0.124	0.000	0.434	0.158	0.000	0.046	0.017	0.000
690	0.153	0.055	0.000	0.194	0.070	0.000	0.028	0.010	0.000
700	0.151	0.053	0.000	0.191	0.068	0.000	0.034	0.013	0.000
Sum	95.049	99.999	108.882	96.421	99.997	82.524	100.964	100.002	64.369

Table A-1 Weights for Illuminant D65, Illuminant D50, Illuminant F11 1931 Observer, 10 nm Interval

APPENDIX B

The Amount of Inks

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	1	2	3	4	5
1	100	0	0	0	0
2	25	75	0	0	0
3	25	0	75	0	0
4	25	0	0	75	0
5	25	0	0	0	75
6	75	25	0	0	0
7	75	0	25	0	0
8	75	0	0	25	0
9	75	0	0	0	25
10	25	50	25	0	0
11	25	50	0	25	0
12	25	50	0	0	25
13	25	0	50	25	0
14	25	0	50	0	25
15	25	0	0	50	25
16	50	50	0	0	0
17	50	0	50	0	0
18	50	0	0	50	0
19	50	0	0	0	50
20	25	25	50	0	0
21	25	25	0	50	0
22	25	25	0	0	50
23	25	0	25	50	0
24	25	0	25	0	50
25	25	0	0	25	50
26	50	25	25	0	0
27	50	25	0	25	0
28	50	25	0	0	25
29	50	0	25	25	0
30	50	0	25	0	25
31	50	0	0	25	25
32	25	25	25	25	0
33	25	25	25	0	25
34	25	25	0	25	25
35	25	0	25	25	25

	1	2	3	4	5
36	0	100	0	0	0
37	0	25	75	0	0
38	0	25	0	75	0
39	0	25	0	0	75
40	0	75	25	0	0
41	0	75	0	25	0
42	0	75	0	0	25
43	0	25	50	25	0
44	0	25	50	0	25
45	0	25	0	50	25
46	0	50	50	0	0
47	0	50	0	50	0
48	0	50	0	0	50
49	0	25	25	50	0
50	0	25	25	0	50
51	0	25	0	25	50
52	0	50	25	25	0
53	0	50	25	0	25
54	0	50	0	25	25
55	0	25	25	25	25
56	0	0	100	0	0
57	0	0	25	75	0
58	0	0	25	0	75
59	0	0	75	25	0
60	0	0	75	0	25
61	0	0	25	50	25
62	0	0	50	50	0
63	0	0	50	0	50
64	0	0	25	25	50
65	0	0	50	25	25
66	0	0	0	100	0
67	0	0	0	25	75
68	0	0	0	75	25
69	0	0	0	0	100
70	0	0	0	50	50

Table B-1 The amount of inks used in the gamut mapping tool, 5 components.

	1	2	3	4	5	6
1	100	0	0	0	0	0
2	25	75	0	0	0	0
3	25	0	75	0	0	0
4	25	0	0	75	0	0
5	25	0	0	0	75	0
6	25	0	0	0	0	75
7	75	25	0	0	0	0
8	75	0	25	0	0	0
9	75	0	0	25	0	0
10	75	0	0	0	25	0
11	75	0	0	0	0	25
12	25	50	25	0	0	0
13	25	50	0	25	0	0
14	25	50	0	0	25	0
15	25	50	0	0	0	25
16	25	0	50	25	0	0
17	25	0	50	0	25	0
18	25	0	50	0	0	25
19	25	0	0	50	25	0
20	25	0	0	50	0	25
21	25	0	0	0	50	25
22	50	50	0	0	0	0
23	50	0	50	0	0	0
24	50	0	0	50	0	0
25	50	0	0	0	50	0
26	50	0	0	0	0	50
27	25	25	50	0	0	0
28	25	25	0	50	0	0
29	25	25	0	0	50	0
30	25	25	0	0	0	50
31	25	0	25	50	0	0
32	25	0	25	0	50	0
33	25	0	25	0	0	50
34	25	0	0	25	50	0
35	25	0	0	25	0	50
36	25	0	0	0	25	50
37	50	25	25	0	0	0
38	50	25	0	25	0	0
39	50	25	0	0	25	0
40	50	25	0	0	0	25
41	50	0	25	25	0	0
42	50	0	25	0	25	0
43	50	0	25	0	0	25
44	50	0	0	25	25	0
45	50	0	0	25	0	25
46	50	0	0	0	25	25
47	25	25	25	25	0	0
48	25	25	25	0	25	0
49	25	25	25	0	0	25
50	25	25	0	25	25	0
51	25	25	0	25	0	25
52	25	25	0	0	25	25
53	25	0	25	25	25	0
54	25	0	25	25	0	25
55	25	0	25	0	25	25
56	25	0	0	25	25	25
57	0	100	0	0	0	0
58	0	25	75	0	0	0
59	0	25	0	75	0	0
60	0	25	0	0	75	0
61	0	25	0	0	0	75
62	0	75	25	0	0	0
63	0	75	0	25	0	0
64	0	75	0	0	25	0
65	0	75	0	0	0	25
66	0	25	50	25	0	0
67	0	25	50	0	25	0
68	0	25	50	0	0	25
69	0	25	0	50	25	0
70	0	25	0	50	0	25
71	0	25	0	0	50	25
72	0	50	50	0	0	0
73	0	50	0	50	0	0
74	0	50	0	0	50	0
75	0	50	0	0	0	50
76	0	25	25	50	0	0
77	0	25	25	0	50	0
78	0	25	25	0	0	50
79	0	25	0	25	50	0
80	0	25	0	25	0	50
81	0	25	0	0	25	50
82	0	50	25	25	0	0
83	0	50	25	0	25	0
84	0	50	25	0	0	25
85	0	50	0	25	25	0
86	0	50	0	25	0	25
87	0	50	0	0	25	25
88	0	25	25	25	25	0
89	0	25	25	25	0	25
90	0	25	25	0	25	25
91	0	25	0	25	25	25
92	0	0	100	0	0	0
93	0	0	25	75	0	0
94	0	0	25	0	75	0
95	0	0	25	0	0	75
96	0	0	75	25	0	0
97	0	0	75	0	25	0
98	0	0	75	0	0	25
99	0	0	25	50	25	0
100	0	0	25	50	0	25
101	0	0	25	0	50	25
102	0	0	50	50	0	0
103	0	0	50	0	50	0
104	0	0	50	0	0	50
105	0	0	25	25	50	0
106	0	0	25	25	0	50
107	0	0	25	0	25	50
108	0	0	50	25	25	0
109	0	0	50	25	0	25
110	0	0	50	0	25	25
111	0	0	25	25	25	25
112	0	0	0	100	0	0
113	0	0	0	25	75	0
114	0	0	0	25	0	75
115	0	0	0	75	25	0
116	0	0	0	75	0	25
117	0	0	0	25	50	25
118	0	0	0	50	50	0
119	0	0	0	50	0	50
120	0	0	0	25	25	50
121	0	0	0	50	25	25
122	0	0	0	0	100	0
123	0	0	0	0	25	75
124	0	0	0	0	75	25
125	0	0	0	0	50	50
126	0	0	0	0	0	100

Table B-2 The amount of inks used in the gamut mapping tool, 6 components.

	1	2	3	4	5	6	7
1	100	0	0	0	0	0	0
2	25	75	0	0	0	0	0
3	25	0	75	0	0	0	0
4	25	0	0	75	0	0	0
5	25	0	0	0	75	0	0
6	25	0	0	0	0	75	0
7	25	0	0	0	0	0	75
8	75	25	0	0	0	0	0
9	75	0	25	0	0	0	0
10	75	0	0	25	0	0	0
11	75	0	0	0	25	0	0
12	75	0	0	0	0	25	0
13	75	0	0	0	0	0	25
14	25	50	25	0	0	0	0
15	25	50	0	25	0	0	0
16	25	50	0	0	25	0	0
17	25	50	0	0	0	25	0
18	25	50	0	0	0	0	25
19	25	0	50	25	0	0	0
20	25	0	50	0	25	0	0
21	25	0	50	0	0	25	0
22	25	0	50	0	0	0	25
23	25	0	0	50	25	0	0
24	25	0	0	50	0	25	0
25	25	0	0	50	0	0	25
26	25	0	0	0	50	25	0
27	25	0	0	0	50	0	25
28	25	0	0	0	0	50	25
29	50	50	0	0	0	0	0
30	50	0	50	0	0	0	0
31	50	0	0	50	0	0	0
32	50	0	0	0	50	0	0
33	50	0	0	0	0	50	0
34	50	0	0	0	0	0	50
35	25	25	50	0	0	0	0
36	25	25	0	50	0	0	0
37	25	25	0	0	50	0	0
38	25	25	0	0	0	50	0
39	25	25	0	0	0	0	50
40	25	0	25	50	0	0	0
41	25	0	25	0	50	0	0
42	25	0	25	0	0	50	0
43	25	0	25	0	0	0	50
44	25	0	0	25	50	0	0
45	25	0	0	25	0	50	0
46	25	0	0	25	0	0	50
47	25	0	0	0	25	50	0
48	25	0	0	0	25	0	50
49	25	0	0	0	0	25	50
50	50	25	25	0	0	0	0
51	50	25	0	25	0	0	0
52	50	25	0	0	25	0	0
53	50	25	0	0	0	25	0
54	50	25	0	0	0	0	25
55	50	0	25	25	0	0	0
56	50	0	25	0	25	0	0
57	50	0	25	0	0	25	0
58	50	0	25	0	0	0	25
59	50	0	0	25	25	0	0
60	50	0	0	25	0	25	0
61	50	0	0	25	0	0	25
62	50	0	0	0	25	25	0
63	50	0	0	0	25	0	25
64	50	0	0	0	0	25	25
65	25	25	25	25	0	0	0
66	25	25	25	0	25	0	0
67	25	25	25	0	0	25	0
68	25	25	25	0	0	0	25
69	25	25	0	25	25	0	0
70	25	25	0	25	0	25	0
71	25	25	0	25	0	0	25
72	25	25	0	0	25	25	0
73	25	25	0	0	25	0	25
74	25	25	0	0	0	25	25
75	25	0	25	25	25	0	0
76	25	0	25	25	0	25	0
77	25	0	25	25	0	0	25
78	25	0	25	0	25	25	0
79	25	0	25	0	25	0	25
80	25	0	25	0	0	25	25
81	25	0	0	25	25	25	0
82	25	0	0	25	25	0	25
83	25	0	0	25	0	25	25
84	25	0	0	0	25	25	25
85	0	100	0	0	0	0	0
86	0	25	75	0	0	0	0
87	0	25	0	75	0	0	0
88	0	25	0	0	75	0	0
89	0	25	0	0	0	75	0
90	0	25	0	0	0	0	75
91	0	75	25	0	0	0	0
92	0	75	0	25	0	0	0
93	0	75	0	0	25	0	0
94	0	75	0	0	0	25	0
95	0	75	0	0	0	0	25
96	0	25	50	25	0	0	0
97	0	25	50	0	25	0	0
98	0	25	50	0	0	25	0
99	0	25	50	0	0	0	25
100	0	25	0	50	25	0	0
101	0	25	0	50	0	25	0
102	0	25	0	50	0	0	25
103	0	25	0	0	50	25	0
104	0	25	0	0	50	0	25
105	0	25	0	0	0	50	25
106	0	50	50	0	0	0	0
107	0	50	0	50	0	0	0
108	0	50	0	0	50	0	0
109	0	50	0	0	0	50	0
110	0	50	0	0	0	0	50
111	0	25	25	50	0	0	0
112	0	25	25	0	50	0	0
113	0	25	25	0	0	50	0
114	0	25	25	0	0	0	50
115	0	25	0	25	50	0	0
116	0	25	0	25	0	50	0
117	0	25	0	25	0	0	50
118	0	25	0	0	25	50	0
119	0	25	0	0	25	0	50
120	0	25	0	0	0	25	50
121	0	50	25	25	0	0	0
122	0	50	25	0	25	0	0
123	0	50	25	0	0	25	0
124	0	50	25	0	0	0	25
125	0	50	0	25	25	0	0
126	0	50	0	25	0	25	0
127	0	50	0	25	0	0	25
128	0	50	0	0	25	25	0
129	0	50	0	0	25	0	25
130	0	50	0	0	0	25	25
131	0	25	25	25	25	0	0
132	0	25	25	25	0	25	0
133	0	25	25	25	0	0	25
134	0	25	25	0	25	25	0
135	0	25	25	0	25	0	25
136	0	25	25	0	0	25	25
137	0	25	0	25	25	25	0
138	0	25	0	25	25	0	25
139	0	25	0	25	0	25	25
140	0	25	0	0	25	25	25
141	0	0	100	0	0	0	0
142	0	0	25	75	0	0	0
143	0	0	25	0	75	0	0
144	0	0	25	0	0	75	0
145	0	0	25	0	0	0	75
146	0	0	75	25	0	0	0
147	0	0	75	0	25	0	0
148	0	0	75	0	0	25	0
149	0	0	75	0	0	0	25
150	0	0	25	50	25	0	0
151	0	0	25	50	0	25	0
152	0	0	25	50	0	0	25
153	0	0	25	0	50	25	0
154	0	0	25	0	50	0	25
155	0	0	25	0	0	50	25
156	0	0	50	50	0	0	0
157	0	0	50	0	50	0	0
158	0	0	50	0	0	50	0
159	0	0	50	0	0	0	50
160	0	0	25	25	50	0	0
161	0	0	25	25	0	50	0
162	0	0	25	25	0	0	50
163	0	0	25	0	25	50	0
164	0	0	25	0	25	0	50
165	0	0	25	0	0	25	50
166	0	0	50	25	25	0	0
167	0	0	50	25	0	25	0
168	0	0	50	25	0	0	25
169	0	0	50	0	25	25	0
170	0	0	50	0	25	0	25
171	0	0	50	0	0	25	25
172	0	0	25	25	25	25	0
173	0	0	25	25	25	0	25
174	0	0	25	25	0	25	25
175	0	0	25	0	25	25	25
176	0	0	0	100	0	0	0
177	0	0	0	25	75	0	0
178	0	0	0	25	0	75	0
179	0	0	0	25	0	0	75
180	0	0	0	75	25	0	0
181	0	0	0	75	0	25	0
182	0	0	0	75	0	0	25
183	0	0	0	25	50	25	0
184	0	0	0	25	50	0	25
185	0	0	0	25	0	50	25
186	0	0	0	50	50	0	0
187	0	0	0	50	0	50	0
188	0	0	0	50	0	0	50
189	0	0	0	25	25	50	0
190	0	0	0	25	25	0	50
191	0	0	0	25	0	25	50
192	0	0	0	50	25	25	0
193	0	0	0	50	25	0	25
194	0	0	0	50	0	25	25
195	0	0	0	25	25	25	25
196	0	0	0	0	100	0	0
197	0	0	0	0	25	75	0
198	0	0	0	0	25	0	75
199	0	0	0	0	75	25	0
200	0	0	0	0	75	0	25
201	0	0	0	0	25	50	25
202	0	0	0	0	50	50	0
203	0	0	0	0	50	0	50
204	0	0	0	0	25	25	50
205	0	0	0	0	50	25	25
206	0	0	0	0	0	100	0
207	0	0	0	0	0	25	75
208	0	0	0	0	0	75	25
209	0	0	0	0	0	50	50
210	0	0	0	0	0	0	100

Table B-3 The amount of inks used in the gamut mapping tool, 7 components.

	1	2	3	4	5	6	7	8	9
1	0	0	0	0	50	0	50	0	0
2	0	0	0	0	0	0	50	0	50
3	50	0	0	0	50	0	0	0	0
4	100	0	0	0	0	0	0	0	0
5	50	0	0	50	0	0	0	0	0
6	0	100	0	0	0	0	0	0	0
7	50	0	0	0	0	0	0	50	0
8	0	0	0	0	0	0	100	0	0
9	0	50	0	50	0	0	0	0	0
10	0	0	0	0	50	50	0	0	0
11	0	0	0	50	50	0	0	0	0
12	0	0	0	0	0	100	0	0	0
13	0	0	50	0	0	0	50	0	0
14	0	0	0	0	100	0	0	0	0
15	0	0	50	0	0	0	0	50	0
16	0	0	0	50	0	50	0	0	0
17	0	50	0	0	0	0	50	0	0
18	0	50	0	0	0	0	0	50	0
19	50	0	0	0	0	0	50	0	0
20	0	0	100	0	0	0	0	0	0
21	0	50	0	0	50	0	0	0	0
22	0	0	0	0	0	0	0	0	100
23	0	0	0	0	0	50	0	50	0
24	0	0	0	0	0	50	0	0	50
25	0	0	0	100	0	0	0	0	0
26	0	0	0	0	0	0	0	100	0
27	0	0	0	50	0	0	50	0	0
28	0	0	0	0	50	0	0	50	0
29	0	0	0	0	50	0	0	0	50
30	50	0	0	0	0	0	0	0	50
31	50	0	50	0	0	0	0	0	0
32	0	0	0	0	0	50	50	0	0
33	0	0	50	0	0	0	0	0	50
34	0	50	0	0	0	0	0	0	50
35	0	0	0	50	0	0	0	50	0
36	0	0	50	0	0	50	0	0	0
37	0	0	0	50	0	0	0	0	50
38	0	0	50	50	0	0	0	0	0
39	0	0	0	0	0	0	0	50	50
40	0	0	50	0	50	0	0	0	0
41	50	0	0	0	0	50	0	0	0
42	0	0	0	0	0	0	50	50	0
43	0	50	50	0	0	0	0	0	0
44	0	50	0	0	0	50	0	0	0
45	50	50	0	0	0	0	0	0	0
46	25	75	0	0	0	0	0	0	0
47	25	0	0	0	0	0	75	0	0
48	25	0	0	0	0	75	0	0	0
49	25	0	0	0	75	0	0	0	0
50	25	0	75	0	0	0	0	0	0
51	25	0	0	0	0	0	0	0	75
52	25	0	0	75	0	0	0	0	0
53	25	0	0	0	0	0	0	75	0
54	75	25	0	0	0	0	0	0	0
55	0	25	0	0	0	0	75	0	0
56	0	25	0	0	0	75	0	0	0
57	0	25	0	0	75	0	0	0	0
58	0	25	75	0	0	0	0	0	0
59	0	25	0	0	0	0	0	0	75
60	0	25	0	75	0	0	0	0	0
61	0	25	0	0	0	0	0	75	0
62	75	0	25	0	0	0	0	0	0

	1	2	3	4	5	6	7	8	9
63	0	75	25	0	0	0	0	0	0
64	0	0	25	0	0	0	75	0	0
65	0	0	25	0	0	75	0	0	0
66	0	0	25	0	75	0	0	0	0
67	0	0	25	0	0	0	0	0	75
68	0	0	25	75	0	0	0	0	0
69	0	0	25	0	0	0	0	75	0
70	75	0	0	25	0	0	0	0	0
71	0	75	0	25	0	0	0	0	0
72	0	0	0	25	0	0	75	0	0
73	0	0	0	25	0	75	0	0	0
74	0	0	0	25	75	0	0	0	0
75	0	0	75	25	0	0	0	0	0
76	0	0	0	25	0	0	0	0	75
77	0	0	0	25	0	0	0	75	0
78	75	0	0	0	25	0	0	0	0
79	0	75	0	0	25	0	0	0	0
80	0	0	0	0	25	0	75	0	0
81	0	0	0	0	25	75	0	0	0
82	0	0	75	0	25	0	0	0	0
83	0	0	0	0	25	0	0	0	75
84	0	0	0	75	25	0	0	0	0
85	0	0	0	0	25	0	0	75	0
86	75	0	0	0	0	25	0	0	0
87	0	75	0	0	0	25	0	0	0
88	0	0	0	0	0	25	75	0	0
89	0	0	0	0	75	25	0	0	0
90	0	0	75	0	0	25	0	0	0
91	0	0	0	75	0	25	0	0	0
92	0	0	0	0	0	25	0	75	0
93	75	0	0	0	0	0	25	0	0
94	0	75	0	0	0	0	25	0	0
95	0	0	0	0	0	75	25	0	0
96	0	0	0	0	75	0	25	0	0
97	0	0	75	0	0	0	25	0	0
98	0	0	0	0	0	0	25	0	75
99	0	0	0	75	0	0	25	0	0
100	0	0	0	0	0	0	25	75	0
101	75	0	0	0	0	0	0	25	0
102	0	75	0	0	0	0	0	25	0
103	0	0	0	0	0	0	75	25	0
104	0	0	0	0	0	75	0	25	0
105	0	0	0	0	75	0	0	25	0
106	0	0	75	0	0	0	0	25	0
107	0	0	0	0	0	0	0	25	75
108	0	0	0	75	0	0	0	25	0
109	75	0	0	0	0	0	0	0	25
110	0	75	0	0	0	0	0	0	25
111	0	0	0	0	0	0	75	0	25
112	0	0	0	0	0	75	0	0	25
113	0	0	0	0	75	0	0	0	25
114	0	0	75	0	0	0	0	0	25
115	0	0	0	75	0	0	0	0	25
116	0	0	0	0	0	0	0	75	25
117	25	25	0	0	25	0	0	0	25
118	25	25	0	0	50	0	0	0	0
119	25	25	0	0	0	50	0	0	0
120	25	25	0	0	0	0	50	0	0
121	25	25	0	0	0	0	0	0	50
122	25	25	0	50	0	0	0	0	0
123	25	25	50	0	0	0	0	0	0
124	25	25	0	0	0	0	0	50	0

Table B-4 The amount of inks used in the gamut mapping tool, 9 components.

	1	2	3	4	5	6	7	8	9
125	25	50	0	0	0	0	0	25	0
126	25	50	25	0	0	0	0	0	0
127	25	50	0	0	25	0	0	0	0
128	25	50	0	0	0	0	0	0	25
129	25	50	0	0	0	0	25	0	0
130	25	50	0	0	0	25	0	0	0
131	25	50	0	25	0	0	0	0	0
132	50	25	0	0	25	0	0	0	0
133	50	25	0	0	0	25	0	0	0
134	50	25	25	0	0	0	0	0	0
135	50	25	0	0	0	0	0	25	0
136	50	25	0	0	0	0	25	0	0
137	50	25	0	25	0	0	0	0	0
138	50	25	0	0	0	0	0	0	25
139	50	0	25	25	0	0	0	0	0
140	50	0	25	0	25	0	0	0	0
141	50	0	25	0	0	25	0	0	0
142	50	0	25	0	0	0	25	0	0
143	50	0	25	0	0	0	0	25	0
144	50	0	25	0	0	0	0	0	25
145	50	0	0	25	25	0	0	0	0
146	50	0	0	25	0	25	0	0	0
147	50	0	0	25	0	0	25	0	0
148	50	0	0	25	0	0	0	25	0
149	50	0	0	0	25	25	0	0	0
150	50	0	0	0	25	0	25	0	0
151	50	0	0	0	25	0	0	25	0
152	50	0	0	0	25	0	0	0	25
153	50	0	0	0	0	25	25	0	0
154	50	0	0	0	0	25	0	25	0
155	50	0	0	0	0	25	0	0	25
156	50	0	0	0	0	0	25	25	0
157	50	0	0	0	0	0	25	0	25
158	50	0	0	0	0	0	0	25	25
159	0	50	25	0	0	25	0	0	0
160	0	50	25	25	0	0	0	0	0
161	0	50	25	0	0	0	25	0	0
162	0	50	25	0	0	0	0	25	0
163	0	50	25	0	25	0	0	0	0
164	0	50	25	0	0	0	0	0	25
165	0	50	0	25	25	0	0	0	0
166	0	50	0	25	0	25	0	0	0
167	0	50	0	25	0	0	25	0	0
168	0	50	0	25	0	0	0	25	0
169	0	50	0	25	0	0	0	0	25
170	0	50	0	0	25	25	0	0	0
171	0	50	0	0	25	0	25	0	0
172	0	50	0	0	25	0	0	25	0
173	0	50	0	0	25	0	0	0	25
174	0	50	0	0	0	25	25	0	0
175	0	50	0	0	0	25	0	25	0
176	0	50	0	0	0	25	0	0	25
177	0	50	0	0	0	0	25	25	0
178	0	50	0	0	0	0	25	0	25
179	0	50	0	0	0	0	0	25	25
180	0	0	50	25	25	0	0	0	0
181	0	0	50	25	0	25	0	0	0
182	0	0	50	25	0	0	25	0	0
183	0	0	50	25	0	0	0	25	0
184	0	0	50	25	0	0	0	0	25
185	0	0	50	0	25	25	0	0	0
186	0	0	50	0	25	0	25	0	0

	1	2	3	4	5	6	7	8	9
187	0	0	50	0	25	0	0	25	0
188	0	0	50	0	25	0	0	0	25
189	0	0	50	0	0	25	25	0	0
190	0	0	50	0	0	25	0	25	0
191	0	0	50	0	0	25	0	0	25
192	0	0	50	0	0	0	25	25	0
193	0	0	50	0	0	0	25	0	25
194	0	0	50	0	0	0	0	25	25
195	0	0	0	50	25	25	0	0	0
196	0	0	0	50	25	0	25	0	0
197	0	0	0	50	25	0	0	25	0
198	0	0	0	50	25	0	0	0	25
199	0	0	0	50	0	25	25	0	0
200	0	0	0	50	0	25	0	25	0
201	0	0	0	50	0	25	0	0	25
202	0	0	0	50	0	0	25	25	0
203	0	0	0	50	0	0	25	0	25
204	0	0	0	50	0	0	0	25	25
205	0	0	0	0	50	25	25	0	0
206	0	0	0	0	50	25	0	25	0
207	0	0	0	0	50	25	0	0	25
208	0	0	0	0	50	0	25	25	0
209	0	0	0	0	50	0	25	0	25
210	0	0	0	0	50	0	0	25	25
211	0	0	0	0	0	50	25	25	0
212	0	0	0	0	0	50	25	0	25
213	0	0	0	0	0	50	0	25	25
214	0	0	0	0	0	0	50	25	25
215	0	0	0	0	0	0	25	50	25
216	0	0	0	0	0	25	0	50	25
217	0	0	0	0	25	0	0	50	25
218	0	0	0	25	0	0	0	50	25
219	0	0	25	0	0	0	0	50	25
220	0	25	0	0	0	0	0	50	25
221	25	0	0	0	0	0	0	50	25
222	0	0	0	0	0	0	25	25	50
223	0	0	0	0	0	25	0	25	50
224	0	0	0	0	25	0	0	25	50
225	0	0	0	25	0	0	0	25	50
226	0	0	25	0	0	0	0	25	50
227	0	25	0	0	0	0	0	25	50
228	25	0	0	0	0	0	0	25	50
229	0	0	0	0	0	25	25	0	50
230	0	0	0	0	25	0	25	0	50
231	0	0	0	25	0	0	25	0	50
232	0	0	25	0	0	0	25	0	50
233	0	25	0	0	0	0	25	0	50
234	25	0	0	0	0	0	25	0	50
235	0	0	0	0	25	25	0	0	50
236	0	0	0	25	0	25	0	0	50
237	0	0	25	0	0	25	0	0	50
238	0	25	0	0	0	25	0	0	50
239	25	0	0	0	0	25	0	0	50
240	0	0	0	25	25	0	0	0	50
241	0	0	25	0	25	0	0	0	50
242	0	25	0	0	25	0	0	0	50
243	25	0	0	0	25	0	0	0	50
244	0	0	25	25	0	0	0	0	50
245	0	25	0	25	0	0	0	0	50
246	25	0	0	25	0	0	0	0	50
247	0	25	25	0	0	0	0	0	50
248	25	0	25	0	0	0	0	0	50

Table B-4 The amount of inks used in the gamut mapping tool, 9 components, Continued…

	1	2	3	4	5	6	7	8	9
249	25	25	0	0	0	0	0	0	50
250	0	0	0	0	0	25	25	50	0
251	0	0	0	0	25	0	25	50	0
252	0	0	0	25	0	0	25	50	0
253	0	0	25	0	0	0	25	50	0
254	0	25	0	0	0	0	25	50	0
255	25	0	0	0	0	0	25	50	0
256	0	0	0	0	25	25	0	50	0
257	0	0	0	25	0	25	0	50	0
258	0	0	25	0	0	25	0	50	0
259	0	25	0	0	0	25	0	50	0
260	25	0	0	0	0	25	0	50	0
261	0	0	0	25	25	0	0	50	0
262	0	0	25	0	25	0	0	50	0
263	0	25	0	0	25	0	0	50	0
264	25	0	0	0	25	0	0	50	0
265	0	0	25	25	0	0	0	50	0
266	0	25	0	25	0	0	0	50	0
267	25	0	0	25	0	0	0	50	0
268	0	25	25	0	0	0	0	50	0
269	25	0	25	0	0	0	0	50	0
270	25	25	0	0	0	0	0	50	0
271	0	0	0	0	25	25	50	0	0
272	0	0	0	25	0	25	50	0	0
273	0	0	25	0	0	25	50	0	0
274	0	25	0	0	0	25	50	0	0
275	25	0	0	0	0	25	50	0	0
276	0	0	0	25	25	0	50	0	0
277	0	0	25	0	25	0	50	0	0
278	0	25	0	0	25	0	50	0	0
279	25	0	0	0	25	0	50	0	0
280	0	0	25	25	0	0	50	0	0
281	0	25	0	25	0	0	50	0	0
282	25	0	0	25	0	0	50	0	0
283	0	25	25	0	0	0	50	0	0
284	25	0	25	0	0	0	50	0	0
285	25	25	0	0	0	0	50	0	0
286	0	0	0	25	25	50	0	0	0
287	0	0	25	0	25	50	0	0	0
288	0	25	0	0	25	50	0	0	0
289	25	0	0	0	25	50	0	0	0
290	0	0	25	25	0	50	0	0	0
291	0	25	0	25	0	50	0	0	0
292	25	0	0	25	0	50	0	0	0
293	0	25	25	0	0	50	0	0	0
294	25	0	25	0	0	50	0	0	0
295	25	25	0	0	0	50	0	0	0
296	0	0	25	25	50	0	0	0	0
297	0	25	0	25	50	0	0	0	0
298	25	0	0	25	50	0	0	0	0
299	0	25	25	0	50	0	0	0	0
300	25	0	25	0	50	0	0	0	0
301	25	25	0	0	50	0	0	0	0
302	0	25	25	50	0	0	0	0	0
303	25	0	25	50	0	0	0	0	0
304	25	25	0	50	0	0	0	0	0
305	25	25	50	0	0	0	0	0	0
306	25	50	25	0	0	0	0	0	0
307	25	50	0	25	0	0	0	0	0
308	25	50	0	0	25	0	0	0	0
309	25	50	0	0	0	25	0	0	0
310	25	50	0	0	0	0	25	0	0

	1	2	3	4	5	6	7	8	9
311	25	50	0	0	0	0	0	25	0
312	25	50	0	0	0	0	0	0	25
313	0	25	50	25	0	0	0	0	0
314	0	25	50	0	25	0	0	0	0
315	0	25	50	0	0	25	0	0	0
316	0	25	50	0	0	0	25	0	0
317	0	25	50	0	0	0	0	25	0
318	0	25	50	0	0	0	0	0	25
319	25	0	50	25	0	0	0	0	0
320	25	0	50	0	25	0	0	0	0
321	25	0	50	0	0	25	0	0	0
322	25	0	50	0	0	0	25	0	0
323	25	0	50	0	0	0	0	25	0
324	25	0	50	0	0	0	0	0	25
325	0	0	25	50	25	0	0	0	0
326	0	0	25	50	0	25	0	0	0
327	0	0	25	50	0	0	25	0	0
328	0	0	25	50	0	0	0	25	0
329	0	0	25	50	0	0	0	0	25
330	0	25	0	50	25	0	0	0	0
331	0	25	0	50	0	25	0	0	0
332	0	25	0	50	0	0	25	0	0
333	0	25	0	50	0	0	0	25	0
334	0	25	0	50	0	0	0	0	25
335	25	0	0	50	25	0	0	0	0
336	25	0	0	50	0	25	0	0	0
337	25	0	0	50	0	0	25	0	0
338	25	0	0	50	0	0	0	25	0
339	25	0	0	50	0	0	0	0	25
340	0	0	0	25	50	25	0	0	0
341	0	0	0	25	50	0	25	0	0
342	0	0	0	25	50	0	0	25	0
343	0	0	0	25	50	0	0	0	25
344	0	0	25	0	50	25	0	0	0
345	0	0	25	0	50	0	25	0	0
346	0	0	25	0	50	0	0	25	0
347	0	0	25	0	50	0	0	0	25
348	0	25	0	0	50	25	0	0	0
349	0	25	0	0	50	0	25	0	0
350	0	25	0	0	50	0	0	25	0
351	0	25	0	0	50	0	0	0	25
352	25	0	0	0	50	25	0	0	0
353	25	0	0	0	50	0	25	0	0
354	25	0	0	0	50	0	0	25	0
355	25	0	0	0	50	0	0	0	25
356	0	0	0	0	25	50	25	0	0
357	0	0	0	0	25	50	0	25	0
358	0	0	0	0	25	50	0	0	25
359	0	0	0	25	0	50	25	0	0
360	0	0	0	25	0	50	0	25	0
361	0	0	0	25	0	50	0	0	25
362	0	0	25	0	0	50	25	0	0
363	0	0	25	0	0	50	0	25	0
364	0	0	25	0	0	50	0	0	25
365	0	25	0	0	0	50	25	0	0
366	0	25	0	0	0	50	0	25	0
367	0	25	0	0	0	50	0	0	25
368	25	0	0	0	0	0	50	25	0
369	25	0	0	0	0	0	50	0	25
370	25	25	25	25	0	0	0	0	0
371	25	0	25	25	25	0	0	0	0
372	25	0	0	25	25	25	0	0	0

Table B-4 The amount of inks used in the gamut mapping tool, 9 components, Continued…

	1	2	3	4	5	6	7	8	9
373	25	0	0	0	25	25	25	0	0
374	25	0	0	0	0	25	25	25	0
375	25	0	0	0	0	0	25	25	25
376	25	0	25	0	25	25	0	0	0
377	25	0	25	0	25	0	25	0	0
378	25	0	25	0	25	0	0	25	0
379	25	0	25	0	25	0	0	0	25
380	25	0	25	0	0	25	25	0	0
381	25	0	25	0	0	25	0	25	0
382	25	0	25	0	0	25	0	0	25
383	25	0	25	0	0	0	25	25	0
384	25	0	25	0	0	0	25	0	25
385	25	0	25	0	0	0	0	25	25
386	25	0	0	25	0	25	25	0	0
387	25	0	0	25	0	25	0	25	0
388	25	0	0	25	0	25	0	0	25
389	25	0	0	25	0	0	25	25	0
390	25	0	0	25	0	0	25	0	25
391	25	0	0	25	0	0	0	25	25
392	25	0	0	0	25	0	25	25	0
393	25	0	0	0	25	0	25	0	25
394	25	0	0	0	25	0	0	25	25
395	25	0	0	0	0	25	0	25	25
396	25	25	0	25	25	0	0	0	0
397	25	25	0	25	0	25	0	0	0
398	25	25	0	25	0	0	25	0	0
399	25	25	0	25	0	0	0	25	0
400	25	25	0	25	0	0	0	0	25
401	25	25	0	0	25	25	0	0	0
402	25	25	0	0	25	0	25	0	0
403	25	25	0	0	25	0	0	25	0
404	25	25	0	0	25	0	0	0	25
405	25	25	0	0	0	25	25	0	0
406	25	25	0	0	0	25	0	25	0
407	25	25	0	0	0	25	0	0	25
408	25	25	0	0	0	0	25	25	0
409	25	25	0	0	0	0	25	0	25
410	25	25	0	0	0	0	0	25	25
411	25	0	25	25	0	25	0	0	0
412	25	0	25	25	0	0	25	0	0
413	25	0	25	25	0	0	0	25	0
414	25	0	25	25	0	0	0	0	25
415	25	0	0	25	25	0	25	0	0
416	25	0	0	25	25	0	0	25	0
417	25	0	0	25	25	0	0	0	25
418	25	0	0	0	25	25	0	25	0
419	25	0	0	0	25	25	0	0	25
420	25	0	0	0	0	25	25	0	25
421	25	25	25	0	25	0	0	0	0
422	25	25	25	0	0	25	0	0	0
423	25	25	25	0	0	0	25	0	0
424	25	25	25	0	0	0	0	25	0
425	25	25	25	0	0	0	0	0	25
426	0	25	25	25	25	0	0	0	0
427	0	25	0	25	25	25	0	0	0
428	0	25	0	0	25	25	25	0	0
429	0	25	0	0	0	25	25	25	0
430	0	25	0	0	0	0	25	25	25
431	0	25	0	25	0	25	25	0	0
432	0	25	0	25	0	25	0	25	0
433	0	25	0	25	0	25	0	0	25
434	0	25	0	25	0	0	25	25	0

	1	2	3	4	5	6	7	8	9
435	0	25	0	25	0	0	25	0	25
436	0	25	0	25	0	0	0	25	25
437	0	25	0	0	25	0	25	25	0
438	0	25	0	0	25	0	25	0	25
439	0	25	0	0	25	0	0	25	25
440	0	25	0	0	0	25	0	25	25
441	0	25	25	0	25	25	0	0	0
442	0	25	25	0	25	0	25	0	0
443	0	25	25	0	25	0	0	25	0
444	0	25	25	0	25	0	0	0	25
445	0	25	25	0	0	25	25	0	0
446	0	25	25	0	0	25	0	25	0
447	0	25	25	0	0	25	0	0	25
448	0	25	25	0	0	0	25	25	0
449	0	25	25	0	0	0	25	0	25
450	0	25	25	0	0	0	0	25	25
451	0	25	25	25	0	25	0	0	0
452	0	25	25	25	0	0	25	0	0
453	0	25	25	25	0	0	0	25	0
454	0	25	25	25	0	0	0	0	25
455	0	0	25	25	25	25	0	0	0
456	0	0	25	0	25	25	25	0	0
457	0	0	25	0	0	25	25	25	0
458	0	0	25	0	0	0	25	25	25
459	0	0	25	0	25	0	25	25	0
460	0	0	25	0	25	0	25	0	25
461	0	0	25	0	25	0	0	25	25
462	0	0	25	0	0	25	0	25	25
463	0	0	25	25	0	25	25	0	0
464	0	0	25	25	0	25	0	25	0
465	0	0	25	25	0	25	0	0	25
466	0	0	25	25	0	0	25	25	0
467	0	0	25	25	0	0	25	0	25
468	0	0	25	25	0	0	0	25	25
469	0	0	25	25	25	0	25	0	0
470	0	0	25	25	25	0	0	25	0
471	0	0	25	25	25	0	0	0	25
472	0	0	0	25	25	25	25	0	0
473	0	0	0	25	0	25	25	25	0
474	0	0	0	25	0	0	25	25	25
475	0	0	0	25	0	25	0	25	25
476	0	0	0	25	25	0	25	25	0
477	0	0	0	25	25	0	25	0	25
478	0	0	0	25	25	0	0	25	25
479	0	0	0	25	25	25	0	25	0
480	0	0	0	25	25	25	0	0	25
481	0	0	0	0	25	25	25	25	0
482	0	0	0	0	25	0	25	25	25
483	0	0	0	0	25	25	0	25	25
484	0	0	0	0	25	25	25	0	25
485	0	0	0	0	0	25	25	25	25
486	25	0	25	0	25	0	25	0	0
487	25	0	25	0	25	0	0	25	0
488	25	0	25	0	25	0	0	0	25
489	25	0	25	0	25	0	0	25	0
490	25	0	25	0	25	0	0	0	25
491	25	0	25	0	0	25	0	25	0
492	25	0	25	0	0	25	0	0	25
493	25	0	25	0	0	0	25	0	25
494	25	0	25	0	0	0	0	25	25
495	25	0	0	25	0	0	25	0	25

Table B-4 The amount of inks used in the gamut mapping tool, 9 components, Continued…

	1	2	3	4	5	6	7	8	9	10
1	0	0	0	50	0	0	50	0	0	0
2	0	0	0	0	50	0	0	0	50	0
3	50	0	0	50	0	0	0	0	0	0
4	100	0	0	0	0	0	0	0	0	0
5	50	0	50	0	0	0	0	0	0	0
6	0	100	0	0	0	0	0	0	0	0
7	0	0	0	0	0	50	50	0	0	0
8	50	0	0	0	0	0	50	0	0	0
9	0	0	0	0	0	0	50	0	0	50
10	0	0	0	0	0	0	100	0	0	0
11	50	0	0	0	0	0	0	0	0	50
12	0	0	0	50	0	50	0	0	0	0
13	0	0	50	0	0	0	50	0	0	0
14	0	0	0	0	0	100	0	0	0	0
15	0	0	0	0	0	0	50	50	0	0
16	0	0	0	0	0	0	50	0	50	0
17	0	0	50	50	0	0	0	0	0	0
18	0	0	0	0	100	0	0	0	0	0
19	0	0	50	0	50	0	0	0	0	0
20	0	0	50	0	0	0	0	50	0	0
21	0	0	0	0	0	0	0	50	50	0
22	0	0	0	0	0	50	0	0	0	50
23	0	50	0	0	50	0	0	0	0	0
24	0	50	0	0	0	50	0	0	0	0
25	50	0	0	0	0	50	0	0	0	0
26	0	0	100	0	0	0	0	0	0	0
27	0	50	50	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	100	0
29	0	0	0	0	50	50	0	0	0	0
30	0	0	0	0	50	0	50	0	0	0
31	0	0	0	100	0	0	0	0	0	0
32	0	0	0	0	0	0	0	100	0	0
33	0	0	0	0	0	0	0	0	50	50
34	0	0	0	0	0	50	0	50	0	0
35	0	0	50	0	0	0	0	0	50	0
36	0	0	0	0	0	0	0	50	0	50
37	0	0	0	50	0	0	0	50	0	0
38	0	0	0	0	0	50	0	0	50	0
39	0	0	0	50	0	0	0	0	50	0
40	50	0	0	0	0	0	0	50	0	0
41	50	50	0	0	0	0	0	0	0	0
42	0	0	0	50	0	0	0	0	0	50
43	0	0	50	0	0	50	0	0	0	0
44	0	50	0	0	0	0	50	0	0	0
45	0	0	50	0	0	0	0	0	0	50
46	0	50	0	0	0	0	0	0	0	50
47	0	0	0	50	50	0	0	0	0	0
48	0	50	0	0	0	0	0	50	0	0
49	0	0	0	0	50	0	0	0	0	50
50	0	50	0	0	0	0	0	0	50	0
51	50	0	0	0	50	0	0	0	0	0
52	0	0	0	0	50	0	0	50	0	0
53	50	0	0	0	0	0	0	0	50	0
54	0	50	0	50	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	100
56	25	75	0	0	0	0	0	0	0	0
57	25	0	0	0	0	0	75	0	0	0
58	25	0	0	0	0	75	0	0	0	0
59	25	0	0	0	75	0	0	0	0	0
60	25	0	75	0	0	0	0	0	0	0
61	25	0	0	0	0	0	0	0	75	0
62	25	0	0	75	0	0	0	0	0	0
63	25	0	0	0	0	0	0	75	0	0
64	25	0	0	0	0	0	0	0	0	75
65	0	25	0	0	0	0	75	0	0	0
66	0	25	0	0	0	75	0	0	0	0
67	0	25	0	0	75	0	0	0	0	0
68	0	25	75	0	0	0	0	0	0	0
69	0	25	0	0	0	0	0	0	75	0
70	0	25	0	75	0	0	0	0	0	0
71	0	25	0	0	0	0	0	75	0	0
72	0	25	0	0	0	0	0	0	0	75
73	75	0	25	0	0	0	0	0	0	0
74	0	75	25	0	0	0	0	0	0	0
75	0	0	25	0	0	0	75	0	0	0
76	0	0	25	0	0	75	0	0	0	0
77	0	0	25	0	75	0	0	0	0	0
78	0	0	25	0	0	0	0	0	75	0
79	0	0	25	75	0	0	0	0	0	0
80	0	0	25	0	0	0	0	75	0	0
81	0	0	25	0	0	0	0	0	0	75
82	0	0	0	25	0	75	0	0	0	0
83	0	0	0	25	75	0	0	0	0	0
84	75	0	0	25	0	0	0	0	0	0
85	0	0	0	25	0	0	75	0	0	0
86	0	0	0	25	0	0	0	0	75	0
87	0	75	0	25	0	0	0	0	0	0
88	0	0	75	25	0	0	0	0	0	0
89	0	0	0	25	0	0	0	0	0	75
90	0	0	0	25	0	0	0	75	0	0
91	75	0	0	0	25	0	0	0	0	0
92	0	75	0	0	25	0	0	0	0	0
93	0	0	0	0	25	0	75	0	0	0
94	0	0	0	0	25	75	0	0	0	0
95	0	0	75	0	25	0	0	0	0	0
96	0	0	0	0	25	0	0	0	75	0
97	0	0	0	75	25	0	0	0	0	0
98	0	0	0	0	25	0	0	75	0	0
99	0	0	0	0	25	0	0	0	0	75
100	75	0	0	0	0	25	0	0	0	0
101	0	75	0	0	0	25	0	0	0	0
102	0	0	0	0	0	25	75	0	0	0
103	0	0	0	0	75	25	0	0	0	0
104	0	0	75	0	0	25	0	0	0	0
105	0	0	0	0	0	25	0	0	75	0
106	0	0	0	75	0	25	0	0	0	0
107	0	0	0	0	0	25	0	75	0	0
108	0	0	0	0	0	25	0	0	0	75
109	75	0	0	0	0	0	25	0	0	0
110	0	75	0	0	0	0	25	0	0	0
111	0	0	0	0	0	75	25	0	0	0
112	0	0	0	0	75	0	25	0	0	0
113	0	0	75	0	0	0	25	0	0	0
114	0	0	0	0	0	0	25	0	75	0
115	0	0	0	75	0	0	25	0	0	0
116	0	0	0	0	0	0	25	75	0	0
117	0	0	0	0	0	0	25	0	0	75
118	75	0	0	0	0	0	0	25	0	0
119	0	75	0	0	0	0	0	25	0	0
120	0	0	0	0	0	0	75	25	0	0
121	0	0	0	0	0	75	0	25	0	0
122	0	0	0	0	75	0	0	25	0	0
123	0	0	75	0	0	0	0	25	0	0
124	0	0	0	0	0	0	0	25	75	0
125	0	0	0	75	0	0	0	25	0	0
126	0	0	0	0	0	0	0	25	0	75
127	75	0	0	0	0	0	0	0	25	0
128	0	75	0	0	0	0	0	0	25	0
129	0	0	0	0	0	0	75	0	25	0
130	0	0	0	0	0	75	0	0	25	0
131	0	0	0	0	75	0	0	0	25	0
132	0	0	75	0	0	0	0	0	25	0
133	0	0	0	75	0	0	0	0	25	0
134	0	0	0	0	0	0	0	75	25	0
135	0	0	0	0	0	0	0	0	25	75
136	75	0	0	0	0	0	0	0	0	25
137	0	75	0	0	0	0	0	0	0	25
138	0	0	0	0	0	0	75	0	0	25
139	0	0	0	0	0	75	0	0	0	25
140	0	0	0	0	75	0	0	0	0	25
141	0	0	75	0	0	0	0	0	0	25
142	0	0	0	0	0	0	0	0	75	25
143	0	0	0	75	0	0	0	0	0	25

Table B-5 The amount of inks used in the gamut mapping tool, 10 components.

	1	2	3	4	5	6	7	8	9	10
144	0	0	0	0	0	0	0	75	0	25
145	75	25	0	0	0	0	0	0	0	0
146	50	25	25	0	0	0	0	0	0	0
147	50	25	0	25	0	0	0	0	0	0
148	50	25	0	0	25	0	0	0	0	0
149	50	25	0	0	0	25	0	0	0	0
150	50	25	0	0	0	0	25	0	0	0
151	50	25	0	0	0	0	0	25	0	0
152	50	25	0	0	0	0	0	0	25	0
153	50	25	0	0	0	0	0	0	0	25
154	50	0	25	25	0	0	0	0	0	0
155	50	0	25	0	25	0	0	0	0	0
156	50	0	25	0	0	25	0	0	0	0
157	50	0	25	0	0	0	25	0	0	0
158	50	0	25	0	0	0	0	25	0	0
159	50	0	25	0	0	0	0	0	25	0
160	50	0	25	0	0	0	0	0	0	25
161	50	0	0	25	25	0	0	0	0	0
162	50	0	0	25	0	25	0	0	0	0
163	50	0	0	25	0	0	25	0	0	0
164	50	0	0	25	0	0	0	25	0	0
165	50	0	0	25	0	0	0	0	25	0
166	50	0	0	25	0	0	0	0	0	25
167	50	0	0	0	25	25	0	0	0	0
168	50	0	0	0	25	0	25	0	0	0
169	50	0	0	0	25	0	0	25	0	0
170	50	0	0	0	25	0	0	0	25	0
171	50	0	0	0	25	0	0	0	0	25
172	50	0	0	0	0	25	25	0	0	0
173	50	0	0	0	0	25	0	25	0	0
174	50	0	0	0	0	25	0	0	25	0
175	50	0	0	0	0	25	0	0	0	25
176	50	0	0	0	0	0	25	25	0	0
177	50	0	0	0	0	0	25	0	25	0
178	50	0	0	0	0	0	25	0	0	25
179	50	0	0	0	0	0	0	25	25	0
180	50	0	0	0	0	0	0	25	0	25
181	50	0	0	0	0	0	0	0	25	25
182	25	50	25	0	0	0	0	0	0	0
183	25	50	0	25	0	0	0	0	0	0
184	25	50	0	0	25	0	0	0	0	0
185	25	50	0	0	0	25	0	0	0	0
186	25	50	0	0	0	0	25	0	0	0
187	25	50	0	0	0	0	0	25	0	0
188	25	50	0	0	0	0	0	0	25	0
189	25	50	0	0	0	0	0	0	0	25
190	25	0	50	25	0	0	0	0	0	0
191	25	0	50	0	25	0	0	0	0	0
192	25	0	50	0	0	25	0	0	0	0
193	25	0	50	0	0	0	25	0	0	0
194	25	0	50	0	0	0	0	25	0	0
195	25	0	50	0	0	0	0	0	25	0
196	25	0	50	0	0	0	0	0	0	25
197	25	0	0	50	25	0	0	0	0	0
198	25	0	0	50	0	25	0	0	0	0
199	25	0	0	50	0	0	25	0	0	0
200	25	0	0	50	0	0	0	25	0	0
201	25	0	0	50	0	0	0	0	25	0
202	25	0	0	50	0	0	0	0	0	25
203	25	0	0	0	50	25	0	0	0	0
204	25	0	0	0	50	0	25	0	0	0
205	25	0	0	0	50	0	0	25	0	0
206	25	0	0	0	50	0	0	0	25	0
207	25	0	0	0	50	0	0	0	0	25
208	25	0	0	0	0	50	25	0	0	0
209	25	0	0	0	0	50	0	25	0	0
210	25	0	0	0	0	50	0	0	25	0
211	25	0	0	0	0	50	0	0	0	25
212	25	0	0	0	0	0	50	25	0	0
213	25	0	0	0	0	0	50	0	25	0
214	25	0	0	0	0	0	50	0	0	25
215	25	0	0	0	0	0	0	50	25	0

	1	2	3	4	5	6	7	8	9	10
216	25	0	0	0	0	0	0	50	0	25
217	25	0	0	0	0	0	0	0	50	25
218	25	25	50	0	0	0	0	0	0	0
219	25	25	0	50	0	0	0	0	0	0
220	25	25	0	0	50	0	0	0	0	0
221	25	25	0	0	0	50	0	0	0	0
222	25	25	0	0	0	0	50	0	0	0
223	25	25	0	0	0	0	0	50	0	0
224	25	25	0	0	0	0	0	0	50	0
225	25	25	0	0	0	0	0	0	0	50
226	25	0	25	50	0	0	0	0	0	0
227	25	0	25	0	50	0	0	0	0	0
228	25	0	25	0	0	50	0	0	0	0
229	25	0	25	0	0	0	50	0	0	0
230	25	0	25	0	0	0	0	50	0	0
231	25	0	25	0	0	0	0	0	50	0
232	25	0	25	0	0	0	0	0	0	50
233	25	0	0	25	50	0	0	0	0	0
234	25	0	0	25	0	50	0	0	0	0
235	25	0	0	25	0	0	50	0	0	0
236	25	0	0	25	0	0	0	50	0	0
237	25	0	0	25	0	0	0	0	50	0
238	25	0	0	25	0	0	0	0	0	50
239	25	0	0	0	25	50	0	0	0	0
240	25	0	0	0	25	0	50	0	0	0
241	25	0	0	0	25	0	0	50	0	0
242	25	0	0	0	25	0	0	0	50	0
243	25	0	0	0	25	0	0	0	0	50
244	25	0	0	0	0	25	50	0	0	0
245	25	0	0	0	0	25	0	50	0	0
246	25	0	0	0	0	25	0	0	50	0
247	25	0	0	0	0	25	0	0	0	50
248	25	0	0	0	0	0	25	50	0	0
249	25	0	0	0	0	0	25	0	50	0
250	25	0	0	0	0	0	25	0	0	50
251	25	0	0	0	0	0	0	25	50	0
252	25	0	0	0	0	0	0	25	0	50
253	25	0	0	0	0	0	0	0	25	50
254	0	50	25	0	0	0	25	0	0	0
255	0	50	25	25	0	0	0	0	0	0
256	0	50	25	0	0	0	0	0	25	0
257	0	50	25	0	0	0	0	25	0	0
258	0	50	25	0	25	0	0	0	0	0
259	0	50	25	0	0	0	0	0	0	25
260	0	50	0	25	25	0	0	0	0	0
261	0	50	0	25	0	25	0	0	0	0
262	0	50	0	25	0	0	25	0	0	0
263	0	50	0	25	0	0	0	25	0	0
264	0	50	0	25	0	0	0	0	25	0
265	0	50	0	25	0	0	0	0	0	25
266	0	50	0	0	25	25	0	0	0	0
267	0	50	0	0	25	0	25	0	0	0
268	0	50	0	0	25	0	0	25	0	0
269	0	50	0	0	25	0	0	0	25	0
270	0	50	0	0	0	25	25	0	0	0
271	0	50	0	0	0	25	0	25	0	0
272	0	50	0	0	0	25	0	0	25	0
273	0	50	0	0	0	25	0	0	0	25
274	0	50	0	0	0	0	25	25	0	0
275	0	50	0	0	0	0	25	0	25	0
276	0	50	0	0	0	0	25	0	0	25
277	0	50	0	0	0	0	0	25	25	0
278	0	50	0	0	0	0	0	25	0	25
279	0	50	0	0	0	0	0	0	25	25
280	0	0	50	25	0	0	25	0	0	0
281	0	0	50	25	25	0	0	0	0	0
282	0	0	50	25	0	0	0	25	0	0
283	0	0	50	25	0	0	0	0	25	0
284	0	0	50	25	0	25	0	0	0	0
285	0	0	50	25	0	0	0	0	0	25
286	0	0	50	0	25	25	0	0	0	0
287	0	0	50	0	25	0	25	0	0	0

Table B-5 The amount of inks used in the gamut mapping tool, 10 components, continued...

	1	2	3	4	5	6	7	8	9	10
288	0	0	50	0	25	0	0	25	0	0
289	0	0	50	0	25	0	0	0	25	0
290	0	0	50	0	25	0	0	0	0	25
291	0	0	50	0	0	25	25	0	0	0
292	0	0	50	0	0	25	0	25	0	0
293	0	0	50	0	0	25	0	0	25	0
294	0	0	50	0	0	25	0	0	0	25
295	0	0	50	0	0	0	25	25	0	0
296	0	0	50	0	0	0	25	0	25	0
297	0	0	50	0	0	0	25	0	0	25
298	0	0	50	0	0	0	0	25	25	0
299	0	0	50	0	0	0	0	25	0	25
300	0	0	50	0	0	0	0	0	25	25
301	0	0	0	50	25	25	0	0	0	0
302	0	0	0	50	25	0	25	0	0	0
303	0	0	0	50	25	0	0	25	0	0
304	0	0	0	50	25	0	0	0	25	0
305	0	0	0	50	25	0	0	0	0	25
306	0	0	0	50	0	25	25	0	0	0
307	0	0	0	50	0	25	0	25	0	0
308	0	0	0	50	0	25	0	0	25	0
309	0	0	0	50	0	25	0	0	0	25
310	0	0	0	50	0	0	25	25	0	0
311	0	0	0	50	0	0	25	0	25	0
312	0	0	0	50	0	0	25	0	0	25
313	0	0	0	50	0	0	0	25	25	0
314	0	0	0	50	0	0	0	25	0	25
315	0	0	0	50	0	0	0	0	25	25
316	0	0	0	0	50	25	25	0	0	0
317	0	0	0	0	50	25	0	25	0	0
318	0	0	0	0	50	25	0	0	25	0
319	0	0	0	0	50	25	0	0	0	25
320	0	0	0	0	50	0	25	25	0	0
321	0	0	0	0	50	0	25	0	25	0
322	0	0	0	0	50	0	25	0	0	25
323	0	0	0	0	50	0	0	25	25	0
324	0	0	0	0	50	0	0	25	0	25
325	0	0	0	0	50	0	0	0	25	25
326	0	0	0	0	0	50	25	25	0	0
327	0	0	0	0	0	50	25	0	25	0
328	0	0	0	0	0	50	25	0	0	25
329	0	0	0	0	0	50	0	25	25	0
330	0	0	0	0	0	50	0	25	0	25
331	0	0	0	0	0	50	0	0	25	25
332	0	0	0	0	0	0	50	25	25	0
333	0	0	0	0	0	0	50	25	0	25
334	0	0	0	0	0	0	50	0	25	25
335	0	0	0	0	0	0	0	50	25	25
336	0	0	0	0	0	0	0	25	50	25
337	0	0	0	0	0	0	25	0	50	25
338	0	0	0	0	0	25	0	0	50	25
339	0	0	0	0	25	0	0	0	50	25
340	0	0	0	25	0	0	0	0	50	25
341	0	0	25	0	0	0	0	0	50	25
342	0	25	0	0	0	0	0	0	50	25
343	0	0	0	0	0	0	0	25	25	50
344	0	0	0	0	0	0	25	0	25	50
345	0	0	0	0	0	25	0	0	25	50
346	0	0	0	0	25	0	0	0	25	50
347	0	0	0	25	0	0	0	0	25	50
348	0	0	25	0	0	0	0	0	25	50
349	0	25	0	0	0	0	0	0	25	50
350	0	0	0	0	0	0	25	25	0	50
351	0	0	0	0	0	25	0	25	0	50
352	0	0	0	0	25	0	0	25	0	50
353	0	0	0	25	0	0	0	25	0	50
354	0	0	25	0	0	0	0	25	0	50
355	0	25	0	0	0	0	0	25	0	50
356	0	0	0	0	0	25	25	0	0	50
357	0	0	0	0	25	0	25	0	0	50
358	0	0	0	25	0	0	25	0	0	50

	1	2	3	4	5	6	7	8	9	10
359	0	0	25	0	0	0	25	0	0	50
360	0	25	0	0	0	0	25	0	0	50
361	0	0	0	0	25	25	0	0	0	50
362	0	0	0	25	0	25	0	0	0	50
363	0	0	25	0	0	25	0	0	0	50
364	0	25	0	0	0	25	0	0	0	50
365	0	0	0	25	25	0	0	0	0	50
366	0	0	25	0	25	0	0	0	0	50
367	0	25	0	0	25	0	0	0	0	50
368	0	0	25	25	0	0	0	0	0	50
369	0	25	0	25	0	0	0	0	0	50
370	0	25	25	0	0	0	0	0	0	50
371	0	0	0	0	0	0	25	25	50	0
372	0	0	0	0	0	25	0	25	50	0
373	0	0	0	0	25	0	0	25	50	0
374	0	0	0	25	0	0	0	25	50	0
375	0	0	25	0	0	0	0	25	50	0
376	0	25	0	0	0	0	0	25	50	0
377	0	0	0	0	0	25	25	0	50	0
378	0	0	0	0	25	0	25	0	50	0
379	0	0	0	25	0	0	25	0	50	0
380	0	0	25	0	0	0	25	0	50	0
381	0	25	0	0	0	0	25	0	50	0
382	0	0	0	0	25	25	0	0	50	0
383	0	0	0	25	0	25	0	0	50	0
384	0	0	25	0	0	25	0	0	50	0
385	0	25	0	0	0	25	0	0	50	0
386	0	0	0	25	25	0	0	0	50	0
387	0	0	25	0	25	0	0	0	50	0
388	0	25	0	0	25	0	0	0	50	0
389	0	0	25	25	0	0	0	0	50	0
390	0	25	0	25	0	0	0	0	50	0
391	0	25	25	0	0	0	0	0	50	0
392	0	0	0	0	0	25	25	50	0	0
393	0	0	0	0	25	0	25	50	0	0
394	0	0	0	25	0	0	25	50	0	0
395	0	0	25	0	0	0	25	50	0	0
396	0	25	0	0	0	0	25	50	0	0
397	0	0	0	0	25	25	0	50	0	0
398	0	0	0	25	0	25	0	50	0	0
399	0	0	25	0	0	25	0	50	0	0
400	0	25	0	0	0	25	0	50	0	0
401	0	0	0	25	25	0	0	50	0	0
402	0	0	25	0	25	0	0	50	0	0
403	0	25	0	0	25	0	0	50	0	0
404	0	0	25	25	0	0	0	50	0	0
405	0	25	0	25	0	0	0	50	0	0
406	0	25	25	0	0	0	0	50	0	0
407	0	0	0	0	25	25	50	0	0	0
408	0	0	0	25	0	25	50	0	0	0
409	0	0	25	0	0	25	50	0	0	0
410	0	25	0	0	0	25	50	0	0	0
411	0	0	0	25	25	0	50	0	0	0
412	0	0	25	0	25	0	50	0	0	0
413	0	25	0	0	25	0	50	0	0	0
414	0	0	25	25	0	0	50	0	0	0
415	0	25	0	25	0	0	50	0	0	0
416	0	25	25	0	0	0	50	0	0	0
417	0	0	0	25	25	50	0	0	0	0
418	0	0	25	0	25	50	0	0	0	0
419	0	25	0	0	25	50	0	0	0	0
420	0	0	25	25	0	50	0	0	0	0
421	0	25	0	25	0	50	0	0	0	0
422	0	25	25	0	0	50	0	0	0	0
423	0	0	25	25	50	0	0	0	0	0
424	0	25	0	25	50	0	0	0	0	0
425	0	25	25	0	50	0	0	0	0	0
426	0	25	25	50	0	0	0	0	0	0
427	0	25	50	25	0	0	0	0	0	0
428	0	25	50	0	25	0	0	0	0	0
429	0	25	50	0	0	25	0	0	0	0
430	0	25	50	0	0	0	25	0	0	0

Table B-5 The amount of inks used in the gamut mapping tool, 10 components, continued...

	1	2	3	4	5	6	7	8	9	10
431	0	25	50	0	0	0	0	25	0	0
432	0	25	50	0	0	0	0	0	25	0
433	0	0	25	50	0	25	0	0	0	0
434	0	0	25	50	0	0	25	0	0	0
435	0	0	25	50	0	0	0	25	0	0
436	0	0	25	50	0	0	0	0	25	0
437	0	25	0	50	25	0	0	0	0	0
438	0	25	0	50	0	25	0	0	0	0
439	0	25	0	50	0	0	25	0	0	0
440	0	25	0	50	0	0	0	25	0	0
441	0	25	0	50	0	0	0	0	25	0
442	0	0	0	25	50	25	0	0	0	0
443	0	0	0	25	50	0	25	0	0	0
444	0	0	0	25	50	0	0	25	0	0
445	0	0	0	25	50	0	0	0	25	0
446	0	0	25	0	50	25	0	0	0	0
447	0	0	25	0	50	0	25	0	0	0
448	0	0	25	0	50	0	0	25	0	0
449	0	0	25	0	50	0	0	0	25	0
450	0	25	0	0	50	25	0	0	0	0
451	0	25	0	0	50	0	25	0	0	0
452	0	25	0	0	50	0	0	25	0	0
453	0	25	0	0	50	0	0	0	25	0
454	0	0	0	0	25	50	25	0	0	0
455	0	0	0	0	25	50	0	25	0	0
456	0	0	0	0	25	50	0	0	25	0
457	0	0	0	25	0	50	25	0	0	0
458	0	0	0	25	0	50	0	25	0	0
459	0	0	0	25	0	50	0	0	25	0
460	0	0	25	0	0	50	25	0	0	0
461	0	0	25	0	0	50	0	25	0	0
462	0	0	25	0	0	50	0	0	25	0
463	0	25	0	0	0	50	25	0	0	0
464	0	25	0	0	0	50	0	25	0	0
465	0	25	0	0	0	50	0	0	25	0
466	0	0	0	0	0	25	50	25	0	0
467	0	0	0	0	0	25	50	0	25	0
468	0	0	0	0	25	0	50	25	0	0
469	0	0	0	0	25	0	50	0	25	0
470	0	0	0	25	0	0	50	25	0	0
471	0	0	0	25	0	0	50	0	25	0
472	0	0	25	0	0	0	50	25	0	0
473	0	0	25	0	0	0	50	0	25	0
474	0	25	0	0	0	0	0	50	25	0
475	0	50	25	0	0	25	0	0	0	0
476	0	50	0	0	25	0	0	0	0	25
477	0	0	0	0	0	0	25	50	0	25
478	0	0	0	0	0	25	0	50	0	25
479	0	0	0	0	25	0	0	50	0	25
480	0	0	0	25	0	0	0	50	0	25
481	0	0	25	0	0	0	0	50	0	25
482	0	25	0	0	0	0	0	50	0	25
483	0	0	0	0	0	25	50	0	0	25
484	0	0	0	0	25	0	50	0	0	25
485	0	0	0	25	0	0	50	0	0	25
486	0	0	25	0	0	0	50	0	0	25
487	0	25	0	0	0	0	50	0	0	25
488	0	0	0	0	25	50	0	0	0	25
489	0	0	0	25	0	50	0	0	0	25
490	0	0	25	0	0	50	0	0	0	25
491	0	25	0	0	0	50	0	0	0	25
492	0	0	0	25	50	0	0	0	0	25
493	0	0	25	0	50	0	0	0	0	25
494	0	25	0	0	50	0	0	0	0	25
495	0	0	25	50	0	0	0	0	0	25
496	0	25	0	50	0	0	0	0	0	25
497	0	25	50	0	0	0	0	0	0	25
498	0	25	0	0	0	0	50	25	0	0
499	0	25	0	0	0	0	50	0	25	0
500	0	0	25	0	0	0	0	50	25	0
501	0	0	0	25	0	0	0	50	25	0
502	0	0	0	0	25	0	0	50	25	0

	1	2	3	4	5	6	7	8	9	10
503	0	0	0	0	0	0	25	50	25	0
504	0	0	0	0	0	25	0	50	25	0
505	0	0	0	0	0	25	50	25	0	0
506	0	25	25	25	25	0	0	0	0	0
507	0	25	0	25	25	25	0	0	0	0
508	0	25	0	0	25	25	25	0	0	0
509	0	25	0	0	0	25	25	25	0	0
510	0	25	0	0	0	0	25	25	25	0
511	0	25	0	0	0	0	0	25	25	25
512	0	25	0	25	0	25	25	0	0	0
513	0	25	0	25	0	25	0	25	0	0
514	0	25	0	25	0	25	0	0	25	0
515	0	25	0	25	0	25	0	0	0	25
516	0	25	0	25	0	0	25	25	0	0
517	0	25	0	25	0	0	25	0	25	0
518	0	25	0	25	0	0	25	0	0	25
519	0	25	0	25	0	0	0	25	25	0
520	0	25	0	25	0	0	0	25	0	25
521	0	25	0	25	0	0	0	0	25	25
522	0	25	0	0	25	0	25	25	0	0
523	0	25	0	0	25	0	25	0	25	0
524	0	25	0	0	25	0	25	0	0	25
525	0	25	0	0	25	0	0	25	25	0
526	0	25	0	0	25	0	0	25	0	25
527	0	25	0	0	25	0	0	0	25	25
528	0	25	0	0	0	25	0	25	25	0
529	0	25	0	0	0	25	0	25	0	25
530	0	25	0	0	0	25	0	0	25	25
531	0	25	0	0	0	0	25	0	25	25
532	0	25	25	0	25	25	0	0	0	0
533	0	25	25	0	25	0	25	0	0	0
534	0	25	25	0	25	0	0	25	0	0
535	0	25	25	0	25	0	0	0	25	0
536	0	25	25	0	25	0	0	0	0	25
537	0	25	25	0	0	25	25	0	0	0
538	0	25	25	0	0	25	0	25	0	0
539	0	25	25	0	0	25	0	0	25	0
540	0	25	25	0	0	25	0	0	0	25
541	0	25	25	0	0	0	25	25	0	0
542	0	25	25	0	0	0	25	0	25	0
543	0	25	25	0	0	0	25	0	0	25
544	0	25	25	0	0	0	0	25	25	0
545	0	25	25	0	0	0	0	25	0	25
546	0	25	25	0	0	0	0	0	25	25
547	0	25	0	25	25	0	25	0	0	0
548	0	25	0	25	25	0	0	25	0	0
549	0	25	0	25	25	0	0	0	25	0
550	0	25	0	25	25	0	0	0	0	25
551	0	25	0	0	25	25	0	25	0	0
552	0	25	0	0	25	25	0	0	25	0
553	0	25	0	0	25	25	0	0	0	25
554	0	25	0	0	0	25	25	0	25	0
555	0	25	0	0	0	25	25	0	0	25
556	0	25	0	0	0	0	25	25	0	25
557	0	25	25	25	0	25	0	0	0	0
558	0	25	25	25	0	0	25	0	0	0
559	0	25	25	25	0	0	0	25	0	0
560	0	25	25	25	0	0	0	0	25	0
561	0	25	25	25	0	0	0	0	0	25
562	0	0	25	25	25	25	0	0	0	0
563	0	0	25	0	25	25	25	0	0	0
564	0	0	25	0	0	25	25	25	0	0
565	0	0	25	0	0	0	25	25	25	0
566	0	0	25	0	0	0	0	25	25	25
567	0	0	25	0	25	0	25	25	0	0
568	0	0	25	0	25	0	25	0	25	0
569	0	0	25	0	25	0	25	0	0	25
570	0	0	25	0	25	0	0	25	25	0
571	0	0	25	0	25	0	0	25	0	25
572	0	0	25	0	25	0	0	0	25	25
573	0	0	25	0	0	25	0	25	25	0
574	0	0	25	0	0	25	0	25	0	25

Table B-5 The amount of inks used in the gamut mapping tool, 10 components, continued...

	1	2	3	4	5	6	7	8	9	10
575	0	0	25	0	0	25	0	0	25	25
576	0	0	25	0	0	0	25	0	25	25
577	0	0	25	25	0	25	25	0	0	0
578	0	0	25	25	0	25	0	25	0	0
579	0	0	25	25	0	25	0	0	25	0
580	0	0	25	25	0	25	0	0	0	25
581	0	0	25	25	0	0	25	25	0	0
582	0	0	25	25	0	0	25	0	25	0
583	0	0	25	25	0	0	25	0	0	25
584	0	0	25	25	0	0	0	25	25	0
585	0	0	25	25	0	0	0	25	0	25
586	0	0	25	25	0	0	0	0	25	25
587	0	0	25	25	25	0	25	0	0	0
588	0	0	25	25	25	0	0	25	0	0
589	0	0	25	25	25	0	0	0	25	0
590	0	0	25	25	25	0	0	0	0	25
591	0	0	0	25	25	25	25	0	0	0
592	0	0	0	25	0	25	25	25	0	0
593	0	0	0	25	0	0	25	25	25	0
594	0	0	0	25	0	0	0	25	25	25
595	0	0	0	25	0	25	0	25	25	0
596	0	0	0	25	0	25	0	25	0	25
597	0	0	0	25	0	25	0	0	25	25
598	0	0	0	25	0	0	25	0	25	25
599	0	0	0	25	25	0	25	25	0	0
600	0	0	0	25	25	0	25	0	25	0
601	0	0	0	25	25	0	25	0	0	25
602	0	0	0	25	25	0	0	25	25	0
603	0	0	0	25	25	0	0	25	0	25
604	0	0	0	25	25	0	0	0	25	25
605	0	0	0	25	25	25	0	25	0	0
606	0	0	0	25	25	25	0	0	25	0
607	0	0	0	25	25	25	0	0	0	25
608	0	0	0	0	25	25	25	25	0	0
609	0	0	0	0	25	0	25	25	25	0
610	0	0	0	0	25	0	0	25	25	25
611	0	0	0	0	25	0	25	0	25	25
612	0	0	0	0	25	25	0	25	25	0
613	0	0	0	0	25	25	0	25	0	25
614	0	0	0	0	25	25	0	0	25	25
615	0	0	0	0	25	25	25	0	25	0
616	0	0	0	0	25	25	25	0	0	25
617	0	0	0	0	0	25	25	25	25	0
618	0	0	0	0	0	25	0	25	25	25
619	0	0	0	0	0	25	25	0	25	25
620	0	0	0	0	0	25	25	25	0	25
621	0	0	0	0	0	0	25	25	25	25
622	0	25	0	25	0	25	0	25	0	0
623	0	25	0	25	0	25	0	0	25	0
624	0	25	0	25	0	25	0	0	0	25
625	0	25	0	25	0	25	0	0	25	0
626	0	25	0	25	0	25	0	0	0	25
627	0	25	0	25	0	0	25	0	25	0
628	0	25	0	25	0	0	25	0	0	25
629	0	25	0	25	0	0	0	25	0	25
630	0	25	0	25	0	0	0	0	25	25
631	0	25	0	0	25	0	0	25	0	25
632	25	25	25	25	0	0	0	0	0	0
633	25	25	25	0	25	0	0	0	0	0
634	25	25	25	0	0	25	0	0	0	0
635	25	25	25	0	0	0	25	0	0	0
636	25	25	25	0	0	0	0	25	0	0
637	25	25	25	0	0	0	0	0	25	0
638	25	25	25	0	0	0	0	0	0	25
639	25	25	0	25	25	0	0	0	0	0
640	25	25	0	25	0	25	0	0	0	0
641	25	25	0	25	0	0	25	0	0	0
642	25	25	0	25	0	0	0	25	0	0
643	25	25	0	25	0	0	0	0	25	0
644	25	25	0	25	0	0	0	0	0	25
645	25	25	0	0	25	25	0	0	0	0
646	25	25	0	0	25	0	25	0	0	0
647	25	25	0	0	25	0	0	25	0	0
648	25	25	0	0	25	0	0	0	25	0
649	25	25	0	0	25	0	0	0	0	25
650	25	25	0	0	0	25	25	0	0	0
651	25	25	0	0	0	25	0	25	0	0
652	25	25	0	0	0	25	0	0	25	0
653	25	25	0	0	0	25	0	0	0	25
654	25	25	0	0	0	0	25	25	0	0
655	25	25	0	0	0	0	25	0	25	0
656	25	25	0	0	0	0	25	0	0	25
657	25	25	0	0	0	0	0	25	25	0
658	25	25	0	0	0	0	0	25	0	25
659	25	25	0	0	0	0	0	0	25	25
660	25	0	25	25	25	0	0	0	0	0
661	25	0	25	25	0	25	0	0	0	0
662	25	0	25	25	0	0	25	0	0	0
663	25	0	25	25	0	0	0	25	0	0
664	25	0	25	25	0	0	0	0	25	0
665	25	0	25	25	0	0	0	0	0	25
666	25	0	25	0	25	25	0	0	0	0
667	25	0	25	0	25	0	25	0	0	0
668	25	0	25	0	25	0	0	25	0	0
669	25	0	25	0	25	0	0	0	25	0
670	25	0	25	0	25	0	0	0	0	25
671	25	0	25	0	0	25	25	0	0	0
672	25	0	25	0	0	25	0	25	0	0
673	25	0	25	0	0	25	0	0	25	0
674	25	0	25	0	0	25	0	0	0	25
675	25	0	25	0	0	0	25	25	0	0
676	25	0	25	0	0	0	25	0	25	0
677	25	0	25	0	0	0	25	0	0	25
678	25	0	25	0	0	0	0	25	25	0
679	25	0	25	0	0	0	0	25	0	25
680	25	0	25	0	0	0	0	0	25	25
681	25	0	0	25	25	25	0	0	0	0
682	25	0	0	25	25	0	25	0	0	0
683	25	0	0	25	25	0	0	25	0	0
684	25	0	0	25	25	0	0	0	25	0
685	25	0	0	25	25	0	0	0	0	25
686	25	0	0	25	0	25	25	0	0	0
687	25	0	0	25	0	25	0	25	0	0
688	25	0	0	25	0	25	0	0	25	0
689	25	0	0	25	0	25	0	0	0	25
690	25	0	0	25	0	0	25	25	0	0
691	25	0	0	25	0	0	25	0	25	0
692	25	0	0	25	0	0	25	0	0	25
693	25	0	0	25	0	0	0	25	25	0
694	25	0	0	25	0	0	0	25	0	25
695	25	0	0	25	0	0	0	0	25	25
696	25	0	0	0	25	25	25	0	0	0
697	25	0	0	0	25	25	0	25	0	0
698	25	0	0	0	25	25	0	0	25	0
699	25	0	0	0	25	25	0	0	0	25
700	25	0	0	0	25	0	25	25	0	0
701	25	0	0	0	25	0	25	0	25	0
702	25	0	0	0	25	0	25	0	0	25
703	25	0	0	0	25	0	0	25	25	0
704	25	0	0	0	25	0	0	25	0	25
705	25	0	0	0	25	0	0	0	25	25
706	25	0	0	0	0	25	25	25	0	0
707	25	0	0	0	0	25	25	0	25	0
708	25	0	0	0	0	25	25	0	0	25
709	25	0	0	0	0	25	0	25	25	0
710	25	0	0	0	0	25	0	25	0	25
711	25	0	0	0	0	25	0	0	25	25
712	25	0	0	0	0	0	25	25	25	0
713	25	0	0	0	0	0	25	25	0	25
714	25	0	0	0	0	0	25	0	25	25
715	25	0	0	0	0	0	0	25	25	25

Table B-5 The amount of inks used in the gamut mapping tool, 10 components, continued...

APPENDIX C

The Visual Basic Code

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```
Sub Step1()
MsgBox "Select the Table to define the maximum number of inks in the
combination to see the gamut then go to step 2"
End Sub

Sub Step2()
MsgBox "Select Operation 1 if Table 1 is selected or Select Operation
2 if Table 2 is selected or Select Operation 3 if Table 3 is
selected"
End Sub

Sub Operation1()
Dim R%
 Dim RE% 'new
    Dim RowInd%, dum ' give row as integer
    RowInd = 3 'amount begin in row 2
    RE = 1000 'new
    R = 101
    Do
        Range(Cells(RowInd, 98), Cells(RowInd, 104)).Copy
        Range("n17").PasteSpecial Paste:=xlAll, Operation:=xlNone, _
                                SkipBlanks:=False, Transpose:=True
        Range(Cells(128, 12), Cells(163, 12)).Copy
        Cells(RE, 2).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(101, 9), Cells(109, 9)).Copy
        Cells(R, 17).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(113, 9), Cells(121, 9)).Copy
        Cells(R, 26).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(102, 6), Cells(104, 6)).Copy
        Cells(R, 35).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        RowInd = RowInd + 1
        RE = RE + 1
        R = R + 1
         Application.ScreenUpdating = False
        If RowInd > 65000 Then ' all row in a spreadsheet has about
65500 row
                        dum = MsgBox("Reached the 65000th row! Help
me out!")
            Exit Sub
        End If
    Loop While Cells(RowInd, 105).Value <> 0
     Application.ScreenUpdating = True
    Application.CutCopyMode = False
End Sub

Sub operation2()
     Dim R%
    Dim RowInd%, dum ' give row as integer
    RowInd = 3 'amount begin in row 2
    R = 101
    Do
```

```
        Range(Cells(RowInd, 98), Cells(RowInd, 103)).Copy
        Range("n17").PasteSpecial Paste:=xlAll, Operation:=xlNone, _
                                SkipBlanks:=False, Transpose:=True
        Range(Cells(101, 9), Cells(109, 9)).Copy
        Cells(R, 17).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(113, 9), Cells(121, 9)).Copy
        Cells(R, 26).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(102, 6), Cells(104, 6)).Copy
        Cells(R, 35).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        RowInd = RowInd + 1
        R = R + 1
         Application.ScreenUpdating = False
        If RowInd > 65000 Then ' all row in a spreadsheet has about
65500 row
                        dum = MsgBox("Reached the 65000th row! Help
me out!")
            Exit Sub
        End If
    Loop While Cells(RowInd, 104).Value <> 0
         Application.ScreenUpdating = True
    Application.CutCopyMode = False
End Sub

Sub operation3()
    Dim R%
    Dim RowInd%, dum ' give row as integer
    RowInd = 3 'amount begin in row 2
    R = 101
    Do
        Range(Cells(RowInd, 98), Cells(RowInd, 102)).Copy
        Range("n17").PasteSpecial Paste:=xlAll, Operation:=xlNone, _
                                SkipBlanks:=False, Transpose:=True
        Range(Cells(101, 9), Cells(109, 9)).Copy
        Cells(R, 17).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(113, 9), Cells(121, 9)).Copy
        Cells(R, 26).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(102, 6), Cells(104, 6)).Copy
        Cells(R, 35).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        RowInd = RowInd + 1
        R = R + 1
        Application.ScreenUpdating = False
        If RowInd > 65000 Then ' all row in a spreadsheet has about
65500 row
                        dum = MsgBox("Reached the 65000th row! Help
me out!")
            Exit Sub
        End If
    Loop While Cells(RowInd, 103).Value <> 0
         Application.ScreenUpdating = True
```

```
    Application.CutCopyMode = False
End Sub

Sub Operation4()
Dim R%
    Dim RowInd%, dum ' give row as integer
    RowInd = 3 'amount begin in row 2
    R = 101
    Do
        Range(Cells(RowInd, 98), Cells(RowInd, 106)).Copy
        Range("n17").PasteSpecial Paste:=xlAll, Operation:=xlNone, _
                                SkipBlanks:=False, Transpose:=True
        Range(Cells(101, 9), Cells(109, 9)).Copy
        Cells(R, 17).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(113, 9), Cells(121, 9)).Copy
        Cells(R, 26).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(102, 6), Cells(104, 6)).Copy
        Cells(R, 35).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        RowInd = RowInd + 1
        R = R + 1
         Application.ScreenUpdating = False
        If RowInd > 65000 Then ' all row in a spreadsheet has about
65500 row
                        dum = MsgBox("Reached the 65000th row! Help
me out!")
            Exit Sub
        End If
    Loop While Cells(RowInd, 107).Value <> 0
     Application.ScreenUpdating = True
    Application.CutCopyMode = False
End Sub

Sub Operation5()
Dim R%
    Dim RowInd%, dum ' give row as integer
    RowInd = 3 'amount begin in row 2
    R = 101
    Do
        Range(Cells(RowInd, 98), Cells(RowInd, 107)).Copy
        Range("n17").PasteSpecial Paste:=xlAll, Operation:=xlNone, _
                                SkipBlanks:=False, Transpose:=True
        Range(Cells(101, 9), Cells(109, 9)).Copy
        Cells(R, 17).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(113, 9), Cells(121, 9)).Copy
        Cells(R, 26).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        Range(Cells(102, 6), Cells(104, 6)).Copy
        Cells(R, 35).PasteSpecial Paste:=xlValues, Operation:=xlNone,
SkipBlanks:= _
                       False, Transpose:=True
        RowInd = RowInd + 1
        R = R + 1
```

```
         Application.ScreenUpdating = False
        If RowInd > 65000 Then ' all row in a spreadsheet has about
65500 row
                        dum = MsgBox("Reached the 65000th row! Help
me out!")
            Exit Sub
        End If
    Loop While Cells(RowInd, 108).Value <> 0
     Application.ScreenUpdating = True
    Application.CutCopyMode = False
End Sub

Sub Clear()
Clear Macro
Macro recorded 18/08/02 by Pattamas
Keyboard Shortcut: Ctrl+m
Application.ScreenUpdating = False
    Range("m17:n26").Select
    Selection.ClearContents
    Range("Q101:AK815").Select
    Selection.ClearContents
    Application.ScreenUpdating = True
    Range("h3").Select
End Sub

Sub Home()
Home Macro
Macro recorded 18/08/02 by Pattamas
Keyboard Shortcut: Ctrl+h
    Range("h3").Select
End Sub
```

APPENDIX D

The Reflectance Data

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Wavelength (nm)	2% Cyan	10% Cyan	20% Cyan	30% Cyan	50% Cyan	75% Cyan	100% Cyan	2% Magenta	10% Magenta	20% Magenta	30% Magenta	50% Magenta	75% Magenta	100% Magenta
400	0.4094	0.3800	0.2908	0.2760	0.1841	0.1542	0.1275	0.4022	0.3678	0.3308	0.2861	0.0992	0.0823	0.0640
410	0.5427	0.5044	0.4024	0.3781	0.2632	0.2208	0.1848	0.5320	0.4776	0.4279	0.3645	0.1109	0.0891	0.0667
420	0.7156	0.6607	0.5384	0.4998	0.3489	0.2909	0.2463	0.6993	0.6175	0.5534	0.4656	0.1283	0.0996	0.0722
430	0.7967	0.7423	0.6255	0.5834	0.4301	0.3652	0.3174	0.7761	0.6840	0.6143	0.5158	0.1406	0.1082	0.0771
440	0.8177	0.7771	0.6874	0.6514	0.5268	0.4647	0.4191	0.7955	0.7033	0.6333	0.5342	0.1485	0.1138	0.0810
450	0.8212	0.7917	0.7264	0.6983	0.6026	0.5472	0.5064	0.7964	0.7050	0.6355	0.5353	0.1448	0.1105	0.0782
460	0.8173	0.7926	0.7361	0.7107	0.6246	0.5725	0.5341	0.7903	0.6959	0.6255	0.5239	0.1278	0.0967	0.0678
470	0.8137	0.7906	0.7366	0.7123	0.6275	0.5766	0.5389	0.7829	0.6837	0.6118	0.5068	0.1073	0.0809	0.0571
480	0.8120	0.7878	0.7298	0.7043	0.6124	0.5594	0.5204	0.7779	0.6720	0.5982	0.4896	0.0891	0.0675	0.0489
490	0.8074	0.7804	0.7139	0.6865	0.5809	0.5242	0.4821	0.7685	0.6576	0.5832	0.4720	0.0756	0.0581	0.0440
500	0.8044	0.7722	0.6924	0.6605	0.5362	0.4743	0.4287	0.7625	0.6451	0.5704	0.4565	0.0663	0.0520	0.0408
510	0.8001	0.7590	0.6609	0.6239	0.4743	0.4078	0.3592	0.7539	0.6302	0.5558	0.4393	0.0605	0.0481	0.0392
520	0.7936	0.7401	0.6172	0.5742	0.3948	0.3256	0.2759	0.7436	0.6136	0.5403	0.4218	0.0594	0.0477	0.0397
530	0.7862	0.7163	0.5658	0.5167	0.3069	0.2390	0.1915	0.7351	0.6017	0.5292	0.4096	0.0631	0.0512	0.0427
540	0.7783	0.6903	0.5136	0.4591	0.2242	0.1628	0.1222	0.7299	0.5956	0.5236	0.4041	0.0664	0.0541	0.0454
550	0.7699	0.6630	0.4622	0.4037	0.1518	0.1025	0.0737	0.7244	0.5878	0.5172	0.3972	0.0703	0.0568	0.0473
560	0.7592	0.6343	0.4142	0.3526	0.0969	0.0635	0.0473	0.7152	0.5742	0.5059	0.3847	0.0815	0.0651	0.0537
570	0.7504	0.6119	0.3796	0.3163	0.0690	0.0477	0.0387	0.7064	0.5617	0.4957	0.3736	0.1045	0.0864	0.0725
580	0.7432	0.5970	0.3588	0.2949	0.0600	0.0445	0.0374	0.7125	0.5745	0.5063	0.3879	0.1224	0.1064	0.0923
590	0.7389	0.5878	0.3468	0.2828	0.0584	0.0452	0.0383	0.7403	0.6348	0.5660	0.4625	0.1536	0.1294	0.1073
600	0.7347	0.5800	0.3371	0.2729	0.0595	0.0475	0.0402	0.7652	0.7080	0.6591	0.5849	0.2901	0.2490	0.2091
610	0.7328	0.5751	0.3298	0.2658	0.0624	0.0512	0.0432	0.7769	0.7512	0.7269	0.6848	0.4797	0.4378	0.3979
620	0.7337	0.5734	0.3267	0.2629	0.0663	0.0557	0.0470	0.7834	0.7722	0.7640	0.7435	0.6337	0.6040	0.5748
630	0.7360	0.5737	0.3259	0.2623	0.0698	0.0595	0.0502	0.7876	0.7816	0.7805	0.7706	0.7181	0.7017	0.6834
640	0.7378	0.5749	0.3263	0.2630	0.0733	0.0635	0.0538	0.7904	0.7864	0.7879	0.7821	0.7552	0.7467	0.7356
650	0.7406	0.5782	0.3296	0.2668	0.0763	0.0666	0.0567	0.7924	0.7889	0.7912	0.7874	0.7709	0.7662	0.7584
660	0.7444	0.5838	0.3362	0.2739	0.0782	0.0678	0.0578	0.7939	0.7909	0.7934	0.7903	0.7785	0.7754	0.7693
670	0.7464	0.5875	0.3408	0.2787	0.0787	0.0672	0.0572	0.7943	0.7913	0.7945	0.7916	0.7811	0.7799	0.7753
680	0.7466	0.5872	0.3400	0.2780	0.0779	0.0664	0.0564	0.7951	0.7921	0.7953	0.7928	0.7840	0.7831	0.7790
690	0.7457	0.5840	0.3359	0.2736	0.0770	0.0663	0.0564	0.7960	0.7932	0.7961	0.7938	0.7871	0.7857	0.7817
700	0.7439	0.5784	0.3289	0.2664	0.0780	0.0686	0.0582	0.7970	0.7944	0.7972	0.7953	0.7896	0.7883	0.7844

Wavelength (nm)	2% Yellow	10% Yellow	20% Yellow	30% Yellow	50% Yellow	75% Yellow	100% Yellow	2% Black	10% Black	20% Black	30% Black	50% Black	75% Black	100% Black
400	0.3958	0.3252	0.2771	0.2774	0.0589	0.0488	0.0586	0.3914	0.3043	0.2370	0.0867	0.0649	0.0599	0.0521
410	0.5200	0.4174	0.3446	0.3445	0.0584	0.0475	0.0594	0.5040	0.3903	0.2992	0.0978	0.0660	0.0616	0.0532
420	0.6777	0.5320	0.4269	0.4257	0.0607	0.0488	0.0627	0.6480	0.4994	0.3750	0.1105	0.0670	0.0631	0.0543
430	0.7468	0.5791	0.4597	0.4585	0.0642	0.0520	0.0658	0.7131	0.5481	0.4089	0.1168	0.0676	0.0636	0.0548
440	0.7623	0.5884	0.4656	0.4648	0.0685	0.0561	0.0692	0.7295	0.5610	0.4190	0.1196	0.0682	0.0643	0.0553
450	0.7646	0.5911	0.4691	0.4685	0.0732	0.0606	0.0732	0.7318	0.5633	0.4218	0.1215	0.0685	0.0645	0.0557
460	0.7630	0.5926	0.4734	0.4732	0.0770	0.0639	0.0761	0.7300	0.5629	0.4227	0.1234	0.0693	0.0652	0.0565
470	0.7623	0.5950	0.4785	0.4785	0.0821	0.0682	0.0798	0.7275	0.5619	0.4228	0.1248	0.0698	0.0657	0.0569
480	0.7663	0.6051	0.4932	0.4926	0.0922	0.0755	0.0860	0.7263	0.5615	0.4233	0.1261	0.0701	0.0658	0.0571
490	0.7746	0.6337	0.5353	0.5335	0.1268	0.0996	0.1061	0.7237	0.5602	0.4231	0.1275	0.0706	0.0662	0.0575
500	0.7898	0.6897	0.6203	0.6147	0.2393	0.1947	0.1919	0.7224	0.5595	0.4232	0.1286	0.0710	0.0664	0.0577
510	0.7992	0.7479	0.7146	0.7081	0.4465	0.3976	0.3881	0.7196	0.5577	0.4224	0.1293	0.0716	0.0668	0.0579
520	0.8002	0.7786	0.7670	0.7630	0.6293	0.5959	0.5873	0.7162	0.5553	0.4208	0.1295	0.0721	0.0669	0.0579
530	0.7977	0.7877	0.7854	0.7831	0.7215	0.7057	0.7012	0.7126	0.5527	0.4193	0.1298	0.0729	0.0674	0.0584
540	0.7945	0.7886	0.7897	0.7881	0.7566	0.7503	0.7491	0.7100	0.5508	0.4184	0.1303	0.0740	0.0683	0.0591
550	0.7919	0.7875	0.7904	0.7890	0.7698	0.7682	0.7683	0.7075	0.5489	0.4171	0.1308	0.0750	0.0690	0.0597
560	0.7888	0.7848	0.7886	0.7872	0.7736	0.7738	0.7748	0.7047	0.5467	0.4160	0.1314	0.0760	0.0699	0.0604
570	0.7866	0.7828	0.7870	0.7859	0.7747	0.7762	0.7776	0.7028	0.5454	0.4151	0.1321	0.0767	0.0706	0.0610
580	0.7845	0.7815	0.7855	0.7845	0.7748	0.7767	0.7784	0.7011	0.5441	0.4145	0.1330	0.0776	0.0714	0.0617
590	0.7832	0.7809	0.7851	0.7839	0.7751	0.7773	0.7788	0.7004	0.5438	0.4145	0.1343	0.0786	0.0724	0.0625
600	0.7825	0.7804	0.7843	0.7829	0.7747	0.7774	0.7791	0.6997	0.5435	0.4147	0.1358	0.0796	0.0734	0.0635
610	0.7835	0.7816	0.7851	0.7836	0.7755	0.7786	0.7804	0.7008	0.5442	0.4154	0.1374	0.0803	0.0741	0.0642
620	0.7861	0.7840	0.7876	0.7854	0.7777	0.7809	0.7830	0.7036	0.5463	0.4173	0.1392	0.0810	0.0748	0.0648
630	0.7890	0.7868	0.7903	0.7879	0.7805	0.7837	0.7855	0.7058	0.5480	0.4190	0.1412	0.0816	0.0756	0.0655
640	0.7909	0.7887	0.7925	0.7898	0.7826	0.7860	0.7879	0.7085	0.5502	0.4209	0.1434	0.0822	0.0763	0.0662
650	0.7926	0.7903	0.7941	0.7911	0.7843	0.7878	0.7897	0.7100	0.5512	0.4221	0.1454	0.0827	0.0769	0.0668
660	0.7940	0.7916	0.7959	0.7927	0.7858	0.7895	0.7914	0.7115	0.5528	0.4237	0.1476	0.0832	0.0775	0.0673
670	0.7945	0.7919	0.7966	0.7932	0.7854	0.7901	0.7923	0.7124	0.5538	0.4250	0.1497	0.0836	0.0781	0.0678
680	0.7954	0.7929	0.7978	0.7941	0.7864	0.7910	0.7932	0.7139	0.5550	0.4266	0.1520	0.0842	0.0786	0.0684
690	0.7960	0.7936	0.7988	0.7948	0.7880	0.7917	0.7939	0.7152	0.5565	0.4279	0.1546	0.0847	0.0792	0.0689
700	0.7968	0.7947	0.7999	0.7956	0.7893	0.7931	0.7949	0.7159	0.5575	0.4293	0.1569	0.0850	0.0796	0.0693

Table D-1 The data set of reflectance ratio of Geos four-colour process inks.

Wavelength (nm)	2% Cyan	10% Cyan	20% Cyan	30% Cyan	50% Cyan	75% Cyan	100% Cyan	2% Magenta	10% Magenta	20% Magenta	30% Magenta	50% Magenta	75% Magenta	100% Magenta
400	0.4106	0.3768	0.3192	0.2689	0.1773	0.1466	0.1440	0.4041	0.3384	0.2465	0.1631	0.0942	0.0707	0.0739
410	0.5366	0.5028	0.4342	0.3730	0.2521	0.2095	0.2084	0.5265	0.4437	0.3093	0.1959	0.1069	0.0762	0.0788
420	0.7022	0.6654	0.5770	0.4956	0.3349	0.2765	0.2777	0.6842	0.5800	0.3897	0.2389	0.1248	0.0853	0.0879
430	0.7819	0.7496	0.6640	0.5834	0.4139	0.3489	0.3523	0.7588	0.6454	0.4323	0.2644	0.1374	0.0928	0.0955
440	0.8049	0.7823	0.7177	0.6555	0.5079	0.4451	0.4504	0.7786	0.6659	0.4504	0.2781	0.1454	0.0983	0.1010
450	0.8111	0.7958	0.7493	0.7036	0.5826	0.5261	0.5322	0.7806	0.6672	0.4499	0.2754	0.1419	0.0952	0.0976
460	0.8102	0.7975	0.7567	0.7163	0.6056	0.5533	0.5592	0.7740	0.6552	0.4293	0.2532	0.1247	0.0818	0.0835
470	0.8082	0.7963	0.7573	0.7179	0.6100	0.5598	0.5654	0.7656	0.6378	0.3997	0.2232	0.1041	0.0669	0.0678
480	0.8074	0.7951	0.7530	0.7103	0.5965	0.5454	0.5505	0.7579	0.6200	0.3679	0.1934	0.0861	0.0548	0.0550
490	0.8034	0.7891	0.7412	0.6919	0.5663	0.5130	0.5173	0.7477	0.6003	0.3368	0.1670	0.0729	0.0470	0.0468
500	0.8012	0.7832	0.7254	0.6657	0.5235	0.4661	0.4693	0.7393	0.5822	0.3082	0.1447	0.0642	0.0423	0.0417
510	0.7966	0.7730	0.7006	0.6257	0.4641	0.4019	0.4035	0.7279	0.5610	0.2771	0.1241	0.0591	0.0401	0.0391
520	0.7899	0.7580	0.6652	0.5696	0.3871	0.3219	0.3215	0.7153	0.5377	0.2456	0.1070	0.0588	0.0409	0.0393
530	0.7814	0.7381	0.6197	0.4998	0.3019	0.2365	0.2343	0.7051	0.5211	0.2259	0.0994	0.0630	0.0452	0.0427
540	0.7714	0.7146	0.5695	0.4251	0.2215	0.1608	0.1572	0.6993	0.5134	0.2184	0.0978	0.0664	0.0485	0.0457
550	0.7602	0.6885	0.5157	0.3476	0.1506	0.1007	0.0963	0.6926	0.5030	0.2069	0.0948	0.0707	0.0515	0.0481
560	0.7461	0.6593	0.4596	0.2716	0.0965	0.0614	0.0577	0.6803	0.4823	0.1852	0.0924	0.0818	0.0601	0.0552
570	0.7338	0.6348	0.4145	0.2148	0.0681	0.0452	0.0423	0.6684	0.4628	0.1691	0.0999	0.1048	0.0812	0.0744
580	0.7241	0.6176	0.3848	0.1812	0.0582	0.0418	0.0393	0.6793	0.4874	0.2075	0.1265	0.1230	0.1008	0.0938
590	0.7182	0.6067	0.3670	0.1632	0.0565	0.0424	0.0400	0.7212	0.5822	0.3503	0.2203	0.1549	0.1209	0.1180
600	0.7124	0.5975	0.3521	0.1492	0.0573	0.0445	0.0417	0.7587	0.6865	0.5452	0.4163	0.2932	0.2409	0.2518
610	0.7091	0.5905	0.3412	0.1404	0.0601	0.0479	0.0449	0.7756	0.7446	0.6742	0.5922	0.4801	0.4301	0.4493
620	0.7091	0.5888	0.3375	0.1386	0.0638	0.0518	0.0486	0.7837	0.7712	0.7394	0.6980	0.6290	0.5932	0.6089
630	0.7109	0.5892	0.3376	0.1402	0.0671	0.0552	0.0517	0.7886	0.7832	0.7674	0.7474	0.7112	0.6901	0.6998
640	0.7132	0.5908	0.3399	0.1441	0.0704	0.0583	0.0547	0.7911	0.7885	0.7789	0.7678	0.7483	0.7361	0.7426
650	0.7167	0.5950	0.3472	0.1527	0.0732	0.0605	0.0569	0.7931	0.7914	0.7841	0.7770	0.7648	0.7571	0.7622
660	0.7213	0.6016	0.3580	0.1645	0.0752	0.0616	0.0579	0.7945	0.7936	0.7873	0.7818	0.7733	0.7676	0.7718
670	0.7234	0.6056	0.3648	0.1717	0.0757	0.0612	0.0575	0.7953	0.7946	0.7890	0.7843	0.7778	0.7733	0.7773
680	0.7237	0.6053	0.3632	0.1695	0.0749	0.0605	0.0570	0.7960	0.7959	0.7906	0.7864	0.7814	0.7777	0.7810
690	0.7226	0.6017	0.3562	0.1621	0.0742	0.0606	0.0570	0.7964	0.7963	0.7912	0.7879	0.7835	0.7801	0.7833
700	0.7197	0.5955	0.3457	0.1521	0.0753	0.0628	0.0590	0.7977	0.7976	0.7924	0.7897	0.7862	0.7831	0.7859

Wavelength (nm)	2% Yellow	10% Yellow	20% Yellow	30% Yellow	50% Yellow	75% Yellow	100% Yellow	2% Black	10% Black	20% Black	30% Black	50% Black	75% Black	100% Black
400	0.3899	0.3525	0.2726	0.1053	0.0674	0.0512	0.0489	0.3672	0.3289	0.1875	0.1021	0.0634	0.0544	0.0476
410	0.5111	0.4567	0.3410	0.1100	0.0665	0.0486	0.0463	0.4706	0.4240	0.2285	0.1172	0.0650	0.0559	0.0482
420	0.6685	0.5899	0.4244	0.1166	0.0675	0.0487	0.0461	0.6018	0.5442	0.2771	0.1336	0.0657	0.0564	0.0486
430	0.7398	0.6486	0.4562	0.1169	0.0687	0.0503	0.0477	0.6622	0.5994	0.2998	0.1417	0.0666	0.0572	0.0493
440	0.7565	0.6617	0.4613	0.1163	0.0712	0.0530	0.0502	0.6773	0.6136	0.3067	0.1450	0.0673	0.0577	0.0497
450	0.7597	0.6653	0.4664	0.1210	0.0759	0.0568	0.0536	0.6801	0.6165	0.3093	0.1470	0.0681	0.0586	0.0505
460	0.7590	0.6665	0.4743	0.1292	0.0811	0.0600	0.0561	0.6789	0.6158	0.3105	0.1483	0.0686	0.0589	0.0508
470	0.7585	0.6682	0.4825	0.1386	0.0876	0.0643	0.0596	0.6770	0.6144	0.3114	0.1498	0.0695	0.0597	0.0515
480	0.7626	0.6768	0.5028	0.1612	0.1023	0.0730	0.0663	0.6769	0.6142	0.3123	0.1508	0.0699	0.0601	0.0518
490	0.7713	0.6991	0.5544	0.2306	0.1528	0.1058	0.0936	0.6747	0.6130	0.3128	0.1519	0.0706	0.0609	0.0526
500	0.7873	0.7409	0.6424	0.3867	0.2922	0.2216	0.2022	0.6741	0.6124	0.3135	0.1528	0.0710	0.0613	0.0530
510	0.7979	0.7777	0.7286	0.5879	0.5115	0.4407	0.4210	0.6721	0.6108	0.3135	0.1533	0.0718	0.0622	0.0537
520	0.7986	0.7913	0.7716	0.7128	0.6734	0.6282	0.6147	0.6695	0.6086	0.3127	0.1532	0.0722	0.0627	0.0543
530	0.7961	0.7929	0.7839	0.7593	0.7414	0.7175	0.7089	0.6665	0.6060	0.3116	0.1528	0.0729	0.0635	0.0552
540	0.7932	0.7911	0.7861	0.7733	0.7636	0.7503	0.7442	0.6637	0.6035	0.3105	0.1524	0.0738	0.0644	0.0563
550	0.7908	0.7892	0.7861	0.7784	0.7721	0.7634	0.7590	0.6618	0.6018	0.3099	0.1523	0.0749	0.0656	0.0576
560	0.7875	0.7860	0.7837	0.7781	0.7736	0.7674	0.7632	0.6592	0.5994	0.3089	0.1522	0.0758	0.0667	0.0588
570	0.7855	0.7844	0.7821	0.7776	0.7739	0.7691	0.7652	0.6575	0.5980	0.3086	0.1525	0.0768	0.0678	0.0599
580	0.7834	0.7825	0.7806	0.7769	0.7735	0.7696	0.7661	0.6564	0.5969	0.3087	0.1531	0.0777	0.0689	0.0610
590	0.7824	0.7814	0.7798	0.7762	0.7732	0.7698	0.7663	0.6559	0.5963	0.3093	0.1544	0.0786	0.0698	0.0618
600	0.7814	0.7804	0.7788	0.7755	0.7728	0.7701	0.7668	0.6559	0.5961	0.3104	0.1558	0.0795	0.0707	0.0628
610	0.7827	0.7816	0.7799	0.7766	0.7744	0.7714	0.7683	0.6569	0.5966	0.3115	0.1572	0.0802	0.0712	0.0634
620	0.7850	0.7838	0.7819	0.7784	0.7767	0.7743	0.7712	0.6593	0.5987	0.3134	0.1592	0.0809	0.0720	0.0640
630	0.7883	0.7870	0.7850	0.7813	0.7799	0.7772	0.7742	0.6620	0.6007	0.3155	0.1614	0.0815	0.0725	0.0647
640	0.7906	0.7889	0.7870	0.7833	0.7824	0.7799	0.7768	0.6644	0.6025	0.3177	0.1637	0.0821	0.0729	0.0652
650	0.7922	0.7906	0.7888	0.7849	0.7843	0.7819	0.7789	0.6665	0.6043	0.3197	0.1660	0.0826	0.0735	0.0656
660	0.7938	0.7923	0.7904	0.7867	0.7862	0.7836	0.7808	0.6686	0.6059	0.3218	0.1683	0.0831	0.0738	0.0660
670	0.7943	0.7929	0.7910	0.7873	0.7867	0.7844	0.7821	0.6698	0.6071	0.3240	0.1707	0.0836	0.0743	0.0664
680	0.7955	0.7937	0.7919	0.7884	0.7879	0.7856	0.7830	0.6715	0.6085	0.3261	0.1733	0.0841	0.0747	0.0668
690	0.7960	0.7944	0.7925	0.7888	0.7886	0.7861	0.7833	0.6731	0.6097	0.3282	0.1756	0.0844	0.0749	0.0670
700	0.7970	0.7954	0.7939	0.7903	0.7904	0.7877	0.7851	0.6744	0.6110	0.3303	0.1781	0.0847	0.0750	0.0672

Table D-2 The data set of reflectance ratio of Fresh & Fast four-colour process inks.

Wavelength (nm)	2% Cyan	10% Cyan	20% Cyan	30% Cyan	50% Cyan	75% Cyan	100% Cyan	2% Magenta	10% Magenta	20% Magenta	30% Magenta	50% Magenta	75% Magenta	100% Magenta
400	0.3842	0.3455	0.3232	0.2475	0.1729	0.1470	0.1228	0.3929	0.3470	0.3018	0.2658	0.1111	0.0844	0.0610
410	0.5206	0.4747	0.4409	0.3484	0.2449	0.2089	0.1755	0.5235	0.4572	0.3926	0.3391	0.1266	0.0922	0.0641
420	0.7012	0.6446	0.5919	0.4729	0.3278	0.2758	0.2318	0.6959	0.6023	0.5131	0.4347	0.1485	0.1046	0.0690
430	0.7865	0.7332	0.6791	0.5584	0.4032	0.3460	0.2968	0.7757	0.6711	0.5723	0.4833	0.1637	0.1144	0.0741
440	0.8108	0.7700	0.7263	0.6262	0.4897	0.4369	0.3886	0.7957	0.6918	0.5924	0.5026	0.1728	0.1209	0.0780
450	0.8153	0.7854	0.7528	0.6722	0.5578	0.5118	0.4670	0.7976	0.6934	0.5943	0.5031	0.1694	0.1173	0.0753
460	0.8118	0.7861	0.7583	0.6859	0.5798	0.5365	0.4939	0.7911	0.6826	0.5810	0.4861	0.1512	0.1020	0.0652
470	0.8080	0.7843	0.7588	0.6892	0.5848	0.5425	0.5005	0.7838	0.6673	0.5610	0.4603	0.1283	0.0842	0.0548
480	0.8067	0.7822	0.7558	0.6834	0.5734	0.5288	0.4858	0.7781	0.6519	0.5402	0.4329	0.1075	0.0691	0.0464
490	0.8003	0.7736	0.7453	0.6662	0.5461	0.4975	0.4518	0.7689	0.6334	0.5175	0.4048	0.0912	0.0584	0.0417
500	0.7967	0.7649	0.7323	0.6419	0.5063	0.4520	0.4036	0.7621	0.6165	0.4964	0.3780	0.0793	0.0513	0.0386
510	0.7909	0.7512	0.7116	0.6057	0.4506	0.3899	0.3388	0.7533	0.5967	0.4721	0.3484	0.0709	0.0473	0.0369
520	0.7820	0.7310	0.6811	0.5547	0.3777	0.3117	0.2601	0.7423	0.5743	0.4458	0.3174	0.0673	0.0473	0.0372
530	0.7713	0.7047	0.6422	0.4931	0.2967	0.2281	0.1797	0.7338	0.5580	0.4280	0.2975	0.0687	0.0512	0.0399
540	0.7589	0.6750	0.5992	0.4289	0.2205	0.1540	0.1136	0.7284	0.5507	0.4204	0.2901	0.0708	0.0544	0.0423
550	0.7446	0.6411	0.5520	0.3633	0.1538	0.0954	0.0674	0.7227	0.5400	0.4093	0.2777	0.0735	0.0578	0.0442
560	0.7278	0.6046	0.5028	0.3013	0.1031	0.0584	0.0437	0.7120	0.5199	0.3871	0.2539	0.0819	0.0672	0.0502
570	0.7128	0.5739	0.4635	0.2555	0.0761	0.0443	0.0372	0.7021	0.4997	0.3670	0.2350	0.1009	0.0891	0.0677
580	0.7015	0.5532	0.4383	0.2289	0.0663	0.0425	0.0374	0.7110	0.5232	0.3976	0.2758	0.1199	0.1091	0.0879
590	0.6947	0.5411	0.4236	0.2145	0.0637	0.0440	0.0393	0.7444	0.6192	0.5175	0.4232	0.1754	0.1430	0.1092
600	0.6885	0.5303	0.4110	0.2029	0.0636	0.0469	0.0420	0.7698	0.7157	0.6571	0.6057	0.3582	0.2996	0.2358
610	0.6850	0.5228	0.4018	0.1949	0.0654	0.0510	0.0456	0.7794	0.7591	0.7321	0.7103	0.5538	0.4995	0.4364
620	0.6855	0.5209	0.3988	0.1927	0.0684	0.0555	0.0495	0.7845	0.7768	0.7645	0.7573	0.6794	0.6432	0.5996
630	0.6873	0.5213	0.3987	0.1932	0.0715	0.0592	0.0527	0.7883	0.7847	0.7784	0.7769	0.7391	0.7180	0.6923
640	0.6893	0.5232	0.4001	0.1953	0.0748	0.0627	0.0561	0.7902	0.7885	0.7843	0.7851	0.7644	0.7510	0.7356
650	0.6933	0.5290	0.4064	0.2020	0.0781	0.0653	0.0585	0.7918	0.7907	0.7877	0.7892	0.7755	0.7656	0.7549
660	0.6989	0.5378	0.4162	0.2118	0.0810	0.0660	0.0590	0.7931	0.7928	0.7903	0.7920	0.7812	0.7728	0.7648
670	0.7020	0.5431	0.4225	0.2178	0.0819	0.0652	0.0582	0.7938	0.7936	0.7914	0.7935	0.7841	0.7764	0.7702
680	0.7019	0.5419	0.4207	0.2158	0.0808	0.0646	0.0576	0.7946	0.7947	0.7923	0.7950	0.7865	0.7794	0.7741
690	0.6994	0.5362	0.4140	0.2094	0.0794	0.0651	0.0583	0.7949	0.7953	0.7933	0.7958	0.7885	0.7818	0.7766
700	0.6953	0.5280	0.4039	0.2008	0.0797	0.0682	0.0612	0.7956	0.7963	0.7946	0.7968	0.7905	0.7842	0.7794

Wavelength (nm)	2% Yellow	10% Yellow	20% Yellow	30% Yellow	50% Yellow	75% Yellow	100% Yellow	2% Black	10% Black	20% Black	30% Black	50% Black	75% Black	100% Black
400	0.3811	0.3404	0.3024	0.2587	0.0733	0.0561	0.0551	0.3734	0.2764	0.1814	0.1512	0.0613	0.0589	0.0553
410	0.4993	0.4330	0.3814	0.3099	0.0693	0.0527	0.0514	0.4930	0.3616	0.2303	0.1859	0.0627	0.0603	0.0563
420	0.6509	0.5476	0.4808	0.3706	0.0683	0.0527	0.0507	0.6502	0.4694	0.2897	0.2266	0.0634	0.0605	0.0566
430	0.7173	0.5949	0.5209	0.3922	0.0691	0.0551	0.0524	0.7220	0.5181	0.3164	0.2450	0.0641	0.0611	0.0569
440	0.7309	0.6034	0.5280	0.3948	0.0719	0.0588	0.0553	0.7401	0.5304	0.3241	0.2512	0.0645	0.0614	0.0572
450	0.7336	0.6066	0.5331	0.4008	0.0776	0.0639	0.0596	0.7424	0.5331	0.3267	0.2540	0.0650	0.0619	0.0577
460	0.7358	0.6147	0.5441	0.4167	0.0851	0.0680	0.0628	0.7394	0.5320	0.3274	0.2553	0.0652	0.0618	0.0577
470	0.7369	0.6202	0.5520	0.4282	0.0910	0.0709	0.0651	0.7369	0.5313	0.3278	0.2568	0.0657	0.0622	0.0579
480	0.7390	0.6255	0.5593	0.4382	0.0993	0.0763	0.0698	0.7363	0.5311	0.3286	0.2581	0.0658	0.0621	0.0578
490	0.7479	0.6484	0.5874	0.4773	0.1323	0.0972	0.0879	0.7326	0.5299	0.3284	0.2587	0.0661	0.0624	0.0580
500	0.7703	0.6993	0.6509	0.5651	0.2324	0.1720	0.1578	0.7313	0.5293	0.3285	0.2593	0.0662	0.0623	0.0578
510	0.7899	0.7530	0.7255	0.6757	0.4280	0.3532	0.3384	0.7288	0.5274	0.3276	0.2593	0.0665	0.0625	0.0579
520	0.7967	0.7814	0.7705	0.7503	0.6258	0.5715	0.5612	0.7248	0.5246	0.3258	0.2581	0.0667	0.0624	0.0576
530	0.7957	0.7888	0.7854	0.7782	0.7272	0.7006	0.6955	0.7208	0.5212	0.3235	0.2566	0.0672	0.0629	0.0580
540	0.7930	0.7882	0.7871	0.7841	0.7586	0.7449	0.7423	0.7172	0.5177	0.3210	0.2551	0.0678	0.0635	0.0584
550	0.7904	0.7867	0.7861	0.7847	0.7680	0.7592	0.7574	0.7141	0.5151	0.3189	0.2537	0.0690	0.0646	0.0592
560	0.7872	0.7839	0.7838	0.7834	0.7702	0.7633	0.7622	0.7109	0.5119	0.3167	0.2520	0.0700	0.0658	0.0603
570	0.7852	0.7823	0.7825	0.7825	0.7715	0.7659	0.7649	0.7087	0.5098	0.3150	0.2512	0.0712	0.0670	0.0613
580	0.7832	0.7803	0.7812	0.7811	0.7716	0.7672	0.7661	0.7065	0.5081	0.3138	0.2508	0.0724	0.0685	0.0627
590	0.7823	0.7795	0.7804	0.7806	0.7722	0.7683	0.7673	0.7052	0.5071	0.3133	0.2510	0.0735	0.0700	0.0640
600	0.7812	0.7784	0.7795	0.7800	0.7722	0.7694	0.7683	0.7046	0.5067	0.3132	0.2516	0.0747	0.0713	0.0655
610	0.7823	0.7794	0.7799	0.7804	0.7734	0.7707	0.7698	0.7056	0.5072	0.3139	0.2528	0.0755	0.0725	0.0666
620	0.7851	0.7817	0.7823	0.7824	0.7762	0.7739	0.7729	0.7081	0.5091	0.3154	0.2546	0.0764	0.0735	0.0677
630	0.7879	0.7844	0.7848	0.7852	0.7791	0.7774	0.7762	0.7111	0.5116	0.3172	0.2569	0.0772	0.0746	0.0687
640	0.7904	0.7862	0.7867	0.7872	0.7818	0.7800	0.7790	0.7133	0.5138	0.3192	0.2592	0.0779	0.0756	0.0697
650	0.7918	0.7878	0.7883	0.7889	0.7839	0.7822	0.7809	0.7157	0.5161	0.3214	0.2618	0.0784	0.0764	0.0705
660	0.7935	0.7893	0.7897	0.7903	0.7856	0.7841	0.7831	0.7177	0.5184	0.3236	0.2646	0.0789	0.0770	0.0712
670	0.7943	0.7900	0.7905	0.7913	0.7865	0.7855	0.7842	0.7193	0.5206	0.3260	0.2672	0.0795	0.0776	0.0719
680	0.7952	0.7906	0.7913	0.7918	0.7872	0.7860	0.7851	0.7211	0.5226	0.3281	0.2699	0.0799	0.0782	0.0725
690	0.7956	0.7909	0.7914	0.7922	0.7872	0.7858	0.7853	0.7222	0.5245	0.3302	0.2725	0.0802	0.0787	0.0730
700	0.7966	0.7918	0.7924	0.7932	0.7888	0.7876	0.7869	0.7240	0.5267	0.3327	0.2752	0.0807	0.0792	0.0734

Table D-3 The data set of reflectance ratio of Hostmann four-colour process inks.

Wavelength (nm)	2% Green	10% Green	20% Green	30% Green	50% Green	75% Green	100% Green	2% Green52	10% Green52	20% Green52	30% Green52	50% Green52	75% Green52	100% Green52
400	0.3778	0.3390	0.3218	0.2851	0.1171	0.0715	0.0638	0.3860	0.3326	0.2855	0.2246	0.1019	0.0770	0.0619
410	0.4937	0.4349	0.4179	0.3712	0.1419	0.0808	0.0715	0.5047	0.4275	0.3627	0.2761	0.1062	0.0768	0.0608
420	0.6460	0.5587	0.5459	0.4856	0.1787	0.0971	0.0864	0.6553	0.5447	0.4550	0.3330	0.1069	0.0749	0.0591
430	0.7202	0.6208	0.6148	0.5482	0.2118	0.1176	0.1060	0.7225	0.5954	0.4933	0.3546	0.1055	0.0736	0.0590
440	0.7438	0.6444	0.6455	0.5792	0.2457	0.1438	0.1323	0.7374	0.6061	0.5008	0.3581	0.1052	0.0742	0.0602
450	0.7546	0.6600	0.6693	0.6056	0.2891	0.1826	0.1720	0.7405	0.6094	0.5051	0.3639	0.1119	0.0795	0.0640
460	0.7641	0.6795	0.6972	0.6402	0.3564	0.2486	0.2404	0.7410	0.6138	0.5141	0.3776	0.1277	0.0908	0.0707
470	0.7767	0.7067	0.7309	0.6839	0.4499	0.3479	0.3429	0.7417	0.6174	0.5206	0.3880	0.1407	0.1005	0.0769
480	0.7886	0.7343	0.7582	0.7231	0.5399	0.4499	0.4475	0.7427	0.6204	0.5257	0.3961	0.1521	0.1102	0.0840
490	0.7933	0.7527	0.7736	0.7480	0.6094	0.5339	0.5334	0.7500	0.6366	0.5496	0.4300	0.2007	0.1530	0.1177
500	0.7945	0.7600	0.7784	0.7567	0.6353	0.5672	0.5673	0.7676	0.6733	0.5997	0.5012	0.3111	0.2592	0.2107
510	0.7908	0.7557	0.7750	0.7529	0.6282	0.5588	0.5588	0.7811	0.7098	0.6499	0.5744	0.4348	0.3862	0.3329
520	0.7845	0.7454	0.7663	0.7416	0.6015	0.5262	0.5258	0.7809	0.7166	0.6609	0.5929	0.4681	0.4221	0.3691
530	0.7767	0.7312	0.7541	0.7251	0.5623	0.4784	0.4769	0.7719	0.7000	0.6404	0.5654	0.4217	0.3723	0.3186
540	0.7674	0.7136	0.7382	0.7032	0.5111	0.4174	0.4142	0.7594	0.6753	0.6090	0.5224	0.3493	0.2964	0.2432
550	0.7566	0.6931	0.7176	0.6754	0.4479	0.3450	0.3393	0.7457	0.6488	0.5746	0.4749	0.2716	0.2175	0.1686
560	0.7440	0.6707	0.6922	0.6431	0.3790	0.2694	0.2617	0.7293	0.6210	0.5383	0.4265	0.1990	0.1478	0.1077
570	0.7315	0.6498	0.6655	0.6105	0.3123	0.2001	0.1907	0.7162	0.5996	0.5100	0.3890	0.1489	0.1030	0.0734
580	0.7184	0.6291	0.6363	0.5768	0.2481	0.1389	0.1287	0.7068	0.5850	0.4910	0.3650	0.1215	0.0811	0.0589
590	0.7052	0.6098	0.6047	0.5426	0.1874	0.0890	0.0796	0.7000	0.5754	0.4783	0.3493	0.1066	0.0705	0.0531
600	0.6917	0.5916	0.5729	0.5108	0.1368	0.0584	0.0509	0.6939	0.5668	0.4666	0.3350	0.0951	0.0634	0.0500
610	0.6841	0.5811	0.5534	0.4921	0.1123	0.0496	0.0430	0.6908	0.5608	0.4582	0.3248	0.0889	0.0604	0.0493
620	0.6814	0.5768	0.5449	0.4839	0.1042	0.0500	0.0433	0.6907	0.5590	0.4548	0.3203	0.0880	0.0609	0.0506
630	0.6812	0.5755	0.5424	0.4814	0.1030	0.0526	0.0451	0.6921	0.5590	0.4539	0.3189	0.0891	0.0625	0.0520
640	0.6815	0.5744	0.5410	0.4799	0.1033	0.0552	0.0471	0.6934	0.5595	0.4541	0.3191	0.0915	0.0648	0.0542
650	0.6814	0.5738	0.5403	0.4790	0.1048	0.0587	0.0497	0.6960	0.5618	0.4569	0.3228	0.0968	0.0688	0.0567
660	0.6834	0.5746	0.5435	0.4816	0.1113	0.0636	0.0539	0.6998	0.5666	0.4632	0.3307	0.1049	0.0742	0.0597
670	0.6865	0.5777	0.5520	0.4891	0.1239	0.0699	0.0592	0.7028	0.5703	0.4684	0.3377	0.1114	0.0784	0.0617
680	0.6915	0.5828	0.5638	0.4994	0.1399	0.0772	0.0660	0.7041	0.5712	0.4695	0.3390	0.1125	0.0789	0.0618
690	0.6961	0.5880	0.5755	0.5102	0.1563	0.0855	0.0738	0.7032	0.5689	0.4666	0.3356	0.1095	0.0769	0.0607
700	0.7004	0.5930	0.5853	0.5193	0.1695	0.0928	0.0810	0.7008	0.5648	0.4610	0.3286	0.1041	0.0738	0.0597

Wavelength (nm)	2% OY42	10% OY42	20% OY42	30% OY42	50% OY42	75% OY42	100% OY42	2% O31	10% O31	20% O31	30% O31	50% O31	75% O31	100% O31
400	0.3815	0.3323	0.2988	0.2281	0.0780	0.0554	0.0523	0.3774	0.3285	0.2941	0.2044	0.0687	0.0524	0.0509
410	0.4976	0.4242	0.3697	0.2673	0.0751	0.0512	0.0487	0.4836	0.4198	0.3741	0.2471	0.0692	0.0520	0.0497
420	0.6462	0.5402	0.4550	0.3121	0.0737	0.0500	0.0480	0.6178	0.5374	0.4744	0.2977	0.0710	0.0524	0.0498
430	0.7117	0.5903	0.4905	0.3287	0.0737	0.0514	0.0496	0.6789	0.5901	0.5186	0.3179	0.0722	0.0534	0.0510
440	0.7255	0.6000	0.4968	0.3298	0.0753	0.0543	0.0527	0.6929	0.6020	0.5283	0.3213	0.0738	0.0548	0.0522
450	0.7269	0.6010	0.4981	0.3311	0.0803	0.0590	0.0571	0.6947	0.6035	0.5296	0.3222	0.0764	0.0569	0.0541
460	0.7258	0.6019	0.5008	0.3370	0.0870	0.0629	0.0601	0.6930	0.6016	0.5282	0.3222	0.0794	0.0582	0.0554
470	0.7242	0.6019	0.5020	0.3405	0.0919	0.0657	0.0623	0.6908	0.5997	0.5266	0.3218	0.0826	0.0606	0.0575
480	0.7242	0.6027	0.5037	0.3446	0.0991	0.0711	0.0668	0.6915	0.6007	0.5275	0.3252	0.0899	0.0651	0.0615
490	0.7294	0.6133	0.5187	0.3678	0.1276	0.0915	0.0827	0.6963	0.6069	0.5346	0.3408	0.1102	0.0764	0.0718
500	0.7458	0.6421	0.5562	0.4252	0.2007	0.1534	0.1351	0.7085	0.6220	0.5512	0.3714	0.1476	0.0986	0.0931
510	0.7628	0.6776	0.6041	0.5003	0.3099	0.2608	0.2349	0.7174	0.6343	0.5657	0.3985	0.1835	0.1231	0.1172
520	0.7712	0.7004	0.6365	0.5529	0.3929	0.3480	0.3203	0.7194	0.6377	0.5703	0.4088	0.1998	0.1353	0.1297
530	0.7740	0.7142	0.6580	0.5888	0.4526	0.4123	0.3852	0.7177	0.6366	0.5700	0.4111	0.2054	0.1399	0.1345
540	0.7781	0.7325	0.6868	0.6349	0.5290	0.4964	0.4711	0.7164	0.6361	0.5701	0.4137	0.2119	0.1456	0.1406
550	0.7831	0.7551	0.7243	0.6928	0.6254	0.6037	0.5835	0.7192	0.6408	0.5764	0.4262	0.2328	0.1640	0.1599
560	0.7848	0.7717	0.7556	0.7399	0.7063	0.6957	0.6827	0.7287	0.6562	0.5956	0.4608	0.2885	0.2157	0.2134
570	0.7852	0.7798	0.7726	0.7654	0.7507	0.7464	0.7384	0.7484	0.6905	0.6401	0.5364	0.4100	0.3374	0.3381
580	0.7839	0.7817	0.7788	0.7749	0.7681	0.7666	0.7616	0.7689	0.7341	0.7010	0.6407	0.5758	0.5192	0.5214
590	0.7830	0.7821	0.7807	0.7784	0.7751	0.7745	0.7706	0.7795	0.7643	0.7493	0.7241	0.7018	0.6716	0.6725
600	0.7821	0.7818	0.7812	0.7791	0.7774	0.7777	0.7742	0.7829	0.7773	0.7727	0.7659	0.7609	0.7494	0.7490
610	0.7831	0.7829	0.7824	0.7807	0.7795	0.7804	0.7773	0.7853	0.7822	0.7814	0.7805	0.7803	0.7756	0.7753
620	0.7858	0.7854	0.7849	0.7834	0.7824	0.7836	0.7802	0.7876	0.7856	0.7861	0.7869	0.7882	0.7859	0.7852
630	0.7886	0.7882	0.7876	0.7862	0.7857	0.7872	0.7838	0.7906	0.7885	0.7896	0.7910	0.7926	0.7913	0.7907
640	0.7907	0.7902	0.7898	0.7884	0.7881	0.7901	0.7864	0.7923	0.7903	0.7915	0.7937	0.7956	0.7946	0.7938
650	0.7920	0.7917	0.7912	0.7901	0.7902	0.7922	0.7885	0.7937	0.7914	0.7930	0.7949	0.7969	0.7959	0.7952
660	0.7935	0.7931	0.7929	0.7918	0.7918	0.7942	0.7903	0.7951	0.7927	0.7943	0.7962	0.7983	0.7971	0.7968
670	0.7938	0.7938	0.7937	0.7926	0.7930	0.7952	0.7914	0.7956	0.7929	0.7946	0.7966	0.7984	0.7975	0.7969
680	0.7948	0.7947	0.7947	0.7939	0.7939	0.7964	0.7924	0.7965	0.7937	0.7955	0.7972	0.7991	0.7978	0.7974
690	0.7950	0.7948	0.7950	0.7938	0.7941	0.7965	0.7922	0.7967	0.7935	0.7953	0.7971	0.7987	0.7975	0.7970
700	0.7957	0.7956	0.7959	0.7949	0.7952	0.7977	0.7935	0.7975	0.7942	0.7962	0.7978	0.7998	0.7983	0.7981

Table D-4 The data set of reflectance ratio of HIZGT special inks that is Green, Green 52, Orange yellow 42 (OY) and Orange 31 (O31).

Wavelength (nm)	2% Bl58	10% Bl58	20% Bl58	30% Bl58	50% Bl58	75% Bl58	100% Bl58	2% M14	10% M14	20% M14	30% M14	50% M14	75% M14	100% M14
400	0.3984	0.3937	0.3526	0.2670	0.1831	0.1567	0.1330	0.3906	0.3408	0.3075	0.2679	0.1048	0.0873	0.0988
410	0.5248	0.5179	0.4690	0.3605	0.2578	0.2236	0.1919	0.5062	0.4403	0.3947	0.3401	0.1184	0.0953	0.1086
420	0.6867	0.6762	0.6175	0.4702	0.3379	0.2943	0.2535	0.6537	0.5676	0.5052	0.4307	0.1365	0.1071	0.1232
430	0.7684	0.7573	0.7000	0.5464	0.4145	0.3682	0.3235	0.7228	0.6269	0.5571	0.4733	0.1480	0.1157	0.1333
440	0.7966	0.7888	0.7430	0.6130	0.5080	0.4661	0.4227	0.7402	0.6428	0.5716	0.4865	0.1542	0.1208	0.1394
450	0.8063	0.8011	0.7671	0.6630	0.5834	0.5477	0.5082	0.7411	0.6430	0.5720	0.4862	0.1504	0.1166	0.1344
460	0.8051	0.8005	0.7708	0.6760	0.6044	0.5715	0.5344	0.7330	0.6332	0.5619	0.4739	0.1348	0.1011	0.1166
470	0.8021	0.7982	0.7697	0.6767	0.6065	0.5742	0.5387	0.7233	0.6203	0.5481	0.4575	0.1162	0.0832	0.0959
480	0.7996	0.7951	0.7648	0.6661	0.5902	0.5565	0.5198	0.7144	0.6083	0.5350	0.4406	0.0996	0.0686	0.0782
490	0.7929	0.7879	0.7544	0.6449	0.5579	0.5209	0.4825	0.7045	0.5960	0.5221	0.4248	0.0868	0.0584	0.0654
500	0.7868	0.7803	0.7409	0.6162	0.5128	0.4708	0.4297	0.6962	0.5853	0.5106	0.4105	0.0774	0.0519	0.0568
510	0.7770	0.7688	0.7212	0.5774	0.4516	0.4041	0.3602	0.6871	0.5741	0.4987	0.3959	0.0706	0.0481	0.0512
520	0.7640	0.7524	0.6949	0.5285	0.3742	0.3221	0.2767	0.6767	0.5616	0.4860	0.3802	0.0661	0.0472	0.0490
530	0.7473	0.7325	0.6638	0.4743	0.2897	0.2353	0.1918	0.6682	0.5526	0.4766	0.3692	0.0658	0.0497	0.0510
540	0.7290	0.7110	0.6328	0.4219	0.2121	0.1596	0.1220	0.6630	0.5473	0.4718	0.3638	0.0669	0.0522	0.0534
550	0.7100	0.6891	0.6021	0.3717	0.1463	0.1004	0.0729	0.6580	0.5418	0.4667	0.3576	0.0681	0.0548	0.0556
560	0.6896	0.6661	0.5718	0.3253	0.0974	0.0630	0.0469	0.6492	0.5324	0.4573	0.3457	0.0722	0.0609	0.0614
570	0.6730	0.6486	0.5492	0.2913	0.0720	0.0487	0.0395	0.6410	0.5236	0.4485	0.3349	0.0843	0.0767	0.0771
580	0.6618	0.6366	0.5343	0.2710	0.0628	0.0461	0.0396	0.6465	0.5314	0.4570	0.3507	0.1017	0.0941	0.0951
590	0.6549	0.6295	0.5255	0.2593	0.0600	0.0470	0.0416	0.6791	0.5773	0.5079	0.4198	0.1463	0.1257	0.1360
600	0.6485	0.6230	0.5177	0.2496	0.0595	0.0492	0.0444	0.7244	0.6502	0.5914	0.5267	0.2811	0.2607	0.2899
610	0.6447	0.6188	0.5120	0.2423	0.0606	0.0526	0.0480	0.7572	0.7132	0.6685	0.6265	0.4625	0.4544	0.4865
620	0.6444	0.6178	0.5099	0.2395	0.0633	0.0565	0.0519	0.7757	0.7558	0.7279	0.7052	0.6208	0.6188	0.6413
630	0.6449	0.6182	0.5094	0.2387	0.0660	0.0597	0.0553	0.7848	0.7772	0.7627	0.7524	0.7130	0.7123	0.7259
640	0.6461	0.6189	0.5097	0.2391	0.0691	0.0631	0.0587	0.7892	0.7867	0.7789	0.7747	0.7549	0.7545	0.7632
650	0.6492	0.6215	0.5123	0.2432	0.0723	0.0657	0.0612	0.7916	0.7909	0.7861	0.7843	0.7724	0.7719	0.7790
660	0.6541	0.6259	0.5176	0.2505	0.0753	0.0667	0.0618	0.7930	0.7935	0.7898	0.7890	0.7803	0.7799	0.7861
670	0.6569	0.6285	0.5211	0.2553	0.0763	0.0661	0.0609	0.7936	0.7945	0.7914	0.7913	0.7841	0.7836	0.7896
680	0.6573	0.6288	0.5206	0.2542	0.0753	0.0653	0.0602	0.7946	0.7958	0.7930	0.7933	0.7867	0.7862	0.7920
690	0.6545	0.6260	0.5170	0.2491	0.0737	0.0652	0.0605	0.7948	0.7962	0.7934	0.7939	0.7883	0.7872	0.7928
700	0.6499	0.6215	0.5111	0.2413	0.0735	0.0674	0.0630	0.7957	0.7973	0.7948	0.7954	0.7903	0.7894	0.7944
Wavelength (nm)	2% Y47	10% Y47	20% Y47	30% Y47	50% Y47	75% Y47	100% Y47	2% Bk84	10% Bk84	20% Bk84	30% Bk84	50% Bk84	75% Bk84	100% Bk84
400	0.3811	0.3396	0.2971	0.2477	0.0988	0.0677	0.0627	0.3588	0.2750	0.2135	0.0923	0.0618	0.0542	0.0541
410	0.4954	0.4341	0.3753	0.3014	0.0946	0.0606	0.0566	0.4620	0.3468	0.2654	0.1040	0.0636	0.0556	0.0549
420	0.6410	0.5533	0.4710	0.3640	0.0919	0.0568	0.0542	0.5922	0.4340	0.3273	0.1161	0.0645	0.0563	0.0555
430	0.7054	0.6047	0.5103	0.3876	0.0895	0.0564	0.0543	0.6518	0.4736	0.3558	0.1223	0.0657	0.0569	0.0560
440	0.7189	0.6145	0.5172	0.3901	0.0888	0.0582	0.0563	0.6661	0.4834	0.3637	0.1250	0.0665	0.0574	0.0564
450	0.7208	0.6158	0.5184	0.3917	0.0944	0.0629	0.0608	0.6676	0.4848	0.3659	0.1268	0.0672	0.0580	0.0570
460	0.7209	0.6168	0.5213	0.3981	0.1061	0.0693	0.0658	0.6645	0.4836	0.3664	0.1280	0.0676	0.0582	0.0570
470	0.7209	0.6178	0.5232	0.4027	0.1147	0.0744	0.0698	0.6623	0.4823	0.3667	0.1296	0.0685	0.0589	0.0577
480	0.7216	0.6192	0.5256	0.4071	0.1246	0.0819	0.0762	0.6613	0.4819	0.3674	0.1306	0.0688	0.0590	0.0578
490	0.7291	0.6317	0.5436	0.4332	0.1690	0.1159	0.1061	0.6578	0.4805	0.3676	0.1319	0.0695	0.0596	0.0583
500	0.7529	0.6689	0.5939	0.5039	0.2889	0.2245	0.2088	0.6564	0.4795	0.3677	0.1328	0.0698	0.0598	0.0584
510	0.7810	0.7241	0.6728	0.6162	0.4908	0.4347	0.4180	0.6539	0.4778	0.3673	0.1336	0.0704	0.0603	0.0588
520	0.7960	0.7693	0.7431	0.7180	0.6706	0.6399	0.6293	0.6508	0.4756	0.3665	0.1338	0.0709	0.0604	0.0590
530	0.7986	0.7876	0.7765	0.7680	0.7527	0.7393	0.7353	0.6469	0.4729	0.3652	0.1341	0.0713	0.0609	0.0594
540	0.7968	0.7909	0.7844	0.7818	0.7752	0.7682	0.7667	0.6437	0.4706	0.3641	0.1344	0.0720	0.0615	0.0600
550	0.7945	0.7905	0.7858	0.7851	0.7813	0.7765	0.7762	0.6411	0.4688	0.3635	0.1350	0.0728	0.0624	0.0610
560	0.7916	0.7879	0.7839	0.7841	0.7815	0.7780	0.7782	0.6381	0.4663	0.3621	0.1353	0.0736	0.0632	0.0617
570	0.7897	0.7865	0.7831	0.7834	0.7816	0.7790	0.7793	0.6365	0.4650	0.3619	0.1360	0.0744	0.0640	0.0626
580	0.7877	0.7847	0.7816	0.7821	0.7808	0.7785	0.7793	0.6346	0.4636	0.3615	0.1368	0.0752	0.0649	0.0635
590	0.7866	0.7835	0.7808	0.7816	0.7811	0.7792	0.7798	0.6333	0.4628	0.3613	0.1378	0.0761	0.0659	0.0644
600	0.7856	0.7828	0.7804	0.7813	0.7809	0.7790	0.7800	0.6326	0.4623	0.3618	0.1391	0.0771	0.0669	0.0655
610	0.7869	0.7838	0.7813	0.7823	0.7822	0.7804	0.7816	0.6332	0.4627	0.3623	0.1402	0.0777	0.0678	0.0662
620	0.7893	0.7865	0.7838	0.7847	0.7848	0.7828	0.7844	0.6352	0.4641	0.3637	0.1417	0.0784	0.0685	0.0670
630	0.7917	0.7893	0.7864	0.7874	0.7877	0.7860	0.7874	0.6373	0.4655	0.3654	0.1433	0.0791	0.0693	0.0676
640	0.7938	0.7917	0.7885	0.7897	0.7902	0.7884	0.7900	0.6393	0.4671	0.3669	0.1451	0.0798	0.0700	0.0684
650	0.7956	0.7934	0.7900	0.7916	0.7924	0.7904	0.7918	0.6408	0.4682	0.3683	0.1468	0.0803	0.0707	0.0688
660	0.7969	0.7948	0.7914	0.7930	0.7941	0.7920	0.7937	0.6424	0.4695	0.3699	0.1487	0.0809	0.0713	0.0694
670	0.7973	0.7954	0.7918	0.7936	0.7951	0.7928	0.7947	0.6432	0.4706	0.3714	0.1507	0.0817	0.0720	0.0701
680	0.7982	0.7964	0.7926	0.7945	0.7962	0.7939	0.7958	0.6444	0.4717	0.3727	0.1525	0.0823	0.0726	0.0706
690	0.7984	0.7967	0.7928	0.7947	0.7966	0.7943	0.7962	0.6453	0.4728	0.3741	0.1545	0.0827	0.0731	0.0710
700	0.7992	0.7977	0.7937	0.7957	0.7976	0.7955	0.7971	0.6463	0.4739	0.3757	0.1564	0.0832	0.0735	0.0713

Table D-5 The data set of reflectance ratio of HIZGT special inks that is proccess Blue 58 (Bl58), Process Magenta14 (M14), Process Yellow 47 (Y47) and Black 84 (Bk84).

Wavelength (nm)	2% Bl62	10% Bl62	20% Bl62	30% Bl62	50% Bl62	75% Bl62	100% Bl62	2% Bl61	10% Bl61	20% Bl61	30% Bl61	50% Bl61	75% Bl61	100% Bl61
400	0.4041	0.3776	0.3351	0.3000	0.2500	0.2271	0.1939	0.3998	0.3400	0.3040	0.2728	0.1525	0.1408	0.1255
410	0.5317	0.4959	0.4413	0.3897	0.3200	0.2874	0.2418	0.5232	0.4487	0.4018	0.3619	0.2041	0.1909	0.1697
420	0.6988	0.6490	0.5791	0.5049	0.4086	0.3631	0.3020	0.6814	0.5866	0.5252	0.4692	0.2579	0.2419	0.2147
430	0.7764	0.7208	0.6444	0.5606	0.4524	0.4012	0.3334	0.7587	0.6596	0.5932	0.5326	0.3063	0.2909	0.2607
440	0.7950	0.7382	0.6604	0.5733	0.4622	0.4092	0.3404	0.7836	0.6933	0.6284	0.5712	0.3583	0.3466	0.3153
450	0.7948	0.7367	0.6575	0.5651	0.4515	0.3980	0.3291	0.7903	0.7077	0.6454	0.5918	0.3909	0.3813	0.3500
460	0.7869	0.7255	0.6431	0.5400	0.4214	0.3669	0.2985	0.7867	0.7050	0.6427	0.5890	0.3858	0.3752	0.3439
470	0.7765	0.7096	0.6219	0.5002	0.3744	0.3193	0.2520	0.7809	0.6964	0.6330	0.5771	0.3651	0.3520	0.3208
480	0.7648	0.6900	0.5943	0.4464	0.3135	0.2584	0.1945	0.7762	0.6858	0.6205	0.5609	0.3357	0.3195	0.2884
490	0.7477	0.6661	0.5617	0.3829	0.2470	0.1936	0.1366	0.7675	0.6718	0.6043	0.5413	0.3020	0.2827	0.2518
500	0.7330	0.6459	0.5334	0.3241	0.1895	0.1401	0.0928	0.7605	0.6575	0.5876	0.5203	0.2664	0.2438	0.2139
510	0.7181	0.6276	0.5077	0.2733	0.1445	0.1009	0.0648	0.7507	0.6397	0.5672	0.4946	0.2259	0.1996	0.1715
520	0.7048	0.6125	0.4872	0.2327	0.1130	0.0757	0.0497	0.7392	0.6193	0.5435	0.4648	0.1824	0.1529	0.1280
530	0.6931	0.6000	0.4713	0.2027	0.0930	0.0614	0.0427	0.7274	0.5999	0.5212	0.4368	0.1463	0.1149	0.0942
540	0.6840	0.5912	0.4599	0.1827	0.0816	0.0545	0.0404	0.7168	0.5831	0.5022	0.4130	0.1189	0.0875	0.0710
550	0.6769	0.5842	0.4520	0.1693	0.0759	0.0516	0.0403	0.7056	0.5651	0.4812	0.3860	0.0929	0.0642	0.0531
560	0.6707	0.5782	0.4458	0.1604	0.0728	0.0509	0.0411	0.6919	0.5447	0.4577	0.3553	0.0710	0.0488	0.0430
570	0.6666	0.5740	0.4417	0.1552	0.0721	0.0518	0.0428	0.6805	0.5283	0.4387	0.3308	0.0617	0.0466	0.0436
580	0.6639	0.5713	0.4396	0.1553	0.0740	0.0541	0.0453	0.6750	0.5208	0.4307	0.3224	0.0635	0.0517	0.0492
590	0.6627	0.5701	0.4395	0.1591	0.0771	0.0569	0.0475	0.6740	0.5198	0.4300	0.3233	0.0656	0.0537	0.0511
600	0.6622	0.5690	0.4398	0.1636	0.0805	0.0596	0.0494	0.6712	0.5158	0.4260	0.3189	0.0648	0.0536	0.0514
610	0.6635	0.5697	0.4413	0.1684	0.0839	0.0622	0.0512	0.6692	0.5119	0.4212	0.3131	0.0646	0.0551	0.0531
620	0.6669	0.5721	0.4444	0.1753	0.0883	0.0656	0.0532	0.6695	0.5105	0.4188	0.3104	0.0662	0.0579	0.0558
630	0.6705	0.5749	0.4483	0.1842	0.0941	0.0697	0.0557	0.6707	0.5101	0.4181	0.3094	0.0681	0.0606	0.0585
640	0.6744	0.5781	0.4530	0.1954	0.1014	0.0750	0.0583	0.6720	0.5103	0.4179	0.3095	0.0706	0.0636	0.0613
650	0.6789	0.5819	0.4588	0.2092	0.1107	0.0818	0.0619	0.6743	0.5125	0.4202	0.3132	0.0737	0.0661	0.0637
660	0.6843	0.5870	0.4659	0.2263	0.1228	0.0910	0.0670	0.6781	0.5170	0.4250	0.3202	0.0768	0.0673	0.0643
670	0.6894	0.5924	0.4742	0.2467	0.1383	0.1034	0.0742	0.6799	0.5197	0.4283	0.3246	0.0781	0.0669	0.0634
680	0.6958	0.5993	0.4840	0.2701	0.1572	0.1191	0.0844	0.6803	0.5193	0.4277	0.3236	0.0769	0.0659	0.0625
690	0.7033	0.6076	0.4955	0.2975	0.1806	0.1397	0.0989	0.6788	0.5162	0.4237	0.3187	0.0750	0.0653	0.0624
700	0.7115	0.6178	0.5090	0.3285	0.2089	0.1654	0.1188	0.6759	0.5111	0.4180	0.3111	0.0741	0.0670	0.0645
Wavelength (nm)	2% R29	10% R29	20% R29	30% R29	50% R29	75% R29	100% R29	2% R30	10% R30	20% R30	30% R30	50% R30	75% R30	100% R30
400	0.3793	0.3288	0.2813	0.2309	0.0892	0.0658	0.0690	0.3841	0.3193	0.2881	0.2477	0.0738	0.0568	0.0523
410	0.4932	0.4182	0.3515	0.2820	0.0949	0.0661	0.0690	0.4929	0.4087	0.3684	0.3018	0.0758	0.0561	0.0511
420	0.6395	0.5315	0.4389	0.3444	0.1025	0.0680	0.0705	0.6295	0.5215	0.4676	0.3672	0.0791	0.0564	0.0508
430	0.7057	0.5813	0.4769	0.3705	0.1043	0.0679	0.0703	0.6910	0.5709	0.5104	0.3947	0.0798	0.0566	0.0509
440	0.7201	0.5920	0.4842	0.3745	0.1024	0.0662	0.0685	0.7048	0.5817	0.5191	0.3996	0.0796	0.0566	0.0508
450	0.7181	0.5891	0.4804	0.3689	0.0963	0.0624	0.0641	0.7048	0.5811	0.5188	0.3986	0.0790	0.0563	0.0506
460	0.7080	0.5783	0.4680	0.3540	0.0851	0.0566	0.0577	0.6990	0.5751	0.5128	0.3923	0.0759	0.0545	0.0491
470	0.6971	0.5662	0.4537	0.3366	0.0754	0.0531	0.0536	0.6925	0.5678	0.5057	0.3844	0.0730	0.0537	0.0486
480	0.6883	0.5563	0.4413	0.3213	0.0693	0.0523	0.0525	0.6876	0.5621	0.4993	0.3773	0.0718	0.0542	0.0492
490	0.6774	0.5454	0.4293	0.3073	0.0667	0.0542	0.0543	0.6818	0.5557	0.4939	0.3722	0.0730	0.0565	0.0514
500	0.6708	0.5385	0.4214	0.2983	0.0672	0.0578	0.0581	0.6790	0.5527	0.4907	0.3696	0.0751	0.0590	0.0538
510	0.6659	0.5340	0.4166	0.2942	0.0698	0.0621	0.0624	0.6762	0.5502	0.4883	0.3682	0.0773	0.0616	0.0564
520	0.6623	0.5308	0.4141	0.2928	0.0722	0.0653	0.0659	0.6732	0.5477	0.4858	0.3668	0.0792	0.0634	0.0581
530	0.6586	0.5278	0.4118	0.2920	0.0752	0.0691	0.0696	0.6701	0.5450	0.4833	0.3654	0.0813	0.0658	0.0605
540	0.6560	0.5261	0.4110	0.2930	0.0797	0.0738	0.0745	0.6684	0.5432	0.4820	0.3655	0.0852	0.0696	0.0641
550	0.6580	0.5290	0.4161	0.3016	0.0883	0.0806	0.0812	0.6706	0.5467	0.4859	0.3719	0.0937	0.0761	0.0701
560	0.6685	0.5425	0.4346	0.3273	0.1070	0.0910	0.0919	0.6794	0.5603	0.5002	0.3924	0.1144	0.0896	0.0821
570	0.6946	0.5783	0.4821	0.3880	0.1600	0.1260	0.1314	0.7028	0.5968	0.5391	0.4456	0.1760	0.1371	0.1296
580	0.7309	0.6382	0.5605	0.4867	0.2859	0.2399	0.2570	0.7345	0.6558	0.6045	0.5368	0.3170	0.2712	0.2701
590	0.7611	0.7042	0.6505	0.5993	0.4707	0.4310	0.4537	0.7609	0.7175	0.6793	0.6406	0.5077	0.4703	0.4752
600	0.7757	0.7522	0.7234	0.6951	0.6403	0.6157	0.6311	0.7742	0.7592	0.7393	0.7221	0.6655	0.6440	0.6488
610	0.7821	0.7735	0.7600	0.7471	0.7285	0.7153	0.7228	0.7799	0.7770	0.7685	0.7608	0.7399	0.7295	0.7332
620	0.7865	0.7836	0.7762	0.7712	0.7669	0.7597	0.7638	0.7836	0.7855	0.7816	0.7774	0.7703	0.7654	0.7684
630	0.7897	0.7889	0.7840	0.7821	0.7828	0.7786	0.7811	0.7871	0.7906	0.7884	0.7856	0.7834	0.7805	0.7835
640	0.7921	0.7920	0.7879	0.7873	0.7900	0.7871	0.7892	0.7891	0.7934	0.7919	0.7896	0.7892	0.7876	0.7905
650	0.7938	0.7939	0.7903	0.7901	0.7932	0.7911	0.7927	0.7908	0.7954	0.7942	0.7918	0.7919	0.7909	0.7936
660	0.7950	0.7952	0.7916	0.7919	0.7950	0.7935	0.7949	0.7922	0.7967	0.7957	0.7935	0.7936	0.7930	0.7956
670	0.7953	0.7958	0.7922	0.7925	0.7953	0.7945	0.7960	0.7924	0.7972	0.7961	0.7939	0.7939	0.7935	0.7960
680	0.7962	0.7965	0.7927	0.7931	0.7959	0.7950	0.7966	0.7929	0.7978	0.7966	0.7947	0.7941	0.7939	0.7965
690	0.7964	0.7967	0.7932	0.7934	0.7960	0.7955	0.7967	0.7933	0.7983	0.7969	0.7944	0.7936	0.7936	0.7959
700	0.7970	0.7972	0.7941	0.7943	0.7971	0.7968	0.7978	0.7940	0.7989	0.7978	0.7958	0.7949	0.7951	0.7974

Table D-6 The data set of reflectance ratio of HIZGT special inks that is Bronze Blue 62 (Bl62), Bronze Blue 61 (Bl61), Bronze Red 29 (R29) and Bronze Red30 (R30).

Wavelength (nm)	2% Bl69	10% Bl69	20% Bl69	30% Bl69	50% Bl69	75% Bl69	100% Bl69	2% Bl54	10% Bl54	20% Bl54	30% Bl54	50% Bl54	75% Bl54	100% Bl54
400	0.3841	0.3362	0.2889	0.2394	0.1137	0.0855	0.0826	0.3922	0.3536	0.3206	0.2629	0.1718	0.1233	0.1260
410	0.5064	0.4404	0.3763	0.3075	0.1362	0.0964	0.0943	0.5170	0.4629	0.4237	0.3455	0.2264	0.1626	0.1683
420	0.6638	0.5725	0.4839	0.3900	0.1597	0.1076	0.1053	0.6798	0.6029	0.5570	0.4490	0.2937	0.2116	0.2202
430	0.7375	0.6346	0.5353	0.4308	0.1755	0.1169	0.1149	0.7597	0.6756	0.6291	0.5137	0.3530	0.2621	0.2737
440	0.7571	0.6529	0.5523	0.4463	0.1871	0.1252	0.1237	0.7862	0.7074	0.6644	0.5577	0.4129	0.3214	0.3361
450	0.7596	0.6562	0.5567	0.4517	0.1922	0.1288	0.1276	0.7961	0.7271	0.6890	0.5949	0.4722	0.3839	0.4007
460	0.7552	0.6525	0.5533	0.4489	0.1885	0.1256	0.1243	0.7987	0.7406	0.7081	0.6279	0.5273	0.4455	0.4629
470	0.7504	0.6476	0.5480	0.4436	0.1811	0.1194	0.1176	0.8012	0.7541	0.7270	0.6608	0.5812	0.5079	0.5248
480	0.7467	0.6424	0.5419	0.4367	0.1708	0.1109	0.1087	0.8023	0.7609	0.7376	0.6783	0.6101	0.5420	0.5581
490	0.7396	0.6352	0.5336	0.4281	0.1595	0.1022	0.0995	0.7986	0.7589	0.7357	0.6786	0.6113	0.5439	0.5592
500	0.7346	0.6286	0.5256	0.4191	0.1471	0.0929	0.0897	0.7941	0.7501	0.7253	0.6624	0.5861	0.5138	0.5290
510	0.7275	0.6196	0.5146	0.4073	0.1323	0.0826	0.0788	0.7862	0.7345	0.7059	0.6328	0.5390	0.4593	0.4738
520	0.7189	0.6083	0.5015	0.3930	0.1158	0.0719	0.0677	0.7751	0.7129	0.6793	0.5921	0.4728	0.3852	0.3982
530	0.7102	0.5978	0.4893	0.3801	0.1027	0.0643	0.0601	0.7610	0.6871	0.6473	0.5444	0.3942	0.3017	0.3120
540	0.7031	0.5892	0.4794	0.3702	0.0937	0.0594	0.0552	0.7452	0.6607	0.6148	0.4957	0.3140	0.2215	0.2285
550	0.6951	0.5792	0.4676	0.3581	0.0834	0.0544	0.0503	0.7289	0.6347	0.5824	0.4475	0.2358	0.1502	0.1527
560	0.6839	0.5655	0.4516	0.3419	0.0729	0.0514	0.0475	0.7111	0.6090	0.5512	0.4018	0.1674	0.0958	0.0939
570	0.6736	0.5528	0.4370	0.3277	0.0698	0.0549	0.0511	0.6969	0.5897	0.5285	0.3681	0.1233	0.0672	0.0630
580	0.6710	0.5498	0.4340	0.3251	0.0759	0.0622	0.0586	0.6866	0.5770	0.5140	0.3471	0.1010	0.0562	0.0514
590	0.6745	0.5551	0.4411	0.3321	0.0825	0.0644	0.0608	0.6801	0.5688	0.5049	0.3339	0.0898	0.0521	0.0473
600	0.6748	0.5555	0.4418	0.3331	0.0829	0.0631	0.0593	0.6742	0.5611	0.4965	0.3218	0.0818	0.0504	0.0455
610	0.6741	0.5535	0.4393	0.3303	0.0814	0.0623	0.0585	0.6705	0.5558	0.4909	0.3127	0.0780	0.0511	0.0462
620	0.6753	0.5538	0.4384	0.3288	0.0816	0.0627	0.0591	0.6700	0.5539	0.4883	0.3085	0.0783	0.0534	0.0483
630	0.6769	0.5544	0.4384	0.3285	0.0825	0.0638	0.0600	0.6705	0.5534	0.4876	0.3066	0.0800	0.0559	0.0506
640	0.6785	0.5554	0.4388	0.3287	0.0842	0.0653	0.0615	0.6718	0.5535	0.4874	0.3061	0.0826	0.0585	0.0533
650	0.6811	0.5579	0.4419	0.3315	0.0878	0.0673	0.0633	0.6736	0.5548	0.4886	0.3082	0.0872	0.0614	0.0561
660	0.6853	0.5627	0.4473	0.3369	0.0927	0.0691	0.0651	0.6770	0.5582	0.4919	0.3138	0.0934	0.0641	0.0588
670	0.6869	0.5654	0.4508	0.3404	0.0954	0.0695	0.0654	0.6794	0.5607	0.4947	0.3188	0.0982	0.0656	0.0603
680	0.6869	0.5649	0.4500	0.3397	0.0941	0.0686	0.0645	0.6808	0.5617	0.4956	0.3202	0.0992	0.0659	0.0605
690	0.6859	0.5622	0.4463	0.3359	0.0910	0.0673	0.0633	0.6800	0.5601	0.4938	0.3176	0.0973	0.0651	0.0597
700	0.6829	0.5575	0.4406	0.3299	0.0874	0.0669	0.0630	0.6778	0.5567	0.4902	0.3120	0.0936	0.0649	0.0594

Wavelength (nm)	2% Bl56	10% Bl56	20% Bl56	30% Bl56	50% Bl56	75% Bl56	100% Bl56	2% Ul63	10% Ul63	20% Ul63	30% Ul63	50% Ul63	75% Ul63	100% Ul63
400	0.3869	0.3515	0.3004	0.2562	0.1833	0.1283	0.1248	0.4078	0.3787	0.3626	0.3187	0.2923	0.2642	0.2356
410	0.5129	0.4620	0.4016	0.3437	0.2472	0.1731	0.1705	0.5380	0.4997	0.4710	0.4160	0.3783	0.3389	0.3064
420	0.6819	0.6084	0.5352	0.4555	0.3252	0.2275	0.2249	0.7080	0.6589	0.6146	0.5446	0.4920	0.4345	0.3979
430	0.7665	0.6868	0.6104	0.5275	0.3918	0.2832	0.2821	0.7875	0.7361	0.6868	0.6119	0.5537	0.4896	0.4505
440	0.7936	0.7210	0.6509	0.5783	0.4582	0.3499	0.3509	0.8068	0.7572	0.7091	0.6352	0.5769	0.5117	0.4733
450	0.8032	0.7409	0.6795	0.6192	0.5189	0.4159	0.4192	0.8088	0.7610	0.7139	0.6407	0.5823	0.5176	0.4794
460	0.8047	0.7527	0.6991	0.6493	0.5660	0.4708	0.4753	0.8035	0.7564	0.7099	0.6342	0.5736	0.5082	0.4698
470	0.8051	0.7617	0.7161	0.6753	0.6069	0.5200	0.5254	0.7974	0.7476	0.6992	0.6166	0.5509	0.4828	0.4439
480	0.8054	0.7656	0.7237	0.6865	0.6241	0.5409	0.5460	0.7916	0.7360	0.6824	0.5868	0.5123	0.4403	0.3999
490	0.8014	0.7618	0.7195	0.6818	0.6172	0.5331	0.5377	0.7803	0.7171	0.6563	0.5415	0.4563	0.3805	0.3390
500	0.7969	0.7528	0.7058	0.6633	0.5887	0.4980	0.5015	0.7687	0.6961	0.6259	0.4857	0.3894	0.3108	0.2689
510	0.7895	0.7374	0.6833	0.6314	0.5391	0.4404	0.4419	0.7543	0.6722	0.5917	0.4228	0.3173	0.2389	0.1987
520	0.7787	0.7162	0.6524	0.5875	0.4706	0.3637	0.3626	0.7391	0.6491	0.5588	0.3618	0.2513	0.1766	0.1403
530	0.7649	0.6907	0.6166	0.5355	0.3895	0.2787	0.2746	0.7246	0.6290	0.5310	0.3099	0.1988	0.1302	0.0991
540	0.7491	0.6638	0.5799	0.4820	0.3074	0.1993	0.1926	0.7128	0.6140	0.5103	0.2716	0.1628	0.1013	0.0753
550	0.7323	0.6374	0.5439	0.4293	0.2280	0.1310	0.1225	0.7042	0.6034	0.4955	0.2449	0.1398	0.0846	0.0629
560	0.7132	0.6110	0.5086	0.3794	0.1593	0.0816	0.0730	0.6964	0.5945	0.4847	0.2268	0.1256	0.0756	0.0567
570	0.6973	0.5912	0.4826	0.3430	0.1156	0.0579	0.0506	0.6917	0.5890	0.4776	0.2158	0.1179	0.0713	0.0543
580	0.6862	0.5779	0.4660	0.3210	0.0944	0.0498	0.0438	0.6880	0.5848	0.4727	0.2099	0.1146	0.0701	0.0539
590	0.6791	0.5697	0.4558	0.3077	0.0846	0.0478	0.0425	0.6857	0.5820	0.4701	0.2082	0.1144	0.0708	0.0549
600	0.6727	0.5622	0.4466	0.2958	0.0778	0.0475	0.0425	0.6845	0.5808	0.4687	0.2094	0.1166	0.0730	0.0569
610	0.6688	0.5573	0.4399	0.2872	0.0747	0.0490	0.0440	0.6853	0.5811	0.4692	0.2131	0.1202	0.0762	0.0592
620	0.6683	0.5553	0.4370	0.2832	0.0754	0.0518	0.0465	0.6884	0.5835	0.4716	0.2195	0.1259	0.0803	0.0624
630	0.6692	0.5550	0.4359	0.2818	0.0775	0.0543	0.0488	0.6919	0.5863	0.4751	0.2274	0.1330	0.0856	0.0663
640	0.6705	0.5551	0.4356	0.2818	0.0802	0.0571	0.0514	0.6953	0.5895	0.4792	0.2373	0.1419	0.0922	0.0712
650	0.6733	0.5570	0.4376	0.2849	0.0851	0.0598	0.0540	0.6990	0.5932	0.4845	0.2492	0.1529	0.1004	0.0776
660	0.6777	0.5609	0.4421	0.2913	0.0916	0.0620	0.0559	0.7030	0.5980	0.4911	0.2638	0.1662	0.1111	0.0860
670	0.6803	0.5634	0.4458	0.2966	0.0962	0.0629	0.0565	0.7072	0.6030	0.4990	0.2816	0.1833	0.1250	0.0976
680	0.6817	0.5639	0.4462	0.2972	0.0963	0.0626	0.0563	0.7122	0.6100	0.5089	0.3026	0.2042	0.1426	0.1127
690	0.6805	0.5618	0.4436	0.2938	0.0936	0.0619	0.0557	0.7185	0.6187	0.5218	0.3288	0.2310	0.1662	0.1336
700	0.6776	0.5578	0.4385	0.2871	0.0895	0.0624	0.0562	0.7256	0.6295	0.5372	0.3588	0.2629	0.1953	0.1604

Table D-7 The data set of reflectance ratio of HIZGT special inks that is Dark blue 69 (Bl69), Peacock Blue 54 (Bl54), Peacock Blue 56 (Bl56) and Ultramarine63 (Ul63).

Wavelength (nm)	2% Brown77	10% Brown77	20% Brown77	30% Brown77	50% Brown77	75% Brown77	100% Brown77	2% R24	10% R24	20% R24	30% R24	50% R24	75% R24	100% R24
400	0.3711	0.3284	0.2844	0.2229	0.0792	0.0551	0.0506	0.3644	0.3266	0.2696	0.1768	0.0674	0.0529	0.0512
410	0.4852	0.4187	0.3620	0.2774	0.0846	0.0569	0.0511	0.4701	0.4132	0.3352	0.2063	0.0694	0.0526	0.0504
420	0.6328	0.5331	0.4566	0.3425	0.0904	0.0581	0.0513	0.6075	0.5248	0.4165	0.2398	0.0719	0.0530	0.0509
430	0.7002	0.5844	0.4985	0.3701	0.0925	0.0587	0.0518	0.6701	0.5756	0.4527	0.2529	0.0730	0.0536	0.0514
440	0.7157	0.5961	0.5080	0.3758	0.0927	0.0590	0.0520	0.6847	0.5876	0.4611	0.2556	0.0740	0.0544	0.0521
450	0.7164	0.5966	0.5084	0.3756	0.0923	0.0590	0.0520	0.6861	0.5893	0.4627	0.2560	0.0750	0.0551	0.0528
460	0.7118	0.5920	0.5043	0.3713	0.0895	0.0579	0.0510	0.6832	0.5873	0.4611	0.2539	0.0752	0.0552	0.0528
470	0.7065	0.5865	0.4991	0.3658	0.0857	0.0572	0.0504	0.6792	0.5839	0.4580	0.2487	0.0752	0.0558	0.0532
480	0.7029	0.5822	0.4948	0.3609	0.0832	0.0571	0.0505	0.6777	0.5823	0.4566	0.2460	0.0770	0.0578	0.0547
490	0.6975	0.5772	0.4902	0.3570	0.0830	0.0585	0.0519	0.6766	0.5825	0.4590	0.2512	0.0826	0.0620	0.0582
500	0.6951	0.5747	0.4877	0.3548	0.0839	0.0601	0.0534	0.6789	0.5856	0.4650	0.2606	0.0891	0.0659	0.0610
510	0.6919	0.5720	0.4856	0.3532	0.0857	0.0619	0.0553	0.6778	0.5854	0.4661	0.2633	0.0913	0.0672	0.0618
520	0.6887	0.5693	0.4832	0.3517	0.0875	0.0634	0.0564	0.6734	0.5809	0.4618	0.2578	0.0894	0.0664	0.0612
530	0.6849	0.5663	0.4808	0.3503	0.0894	0.0651	0.0582	0.6683	0.5764	0.4569	0.2522	0.0878	0.0663	0.0613
540	0.6823	0.5645	0.4794	0.3498	0.0931	0.0679	0.0609	0.6649	0.5734	0.4543	0.2514	0.0889	0.0679	0.0629
550	0.6824	0.5661	0.4816	0.3539	0.1019	0.0734	0.0657	0.6633	0.5723	0.4538	0.2539	0.0915	0.0706	0.0653
560	0.6859	0.5734	0.4907	0.3667	0.1218	0.0840	0.0750	0.6614	0.5707	0.4533	0.2568	0.0947	0.0741	0.0687
570	0.6961	0.5906	0.5108	0.3945	0.1621	0.1079	0.0973	0.6604	0.5699	0.4531	0.2607	0.0997	0.0800	0.0742
580	0.7063	0.6086	0.5320	0.4248	0.2102	0.1413	0.1305	0.6725	0.5844	0.4752	0.3031	0.1298	0.1027	0.0928
590	0.7118	0.6191	0.5445	0.4431	0.2413	0.1655	0.1552	0.7109	0.6363	0.5485	0.4228	0.2464	0.2048	0.1833
600	0.7138	0.6231	0.5494	0.4508	0.2553	0.1769	0.1668	0.7506	0.7031	0.6428	0.5731	0.4512	0.4120	0.3861
610	0.7157	0.6257	0.5519	0.4543	0.2610	0.1814	0.1713	0.7716	0.7485	0.7128	0.6823	0.6205	0.5940	0.5749
620	0.7187	0.6281	0.5544	0.4573	0.2647	0.1841	0.1743	0.7819	0.7729	0.7552	0.7446	0.7193	0.7044	0.6951
630	0.7218	0.6306	0.5565	0.4596	0.2678	0.1864	0.1766	0.7872	0.7839	0.7748	0.7721	0.7627	0.7539	0.7511
640	0.7239	0.6324	0.5580	0.4615	0.2703	0.1885	0.1786	0.7903	0.7888	0.7833	0.7834	0.7802	0.7735	0.7739
650	0.7257	0.6339	0.5596	0.4632	0.2728	0.1903	0.1806	0.7921	0.7914	0.7871	0.7880	0.7874	0.7815	0.7834
660	0.7271	0.6352	0.5608	0.4647	0.2751	0.1922	0.1824	0.7935	0.7931	0.7894	0.7905	0.7910	0.7856	0.7880
670	0.7279	0.6359	0.5616	0.4658	0.2773	0.1940	0.1844	0.7941	0.7939	0.7902	0.7915	0.7926	0.7868	0.7899
680	0.7289	0.6367	0.5623	0.4669	0.2794	0.1958	0.1861	0.7950	0.7948	0.7911	0.7922	0.7935	0.7883	0.7918
690	0.7296	0.6374	0.5628	0.4678	0.2813	0.1975	0.1879	0.7954	0.7950	0.7915	0.7922	0.7940	0.7884	0.7921
700	0.7306	0.6384	0.5636	0.4689	0.2833	0.1993	0.1898	0.7961	0.7958	0.7926	0.7932	0.7954	0.7897	0.7937

Wavelength (nm)	2% R22	10% R22	20% R22	30% R22	50% R22	75% R22	100% R22	2% Y40	10% Y40	20% Y40	30% Y40	50% Y40	75% Y40	100% Y40
400	0.4015	0.3436	0.3012	0.2522	0.0982	0.0805	0.0679	0.3750	0.3227	0.2535	0.1983	0.0683	0.0496	0.0478
410	0.5110	0.4368	0.3764	0.3141	0.1059	0.0837	0.0692	0.4807	0.4070	0.3176	0.2399	0.0692	0.0491	0.0465
420	0.6524	0.5576	0.4718	0.3912	0.1168	0.0899	0.0721	0.6182	0.5156	0.3967	0.2895	0.0716	0.0504	0.0473
430	0.7177	0.6136	0.5154	0.4259	0.1214	0.0922	0.0734	0.6802	0.5639	0.4299	0.3087	0.0733	0.0526	0.0490
440	0.7340	0.6275	0.5261	0.4344	0.1213	0.0914	0.0725	0.6942	0.5750	0.4366	0.3122	0.0754	0.0550	0.0514
450	0.7338	0.6268	0.5244	0.4314	0.1147	0.0845	0.0672	0.6964	0.5769	0.4376	0.3140	0.0789	0.0578	0.0541
460	0.7266	0.6184	0.5143	0.4189	0.1004	0.0712	0.0577	0.6949	0.5762	0.4378	0.3164	0.0831	0.0601	0.0560
470	0.7180	0.6080	0.5018	0.4038	0.0867	0.0595	0.0501	0.6938	0.5758	0.4384	0.3193	0.0882	0.0634	0.0590
480	0.7115	0.5990	0.4907	0.3902	0.0767	0.0523	0.0460	0.6967	0.5792	0.4438	0.3285	0.0995	0.0697	0.0643
490	0.7023	0.5891	0.4797	0.3774	0.0711	0.0491	0.0448	0.7071	0.5938	0.4666	0.3624	0.1367	0.0897	0.0819
500	0.6970	0.5825	0.4720	0.3683	0.0689	0.0492	0.0459	0.7356	0.6344	0.5279	0.4465	0.2405	0.1659	0.1547
510	0.6922	0.5771	0.4660	0.3617	0.0692	0.0511	0.0481	0.7679	0.6918	0.6140	0.5611	0.4117	0.3287	0.3156
520	0.6870	0.5717	0.4607	0.3561	0.0700	0.0533	0.0504	0.7824	0.7280	0.6700	0.6352	0.5353	0.4640	0.4509
530	0.6824	0.5672	0.4561	0.3515	0.0721	0.0567	0.0539	0.7842	0.7387	0.6884	0.6597	0.5795	0.5161	0.5039
540	0.6789	0.5639	0.4535	0.3496	0.0751	0.0605	0.0578	0.7830	0.7414	0.6939	0.6683	0.5959	0.5365	0.5248
550	0.6774	0.5629	0.4530	0.3501	0.0793	0.0653	0.0623	0.7823	0.7455	0.7024	0.6794	0.6163	0.5621	0.5514
560	0.6762	0.5625	0.4536	0.3517	0.0848	0.0713	0.0679	0.7827	0.7539	0.7193	0.7013	0.6544	0.6101	0.6007
570	0.6762	0.5634	0.4555	0.3547	0.0923	0.0796	0.0757	0.7849	0.7678	0.7454	0.7354	0.7104	0.6815	0.6742
580	0.6856	0.5775	0.4741	0.3797	0.1169	0.1001	0.0910	0.7856	0.7782	0.7673	0.7638	0.7564	0.7420	0.7368
590	0.7182	0.6273	0.5383	0.4592	0.2104	0.1913	0.1662	0.7856	0.7827	0.7774	0.7777	0.7778	0.7712	0.7675
600	0.7527	0.6944	0.6307	0.5733	0.3984	0.3928	0.3592	0.7852	0.7836	0.7805	0.7817	0.7846	0.7805	0.7775
610	0.7717	0.7423	0.7057	0.6684	0.5766	0.5794	0.5525	0.7857	0.7845	0.7819	0.7837	0.7870	0.7836	0.7805
620	0.7813	0.7691	0.7522	0.7326	0.6946	0.6983	0.6823	0.7879	0.7867	0.7842	0.7860	0.7895	0.7861	0.7833
630	0.7865	0.7811	0.7739	0.7651	0.7508	0.7542	0.7458	0.7905	0.7894	0.7871	0.7887	0.7922	0.7888	0.7858
640	0.7891	0.7864	0.7832	0.7790	0.7739	0.7771	0.7727	0.7925	0.7914	0.7893	0.7908	0.7942	0.7910	0.7879
650	0.7909	0.7889	0.7872	0.7851	0.7833	0.7865	0.7839	0.7941	0.7930	0.7909	0.7923	0.7956	0.7924	0.7891
660	0.7924	0.7907	0.7897	0.7881	0.7877	0.7909	0.7891	0.7955	0.7946	0.7922	0.7938	0.7972	0.7941	0.7907
670	0.7931	0.7913	0.7906	0.7895	0.7896	0.7931	0.7919	0.7960	0.7951	0.7928	0.7942	0.7976	0.7946	0.7914
680	0.7938	0.7922	0.7913	0.7905	0.7910	0.7940	0.7933	0.7970	0.7960	0.7937	0.7950	0.7984	0.7954	0.7924
690	0.7941	0.7926	0.7918	0.7909	0.7916	0.7945	0.7939	0.7973	0.7960	0.7938	0.7951	0.7981	0.7952	0.7920
700	0.7948	0.7934	0.7927	0.7920	0.7930	0.7958	0.7955	0.7984	0.7972	0.7952	0.7962	0.7994	0.7964	0.7934

Table D-8 The data set of reflectance ratio of HIZGT special inks that is Brown 77, Deep Red 24 (R24), Medium Red 22 (R22) and Reddish Yellow 40 (Y40).

Wavelength (nm)	2% V68	10% V68	20% V68	30% V68	50% V68	75% V68	100% V68
400	0.3856	0.3486	0.3012	0.2320	0.1501	0.1015	0.1070
410	0.5062	0.4512	0.3897	0.2945	0.1794	0.1158	0.1225
420	0.6625	0.5813	0.5026	0.3734	0.2161	0.1356	0.1433
430	0.7349	0.6427	0.5561	0.4124	0.2374	0.1486	0.1570
440	0.7538	0.6594	0.5717	0.4257	0.2468	0.1552	0.1644
450	0.7544	0.6591	0.5714	0.4242	0.2419	0.1506	0.1593
460	0.7461	0.6490	0.5597	0.4085	0.2197	0.1323	0.1394
470	0.7350	0.6349	0.5423	0.3851	0.1890	0.1085	0.1131
480	0.7247	0.6203	0.5237	0.3580	0.1566	0.0854	0.0871
490	0.7110	0.6036	0.5033	0.3292	0.1267	0.0669	0.0661
500	0.6993	0.5887	0.4848	0.3018	0.1023	0.0542	0.0518
510	0.6866	0.5736	0.4666	0.2754	0.0831	0.0466	0.0431
520	0.6740	0.5592	0.4497	0.2515	0.0699	0.0435	0.0394
530	0.6632	0.5477	0.4368	0.2342	0.0642	0.0442	0.0397
540	0.6556	0.5400	0.4284	0.2236	0.0626	0.0461	0.0412
550	0.6493	0.5334	0.4213	0.2145	0.0623	0.0484	0.0432
560	0.6407	0.5248	0.4125	0.2041	0.0639	0.0535	0.0470
570	0.6333	0.5172	0.4048	0.1963	0.0716	0.0646	0.0571
580	0.6339	0.5181	0.4068	0.2069	0.0835	0.0759	0.0689
590	0.6451	0.5311	0.4228	0.2323	0.0948	0.0771	0.0717
600	0.6540	0.5419	0.4365	0.2509	0.1046	0.0763	0.0720
610	0.6593	0.5476	0.4435	0.2604	0.1104	0.0760	0.0726
620	0.6642	0.5523	0.4486	0.2681	0.1154	0.0772	0.0742
630	0.6693	0.5572	0.4542	0.2762	0.1215	0.0795	0.0770
640	0.6742	0.5622	0.4601	0.2856	0.1293	0.0832	0.0814
650	0.6792	0.5680	0.4670	0.2969	0.1395	0.0885	0.0879
660	0.6853	0.5750	0.4757	0.3103	0.1529	0.0963	0.0970
670	0.6912	0.5826	0.4856	0.3259	0.1698	0.1070	0.1098
680	0.6986	0.5919	0.4973	0.3434	0.1901	0.1212	0.1264
690	0.7060	0.6023	0.5107	0.3632	0.2153	0.1402	0.1482
700	0.7149	0.6147	0.5265	0.3858	0.2453	0.1647	0.1757

Table D-9 The data set of reflectance ratio of HIZGT special inks Violet 68.

VITA

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