CHAPTER V

CONCLUSION AND SUGGESTIONS

5.1 Conclusion

The water-based ink formulations were developed for printing on nonporous, low surface energy substrates, for example, polyolefins film in order to obtain the satisfactory print qualities. To carry out the research, the preparation of acrylic acid-cassava starch graft copolymer as a thickener for water-based screen inks was accomplished first. The effect of the crosslinker on starch-g-copolymer was studied to acquire the suitable thickener for screen ink. The water absorption capacity and rheology of the thickener were examined. Two water-based ink formulations were prepared using the synthesized thickener. Inks properties, i.e. viscosity, dispersion and surface tension were determined. Surface of the cast polypropylene film was treated with a corona discharger. We determined the surface energy and its components of the treated plastic film. Furthermore, the effect of charge ageing due to storage of treated plastic films on surface energy was investigated. The treated plastic film was printed by screen printing using the two water-based inks. The evaluation for print qualities was then carried out. The results can be summarized as follows:

(1) The appropriate thickener for the water-based inks was the graft copolymer synthesized with 0.5 wt% crosslinking concentration. The crosslinker affects the water absorption capacity and the rheology of the thickener. Cassava starch-acrylic

acid thickener is a water-soluble polymer. Increasing crosslinking points decreased the soluble polymers. Increasing the crosslinking concentration increased the water absorption capacity. Therefore, the graft copolymer gave minimum water absorption capacity was a suitable thickener for water-based inks.

For the effect of the crosslinking reaction on the rheology of the thickeners, the thickeners displayed the pseudoplastic behavior. Increasing the chain entanglement resulted from the crosslinking reaction led to increase in the viscosity while decrease of the flow characteristic. The suitably rheological properties of the thickener required for screen printing ink were the short flow characteristic, medium or high viscosity, and minimum swelling. Therefore, the appropriate thickener was the graft copolymer synthesized with 0.5 wt% of *N,N*-methylenebisacrylamide.

(2) For the formulated inks properties, the rheologies of both ink I and ink II were characterized by non-Newtonian pseudoplastic behavior. The viscosity of the ink II is slight lower than that of the ink I. For dispersion of the two inks, both inks gave poor dispersion. However, the ink II gave slightly better finess of grind than that of the ink I. The surface tension values obtained were 34 and 32 mN m^{-1} for the ink I and ink II, respectively. They were insignificantly different because the same surfactant was used. Nevertheless, silicone defoamer used in the ink II formulation reduced the surface tension of water. The ink II, therefore, gave the lower surface tension than the other.

(3) The extent of corona treatment and the charge ageing due to storage time are the other main parameters affecting the surface energy of the corona treated plastic film. Increasing the treatment watt increased the surface energy of the plastic

film. In contrast, prolonging the storage time before printing decreased the surface energy of the treated plastic film due to charge decay on ageing.

(4) The wetting tension of the treated plastic film was used for approximately determining the surface energy of the film. The optimum surface energy of the treated plastic film was 42 mN m^{-1}.

(5) The advancing contact angle illustrated the wetting spreading of the ink, i.e. printability and penetration into recessed areas, while the receding contact angle indicated the tendency of the ink to leave the substrate, i.e. the adhesion for the solid film.

(6) The difference between the advancing and receding contact angle indicated the surface roughness of the plastic film. This is known as the contact angle hysteresis. The hysteresis increased with increases in the surface roughness and heterogeneity. Increasing the power for the treatment from 300 to 350 watts, the surface roughness increased slightly.

(7) The critical surface energy was determined by Zisman plot. For the condition for a good printing, the critical surface energy of the plastic film must be higher than or equal to the surface tension of the printing ink. The surface tension value of the ink must be, at least, equal to 23 mN m^{-1} for the plastic film treated with 350 watts of output power. As such, the wetting on the treated plastic could take place instantaneously and properly.

(8) Surface energy components of the plastic film consist of the polar and the dispersive portions. Increasing the treatment increased the polar component and decreased the disperive component simultaneously. The CPP film treated with the power of 350 watts gave the highest polar surface energy component of 30.2 mN m^{-1}.

(9) For the print qualities of the print plastic film, the plastic film printed by the ink I showed the highest % dot gain at 40 and 60 % dot area; whereas the plastic film printed by the ink II displayed the highest % dot gain at midtone area to 80 % dot ares. The tone reproduction of both plastic films printed by the ink I and ink II was similar. Densities of the print from 0 to 90% dot area were reproduced similarly to those of original film. But at the solid tone, the density was dramatically different from that of the original film. For the shadow area, flocculation of the pigment of the ink I and ink II was anticipated, which caused by poor pigment dispersion. Furthermore, the % print contrast of the plastic films printed by the ink I was better than that of the plastic film printed by the ink II. The highest print contrast indicated the minimum dot gain. On the other hand, the lowest print contrast presented the maximum dot gain. In addition, the plastic film printed by the ink II gave the higher gloss than that printed by the ink I. Lastly, adhesion test results of the plastic film printed by the ink I gave the removed percentage area removed in a range of 15-35%, while that of the plastic film printed by the ink II was in a range of 35-65%. It is no doubt that the adhesion of the plastic film printed by the ink I was better than that printed by the ink II.

(10) From the evaluation of the adhesion, the appropriate screen printing ink investigated from the current research is the ink I.

5.2 Suggestions for Future Work

To develop a water-based ink for printing on polymeric films, more investigations should be carried out as follows:

(1) Use other surfactants of low foaming property. Foaming is a major problem for the water-based inks and it is difficult to get rid off. Although, the defoamer can reduce foaming behavior of the ink.

(2) The synthesized thickener used in the water-based ink formulations is not heat resistant. It cannot be ground in three rolls mill. As such a result, the flocculation of pigment takes place. The problem should be dealt with by the pigment dispersion performance before formulating the inks.

(3) The relationship between average molecular weights and viscosity should also be extensively investigated to justify the appropriateness of starting materials.

(4) Instead of using a surfactant in ink formulations, an adhesive promoter should also be tried.

(5) Other surface treatment technique for example plasma treatment could be tried.