สารที่มีฤทธิ์ยับยั้งเอนไซม์แอลฟา-กลูโคซิเดสจากเอื้องไม้ตึง

นางสาวราชาวดี ลิมพานิชย์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาเภสัชศาสตรมหาบัณฑิต
สาขาวิชาเภสัชเวท ภาควิชาเภสัชเวทและเภสัชพฤกษศาสตร์
คณะเภสัชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2558

ALPHA-GLUCOSIDASE INHIBITORS FROM *DENDROBIUM TORTILE*

Miss Rachawadee Limpanit

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Pharmacy Program in Pharmacognosy
Department of Pharmacognosy and Pharmaceutical Botany
Faculty of Pharmaceutical Sciences
Chulalongkorn University
Academic Year 2015

Thesis Title	ALPHA-GLUCOSIDASE INHIBITORS FROM *DENDROBIUM TORTILE*
By	Miss Rachawadee Limpanit
Field of Study	Pharmacognosy
Thesis Advisor	Associate Professor Boonchoo Sritularak, Ph.D.
Thesis Co-Advisor	Professor Kittisak Likhitwitayawuid, Ph.D.

Accepted by the Faculty of Pharmaceutical Sciences, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

.....Dean of the Faculty of Pharmaceutical Sciences
(Assistant Professor Rungpetch Sakulbumrungsil, Ph.D.)

THESIS COMMITTEE

.....Chairman
(Associate Professor Surattana Amnuoypol, Ph.D.)

.....Thesis Advisor
(Associate Professor Boonchoo Sritularak, Ph.D.)

.....Thesis Co-Advisor
(Professor Kittisak Likhitwitayawuid, Ph.D.)

.....Examiner
(Assistant Professor Witchuda Thanakijcharoenpath, Ph.D.)

.....Examiner
(Assistant Professor Taksina Chuanasa, Ph.D.)

.....External Examiner
(Assistant Professor Sarin Tadtong, Ph.D.)

ราชาวดี ลิมพานิชย์ : สารที่มีฤทธิ์ยับยั้งเอนไซม์แอลฟา-กลูโคซิเดสจากเอื้องไม้ตึง (ALPHA-GLUCOSIDASE INHIBITORS FROM *DENDROBIUM TORTILE*) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ภก. ดร.บุญชู ศรีตุลารักษ์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ศ. ภก. ดร.กิตติศักดิ์ ลิขิตวิทยาวุฒิ, 154 หน้า.

จากการศึกษาองค์ประกอบทางเคมีของสารสกัดหยาบด้วยเมทานอลจากเอื้องไม้ตึง *Dendrobium tortile* (วงศ์กล้วยไม้) ทั้งต้น สามารถแยกสารบริสุทธิ์ออกมาได้ 7 ชนิด ได้แก่ สารใหม่ 1 ชนิด คือ 4-(2-hydroxypropyl-2(5*H*)-furanone, และสารที่เคยมีรายงานมาแล้ว 6 ชนิด ได้แก่ *trans*-tetracosylferulate, *cis*-hexacosanoyl ferulate, *p*-hydroxybenzaldehyde, 3,4-dihydroxy-5,4'-dimethoxybibenzyl, eriodictyol และ dendrofalconerol A สารที่แยกมาได้ทั้งหมดนำไปพิสูจน์โครงสร้างทางเคมีด้วยการวิเคราะห์ 1-D และ 2-D NMR ร่วมกับข้อมูล HR-ESI-MS เมื่อนำสารทั้ง 7 ชนิดไปทดสอบฤทธิ์ยับยั้งเอนไซม์แอลฟากลูโคซิเดสพบว่าสาร 3 ชนิด ได้แก่ 3,4-dihydroxy-5,4'-dimethoxybibenzyl, eriodictyol และ dendrofalconerol A มีฤทธิ์ในการยับยั้งเอนไซม์แอลฟากลูโคซิเดสเมื่อเปรียบเทียบกับ acarbose ที่เป็น positive control โดย dendrofalconerol A ที่มีฤทธิ์แรงที่สุดถูกนำไปทดสอบต่อเพื่อศึกษาข้อมูลทาง kinetic และพบว่าเป็น non-competitive inhibitor ต่อเอนไซม์แอลฟากลูโคซิเดส งานวิจัยครั้งนี้เป็นการรายงานองค์ประกอบทางเคมีและฤทธิ์ทางชีวภาพเป็นครั้งแรกของเอื้องไม้ตึง

ภาควิชา	เภสัชเวทและเภสัชพฤกษศาสตร์	ลายมือชื่อนิสิต .....
สาขาวิชา	เภสัชเวท	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....
ปีการศึกษา	2558	ลายมือชื่อ อ.ที่ปรึกษาร่วม .....

5676232833 : MAJOR PHARMACOGNOSY
KEYWORDS:

RACHAWADEE LIMPANIT: ALPHA-GLUCOSIDASE INHIBITORS FROM *DENDROBIUM TORTILE*. ADVISOR: ASSOC. PROF. BOONCHOO SRITULARAK, Ph.D., CO-ADVISOR: PROF. KITTISAK LIKHITWITAYAWUID, Ph.D., 154 pp.

Phytochemical investigation of the crude methanol extract of *Dendrobium tortile* (Orchidaceae) led to the isolation of a new compound, namely 4-(2-hydroxypropyl)-2(5*H*)-furanone, together with six known compounds,which included *trans*-tetracosylferulate, *cis*-hexacosanoyl ferulate, *p*-hydroxybenzaldehyde, 3,4-dihydroxy-5,4'-dimethoxybibenzyl, eriodictyol and dendrofalconerol A. The structures of these compounds were determined through analysis of 1-D and 2-D NMR and HR-ESI-MS data. All of the isolates were evaluated for their **α**-glucosidase inhibitory activity. Dendrofalconerol A showed strong activity when compared with the positive control acarbose, whereas 3,4-dihydroxy-5,4'-dimethoxybibenzyl and eriodictyol showed appreciable effects. An enzyme kinetics study revealed that dendrofalconerol A is a reversible non-competitive inhibitor of **α**-glucosidase. This is the first report on the chemical composition and the biological activity of *D. tortile*.

Department:	Pharmacognosy and Pharmaceutical Botany	Student's Signature .....
		Advisor's Signature .....
Field of Study:	Pharmacognosy	Co-Advisor's Signature .....
Academic Year:	2015	

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to my thesis advisor, Associate Professor Dr. Boonchoo Sritularak, and my co-advisor, Professor Dr. Kittisak Likhitwitayawuid for their invaluable help and constant encouragement throughout the course of this thesis. I am most grateful for their teaching and advice, which encompass not only research and academic skills but also many other aspects of life. I would not have achieved this far and this thesis would not have been completed without all the support that I have always received from them. In addition, I am grateful for all assistance and beneficial advice from the members of my thesis committee. I also wish to express my thanks to all staff members of the Department of Pharmacognosy and Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University, for the assistance and research facilities, as well as many other persons for their valuable help. Finally, I most gratefully acknowledge my parents and my lovely friends for all their support throughout the period of this study.

CONTENTS

Page

Page

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF SCHEMES

Page

ABBREVIATIONS AND SYMBOLS

Acetone-d_6	=	Deuterated acetone
α	=	Alpha
β	=	Beta
brs	=	Broad singlet (for NMR spectra)
°C	=	Degree Celsius
CC	=	Column chromatography
$CDCl_3$	=	Deuterated chloroform
CH_2Cl_2	=	Dichloromethane
cm	=	Centimeter
^{13}C NMR	=	Carbon-13 Nuclear Magnetic Resonance
1-D NMR	=	One dimensional Nuclear Magnetic Resonance
2-D NMR	=	Two dimensional Nuclear Magnetic Resonance
d	=	Doublet (for NMR spectra)
dd	=	Doublet of doublets (for NMR spectra)
δ	=	Chemical shift
DMSO-d_6	=	Deuterated dimethylsulfoxide
DEPT	=	Distortionless Enhancement by Polarization Transfer
ESIMS	=	Electrospray Ionization Mass Spectrometry
EtOAc	=	Ethyl acetate
FCC	=	Flash Column Chromatography
g	=	Gram
GF	=	Gel Filtration Chromatography
Glc	=	Glucose
hr	=	Hour
^1H-NMR	=	Proton Nuclear Magnetic Resonance
HMBC	=	Heteronuclear Multiple Bond Correlation
HSQC	=	Heteronuclear Single Quantum Coherence
Hz	=	Hertz
IC_{50}	=	Concentration exhibiting 50% inhibition
IR	=	Infrared
J	=	Coupling constant
Kg	=	Kilogram
L	=	Liter
λ_{max}	=	Wavelength at maximal absorption

ε	=	Molar absorptivity
$[M]^+$	=	Molecular ion
$[M+H]^+$	=	Protonated molecular ion
$[M+Na]^+$	=	Sodium-adduct molecular ion
m	=	Multiplet (for NMR spectra)
MeOH	=	Methanol
mg	=	Milligram
mL	=	Milliliter
µg	=	Microgram
µg/mL	=	Microgram per milliliter
µL	=	Microliter
µM	=	Micromolar
min	=	Minute
mm	=	Millimeter
MS	=	Mass spectrum
MW	=	Molecular weight
m/z	=	Mass to charge ratio
nm	=	Nanometer
NMR	=	Nuclear Magnetic Resonance
NOESY	=	Nuclear Overhauser Effect Spectroscopy
PTLC	=	Preperative thin-layer chromatography
ppm	=	Part per million
Rha	=	Rhamnose
s	=	Singlet (for NMR spectra)
t	=	Triplet (for NMR spectra)
TLC	=	Thin Layer Chromatography
UV-VIS	=	Ultraviolet and Visible spectrophotometry
VLC	=	Vacuum Liquid Column Chromatography

CHAPTER I
INTRODUCTION

Diabetes mellitus (DM) is a common metabolic disease characterized by high plasma glucose level, which is due to the body being incompetent to make or use insulin. This irregularity can cause many complications, for example, retinopathy, neuropathy, cardiovascular disease and brain damage (Patel *et al*., 2012).

There are two major types of diabetes, types 1 and 2 diabetes. Type 1 diabetes is an autoimmune disorder that destroys β-cells of the pancreas. It is usually found in young adults, adolescents and children. Patients must take insulin to survive. Type 1 diabetes is also known as insulin-dependent diabetes mellitus (IDDM) and juvenile diabetes. However, these terms are not accurate as children sometimes develop other forms of diabetes. Moreover, adults can develop type 1 and insulin medication maybe required in the other form of diabetes. Type 1 diabetes that develops later in life, mostly after age 30, is known as latent autoimmune diabetes of adulthood (LADA). Sometimes, weight gain or genetic factors can cause insulin resistance. This phenomenon is called double diabetes (Patel *et al*., 2012).

Type 2 diabetes is a disorder of metabolism. It is the most commonly form of diabetes mellitus, accounting for 85% to 95%. Excess weight and insulin resistance are usually found. In these patients, the pancreas can produce insulin but the body has low ability to take glucose into cells. The resulting over excretion of insulin finally leads to pancreas dysfunction. This complication may take a year or several to develop. Losing weight, exercise and diet improving can delay or prevent the progression of type 2 diabetes. It is known as adult-onset diabetes and non-insulin-dependent diabetes mellitus (NIDDM) (Raman *et al*., 2012).

In addition, there are two minor types of DM: gestational diabetes and secondary diabetes. Gestational diabetes is a temporary metabolic disorder which is found in any pregnancy woman who previously is non diabetic. It usually occurs at the beginning of the third trimester due to a lot of hormone changing and is associated with excessive weight and family history of diabetes.

Secondary diabetes is the diabetes caused by other conditions. There are many causes of secondary diabetes, ranging from the side effects from drugs such as corticosteroids, pentamidine, nicotinic acid, thyroid hormone, immunosuppressives agents and thiazide, to the complications from diseases such as pancreatitis, neoplasia, hemochromatosis, pancreatectomy, acromegaly, cushing' s syndrome, down's syndrome and myotonic dystrophy (Raman *et al*., 2012).

Diabetic treatment is mainly focused on controlling and lowering blood glucose level to the normal level. Drugs used for the DM treatment have several mechanisms. They may (1) stimulate the β-cell of pancreatic islet to excrete insulin, (2) inhibit the factors which levels up blood glucose, (3) enhance insulin receptor sensitivity, 4) delay carbohydrate break down, (5) promote the use of glucose in tissues and organs, (6) eliminate free radicals, and inhibit lipid peroxidation and (7) lower the metabolic disorder of proteins and lipids (Raman *et al*., 2012).

Based on the mechanisms mentioned above, the drugs usually used in DM can be classified as insulin secretagogues, insulin, insulin-like growth factors, insulin sensitivity improving agents, aldose reductase inhibitors, protein glycation inhibitors and α-glucosidase inhibitors. The drugs commonly used to treat diabetes are shown below (Liu and Wang, 1996):

Sulfonylureas:	Glibencamide, Glicazide, and Glimepiride.
Biguanides:	Phenformin, Metformin and Melbine
α-Glucosidase inhibitors:	Acarbose, Volgibose and Migitol
Aldose reductase inhibitors:	Tolrestat, Alredase, and Imirestat
Thiazolidinediones:	Troglitazone, Rosigitazone and Pioglitazone
Insulin-like growth factor:	IGF-1

α-Glucosidase inhibitors inhibit carbohydrate digestion by restraining the cleavage of glucosidic bonds. They have been found in plants, animals and microorganism. Compounds that can inhibit α-glucosidase mostly are polyhydroxylated *N*-substituted heterocyclic compounds, polyhydroxylated cycloalkenes and oligomers of pseudosugar since these groups possess structures similar to starch or sugar. (Hillebrand *et al*., 1979).

Recently, several plant secondary metabolites have been reported to possess α-glucosidase inhibitory activity. Three alkaloids from branches of *Piper umbellatum* named piperumbellactam A, piperumbellactam B and piperumbellactam C exhibited moderate α-glucosidase inhibitory activity with IC_{50} values of 98.07$\pm$ 0.44, 43.80 $\pm$ 0.56, and 29.64 $\pm$ 0.46 μM, respectively. Curcumin from *Curcuma longa* showed α-glucosidase inhibitory effect with with an IC_{50} value of 23.0 μM. The triterpenoid 3β -acetoxy-16β-hydroxybetulinic acid from *Fagara tessmannii* exhibited potent α-glucosidase inhibitory activity with an IC_{50} value of 7.6 $\pm$ 0.6 μM (Kumar *et al*., 2011).

Recently, several α-glucosidase inhibiting compounds have been reported from plants in the genus *Dendrobium,* i.e*. Dendrobium devonianum* (Sun, *et al*., 2014*)* and *D. loddigesii* (Lu *et al*., 2014).

The genus *Dendrobium* is a member of Orchidaceae family. About 1,100 species have been identified in Asia and Australia. In Thailand, more than 90 species have been identified, as follows (Smitinand, 2001):

Dendrobium acerosum Lindl.	**กล้วยไม้มือนาง** Kluai mai mue nang (Chumphon)
D. acinaciforme Roxb.	**เอื้องยอดสร้อย** Ueang yot soi (Northern)
D. albosanguineum Lindl.	**เอื้องตางัว** Ueang ta ngua (Mae Hong Son)
D. aloifolium (Blume) Rchb.f.	**เอื้องมณี** Ueang mani (Bangkok)
D. anosmum Lindl.	**เอื้องสาย** Ueang sai (Chiang Mai, Peninsular)
D. aphyllum (Roxb.) C.E.C.Fisch.	**เอื้องงวงช้าง** Ueang nguang chang (Mae Hong Son)
D. bellatulum Rolfe	**เอื้องแซะภู** Ueng sae phu
D. bicameratum Lindl.	**เอื้องเข็ม** Ueang khem (Northern)
D. bilobulatum Seidenf.	**กล้วยไม้ก้างปลา** Kluai mai kang pla (General)
D. binoculare Rchb.f.	**เอื้องคำสาย** Ueang kham sai (Northern)
D. brymerianum Rchb.f.	**เอื้องคำฝอย** Ueang kham foi (Northern)
D. capillipes Rchb.f.	**เอื้องคำกิ่ว** Ueang kham kio (Lampang, Phrae)
D. cariniferum Rchb.f.	**เอื้องกาจก** Ueang kachok (Chiang Mai)
D. christyanum Rchb.f.	**เอื้องแซะภูกระดึง** Ueang sae phu kradueng (Loei)
D. chrysanthum Lindl.	**เอื้องสายมรกต** Ueang sai morakot (Bangkok)
D. chrysotoxum Lindl.	**เอื้องคำ** Ueang kham (Northern)
D. compactum Rolfe ex Hackett	**เอื้องข้าวตอก** Ueang khao tok (Northern)
D. concinnum Miq.	**หางเปีย** Hang pia (Narathiwat)
D. crepidatum Lindl. & Paxton	**เอื้องสายน้ำเขียว** Ueang sai nam khiao (General)
D. crocatum Hook.f.	**เอื้องนางนวล** Ueang nang nuan (Peninsular)
D. cruentum Rchb.f.	**เอื้องนกแก้ว** Ueang nok kaeo (Bangkok)
D. crumenatum Sw.	**หวายตะมอย** Wai tamoi (Central, Peninsular)

D. crystallinum Rchb.f.	**เอื้องนางฟ่อน** Ueang nang fon (Chiang Mai)
D. cumulatum Lindl.	**เอื้องสายสี่ดอก** Ueang sai si dok (Northern, Southeastern)
D. dantaniense Guillaumin	**เอื้องเข็ม** Ueang khem (Chiang Mai)
D. densiflorum Lindl.	**เอื้องมอนไข่** Ueang mon khai (Northern)
D. devonianum Paxton	**เอื้องเมี่ยง** Ueang miang (Chiang Mai)
D. dickasonii L.O. Williams	**เอื้องเคี้ยะ** Ueang khia (Chiang Mai)
D. discolor Lindl.	**หวายกลัก** Wai klak (Bangkok)
D. dixanthum Rchb.f.	**เอื้องเทียน** Ueang thian (Northern)
D. draconis Rchb.f.	**เอื้องเงิน** Ueang ngoen (Northern)
D. ellipsophyllum Tang & Wang	**เอื้องทอง** Ueang thong (Genaeral)
D. exile Schltr.	**เอื้องเสี้ยน** Ueang sian (General)
D. falconeri Hook.	**เอื้องสายวิสูตร** Ueang sai wisut (Bangkok)
D. farmeri Paxton	**เอื้องมัจฉาณุ** Ueang mat chanu (Bangkok)
D. fimbriatum Hook.	**เอื้องคำน้อย** Ueang kham noi (Chiang Mai)
*D. findlayanu*m Parish & Rchb.f.	**พวงหยก** Phuang yok (Bangkok)
D. formosum Roxb. ex Lindl.	**เอื้องเงินหลวง** Ueang ngoen luang (Chiang Mai)
D. friedericksianum Rchb.f.	**เอื้องเหลืองจันทบูร** Ueang Lueang chantabun (Bangkok)
D. fuerstenbergianum Schltr.	**เอื้องแซะภูกระดึง** Ueang sae phukradueng (Loei)
D. gibsonii Lindl.	**เอื้องคำสาย** Ueang kham sai (Northern)
D. grande Hook.f	**เอื้องแผงใบใหญ่** Ueang pheang bai yai (Peninsular)
D. gratiosissimum Rchb.f.	**เอื้องกิ่งดำ** Ueang king dam (Bangkok)
D. gregulus Seidenf.	**เอื้องมะต่อม** Ueang matom (Chiang Mai)
D.griffithianum Lindl.	**เอื้องมัจฉาณุ** Ueang matchanu (Bangkok)
D. harveyanum Rchb.f.	**เอื้องคำฝอย** Ueang kham foi (Chiang Mai)
D. hendersonii Hawkes & Heller	**หวายตะมอยน้อย** Wai tamoi noi (Peninsular)
D. hercoglossum Rchb.f.	**เอื้องดอกมะเขือ** Ueang dok ma kuea (Bangkok)
D. heterocarpum Lindl.	**เอื้องสีตาล** Ueang si tan (Chiang Mai)
D. indivisum (Blume) Miq.	**ตานเสี้ยนไม้** Tan sian mai (Chumphon)

var. *indivisum*	
D. indivisum (Blume) Miq.	**ก้างปลา** Kang pla (General)
var. *pallidum* Seidenf.	
D. infundibulum Lindl.	**เอื้องตาเหิน** Ueang ta hoen (General)
D. intricatum Gagnep.	**เอื้องชมพู** Ueang chom phu (Chanthaburi)
D. jenkinsii Wall. ex Lindl.	**เอื้องผึ้งน้อย** Ueang phueng noi(Chiang Mai)
D. kanburiense Seidenf.	**หวายเมืองกาญจน์** Wai muang kan (Kanchanaburi)
D. leonis (Lindl.) Rchb.f.	**เอื้องตะขาบใหญ่** Ueang ta khap yai (General)
D. lindleyi Steud.	**เอื้องผึ้ง** Ueang phueng (Northern)
D. lituiflorum Lindl.	**เอื้องสายม่วง** Ueang sai muang (Bangkok, Northern)
D. moschatum (Buch.-Ham.) Sw.	**เอื้องจำปา** Ueang champa (Northern)
D. nathanielis Rchb.f.	**เกล็ดนิ่ม** Klet nim (Chantaburi)
D. nobile Lindl.	**เอื้องเค้ากิ่ว** Ueang khao kio (Northern)
D. ochreatum Lindl.	**เอื้องตะขาบ** Ueang ta khap (Chiang Mai)
D. oligophyllum Gagnep.	**ข้าวตอกปราจีน** Khao tok prachin (General)
D. pachyglossum	**เอื้องขนหมู** Ueang khon mu (Mae Hong Son)
C.S.P.Parish & Rchb.f	
D. pachyphyllum (Kuntze) Bakh.f.	**เอื้องน้อย** Ueang noi (General)
D. palpebrae Lindl.	**เอื้องมัจฉา** Ueang mat cha, **เอื้องมัจฉาณุ** Ueang mat chanu (Bangkok)
D. parcum Rchb.f.	**เอื้องก้านกิ่ว** Ueang kan kio (Bangkok)
D. parishii Rchb.f.	**เอื้องครั่ง** Ueang khrang (Northern)
D. pendulum Roxb.	**เอื้องไม้เท้าฤาษี** Ueang mai thao ruesi (Bangkok, Chiang Mai)
D. pensile Ridl.	**หวาย** Wai (Narathiwat)
D. porphyrophyllum Guillaumin	**เอื้องลิ้น** Ueang lin (Lampang)
D. primulinum Lindl.	**เอื้องสายประสาท** Ueang sai prasat (Bangkok)
D. pulchellum Roxb. ex Lindl.	**เอื้องคำตาควาย** Ueang kham ta khwai (Mae Hong Son)

D. pychnostachyum Lindl.	**เศวตสอดสี** Sawet sot si (Chiang Mai)
D. salaccense (Blume) Lindl.	**เอื้องใบไผ่** Ueang bai phai (Chiang Mai)
D. scabrilingue Lindl.	**เอื้องแซะ** Ueang sae (Mae Hong Son)
D. secundum (Blume) Lindl.	**เอื้องแปรงสีฟัน** Ueang preang si fan (Bangkok)
D. seidenfadenii Rchb.f.	**เอื้องเกี๊ยะ** Ueang kia (Chiang Mai)
D. senile Parish & Rchb.f.	**เอื้องชะนี** Ueang chani (Bangkok)
D. signatum Rchb.f.	**เอื้องเค้ากิ่ว** Ueang khao kio (Chiang Mai)
D. stuposum Lindl.	**เอื้องสาย** Ueang sai (Chiang Mai)
D. sulcatum Lindl.	**เอื้องจำปาน่าน** Ueang champa nan (Bangkok)
D. superbiens Rchb.f.	**หวายคิง** Wai khing (Bangkok)
D. sutepense Rolfe ex Downie	**เอื้องมะลิ** Ueang mali (Chiang Mai)
D. terminale Parish & Rchb.f	**เอื้องแผงโสภา** Ueang phaeng sopha (Peninsular)
D. thyrsiflorum Rchb.f	**เอื้องมอนไข่ใบมน** Ueang mon khai bai mon (Northern)
D. tortile Lindl.	**เอื้องไม้ตึง** Ueang mai tueng (Mae Hong Son)
D. trigonopus Rchb.f.	**เอื้องคำเหลี่ยม** Ueang kham liam (Chiang Mai)
D. trinervium Ridl.	**เทียนลิง** Thian ling (Chumphon)
D. unicum Seidenf.	**เอื้องครั่งแสด** Ueang krang saet (General)
D. uniflorum Griff.	**เอื้องทอง** Ueang thong (Pattani)
D. venustum Teijsm. & Binn	**ข้าวเหนียวลิง** Khao niao ling (Central)
D. villosulum Lindl.	**กล้วยหญ้านา** Kluai ya na (Bangkok)
D. virgineum Rchb.f.	**เอื้องเงินวิลาศ** Ueang ngoen wilat (Northern)
D. wardianum Warner	**เอื้องมณีไตรรงค์** Ueang mani trai rong (Northern)
D. wattii (Hook.f.) Rchb.f.	**เอื้องแซะ** Ueang sae (Northern)
D. ypsilon Seidenf.	**เอื้องแบนปากตัด** Ueang baen pak tat (General)

Dendrobium tortile Linl was first described by John Lindley. It has been found in Assam India, Bangladesh, Malaysia, Myanmar, Andaman Island, Laos, Vietnam and Thailand. It is known in Thai as “Ueang mai tueng (เอื้องไม้ตึง)” or “Ueang kao kio (เอื้อง

เค้ากิ่ว)". It is an epiphyte with height about 30-50 cm (Figure 1). Stems are flat, and leaves are sharply pointed. Leaf sheaths are tubular and thin. Flowers are fragrant and bloom in February and April (Smitinand, 2001)

Prior to this study, there were no previous report about chemical constituents and biological activities of *Dendrobium tortile.* A methanol crude extract prepared from whole plant was evaluated for α-glucosidase inhibitory activity and showed 70% inhibition at a concentration of 2 mg/mL. This author was interested in identifying the active principles responsible for the α-glucosidase inhibitory activity of this plant. The biological results obtained from this research might lead to the discovery of lead compounds, which might later be developed into new antidiabetic drugs. The chemical information may also be useful for further chemotaxonomic studies of the genus *Dendrobium*. In the present investigation, the following objectives have been put forward:

1. To isolate and purify the chemical constituents of *Dendrobium tortile*
2. To characterize the structures of the isolated compounds.
3. To evaluate the α-glucosidase inhibitory activity of the isolated compounds

Figure 1 *Dendrobium tortile* Lindl

CHAPTER II

HISTORICAL

1. Chemical constituents of *Dendrobium* species.

According to previously reported investigations, the chemical constituents of plants in the genus *Dendrobium* could be classified into several categories, for instance, bibenzyls and derivatives, flavonoids, terpenoids and miscellaneous compounds (**Figure 2**).

The bibenzyls and derivatives from *Dendrobium* are shown in **Table 1**, whereas the flavonoids are shown in **Table 2**. Bibenzyl compounds could be considered as derived from stilbenes. Biogenetically, both stilbenes and flavonoids are derived from 4-hydroxycinnamoyl CoA unit via the shikimate pathway, with chain extension linking to three molecules of malonyl CoA. Depending on the nature of the enzyme, the next reaction can proceed in two different directions, i.e. via the enzyme stilbene synthase to give a stilbene or the enzyme chalcone synthase to give a chalcone. Chalcones then act as precursors for flavonoids (Dewick, 2002).

Terpenoids, as shown in **Table 3**, can occur via two pathways: the mevalonate pathway and mevalonate-independent pathway through the intermediate deoxyxylulose phosphate. They all are derived from C_5 (isoprene) units. Typical structures have carbon skeletons represented by $(C_5)_n$, which are called hemiterpenes (C_5), monoterpenes (C_{10}), sesquiterpenes (C_{15}), diterpenes (C_{20}), sesterterpenes (C_{25}), triterpene (C_{30}) and tetraterpenes (C_{40}) (Dewick, 2002).

Several minor constituents are grouped together as miscellaneous compounds in **Table 4**. They include aliphatic compounds, benzoic acid derivatives, coumarins, fluorenones, lignans, neolignans and phenylpropanoids.

Table 1 Distribution of bibenzyls and derivatives in the genus *Dendrobium*

Compound	Plant	Plant part	Reference
Dendrocandin A [**1**]	*D. candidum*	Stem	Li *et al*., 2008
Dendrocandin B [**2**]	*D. candidum*	Stem	Li *et al*., 2008
Dendrocandin C [**3**]	*D. candidum*	Stem	Li *et al.,* 2009a
Dendrocandin D [**4**]	*D. candidum*	Stem	Li *et al.,* 2009a
Dendrocandin E [**5**]	*D. candidum*	Stem	Li *et al.,* 2009a
Dendrocandin F [**6**]	*D. candidum*	Stem	Li *et al.,* 2009b
Dendrocandin G [**7**]	*D. candidum*	Stem	Li *et al.,* 2009b
Dendrocandin H [**8**]	*D. candidum*	Stem	Li *et al.,* 2009b
Dendrosinen A [**9**]	*D. sinense*	Whole plant	Chen *et al.,* 2014
Dendrosinen B [**10**]	*D. sinense*	Whole plant	Chen *et al.,* 2014
Dendrosinen C [**11**]	*D. sinense*	Whole plant	Chen *et al.,* 2014
Dendrosinen D [**12**]	*D. sinense*	Whole plant	Chen *et al.,* 2014
Aloifol I [**13**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Amoenylin [**14**]	*D. amoenum*	Whole plant	Majumder *et al*., 1999

Table 1 (continued)

Compound	Plant	Plant part	Reference
Betatasin [**15**]	*D. longicornu*	Stem	Hu *et al*., 2008a
	D. plicatile	Stem	Yamaki and Honda, 1996
Batatasin III [**16**]	*D. aphyllum*	Whole plant	Chen *et al.*, 2008a
	D. chrysotoxum	Whole plant	Li *et al*., 2009c
	D. cariniferum	Stem	Chen *et al*., 2009c
	D. draconis	Stem	Sritularak *et al*., 2011a
	D. gratiosissimum	Stem	Zhang *et al*., 2008a
	D. loddigesii	Whole plant	Ito *et al*., 2010
	D. aphyllum	Stem	Yang *et al*., 2015
Brittonin A [**17**]	*D. secundum*	Stem	Sritularak *et al.*, 2011b
Chrysotobibenzyl [**18**]	*D. aurantiacum* var.*denneanum*	Stem	Yang *et al*., 2006a
	D. capillipes	Stem	Phechrmeekha *et al*., 2012
	D. chrysanthum	Stem	Yang *et al*., 2006b
	D. chryseum	Stem	Hu *et al*., 2012
	D. chrysotoxum	Stem	Hu *et al*., 2012
	D. nobile	Stem	Zhang *et al*., 2007a
	D. pulchellum	Stem	Chanvorachote *et al*., 2013

Table 1 (continued)

Compound	Plant	Plant part	Reference
Chrysotoxine [**19**]	*D. aurantiacum* var.*denneanum*	Stem	Yang *et al.*, 2006a
	D. capillipes	Stem	Phechrmeekha *et al*., 2012
	D. chrysanthum	Stem	Yang *et al*., 2006b
	D. chryseum	Stem	Ma *et al*., 1998
	D. nobile	Stem	Zhang *et al*., 2007a
	D. pulchellum	Stem	Chanvorachote *et al*., 2013
Crepidatin [**20**]	*D. aurantiacum* var.*denneanum*	Whole plant	Liu *et al*., 2009
	D. capillipes	Stem	Phechrmeekha *et al*., 2012
	D. chrysanthum	Stem	Yang *et al*., 2006b
	D. crepidatum	Whole plant	Majumder *et al*., 1989
	D. nobile	Stem	Zhang *et al*., 2007a
	D. pulchellum	Stem	Chanvorachote *et al*., 2013
Cumulatin [**21**]	*D. cumulatum*	Whole plant	Majumer and Pal, 1993
Dendrobin A [**22**]	*D. nobile*	Stem	Wang *et al*., 1985, Ye and Zhao, 2002a
3,4′-Dihydroxy-5-methoxybibenzyl [**23**]	*D. amoenum*	Whole plant	Majumder *et al*., 1999

Table 1 (continued)

Compound	Plant	Plant part	Reference
3,4′-Dihydroxy-5,5′-dimethoxydihydro Stilbene [**24**]	*D. nobile*	Stem	Hwang *et al*., 2010
4,5-Dihydroxy-3,3′-dimethoxybibenzyl [**25**]	*D. nobile*	Stem	Ye *et al.*, 2002a
Gigantol [**26**]	*D. aphyllum*	Whole plant	Chen *et al*., 2008a
	D. aurantiacum var.denneanum	Whole plant	Liu *et al*., 2009a
	D. candidum	Stem	Li *et al*., 2008
	D. brymerianum	Whole plant	Klongkumnuankarn *et al*., 2014
	D. cariniferum	Stem	Chen *et al*., 2008c
	D. chrysanthum	Stem	Yang *et al*., 2006b
	D. chrysotoxum	Whole plant	Li *et al*., 2009c
	D. densiflorum	Stem	Fan *et al.*, 2001
	D. draconis	Stem	Sritularak *et al*., 2011a
	D. gratiosissimum	Stem	Zhang *et al.*, 2008a
	D. loddigesii	Whole plant	Ito *et al.*, 2010
	D. longicornu	Stem	Hu *et al*., 2008a
	D. nobile	Stem	Zhang *et al*., 2007a
	D. polyanthum	Stem	Hu *et al.*, 2009
	D. trigonopus	Stem	Hu *et al*., 2008b
	D. devonianum	Whole plant	Sun *et al*., 2014
4-Hydroxy-3,5,3′-trimethoxybibenzyl [**27**]	*D. nobile*	Stem	Ye *et al.*, 2002a

Table 1 (continued)

Compounds	Plant	Plant part	Reference
5-Hydroxy-3,4,3′,4′,5′-pentamethoxybibenzyl [**28**]	*D. secundum*	Stem	Phechrmeekha *et al*., 2012
Isoamoenylin [**29**]	*D. amoenum*	Whole plant	Majumder *et al.*,1999
Moscatilin [**30**]	*D. amoenum*	Whole plant	Majumder *et al.*, 1999
	D. aurantiacum var.*denneanum*	Stem	Yang *et al.,* 2006a
	D. brymerianum	Whole plant	Klongkumnuankarn *et al*., 2014
	D. chrysanthum	Stem	Yang *et al.,* 2006b
	D. densiflorum	Stem	Fan *et al.*, 2001
	D. gratiosissimum	Stem	Zhang *et al.*, 2008a
	D. loddigesii	Whole plant	Chen *et al.*, 1994,
	D. longicornu	Stem	Ito *et al.*, 2010
	D. moscatum	Whole plant	Hu *et al*., 2008a
	D. nobile	Stem	Yang *et al*., 2007
	D. polyanthum	Stem	Sritularak *et al.*, 2011b
	D. pulchellum	Stem	Chanvorachote *et al*., 2013
	D. secundum	Stem	Sritularak *et al.*, 2011b

Table 1 (continued)

Compound	Plant	Plant part	Reference
3,3′,4-Trihydroxy bibenzyl [**31**]	*D. longicornu*	Stem	Hu *et al*., 2008a
3,3′,5-Trihydroxy bibenzyl [**32**]	*D. cariniferum*	Whole plant	Liu *et al*., 2009b
3,5,4′-Trihydroxy bibenzyl [**33**]	*D. gratiosissimum*	Stem	Zhang *et al.*, 2008a
4,5,4′-Trihydroxy-3,3′-dimethoxy bibenzyl [**34**]	*D. secundum*	Stem	Sritularak *et al.*, 2011b
Tristin [**35**]	*D. chrysotoxum*	Stem	Hu *et al.*, 2012
	D. densiflorum	Stem	Fan *et al.*, 2001
	D. gratiosissimum	Stem	Zhang *et al.*, 2008a
	D. longicornu	Stem	Hu *et al*., 2008a
	D. trigonopus	Stem	Hu *et al.*, 2008b
Dendromoniliside E [**36**]	*D. aphyllum*	Stem	Yang *et al.,* 2015
Dendrocandin A [**37**]	*D. moniliforme*	Stem	Zhao *et al*., 2003
Dendrophenol [**38**]	*D. candidum*	Stem	Li *et al.,* 2008
3,4-Dihydroxy-5,4′-dimethoxybibenzyl [**39**]	*D. candidum*	Stem	Li *et al.,* 2008
4,4′-Dihydroxy-3,5-dimethoxybibenzyl [**40**]	*D. candidum*	Stem	Li *et al.,* 2008
Loddigesiinol C [**41**]	*D. loddigesii*	Whole plant	Ito *et al.*, 2010
3-*O*-Methylgigantol [**42**]	*D. candidum*	Stem	Li *et al.,* 2008
	D. plicatile	Stem	Yamaki and Honda, 1996

Table 1 (continued)

Compound	Plant	Plant part	Reference
Dendrocandin I [**43**]	*D. candidum*	Stem	Li *et al.,* 2009b
Densiflorol A [**44**]	*D. densiflorum*	Stem	Fan *et al*., 2001
Longicornuol A [**45**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Trigonopol A [**46**]	*D. trigonopus*	Stem	Hu *et al.*, 2008b
Trigonopol B [**47**]	*D. chrysotoxum*	Stem	Hu *et al.*, 2012
	D. trigonopus	Stem	Hu *et al.*, 2008b
Crepidatuols A [**48**]	*D. crepidatum*	Stem	Li et al., 2013
Crepidatuols B [**49**]	*D. crepidatum*	Stem	Li et al., 2013
Loddigesiinol D [**50**]	*D. loddigesii*	Whole plant	Ito *et al.*, 2010
Dencryol A [**51**]	*D. crystallinum*	Stem	Wang *et al.*, 2009
Dencryol B [**52**]	*D. crystallinum*	Stem	Wang *et al.*, 2009
Dengraol A [**53**]	*D. gratiosissimum*	Stem	Zhang *et al.*, 2008a
Dengraol B [**54**]	*D. gratiosissimum*	Stem	Zhang *et al.*, 2008a
4-[2-(3-Hydroxyphenol)-1-methoxyethyl]-2,6-dimethoxy phenol [**55**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Nobilin A [**56**]	*D. nobile*	Stem	Zhang *et al*., 2006
Nobilin B [**57**]	*D. nobile*	Stem	Zhang *et al*., 2006
Nobilin C [**58**]	*D. nobile*	Stem	Zhang *et al*., 2006
Nobilin D [**59**]	*D. nobile*	Stem	Zhang *et al*., 2007a
Nobilin E [**60**]	*D. nobile*	Stem	Zhang *et al*., 2007a
Dendrofalconerol A [**61**]	*D. falconeri*	Stem	Sritularak *et al*., 2009
Dendrofalconerol B [**62**]	*D. falconeri*	Stem	Sritularak et al., 2009

Table 1 (continued)

Compound	Plant	Plant part	Reference
2,2′-Dihydroxy-3,3′,4,4′,7,7-hexamethoxy-9,9′,10,10′-tetrahydro-1,1′-biphenanthrene [**63**]	*D. nobile*	Stem	Yang *et al*., 2007
2,2′-Dimethoxy-4,4′,7,7′-tetrahydroxy-9′,10,10′-tetrahydro-1,1′-biphenanthrene [**64**]	*D. plicatile*	Stem	Yamaki and Honda, 1996
Flavanthrin [**65**]	*D. aphyllum*	Whole plant	Chen *et al.*, 2008a
(*S*)-3,4,α-trihydroxy-5,4′ dimethoxybibenzyl [**66**]	*D. candidum*	Stem	Li *et al*., 2015
Amoenumin [**67**]	*D. amoenum*	Whole plant	Veerraju *et al*., 1989
Crystalltone [**68**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
	D. crystallinum	Stem	Wang *et al.*, 2009
Chrysotoxol A [**69**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
Chrysotoxol B [**70**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
Confusarin [**71**]	*D. chryseum*	Stem	Ma *et al*., 1998
	D. chrysotoxum	Stem	Hu *et al*., 2012
	D. nobile	Stem	Zhang *et al.*, 2008b
2,6-Dihydroxy-1,5,7-trimethoxyphenanthrene [**72**]	*D. densiflorum*	Stem	Fan *et al*., 2001
Dendrochrysanene [**73**]	*D. chrysanthum*	Stem	Yang *et al*., 2006b
Bulbophyllanthrin [**74**]	*D. nobile*	Stem	Yang *et al.*, 2007
Denthyrsinin [**75**]	*D. thyrsiforum*	Stem	Zhang *et al.*, 2005

Table 1 (continued)

Compound	Plant	Plant part	Reference
5-Hydroxy-2,4-dimethoxy phenanthrene [**76**]	*D. loddigesii*	Whole plant	Ito *et al.*, 2010
3-Hydroxy-2,4,7-trimethoxyphenanthrene [**77**]	*D. nobile*	Stem	Yang *et al.*, 2007
Cypripedin [**78**]	*D. densiflorum*	Stem	Fan *et al.,* 2001
Densiflorol B [**79**]	*D. densiflorum*	Stem	Fan *et al.,* 2001
Denbinobin [**80**]	*D. moniliforme*	Stem	Linet *et al*., 2001
	D. nobile	Stem	Yang *et al.*, 2007
Fimbriatone [**81**]	*D. nobile*	Stem	Zhang *et al.*, 2008b
	D. pulchellum	Stem	Chanvorachote *et al.*, 2013
Loddigesiinol B [**82**]	*D. loddigesii*	Whole plant	Ito *et al.*, 2010
Dendronone [**83**]	*D. chrysanthum*	Stem	Yang *et al*., 2006b
	D. longicornu	Stem	Hu *et al.*, 2008a
Ephemeranthoquinone [**84**]	*D. plicatile*	Stem	Yamaki and Honda, 1996
5-Methoxy-7-hydroxy-9,10-dihydro-1,4-phenanthrenequinone [**85**]	*D. draconis*	Stem	Sritularak *et al.,* 2011a
Moniliformin [**86**]	*D. moniliforme*	Stem	Lin *et al.*, 2001
Moscatin [**87**]	*D. aphyllum*	Whole plant	Chen *et al.*, 2008a
	D. chrysanthum	Stem	Yang *et al*., 2006b
	D. chrysotoxum	Whole plant	Li *et al.*, 2009c
	D. densiflorum	Stem	Fan *et al.,* 2001
	D. polyanthum	Stem	Hu *et al*., 2009

Table 1 (continued)

Compound	Plant	Plant part	Reference
Coelonin [**88**]	*D. aphyllum*	Whole plant	Chen *et al.*, 2008a
	D. nobile	Stem	Yang *et al.*, 2007
9,10-Dihydromoscatin [**89**]	*D. polyanthum*	Stem	Hu *et al.*, 2009
9,10-Dihydrophenanthrene-2,4,7-triol [**90**]	*D. polyanthum*	Stem	Hu *et al.*, 2009
4,5-Dihydroxy-2,3-dimethoxy-9,10-dihydrophenanthrene [**91**]	*D. sinense*	Whole plant	Chen *et al.*, 2013
4,5-Dihydroxy-2,6-dimethoxy-9,10-dihydrophenanthrene [**92**]	*D. chrysotoxum*	Stem	Hu *et al.*, 2012
4,5-Dihydroxy-3,7-dimethoxy-9,10-dihydrophenanthrene [**93**]	*D. nobile*	Stem	Ye *et al.*, 2002a
4,5-Dihydroxy-2-methoxy-9,10-dihydrophenanthrene [**94**]	*D. nobile*	Stem	Zhang *et al.*, 2008b
2,7-Dihydroxy-3,4,6-trimethoxy-9,10-dihydrophenanthrene [**95**]	*D. nobile*	Stem	Yang *et al.*, 2007
2,8-Dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene [**96**]	*D. densifloru*	Stem	Fan *et al.,* 2001
4,7-Dihydroxy-2,3,6-trimethoxy-9,10-dihydrophenanthrene [**97**]	*D. rotundatum*	Whole plant	Majumder and Pal, 1992

Table 1 (continued)

Compound	Plant	Plant part	Reference
Ephemeranthol A [**98**]	*D. nobile*	Stem	Yang *et al.*, 2007 Hwang *et al.*, 2010
Ephemeranthol C [**99**]	*D. nobile*	Stem	Yang *et al.*, 2007 Hwang *et al.*, 2010
Erianthridin [**100**]	*D. nobile*	Stem	Hwang *et al.*, 2010
Flavanthridin [**101**]	*D. nobile*	Stem	Hwang *et al.*, 2010
Hircinol [**102**]	*D. draconis*	Stem	Sritularak *et al.*, 2011a
	D. aphyllum	Stem	Yang *et al.*, 2015
3-Hydroxy-2,4,7-trimethoxy-9,10-dihydrophenanthrene [**103**]	*D. nobile*	Stem	Yang *et al.*, 2007
2-Hydroxy-4,7-dimethoxy-9,10-dihydrophenanthrene [**104**]	*D. nobile*	Stem	Yang *et al.*, 2007
7-Methoxy-9,10-dihydrophenanthrene-2,4,5-triol [**105**]	*D. draconis*	Stem	Sritularak *et al.*, 2011a
Plicatol C [**106**]	*D. plicatile*	Stem	Honda and Yamaki, 2000
Rotundatin [**107**]	*D. rotundatum*	Whole plant	Majumder and Pal, 1992

Table 1 (continued)

Compound	Plant	Plant part	Reference
2,5-Dihydroxy-3,4-Dimethoxyphenanthrene [**108**]	*D. nobile*	Stem	Yang *et al.*, 2007
2,5-Dihydroxy-4,9-Dimethoxyphenanthrene [**109**]	*D. nobile*	Stem	Zhang *et al.*, 2008b
2,8-Dihydroxy-3,4,7-Trimethoxyphenanthrene [**110**]	*D. nobile*	Stem	Yang *et al.*, 2007
Epheranthol B [**111**]	*D. chrysotoxum*	Stem	Hu *et al.*, 2012
	D. plicatile	Stem	Yamaki and Honda, 1996
Fimbriol B [**112**]	*D. nobile*	Stem	Yang *et al.*, 2007; Hwang *et al.*, 2010
Flavanthrinin [**113**]	*D. nobile*	Stem	Zhang *et al.*, 2008b
Loddigesiinol A [**114**]	*D. loddigesii*	Whole plant	Ito *et al.*, 2010
Nudol [**115**]	*D. nobile*	Stem	Yang *et al.*, 2007
	D. rotundatum	Whole plant	Majumder and Pal, 1992
Plicatol A [**116**]	*D. nobile*	Stem	Yang *et al.*, 2007
	D. plicatile	Stem	Honda and Yamaki, 2000
Plicatol B [**117**]	*D. plicatile*	Stem	Honda and Yamaki, 2000
2,3,5-Trihydroxy-4,9-dimethoxyphenanthrene [**118**]	*D. nobile*	Stem	Yang *et al.*, 2007

Table 1 (continued)

Compound	Plant	Plant part	Reference
3,4,8-Trimethoxy phenanthrene-2,5-diol [**119**]	*D. nobile*	Stem	Hwang *et al.*, 2010
Aphyllone [**120**]	*D. nobile*	Stem	Hwang *et al.*, 2010
(*S*)-2,4,5,9-tetrahydroxy-9,10-dihydro phenanthrene [**121**]	*D. fimbriatum*	Stem	Xu *et al*., 2014
1,5,7-trimethoxyphenanthren-2-ol [**122**]	*D. nobile*	Stem	Kim *et al*., 2015
dihydrophenanthrene,1,5-dihydroxy-3,4,7-trimthoxy-9,10-dihydro phenanthrene [**123**]	*D. moniliforme*	Whole plant	Zhao *et al.*, 2015
2,4,5,9S-tetrahydroxy-9,10-dihydrophenanthrene 4-*O*-β-*D*-glucopyranoside [**124**]	*D. primulinum*	Whole plant	Ye *et al*., 2016
Loddigesiinol G [**125**]	*D. loddigesii*	Stem	Lu *et al*., 2014
Loddigesiinol H [**126**]	*D. loddigesii*	Stem	Lu *et al*., 2014
Loddigesiinol I [**127**]	*D. loddigesii*	Stem	Lu *et al*., 2014
Loddigesiinol J [**128**]	*D. loddigesii*	Stem	Lu *et al*., 2014

Table 2 Distribution of flavonoids in the genus *Dendrobium*

Compound	Plant	Plant part	Reference
(2*S*)-Homoeriodictyol [**129**]	*D. densiflorum*	Stem	Fan et al., 2001
Naringenin [**130**]	*D. aurantiacum var.denneanum*	Stem	Yang *et al*., 2006a
	D. densiflorum	Stem	Fan *et al*., 2001
	D. longicornu	Stem	Hu *et al*., 2008a
	D. trigonopus	Stem	Hu *et al*., 2008b
Eriodictyol [**131**]	*D. ellipsophyllum*	Whole plant	Tanagormmeatar *et al*., 2014
Apigenin [**132**]	*D. crystallinum*	Stem	Wang *et al.*, 2009
5,6-Dihydroxy-4′-methoxy-flavone [**133**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
Luteolin [**134**]	*D. aurantiacum* var.*denneanum*	Whole plant	Liu *et al.*, 2009a
6-*C*-(α-Arabino pyranosyl)-8-*C*-[(2-*O*-α-rhamnopyranosyl) -β-galactopyranosyl] apigenin [**135**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
6-*C*-(α-Arabino pyranosyl)-8-*C*-[(2-*O*-α-rhamnopyranosyl) -β-glucopyranosyl] apigenin [**136**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
6′′′-Glucosyl-vitexin [**137**]	*D. crystallinum*	Stem	Wang *et al.*, 2009
Isoschaftoside [**138**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
Isoviolanthin [**139**]	*D. crystallinum*	Stem	Wang *et al.*, 2009

Table 2 (continued)

Compound	Plant	Plant part	Reference
6-C-[(2-*O*-α-Rhamno pyranosyl)-β-gluco pyranosyl]-8-C-(α-arabinopyranosyl) apigenin [**140**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
6-C-(β-Xylopyranosyl)-8-C-[(2-*O*-α-rhamnopyranosyl)-β-glucopyranosyl] apigenin [**141**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
Kaempferol [**142**]	*D. aurantiacum* var. *denneanum*	Stem	Yang *et al.,* 2006a
Kaempferol-3-*O*-α-L-rhamnopyranoside [**143**]	*D. secundum*	Stem	Phechrmeekha *et al*., 2012
Kaempferol-3,7-*O*-di-α-L-rhamnopyranoside [**144**]	*D. secundum*	Stem	Phechrmeekha *et al*., 2012
Kaempferol-3-*O*-α-L-rhamnopyranosyl-(1⟶2)-β-D-gluco pyranoside [**145**]	*D. capillipes*	Stem	Phechrmeekha *et al*., 2012
Kaempferol-3-*O*-α-L-rhamnopyranosyl-(1⟶2)-β-D-xylo pyranoside [**146**]	*D. capillipes*	Stem	Phechrmeekha *et al*., 2012
Quercetin-3-*O*-L-rhamnopyranoside [**147**]	*D. secundum*	Stem	Phechrmeekha *et al*., 2012
Quercetin-3-*O*-α-L-rhamnopyranosyl-(1⟶2)-β-D-xylopyranoside [**148**]	*D. capillipes*	Stem	Phechrmeekha *et al*., 2012

Table 2 (continued)

Compound	Plant	Plant part	Reference
5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1⟶6)]-β-D-glucoside [**149**]	*D. devonianum*	Stem	Sun *et al*., 2014

Table 3 Distribution of terpenoids in the genus *Dendrobium*

Compound	Plant	Plant part	Reference
Aduncin [**150**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Amoenin [**151**]	*D. aduncum*	Whole plant	Gawell and Leander, 1976
Amotin [**152**]	*D. amoenum*	Whole plant	Majumder *et al*., 1999
α-Dihydropicrotoxinin [**153**]	*D. amoenum*	Whole plant	Majumder *et al*., 1999
Dendrobane A [**154**]	*D. moniliforme*	Stem	Bi *et al*., 2004
Dendronobilin A [**155**]	*D. nobile*	Stem	Zhang *et al*., 2007a
Dendronobilin B [**156**]	*D. wardianum*	Stem	Fan *et al*., 2013
	D. nobile	Stem	Zhang *et al*., 2007b
Dendronobilin C [**157**]	*D. crystallium*	Stem	Wang *et al*., 2009
Dendronobilin D [**158**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin E [**159**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin F [**160**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin G [**161**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin H [**162**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin I [**163**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin J [**164**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin K [**165**]	*D. wardianum*	Stem	Fan *et al*., 2013
Dendronobilin L [**166**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendronobilin M [**167**]	*D. nobile*	Stem	Zhang *et al*., 2008c
Dendronobilin N [**168**]	*D. nobile*	Stem	Zhang *et al*., 2008c
Dendrowarnol A [**169**]	*D. nobile*	Stem	Zhang *et al*., 2008c
Dendrowarnol B [**170**]	*D. nobile*	Stem	Zhang *et al*., 2008c
Dendrowarnol C [**171**]	*D. wardianum*	Stem	Fan *et al*., 2013

Table 3 (continued)

Compound	Plant	Plant part	Reference
Corchoionoside C [**172**]	*D. wardianum*	Stem	Fan *et al*., 2013
Crystallinin [**173**]	*D. wardianum*	Stem	Fan *et al*., 2013
Findlayanin [**174**]	*D. polyanthum*	Stem	Hu *et al*., 2009
3-Hydroxy-2-oxodendrobine [**175**]	*D. findlayanum*	Whole plant	Qin *et al*. 2011
Dendrobine [**176**]	*D. nobile*	Stem	Wang *et al*.,1985
Dendromoniliside A [**177**]	*D. nobile*	Stem	Zhang *et al*., 2007b
Dendromoniliside B [**178**]	*D. moniliforme*	Stem	Zhao *et al*, 2003
Dendromoniliside C [**179**]	*D. moniliforme*	Stem	Zhao *et al*, 2003
Dendromoniliside D [**180**]	*D. moniliforme*	Stem	Zhao *et al*, 2003
Dendronobiloside A [**181**]	*D. moniliforme*	Stem	Zhao et al, 2003
	D. nobile	Stem	Zhao *et al*., 2001; Ye *et al*., 2002a
Dendronobiloside B [**182**]	*D. nobile*	Stem	Zhao et al., 2001; Ye *et al*., 2002a
Dendronobiloside C [**183**]	*D. nobile*	Stem	Zhao et al., 2001; Ye *et al*., 2002a
Dendronobiloside D [**184**]	*D. nobile*	Stem	Zhao et al., 2001; Ye *et al*., 2002a
Dendronobiloside E [**185**]	*D. nobile*	Stem	Zhao et al., 2001; Ye *et al*., 2002a

Table 3 (continued)

Compound	Plant	Plant part	Reference
Dendroside A [**186**]	*D. moniliforme*	Stem	Zhao et al, 2003
	D. nobile	Stem	Zhao et al., 2001; Ye *et al*., 2002a
Dendroside B [**187**]	*D. nobile*	Stem	Ye *et al.*, 2002a
Dendroside C [**188**]	*D. moniliforme*	Stem	Zhao et al, 2003
	D. nobile	Stem	Ye *et al*., 2002a
Dendroside D [**189**]	*D. nobile*	Stem	Ye *et al.*, 2002a
Dendroside E [**190**]	*D. nobile*	Stem	Ye *et al*., 2002b
Dendroside F [**191**]	*D. moniliforme*	Stem	Zhao *et al*, 2003
Dendroside G [**192**]	*D. nobile*	Stem	Ye *et al*., 2002b
	D. nobile	Stem	Ye *et al*., 2002b

Table 4 Micellaneous compounds in the genus *Dendrobium*

Catergory and Compound	Plant	Plant part	Reference
Aliphatic compounds			
Aliphalic acids [**193**]	*D. clavatum* var. *aurantiacum*	Stem	Chang *et al*., 2001
Aliphatic alcohols [**194**]	*D. clavatum* var. *aurantiacum*	Stem	Chang *et al*., 2001
Malic acid [**195**]	*D. huoshanense*	Aerial part	Chang *et al*., 2001
Dimethyl malate [**196**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
(-)-Shikimic acid [**197**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
	D. fuscescens	Whole plant	Talapatra *et al*., 1989
	D. pulchellum	Stem	Chanvorachote *et al*., 2013
	D. longicornu	Stem	Hu *et al*., 2008a
Isopentyl butyrate [**198**]	*D. huoshanense*	Aerial part	Chang *et al.*, 2010

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
Benzoic acid derivatives and small phenolic compounds			
3-Hydroxy-2-methoxy-5,6-dimethylbenzoic acid [**199**]	*D. crystallinum*	Stem	Wang *et al*., 2009
Salicylic acid [**200**]	*D. huoshanense*	Aerial part	Chang *et al*., 2010
Vanilloside [**201**]	*D. denneanum*	Stem	Pan *et al*., 2012
Gallic acid [**202**]	*D. longicornu*	Whole plant	Li *et al*., 2009d
Syringic acid [**203**]	*D. crystallinum*	Stem	Wang *et al.*, 2009
Vanillic acid [**204**]	*D. crystallinum*	Stem	Wang *et al.*, 2009
Antiarol [**205**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
Ethylhaematommate [**206**]	*D. longicornu*	Whole plant	Li *et al*., 2009d

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
p-Hydroxybenzaldehyde [**207**]	*D. falconeri*	Stem	Sritularak *et al*., 2009
	D. devonianum	Whole plant	Sun, Zhang *et al*. 2014
Methyl β-orsellinate [**208**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Protocatechuic acid [**209**]	*D. nobile*	Stem	Ye and Zhao *et al*., 2002a
Tachioside [**210**]	*D. denneanum*	Stem	Pan *et al*., 2012
Phenylpropanoids			
Alkyl 4′-hydroxy-transcinnamates [**211**]	*D. clavatum var. aurantiacum*	Stem	Chang *et al*., 2001
Alkyl trans-ferulates [**212**]	*D. clavatum var. aurantiacum*	Stem	Chang *et al*., 2001
Defuscin [**213**]	*D. aurantiacum var. denneanum*	Stem	Yang *et al*., 2006a

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
n-Octacosyl ferulate [**214**]	*D. aurantiacum var. denneanum*	Stem	Yang *et al*., 2006a
	D. moniliforme	Stem	Bi *et al*., 2004
n-Triacontyl *p*-hydroxy-*cis*-cinnamate [**215**]	*D. moniliforme*	Stem	Bi *et al*., 2004
n-Docosyl *trans*-ferulate [**216**]	*D. longicornu*	Whole plant	Li *et al*., 2009d
Ferulaldehyde [**217**]	*D. longicornu*	Whole plant	Li *et al*., 2009d
Ferulic acid [**218**]	*D. secundum*	Stem	Sritularak *et al*., 2011b
2-(*p*-Hydroxyphenyl) ethyl *p*-coumarate [**219**]	*D. falconeri*	Stem	Sritularak and Likhitwitayawuid, 2009
1-[4-(β-D-lucopyranosyloxy)-3,5-dimethoxyphenyl]-1-propanone [**220**]	*D. aurantiacum* var. *denneanum*	Stem	Xiong *et al*., 2013
3-(4-Hydroxy-3-methoxyphenyl)-2-propen-1-ol [**221**]	*D. trigonopus*	Stem	Hu *et al*., 2008b

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
p-Hydroxyphenyl propionic methyl ester [**222**]	*D. aphyllum*	Whole plant	Chen *et al*., 2008a
Phloretic acid [**223**]	*D. candidum*	Whole plant	Li *et al*., 2010
3-(3-Methoxy,4-hydroxyphenyl)-1-propanol [**224**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Salidrosol [**225**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
Shashenoside I [**226**]	*D. aurantiacum var. denneanum*	Stem	Xiong *et al*., 2013
Syringin [**227**]	*D. aurantiacum var. denneanum*	Stem	Xiong *et al*., 2013
Tetracosyl(*Z*)-*p*-coumarate [**228**]	*D. falconeri*	Whole plant	Sritularak *et al*., 2009

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
Coumarins			
Ayapin [**229**]	*D. densiflorum*	Stem	Fan *et al*., 2001
Coumarin [**230**]	*D. aurantiacum var.denneanum*	Stem	Yang *et al*., 2006a Chang *et al*., 2001
	D. clavatum var. aurantiacum	Stem	
Denthyrsin [**231**]	*D. thyrsiforum*	Stem	Zhang *et al*., 2005
Scoparone [**232**]	*D. densiflorum*	Stem	Fan *et al*., 2001
	D. thyrsiforum	Stem	Zhang *et al*., 2005
Scopoletin [**233**]	*D. densiflorum*	Stem	Fan *et al*., 2001
Lignans and neolignans			
Dehydrodiconiferyl alcohol-4-β-D-glucoside [**234**]	*D. chrysanthum*	Stem	Ye *et al*., 2004
Episyringaresinol [**235**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
	D. longicornu	Stem	Hu *et al*., 2008a
	D. nobile	Stem	Zhang *et al*., 2008b

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
Episyringaresinol 4′′-*O*-β-D-glucopyranoside [**236**]	*D. moniliforme*	Stem	Zhao *et al*, 2003
(-)-(7*S*,8*R*,7′*E*)-4-Hydroxy-3,3',5,5'-tetramethoxy-8,4′-Oxyneolign-7′-ene-7,9′-triol-7,9′-bis-*O*-β-D-glucopyranoside [**237**]	*D. aurantiacum* var. *denneanum*	Stem	Xiong *et al*., 2013
Lyoniresinol [**238**]	*D. chrysanthum*	Stem	Ye *et al*., 2004
(-)-Syringaresinol-4,4′-bis-*O*-β–D-glucopyranoside [**239**]	*D. aurantiacum* var. *denneanum*	Stem	Xiong *et al*., 2013
Syringaresinol-4-*O*-D-monoglucopyranoside [**240**]	*D. aurantiacum* var. *denneanum*	Stem	Xiong *et al*., 2013
(-)-Medioresinol [**241**]	*D. loddigesii*	Whole plant	Ito *et al*., 2010
(-)-Pinoresinol [**242**]	*D. loddigesii*	Whole plant	Ito *et al*., 2010
Syringaresinol [**243**]	*D. secundum*	Stem	Sritularak *et al*., 2011b

Table 4 (continued)

Catergory and Compound	Plant	Plant part	Reference
Pinoresinol [**244**]	*D. nobile*	Stem	Zhang *et al*., 2008b
	D. nobile	Stem	Zhang *et al.,* 2008b
Erythro-1-(4-*O*-β-D-glucopyranosyl-3-methoxyphenyl)-2-[4-(3-hydroxypropyl)-2,6-dimethoxyphenoxy]-1,3-propanediol [**245**]	*D. longicornu*	Stem	Hu *et al*., 2008a
Acanthoside B [**246**]	*D. chrysanthum*	Stem	Ye *et al*., 2004
Liriodendrin [**247**]	*D. pulchellum*	Stem	Chanvorachote *et al*., 2013
(-)-(8*R*,7′*E*)-4-hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-*O*-β-D-glucopyranoside [**248**]	*D. auranticum*	Stem	Li *et al*., 2014

Table 4 (continued)

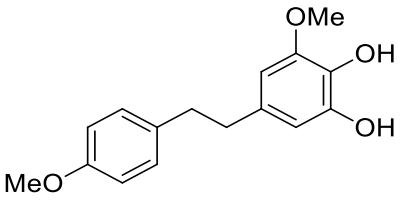
Catergory and Compound	Plant	Plant part	Reference
(-)-(8*R*,7′*E*)-4-hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-O-β-D-glucopyranoside [**249**]	*D. auranticum*	Stem	Li *et al*., 2014
(-)-(8*R*,7′*E*)-4-hydroxy-3,3′,5,5′,9′-pentamethoxy-8,4′-oxyneolign-7′-ene-9-ol 4,9-bis-O-β-D-glucopyranoside [**250**]	*D. auranticum*	Stem	Li *et al*., 2014
Liriodendrin [**251**]	*D. brymerianum*	Whole plant	Chen *et al*., 2014
Fluorenones			
Dencrysan A [**252**]	*D. chrysotoxum*	Whole plant	Li *et al*., 2009c
Dencrysan B [**253**]	*D. chrysotoxum*	Whole plant	Chen *et al*., 2008b

Table 4 (continued)

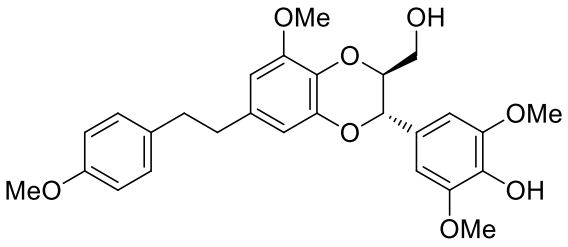
Catergory and Compound	Plant	Plant part	Reference
Dendroflorin [**254**]	*D. aurantiacum var. denneanum*	Stem	Yang *et al*., 2006a
	D. chrysotoxum	Whole plant	Chen *et al*., 2008b
		Stem	Zhang *et al*., 2007a
Dengibsin [**255**]	*D. aurantiacum var. denneanum*	Stem	Yang *et al*., 2006a
	D. chrysanthum	Stem	Yang *et al*., 2006b
	D. chrysotoxum	Whole plant	Li *et al*., 2009c
	D. densiflorum	Stem	Fan *et al*., 2001
Nobilone [**256**]	*D. nobile*	Stem	Zhang *et al*., 2007a
1,4,5-Trihydroxy-7-methoxy-9H-fluoren-9-one [**257**]	*D. chrysotoxum*	Whole plant	Chen *et al*., 2008b
2,4,7-Trihydroxy-5-methoxy-9-fluorenone [**258**]	*D. chrysotoxum*	Stem	Yang *et al*., 2004

Table 4 (continued)

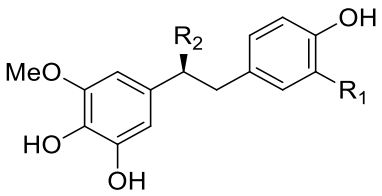
Catergory and Compound	Plant	Plant part	Reference
2,4,7-Trihydroxy-1,5-dimethoxy-9-fluorenone [**222/259**]	*D. chrysotoxum*	Stem	Yang *et al*., 2004
Others			
3,6,9-Trihydroxy-3,4-dihydroanthracen-1-(2H)-one [**260**]	*D. chrysotoxum*	Stem	Hu *et al*., 2012
Palmarumycin JC2 [**261**]	*D. crystallinum*	Stem	Wang *et al*., 2009
Dehydrovomifoliol [**262**]	*D. loddigesii*	Whole plant	Ito *et al*., 2010
2,6-Dimethoxy Benzoquinone [**263**]	*D. chryseum*	Stem	Ma *et al*., 1998



[**1**] Dendrocandin A



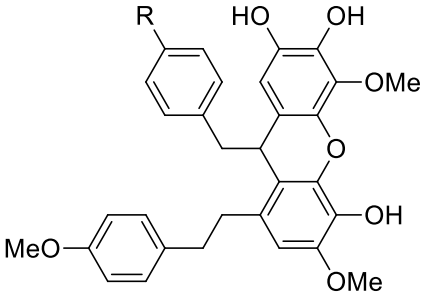
[**2**] Dendrocandin B



[**3**] Dendrocandin C: R_1 = H, R_2 = OMe

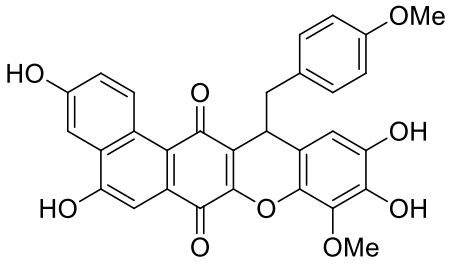
[**4**] Dendrocandin D: R_1 = H, R_2 = OCH_2CH_3

[**5**] Dendrocandin E: R_1 = OH, R_2 = H



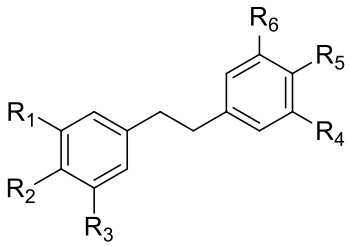
[**6**] Dendrocandin F: R = OMe

[**7**] Dendrocandin G: R= OH



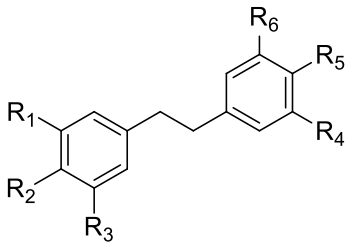
[**8**] Dendrocandin H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species



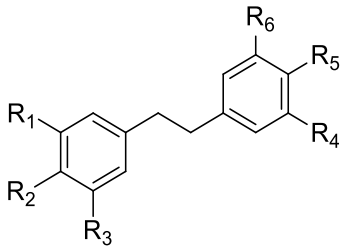
	R_1	R_2	R_3	R_4	R_5	R_6
[**13**] Aloifol I	OMe	OH	OMe	OH	H	H
[**14**] Amoenylin	OMe	OH	OMe	H	OMe	H
[**15**] Betatasin	OMe	H	H	OH	H	OH
[**16**] Betatasin III	OH	H	OMe	H	H	OH
[**17**] Brittonin A	OMe	OMe	OMe	OMe	OMe	OMe
[**18**] Chrysotobibenzyl	OMe	OMe	OMe	OMe	OMe	H
[**19**] Chrysotoxine	OMe	OH	OMe	OMe	OMe	H
[**20**] Crepidatin	OMe	OMe	OMe	OMe	OH	H
[**21**] Cumulatin	OMe	OMe	OH	OH	OMe	OMe
[**22**] Dendrobin A	OH	OH	OMe	H	H	OMe
[**23**] 3,4′-Dihydroxy-5-Methoxybibenzyl	OH	H	OMe	H	OH	H
[**24**] 3,4′-Dihydroxy-5,5′-Dimethoxydihydrostilbene	OH	H	OMe	OMe	OH	H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



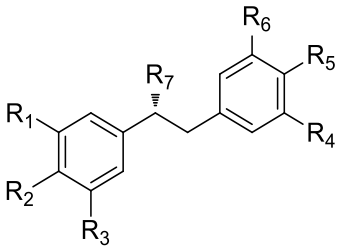
	R_1	R_2	R_3	R_4	R_5	R_6
[**25**] 4,5-Dihydroxy-3,3′-dimethoxybibenzyl (Dendrobin A)	OMe	OH	OH	H	H	OMe
[**26**] Gigantol	OMe	H	H	H	OH	OMe
[**27**] 4-Hydroxy-3,5,3′ Trimethoxybibenzyl	OMe	OH	OMe	H	H	OMe
[**28**] 5-Hydroxy-3,4,3′,4′,5′ Pentamethoxybibenzyl	OMe	OMe	OH	OMe	OMe	OMe
[**29**] Isoamoenylin	OMe	OMe	OMe	H	H	OH
[**30**] Moscatilin	OMe	OH	OMe	H	OH	OMe

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

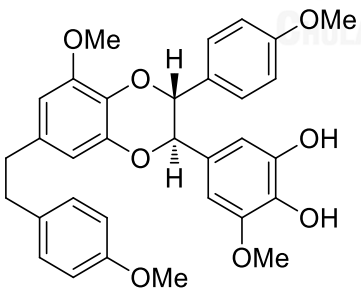


	R_1	R_2	R_3	R_4	R_5	R_6
[**31**] 3,3′,4-Trihydroxybibenzyl	OH	OH	H	H	H	OH
[**32**] 3,3′,5-Trihydroxybibenzyl	OH	H	OH	H	H	OH
[**33**] 3,5,4′-Trihydroxybibenzyl	OH	H	OH	H	OH	H
[**34**] 4,5,4′-Trihydroxy-3-3′-Dimethoxybibenzyl	OMe	OH	OH	H	OH	OMe
[**35**] Tristin	OH	H	OH	H	OH	OMe
[**36**] Dendromoniliside E	OGlc	OGlc	OMe	H	OMe	H

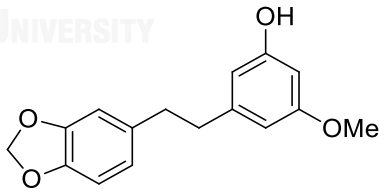
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



	R_1	R_2	R_3	R_4	R_5	R_6	R_7
[**37**] Dendrocandin A	OMe	OH	OH	H	H	H	OMe
[**38**] Dendrophenol	OMe	OH	OMe	OH	OH	H	H
[**39**] 3,4-Dihydroxy-5,4′-Dimethoxybibenzyl	OH	OH	OMe	H	OMe	H	H
[**40**] 4,4′-Dihydroxy-3,5-Dimethoxybibenzyl	OMe	OH	OMe	H	OH	H	H
[**41**] Loddigesiinol C	OMe	OH	OMe	H	OH	OMe	OMe
[**42**] 3-*O*-Methylgigantol	OMe	H	OH	OMe	OMe	H	H

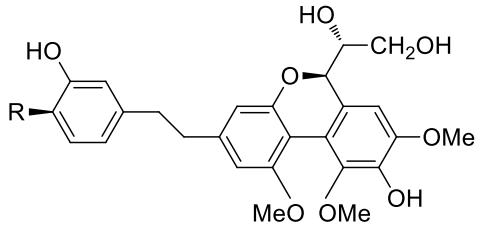


[**43**] Dendrocandin I



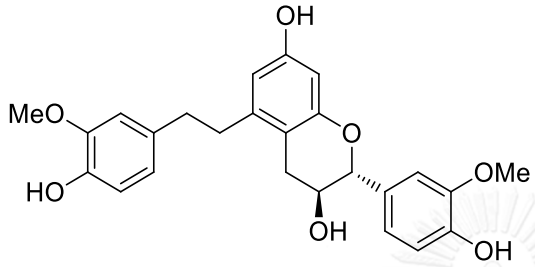
[**44**] Densiflorol A

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

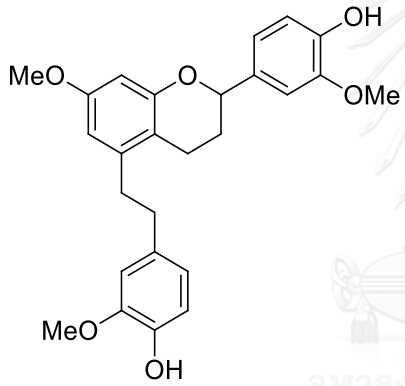


[**45**] Longicornuol A: R = H

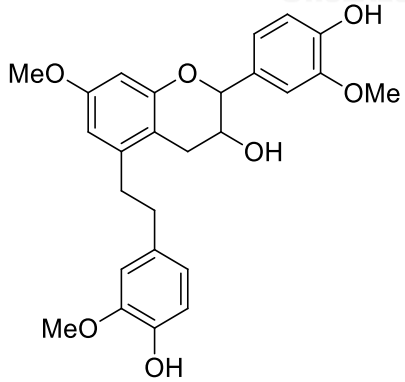
[**46**] Trigonopol A: R = OMe



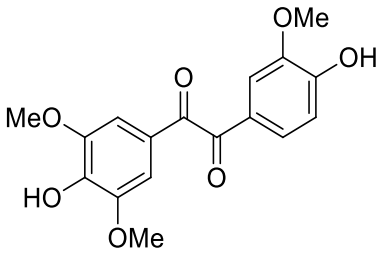
[**47**] Trigonopol B



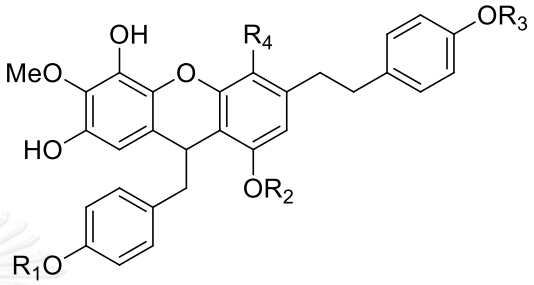
[**48**] Crepidatuols A



[**49**] Crepidatuols B



[**50**] Loddigesiinol D

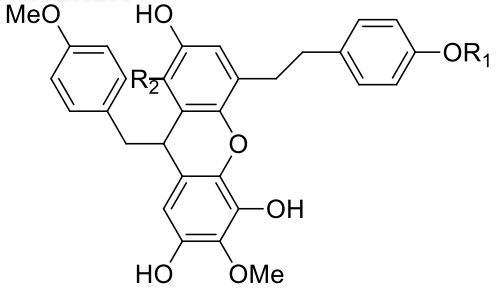


[**51**] Dencryol A:

R_1 = Me, R_2 = R_3 = R_4 = H

[**52**] Dencryol B:

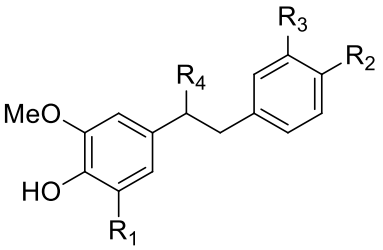
R_1 = H, R_2 = R_3 = Me, R_4 = OH



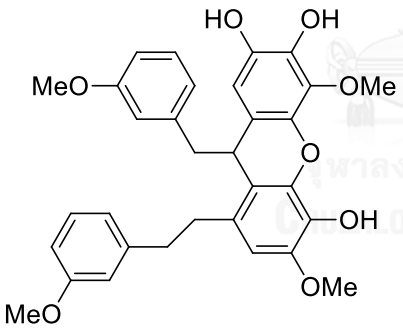
[**53**] Dengraol A: R_1 = R_2 = H

[**54**] Dengraol B: R_1 = Me, R_2 = OMe

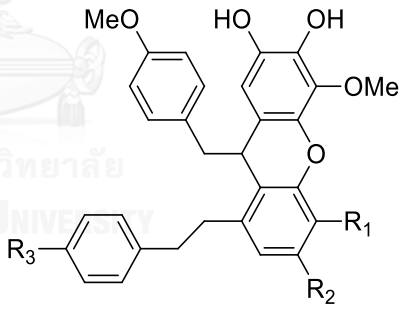
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



	R_1	R_2	R_3	R_4
[**55**] 4-[2-(3-Hydroxyphenol)-1-methoxyethyl]-2,6-dimethoxyphenol	OMe	H	OH	OMe
[**56**] Nobilin A	OH	H	OMe	OMe
[**57**] Nobilin B	OMe	OH	OMe	OMe
[**58**] Nobilin C	OMe	OMe	OMe	OMe
[**59**] Nobilin D	OMe	OH	OMe	OH

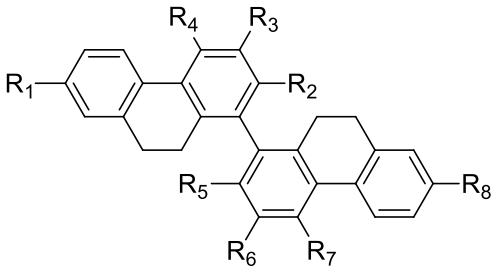


[**60**] Nobilin E

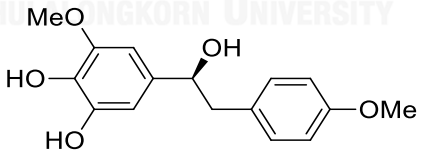


[**61**] Dendrofalconerol A:
R_1 = OH, R_2 = R_3 = OMe
[**62**] Dendrofalconerol B:
R_1 = H, R_2 = R_3 = OH

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

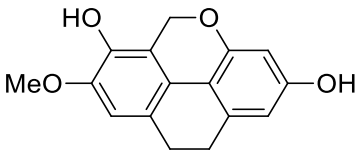


	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
[**63**] 2,2′-Dihydroxy-3,3′,4,4′,7,7′-hexamethoxy-9,9′,10,10′-tetrahydro-1,1′-Biphenanthrene	OMe	OH	OMe	OMe	OH	OMe	OMe	OMe
[**64**] 2,2′-Dimethoxy-4,4′,7,7′-tetrahydroxy-9,9′,10,10′-tetrahydro-1,1′-biphenanthrene	OH	OMe	H	OH	OMe	H	OH	OH
[**65**] Flavanthrin	OH	OH	H	OMe	OH	H	OMe	OH

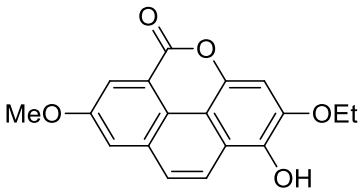


[**66**] (*S*)-3,4,α-Trihydroxy-5,4′-dimethoxybibenzyl

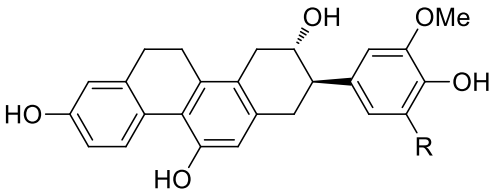
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



[**67**] Amoenumin

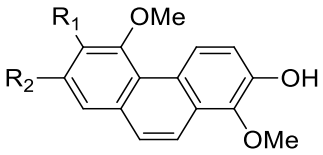


[**68**] Crystalltone



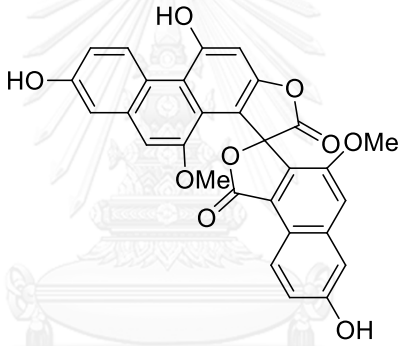
[**69**] Chrysotoxol A: R = H

[**70**] Chrysotoxol A: R = OMe



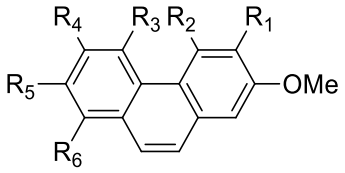
[**71**] Confusarin: R_1 = OMe, R_2 = OH

[**72**] 2,6-Dihydroxy-1,5,7-trimethoxyphenanthrene: R_1 = OH, R_2 = OMe

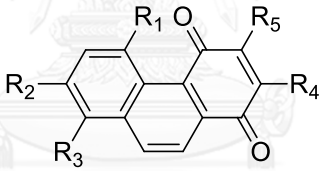


[**73**] Dendrochrysanene

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

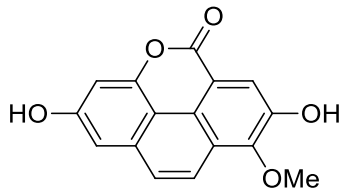


	R_1	R_2	R_3	R_4	R_5	R_6
[**74**] Bulbophyllanthrin	OH	OMe	OH	H	H	H
[**75**] Denthyrsinin	OH	OMe	H	H	OH	OMe
[**76**] 5-Hydroxy-2,4-dimethoxy phenanthrene	H	OMe	OH	H	H	H
[**77**] 3-Hydroxy-2,4,7-trimethoxy phenanthrene	OH	OMe	H	H	OMe	H

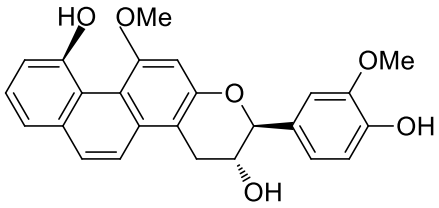


	R_1	R_2	R_3	R_4	R_5
[**78**] Cypripedin	H	OH	OMe	OMe	H
[**79**] Densiflorol B	H	OH	H	OMe	H
[**80**] Denbinobin	OH	OMe	H	H	OMe

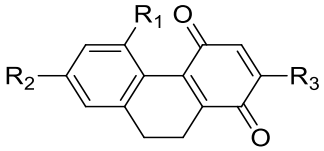
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



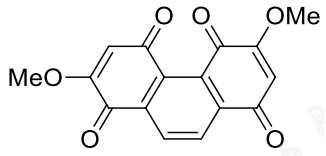
[**81**] Fimbriatone



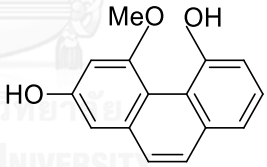
[**82**] Loddigesiinol B



	R_1	R_2	R_3
[**83**] Dendronone	OH	OMe	H
[**84**] Ephemeranthoquinone	H	OH	OMe
[**85**] 5-Methoxy-7-hydroxy-9,10-dihydro-1,4 phenanthrenequinone	OMe	OH	H

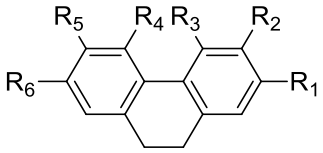


[**86**] Moniliformin



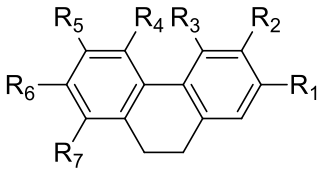
[**87**] Moscatin

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



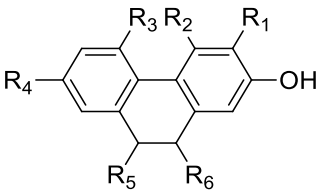
	R_1	R_2	R_3	R_4	R_5	R_6
[**88**] Coelonin	OH	H	OMe	H	H	OH
[**89**] 9,10-Dihydromoscatin	H	H	OH	OMe	H	OH
[**90**] 9,10-Dihydrophenanthrene-2,4,7-triol	OH	H	OH	H	H	OH
[**91**] 4,5-Dihydroxy-2,3-dimethoxy-9,10-dihydrophenanthrene	OMe	OMe	OH	OH	H	H
[**92**] 4,5-Dihydroxy-2,6-dimethoxy-9,10-dihydrophenanthrene	OMe	OH	H	OMe	OH	H
[**93**] 4,5-Dihydroxy-3,7-dimethoxy-9,10-dihydrophenanthrene	H	OMe	OH	OH	H	OMe
[**94**] 4,5-Dihydroxy-2-methoxy-9,10-dihydrophenanthrene	OMe	H	OH	OH	H	H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



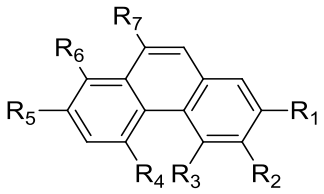
	R_1	R_2	R_3	R_4	R_5	R_6	R_7
[**95**] 2,7-Dihydroxy-3,4,6-trimethoxy-9,10-dihydro phenanthrene	OH	OMe	OMe	H	OMe	OH	H
[**96**] 2,8-Dihydroxy-3,4,7-trimethoxy-9,10-dihydro phenanthrene	OH	OMe	OMe	H	H	OMe	OH
[**97**] 4,7-Dihydroxy-2,3,6-trimethoxy-9,10-dihydro phenanthrene	OMe	OMe	OH	H	OMe	OH	H
[**98**] Ephemeranthol A	OH	H	H	OH	OMe	OMe	H
[**99**] Ephemeranthol C	OH	OH	OMe	OH	H	H	H
[**100**] Erianthridin	OH	OMe	OMe	H	H	OH	H
[**101**] Flavanthridin	OH	H	H	OMe	OH	OMe	H
[**102**] Hircinol	OH	H	OMe	OH	H	H	H
[**103**] 3-Hydroxy-2,4,7-trimethoxy-9,10-dihydro phenanthrene	OMe	OH	OMe	H	H	OMe	H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



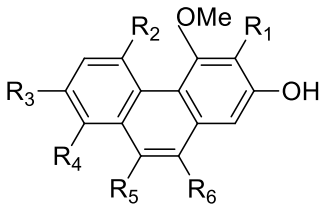
	R_1	R_2	R_3	R_4	R_5	R_6
[**104**] 2-Hydroxy-4,7-dimethoxy-9,10-dihydro Phenanthrene	H	OMe	H	OMe	H	H
[**105**] 7-Methoxy-9,10-dihydrophenanthrene-2,4,5-triol	H	OH	OH	OMe	H	H
[**106**] Plicatol C	H	OMe	OH	H	OMe	OMe
[**107**] Rotundatin	H	OMe	OH	H	OH	OH

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



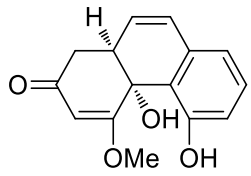
	R_1	R_2	R_3	R_4	R_5	R_6	R_7
[**108**] 2,5-Dihydroxy-3,4-dimethoxyphenanthrene	OH	OMe	OMe	OH	H	H	H
[**109**] 2,5-Dihydroxy-4,9-dimethoxyphenanthrene	OH	H	OMe	OH	H	H	OMe
[**110**] 2,8-Dihydroxy-3,4,7-trimethoxyphenanthrene	OH	OMe	OMe	H	OMe	OH	H
[**111**] Epheranthol B	H	H	OMe	OH	OMe	H	H
[**112**] Fimbriol B	OH	OMe	OH	H	H	H	H
[**113**] Flavanthrinin	H	H	OMe	H	OH	H	H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

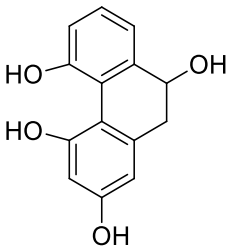


	R_1	R_2	R_3	R_4	R_5	R_6
[**114**] Loddigesiinol A	H	OMe	H	H	OH	H
[**115**] Nudol	OMe	H	OH	H	H	H
[**116**] Plicatol A	H	OH	H	H	OMe	OMe
[**117**] Plicatol B	H	OH	H	H	H	H
[**118**] 2,3,5-Trihydroxy-4,9-dimethoxyphenanthrene	OH	OH	H	H	OMe	H
[**119**] 3,4,8-Trimethoxy phenanthrene-2,5-diol	OMe	OH	H	OMe	H	H

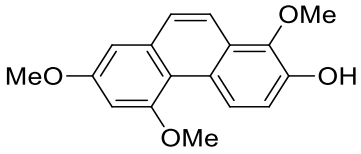
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



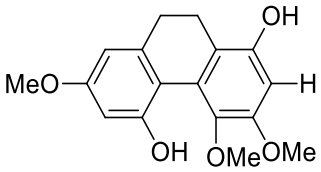
[**120**] Aphyllone



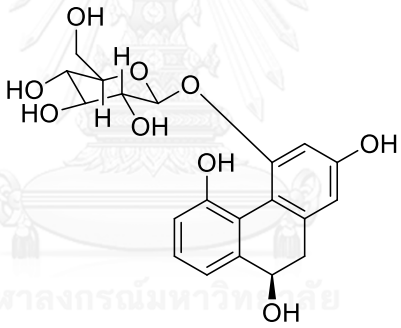
[**121**] (*S*)-2,4,5,9-tetrahydroxy-9,10-dihydrophenanthrene



[**122**] 1,5,7-trimethoxyphenanthren-2-ol

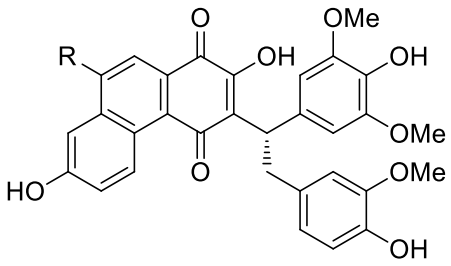


[**123**] 9,10-dihydrophenanthrene,1,5-dihydroxy-3,4,7-trimthoxy-9,10-dihydrophenanthrene



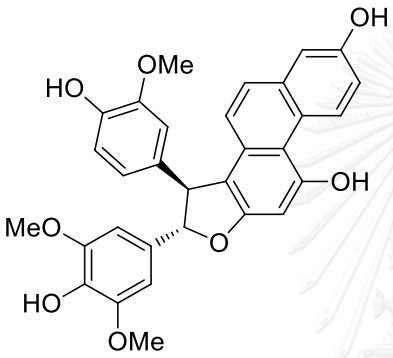
[**124**] 2,4,5,9S-tetrahydroxy-9,10-dihydrophenanthrene 4-*O*-β-*D*-glucopyranoside

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

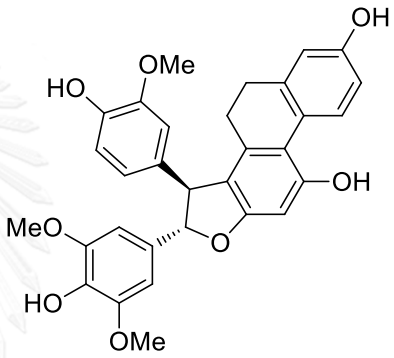


[**125**] Loddigesiinol G: R = H

[**126**] Loddigesiinol H: R = OH

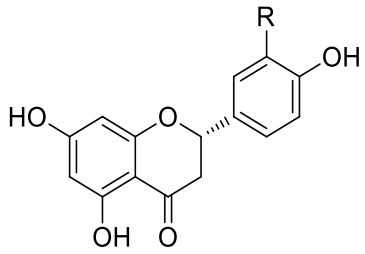


[**127**] Loddigesiinol I

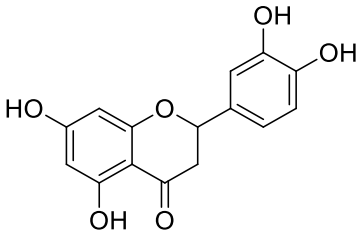


[**128**] Loddigesiinol J

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

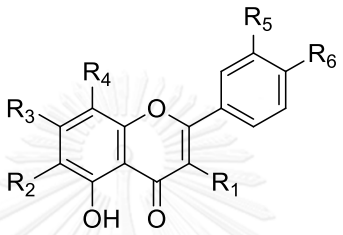


[**129**] (2*S*)-Homoeriodictyol: R = OMe



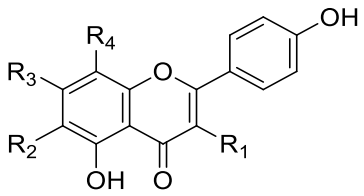
[**131**] Eriodictyol

[**130**] Naringenin: R= H



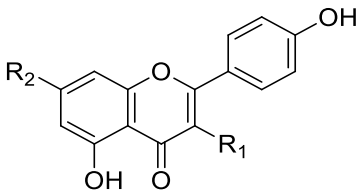
	R_1	R_2	R_3	R_4	R_5	R_6
[**132**] Apigenin	H	H	OH	H	H	OH
[**133**] 5,6-Dihydroxy-4′-methoxy-flavone	H	OH	H	H	H	OMe
[**134**] Luteolin	H	H	OH	H	OH	OH
[**135**] 6-*C*-(α-Arabinopyranosyl)-8-*C*-[(2-*O*-α-rhamnopyranosyl) -β-galactopyranosyl] apigenin	H	-Ara	OH	-Gal-O-Rha	H	OH
[**136**] 6-*C*-(α-Arabinopyranosyl)-8-*C*-[(2-*O*-α-rhamnopyranosyl) - β-glucopyranosyl] apigenin	H	-Ara	OH	-Glc-O-Rha	H	OH

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

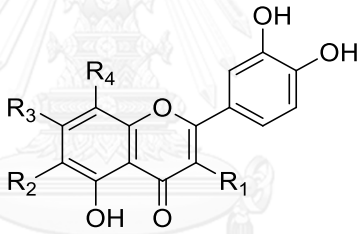


	R_1	R_2	R_3	R_4
[**137**] 6‴-Glucosyl-vitexin	H	H	OH	Glc
[**138**] Isoschaftoside	H	-Ara	OH	-Glc
[**139**] Isoviolanthin	H	-Rha	OH	-Glc
[**140**] 6-*C*-[(2-*O*-α-Rhamnopyranosyl)-β-glucopyranosyl]-8-*C*-(α-arabinopyranosyl) apigenin	H	-Glc-Rha	OH	-Ara
[**141**] 6-*C*-(β-Xylopyranosyl)-8-*C*-[(2-*O*-α-rhamnosepyranosyl)-β-glucosepyranosyl] apigenin	H	-Xyl	OH	-Glc-Rha
[**142**] Kaempferol	OH	H	OH	H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

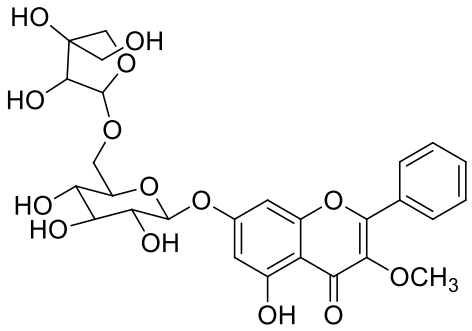


	R_1	R_2
[**143**] Kaempferol-3-*O*-α-L-rhamnopyranoside	O-Rha	OH
[**144**] Kaempferol-3,7-*O*-di-α-L-rhamnopyranoside	O-Rha	O-Rha
[**145**] Kaempferol-3-*O*-α-L-rhamnopyranosyl-(1⟶2)-β-D-glucopyranoside	O-Glc-Rha	OH
[**146**] Kaempferol-3-*O*-α-L-rhamnopyranosyl-(1⟶2)-β-D-xylopyranoside	O-Xyl-Rha	OH



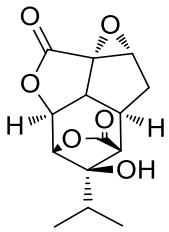
	R_1	R_2	R_3	R_4
[**147**] Quercetin-3-*O*-α-L-rhamnopyranoside	O-Rha	H	OH	H
[**148**] Quercetin-3-*O*-α-L-rham nopyranosyl-(1⟶2)-β-D-xylopyranoside	O-Xyl-Rha	H	OH	H

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

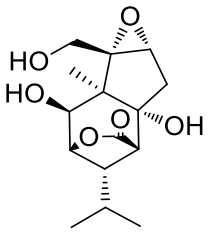


[**149**] 5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1⟶6)]-β-D-glucoside

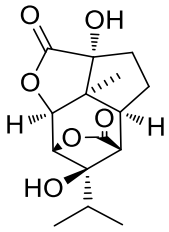
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



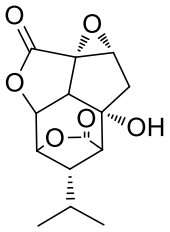
[**150**] Aduncin



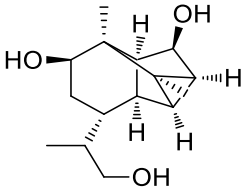
[**151**] Amoenin



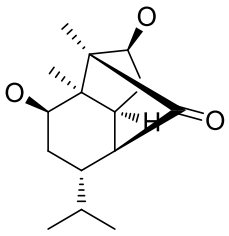
[**152**] Amotin



[**153**] α-Dihydropicrotoxinin

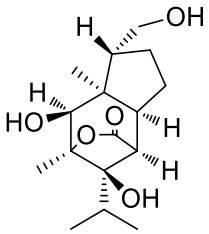


[**154**] Dendrobane A

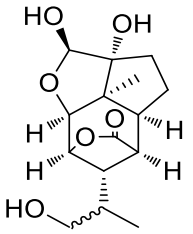


[**155**] Dendronobilin A

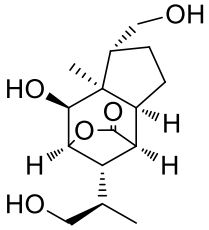
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



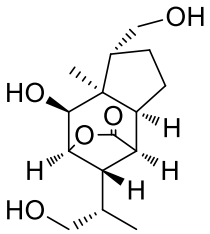
[**156**] Dendronobilin B



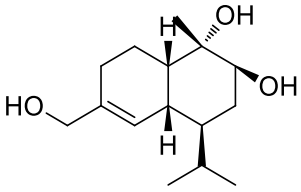
[**157**] Dendronobilin C



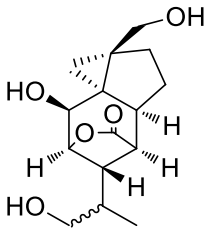
[**158**] Dendronobilin D



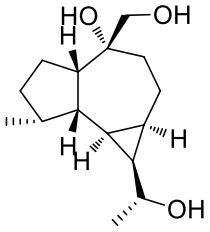
[**159**] Dendronobilin E



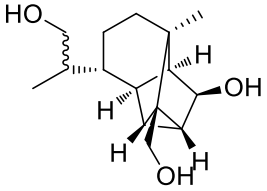
[**160**] Dendronobilin F



[**161**] Dendronobilin G

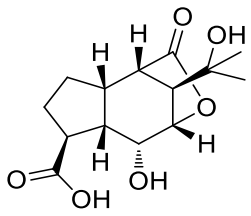


[**162**] Dendronobilin H

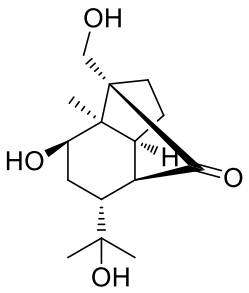


[**163**] Dendronobilin I

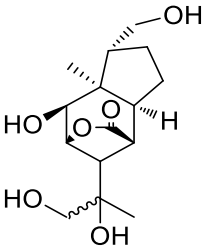
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



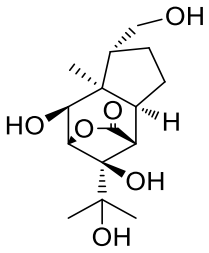
[**164**] Dendronobilin J



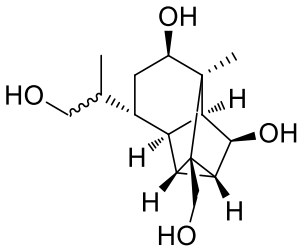
[**165**] Dendronobilin K



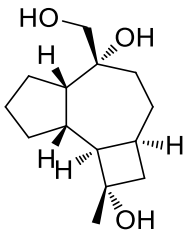
[**166**] Dendronobilin L



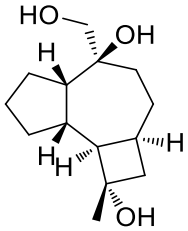
[**167**] Dendronobilin M



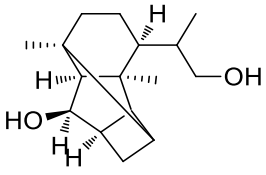
[**168**] Dendronobilin N



[**169**] Dendrowardol A

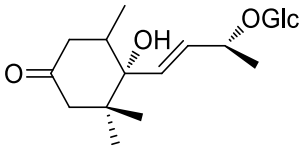


[**170**] Dendrowardol B

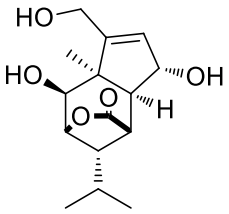


[**171**] Dendrowardol C

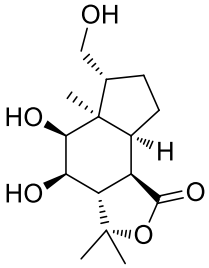
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



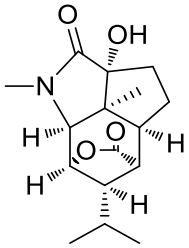
[**172**] Corchoionoside C



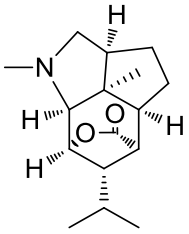
[**173**] Crystallinin



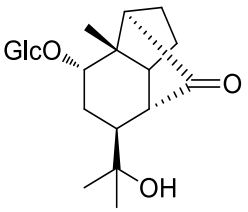
[**174**] Findlayanin



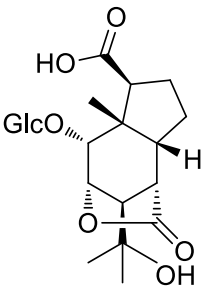
[**175**] 3-Hydroxy-2-oxodendrobine



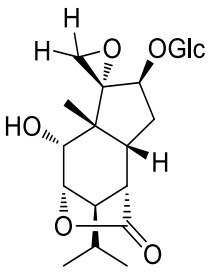
[**176**] Dendrobine



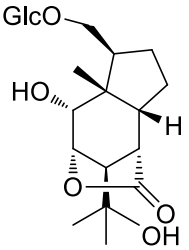
[**177**] Dendromoniliside A



[**178**] Dendromoniliside B

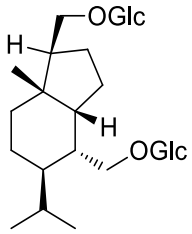


[**179**] Dendromoniliside C

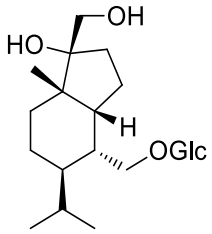


[**180**] Dendromoniliside D

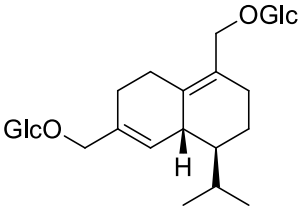
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



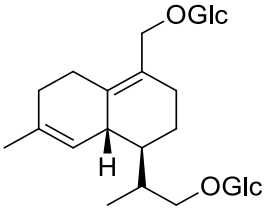
[**181**] Dendronobiloside A



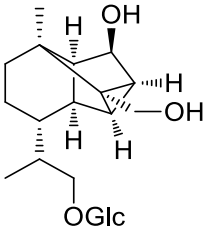
[**182**] Dendronobiloside B



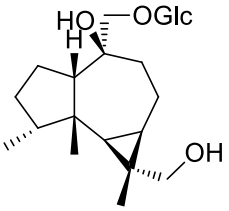
[**183**] Dendronobiloside C



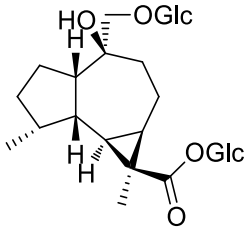
[**184**] Dendronobiloside D



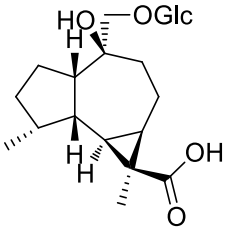
[**185**] Dendronobiloside E



[**186**] Dendroside A

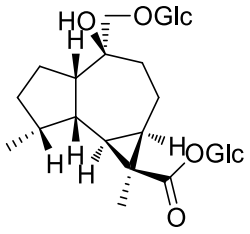


[**187**] Dendroside B

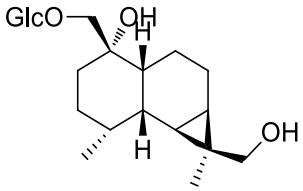


[**188**] Dendroside C

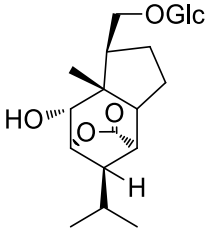
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



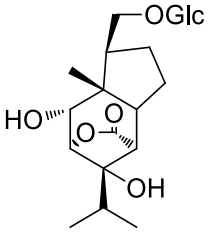
[**189**] Dendroside D



[**190**] Dendroside E

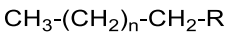


[**191**] Dendroside F

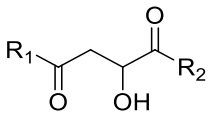


[**192**] Dendroside G

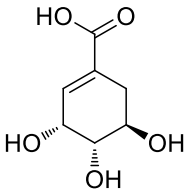
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



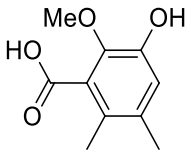
[**193**] Aliphatic acids: R = COOH, n = 19-31
[**194**] Aliphatic alcohol: R = OH, n =22-32



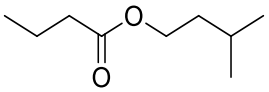
[**195**] Malic acid: R_1 = R_2 = OH
[**196**] Dimethyl malate: R_1 = R_2 =OMe



[**197**] (-)-Shikimic acid

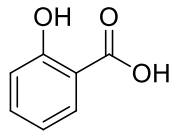


[**199**] 3-Hydroxy-2-methoxy-5,6-dimethylbenzoic acid

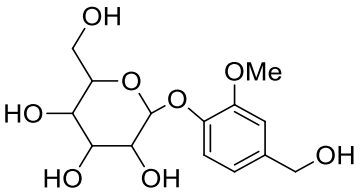


[**198**] Isopentyl butyrate

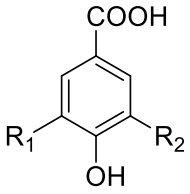
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



[**200**] Salicylic acid



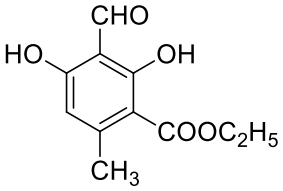
[**201**] Vanilloside



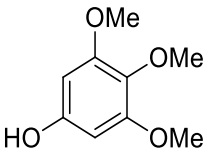
[**202**] Gallic acid: R_1 = OH, R_2 = OH

[**203**] Syringic acid: R_1 = OMe, R_2 = OMe

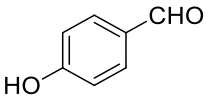
[**204**] Vanillic acid: R_1 = OMe, R_2 = OH



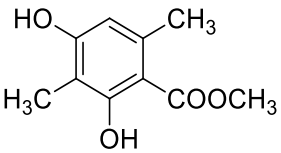
[**205**] Antiarol



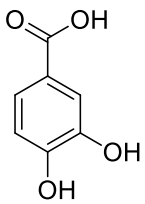
[**206**] Ethylhaematommate



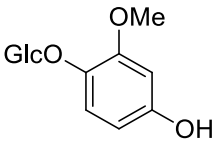
[**207**] *p*-Hydroxybenzaldehyde



[**208**] Methyl β-orsellinate

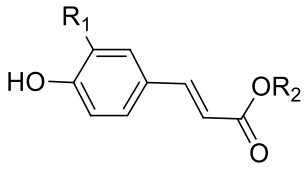


[**209**] Protocatechuic acid



[**210**] Tachioside

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



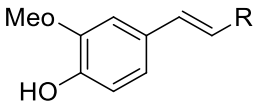
[**211**] Alkyl 4′-hydroxy-*trans*-cinnamates: R_1 = H, R_2 = C_nH_{2n+1}, n =22-32

[**212**] Alkyl *trans*-ferulates: R_1 = OMe, R_2 = C_nH_{2n+1}, n = 18-28, 30

[**213**] Defuscin: R_1 = OMe, R_2 = $(CH_2)_{27}CH_3$

[**214**] *n*-Octacosyl ferulate: R_1 = OMe, R_2 = $(CH_2)_{28}CH_3$

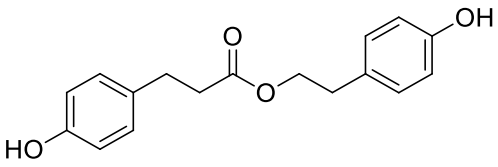
[**215**] *n*-Triacontyl *p*-hydroxy-*cis*-cinnamate: R_1 = H, R_2 = C_nH_{2n+1}, n =30



[**216**] *n*-Docosyl *trans*-ferulate: R = $COOCH_2(CH_2)_{20}CH_3$

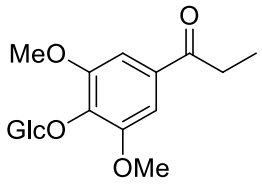
[**217**] Ferulaldehyde: R = CHO

[**218**] Ferulic acid: R = COOH

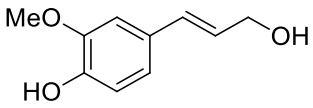


[**219**] 2-(*p*-Hydroxyphenyl) ethyl *p*-coumarate

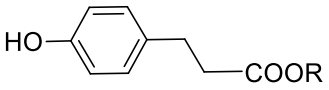
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



[**220**] 1-[4-(β-D-glucopyranosyloxy)-3,5-dimethoxyphenyl]-1-propanone

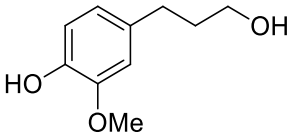


[**221**] 3-(4-Hydroxy-3-methoxyphenyl)-2-propen-1-ol

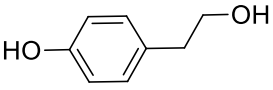


[**222**] *p*-Hydroxyphenyl propionic Methyl ester: R = CH_3

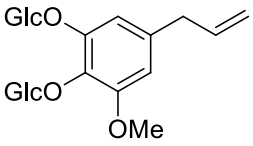
[**223**] Phloretic acid: R = OH



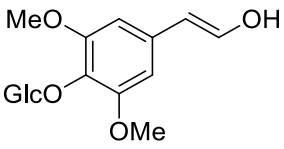
[**224**] 3-(3-Methoxy,4-hydroxyphenyl)-1-propanol



[**225**] Salidrosol

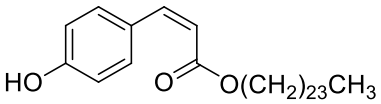


[**226**] Shashenoside I

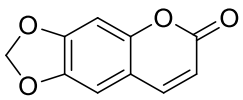


[**227**] Syringin

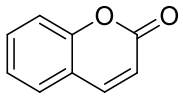
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



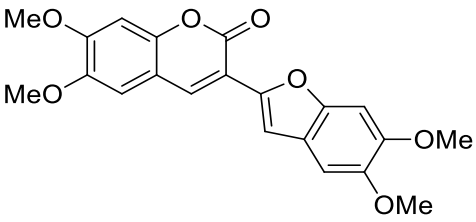
[**228**] Tetracosyl (*Z*)-*p*-coumarate



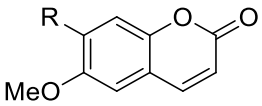
[**229**] Ayapin



[**230**] Coumarin

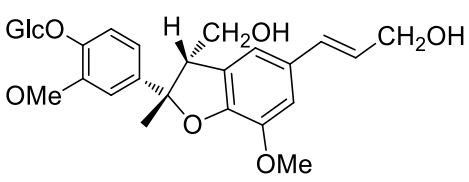


[**231**] Denthysin

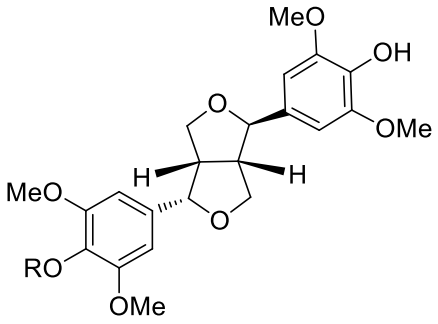


[**232**] Scoparone: R = OMe
[**233**] Scopoletin: R = OH

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

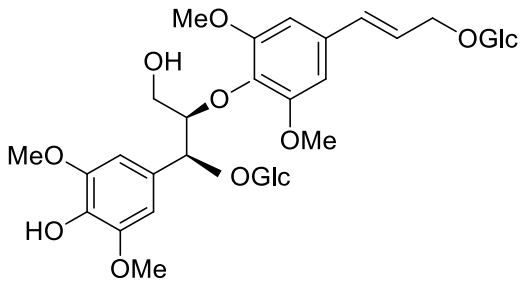


[**234**] Dehydrodiconiferyl alcohol-4-β-D-glucoside

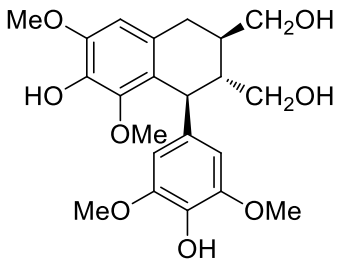


[**235**] Episyringaresinol: R = H

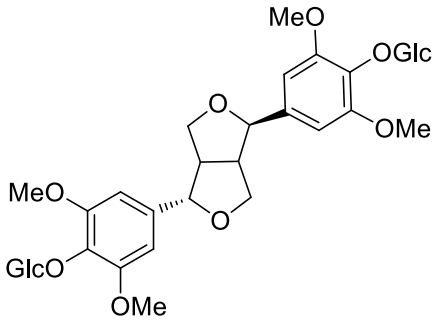
[**236**] Episyringaresinol 4′′-*O*-β-D-glucopyranoside: R = β-D-Glucose



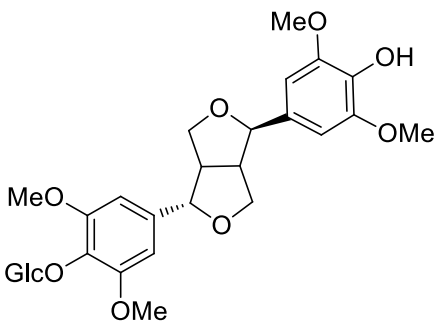
[**237**] (-)-(7*S*,8*R*,7′*E*)-4-hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-7,9,9′-triol-7,9′-bis-*O*-β-D-glucopyranoside



[**238**] Lyoniresinol

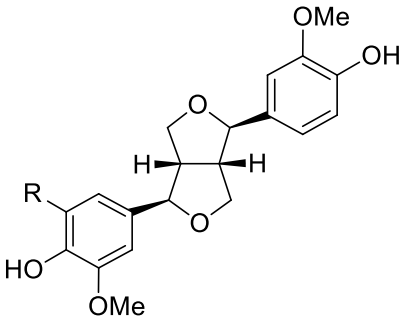


[**239**] (-)-Syringaresinol-4,4′-bis-*O*-β-D-glucopyranoside

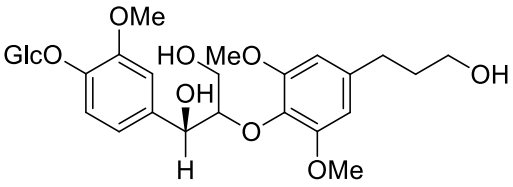


[**240**] Syringaresinol-4-*O*-D-monoglucopyranoside

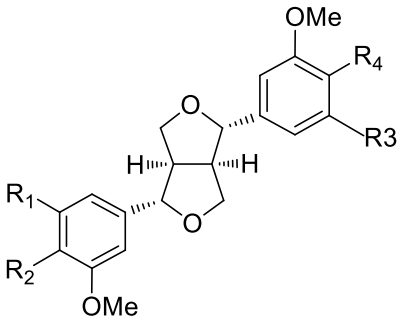
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



[**242**] (-)-Pinoresinol: R = H

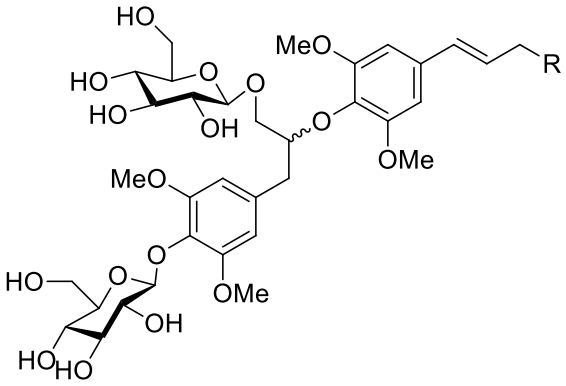


[**245**] Erythro-1-(4-*O*-β-D-glucopyranosyl-3-methoxyphenyl)-2-[4-(3-hydroxypropyl)-2,6-dimethoxyphenoxy]-1,3-propanediol



	R_1	R_2	R_3	R_4
[**243**] Syringaresinol	OMe	OH	OMe	OH
[**244**] Pinoresinol	H	OH	H	OH
[**246**] Acanthoside B	OMe	OGlc	OMe	OH
[**247**] Liriodendrin	OMe	OGlc	OMe	OGlc

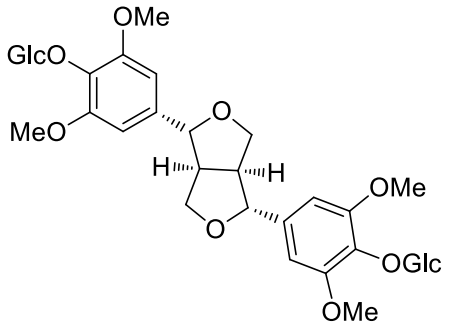
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



[**248**] (-)-(8*R*,7′*E*)-4-hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-*O*-β-D-glucopyranoside: R = OH; 8R

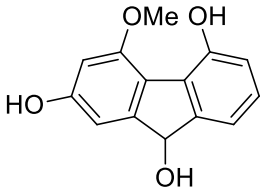
[**249**] (-)-(8*S*,7′*E*)-4-hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-*O*-β-D-glucopyranoside: R = OH; 8S

[**250**] (-)-(8*R*,7′*E*)-4-hydroxy-3,3′,5,5′,9′-pentamethoxy-8,4′-oxyneolign-7′-ene-9-ol 4,9-bis-*O*-β-D-glucopyranoside: R = OMe; 8R

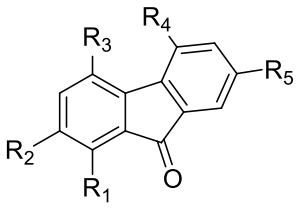


[**251**] Liriodendrin

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

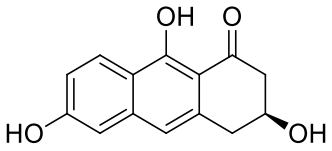


[**253**] Denchrysan B

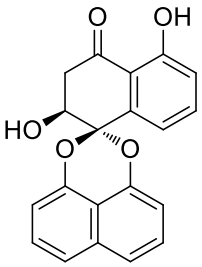


	R_1	R_2	R_3	R_4	R_5
[**252**] Denchrysan A	H	OH	OH	OMe	OH
[**254**] Dendroflorin	OH	H	OH	OMe	OH
[**255**] Dengibsin	H	OH	OMe	OH	H
[**256**] Nobilone	H	OH	H	OMe	OH
[**257**] 1,4,5-Trihydroxy-7-methoxy-9H-fluoren-9-one	OH	H	OH	OH	OMe
[**258**] 2,4,7-Trihydroxy-5-methoxy-9-fluorenone	H	OH	OH	OMe	OH
[**259**] 2,4,7-Trihydroxy-1,5-dimethoxy-9-fluorenone	OMe	OH	OH	OMe	OH

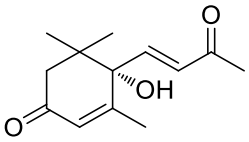
Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)



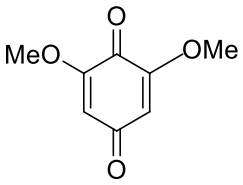
[**260**] 3,6,9-Trihydroxy-3,4-dihydroanthracen-1-(2*H*)-one



[**261**] Palmarumycin JC2



[**262**] Dehydrovomifoliol



[**263**] 2,6-Dimethoxybenzoquinone

Figure 2 Structures of compounds previously isolated from *Dendrobium* species (continued)

2. Traditional uses and biological activities of *Dendrobium* species

A number of orchidaceous plants have been used as herbal medicine in China since 2800 B.C. (Bulpitt., 2005). An illustrious example is the formulation "Shi-Hu" which is composed of several *Dendrobium* species including *D. fimbriatum, D. loddigesii*, *D. nobile*, *D. chrysanthum* and *D. candidum.* Shi-Hu is known as an important remedy for lung, kidney, and stomach diseases. (Hossain, 2011).

Numerous biological activities of the compounds isolated from *Dendrobium* plants have been reported, for example, antioxidative, antiplatelet aggregation, anti-inflammatory, immunomodulatory, cytotoxic and α-glucosidase inhibiting effects (Gutierrez, 2010).

The bibenzyl derivatives derived from *Dendrobium nobile*, including chrysotoxine [**19**], moscatilin [**30**], and nobilin D [**59**] , exhibited antioxidant activity in the DPPH assay with IC_{50} values of 14.0, 14.5, 19.9, and 21.0 μM, respectively (Zhang *et al*., 2007a; 2008b). Furthermore, in DPPH scavenging and ORAC assays, moscatilin [**30**] and chrysotoxine [**19**] showed activity stronger than, or equivalent to, vitamin C (Ono *et al*., 1995).

In an anti-inflammatory activity study, ephemeranthol A [**98**], ephemeranthol C [**99**] and lusianthridin isolated from *Dendrobium nobile* showed inhibitory effect on the lipopolysaccharide-induced nitric oxide production from macrophage cells (RAW 264.7) with IC_{50} values of 12.0, 17.6, and 9.6 μM, respectively (Hwang, *et al*., 2010).

In cytotoxicity studies, denthyrsinin [**75**] from *Dendrobium thyrsiflorum* exhibited cytotoxicity against several cancer cell lines such as Hela, K-562 and MCF-7 (Zhang *et al*., 2005). Denbinobin from *Dendrobium nobile* exhibited inhibitory activity on the proliferation of hepatic stellate cells (HSCs-T6) (Yang, *et al*., 2007). In addition, moscatilin [**30**], a bibenzyl found in several plants of this genus, showed potent cytotoxic effects against lung and stomach cancer cells (Ho and Chen, 2003). It could activate C-Jun NH2- terminal protein kinase (JNK) and mitochondria- involved intrinsic apoptosis pathways (Chen *et al*., 2008a). Additionally, it suppressed tumor angiogenesis and growth *in vitro* and *in vivo* (Tsai, *et al*., 2010).

In antiplatelet aggregation studies, moscatilin [**30**] from *Dendrobium densiflorum* exhibited antiplatelet aggregation activity on rat platelets *in vitro* (Fan *et al*., 2001). In addition, moscatilin [**30**] and moscatin [**87]** strongly inhibited both arachidonic acid and collagen-induced platelet aggregation (Chen, *et al*., 1994).

The sesquiterpene glycosides obtained from *Dendrobium nobile*, including dendrosides A [**186**], D-F [**189**, **190**, **191**], were found to significantly stimulate the generation of mouse T and B lymphocytes (Zhao, *et al*., 2001; Ye and Zhao, 2002).

Regarding α-glucosidase inhibitory activity, several compounds from *Dendrobium* plants exhibited this activity. For example, 5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1→6)]-β-D-glucoside [**149**] and gigantol [**26**] from *Dendrobium devonianum* (Sun, *et al*., 2014*) and* loddigesiinol I [**127**] and loddigesiinol J [**128**] from *D. loddigesii* displayed potent α-glucosidase inhibition, as compared with acarbose (Lu, *et al*., 2014).

CHAPTER III
EXPERIMENTAL

1. Source of plant materials

The whole plants of *Dendrobium tortile* were purchased from chatuchak market, Bangkok, in October 2012. Authentication was performed by comparison with herbarium specimens at the Department of National Park, Wildlife and Plant Conservation, Ministry of National Resources and Environment. A voucher specimen (BS-DT-102555) has been deposited at the Department of Pharmacognosy and Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University.

2. General techniques

2.1 Analytical thin-layer chromatography (TLC)

Technique	:	One dimension ascending
Absorbent	:	Siliga gel 60 F_{254} (E. Merck) precoated plate
Layer thickness	:	0.2 mm
Distance	:	6.5 cm
Temperature	:	Laboratory temperature (30-35 °C)
Detection	:	1. Ultraviolet light at wavelengths of 254 and 365 nm 2. Spraying with anisaldehyde reagent (0.5 ml *p*- anisaldehyde in 50 ml glacial acetic acid and 1 ml conc. sulfuric acid) and heating at 105 °C for 10 min.

2.2 Column chromatography

2.2.1 Vacuum liquid chromatography (VLC)

Adsorbent	:	Siliga gel 60 (No. 7734) particle size 0.063-0.200 mm (E. Merck)
Packing method	:	Dry packing
Sample loading	:	The sample was dissolved in a small amount of organic solvent, mixed with a small quantity of the adsorbent, triturated, dried and then gradually placed on top of the column.
Detection	:	Each fraction was examined by TLC under UV light at the wave lengths of 254 and 365 nm

2.2.2 Flash column chromatography (FCC)

Adsorbent : Siliga gel 60 (No. 9385) particle size 0.040-0.063 mm (E. Merck)

Packing method : Wet packing

Sample loading : The sample was dissolved in a small amount of organic solvent, mixed with a small quantity of the adsorbent, triturated, dried and then gradually placed on top of the column.

Detection : Fractions were examined as described in section 2.2.1

2.2.3 Gel filtration chromatography

Adsorbent : Sephadex LH-20 (Pharmacia)

Packing method : The appropriate organic solvent was used as the eluent. Gel filter was suspended in the eluent, left standing about 24 hours prior to use and then poured into the column and left to set tightly.

Sample loading : The sample was dissolved in a small amount of the eluent and then gradually distributed on top of the column.

Detection : Fractions were examined as described in section 2.2.1

2.3 Spectroscopy

2.3.1 Mass spectra

Mass spectra were recorded on a micrOTOF BRUKER DALTONICS mass spectrometer (Department of chemistry, Faculty of Science, Mahidol University) and a Water, Acquity ultra performance LC Mass Spectrophotometer (Department of Medical Sciences).

2.3.2 Ultraviolet (UV) absorption spectra

UV (in methanol) spectra were obtained on a Milton Roy Spectronic 300 Array spectrophotometer (Pharmaceutical Research Instrument Center, Faculty of Pharmaceutical Sciences, Chulalongkorn University).

2.3.3 Infrared (IR) spectra

IR spectra were obtained on a Perkin-Elmer FT-IR 1760X spectrophotometer (Scientific and Technology Research Equipment Center, Chulalongkorn University).

2.3.4 Proton and carbon-13 nuclear magnetic resonance (^{1}H and ^{13}C-NMR) spectra

^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectra were recorded on a Bruker Avance DPX-300 FT-NMR spectrometer (Faculty of Pharmaceutical Sciences, Chulalongkorn University).

Deuterated for NMR spectra were used by deuteratedacetone (acetone-d_6). Chemical shifts were reported in ppm scale using the chemical shift of the solvent as the reference signal.

2.4 Optical activity

Optical rotation was measured on a Perkin Elmer Polarimeter 341 (Pharmaceutical Research Instrument Center, Faculty of Pharmaceutical Sciences, Chulalongkorn University).

2.5 Solvents

All organic solvents employed throughout this work were of commercial grade and were redistilled prior to use.

3. Extraction and Isolation

The dried whole plants (1.2 kg) were ground up and then macerated with MeOH (3×10 L) for 72 hours three times. The organic solvent was evaporated under reduced pressure to give 153 g of a MeOH extract. Then the MeOH extract (153 g) was firstly partitioned between EtOAc and water to give an EtOAc extract (33 g) after removal of the organic solvent. The aqueous part was treated with n-butanol to give a water extract (61 g) and a butanol extract (54 g), All the three extracts were tested for an α-glucosidase inhibitory activity. The result showed that the EtOAc part possessed highest activity with 100% inhibition at 2 mg/mL. Therefore the EtOAc extract was selected for further studies.

The EtOAc extract (33 g) was initially fractionated by vacuum liquid chromatography (VLC). The procedure was described in section 2.2.1. Silica gel (No.7734, 600 g) was used as the stationary phase and a step gradient of hexane-

acetone (100:0 to 0:100) and acetone-MeOH (100:0 to 0:100) as the mobile phase. The eluates were collected about 500 mL per fraction and examined by TLC (silica gel, hexane-acetone 6:4) to give sixty-two fractions. Fractions showing similar chromatographic patterns were puriified to give eight fractions, including fractions A (2.4 g), B (3.2 g), C (4.2 g), D (2.1 g), E (1.2 g), F (10.4 g), G (0.9 g) and H (8.4 g). Fractions C, D, F and G showed high inhibition of α-glucosidase enzyme, and were selected for further studies.

.

3.1 Isolation of compound DT1 (4-(2-hydroxypropyl)-2(5*H*)-furanone

Fraction G (0.9 g) was further separated by FCC using silica gel (No. 9385) as the stationary phase with gradient elution [hexane-EtOAc (100:0 to 0:100)] to give thirty-one fractions. After combination of the fractions with similar TLC patterns (silica gel, Hexane-EtOAc 6:4), twelve fractions were obtained: GA1-12. GA10 (130.88 mg) was further purified on a Sephadex LH-20 column, eluted with acetone to yield DT1 (32 mg, R_f 0.35, silica gel, hexane-EtOAc = 4:6) as a yellow oil which was identified as 4-(2-Hydroxypropyl)-2(*5H*)-furanone.

3.2 Isolation of compound DT2 (*trans*-tetracosylferulate) and DT3 (*cis*-hexacosanoyl ferulate)

Fraction C (4.2 g) was separated by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-acetone (100:0 to 0:100). Ninety-two fractions were obtained and combined according to the similarity of their TLC patterns (silica gel, hexane-acetone 6:4) to give fourteen fractions: CA1-14. CA4 (100.32 mg) was further separated by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-EtOAc (100:0 to 0:100) to give compound DT2 as an white amorphous solid (18 mg R_f 0.24, silica gel, hexane-EtOAc = 8:2) which was later identified as *trans*-tetracosylferulate and compound DT3 as a white amorphous solid (2 mg, R_f 0.47, silica gel, hexane-EtOAc = 8:2) which was later identified as *cis*-hexacosanoyl ferulate.

3.3 Isolation of compound DT4 (*p*-hydroxybenzaldehyde)

Fraction D (2.1 g) was further separated by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-acetone (100:0 to 0:100). Thirty-one fractions were obtained: fractions DA1-31. DA18 (50.54 mg) was further separated on a Sephadex LH-20 column, eluted with acetone, to yield

compound DT4 as a brown amorphous solid (4 mg, R_f 0.39, silica gel, hexane-acetone = 7:3), which was identified as *p*-hydroxybenzaldehyde.

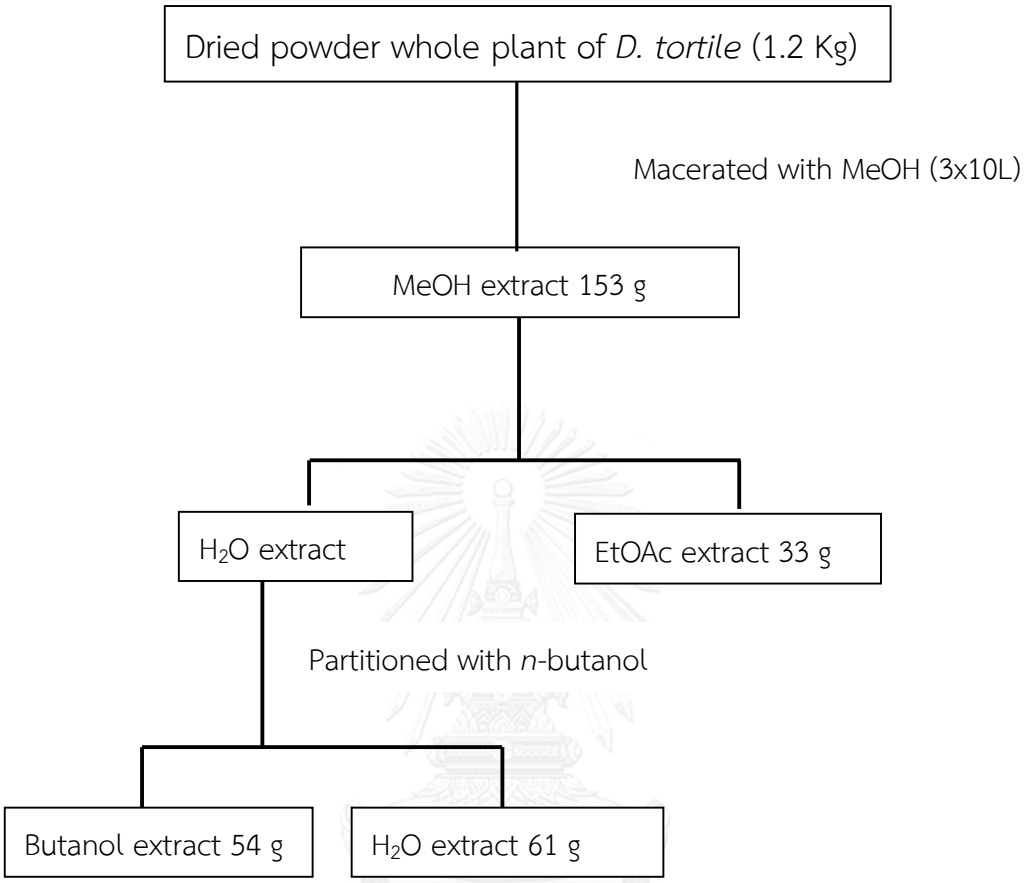
3.4 Isolation of compounds DT5 (3,4-dihydroxy-5,4′dimethoxy-bibenzyl), DT6 (eriodictyol) and DT7 (dendrofalconerol A)

Fraction F (10.4 g) was purified by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-acetone (100:0 to 0:100). Thirty-five fractions were obtained and combined according to the similarity of their TLC patterns (silica gel, hexane-acetone 6:4) to give nine fractions: FA1-9.

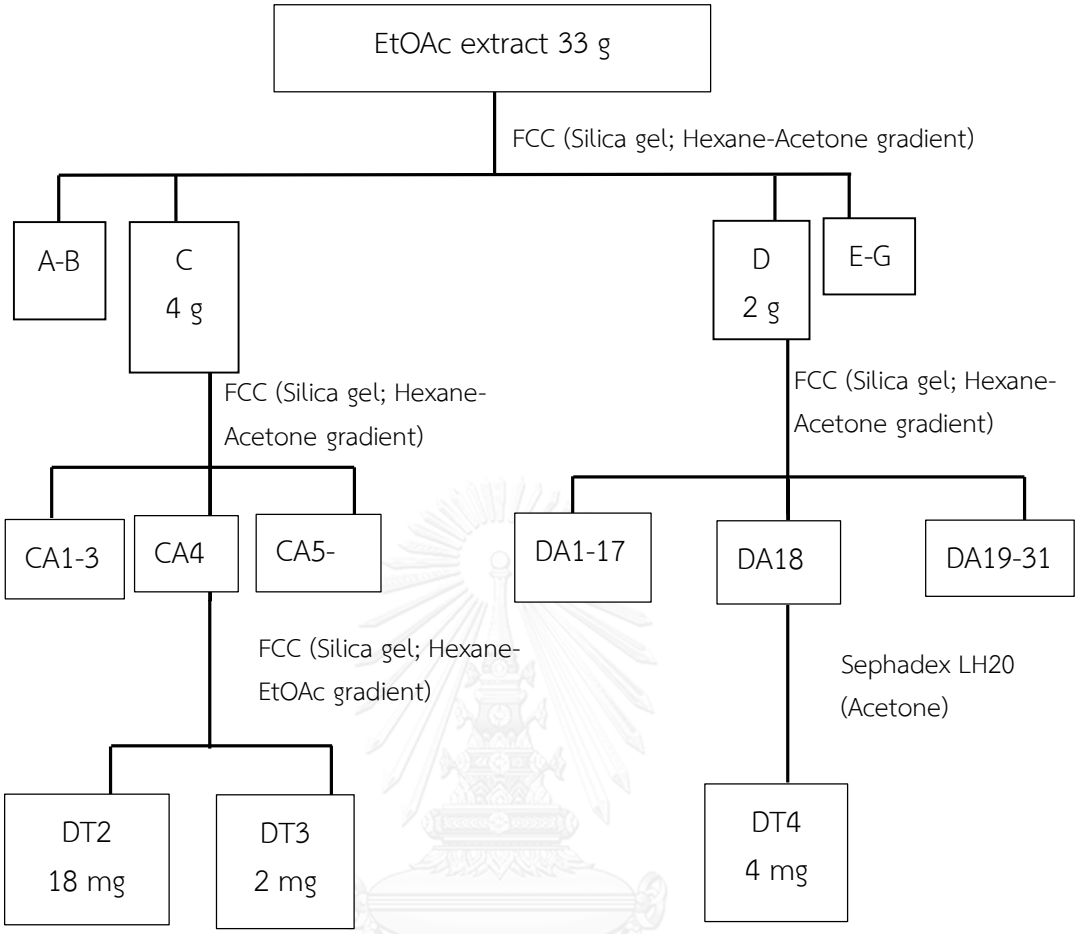
FA3 (50.54 mg) was further purified on a Sephadex LH-20 column, eluted with acetone, to give compound DT5 as a brown amorphous solid (31 mg, R_f 0.56, silica gel, hexane-acetone = 6:4). This was identified as 3,4-dihydroxy-5,4′dimethoxybibenzyl.

FA6 (90.32 mg) was further separated by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-acetone (100:0 to 0:100). Fifty-two fractions were obtained and combined according to the similarity of their TLC patterns (silica gel, hexane-acetone 6:4) to give twelve fractions: FC1-12. FC9 (62.82 mg) was further purified on a Sephadex LH-20 column, eluted with acetone to give thirty fractions which were combined according to the similarity of their TLC patterns (silica gel, hexane-acetone 6:4) to give ten fractions: FD1-10. FD6 (20.89 mg) was further purified on a Sephadex LH-20 column, eluted with acetone to yield compound DT6 (5 mg, R_f 0.30, silica gel, Hexane-EtOAc = 7:3) as a white amorphous solid which was identified as eriodictyol.

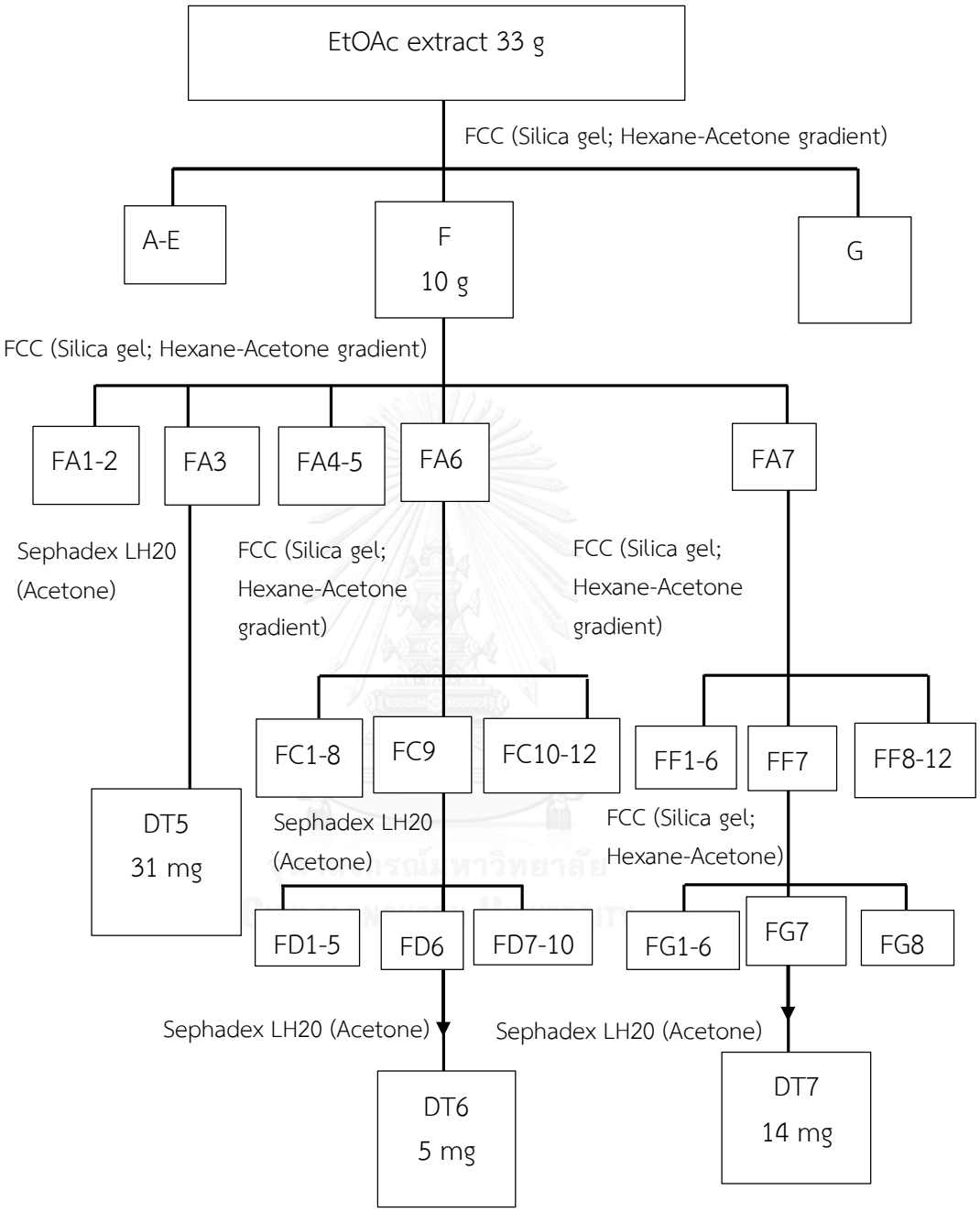
FA7 (130.59 mg) was further separated by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-acetone (100:0 to 0:100). Twenty-three fractions were obtained and combined according to the similarity of their TLC patterns (silica gel, hexane-acetone 6:4) to give twelve fractions: FF1-12. FF7 (75.58 mg) was further purified on a Sephadex LH-20 column, eluted with acetone to give eight fractions: FG1-8. FG7 was (37.77 mg) then further separated by FCC using silica gel (No. 9385) as the stationary phase with a step gradient mixture of hexane-acetone (100:0 to 0:100) to give compound DT7 (14 mg, R_f 0.29, silica gel, hexane-acetone = 6:4)



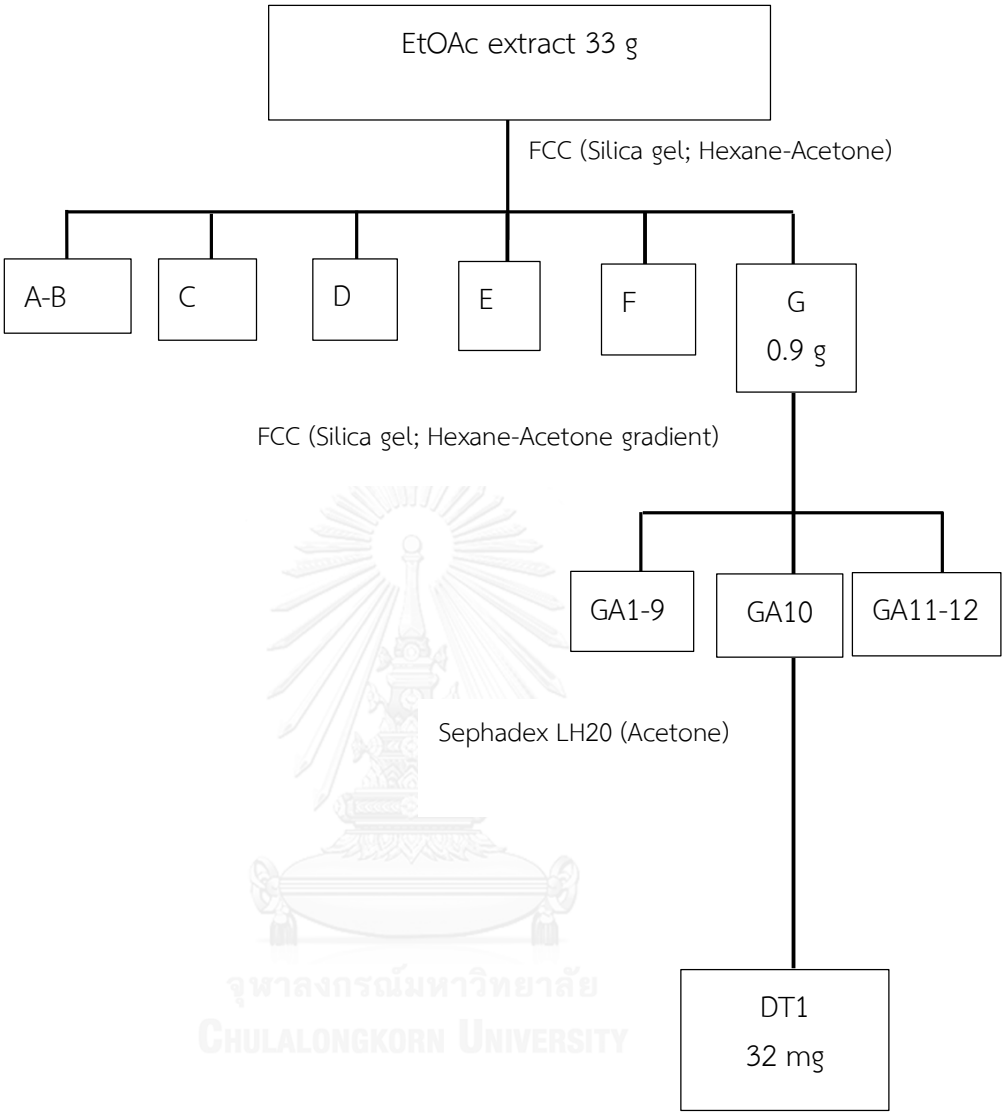
Sheme 1 Separation of the MeOH extract of *Dendrobium tortile*



Sheme 2 Isolation of the EtOAc extract of *Dendrobium tortile*



Scheme 2 Isolation of the EtOAc extract of *Dendrobium tortile* (continued)



Scheme 2 Isolation of the EtOAc extract of *Dendrobium tortile* (continued)

4. Physical and spectral data of isolated compounds

4.1 Compound DT1 (4-(2-hydroxypropyl)-2(5*H*)-furanone)

Compound DT1 was obtained as a yellow oil, soluble in acetone (32.22 mg, 2.69×10^{-3} % based on dried weight of whole plant).

HRESI-MS : $[M+Na]^+$ ion at *m/z* 165.0525 ($C_7H_{10}O_3Na$); **Figure 3**

UV : λ_{max} nm (logε), in methanol: 222 (3.8); **Figure 4**

FT-IR : ν cm^{-1} (KBr) : 3395, 2980, 2934, 1701, 1697, 1391, 1274, 1252, 1133, 1042, 998, 841; **Figure 5**

$[\alpha]_D^{20}$: -162 (*c* = 0.05, MeOH)

^{1}H NMR : δppm, 300 MHz, in acetone- d_6; see **Table 5**, **Figure 6**

^{13}C NMR : δ ppm, 75 MHz, in acetone- d_6; see **Table 5**, **Figure 7**

4.2 Compound DT2 (*trans*-tetracosylferulate)

Compound DT2 was obtained as a white amorphous solid, soluble in acetone (18.34 mg, 1.53×10^{-3} % based on dried weight of whole plant).

ESI-MS : $[M+Na]^+$ ion at *m/z* 553.4188 ($C_{34}H_{58}O_4Na$); **Figure 12**

^{1}H NMR : δ ppm, 300 MHz, in acetone-d_6; see **Table 6**, **Figure 13**

^{13}C NMR : δ ppm, 75 MHz, in acetone-d_6; see **Table 6, Figure 14**

4.3 Compound DT3 (*cis*-hexacosanoyl ferulate)

Compound DT3 was obtained as a white amorphous solid, soluble in acetone (1.82 mg, 1.52×10^{-4} % based on dried weight of whole plant).

ESI-MS : $[M+Na]^+$ ion at *m/z* 581.4545 ($C_{36}H_{62}O_4Na$); **Figure 18**

^{1}H NMR : δ ppm, 300 MHz, in acetone-d_6; see **Table 7**, **Figure 19**

^{13}C NMR : δ ppm, 75 MHz, in acetone-d_6; see **Table 7**, **Figure 20**

4.4 Compound DT4 (*p*-hydroxybenzaldehyde)

Compound DT4 was obtained as a brown amorphous solid, soluble in acetone (4.35 mg, 3.63×10^{-4} % based on dried weight of whole plant).

ESI-MS : $[M+Na]^+$ ion at *m/z* 145.0329 ($C_7H_6O_2Na$); **Figure 24**

^{1}H NMR : δ ppm, 300 MHz, in acetone-d_6; see **Table 8**, **Figure 25**

^{13}C NMR : δ ppm, 75 MHz, in acetone-d_6; see **Table 8**, **Figure 26**

4.5 Compound DT5 (3,4-dihydroxy-5,4′dimethoxybibenzyl)

Compound DT5 was obtained as a brown amorphous solid, soluble in acetone (31.4 mg, 2.62×10^{-3} % based on dried weight of whole plant).

HRESI-MS : $[M+Na]^+$ ion at *m/z* 297.1106 ($C_{16}H_{18}O_4Na$); **Figure 29**

^{1}H NMR : δ ppm, 300 MHz, in acetone-d_6; see **Table 9**, **Figure 30**

^{13}C NMR : δ ppm, 75 MHz, in acetone-d_6; see **Table 9**, **Figure 31**

4.6 Compound DT6 (eriodictyol)

Compound DT6 was obtained as a white amorphous solid, soluble in acetone (5.16 mg, 4.30×10^{-4} % based on dried weight of whole plant).

HRESI-MS : $[M+Na]^+$ ion at *m/z* 311.0505 ($C_{15}H_{12}O_6Na$); **Figure 35**

^{1}H NMR : δ ppm, 300 MHz, in acetone-d_6; see **Table 10**, **Figure 36**

^{13}C NMR : δ ppm, 75 MHz, in acetone-d_6; see **Table 10**, **Figure 37**

4.7 Compound DT7 (dendrofalconerol A)

Compound DT7 was obtained as a red amorphous solid, soluble in acetone (14.10 mg, 1.18×10^{-3} % based on dried weight of whole plant).

HRESI-MS : $[M+Na]^+$ ion at *m/z* 567.2040 ($C_{32}H_{32}O_8Na$); **Figure 38**

^{1}H NMR : δ ppm, 300 MHz, in acetone-d_6; see **Table 11**, **Figure 39**

^{13}C NMR : δ ppm, 75 MHz, in acetone-d_6; see **Table 11**, **Figure 40**

5. Assay for α-glucosidase inhibitory activity

In this research, the α-glucosidase inhibition assay was performed by observing the liberation of *p*-nitrophenol from the substrate *p*-nitrophenyl-α-D-glucopyranoside. The experiment was done in a 96-well plate. 1 mM of *p*-Nitrophenol-α-D-glucopyranoside was dissolved in phosphate buffer (pH6.8) containing 0.04U of enzyme. Each test sample was dissolved in 5% DMSO. First 10 μL of the sample solution was added, followed by 40 μL of α-glucosidase in phosphate buffer (pH6.8). Then the mixture was pre-incubated at 37 °C for 10 minutes. After that, 50 μL of *p*-nitrophenyl-α-D-glucopyranoside was added, and the reaction was allowed to proceed at 37 °C for 20 minutes. Finally, Na_2CO_3 (100 μL, 0.1 mM) solution was added. Acarbose was used as positive control. The reaction was monitored with a microplate reader at 405 nm.

To determine the inhibition mechanism of dendrofalconerol A on α-glucosidase enzyme, the experiment was done in a 96-well plate. 1 mM of *p*-Nitrophenol-α-D-glucopyranoside was dissolved in phosphate buffer (pH6.8). Each test sample was dissolved in 5% DMSO. 10 μL of the sample solution with or without two concentrations of the inhibitor (dendrofalconerol A) (15 and 30 μM) were first added, followed by 40 μL of α-glucosidase with different concentrations (0.01, 0.02, 0.04 and 0.08 U/mL) in phosphate buffer (pH6.8). Then the mixture was pre-incubated at 37 °C for 10 minutes. After that, 50 μL of *p*-nitrophenyl-α-D-glucopyranoside was added, and the reaction were allowed to proceed at 37 °C for 0, 5, 10, 15, and 20 minutes. The reaction was monitored with a microplate reader at 405 nm. The data were analysed by plotting the velocities of the reaction against the concentrations of the enzyme (Hu *et al*., 2015).

In the kinetic study of enzyme inhibition, the experiment was done in a 96-well plate. 1 mM of *p*-Nitrophenol-α-D-glucopyranoside was dissolved in phosphate buffer (pH6.8). Each test sample was dissolved in 5% DMSO. First 10 μL of the sample solution with or without two concentrations of the inhibitor (dendrofalconerol A) (15 and 30 μM) were added, followed by 40 μL of α-glucosidase (0.04 U/mL in phosphate buffer (pH6.8). Then the mixture was pre-incubated at 37 °C for 10 minutes. After that, 50 μL of *p*-nitrophenyl-α-D-glucopyranoside (0.25, 0.5, 1.0, 2.0 mM) were added, and the reaction were allowed to proceed at 37 °C for 0, 5, 10, 15, and 20 minutes. The reaction was monitored with a microplate reader at 405 nm. A double reciprocal Lineweaver-Burk plot was performed. Data were displayed as mean ± SD. The statistical analysis was done by student's t test (Sun *et al*., 2014).

6. Assay for additive effects

To evaluate the additive effect of dendrofalconerol A on acarbose, the experiment was done in a 96-well plate. 1 mM of *p*-Nitrophenol-α-D-glucopyranoside was dissolved in phosphate buffer (pH6.8) containing 0.04U of enzyme. Each test sample was dissolved in 5% DMSO. 10 μL of the sample solution was first added. The sample was divided into two sets. Set I: acarbose 100 μM, dendrofalconerol A 9 μM, and dendrofalconerol A 9 μM+acarbose 100 μM. Set II: acarbose 100 μM, dendrofalconerol A 6 μM, and dendrofalconerol A 6 μM+acarbose 100 μM. 40 μL of α-glucosidase (0.04 U/mL in phosphate buffer (pH6.8) was added. Then the mixture was pre-incubated at 37 °C for 10 minutes. After that, 50 μL of *p*-nitrophenyl-α-D-glucopyranoside was added, and the reaction was allowed to proceed at 37 °C for 20 minutes. Finally, Na_2CO_3 (100 μL, 0.1 mM) solution was added. The reaction was detected with a microplate reader at 405 nm.

CHAPTER IV
RESULTS AND DISCUSSION

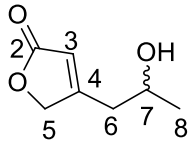
In this study, the dried and powdered whole plants of *Dendrobium tortile* (1.2 kg) were macerated with methanol. The methanol extract was concentrated under reduced pressure to give 153 g of a crude extract. The dried methanol extract exhibited α-glucosidase inhibitory activity with approximately 70 % at a concentration of 2 mg/mL. It was further partitioned with EtOAc, H_2O and butanol. The EtOAc part showed the most potent α-glucosidase inhibitory activity with 100%. Therefore the EtOAc part was further separated using several chromatographic techniques to give seven pure compounds consisting of a new compound named 4-(2-Hydroxypropyl)-2(*5H*)-furanone [**DT1**] and six known compounds including *trans*-tetracosylferulate [**DT2**], *cis*-hexacosanoyl ferulate [**DT3**], *p*-Hydroxybenzaldehyde) [**DT4**], bibenzyls (3,4-dihydroxy-5,4′-dimethoxybibenzyl) [**DT5**], eriodictyol [**DT6**] and dendrofalconerol A [**DT7**]. The structures of these compounds were determined by spectroscopic techniques, consisting of UV, IR, MS and NMR. They were also evaluated for their α-glucosidase inhibitory activity.

1. Structure characterization of isolated compounds

1.1 Structure determination of compound DT1

Compound DT1 was obtained as a yellow oil. The ESI mass spectrum (**Figure 3**) showed a sodium-adduct molecular ion $[M+Na]^+$ at *m/z* 165.0525 (calcd. for $C_7H_{10}O_3Na$. 165.0527), suggesting the molecular formula $C_7H_{10}O_3$. The UV spectrum showed a maximum absorption at 222 nm (**Figure 4**). The specific rotation $[\alpha]_D^{20}$ was found to be -162 (*c* = 0.05 in MeOH). The IR spectrum (**Figure 5**) exhibited intense absorption bands for carbonyl at 1701 cm^{-1} and hydroxyl groups at 3395 cm^{-1}. The ^1H NMR signals (**Figure 6** and **Table 5**) at δ_H 4.24 (2H, br s, H-5) and 5.93 (1H, br s, H-3), and the ^{13}C NMR resonances (**Figure 7** and **Table 5**) at δ_C 164.5 (C-2), 161.2 (C-4), 112.4 (C-3) and 62.8 (C-5) suggested the presence of a 2(5*H*)-furanone structure. This was confirmed by the HMBC correlations (**Figure 8**) from C-2 to H-3, and from C-3 to H-5. The ^1H NMR and ^1H-^1H COSY spectra (**Figure 9**) also exhibited signals for a 2-hydroxy-propyl group at δ_H 1.37 (3H, d, *J*=6.3 Hz, H_3-8), 2.23 (1H, dd, *J*=17.7, 6.6 Hz, H-6), 2.36 (1H, dd, *J*=17.7, 4.2Hz, H-6) and 4.53 (1H, m, H-7) which correlated with the ^{13}C NMR signals at δc 20.0 (C-8), 31.3 (C-6), and 73.6 (C-7), respectively, in the HSQC spectrum

(**Figure 10**). The 2-hydroxy-propyl group should be attached to C-4 of the 2(5*H*)-furanone nucleus, as indicated from the HMBC correlations from H_2-6 to C-3, C-5 and C-8. In the NOESY spectrum (**Figure 11**), H-7 showed NOESY correlations with H-6 and H-8. Based on the above- mentioned spectroscopic evidence, the structure of DT1 was established as 4-(2-hydroxypropyl)-2(5*H*)-furanone [**264**]. Furanones are rarely isolated from *Dendrobium*. Most of them have been found as volatile components and detected by GC-MS analysis.



4-(2-hydroxypropyl)-2(5*H*)-furanone [**264**]

Table 5 NMR spectral data of compound DT1 (in acetone-d_6)

Position	Compound DT1	
	δ_H (mult., *J* in Hz)	δ_C
2	-	164.6
3	5.94 (brs)	112.4
4	-	161.2
5	4.25 (s)	62.8
6	2.24 (dd, 17.7, 6.6) 2.36 (dd, 17.7, 4.2)	31.3
7	4.52 (m)	73.6
8	1.37 (d, 6.3)	20.1

1.2 Structure determination of compound DT2

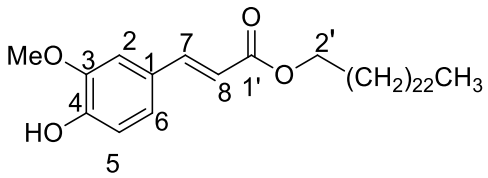
Compound DT2 was obtained as a white amorphous solid. The ESI mass spectrum (**Figure 12**) showed a sodium-adduct molecular ion $[M+Na]^+$ at *m/z* 553.4188 (calcd. for $C_{34}H_{58}O_4Na$. 553.4232), suggesting the molecular formula $C_{34}H_{58}O_4$**.**

The ^1H NMR spectrum (**Figure 13** and **Table 6**) of DT2 shown signals characteristic of a feruloyl moiety: a methoxy signal at δ_H 3.94, two *trans* olefenic protons (δ_H 7.63 and 6.39, *J* = 16 Hz, H-7, H-8) and three aromatic protons (δ_H 6.88 (d, *J*= 8, H-5), 7.15 (br d, , H-6) and 7.35 (s, H-2). The presence of an aliphatic alcohol moiety was indicated from the triplet signal at δ_H 0.89 (terminal methyl), the multiplets at δ_H 1.30-1.69 for aliphatic methylenes and the downfield triplet at δ_H 4.16 representing an oxygen-bearing methylene group.

The ^{13}C NMR spectrum (**Figure 14** and **Table 6**) showed signals for a saturated fatty alcohol moiety at δ_C 22.4-31.8, an oxygenated carbon at δ_C 63.8, an oxycarbonyl function at δ_C 166.6, a terminal methyl at δ_C 13.5 and a methoxy carbon at δ_C 55.5. All of the protonated carbons were assigned from the correlation peaks observed in the HSQC spectrum (**Figure 15**). The NOESY spectrum (**Figure 16**) showed NOE correlations from H-2 to H-8 and MeO-3 protons.

In the HMBC spectrum (**Figure 17**), the methine protons at positions 7 and 8 and the methylene protons at position 2′ showed correlation peaks with the carbonyl carbon at δ_C 166.6. Moreover, the methoxy protons at δ_H 3.94 exhibited correlation with C-3, which was assigned from the 3-bond couplings with H-5.

Based on the above spectral data, the structure of DT2 was established as *trans*-tetracosylferulate [**265**]. This compound has been earlier reported from dried stems of *Gnetum pendulum* (Gnetaceae) (Xiang *et al*., 2008).



trans-tetracosylferulate [**265**]

Table 6 NMR spectral data of compound DT2 (in acetone-d_6) and *trans*-octadecanyl ferulate (in $CDCl_3$)

Position	Compound DT2		*trans*-octadecanyl ferulate	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	126.6	-	127.1
2	7.35 (s)	110.4	7.23 (d, 2)	109.3
3	-	147.9	-	147.8
4	-	149.2	-	147.6
5	6.88 (d, 8)	115.1	6.85 (d, 8)	114.6
6	7.15 (brd, 8)	123.0	7.11 (dd, 2, 8)	122.9
7 (α)	7.60 (d, 16)	144.6	7.64 (d, 16)	144.6
8 (β)	6.41 (d, 16)	115.2	6.39 (d, 16)	115.6
1′	-	166.6	-	167.3
2′ (CH_2O)	4.16 (t)	63.8	4.21 (t)	64.6
$(CH_2)_n$	1.30-1.69 (m)	22.4-31.8	1.33-1.74 (m)	25.9-31.8
Me	0.89 (t)	13.5	0.94 (t)	14.1
OMe	3.94 (s)	55.5	3.93(s)	55.9

(Aliou *et al*., 1991)

1.3 Structure determination of compound DT3

Compound DT3 was obtained as a white amorphous solid. The ESI mass spectrum (**Figure 18**) showed a sodium-adduct molecular ion $[M+Na]^+$ at *m/z* 581.4481 (calcd. for $C_{36}H_{62}O_4Na$. 581.4545), suggesting the molecular formula $C_{36}H_{62}O_4$**.**

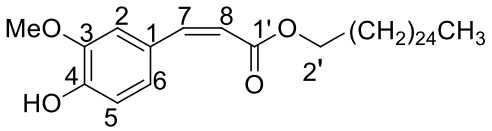
The ^1H NMR spectrum (**Figure 19** and **Table 7**) of DT3 showed signals which were characteristic of a feruloyl moiety: a methoxy signal at δ_H 3.87, two *cis* olefenic protons (δ_H 5.83 and 6.89, *J* = 13 Hz, H-7, H-8) and three aromatic protons (δ_H 6.83 (d, *J*=8, H-5), 7.24 (dd, *J*=2, 8, H-6) and 7.86 (d, *J*=2, H-2) The presence of an aliphatic alcohol moiety was indicated from the triplet signal at δ_H 0.89 (terminal methyl), the multiplets at δ_H 1.30-1.66 for aliphatic methylenes protons and the downfield triplet at δ_H 4.13 attributable to an oxygen-bearing methylene group.

The ^{13}C NMR experiment (**Figure 20** and **Table 7**) indicated signals for a saturated fatty alcohol moiety at δ_C 22.4-31.7, an oxygenated carbon at δ_C 63.8, an oxycarbonyl group at δ_C 166.2, a terminal methyl at δ_C 13.5 and a methoxy carbon at δ_C 55.3.

A NOESY cross peak (**Figure 21**) observed between H-7 and H-8 confirmed their *cis* configuration. In addition, the methoxy protons at δ_H 3.93 showed a NOE with H-2 (δ_H 7.86). The HSQC correlation peaks (**Figure 22**) provides assignments for all the protonated carbons.

In the HMBC spectrum (**Figure 23**), the methine protons at positions 7 and 8 and the methylene protons at position 2′ showed correlation peaks with the carbonyl carbon at δ_C 166.2. Moreover, the methoxy protons at δ_H 3.93 exhibited correlation with C-3, confirmingthe position of the methoxy group at C-3.

On the basis of the above-mentioned spectral data, the structure of DT3 was characterized as *cis*-Hexacosanoyl ferulate [**266**]. This compound has been earlier reported from the stem-bark of *Pavetta owariensis* (Rubiaceae) (Aliou *et al*., 1991).



cis-hexacosanoyl ferulate [**266**]

Table 7 NMR spectral data of compound DT3 (in acetone-d_6) and *cis*-octadecanyl ferulate (in $CDCl_3$)

Position	Compound DT3		*cis*-octadecanyl ferulate	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	126.9	-	127.1
2	7.86 (d,2)	114.4	7.79 (d, 2.0)	109.3
3	-	148.7	-	147.8
4	-	148.9	-	147.6
5	6.83 (d, 8)	114.4	6.80 (d, 8.0)	114.6
6	7.24 (dd, 2, 8)	125.5	7.24 (dd, 2.0, 8.0)	122.9
7 (α)	6.89 (d, 13)	143.4	6.89 (d, 13.0)	144.6
8 (β)	5.83 (d, 13)	116.0	5.81 (d, 13.0)	115.6
1′	-	166.2	-	167.3
2′ (CH_2O)	4.13 (t)	63.8	4.16 (t)	64.6
$(CH_2)_n$	1.30-1.66 (m)	22.4-31.7	1.33-1.74 (m)	25.9-31.8
Me	0.89 (m)	13.5	0.94 (m)	14.1
OMe	3.87 (s)	55.3	3.91 (s)	55.9

(Aliou *et al*., 1991)

1.4 Structure determination of compound DT4

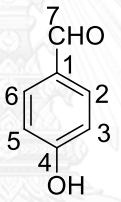
Compound DT4 was obtained as a brown amorphous solid. The HRESIMS of this compound (**Figure 24**) showed a sodium-adduct molecular ion $[M+Na]^+$ at *m/z* 145.0329 (calcd. for $C_7H_6O_2Na$. 145.0265), suggesting the molecular formula $C_7H_6O_2$.

The ^1H NMR spectrum (**Figure 25** and **Table 8**) of DT4 showed signals for two doublets of four aromatic protons at δ_H 7.81 (d, *J*=8.4, H-2, H-6) and δ_H 6.99 (d, *J*=8.7, H-3, H-5) and an aldehydic proton at δ_H 9.85 (s, H-7).

The ^{13}C NMR experiment (**Figure 26** and **Table 8**) indicated the presence of an aldehyde carbon at δ_C 190.7 (C-7), an oxygenated aromatic carbon at δ_C 163.6 (C-4) and aromatic carbons at δ_C 116.3-132.4 (C-1, C-2, C-3, C-5, C-6).

In this study, all the NMR assignments were obtained through analysis of the HSQC (**Figure 27**) and HMBC spectra (**Figure 28**) and summarized in the **Table 8**

The NMR spectral data of DT4 were in agreement with those of *p*-hydroxybenzaldehyde [**207**], which was earlier identified from the sponge *Anchinoe paupertas* (Bouaicha *et a*l., 1994) and *Dendrobium falconeri* (Sritularak *et al*., 2009).



p-hydroxybenzaldehyde [**207**]

Table 8 NMR spectral data of compound DT4 (in acetone-d_6) and *p*-hydroxy-benzaldehyde (in CD_3OD)

Position	Compound DT4		*p*-Hydroxybenzaldehyde	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	129.9	-	130.2
2	7.81 (d, 8.6)	132.4	7.78 (d, 8.0)	133.4
3	6.99 (d, 8.6)	116.3	6.91 (d, 8.0)	116.9
4	-	163.6	-	165.2
5	6.99 (d, 8.6)	116.3	6.91 (d, 8.0)	115.9
6	7.81 (d, 8.6)	132.4	7.78 (d, 8.0)	130.4
7	9.85 (s)	190.7	9.76 (s)	192.8

(Bouaicha *et a*l., 1994)

1.5 Structure determination of compound DT5

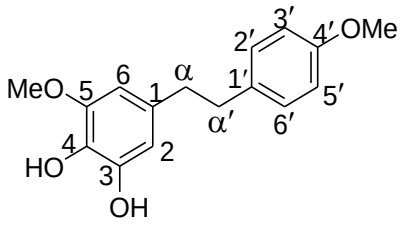
Compound DT5 was obtained as a brown amorphous solid. Its HRESIMS (**Figure 29**) showed a sodium-adduct molecular ion $[M+Na]^+$ at *m/z* 297.1106 (calcd. for $C_{16}H_{18}O_4Na$. 297.1102), suggesting the molecular formula $C_{16}H_{18}O_4$.

The ^1H NMR spectrum of this compound (**Figure 30** and **Table 9**) exhibited signals for four methylene protons at δ_H 2.70 (α, m) and 2.79 (α', m), two methoxy groups at δ_H 3.75 (3H, s) and 3.74 (3H, s) and aromatic protons at δ_H 7.10 (d, *J*=8.2, H-2′, H-6′) and 6.80 (d, *J*=8.2, H-3′, H-5′) due to an $A'_2B'_2$ system. The *meta*-coupled signals at δ_H 6.37 (d, J=1.8, H-2) and 6.34 (d, J=1.8, H-6) suggested asymmetric oxygenation at C-3, C-4 and C-5.

The ^{13}C NMR spectrum (**Figure 31** and **Table 9**) displayed 14 carbons, comprising 12 aromatic carbons δ_C: 158.8 (C-4′), 148.7 (C-5), 146.1 (C-3), 134.8 (C-1′), 134.7 (C-1), 133.5 (C-4), 130.1 (C-2′, C-6′), 114.4 (C-3′, C-5′), 109.6 (C-2), 104.5 (C-6), 56.3 (5-OCH_3), 55.3 (4′-OCH_3), and 2 aliphatic carbons δ_C: 38.7 (α-CH_2), 37.8 (α'-CH_2).

In the NOESY spectrum (**Figure 32**) H-3′ and H-5′ showed correlation peaks with the methoxy protons at δ_H 3.75, and H-6 exhibited a correlation peak with the methoxy protons at δ 3.74. These indicated the locations of the two methoxy groups at C-5 and C-4′. Close examination of the NOESY spectrum also allowed unambiguous assignments for α-CH_2 and α'-CH_2 protons (**Table 9**). All of the ^{13}CNMR assignments for protonated carbons were obtained through analysis of the HSQC spectrum (**Figure 33**). In the HMBC spectrum (**Figure 34**), 4′-OMe protons showed a correlation peak with C-4′ and 5-OMe protons exhibited a correlation peak with C-5, confirming the positions of the methoxy groups.

From the above spectral data, DT5 was identified as 3,4-dihydroxy-5,4′-dimethoxybibenzyl [**39**]. The compound has been earlier reported from *Dendrobium moniliforme* (Bi *et al*., 2004).



3,4-dihydroxy-5,4′-dimethoxybibenzyl [**39**]

Table 9 NMR spectral data of compound DT5 (in acetone-d_6) and 3,4-dihydroxy-5,4′-dimethoxybibenzyl (in $CDCl_3$).

Position	Compound DT5		3,4-dihydroxy-5,4′-dimethoxybibenzyl	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	134.7	-	133.4
2	6.37 (d, 1.8)	104.5	6.20 (d, 1.3)	108.7
3	-	146.1	-	143.7
4	-	133.5	-	130.5
5	-	148.7	-	146.9
5-OCH_3	3.74 (s)	56.3	3.66 (s)	55.7
6	6.34 (d, 1.8)	109.6	6.44 (d, 1.3)	103.6
α-CH_2	2.71 (m)	38.7	2.71 (m)	37.6
1′	-	134.8	-	133.7
2′, 6′	7.11 (d, 8.4)	130.1	7.01 (d, 8.2)	129.3
3′, 5′	6.81 (d, 8.4)	114.4	6.78 (d, 8.2)	113.4
4′	-	158.8	-	157.3
4′-OCH_3	3.75 (s)	55.3	3.69 (s)	54.9
α′-CH_2	2.80 (m)	37.8	2.71 (m)	36.7

(Bi *et al*., 2004)

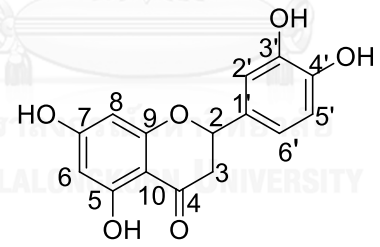
1.6 Structure determination of compound DT6

Compound DT6 was obtained as a white amorphous solid. The HRESIMS of this compound (**Figure 35**) showed a sodium-adduct molecular ion $[M+Na]^+$ at *m/z* 311.0505, indicating the molecular formula $C_{15}H_{12}O_6$.

The ^1H NMR spectrum (**Figure 36** and **Table 10**) showed 5 aromatic protons at δ: 5.93 (brs, H-6), 5.94 (brs, H-8), 7.02 (s, H-2′), 6.86 (s, H-5′), and 6.98 (s, H-6′), and 3 aliphatic protons at δ: 5.39 (dd, *J*=12.6, 3.0 Hz, H-2), 2.69 (dd, *J*=17.1, 3.0 Hz, H-3b), and 3.13 (dd, *J*=17.1, 12.6 Hz, H-3a), and sharp singlet phenolic proton δ: 12.17 (s, 5-OH).

The ^{13}C NMR spectrum (**Figure 37** and **Table 10**) showed 15 carbons consisting of 3 aliphatic carbons: δ_c 43.53 (C-3), 79.94 (C-2), 95.8 (C-8), and 197.2 (C-4), and 12 aromatic carbons δ_c: (C-8), 96.7 (C-6), 103.2 (C-10), 114.7 (C-2′), 115.9 (C-5′), 119.2 (C-6′), 131.5 (C-1′), 146.0 (C-4′), 146.3 (C-3′), 164.3 (C-9), 165.2 (C-5), 167.3 (C-7) and 197.2 (C-4)

Through comparision of the ^1H and ^{13}C NMR data with literature values, DT6 was identified as eriodictyol [**131**], a flavonoid earlier reported from *Solanum hindsianum* (Encarnacion *et al*., 1999) and *Dendrobium ellipsophyllum* (Tanagornmeatar *et al*., 2014).



eriodictyol [**131**]

Table 10 NMR spectral data of compound DT6 (in acetone-d_6) and Eriodictyol (in acetone-d_6)

Position	Compound DT6		Eriodictyol	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	-	-	-
2	5.39 (dd, 12.6, 3.0)	80.1	5.40 (dd, 12.7, 2.8)	79.3
3a	3.13 (dd, 17.1, 12.6)	43.53	3.14 (dd, 17.2, 12.7)	42.9
3b	2.69 (dd, 17.1, 3.0)	43.53	2.73 (dd, 17.2, 2.8)	42.9
4	-	197.2	-	196.5
5	-	165.2	-	164.6
6	5.93 (brs)	96.7	5.97 (m)	95.2
7	-	167.3	-	166.6
8	5.94 (brs)	95.8	5.97 (m)	96.1
9	-	164.3	-	163.7
10	-	103.2	-	102.0
1′	-	131.5	-	129.7
2′	7.02 (s)	114.7	7.05 (s)	115.4
3′	-	146.3	-	145.7
4′	-	146.0	-	145.4
5′	6.86 (s)	115.9	6.88 (s)	114.1
6′	6.86 (s)	119.2	6.88 (s)	118.6
5-OH	12.17 (s)	-	Not given	-
7, 3′, 4′OH	Not given	-	Not given	-

(Encarnacion *et al*., 1999)

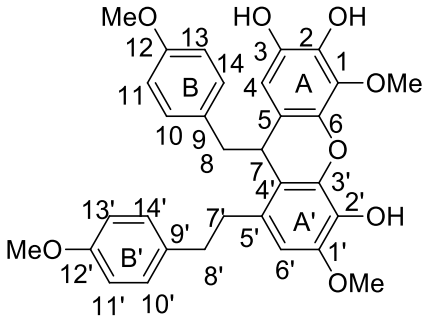
1.7 Structure determination of compound DT7

Compound DT7 was obtained as a red amorphous solid. Its HRESIMS (**Figure 38**) showed a sodium-adduct ion [M+Na$^+$] at *m/z* 567.2040, suggesting the molecular formula $C_{32}H_{32}O_8$.

The ^{1}H NMR spectrum (**Figure 39** and **Table 11**) of DT7 displayed ten aromatic protons at δ 6.13-7.14. In the aliphatic region, the following proton signals were observed : a CH proton at δ 4.09 (m, H-7); three pairs of methylene protons at δ 2.65--2.83 (m, CH_2-8), δ 2.78--2.90 (m, CH_2-7′), and 2.80-2.86 (m, CH_2-8′); four MeO groups at δ 3.69 (s, OCH_3-12), 3.73 (s, OCH_3-12′), 3.80 (s, OCH_3-1′), 3.88 (s, OCH_3-1).

The ^{13}C NMR spectrum (**Figure 40** and **Table 11**) showed 32 carbon signals, corresponding to four aromatic methoxy groups, three methylene groups, one aliphatic methane group, ten aromatic methine groups, and 14 aromatic quaternary carbon. From the molecular formula of DT7, it can be proposed that DT7 was a bis bibenzyl. On ring A, the proton at δ_H 4.09 (m, H-7) displayed a NOESY correlation with the proton at δ_H 6.13 (s, H-4) (**Figure 41**). On ring A′, the proton at δ_H 6.67 (s, H-6′) showed NOESY correlations with methoxyl protons at δ_H 3.80 (s, 1′-OMe). All of the NMR assignments for protonated carbons were obtained through analysis of the HSQC (**Figure 42**). The HMBC spectrum (**Figure 43**) showed corelations from the proton at δ_H 4.09 (m, H-7) to C-5, C-4′ and C-9, and provided complete NMR assignments for all the quaternary carbons.

Based on the above spectral data, DT7 was characterized as Dendrofalconerol A [**61**], which was earlier obtained from *Dendrobium falconeri* (Sritularak and Likhitwitayawuid, 2009).



dendrofalconerol A [**61**]

Table 11 NMR spectral data of compound DT7 (in acetone-d_6) and Dendrofalconerol A (in acetone-d_6)

Position	Compound DT7		Dendrofalconerol A	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	136.9	-	136.8
2	-	137.4	-	137.3
3	-	141.7	-	141.6
4	6.13 (s)	109.7	6.14 (s)	109.7
5	-	117.8	-	117.8
6	-	139.9	-	139.9
7	4.09 (m)	39.6	4.09 (dd, 5,5, 7.0)	39.6
8	2.74-2.83 (m)	45.4	2.76-2.82 (m) 2.66-2.72 (m)	45.4
9	-	131.6	-	131.6
10	6.62 (d, 9)	131.3	6.61 (d, 8.5)	131.3
11	6.67 (d, 9)	113.9	6.67 (d, 8.5)	113.9
12	-	159.1	-	159.1
13	6.67 (d, 9)	113.9	6.67 (d, 8.5)	113.9
14	6.62 (d, 9)	131.3	6.61 (d, 8.5)	131.3

(Sritularak and Likhitwitayawuid, 2009)

Table 11 NMR spectral data of compound DT7 (in acetone-d_6) and Dendrofalconerol A (in acetone-d_6) continued

Position	Compound DT7		Dendrofalconerol A	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1′	-	147.1	-	147.1
2′	-	134.0	-	134.0
3′	-	142.3	-	142.3
4′	-	119.0	-	119.1
5′	-	129.5	-	129.5
6′	6.67 (s)	108.5	6.65 (s)	108.5
7′	2.87-2.90 (m) 2.78-2.86 (m)	34.5	2.86-2.90 (m) 2.79-2.85 (m)	34.4
8′	2.80-2.86 (m)	37.6	2.73-2.84 (m)	37.5
9′	-	134.7	-	134.6
10′	7.14 (d, 8.4)	130.2	7.12 (d, 8.5)	130.2
11′	6.83 (d, 9)	114.5	6.82 (d, 8.5)	114.5
12′	-	158.9	-	158.9
13′	6.83 (d, 9)	114.5	6.82 (d, 8.5)	114.5
14′	7.14 (d, 8.4)	130.2	7.12 (d, 8.5)	130.2
MeO-(1)	3.88 (s)	61.2	3.89 (s)	61.2
MeO-(1′)	3.80 (s)	56.6	3.82 (s)	56.6
MeO-(12)	3.69 (s)	55.3	3.70 (s)	55.3
MeO-(12′)	3.73 (s)	55.4	3.73 (s)	55.4

(Sritularak and Likhitwitayawuid, 2009)

2. α-Glucosidase inhibitory activity evaluation

In this study, all the isolated compounds [**39**, **61**, **131**, **207**, **264** – **266**] were evaluated for their α-glucosidase inhibitory activity. Each compound was first tested at 200 μg/mL. If the compound displayed more than 50% inhibition of the enzyme, an IC_{50} was determined (**Table 12**).

Table 12 α-Glucosidase inhibitory activity of compounds DT 1-7

Compounds	IC_{50} (μM)
4-(2-Hydroxypropy)-2(5*H*)-furanone [DT1, **264**]	NA
trans-Tetracosylferulate [DT2, **265**]	NA
cis-Hexacosanoylferulate [DT3, **266**]	NA
p-Hydroxybenzaldehyde [DT4, **207**]	NA
3,4-Dihydroxy-5,4′-dimethoxybibenzyl [DT5, **39**]	324.6±34.8
Eriodictyol [DT6, **131**]	276.2±25.5
Dendrofalconerol A [DT7, **61**]	18.0±0.8
Acarbose	392.0±15.4

NA = no inhibitory activity

Among the compounds tested in ths investigation, dendrofalconerol A [**61**] showed the strongest α-glucosidase inhibitory activity with an IC_{50} value of 18.0 μM, as compared with the positive control acarbose (IC_{50} 392.0 μM). 3,4-Dihydroxy-3,4′-dimethoxybibenzyl [**39**] and eriodictyol [**131**] exhibited appreciable effects (IC_{50} 324.6 and 276.2 μM, respectively). It is interesting to note that the bisbibenzyl [**61**], which is a dimer of [**39**], was 18-fold more inhibitory than the monomer [**39**]. There are several earlier reports that suggested that stilbene dimers are stronger α-glucosidase inhibitors than their corresponding monomers, probably due to the additional hydroxyl groups in the structures.

The inhibition mechanism of dendrofalconerol A on α-glucosidase enzyme was studied by plotting the initial velocities against the enzyme concentrations (0.01, 0.02, 0.04 and 0.08 U/mL) with or without two concentrations of the inhibitor (15 and 30 μM) (**Figure 44 A**). It can be seen that plot provides a family of straight lines, all of which passed through the origin. Moreover, an increase of the concentration of

compound [**61**] resulted in a decrease in the line slope. Therefore it was concluded that this compound was a reversible α-glucosidase inhibitor (Hu *et al*., 2015).

The kinetic study of enzyme inhibition of dendrofalconerol A [**61**] on α-glucosidase enzyme was then performed by analysis of the plot between the velocity and the substrate concentration (0.25, 0.5, 1.0 and 2.0 mM) with or without two concentrations of the inhibitor (15 and 30 μM) (**Figure 44 B**). As illustrated in **Table 13** the increase of concentration of dendrofalconerol A [**61**] decreased the V_{max} value but did not affect the K_m value of the enzyme. These results indicated that dendrofalconerol A [**61**] is a non-competitive inhibitor with the K_i value 2.0 μM (**Table 13 and Figure 44 B**).

Table 13 Kinetic parameters of α-glucosidase in the presence of Dendrofalconerol A

Inhibitor	**Dose (μM)**	**V_{max} (M/min)**	**K_m (mM)**	**K_i (μM)**
None	-	3.7	0.8	-
Dendrofalconerol A	15	2.8	0.8	2.0
	30	1.3	0.8	-

The effects of acarbose and dendrofalconerol A [**61**] combination were evaluated by adding different combinations of acarbose (100 μM) and dendrofalconerol A [**61**] (6 or 9 μM) in the assay system. The result (**Figure 45**) showed that the combination of acarbose (100 μM) and dendrofalconerol A [**61**] (6 μM) significantly increased the percentage of α-glucosidase inhibition by about 50% when compared with acarbose alone, whereas the combination of acarbose (100 μM) and dendrofalconerol A [**61**] (9 μM) did not cause significant change in the percentage of enzyme inhibition. These data support the earlier report that dendrofalconerol A [**61**], when combined with acarbose at low concentration, displayed additive effect on α-glucosidase inhibition (Akkarachiyasit *et al*., 2010).

CHAPTER V
CONCLUSION

In this research, seven compounds were isolated from the ethylacetate extract of *Dendrobium tortile*, consisting of one new and six known compounds. The new compound was characterized as 4-(2-hydroxypropyl)-2(5*H*)-furanone [**264**]. The known compounds were identified as *trans*-tetracosylferulate [**265**], *cis*-hexacosanoyl ferulate [**266**], *p*-hydroxybenzaldehyde [**207**], 3,4-dihydroxy-5,4′-dimethoxybibenzyl [**39**], eriodictyol [**131**] and dendrofalconerol A [**61**]. These isolated compounds were evaluated for α-glucosidase inhibitory activity. The results showed that 3,4-dihydroxy-5,4′-dimethoxybibenzyl [**39**], eriodictyol [**131**] and dendrofalconerol A [**61**] exhibited α-glucosidase inhibitory activity. The most potent compound is dendrofalconerol A [**61**]. This compound was then selected for further study on the mechanism of enzyme inhibition. The result indicated that dendrofalconerol A [**61**] showed reversible non-competitive type of enzyme inhibition, with a K_i value of 2.0 μM. The study for additive effects showed that the combination of acarbose (100 μM) and dendrofalconerol A [**61**] (6 μM) significantly increased the percentage of α-glucosidase inhibition when compared with acarbose or dendrofalconerol A [**61**] alone.

In conclusion, the identification of the bibenzyl compounds 3,4-dihydroxy-5,4′-dimethoxybibenzyl [**39**] and dendrofalconerol A [**61**], and the flavonoid eriodictyol [**131**] in *D. tortile* should provide useful information for the chemotaxonomic study of plants in the genus *Dendrobium*. The α-glucosidase inhibitory activity observed in these aromatic compounds [**39**, **61**, **131**] suggests their therapeutic potential, but further studies in animals are still needed before any conclusion can be drawn.

REFERENCES

Akkarachiyasit, S., Charoenlertkul, P., Yibchok-anun, S., and Adisakwattana, S. (2010). "Inhibitory activities of cyanidin and its glycosides and alpha-glucosidase and pancreatic alpha-amylase." International Journal of Molecular Science **11**: 3387-3396.

Aliou, M., Cleay, M., Pieters, L. A., Wrayt, V., and Vlietinck, A. J. (1991). "Ferulic acid esters from stem bark of *Pavetta owariensis*." Phytochemisrry **30**: 1204-1206.

Bi, Z. M., Wang, Z.T., and Xu, L.S. (2004). "Chemical constituents of *Dendrobium moniliforme*." Acta Botanica Sinica **46**: 124-126.

Bouaicha, N., Amade, P., and Puel, D. (1994). "Zarzissine, a new cytotoxic guanidine alkaloid from the mediterranean sponge *Anchinoe paupertas*." Journal of Natural Products **57**: 1455-1457.

Chang, C. C., Ku, A.F., Tseng, Y.Y., Yang, W.B., Fang, J.M., and Wong, C.H. (2010). "6,8-Di-C-glycosyl flavonoids from *Dendrobium huoshanense*." Journal of Natural Products **73**: 229-232.

Chang, S. J., T.H., and Chen, C.C. (2001). "Constituents from the stems of *Dendrobium clavatum* var. *auranteacum*." Journal of Chinese Medicine **12**: 211-218.

Chanvorachote, P., Kowitdamrong, A., Ruanghrin, T., Sritularak, B., Mungmee, C., and Likhitwittayawuid, K. (2013). "Anti-metastatic activities of bibenzyl from *Dendrobium pulchellum*." Natural Product Communications **8**: 115-118.

Chen, C. C., Wu, L.G., Ko, F.N., and Teng, C.M. (1994). "Antiplatelet aggregation principles of *Dendrobium loddigesii*." Journal of Natural Products **57**: 1271-1274.

Chen, X. G., Mei, W.L., Zuo, W.J., and Zeng, Y.B. (2013). "A new antibacterial phenanthrenequinone from *Dendrobium sinense*." Journal of Asian Natural Products Research **15**: 67-70.

Chen, X. H., Bai, X., Liu,Y. H., *et al.* (2009). "Anti-diabetic effects of water extract and crude polysaccharides from tuberous root of *Liriope spicata* var. *prolifera* in mice." Journal of Ethnopharmacology **122**: 205-209.

Chen, Y., *et al.* (2008c). "Cytotoxic phenolics from *Bulbophyllum odoratissimum*." Food Chemistry **107**: 169-173.

Chen, Y., Li, J., Wang, L., and Liu, Y. (2008). "Aromatic compounds from *Dendrobium aphyllum*." Biochemical Systematics and Ecology **36**: 458-460.

Chen, Y., Li, Y., Qing, C., Zhang, Y., Wang, L., and Liu, Y. (2008b). "1,4,5-Trihydroxy-7-methoxy-9H-fluoren-9-one, a new cytotoxic compound from *Dendrobium chrysotoxum*." Food Chemistry **108**: 973-976.

Chen, Y., Lui., Jiang, J., Zhang, Y., and Yin, B. (2008a). "Dendronone, a new phenanthrenequinone from *Dendrobium cariniferum*." Food Chemistry **111**: 11-12.

Cho, W. C. S., Yip, T. T., Chung, W., et al., (2006). "Altered expression of serum protein in ginsenoside Re-treated diabetic rats detected by SELDI-TOF MS." Journal of Ethnopharmacology **108**: 272-279.

Dewick, P. (2002). "Medicinal Natural Products." John Wiley and Sons Ltd. England.

Encarnacion, D., Nogueiras, CL., Salinas, VHA., Anthoni U., Nielsen PH., and Christophersen C. (1999)."Isolation of Eriodictyol Identical with Huazhongilexone from *Solanum hindisianum*." Acta Chemica Scandinavica **53**: 375-377.

Fan, C., Wang, W., Wang, Y., Qin, G., and Zhao, W. (2001). "Chemical constituents from *Dendrobium densiflorum*." Phytochemistry **57**: 1255-1258.

Fan, W. W., *et al*. (2013). "Dendrowardol C, a novel sesquiterpenoid from *Dendrobium wardianum* Warner." Natural Products and Bioprospecting **3**: 89-92.

Gawell, L., and Leander, K. (1976). "The constitution of aduncin, a sesquiterpene related to picrotoxinin, found in *Dendrobium aduncum*." Phytochemistry **15**: 1991-1992

Guanghua, Z., Zhanhe, J., Wood, H.P. (2009). "*Dendrobium Swartz.*" Flora of China **25**: 367.

Guo, X. Y., Wang, J., Wang, N.L., Kitanaka, S., and Yao, X.S. (2007). "9, 10 Dihydrophenanthrene derivatives from *Pholidota yunnanensis* and scavenging activity on DPPH free radical." Journal of Asian Natural Products Research **9**: 165-174.

Gutierrez, R. M. P. (2010). "A review of uses in traditional medicine, its phytochemistry and pharmacology." Journal of Medicinal Plants Research **4**: 592-638.

He, K., Li, X., Chen, X., *et al.* (2011). "Evaluation of antidiabetic potential of selected traditional Chinese medicines in STZ-induced diabetic mice." Journal of Ethnopharmacology **137**: 1135-1142.

Ho, C. K., and Chen, C.C. (2003). "Moscatilin from the orchid *Dendrobium loddigesii* is a potential anticancer agent." Cancer Investigation **21**: 729-736.

Honda, C., and Yamaki, M. (2000). "Phenanthrenes from *Dendrobium plicatile*." Phytochemistry **53**: 987-990.

Hossain, M. M. (2011). "Therapeutic orchids: traditional uses and recent advances-an overview." Fitoterapia **82**: 102-140.

Hu, J. M., Chen, J.J., Yu, H., Zhao, Y.X, and Zhou, J. (2008a). "Five new compounds from *Dendrobium longicornu*." Planta Medica **74**: 535-539.

Hu, J. M., Chen, J.J., Yu, H., Zhao, Y.X, and Zhou, J. (2008b). "Two novel bibenzyls from *Dendrobium trigonopus*." Journal of Asian Natural Products Research **10**: 647-651.

Hu, J. M., Fan, W., Dong, F., Miao, Z., and Zhou, J. (2012a). "Chemical components of *Dendrobium chrysotoxum*." Chinese Journal of Chemistry **30**: 1327-1330.

Hu, J. M., Zhao, Y.X., Miao, Z.H., and Zhou, J. (2012). "Chemical components of *Dendrobium polyanthum*." Bulletin of the Korean Chemistry Society **30**: 2098-2100.

Hu, W. P., Cao, G.D., Zhu, J.H., Li, J.Z., and Liu, X.H. (2015). "Naturally occurring betatasins and their derivatives as alpha-glucosidase inhibitors." The Royal Society of Chemistry **5**: 82153-82158.

Hwang, J. S., *et al*. (2010). "Phenanthrenes from *Dendrobium nobile* and their inhibition of the LPS-induced production of nitric oxide in macrophage RAW 2647 cells." Bioorganic & Medicinal Chemistry Letters **20**: 3785-3787.

Ito, M., *et al*. (2010). "New phenanthrenes and stilbenes from *Dendrobium loddigesii*." Chemical & Pharmaceutical Bulletin **58**: 628-633.

Klongkumnuankarn, P., *et al*. (2014). "Cytotoxic and Antimigratory Activities of Phenolic Compounds from *Dendrobium brymerianum*." Evidence-Based Complementary and Alternative Medicine **2015**: 1-9.

Kumar, S., Narwal, S., Kumar, V., Prakash, O. (2011). "**α**-glucosidase inhibitors from plants: A natural approach to treat diabetes." Pharmacognosy Review **5**: 15-29.

Kwon, D. Y., Kim, D. S., Yang, H. J., and Park, S. (2011). "The lignan-rich fractions of *Fructus Schisandrae* improve insulin sensitivity via the PPAR-gamma pathways in in vitro and in vivo studies." Journal of Ethnopharmacology **135**: 455-462.

Lee, Y. H., Park, J.D., Baek, N.I., Kim, S.I., and Ahn, B.Z. (1995). "*In vitro* and *in vivo* antitumoral phenanthrenes from the aerial parts of *Dendrobium nobile*." Planta Medica **61**: 178-180.

Li, J. T., Yin, B.L., Liu, Y., Wang, L.Q., and Chen, Y.G. (2009d). "Mono-aromatic constituents of *Dendrobium longicornu*." Chemistry of Natural Compounds **45**: 234-236.

Li, T. H., Hou, C., Chang, C.C. L., andYang, W. C. (2011). "Antihyperglycemic properties of crude extract and triterpenes from *Poria cocos*." Evidence-Based Complementary and Alternative Medicine **2011**: 1-8.

Li, Y., *et al*. (2009a). "Three new bibenzyl derivative from *Dendrobium candidum*." Chemical & Pharmaceutical Bulletin **57**: 218-219.

Li, Y., et al. (2009b). "Four new bibenzyl derivative from *Dendrobium candidum*." Chemical & Pharmaceutical Bulletin **45**: 997-999.

Li, Y., Wang, C.L., Guo, S.X., Yang, J.S., and Xiao, P.G. (2008). "Two new compounds from *Dendrobium candinum*." Chemical & Pharmaceutical Bulletin **56**: 1477-1479.

Li, Y. M., Wang, H.Y., and Liu, G.Q. (2001). "Erianin induces apoptosis in human leukemia HL-60 cells." Acta Pharmacological Sinica **22**: 1018-1022.

Li, Y. P., Qing, C., Fang, T.T., Liu, Y., and Chen, Y.G. (2009c). "Chemical constituents of *Dendrobium chrysotoxum*." Chemistry of Natural Compounds **45**: 414-416.

Liu, M., Wu, K., Mao X.,Wu, Y., and Ouyang, J. (2010). "Astragalus polysaccharide improves insulin sensitivity in KKAy mice: regulation of PKB/GLUT4 signaling in skeletal muscle." Journal of Ethnopharmacology **127**: 32-37.

Liu, Y., Jiang, J.H., Zhang, Y., and Chen, Y.G. (2009). "Chemical constituents of *Dendrobium auranticum* var *denneanum*." Chemistry of Natural Compounds **45**: 525-527.

Liu., R. Y., Wang, G.Q. (1996). "A survey on drugs synthesized for antidiabetes " Journal of Shenyang Pharmaceutical University **13**: 148-153.

Lu, Y., Kuang, M., Hu, G.P., Wu, R.B., Wang, J., Liu, L. and Lin, Y.C. (2014). "Loddigesiinols G–J: a-glucosidase inhibitors from *Dendrobium loddigesii*." Molecules **19**: 8544-8555.

Ma, G. X., Wang, T.S., L., Pan, Y., Xu, G.J., and Xu, L.S. (1998). "Studies on chemical constituents of *Dendrobium chryseum*." Journal of Chinese Pharmaceutical Science **7**: 52-54.

Majumder, P. L., and Banerjee, S. (1990a). "Two stibenoids from the orchid *Eria flava*." Phytochemistry **29**: 3052-3055.

Majumder, P. L., and Banerjee, S. (1993). "Cumulatin and tristin, two bibenzyl derivatives from the orchids *Dendrobium cumulatum* and *Bulbophyllum triste*." Phytochemistry **32**: 1561-1565.

Majumder, P. L., and Chatterjee, S. (1989). "Crepidatin, a bibenzyl derivative from the orchid *Dendrobium crepidatum*." Phytochemistry **28**: 1986-1988.

Majumder, P. L., and Lahiri, S. (1990b). "Lusianthrin and lusianthridin, two stilbenoids from the orchid *Lusia indivisa*." Phytochemistry **29**: 621-624.

Majumder, P. L., and Pal, S. (1992). "Rotundatin, a new 9,10-dihydrophenanthrene derivative from *Dendrobium rotundatum*." Phytochemistry **31**: 3225-3228.

Majumder, P. L., and Sen, R.C. (1987). "Moscatilin, a bibenzyl derivative from the orchid *Dendrobium moscatum*." Phytochemistry **26**: 2121-2124.

Majumder, P. L., Guha, S., and Sen, S (1999). "Bibenzyl derivatives from the orchid *Dendrobium amoenum*." Phytochemistry **52**: 1365-1369.

Ono, M., Ito, Y., Masuoka, C., Koga, H., and Nohara, T. (1995). "Antioxidative constituents from Dendrobii Herba (Stems of *Dendrobium* spp.)." Food Science Technology International **2**: 115-120.

Pan, H., Chen, B., Li, F., and Wang, M. (2012). "Chemical constituents of *Dendrobium denneanum*." Chinese Journal Application Environmental Biology **18**: 378-380.

Patel, D. K., Kumar, R., Laloo, D., Hemalatha, S. (2012). "Diabetes mellitus: An overview on its pharmacological aspects and reported medicinal plants having antidiabetic activity." Asian Pacific Journal of Tropical Biomedicine **2**: 411-420.

Phechrmeekha, T., Sritularak, B., and Likhitwitayawuid, K. (2012). "New phenolic compounds from *Dendrobium capillipes and Dendrobium secundum*." Journal of Asian Natural Products Research **14**: 748-754.

Qin, X. D., Qu, Y., Ning, L., Liu, J.K., and Fan, S.K. (2011). "A new picrotoxane-type sesquiterpene from *Dendrobium findlayanum*." Journal of Asian Natural Products Research **13**: 1047-1050.

Raman, B., Naga Vamsim Krishna A., Narasimha Rao B., Pardha Saradhi M., and Basaveswara Rao M. (2012). "Plant with the antidiabetic activities and their medicinal values." International Research Journal of Pharmacy. **3**: 11-15.

Smitinand, T. (2001). "Thai plant names (Botanical names-vernacular names). Revised edition. Bangkok: The Forest Herbarium, Royal Forest Department ".

Sritularak, B., and Likhitwitayawuid, K. (2009). "New bibenzyls from *Dendrobium falconeri*." Helvetica Chimica Acta **92**: 740-744.

Sritularak, B., Anuwat, M., and Likhitwitayawuid, K. (2011a). "A new phenanthrenequinone from *Dendrobium draconis*." Journal of Asian Natural Products Research **13**: 251-255.

Sritularak, B., Duangrak, N., and Likhitwitayawuid, K. (2011b). "A new bibenzyl from *Dendrobium secundum*." Zeitschrift Naturforschung **66**: 205-208.

Sun, J., Zhang, F., Yang, M., Zhang, J., Chen, L., Zhan, R., Li, L., Chen, Y. (2014). "Isolation of alpha-glucosidase inhibitors including a new flavonol glycoside from *Dendrobium devonianum*." Natural Product Research **28**: 1900-1905.

Tanagornmeatar K, Sritularak B, Likhitwitayawuid K, Chanvorachote P (2014). "Cytotoxic and anti-metastatic activities of phenolic compounds from *Dendrobium ellipsophyllum*." Anticancer Research **34**: 6573-6579.

Tarapatra, B., Das, A.K., and Tarapatra, S.K. (1989). "Defuscin, a new phenolic ester from *Dendrobium fuscescens*: conformation of shikimic acid." Phytochemistry **28**: 290-292.

Tarapatra, S. K., Rose, S., and Mallik, A.K. (1994). "A new fluorenone derivative from *Dendrobium densiforum*." Journal of Indian Chemistry Society **61**: 1010-1012.

Veerraju, P., Rao, N.S.P., Rao, L.J., Rao, K.V.J., and Rao, P.R.M. (1989). "Amoenumin, a 9,10-dihydro-*5H*-phenanthro-(4,5-*b,c,d*)-pyran from *Dendrobium amoenum*." Phytochemistry **28**: 950-951.

Wang, H., Zhao, T., and Che, C.T. (1985). "Dendrobine and 3-hydroxy-2-oxodendrobine from *Dendrobium nobile*." Journal of Natural Products **48**: 796-801.

Wang, L., Zhang, C.F., Wang, Z.T., Zhang, M., and Xu, L.S. (2009). "Five new compounds from *Dendrobium crystallinum* " Journal of Asian Natural Products Research **11**: 903-911.

Wu, S., Wang, G., Liu, Z., *et al*. (2009). "Effect of geniposide, a hypoglycemic glucoside, on hepatic regulating enzymes in diabetic mice induced by a high-fat diet and streptozotoci." Acta Pharmacologica Sinica **30**: 202-208.

Xiong, L., *et al.* (2013). "Phenolic glucosides from *Dendrobium auranticum* var. denneanum and their bioactivities." Molecules **18**: 6154-6160.

Yamaki, M., and Honda, C. (1996). "The stilbenoids from *Dendrobium plicatile*." Phytochemistry **43**: 207-208.

Yang, H., Sung, S.H., and Kim, Y.C. (2007). "Antifibrotic phenanthrene of *Dendrobium nobile* stems." Journal of Natural Products **70**: 1925-1929.

Yang, L., *et al*. (2006b). "A new phenanthrene with a spirolactone from *Dendrobium chrysanthum* and its anti-inflammatory activities." Bioorganic & Medicinal Chemistry **14**: 3496-3501.

Yang, Y., Wang, Z., and Xu, L. (2006a). "Phenols and a triterpene from *Dendrobium auranticum* var. *denneanum* (Orchidaceae)." Biochemical Systematics and Ecology **34**: 658-660.

Ye, Q., and Zhao, W. (2002). "Immunomodulatory sesquiterpene glycosides from *Dendrobium nobile*." Phytochemistry **61**: 885-890.

Ye, Q., Qin, G., and Zhao, W. (2002a). "New alloaromadendrane, cadinene and cyclocopacamphene type sesquiterpene derivatives and bibenzyl from *Dendrobium nobile*." Planta Medica **68**: 723-729.

Ye, Q. H., Zhao. W.M., and Qin, G.W. (2002b). "New fluorenone and phenanthrene derivatives from *Dendrobium chrysanthum*." Natural Product Research **17**: 201-205.

Ye, Q. H., Zhao. W.M., and Qin, G.W. (2004). "Lignans from *Dendrobium chrysanthum*." Journal of Asian Natural Products Research **6**: 39-43.

Zhang, C. F., *et al.* (2008a). "Chemical constituents from *Dendrobium gratiosissimum* and their cytotoxic activities." Indian Journal of Chemistry **47B**: 952-956.

Zhang, G. N., *et al.* (2005). "B-bicyclic and bitricyclic compounds from *Dendrobium thyrsiflorum*." Phytochemistry **66**: 1113-1120.

Zhang, X., *et al.* (2007a). "Bioactive bibenzyl derivatives and fluorenones from *Dendrobium nobile*." Journal of Natural Products **70**: 24-28.

Zhang, X., *et al.* (2007b). "Sesquiterpenes from *Dendrobium nobile*." Zhongcaoyao **38**: 1771-1774.

Zhang, X., *et al.* (2008c). "Copacamphane, picrotoxane, and cyclopicrocamphane sesquiterpenes from *Dendrobium nobile*." Chemical & Pharmaceutical Bulletin **56**: 854-857.

Zhang, X., Gao, H., Wang, N.L., and Yao, X.S. (2006). "Three new bibenzyl derivatives from *Dendrobium nobile*." Journal of Asian Natural Products Research **8**: 113-118.

Zhang, X., Xu, J.K., Wang, N.L., Kurihara, H., and Yao, X.S. (2008b). "Antioxidant phenanthrenes and lignans from *Dendrobium nobile*." Journal of Chinese Pharmaceutical Science **17**: 314-318.

Zhao, C., *et al.* (2003). "Copacamphane, picrotoxane, and alloaromadendrane sesquiterphene glycosides and phenolic glycosides from *Dendrobium moniliforme*." Journal of Natural Products **66**: 1140-1143.

Zhao, S. Y. (1999). "Drugs to treat diabetes." Guowai Yiyao-Hechengyao, Shenghuayao, Zhiji **20**: 130-135.

Zhao, W., *et al.* (2001). "Three new sesquiterpene glycosides from *Dendrobium nobile* with immunomodulatory activity." Journal of Natural Products **64**: 1196-1200.

APPENDIX

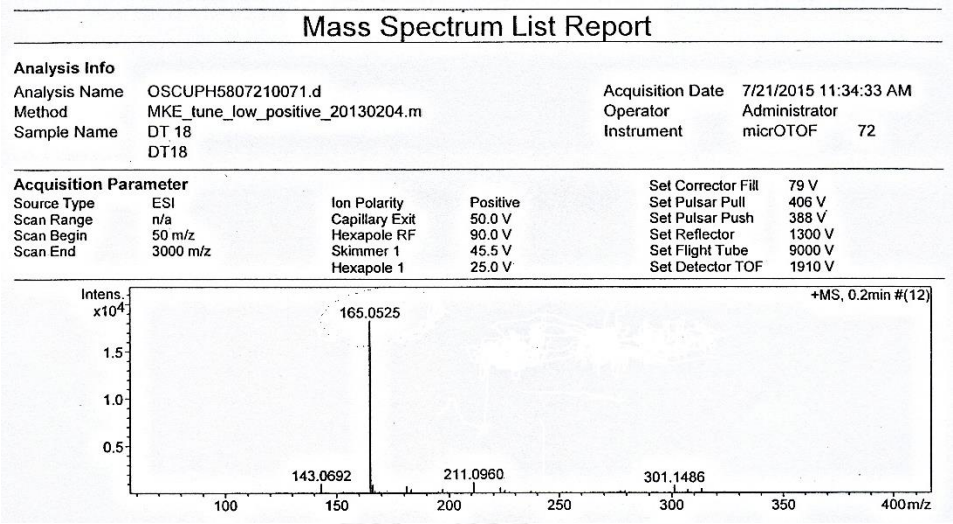


Figure 3 Mass spectrum of compound DT1

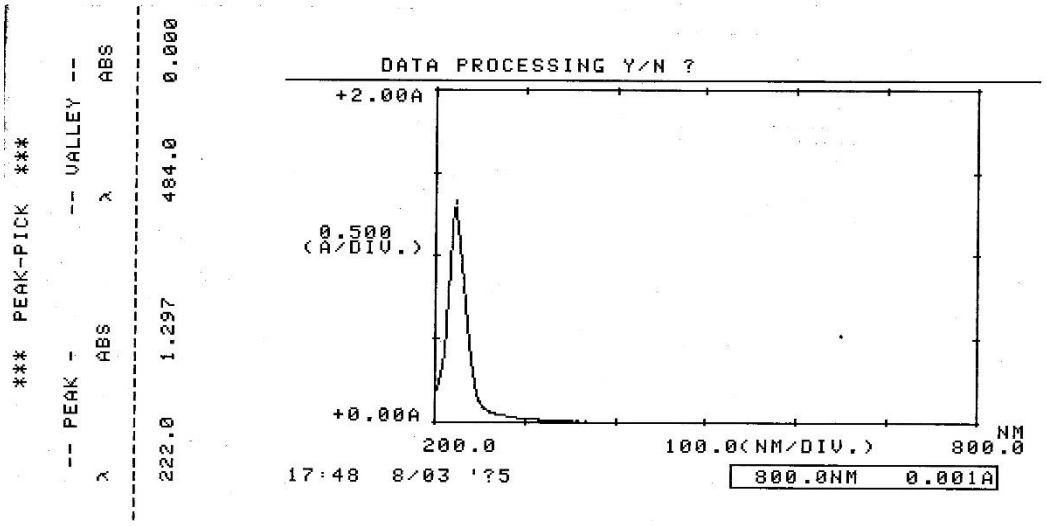


Figure 4 UV spectrum of compound DT1 (methanol)

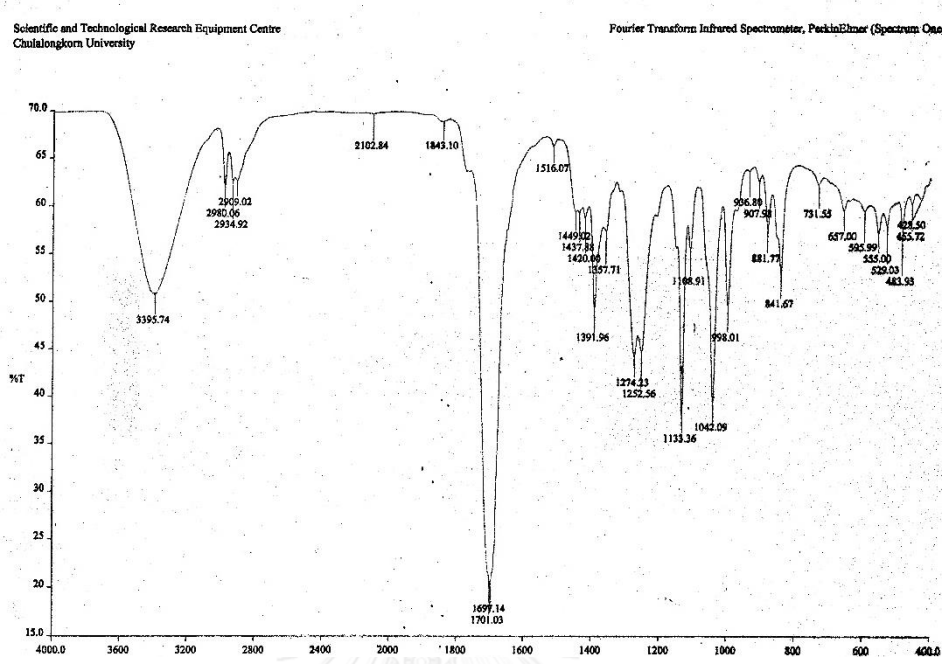
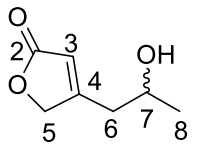


Figure 5 IR spectrum of compound DT1



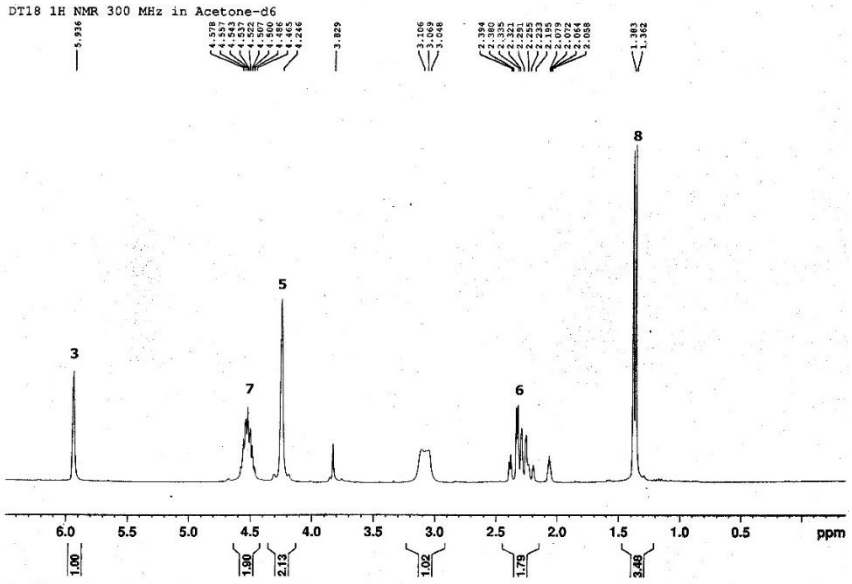


Figure 6 ^{1}H-NMR (300 MHz) spectrum of compound (acetone-d_6)

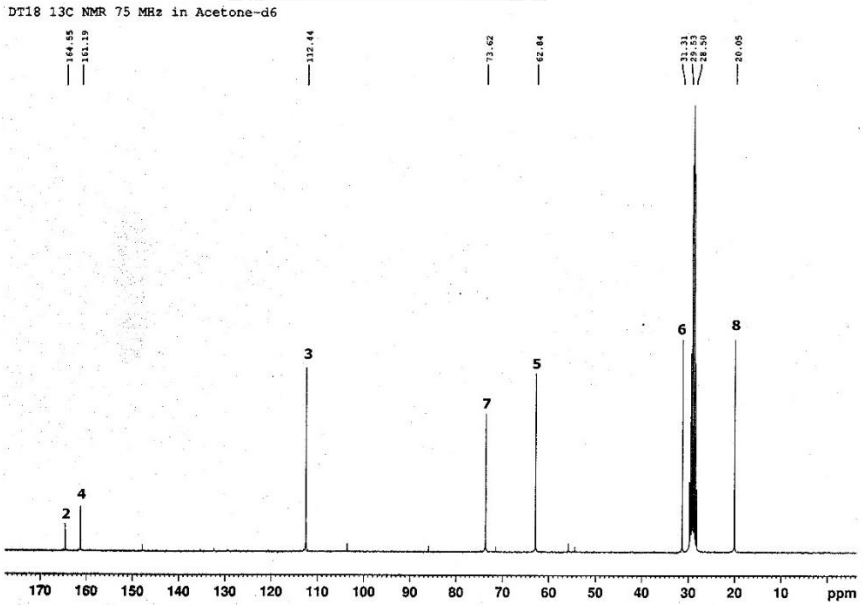
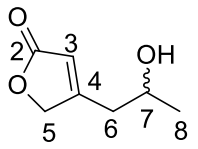


Figure 7 ^{13}C-NMR (75 MHz) spectrum of compound DT1 (acetone-d_6)



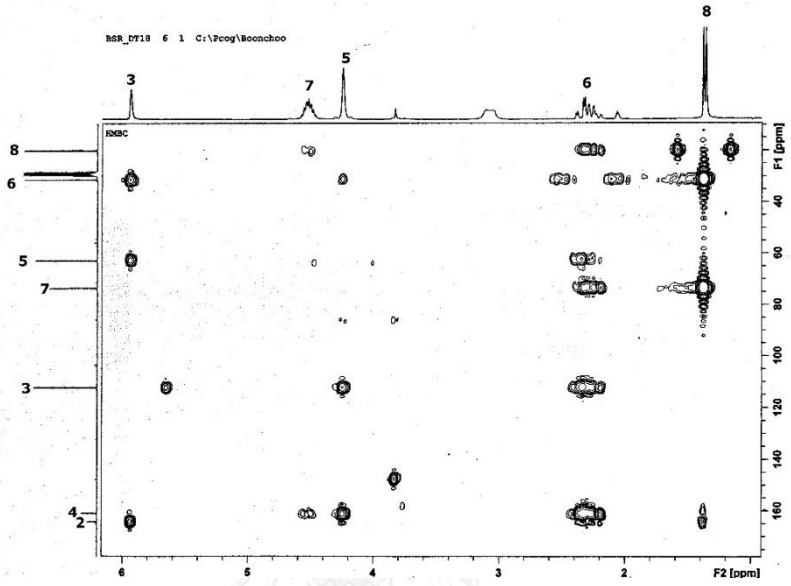


Figure 8 HMBC spectrum of compound DT1 (acetone-d_6)

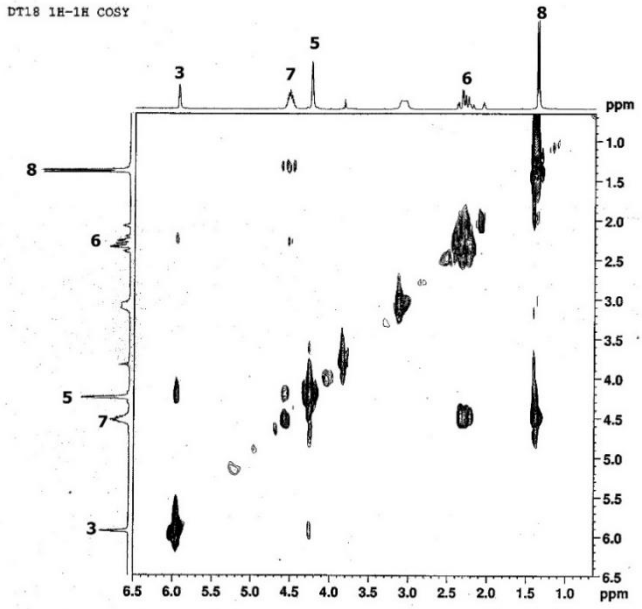
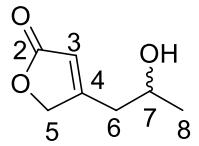


Figure 9 ^{1}H-^{1}H COSY spectrum of compound DT1 (acetone-d_6)



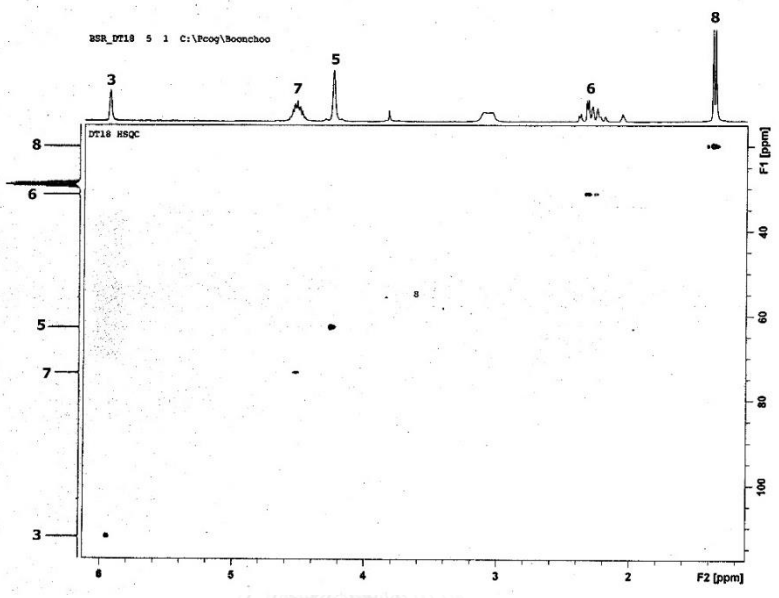


Figure 10 HSQC spectrum of compound DT1 (acetone-d_6)

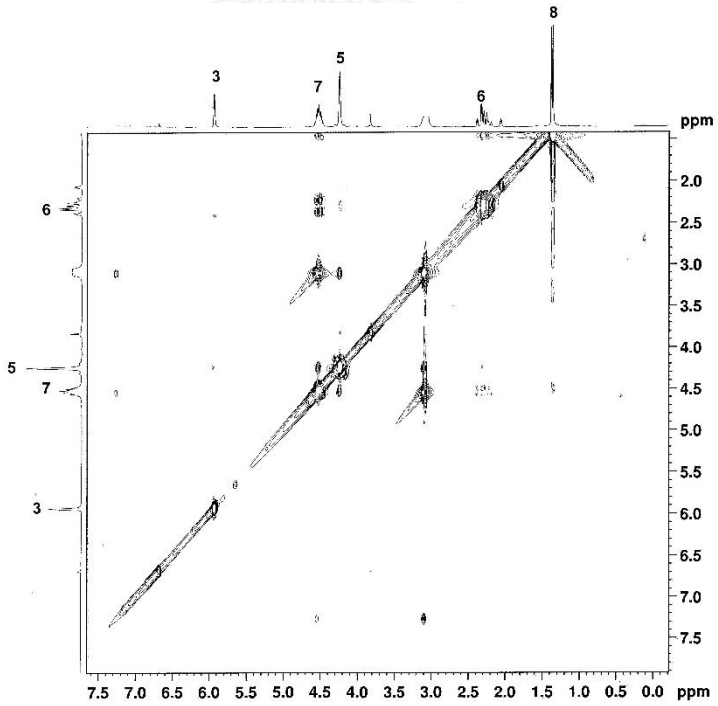


Figure 11 NOESY spectrum of compound DT1 (acetone-d_6)

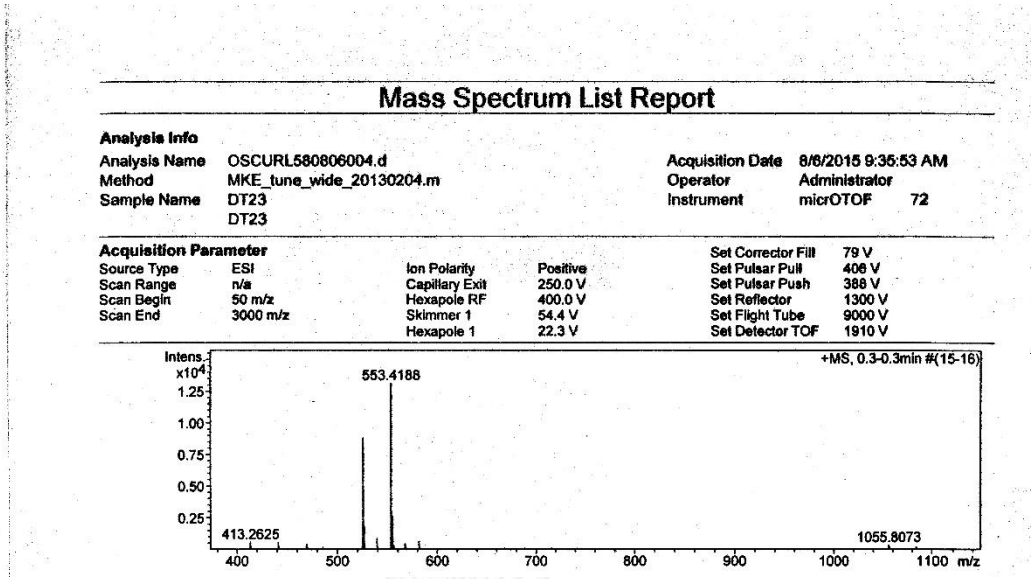
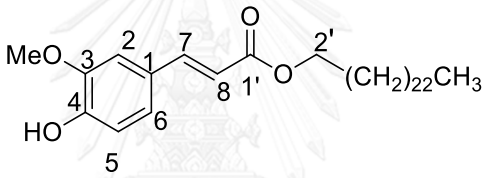


Figure 12 Mass spectrum of compound DT2



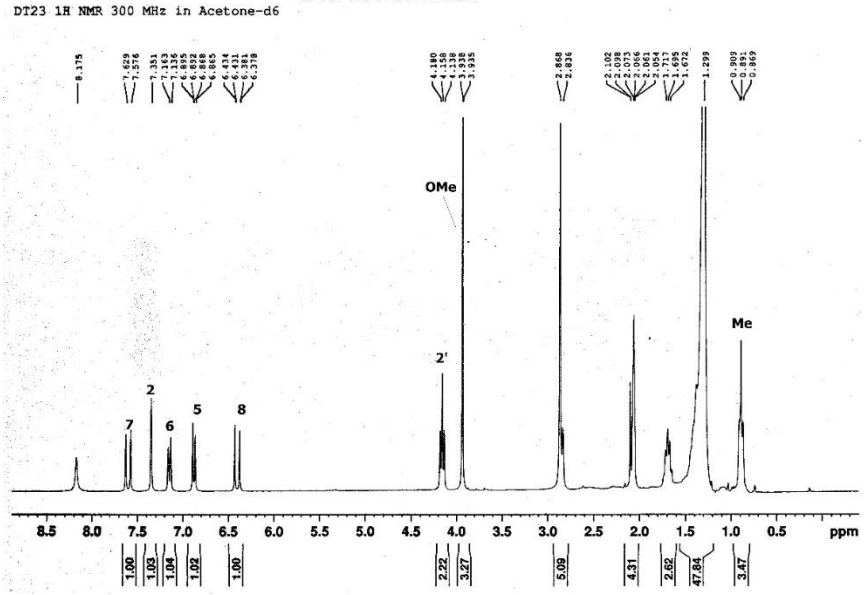
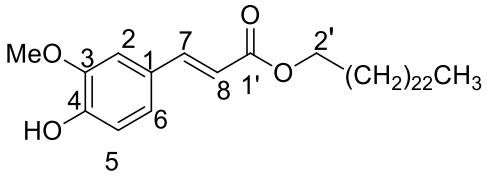


Figure 13 ^{1}H-NMR (300 MHz) spectrum of compound DT2 (acetone-d_6)



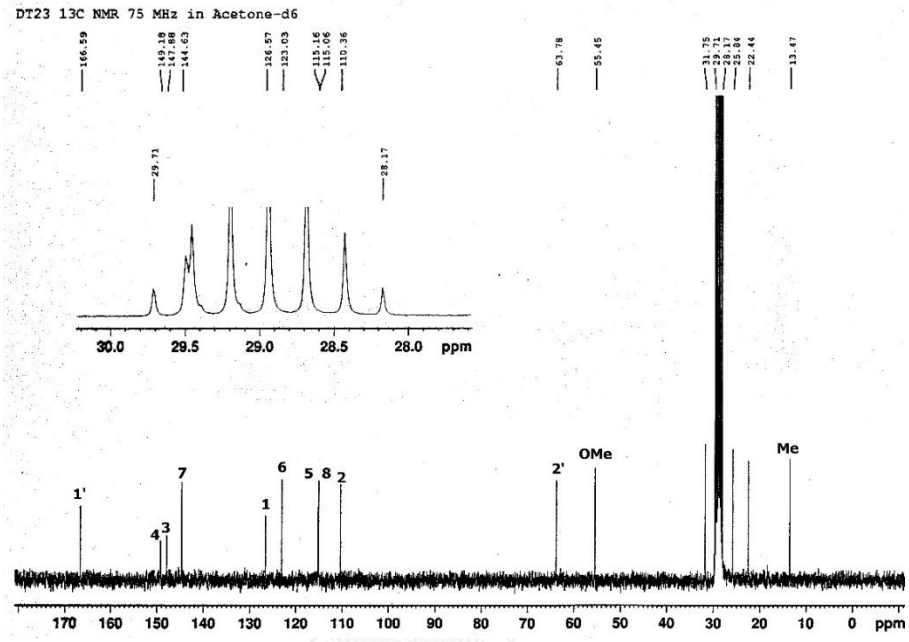


Figure 14 ^{13}C-NMR (75 MHz) spectrum of compound DT2 (acetone-d_6)

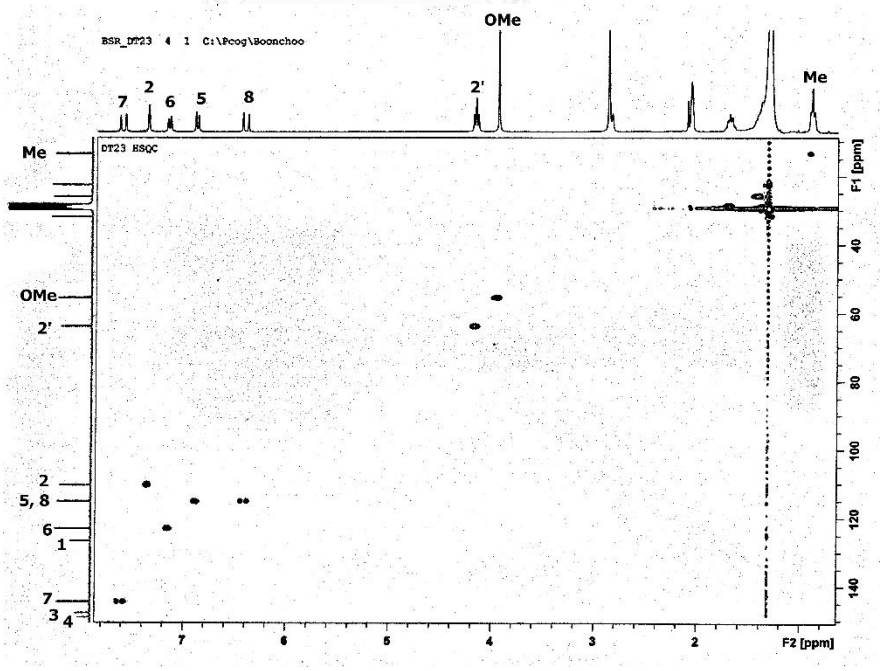
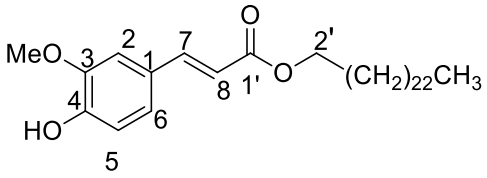


Figure 15 HSQC spectrum of compound DT2 (acetone-d_6)



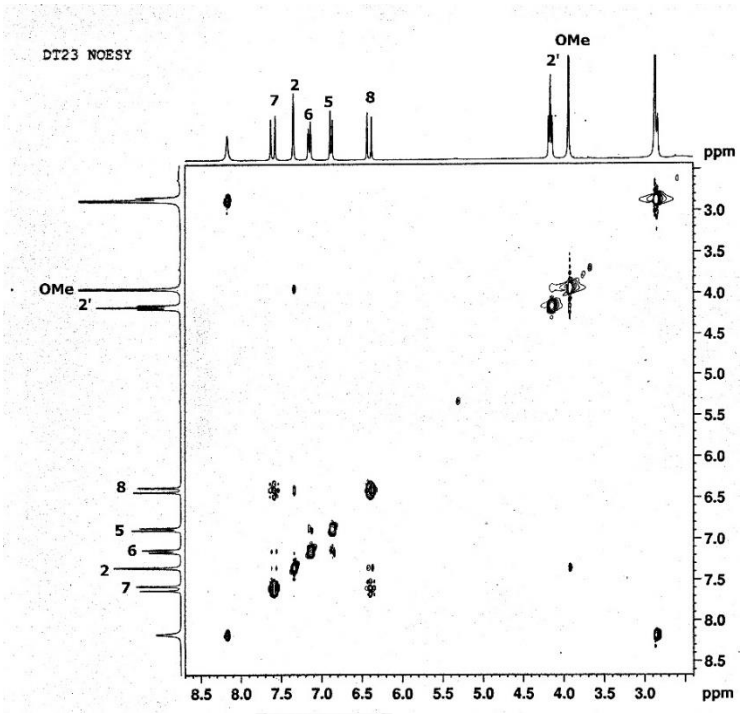


Figure 16 NOESY spectrum of compound DT2 (acetone-d_6)

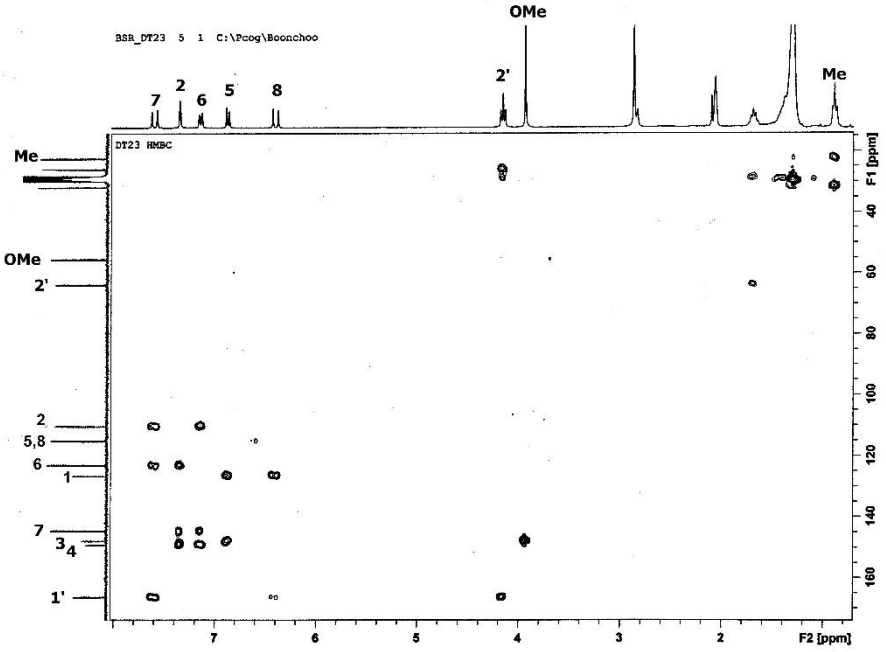


Figure 17 HMBC spectrum of compound DT2 (acetone-d_6)

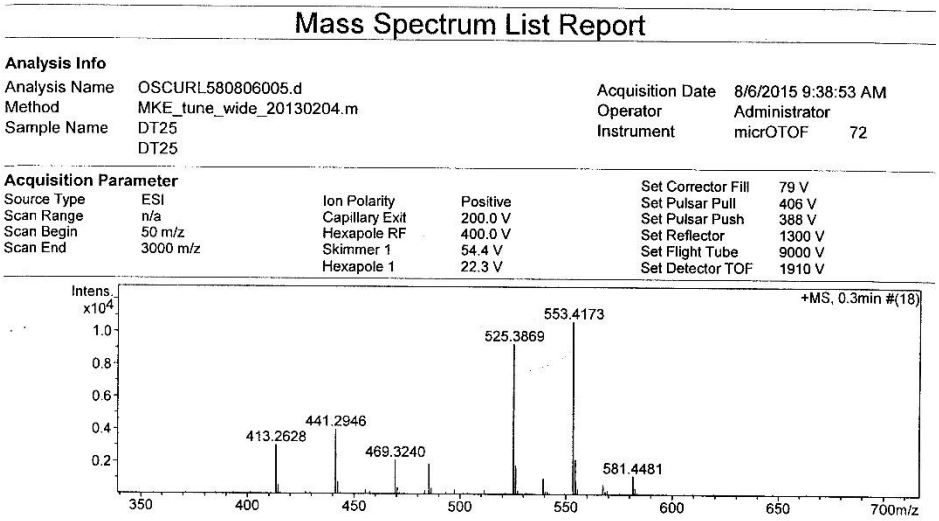
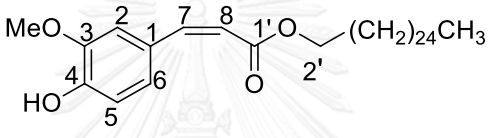


Figure 18 Mass spectrum of compound DT3



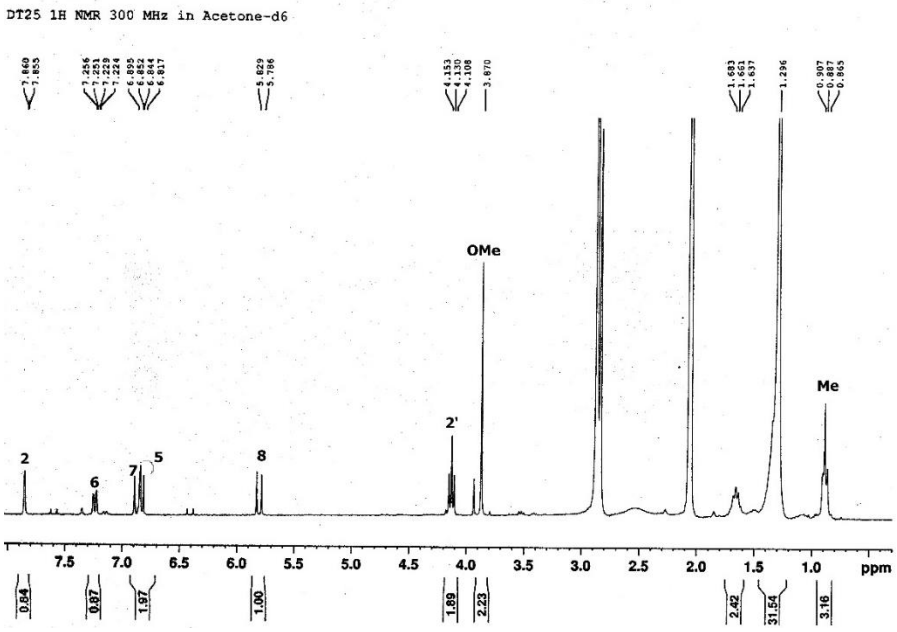
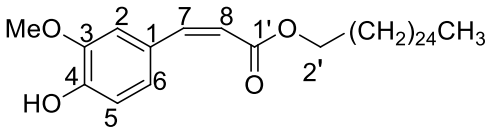


Figure 19 ^{1}H-NMR (300 MHz) spectrum of compound DT3 (acetone-d_6)



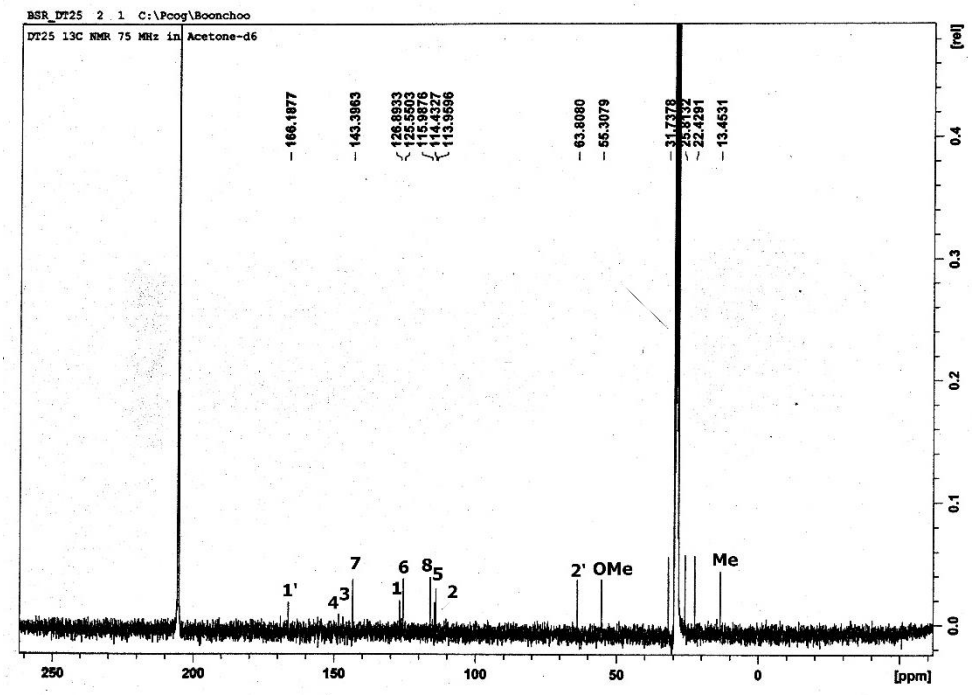


Figure 20 ^{13}C-NMR (75 MHz) of compound DT3 (acetone-d_6)

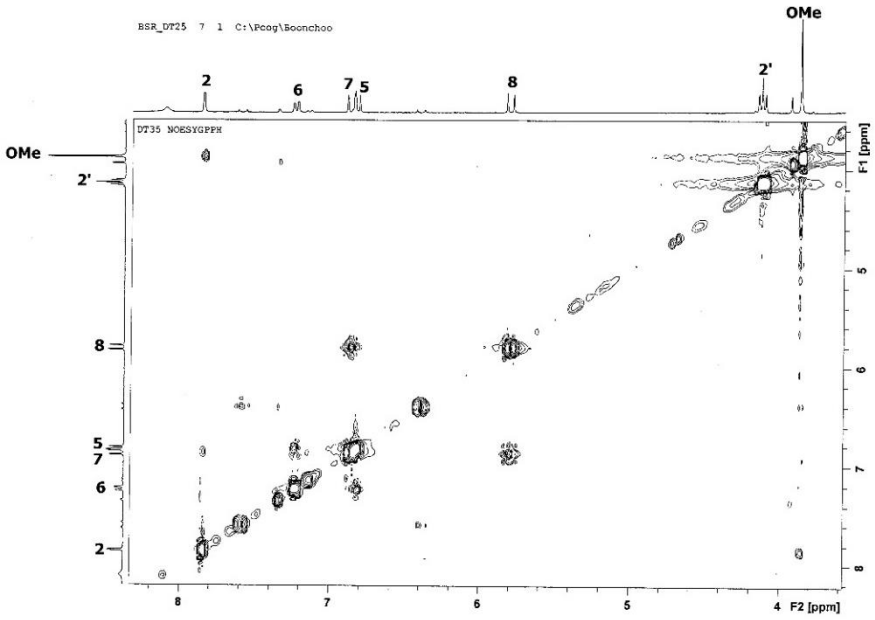


Figure 21 NOESY spectrum of compound DT3 (acetone-d_6)

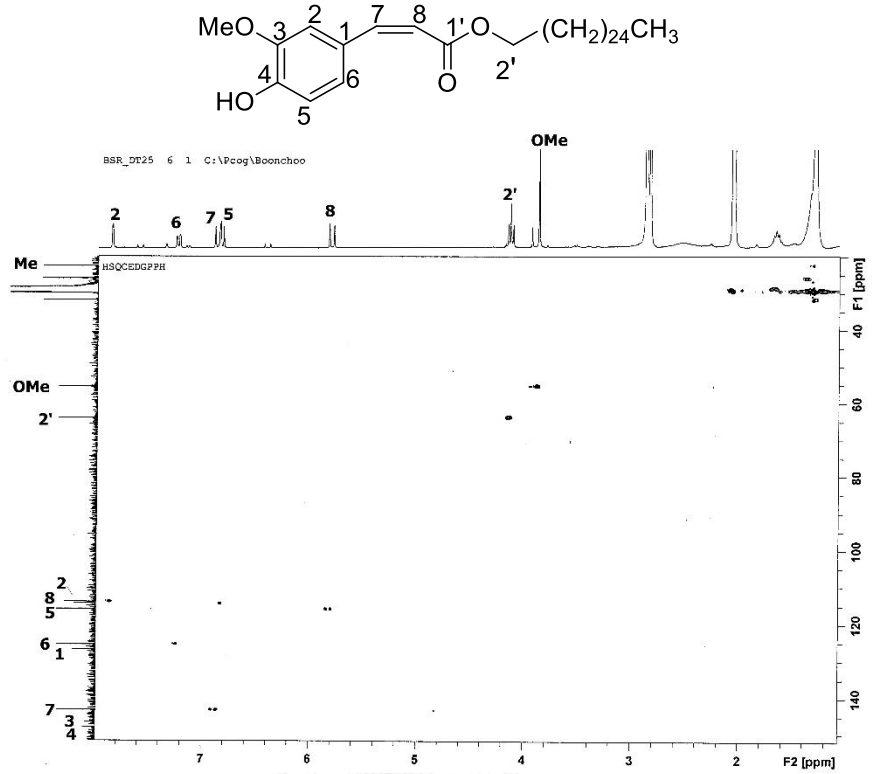


Figure 22 HSQC spectrum of compound DT3 (acetone-d_6)

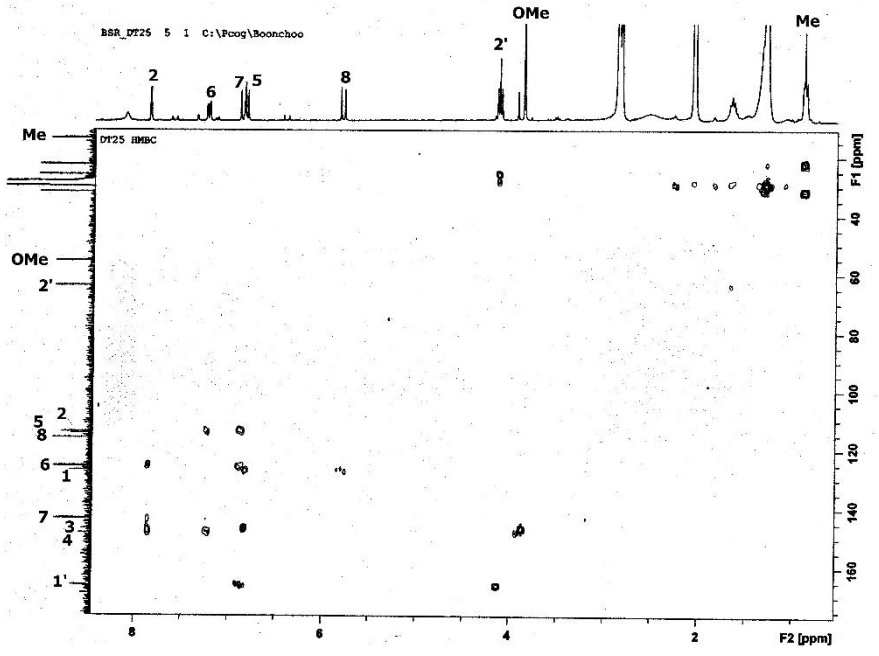


Figure 23 HMBC spectrum of compound DT3 (acetone-d_6)

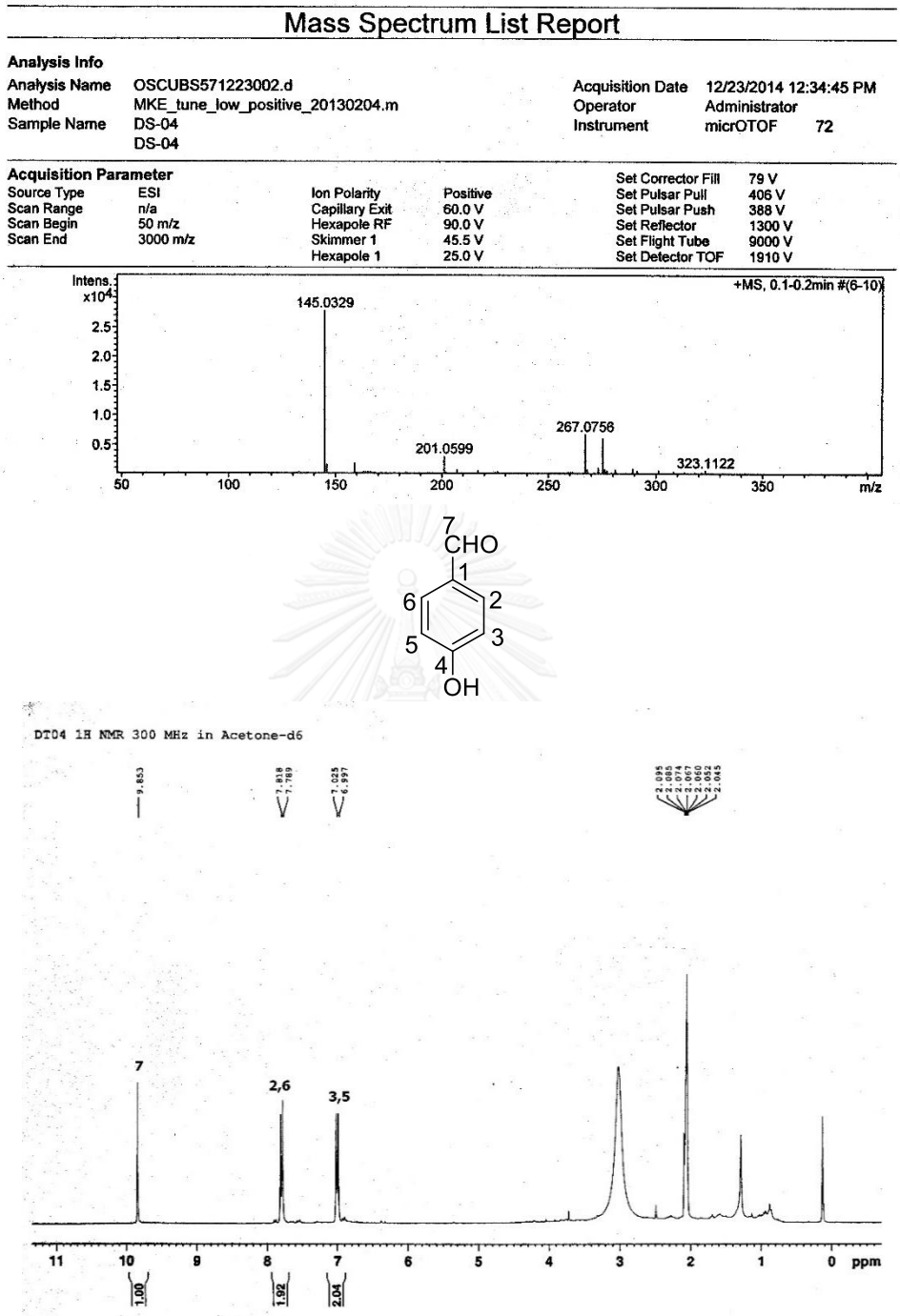


Figure 25 ^{1}H-NMR (300 MHz) spectrum of compound DT4 (acetone-d_6)

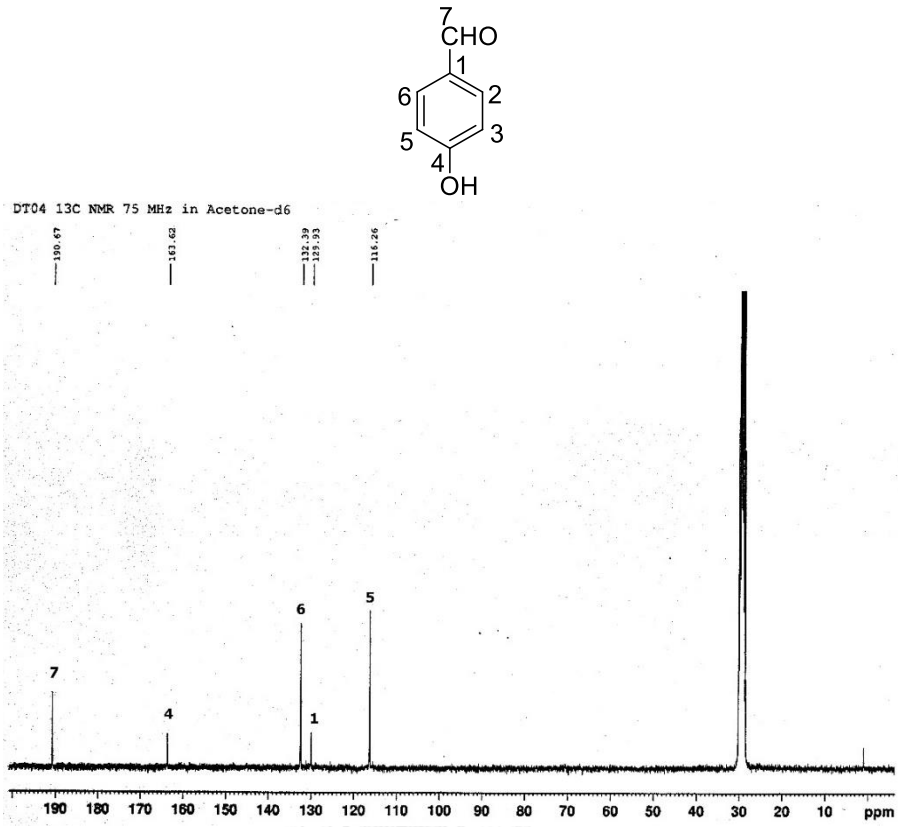


Figure 26 ^{13}C-NMR (75 MHz) spectrum of compound DT4 (acetone-d_6)

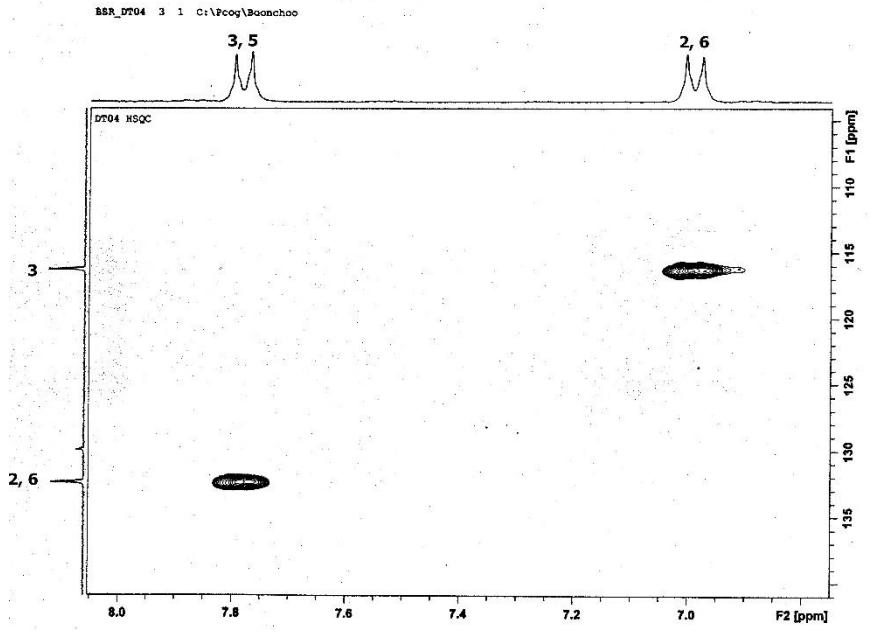
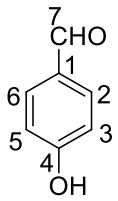


Figure 27 HSQC spectrum of compound DT4 (acetone-d_6)



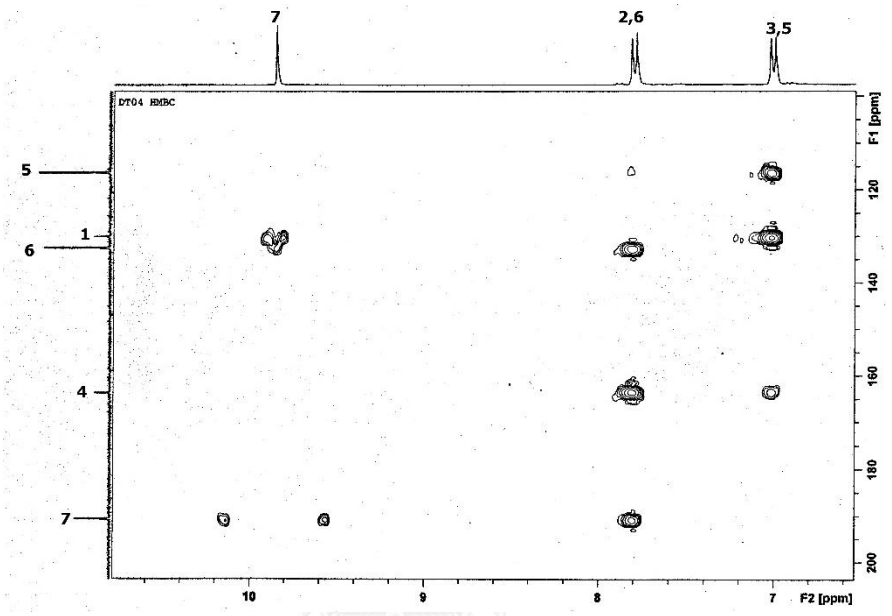


Figure 28 HMBC spectrum of compound DT4 (acetone-d_6)

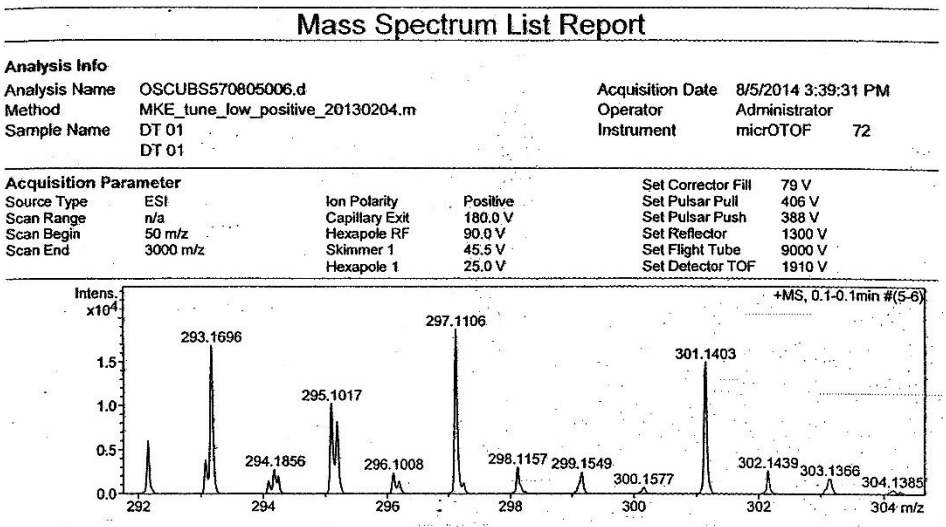
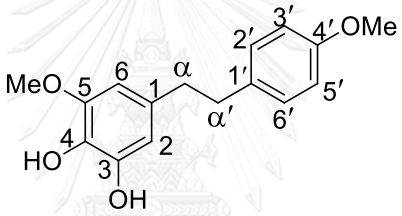


Figure 29 Mass spectrum of compound DT5



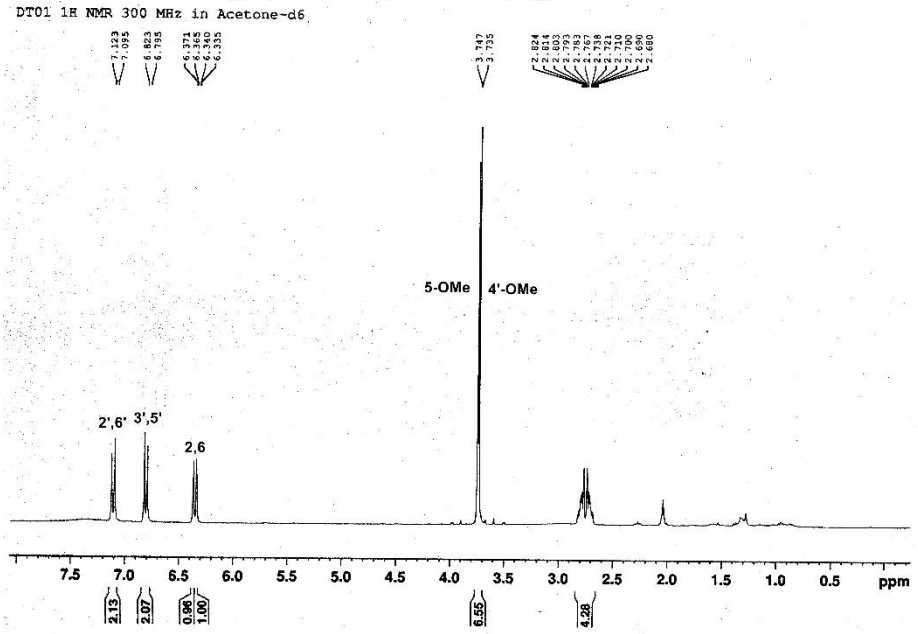


Figure 30 ^{1}H-NMR (300 MHz) spectrum of compound DT5 (acetone-d_6)

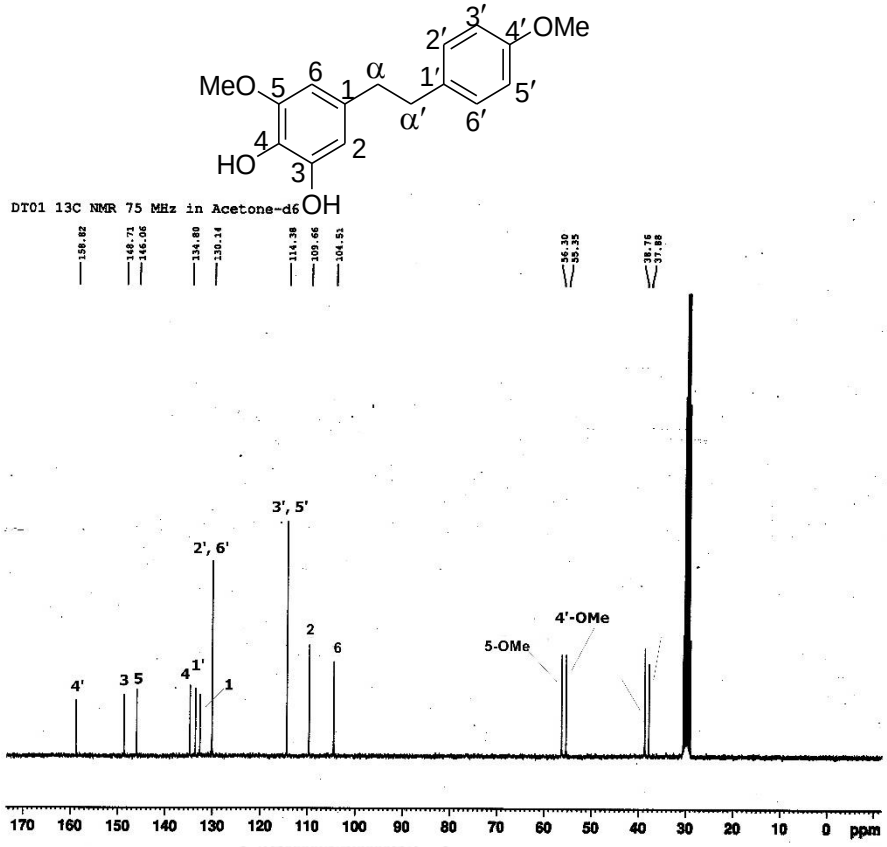


Figure 31 ^{13}C-NMR (75 MHz) spectrum of compound DT5 (acetone-d_6)

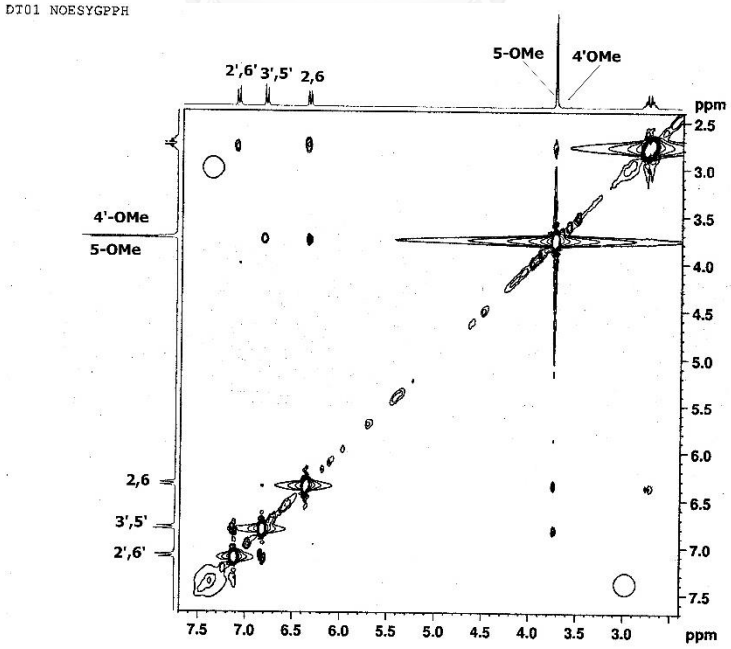
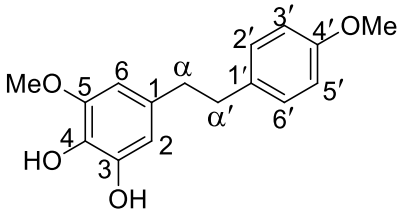


Figure 32 NOESY spectrum of compound DT5 (acetone-d_6)



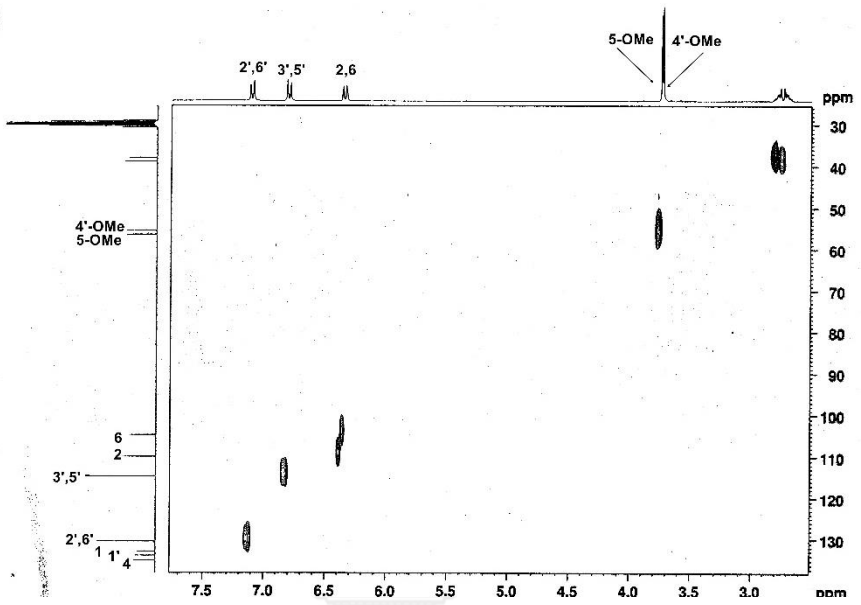


Figure 33 HSQC spectrum of compound DT5 (acetone-d_6)

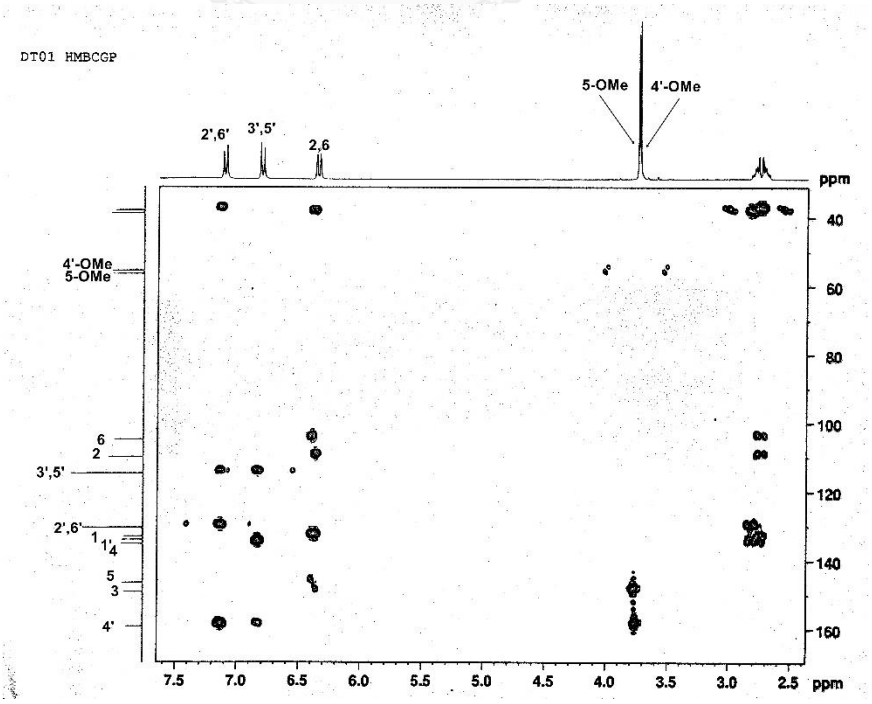


Figure 34 HMBC spectrum of compound DT5 (acetone-d_6)

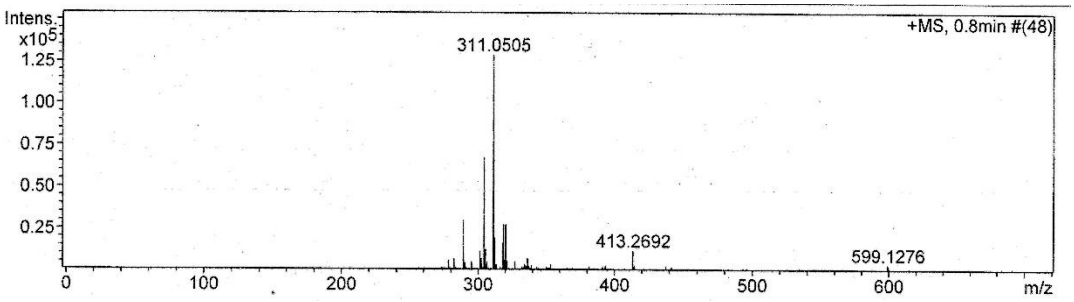
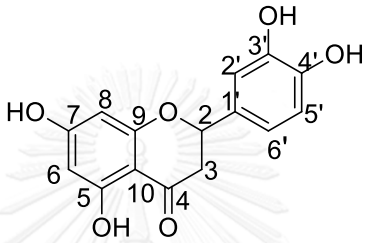


Figure 35 Mass spectrum of compound DT6



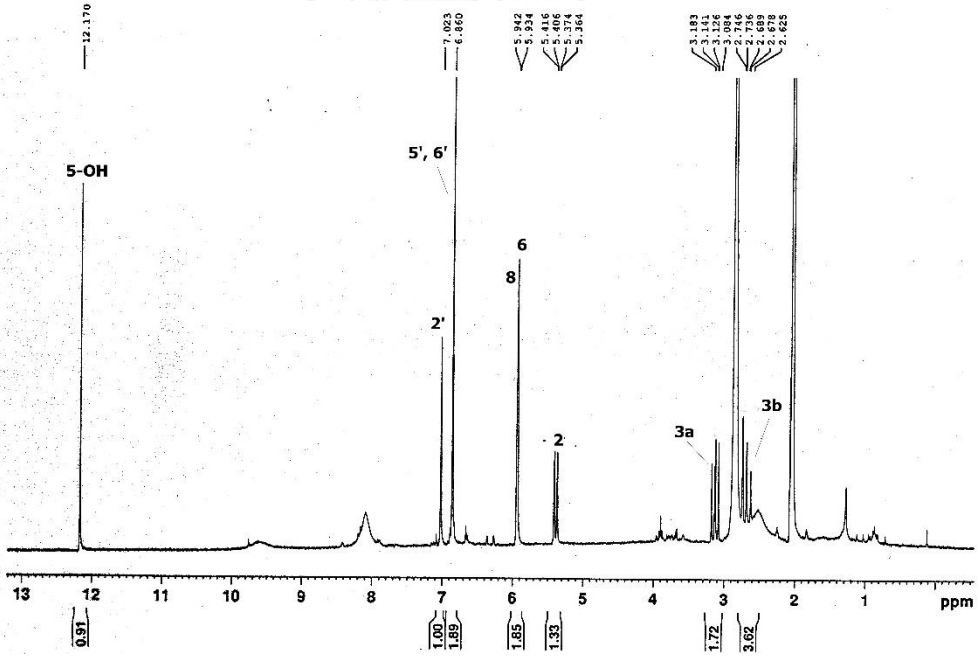


Figure 36 ^{1}H-NMR (300 MHz) spectrum of compound DT6 (acetone-d_6)

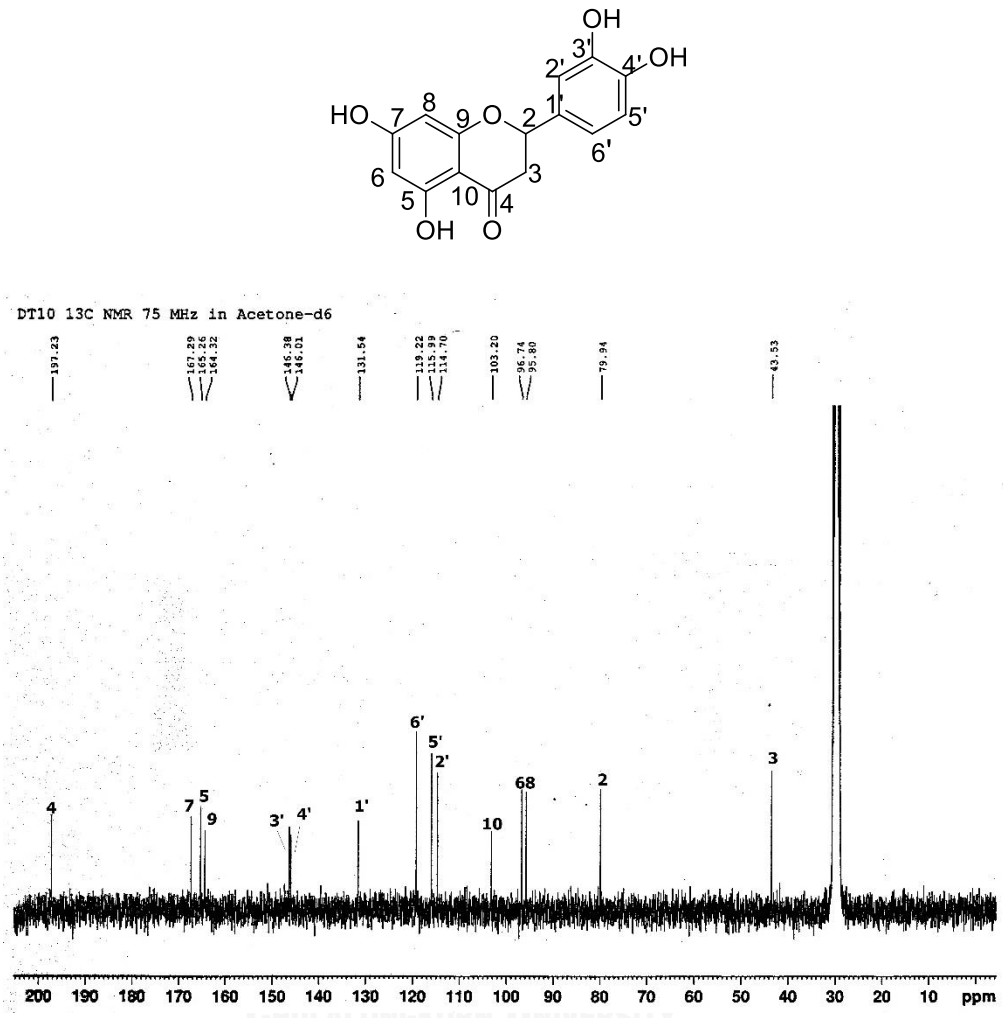


Figure 37 ^{13}C-NMR (75 MHz) spectrum of compound DT6 (acetone-d_6)

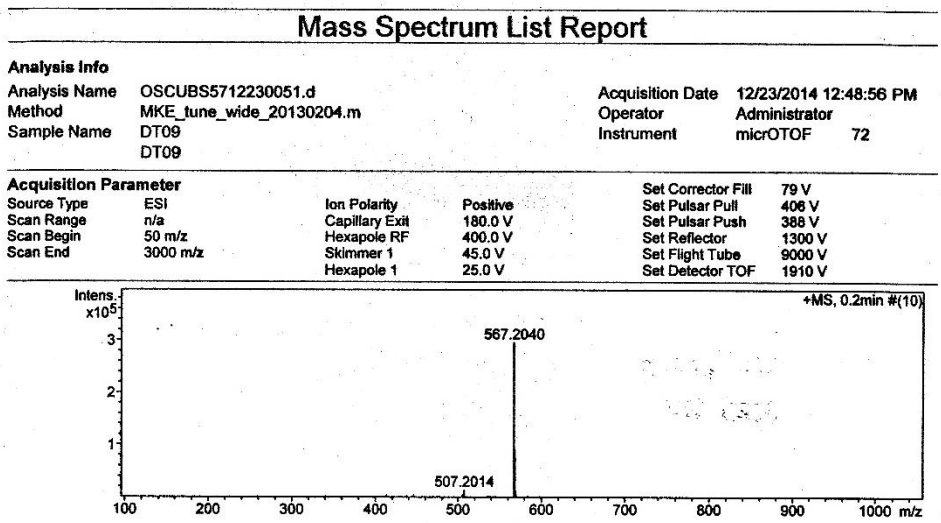
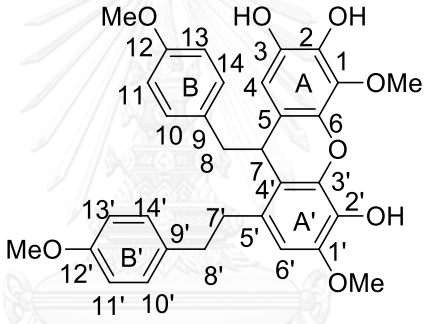


Figure 38 Mass spectrum of compound DT7



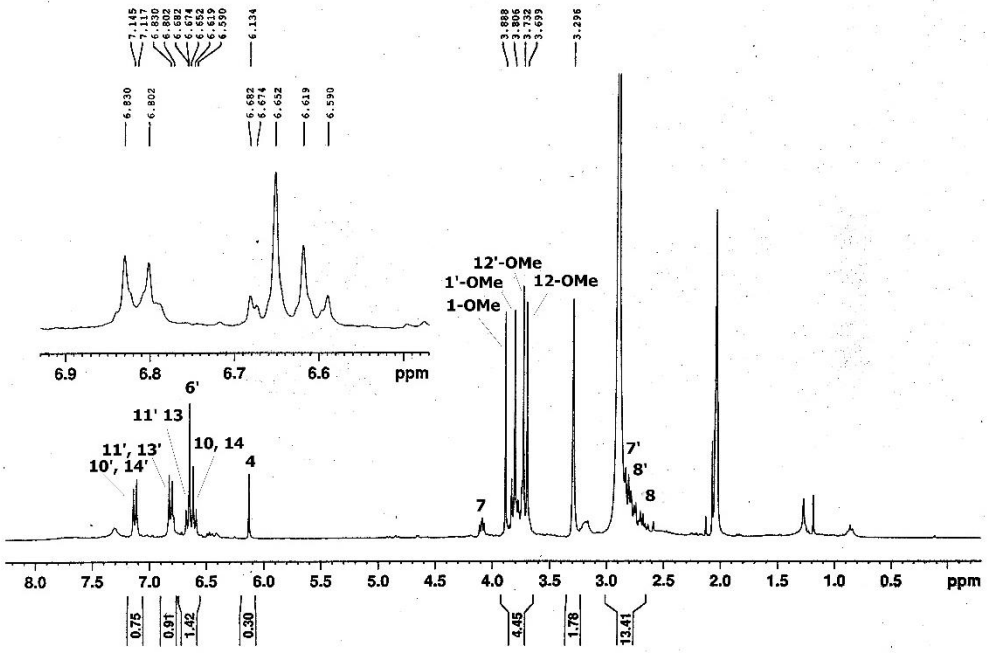
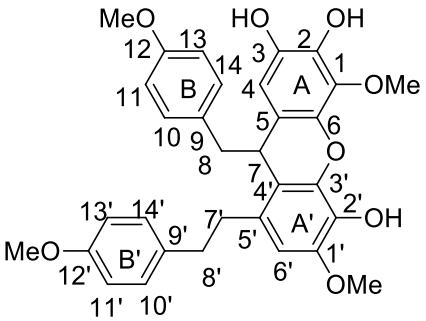


Figure 39 ^{1}H-NMR (300 MHz) spectrum of compound DT7 (acetone-d_6)



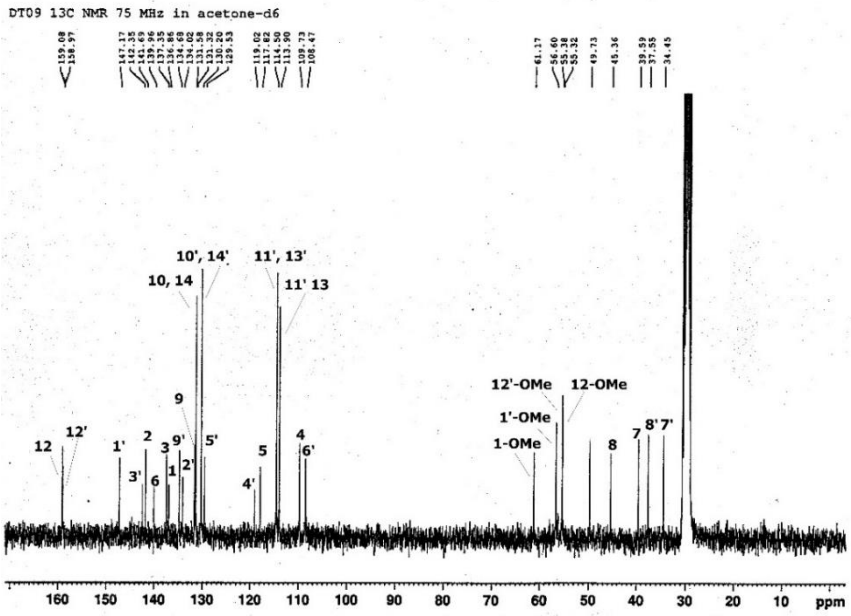


Figure 40 ^{13}C-NMR (75 MHz) spectrum of compound DT7 (acetone-d_6)

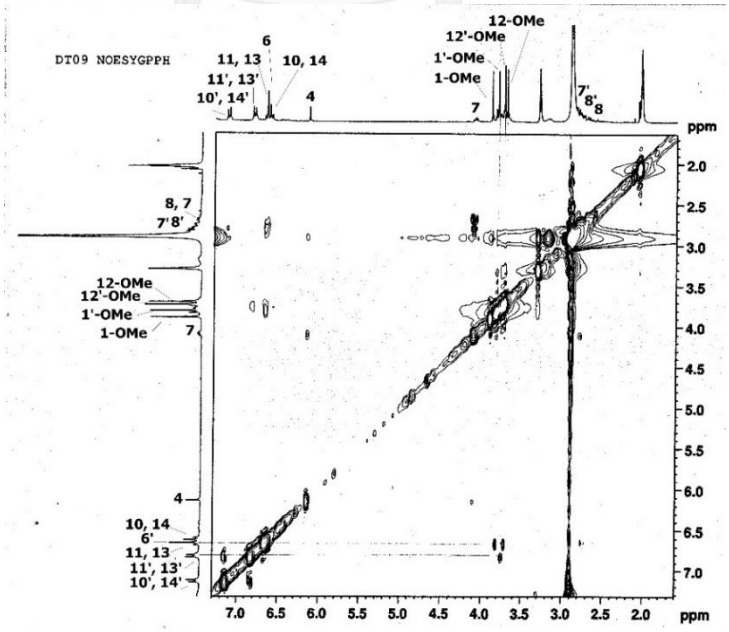
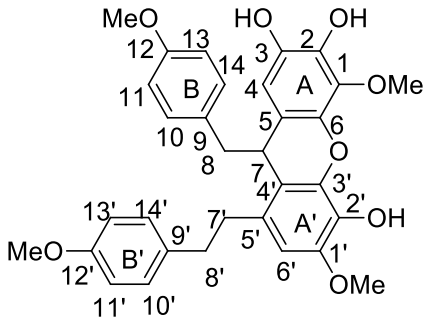


Figure 41 NOESY spectrum of compound DT7 (acetone-d_6)



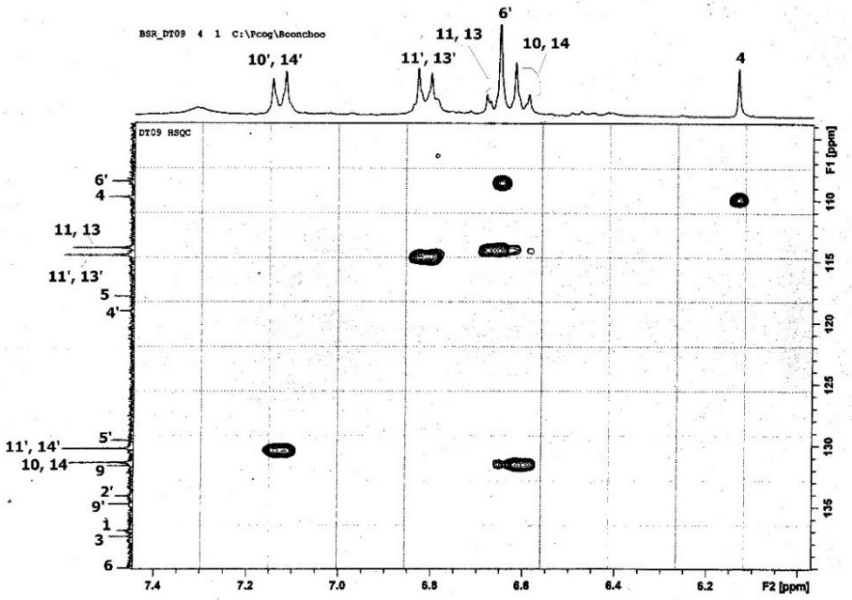


Figure 42 HSQC spectrum of compound DT7 (acetone-d_6)

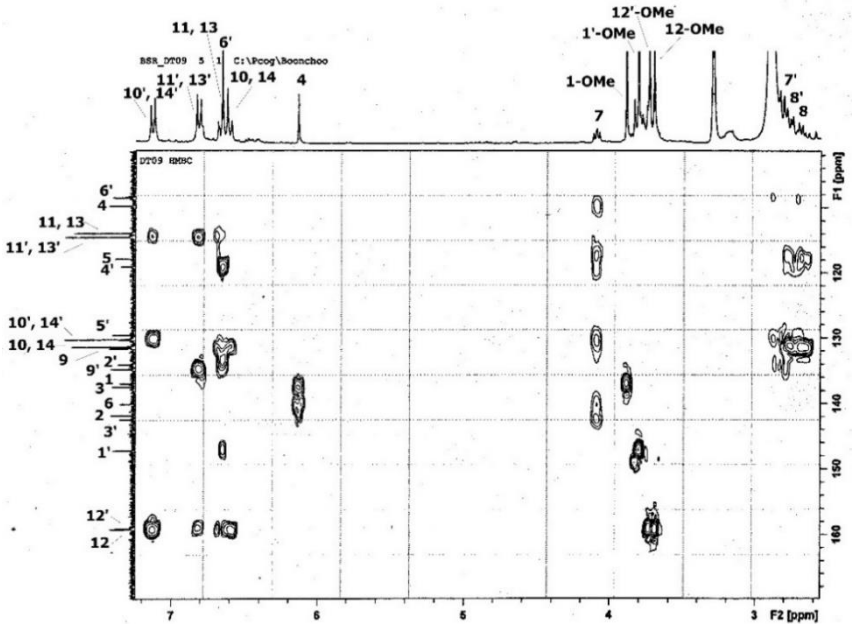


Figure 43 HMBC spectrum of compound DT7 (acetone-d_6)

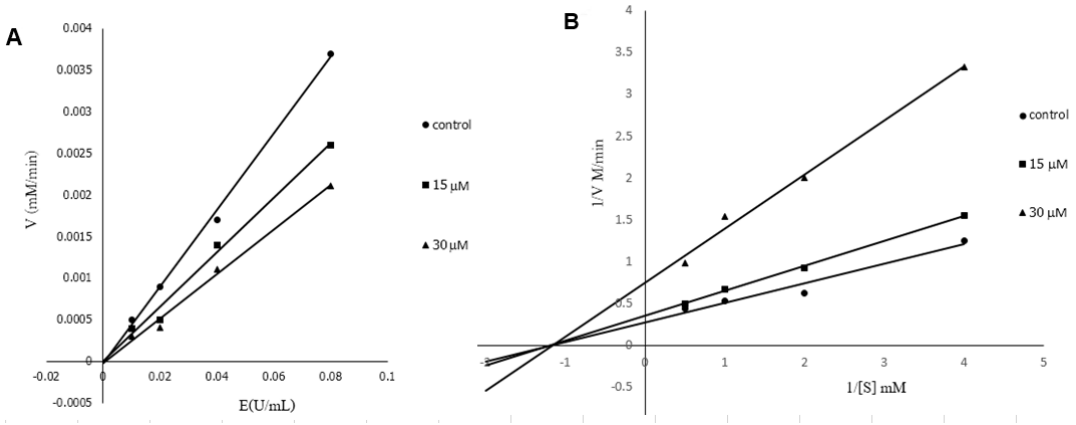


Figure 44 (A) α-Glucosidase inhibition at different concentration of dendrofalconerol A (B) Lineweaver-Burk plot analysis of the inhibition dedrofalconerol A

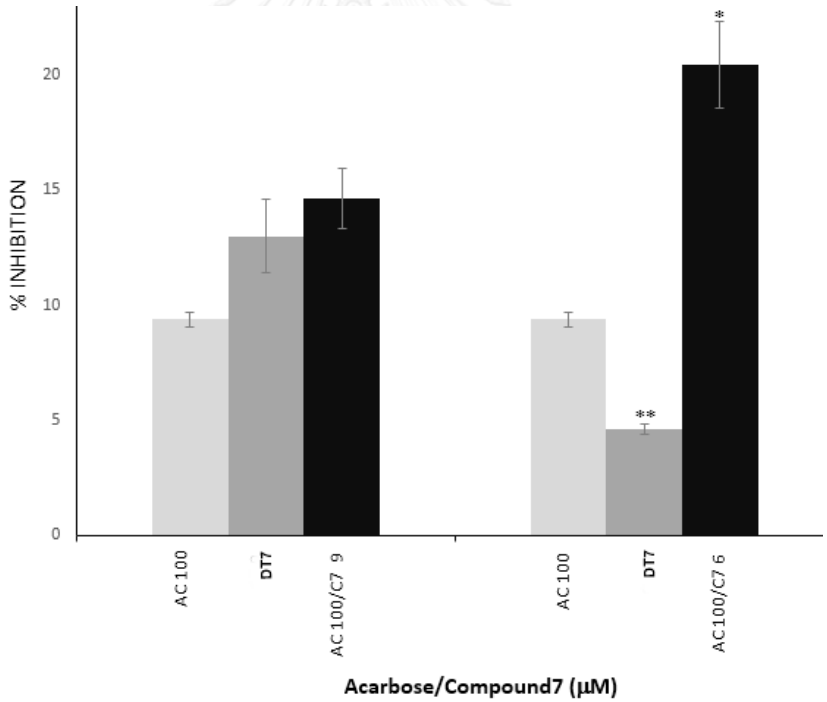


Figure 45 The combination effects of dendrofalconerol A (**DT7**) and acarbose (AC) on α-glucosidase inhibition.

*P< 0.05 compared with acarbose at 100 µM. **P< 0.05 compared with dendrofalconerol A at 6 µM + acarbose 100 µM.

VITA

Miss Rachawadee Limpanit, 5676232833, was born on 1st March, 1990 in Petchaboon, Thailand. She did Bachelor degree in the field of Pharmacy in 2013 from Huachiew Chalermprakiet University. She is currently pursuing her Master's degree at the Department of Pharmacognosy and Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University.

Publication :

1. Limpanit, R., Chuanasa, T., Likhitwitayawuid, K., Jongbunprasert, V., and Sritularak, B. 2016. Alpha-Glucosidase Inhibitors from Dendrobium tortile. Records of Natural Products 10: 609-616.

2. Limpanit, R., Likhitwitayawuid, K., and Sritularak, B. 2015. ALPHA-GLUCOSIDASE INHIBITORS FROM DENDROBIUM TORTILE. การประชุมนำเสนอผลงานวิจัยบัณฑิตศึกษาระดับชาติ ครั้งที่ 9 ประจำปีการศึกษา 2558 ระหว่างวันที่ 19 - 20 กันยายน 2558 ณ อาคารเฉลิมพระเกียรติฯ มหาวิทยาลัยราชภัฏอุดรธานี