การศึกษาทางพฤกษเคมีของสร้อยนกเขา

นางสาว ปัทมา เหละดุหวี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาเภสัชศาสตรมหาบัณฑิต
สาขาวิชาเภสัชพฤกษศาสตร์ ภาควิชาเภสัชพฤกษศาสตร์
คณะเภสัชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2550

PHYTOCHEMICAL STUDY OF

SAUROPUS BACCIFORMIS (L.) AIRY SHAW

Miss Pattama Lekduwee

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science in Pharmacy Program in Pharmaceutical Botany

Department of Pharmaceutical Botany

Faculty of Pharmaceutical Sciences

Chulalongkorn University

Academic Year 2007

Thesis Title	PHYTOCHEMICAL STUDY OF *SAUROPUS BACCIFORMIS* (L.) AIRY SHAW
By	Miss Pattama Lekduwee
Field of Study	Pharmaceutical Botany
Thesis Advisor	Associate Professor Ekarin Saifah, Ph.D.

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

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ปัทมา เหละดุหวี: การศึกษาทางพฤกษเคมีของสร้อยนกเขา. (PHYTOCHEMICAL STUDY OF *SAUROPUS BACCIFORMIS* (L.) AIRY SHAW)
อ. ที่ปรึกษา: รศ.ดร. เอกรินทร์ สายฟ้า, 140 หน้า.

จากส่วนที่อยู่เหนือดินของสร้อยนกเขา (*Sauropus bacciformis* (L.) Airy Shaw) สามารถสกัดแยกสารในกลุ่มฟลาโวนอลกลัยโคไซด์ ได้สารชนิดใหม่ 1 ชนิด คือ rhamnetin-4′-*O*-β-D-glucopyranoside และสารในกลุ่มไตรเทอร์ปีนอยด์ที่เคยมีรายงานมาแล้ว 3 ชนิด คือ friedelin, simiarenol และ glochidonol รวมทั้งได้สารผสมของ β-sitosterol และ stigmasterol การพิสูจน์เอกลักษณ์ของสารเหล่านี้ ทำโดยการวิเคราะห์ข้อมูลทางสเปกโตรสโคปีจาก UV, IR, MS และ NMR ร่วมกับการเปรียบเทียบข้อมูลกับค่าที่ได้มีการรายงานไว้แล้ว

ภาควิชา เภสัชพฤกษศาสตร์ ลายมือชื่อนิสิต..... ปัทมา เหละดุหวี่
สาขาวิชา เภสัชพฤกษศาสตร์ ลายมือชื่ออาจารย์ที่ปรึกษา.....
ปีการศึกษา 2550 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

4876583033: MAJOR PHARMACEUTICAL BOTANY

KEY WORD: *SAUROPUS BACCIFORMIS*/ EUPHORBIACEAE/ FLAVONOL GLYCOSIDE/ TRITERPENOID/ STEROID

PATTAMA LEKDUWEE: PHYTOCHEMICAL STUDY OF *SAUROPUS BACCIFORMIS* (L.) AIRY SHAW. THESIS ADVISOR: ASSOC. PROF. EKARIN SAIFAH, Ph.D., 140 pp.

From the aerial part of *Sauropus bacciformis* (L.) Airy Shaw, one new flavonol glycoside, rhamnetin-4′-*O*-*β*-D-glucopyranoside and three known triterpenoids, friedelin, simiarenol and glochidonol, together with a mixture of *β*-sitosterol and stigmasterol have been isolated. Identification of these compounds was accomplished by analysis of their spectroscopic data (UV, IR, MS and NMR) as well as comparison with reported values.

Department Pharmaceutical Botany — Student's signature Pattama Lekduwee

Field of study Pharmaceutical Botany — Advisor's signature

Academic Year 2007 — Co-advisor's signature

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to my thesis advisor, Associate Professor Dr. Ekarin Saifah of the Department of Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University, for his kindness, proper scientific guidance, suggestion and encouragement throughout the course of this study.

I would like to express my grateful thanks to Associate Professor Dr. Rapepol Bavovada and Associate Professor Dr. Rutt Suttisri, both of the Department of Pharmaceutical Botany, and Dr. Boonchoo Sritularak of the Department of Pharmacognosy, Faculty of Pharmaceutical Sciences, Chulalongkorn University, for their help on NMR measurements, discussion on structure elucidation, constructive suggestions and valuable critical comment.

My appreciations are extended to Dr. Witchuda Thanakitcharoenpath of the Department of Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University, for her help, excellent advice, encouragement, kindness and valuable suggestions on several matters, especially on the interpretation of NMR spectrum.

Additional sincere thanks are expressed to all staff members and friends at the departments of Pharmaceutical Botany and Pharmacognosy, Faculty of Pharmaceutical Sciences, Chulalongkorn University, for their kindness and support during my research work.

Finally, my utmost thanks are due to Ms. Janthima Methaneethorn, Mrs. Rachanee Pongpanit and my family for their love, understanding encouragement and moral support through out my study.

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LIST OF SCHEMES

LIST OF ABBREVIATIONS

br	=	Broad (for NMR spectra)
$^{\circ}C$	=	Degree Celsius
CC	=	Column Chromatography
$CDCl_3$	=	Deuterated chloroform
CH_2Cl_2	=	Dichloromethane
cm	=	Centimeter
cm^{-1}	=	Reciprocal centimeter (unit of wave number)
^{13}C-NMR	=	Carbon-13 Nuclear Magnetic Resonance
δ	=	Chemical shift
d	=	Doublet (for NMR spectra)
dd	=	Doublet of doublets (for NMR spectra)
ddd	=	Doublet of doublets of doublets (for NMR spectra)
DEPT	=	Distortionless Enhancement by Polarization Transfer
DMSO	=	Dimethyl sulfoxide
DMSO-d_6	=	Deuterated dimethyl sulfoxide
dt	=	Doublet of triplets (for NMR spectra)
EIMS	=	Electron Impact Mass Spectroscopy
EtOAc	=	Ethyl acetate
ε	=	Molar absorptivity
g	=	Gram
^1H NMR	=	Proton Nuclear Magnetic Resonance
^1H-^1H COSY	=	Homonuclear (Proton-Proton) Correlation Spectroscopy
HMBC	=	^1H-detected Heteronuclear Multiple Bond Coherence
HMQC	=	^1H-detected Heteronuclear Multiple Quantum Coherence
H_2O	=	Water
Hz	=	Hertz
IR	=	Infrared spectrum
J	=	Coupling constant
KBr	=	Potassium bromide
Kg	=	Kilogram
L	=	Liter

λ_{max}	=	Wavelength at maximal absorption
m	=	Multiplet (for NMR spectra)
$[M]^+$	=	Molecular ion
MeOH	=	Methanol
mg	=	Milligram
MHz	=	Megahertz
mm	=	Millimeter
mp	=	Melting point
MS	=	Mass Spectrometry
MW	=	Molecular weight
m/z	=	Mass to charge ratio
nm	=	Nanometer
NMR	=	Nuclear Magnetic Resonance Airy Shaw was collected from
ν_{max}	=	Wave Sam number of maximal absorption
ppm	=	Part-per-million
Pr	=	Propyl
rel. int.	=	Relative intensity
s	=	Singlet (for NMR spectra)
spp.	=	Species
t	=	Triplet (for NMR spectra)
td	=	Triplet of doublets (for NMR spectra)
TLC	=	Thin Layer Chromatography
UV	=	Ultraviolet
UV-VIS	=	Ultraviolet and Visible Spectrophotometry

CHAPTER I

INTRODUCTION

The genus *Sauropus* belongs to the family Euphorbiaceae. There are at least 50 species of this genus distributed throughout tropical and subtropical parts of the world, ranging from India and Sri Lanka to Southwest China, Southeast Asia (main diversity), Malaysia to Australia (Welzen and Chayamarit, 2006).

Plants in the genus *Sauropus* are usually herbs to undershrubs, and are monoecious. The stem is often with 4 raised ribs. The stipules are triangular and late caducous. The leaves are simple and distichous. These leaves are symmetric and basally attached. The leaf margin is entire. The leaf blade is without glands and with indistinct venation. The inflorescences are ramiflorous or cauliflorous racemes to usually axillary fascicles of usually one to a few bracteate flowers, all hanging down. These flowers are actinomorphic. The imbricate calyx lobes are 6, petals and disc are absent. The staminate flowers consist of obovoid to obtruncate calyx lobes, often inflexed apically, with erect scale near base. The stamens are 3, united in androphore, the apex of which splits horizontally 3 ways. The anthers are underneath, with (2) 4 thecae. The pistillate flowers consist of ovate sepals, which are persistent in fruit. The ovary is 3-locular, subapically lobed and the real apex emarginated, crater-like. The ovules are 2 per locule. The style is absent. The stigmas are 3, on the wall of crater, split to halfway. The fruits are regmas, not lobed, dehiscent, usually thin-walled and woody when dry. They are smooth, glabrous, with one to many seeds (Welzen and Chayamarit, 2006).

Sauropus species found in Thailand are (ส่วนพฤกษศาสตร์ป่าไม้ สำนักวิชาการป่าไม้ กรมป่าไม้, 2544):

Sauropus amabilis Airy Shaw	ใต้ใบใหญ่ Tai bai yai (Nakhon Sawan).
S. amoebiflorus Airy Shaw	กวางหีเปี๊ยะ Kwang hi pia (Lampang), ใต้ใบ Tai bai (Kanchanaburi), ผักหวานบ้าน Phak wan ban (Lamphun).
S. androgynus (L.) Merr.	ก้านตง Kan tong, จ๊าผักหวาน Cha phak wan (Nothern),

	โถหลุ่ยกะนีเด๊าะ Tho lui ka ni do (Karen Mae Hong Son), นานาเซียม Na na siam (Malay Satun), ผักหวาน Phak wan, ผักหวานบ้าน Phak wan ban (General), ผักหวานใต้ใบ Phak wan tai bai (Satun), มะยมป่า Mayom pa (Prachuap Khiri Khan).
S. asteranthos Airy Shaw	มะยมดอน Mayom don (General).
S. bacciformis (L.) Airy Shaw	ทองแล้ง Thong laeng (Ubon Ratchathani), มะพร้าวนกเขา Ma phrao nok khao, สร้อยนกเขา Soi nok khao (Bangkok).
S. bicolor Craib	ผักหวานแดง Phak wan daeng, มะยมเตี้ย Mayom tia, ยมดง Yom dong (Loei), ผักหวานป่า Phak wan pa (Chiang Mai), สีเสียดแพะ Sisiat phae (Lamphun).
S. brevipes Mull. Arg.	กระดูกไก่ดำ Kraduk kai dam (Prachuap Khiri Khan), ข้ามเขา Kham khao (Surat Thani).
S. discocalyx Welzen	มะยมบอน Mayom bon (General).
S. garrettii Craib	มะยมอ่างกา Mayom ang ga (General).
S. granulosus Airy Shaw	โสนรุ่น Sano run (Southeastern), หมากไข่ลาง Mak khai lang (Northeastern).
S. heteroblastus Airy Shaw	ไคร้หางนาค Khrai hang nak (Northeastern).
S. hirsutus Beille	กองกอยลอดขอน Kongkoi lot khon (Central), ก่อมก้อย Komkoi (Phetchaburi), ใต้ใบ Tai bai, ผักหวานนก Phak wan nok (Kanchanaburi), ระงับมนุษย์ Ra ngap manut (Chumphon).
S. kerrii Airy Shaw	หญ้าฮุ่นไฮ Ya hun hai (Lamphun).
S. macranthus Hassk.	มะยมเขา Mayom khao (General).
S. orbicularis Craib	กวางเขายี Kwang khao yi (Lamphun), กล่ำผี Klam phi (Ratchaburi), คำผีน้อย Kham phi noi, สีเสียดโคก Si siat khok (Loei).

S. poomae Welzen & Chayamarit ดอกใต้ต้น Dok tai ton (General).

S. pulchellus Airy Shaw โสนหิน Sano hin (Prachin Buri).

S. quadrangularis (Willd.) Mull. Arg. มะยมเกลี้ยง Mayom kliang (General), มะขามป้อมดิน Ma kham pom din (Chiangmai), มะยมเถื่อน Mayom thuean (Nakhon Sawan), มะยมละมุน Mayom lamun (General).

S. rhamnoides Blume มะยมเหลี่ยม Mayom liam (General).

S. rostratus Miq หมากบางเบา Mak bang bao (Peninsular).

S. similis Craib มะยมละม้าย Mayom lamai (General).

S. spatuliifolius Beille มะยมใบพาย Mayom bai pai (Central), อะจีเจ้า A che chao (Chinese).

S. suberosus Airy Shaw มะยมหยัก Mayom yak (Peninsular).

S. subterblancus (C. E. C. Fisch.) Welzen

S. thorelii Beille สะเลียมหอม Salium hom (Mae Hong Son).

S. thyrsiflorus Welzen

S. villosus (Blanco) Merr. งับไย้ Ngap yai, ตานงันเขา Tan ngan khao (Chumphon).

Sauropus bacciformis vernacular names: “Thong laeng” (Ubon Ratchathani), “Ma phrao nok khao” and “Soi nok khao” (Bangkok) (ส่วนพฤกษศาสตร์ป่าไม้ สำนักวิชาการป่าไม้ กรมป่าไม้, 2544) is a herb to subshrub that can grow up to 50 cm. The branches are 4-ribed, with 1.7-3 by 0.5-1.5 mm triangular stipules. The leaves are simple and distichous. The petiole is less than 1 mm long. The leaf blade is elliptic, 6.5-25 by 1.5-13 mm, with length/width ratio of 1.5-7.8. The leaf base is rounded. The leaf margin is entire, the apex is rounded to acute. The lower surface of the leaf is somewhat papillate and glaucous. The nerves of the leaves are very indistinct. The flowers are green to light purple. The diameter of staminate flowers are 1.2-1.5 mm. Its pedicel is 0.6 mm long. The calyx is deeply lobed and ovate. The size of the calyx lobes are 0.4-0.6 by 0.3-0.4 mm. The apex of calyx is entire and rounded. The stamens consist of androphore (0.2 mm long) and anther (0.2 by 0.2-0.3 mm, 2-locular). The pistillate flowers are 3-5.5 mm in diameter. Its pedicel is 3-4 mm long. The ovary is obtruncate. The size of ovary is 1-1.3 by 0.9-1 mm. The style is erect and 0.5 mm long. The green

fruit is ovoid, 5.5-6.5 by 5-5.2 mm, apically lobed around stigmas. The seeds of this plant are triangular-shaped, 4.5-4.9 by 1.2-1.8 by 1.2-1.5 mm in size (Welzen and Chayamarit, 2006) (**Figure 1**).

The plant is distributed at saline sandy or clayey soil, especially along or near beaches, or in wet, grassy roadsides (Airy Shaw, 1980).

Sauropus can be use for a common food and any medical purposes. Two *Sauropus* species found in China are *Sauropus changianus* S. Y. Hu, which was found to have antibiotic action on certain bacteria, and *S. rostratus* Miq., the boiled leaves of which are considered to be bechic expectorant. In Malay Peninsula, a decoction of *S. parvifolius* Ridl. is drunk to treat colic and diarrhea. In Indonesia, the leaves of *S. androgynus* (L.) Merr. are mixed with coconut milk and onion, then served as a drink for children with hoarse voices. In Vietnam, its roots are used to treat fever (Perry, 1980).

Sauropus androgynus (L.) Merr. (syn. *S. albicans* Bl.) is widely used as a kind of vegetable. It is cultivated in India, Malaysia, Indonesia, Southwest China and Vietnam (Chang *et al*., 1997). The leaves of this plant is comsumed after cooking in Malaysia but never been used for any medical purposes (Luh *et al*., 1999). It contains large amounts of various nutrients reported to contain 70 g of protein/kg of fresh leaves and 1,000 mg of vitamin C/kg of fresh leaves (Yu and Cheah, 1979). However, the aqueous leaf extract contains traces of the alkaloid papaverine and may cause dizziness, drowsiness and constipation (Bender and Ismail, 1973; Yu and Cheah, 1979; Chang *et al*., 1997).

In 1994, this plant was imported into Taiwan from the Indo-Malaysia region to make mixed vegetable-fruit juice and consumed for its alleged effects of body weight reduction (Chang *et al*., 1997). In the following year, an outbreak of its intoxication, causing obliterative bronchiolitis (Lai *et al*., 1996; Chang *et al*., 1998; Wang, Tseng and Lai, 1998; Wang *et al*., 2000), respiratory failure and cardiac arrhythmias (Chen *et al*., 1996), has been reported.

In Thailand, the roots of *S. androgynus* are used ethnomedically as a remedy for fever and externally for mumps. The leaves and fruits of this plant are common food source (มาโนช วามานนท์ และเพ็ญนภา ทรัพย์เจริญ, 2538).

Sauropus bacciformis has no previous report on phytochemical investigation. Preliminary examination of this plant revealed positive results for triterpenoids, steroids, alkaloids and flavonoids. Therefore, it is the purpose of this investigation to study the nature of the compounds in the aerial part of this plant. The result obtained might provide useful information in the field of phytochemistry and chemotaxonomy.

Figure 1. *Sauropus bacciformis* (L.) Airy Shaw

CHAPTER II

HISTORICAL

1. Chemical constituents of plants in the family Euphorbiaceae

A number of compounds have been isolated from plants in the family Euphorbiaceae. They can be classified as terpenoids, steroids, alkaloids, flavonoids, tannins, lignins, lignans, lignan glycosides, phenylpropanoid glucosides, aromatic diglycosides, nucleosides and benzopyran derivatives.

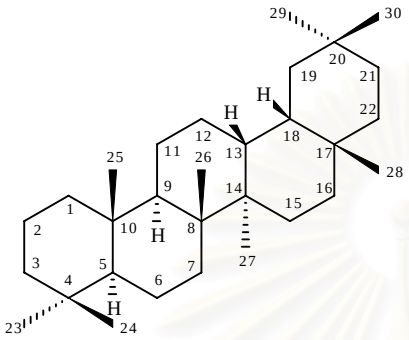
In this topic, reviews of triterpenoids and flavonoids from euphorbiaceous plants, are presented below.

1.1 Triterpenoids

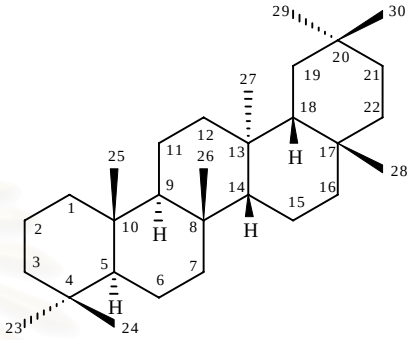
The triterpenoids types reported as chemical constituents within this family are all pentacyclic, belonging to the oleanane (A), taraxerane (B), friedelane (C), glutinane (D), multiflorane (E), ursane (F), lupane (G), hopane (H), filicane (I), adianane (J) and fernane (K) types. Some of these possess interesting pharmacological activities such as anti-tumor [betulinic acid (Yan *et al*., 1989), glochidiol (Tanaka *et al*., 2004; Puapairoj *et al*., 2005), glochidonol and lup-20(29)-ene-3α,23-diol (Puapairoj *et al*., 2005), lupeol (Kuo *et al*., 1997)], anti-inflammatory [β-amyrin (Akihisa *et al*., 1996), taraxerol (Singh, Sahu and Sharma, 2002), friedelin (Shimizu and Tomoo, 1994), α-amyrin and lupeol (Recio *et al*., 1995b; Akihisa *et al*., 1996), betulin and betulinic acid (Recio *et al*., 1995a)], anti-tuberculosis [betulin, betulinic acid, lupeol and lupenone (Wachter *et al*., 1999)], antiviral [lupenone (Madureira *et al*., 2003)], anti-dermatophytic [betulinic acid (Kuiate *et al*., 2007)], antiangiogenic [lupeol (You *et al*., 2003)], antiplasmodial [lupeol (Alves *et al*., 1997)], antimicrobial [lupeol (Ajaiyeoba *et al*., 2003)] and diuretic activities [friedelin (Rizvi *et al*., 1980a)].

Of the eleven triterpene skeletal types found in the family Euphorbiaceae, the lupane skeleton is the most common. Major compounds of this type are lupeol, glochidonol, glochidiol and glochidone. Two other classes of triterpenoids which are prevalent in the family Euphorbiaceae are the friedelane and

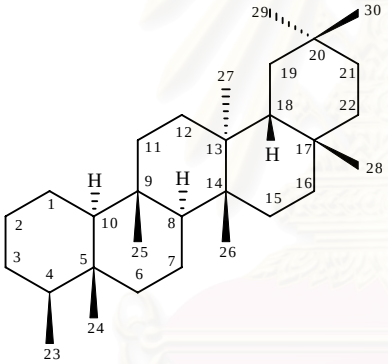
the oleanane skeleton. Friedelin, epifriedelinol and friedelinol are major compounds of the friedelane type while β-amyrin and germanicol are of the oleanane type. For the last eight skeletal types only taraxerane, glutinane, multiflorane, ursane, hopane, filicane, adianane and fernane have so far been isolated from this family as summarized in **Table 1.**



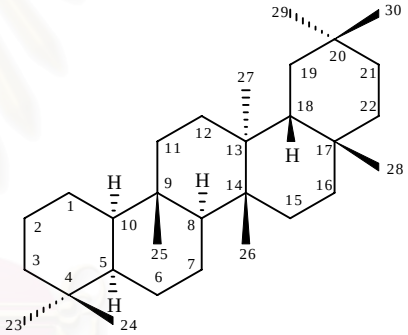
Oleanane (A)



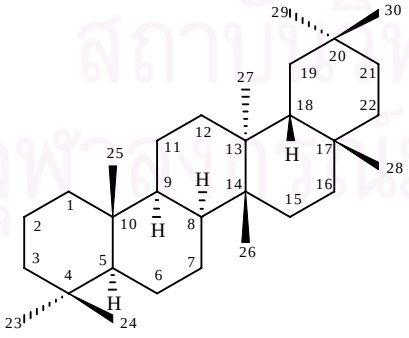
Taraxerane (B)



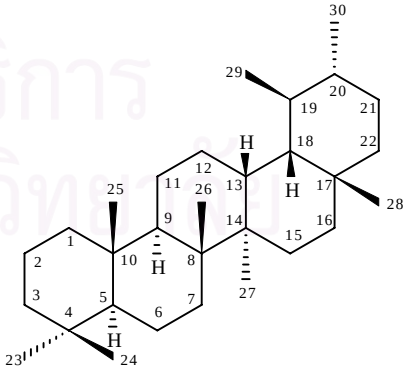
Friedelane (C)



Glutinane (D)

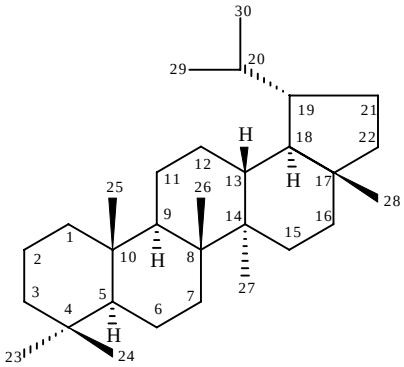


Multiflorane (E)

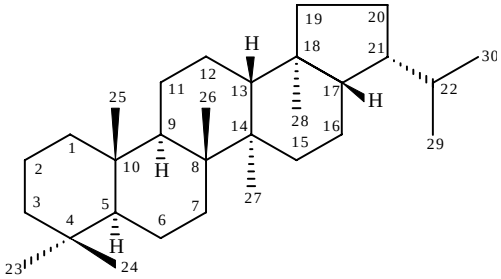


Ursane (F)

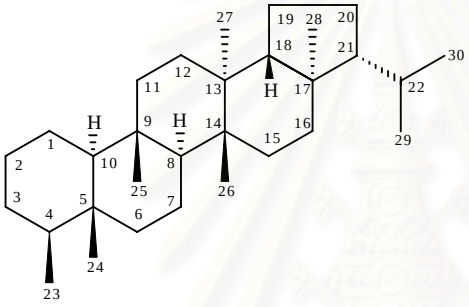
Figure 2. Basic skeleton of pentacyclic triterpenoids



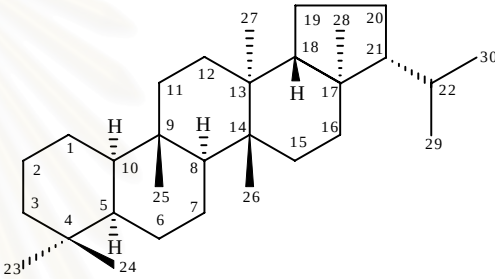
Lupane (G)



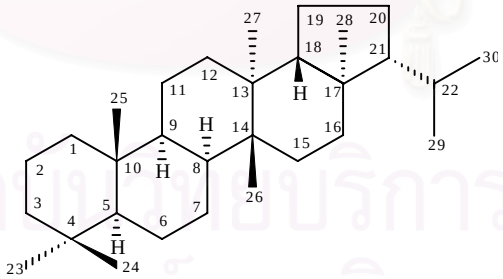
Hopane (H)



Filicane (I)



Adianane (J)



Fernane (K)

Figure 2. Basic skeleton of pentacyclic triterpenoids (continued)

Table 1. Distribution of triterpenoids in the family Euphorbiaceae

Compounds	Sources	Plant part	References
1. Oleanane type			
β-Amyrin [**1**]	*Euphorbia antiquorum*	Stems	Anjaneyulu and Ravi, 1989
	E. cyparissias	Latex	Starratt, 1966
	E. pulcherrima	Latex	Biesboer *et al*., 1982
	Excoecaria agallocha	Leaves and stems	Hui and Sung, 1968
	Glochidion heyneanum	Stems	Srivastava and Kulshrestha, 1988
	Macaranga tanarius	Leaves and stems	Hui, Li and Kai, 1975
	Phyllanthus acidus	Bark	Sengupta and Mukhopadhyay, 1966
	P. flexuosus	Stem bark	Tanaka and Matsunaga, 1988a
	Ricinus communis	Leaves	Khafagy, Mahmoud and Salam, 1979
	Senefelderopsis chiribiquetensis	Stems	Canelon *et al*., 2005
β-Amyrin acetate [**2**]	*Euphorbia maculata*	Whole plant	Matsunaga, Tanaka and Akagi, 1988
	E. pulcherrima	Latex	Biesboer *et al*., 1982
	Phyllanthus flexuosus	Stem bark	Tanaka and Matsunaga, 1988a
δ-Amyrin [**3**]	*Euphorbia supina*	Whole plant	Tanaka and Matsunaga, 1988b
δ-Amyrin formate [**4**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
Drypechevalin A [**5**]	*Drypetes chevalieri*	Stems	Wansi *et al*., 2006
Epimachaerinic acid [**6**]	*Glochidion heyneanum*	Stems	Srivastava and Kulshrestha, 1988
Germanicol [**7**]	*Euphorbia pulcherrima*	Latex	Biesboer *et al*., 1982
	E. supina	Whole plant	Tanaka and Matsunaga, 1988b
Germanicol acetate [**8**]	*E. pulcherrima*	Latex	Biesboer *et al*., 1982
Glochidioside N [**9**]	*Glochidion heyneanum*	Stems	Srivastava and Kulshrestha, 1988

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Glochidioside Q [**10**]	*G. heyneanum*	Stems	Srivastava and Kulshrestha, 1988
Kamaladiol-3-acetate [**11**]	*Mallotus philippinensis*	Stem bark	Nair and Rao, 1993
Oleana-9(11),12-dien-3β-ol [**12**]	*Phyllanthus flexuosus*	Stem bark	Tanaka and Matsunaga, 1988a
Oleana-11,13(18)-dien-3β-ol [**13**]	*Euphorbia supina*	Whole plant	Tanaka and Matsunaga, 1988b
	Phyllanthus flexuosus	Stem bark	Tanaka and Matsunaga, 1988a
Oleana-11,13(18)-dien-3β,24-diol [**14**]	*P. flexuosus*	Stem bark	Tanaka, Tabuse and Matsunaga, 1988
Olean-12-en-3β,24-diol [**15**]	*P. flexuosus*	Stem bark	Tanaka *et al*., 1988
Olean-12-en-3β,15α-diol [**16**]	*P. flexuosus*	Stem bark	Tanaka *et al*., 1988
Olean-12-en-3β,15α, 24-triol [**17**]	*P. flexuosus*	Stem bark	Tanaka *et al*., 1988
Olean-12-en-3β,9α, 11α-triol [**18**]	*Euphorbia supina*	Whole plant	Tanaka and Matsunaga, 1989a
2. Taraxerane type Epitaraxerol [**19**]	*Excoecaria agallocha*	Leaves and stems	Hui and Sung, 1968
	Macaranga triloba	Leaves	Jang *et al*., 2004
Euphorginol [**20**]	*Euphorbia tirucalli*	Stem bark	Rasool, Khan and Malik, 1989
11α,12α-Oxido taraxerol [**21**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
3,4-Seco-4(23),14-taraxeradien-3-oic acid methyl ester [**22**]	*E. broteri*	Aerial part	Teresa *et al*., 1987
Taraxerol [**23**]	*Bridelia micrantha*	Bark and wood	Pegel and Rogers, 1968
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	E. indica	Aerial part	Rizk and Rimpler, 1977

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Taraxerol [**23**]	*Excoecaria agallocha*	Leaves and stems	Hui and Sung, 1968
	Macaranga triloba	Leaves	Jang *et al*., 2004
	Sapium discolor	Leaves and stems	Hui and Sung, 1968
Taraxerone [**24**]	*Bridelia micrantha*	Bark	Pegel and Rogers, 1968
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	Excoecaria agallocha	Leaves	Hui and Sung, 1968
	Sapium discolor	Stems	Hui and Sung, 1968
Taraxeryl acetate [**25**]	*Euphorbia antiquorum*	Stems	Anjaneyulu and Ravi, 1989
	E. maculata	Whole plant	Matsunaga *et al*., 1988
	Excoecaria agallocha	Leaves	Hui and Sung, 1968
3. Friedelane type 30-Acetoxyfriedelan-3β-ol [**26**]	*Euphorbia antiquorum*	Stems	Anjaneyulu and Ravi, 1989
3β-Acetoxy friedelan-30-ol [**27**]	*E. antiquorum*	Stems	Anjaneyulu and Ravi, 1989
Antidesmanol [**28**]	*Antidesma menasu*	Aerial part	Rizvi *et al*., 1980a
Canophyllal [**29**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
Canophyllol [**30**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
1β,22β-Dihydroxy friedelin [**31**]	*Phyllanthus muellerianus*	Bark	Adesida, Girgis and Taylor, 1972
Drypechevalin B [**32**]	*Drypetes chevalieri*	Stems	Wansi *et al*., 2006
Drypemolundein B [**33**]	*D. armoracia*	Stem bark	Wandji *et al*., 2003
Epifriedelinol [**34**]	*Antidesma bunius*	Leaves and stems	Hui and Sung, 1968
	Aporosa cardiosperma	Bark	Carpenter *et al*., 1980
	Bischofia trifoliata	Leaves and stems	Hui and Ho, 1968
	Bridelia crenulata	Bark	Ramesh *et al*., 2001
	B. micrantha	Bark	Pegel and Rogers, 1968

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Epifriedelinol [**34**]	*B. moonii*	Bark	Carpenter *et al*., 1980
	Drypetes armoracia	Stem bark	Wandji *et al*., 2003
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	Fluggea virosa	Stems	Hui, Li and Lee, 1977
	Glochidion macrophyllum	Leaves and stems	Hui *et al*., 1970
	G. puberum	Leaves and stems	Hui and Li, 1978
	G. wrightii	Leaves and stems	Hui and Fung, 1969
	Jatropha maheshwarii	Stems	Viswanathan *et al*., 2004
	Macaranga tanarius	Stems	Hui *et al*., 1975
	Mallotus hookerianus	Leaves and stems	Hui and Li, 1976b
	Phyllanthus reticulatus	Leaves and stems	Hui, Li and Wong, 1976
	P. watsonii	Leaves and stems	Matsunaga *et al*., 1993
	Suregada angustifolia	Stems	Venkatesan *et al*., 2005
Euphorcinol [**35**]	*Euphorbia tirucalli*	Stem bark	Khan *et al*., 1989
Friedelan-3β,30-diol diacetate [**36**]	*Euphorbia antiquorum*	Stems	Anjaneyulu and Ravi, 1989
Friedelan-3β-yl acetate [**37**]	*E. antiquorum*	Stems	Anjaneyulu and Ravi, 1989
Friedelin [**38**]	*Antidesma bunius*	Leaves and stems	Hui and Sung, 1968
	A. menasu	Aerial part	Rizvi *et al*., 1980a
	Aporosa cardiosperma	Bark	Carpenter *et al*., 1980
	Bischofia trifoliata	Leaves and stems	Hui and Ho, 1968
	Bridelia crenulata	Bark	Ramesh *et al*., 2001

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Friedelin [**38**]	*B. micrantha*	Bark and wood	Pegel and Rogers, 1968
	B. moonii	Bark	Carpenter *et al*., 1980
	Claoxylon polot	Leaves and stems	Hui *et al*., 1977
	Drypetes armoracia	Stem bark	Wandji *et al*., 2003
	D. chevalieri	Stems	Wansi *et al*., 2006
	Euphorbia supina	Whole plant	Tanaka and Matsunaga, 1988b
	Excoecaria agallocha	Leaves	Hui and Sung, 1968
	Fluggea virosa	Leaves and stems	Hui *et al*., 1977
	Glochidion macrophyllum	Leaves and stems	Hui *et al*., 1970
	G. puberum	Leaves and stems	Hui and Li, 1978
	G. wrightii	Leaves and stems	Hui and Fung, 1969
	Jatropha maheshwarii	Stems	Viswanathan *et al*., 2004
	Macaranga tanarius	Leaves and stems	Hui *et al*., 1975
	Mallotus hookerianus	Leaves and stems	Hui and Li, 1976b
	M. philippinensis	Stem bark	Nair and Rao, 1993
Friedelinol [**39**]	*Bischofia trifoliata*	Leaves	Hui and Ho, 1968
	Bridelia moonii	Bark	Carpenter *et al*., 1980
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	Fluggea virosa	Leaves and stems	Hui *et al*., 1977
21α-Hydroxyfriedel-4(23)-en-3-one [**40**]	*Phyllanthus reticulatus*	Leaves and stems	Hui *et al*., 1976
21α-Hydroxy friedelan-3-one [**41**]	*P. reticulatus*	Leaves and stems	Hui *et al*., 1976

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
22β-Hydroxy-3-oxo-friedel-1-ene [**42**]	*P. muellerianus*	Bark	Adesida *et al*., 1972
Pentatronol [**43**]	*Alchornea sidifolia*	Leaves	Barbo *et al*., 2002
Putranjivadione [**44**]	*Drypetes armoracia*	Stem bark	Wandji *et al*., 2003
	D. chevalier	Stems	Wansi *et al*., 2006
4. Glutinane type 3-*Epi*-glutinol [**45**]	*Euphorbia cyparissias*	Latex	Starratt, 1966
Glutinone [**46**]	*E. cyparissias*	Latex	Starratt, 1966
Glutinyl acetate [**47**]	*E. maculata*	Whole plant	Matsunaga *et al*., 1988
1β-Hydroxyglut-5(10)-ene [**48**]	*Andrachne cordifolia*	Aerial part and roots	Mukherjee *et al*., 1986
5. Multiflorane type 16α-Acetoxy-3-keto isomultiflorene [**49**]	*Antidesma menasu*	Aerial part	Rizvi *et al*., 1980b
3β-Acetoxy-16-keto isomultiflorene [**50**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
3α,16α-Dihydroxy isomultiflorene [**51**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
3,16-Diketo isomultiflorene [**52**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
16α-Hydroxy-3-keto isomultiflorene [**53**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
3β-Hydroxy-16-keto isomultiflorene [**54**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
Isomultiflorenol [**55**]	*A. menasu*	Aerial part	Rizvi *et al*., 1980b
	Euphorbia supina	Whole plant	Tanaka and Matsunaga, 1988b
16-Keto isomultiflorene [**56**]	*Antidesma menasu*	Aerial part	Rizvi *et al*., 1980b
6. Ursane type α-Amyrin [**57**]	*Aleurites moluccana*	Leaves and stems	Hui and Ho, 1968
	Bridelia crenulata	Bark	Ramesh *et al*., 2001
	Mallotus repandus	Stems	Hui and Li, 1977

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
α-Amyrin [**57**]	*Suregada angustifolia*	Stem bark	Venkatesan *et al*., 2005
3β,20ε-Dihydroxy-ψ-taraxastane [**58**]	*Euphorbia antiquorum*	Stems	Anjaneyulu and Ravi, 1989
3β-Hydroxyurs-9(11),12-diene [**59**]	*E. maculata*	Whole plant	Matsunaga *et al*., 1988
3α-Hydroxy-13α-ursan-28,12β-olide [**60**]	*Mallotus repandus*	Stems	Hui and Li, 1977
3β-Hydroxy-13α-ursan-28,12β-olide [**61**]	*M. repandus*	Leaves	Hui and Li, 1977
Phyllanthol [**62**]	*Phyllanthus acidus*	Bark	Sengupta and Mukhopadhyay, 1966
	P. engleri	Root bark	Alberman and Kipping, 1951
	P. sellowianus	Stem bark	Hnatyszyn and Ferraro, 1985
7. Lupane type 3β-Acetoxy-20-oxo-30-norlupane [**63**]	*Euphorbia maculata*	Whole plant	Matsunaga *et al*., 1988
Betulin [**64**]	*Euphorbia broteri*	Aerial part	Teresa *et al*., 1987
	E. trigona	Stems	Anjaneyulu, Rao and Connolly, 1985
	Phyllanthus flexuosus	Stem bark	Tanaka, Tabuse and Matsunaga, 1988
	Mallotus philippinensis	Stems	Bandopadhyay *et al*., 1972
	Senefelderopsis chiribiquetensis	Stems	Canelon *et al*., 2005
Betulin-3-acetate [**65**]	*Claoxylon polot*	Leaves	Hui *et al*., 1977
	Fluggea virosa	Stems	Hui *et al*., 1977
Betulinic acid [**66**]	*Phyllanthus reticulatus*	Stems	Hui *et al*., 1976
Betulinic acid methyl ester [**67**]	*Glochidion macrophyllum*	Leaves and stems	Hui and Li, 1978
Canaric acid [**68**]	*Euphorbia broteri*	Aerial part	Teresa *et al*., 1987

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
1β,3β-Dihydroxy lup-20(29)-ene [**69**]	*Glochidion eriocarpum*	Roots and stems	Puapairoj *et al*., 2005
	G. heyneanum	Stems	Srivastava and Kulshrestha, 1988
	G. macrophyllum	Stems	Hui *et al*., 1970
	G. puberum	Stems	Hui and Li, 1978
	G. zeylanicum	Stem bark	Tanaka *et al*., 2004
	Phyllanthus watsonii	Leaves and stems	Matsunaga *et al*., 1993
3α,23-Dihydroxy lup-20(29)-ene [**70**]	*Glochidion macrophyllum*	Stems	Hui and Lee, 1971
	G. moonii	Bark	Carpenter *et al*., 1980
	G. sphaerogynum	Roots and stems	Puapairoj *et al*., 2005
	Glochidion spp.	Bark	Carpenter *et al.*, 1980
3β,24-Dihydroxy lup-20(29)-ene [**71**]	*Phyllanthus flexuosus*	Stem bark	Tanaka *et al*., 1988
1,3-Dioxolup-20(29)-ene [**72**]	*Glochidion puberum*	Leaves	Hui and Li, 1978
3-*Epi*-lupeol [**73**]	*G. eriocarpum*	Roots and stems	Puapairoj *et al*., 2005
	G. hongkongense	Stems	Hui *et al*., 1970
Glochidiol [**74**]	*G. dasyphyllum*	Stems	Hui *et al*., 1970
	G. eriocarpum	Roots and stems	Puapairoj *et al*., 2005
	G. heyneanum	Stems	Srivastava and Kulshrestha, 1988
	G. hongkongense	Stems	Hui *et al*., 1970
	G. macrophyllum	Stems	Hui *et al*., 1970
	G. moonii	Bark	Carpenter *et al*., 1980
	G. multiloculare	Whole plant	Talapatra *et al*., 1973
	G. puberum	Stems	Hui and Li, 1978
	G. sphaerogynum	Roots and stems	Puapairoj *et al*., 2005

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Glochidiol [**74**]	*G. wrightii*	Leaves and stems	Hui and Fung, 1969
	G. zeylanicum	Stem bark	Tanaka *et al*., 2004
	Glochidion spp.	Bark	Carpenter *et al*., 1980
Glochidiol-1-acetate [**75**]	*G. puberum*	Stems	Hui and Li, 1978
Glochidiol-3-acetate [**76**]	*G. puberum*	Stems	Hui and Li, 1978
Glochidiol diacetate [**77**]	*G. puberum*	Stems	Hui and Li, 1978
Glochidol [**78**]	*G. eriocarpum*	Roots and stems	Puapairoj *et al*., 2005
	G. zeylanicum	Stem bark	Tanaka *et al*., 2004
Glochidone [**79**]	*Bridelia moonii*	Bark	Carpenter *et al*., 1980
	Glochidion dasyphyllum	Stems	Hui *et al*., 1970
	G. eriocarpum	Roots and stems	Puapairoj *et al*., 2005
	G. heyneanum	Stems	Srivastava and Kulshrestha, 1988
	G. hongkongense	Stems	Hui *et al*., 1970
	G. macrophyllum	Stems	Hui *et al*., 1970
	G. multiloculare	Whole plant	Talapatra *et al*., 1973
	G. puberum	Stems	Hui and Li, 1978
	G. wrightii	Leaves and stems	Hui and Fung, 1969
	Glochidion spp.	Bark	Carpenter *et al*., 1980
	Phyllanthus flexuosus	Stem bark	Tanaka and Matsunaga, 1988a
	P. watsonii	Leaves and stems	Matsunaga *et al*., 1993
Glochidonol [**80**]	*Fluggea virosa*	Stems	Hui *et al*., 1977
	Glochidion eriocarpum	Roots and stems	Puapairoj *et al*., 2005

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

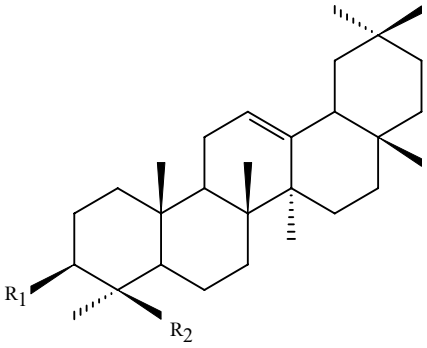
Compounds	Sources	Plant part	References
Glochidonol [**80**]	*G. heyneanum*	Stems	Srivastava and Kulshrestha, 1988
	G. hongkongense	Stems	Hui *et al*., 1970
	G. macrophyllum	Stems	Hui *et al*., 1970
	G. moonii	Bark	Carpenter *et al*., 1980
	G. puberum	Stems	Hui and Li, 1978
	G. sphaerogynum	Roots and stems	Puapairoj *et al*., 2005
	G. wrightii	Leaves and stems	Hui and Fung, 1969
	G. zeylanicum	Stem bark	Tanaka *et al*., 2004
	Glochidion spp.	Bark	Carpenter *et al*., 1980
	Phyllanthus reticulatus	Leaves and stems	Hui *et al*., 1976
	P. watsonii	Leaves and stems	Matsunaga *et al*., 1993
Glochidonyl acetate [**81**]	*Glochidion puberum*	Stems	Hui and Li, 1978
Glochilocudiol [**82**]	*Fluggea virosa*	Stems	Hui *et al*., 1977
	Glochidion multiloculare	Whole plant	Talapatra *et al*., 1973
	G. puberum	Stems	Hui and Li, 1978
3β-Hydroxy-20-oxo-30-norlupane [**83**]	*Claoxylon polot*	Leaves and stems	Hui *et al*., 1977
	Ricinus communis	Leaves	Thompson and Bowers, 1968
Lupenone [**84**]	*Drypetes chevalieri*	Stems	Wansi *et al*., 2006
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	Glochidion dasyphyllum	Stems	Hui *et al*., 1970
	G. eriocarpum	Roots and stems	Puapairoj *et al*., 2005
	G. hongkongense	Stems	Hui *et al*., 1970
	G. puberum	Stems	Hui and Li, 1978
	G. wrightii	Stems	Hui and Fung, 1969
	Phyllanthus emblica	Stems	Hui and Sung, 1968

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

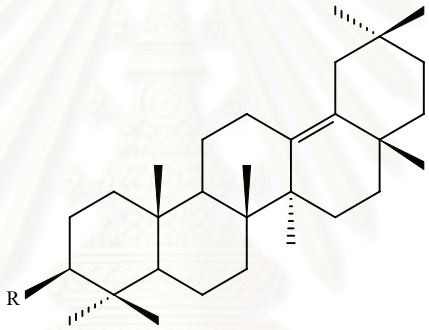
Compounds	Sources	Plant part	References
Lupenyl acetate [**85**]	*Euphorbia maculata*	Whole plant	Matsunaga *et al*., 1988
Lupeol [**86**]	*Drypetes chevalieri*	Stems	Wansi *et al*., 2006
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	E. lateriflora	Leaves and stems	Lavie and Jain, 1968
	Fluggea virosa	Stems	Hui *et al*., 1977
	Glochidion eriocarpum	Stems	Hui and Li, 1976a
	G. hongkongense	Stems	Hui *et al*., 1970
	G. puberum	Leaves	Hui and Li, 1978
	G. wrightii	Stems	Hui and Fung, 1969
	Mallotus philippinensis	Stems	Bandopadhyay *et al*., 1972
	M. repandus	Stems	Hui and Li, 1977
	Phyllanthus emblica	Leaves and stems	Hui and Sung, 1968
	P. flexuosus	Stem bark	Tanaka and Matsunaga, 1988a
	P. watsonii	Leaves and stems	Matsunaga *et al*., 1993
	Ricinus communis	Leaves	Thompson and Bowers, 1968
	Senefelderopsis chiribiquetensis	Stems	Canelon *et al*., 2005
Lupeolactone [**87**]	*Antidesma pentandrum*	Aerial part	Kikuchi *et al*., 1983
1α,3α,23-Trihydroxylup-20(29)-ene [**88**]	*Glochidion spp.*	Bark	Carpenter *et al*., 1980
8. Hopane type Moretenol [**89**]	*Aleurites moluccana*	Leaves and stems	Hui and Ho, 1968
	Euphorbia lateriflora	Leaves and stems	Lavie and Jain, 1968
	E. supina	Whole plant	Matsunaga and Morita, 1983
	E. trigona	Stems	Anjaneyulu *et al*., 1985

Table 1. Distribution of triterpenoids in the family Euphorbiaceae (continued)

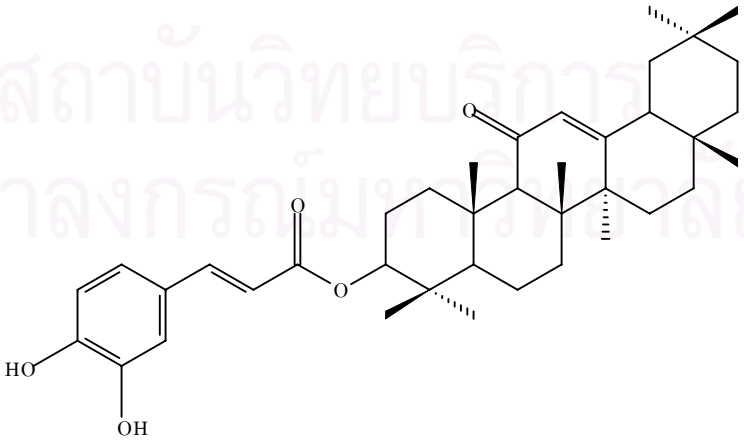
Compounds	Sources	Plant part	References
Moretenone [**90**]	*Aleurites moluccana*	Leaves and stems	Hui and Ho, 1968
	Euphorbia antiquorum	Stems	Anjaneyulu and Ravi, 1989
	E. cyparissias	Stems	Starratt, 1969
	E. lateriflora	Leaves and stems	Lavie and Jain, 1968
29-Nor-21αH-hopane-3,22-dione [**91**]	*Mallotus paniculatus*	Stems	Hui and Li, 1976b
9. Filicane type Trisnorisoespinenoxide [**92**]	*Euphorbia supina*	Whole plant	Tanaka *et al*., 1989
10. Adianane type Espinendiol-A [**93**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
Espinendiol-B [**94**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
Espinenoxide [**95**]	*E. supina*	Whole plant	Tanaka *et al*., 1989
Simiarenol [**96**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b; Tanaka *et al*., 1989
11. Fernane type Arundoin [**97**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
Fern-8-en-3β-ol [**98**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
3β-Hydroxyfern-7,9(11)-diene [**99**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
Isomotiol [**100**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1988b
Motiol [**101**]	*E. supina*	Whole plant	Matsunaga and Morita, 1983
Supinenolone-A [**102**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1989b
Supinenolone-B [**103**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1989b
Supinenolone-C [**104**]	*E. supina*	Whole plant	Tanaka and Matsunaga, 1989b



	R_1	R_2
β-Amyrin [**1**]	OH	CH_3
β-Amyrin acetate [**2**]	$OCOCH_3$	CH_3
Olean-12-en-3β,24-diol [**15**]	OH	CH_2OH

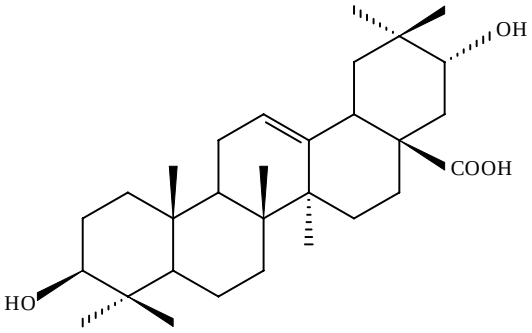


δ-Amyrin [**3**]	R = OH
δ-Amyrin formate [**4**]	R = OCHO

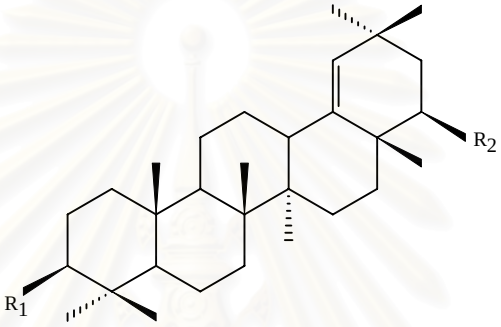


Drypechevalin A [**5**]

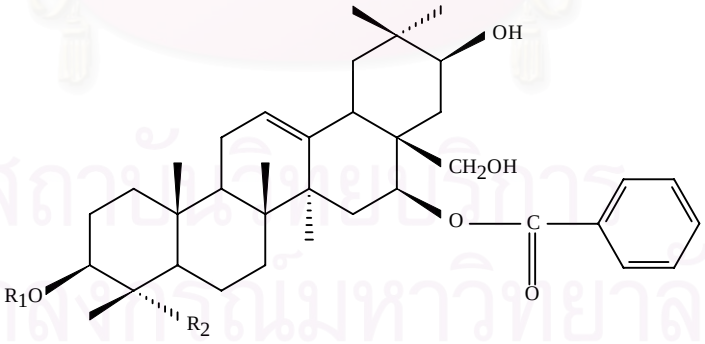
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae



Epimachaerinic acid [**6**]

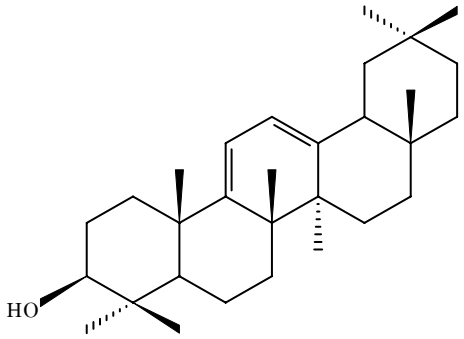


	R_1	R_2
Germanicol [**7**]	OH	H
Germanicol acetate [**8**]	$OCOCH_3$	H
Kamaladiol-3-acetate [**11**]	$OCOCH_3$	OH

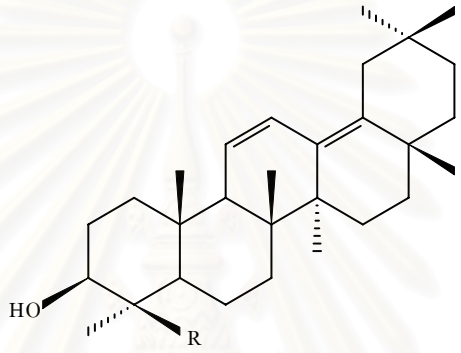


	R_1	R_2
Glochidioside N [**9**]	Glc	CH_2OH
Glochidioside Q [**10**]	Glc-Glc	CH_3

Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)

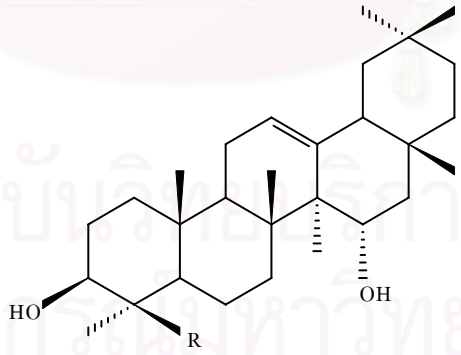


Oleana-9(11),12-dien-3β-ol [**12**]



Oleana-11,13(18)-dien-3β-ol [**13**] R = CH_3

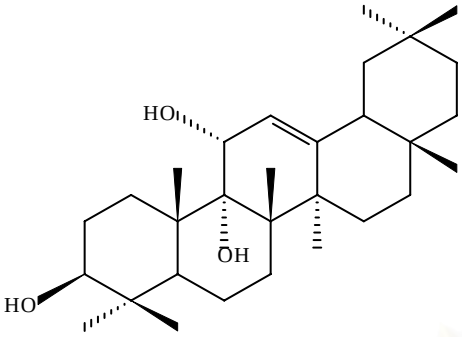
Oleana-11,13(18)-dien-3β,24-diol [**14**] R = CH_2OH



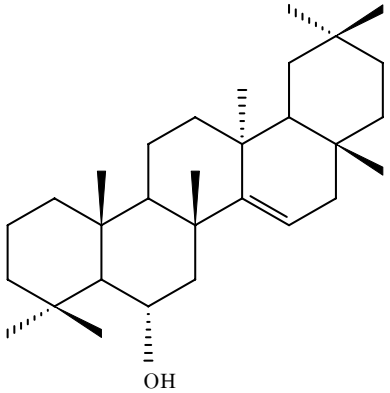
Olean-12-en-3β,15α-diol [**16**] R = CH_3

Olean-12-en-3β,15α,24-triol [**17**] R = CH_2OH

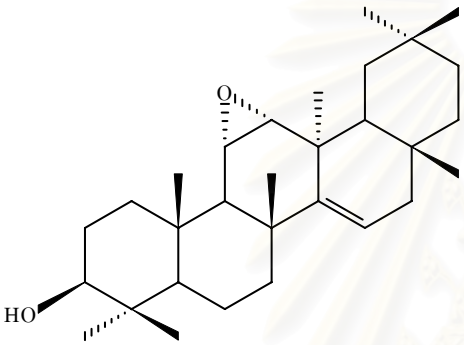
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



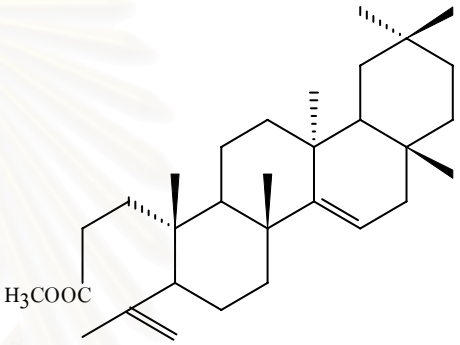
Olean-12-en-3β,9α,11α-triol [**18**]



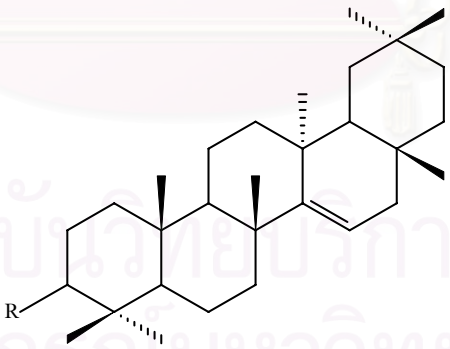
Euphorginol [**20**]



11α,12α-Oxidotaraxerol [**21**]

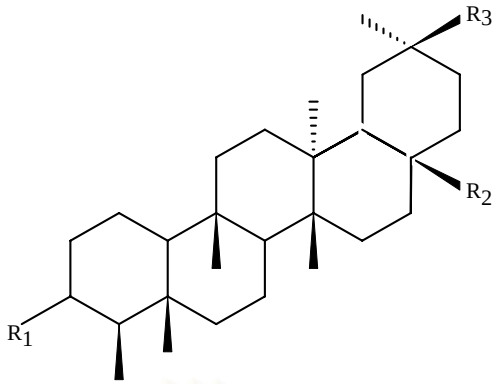


3,4-Seco-4(23),14-taraxeradien-3-oic acid methyl ester [**22**]

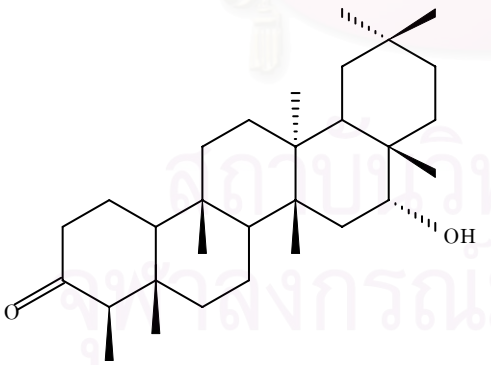


Epitaraxerol [**19**]	R = α-OH
Taraxerol [**23**]	R = β-OH
Taraxerone [**24**]	R = =O
Taraxeryl acetate [**25**]	R = β-$OCOCH_3$

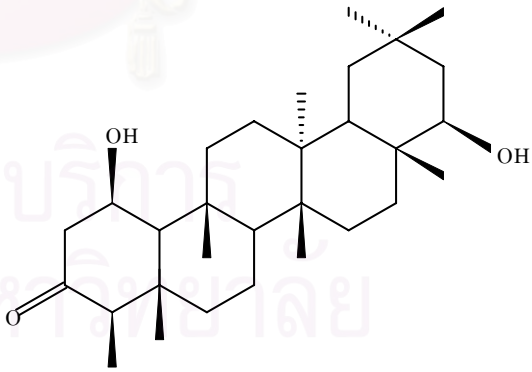
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



	R_1	R_2	R_3
30-Acetoxyfriedelan-3β-ol [**26**]	β-OH	CH_3	CH_2OCOCH_3
3β-Acetoxyfriedelan-30-ol [**27**]	β-$OCOCH_3$	CH_3	CH_2OH
Canophyllal [**29**]	=O	CHO	CH_3
Canophyllol [**30**]	=O	OH	CH_3
Epifriedelinol [**34**]	β-OH	CH_3	CH_3
Friedelan-3β,30-diol diacetate [**36**]	β-$OCOCH_3$	CH_3	CH_2OCOCH_3
Friedelan-3β-yl acetate [**37**]	β-$OCOCH_3$	CH_3	CH_3
Friedelin [**38**]	=O	CH_3	CH_3
Friedelinol [**39**]	α-OH	CH_3	CH_3

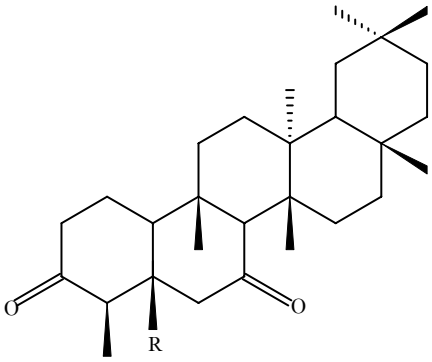


Antidesmanol [**28**]



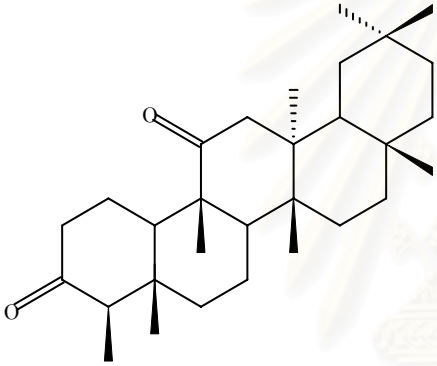
1β,22β-Dihydroxyfriedelin [**31**]

Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)

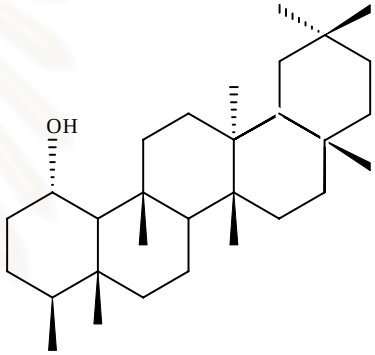


Drypechevalin B [**32**] R = CHO

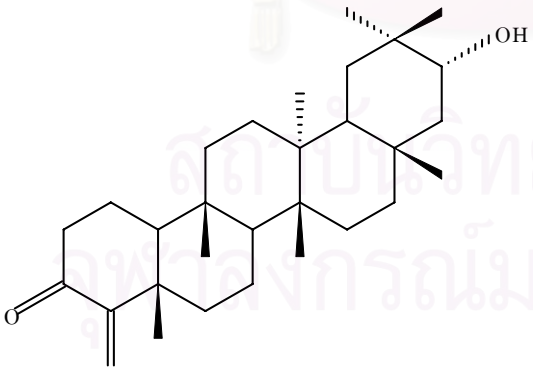
Putranjivadione [**44**] R = CH_3



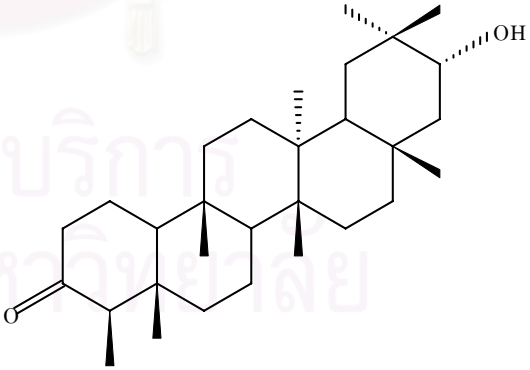
Drypemolundein B [**33**]



Euphorcinol [**35**]

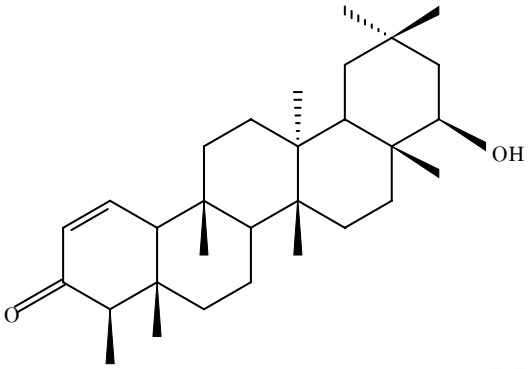


21α-Hydroxyfriedel-4(23)-en-3-one [**40**]

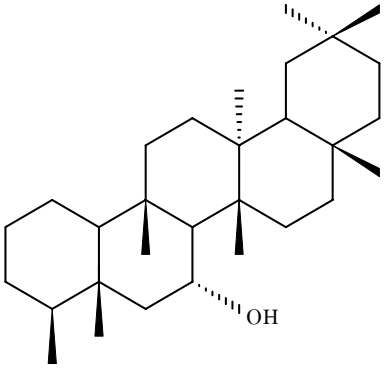


21α-Hydroxyfriedelan-3-one [**41**]

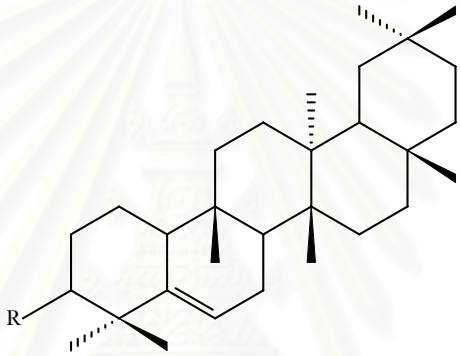
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



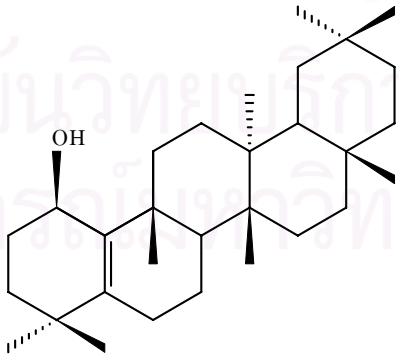
22β-Hydroxy-3-oxo-friedel-1-ene [**42**]



Pentatronol [**43**]

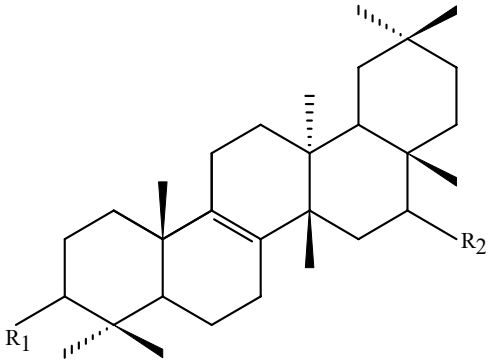


3-*Epi*-glutinol [**45**]	R = α-OH
Glutinone [**46**]	R = =O
Glutinyl acetate [**47**]	R = β-OCOCH$_3$

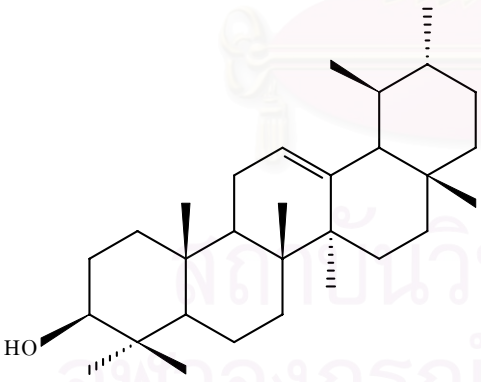


1β-Hydroxyglut-5(10)-ene [**48**]

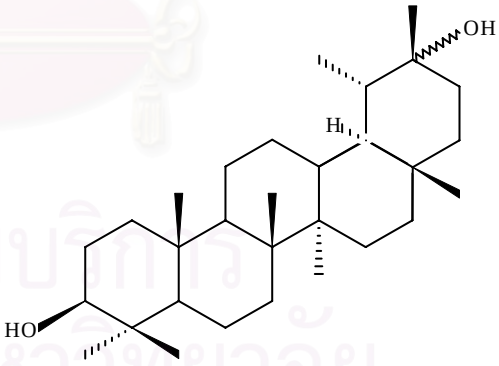
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



	R_1	R_2
16α-Acetoxy-3-ketoisomultiflorene [**49**]	=O	α-$OCOCH_3$
3β-Acetoxy-16-ketoisomultiflorene [**50**]	β-$OCOCH_3$	=O
3α,16α-Dihydroxyisomultiflorene [**51**]	α-OH	α-OH
3,16-Diketoisomultiflorene [**52**]	=O	=O
16α-Hydroxy-3-ketoisomultiflorene [**53**]	=O	α-OH
3β-Hydroxy-16-ketoisomultiflorene [**54**]	β-OH	=O
Isomultiflorenol [**55**]	β-OH	H
16-Ketoisomultiflorene [**56**]	H	=O

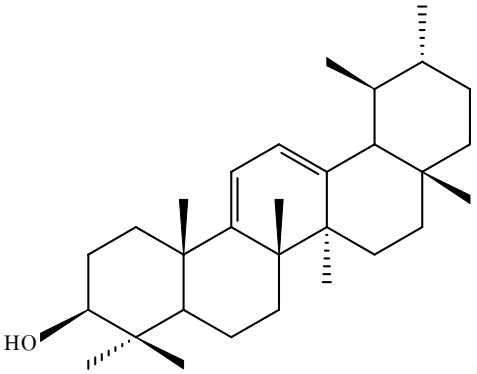


α-Amyrin [**57**]

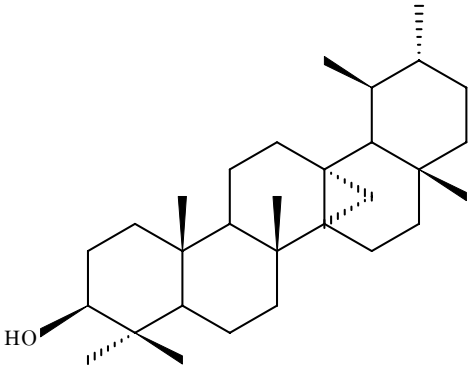


3β,20ε-Dihydroxy-ψ-taraxastane [**58**]

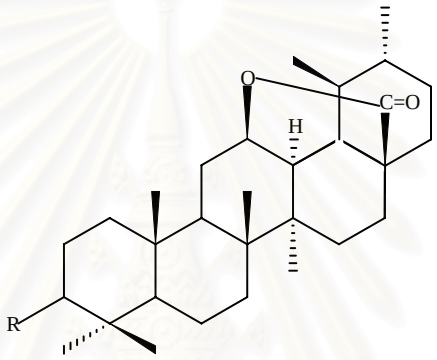
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



3β-Hydroxyurs-9(11),12-diene [**59**]

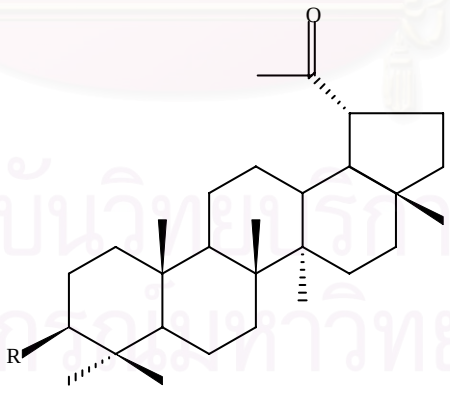


Phyllanthol [**62**]



3α-Hydroxy-13α-ursan-28,12β-olide [**60**] R = α-OH

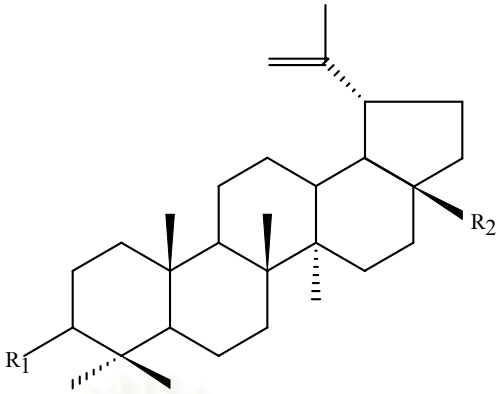
3β-Hydroxy-13α-ursan-28,12β-olide [**61**] R = β-OH



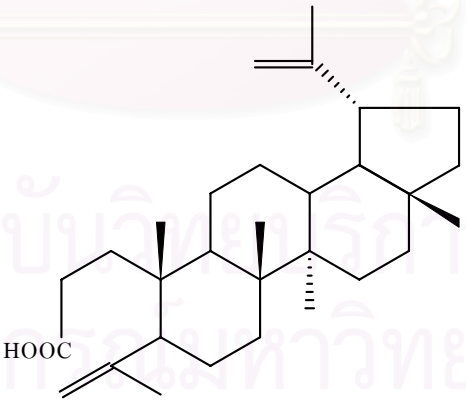
3β-Acetoxy-20-oxo-30-norlupane [**63**] R = $OCOCH_3$

3β-Hydroxy-20-oxo-30-norlupane [**83**] R = OH

Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)

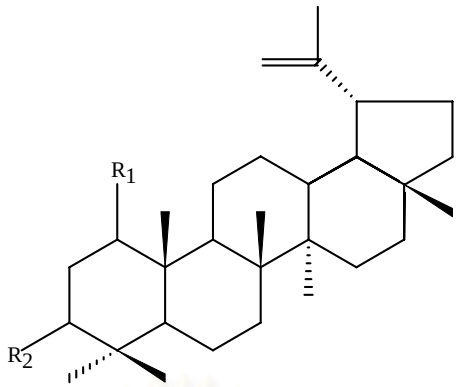


	R_1	R_2
Betulin [**64**]	β-OH	CH_2OH
Betulin-3-acetate [**65**]	β-$OCOCH_3$	CH_2OH
Betulinic acid [**66**]	β-OH	COOH
Betulinic acid methyl ester [**67**]	β-OH	$OCOCH_3$
3-*Epi*-lupeol [**73**]	α-OH	CH_3
Lupenone [**84**]	=O	CH_3
Lupenyl acetate [**85**]	β-$OCOCH_3$	CH_3
Lupeol [**86**]	β-OH	CH_3

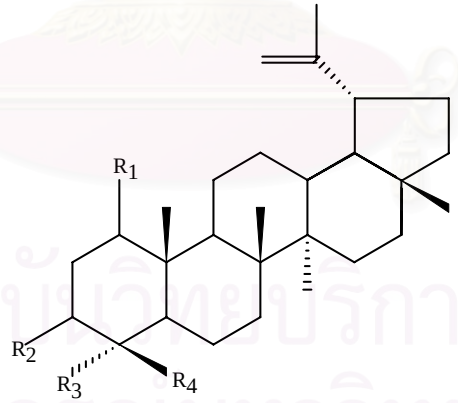


Canaric acid [**68**]

Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)

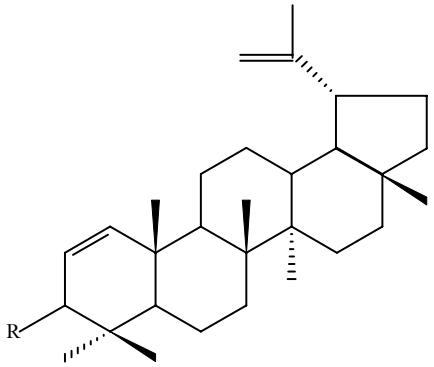


	R_1	R_2
1β,3β-Dihydroxylup-20(29)-ene [**69**]	β-OH	β-OH
1,3-Dioxolup-20(29)-ene [**72**]	=O	=O
Glochidiol [**74**]	β-OH	α-OH
Glochidiol-1-acetate [**75**]	β-$OCOCH_3$	α-OH
Glochidiol-3-acetate [**76**]	β-OH	α-$OCOCH_3$
Glochidiol diacetate [**77**]	β-$OCOCH_3$	α-$OCOCH_3$
Glochidonol [**80**]	β-OH	=O
Glochidonyl acetate [**81**]	β-$OCOCH_3$	=O
Glochilocudiol [**82**]	α-OH	β-OH



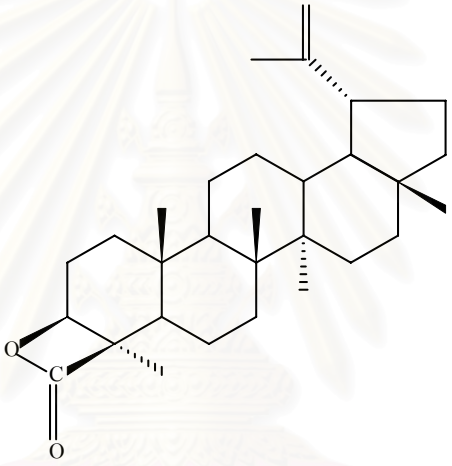
	R_1	R_2	R_3	R_4
3α,23-Dihydroxylup-20(29)-ene [**70**]	H	α-OH	CH_2OH	CH_3
3β,24-Dihydroxylup-20(29)-ene [**71**]	H	β-OH	CH_3	CH_2OH
1α,3α,23-Trihydroxylup-20(29)-ene [**88**]	α-OH	α-OH	CH_2OH	CH_3

Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)

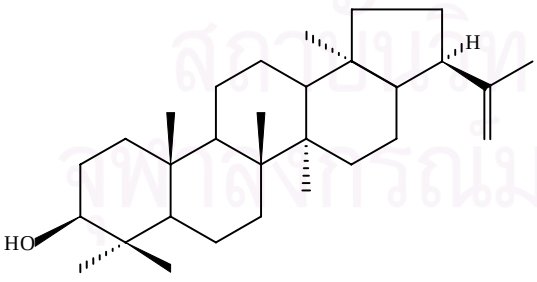


Glochidol [**78**] R = β-OH

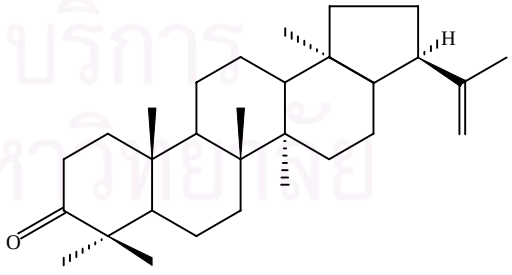
Glochidone [**79**] R = =O



Lupeolactone [**87**]

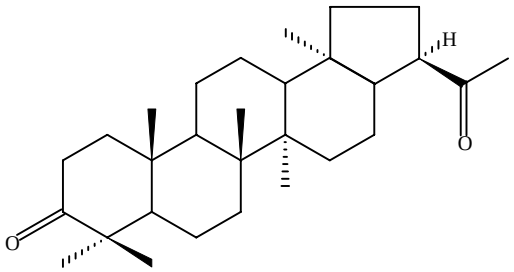


Moretenol [**89**]

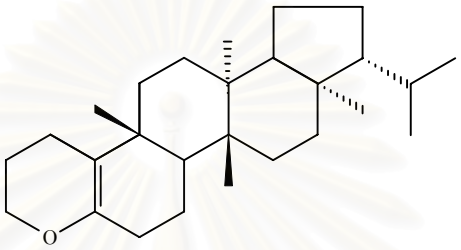


Moretenone [**90**]

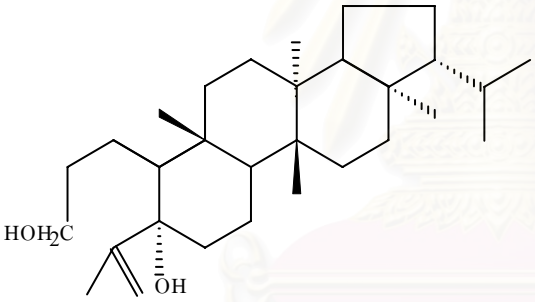
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



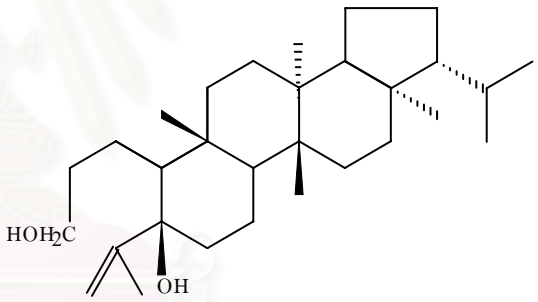
29-Nor-21αH-hopane-3,22-dione [**91**]



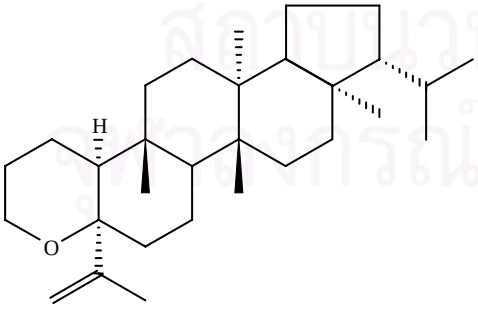
Trisnorisoespinenoxide [**92**]



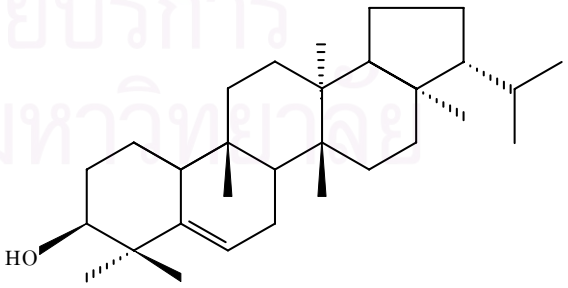
Espinendiol-A [**93**]



Espinendiol-B [**94**]

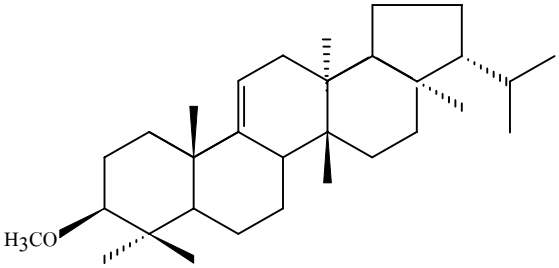


Espinenoxide [**95**]

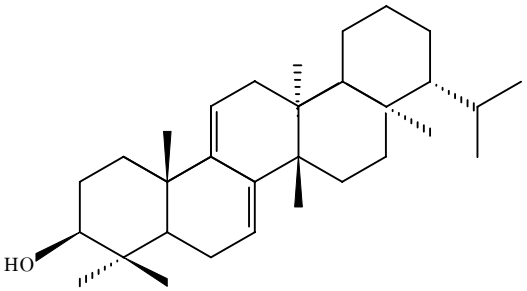


Simiarenol [**96**]

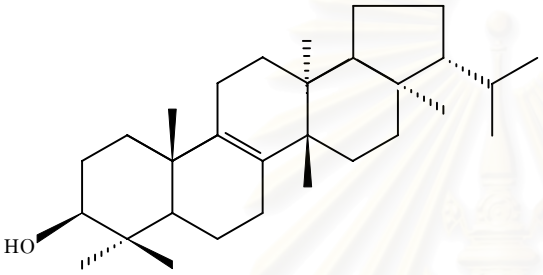
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)



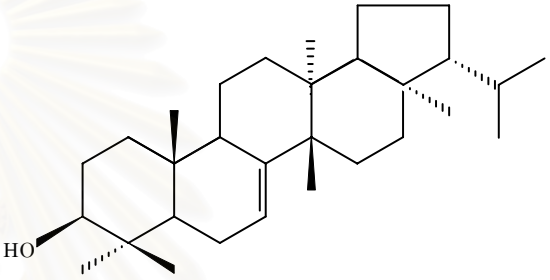
Arundoin [**97**]



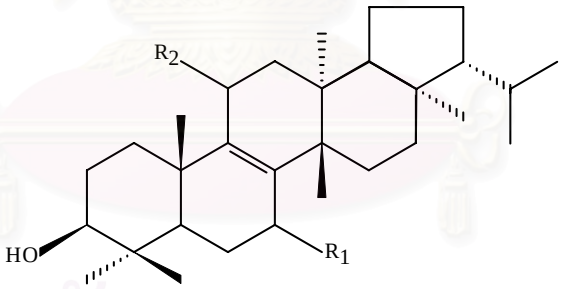
3β-Hydroxyfern-7,9(11)-diene [**99**]



Isomotiol [**100**]



Motiol [**101**]



	R_1	R_2
Fern-8-en-3β-ol [**98**]	H	H
Supinenolone-A [**102**]	α-OH	=O
Supinenolone-B [**103**]	=O	β-OH
Supinenolone-C [**104**]	=O	=O

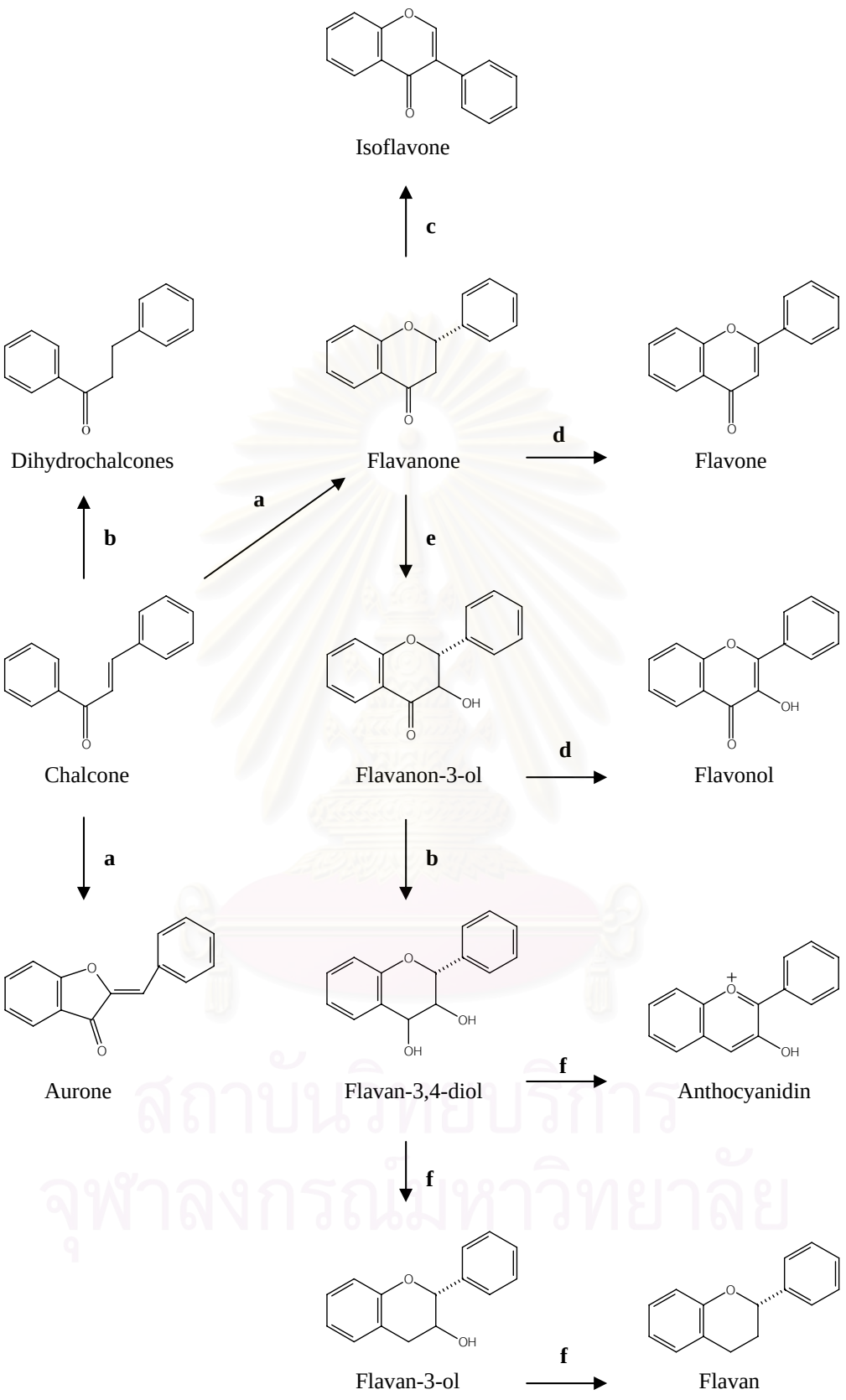
Figure 3. Chemical structures of triterpenoids in the family Euphorbiaceae (continued)

1.2 Flavonoids

The flavonoids, one of the most diverse and widespread groups of natural products, occupy a prominent position among the natural phenols. Interest in flavonoids results particularly from the conspicuously vivid and beautiful colors these pigments impart to various parts of plants. Some of these compounds from euphorbiaceous plants are found to possess interesting pharmacological activities such as anti-inflammatory [artemesin (Sertie *et al.*, 1990), hyperoside and quercitrin (Manga *et al*., 2004)], antibacterial [bonannione A, euchrestaflavanone A, macaranga flavanones A and B (Schutz *et al*., 1995)], antiulcer [myricetin and quercetin (Lacasa *et al*., 2000)], vasorelaxant [quercetin-3,7-dimethyl ether (Guerrero *et al*., 2002)] and hypoglycemic activities [isoquercitrin and rutin (Hnatyszyn *et al*., 2002)].

In plants, flavonoid aglycones occur in a variety of structural forms. All contain fifteen carbon atoms in their basic nucleus and these are arranged in a C_6-C_3-C_6 configuration. Each C_6 represents an aromatic ring. These aromatic rings are linked by a three carbon unit which forms a third heterocyclic ring via cyclization with one of the aromatic ring via an oxygen atom. The aromatic rings are labeled as ring A and B and heterocyclic ring as ring C (Agrawal, 1989). Flavonoids can be classified according to their biosynthetic origin. Some flavonoid types are both intermediates in biosynthesis as well as end-product, which can accumulate in plant tissue. These include chalcone (the first formed C_{15} structure derived from cinnamoyl-coenzyme A and three malonyl-coenzyme A), flavanone, flavanon-3-ol, flavan-3,4-diol and flavan-3-ol. Other classes are only known as end-products of biosynthesis i.e. flavone, flavonol, anthocyanidin and flavan. Two classes of flavonoids are those in which the position 2-phenyl side chain of flavanone isomerizes to the position 3 (giving rise to isoflavone and related isoflavonoids) and then to the position 4 (giving rise to the neoflavonoids) as shown in **Scheme 1** (Dewick, 1997).

Flavonoids are associated with sugars in conjugated form and within any one class may be characterized as monoglycosidic, diglycosidic, triglycosidic, etc. Glycosidic complexity is considerable. There are over 1,500 glycosides of the flavone and flavonol isolated to date. Mono, di and trisaccharides may be linked through a phenolic hydroxyl and one or more hydroxyl groups may carry a sugar substitution. Acylated O-glycosides are known, where aliphatic acids or aromatic are linked through the 6-hydroxyl of a glucose moiety. A special group of mainly flavone-based C-glycosides also occurs in plants (Hocking, 1997).



Scheme 1. Biosynthetic relationship of flavonoids

a = cyclization, **b** = bioreduction, **c** = aryl migration, **d** = dehydrogenation, **e** = hydroxylation, **f** = dehydroxylation

The near ubiquitous distribution of flavonoids in green plants, their relative chemical stability and the ease with which most can be identified have made them particularly useful as taxonomic markers in plant classification (Agrawal, 1989).

The literature reviews of flavonoids in the family Euphorbiaceae are summarized in **Table 2.**

Table 2. Distribution of flavonoids in the family Euphorbiaceae

Compounds	Sources	Plant part	References
1. Flavanone Bonannione A [**105**]	*Macaranga alnifolia*	Leaves	Schutz *et al*., 1995;
		Fruits	Yoder *et al*., 2007
	M. pleiostemona	Leaves	Schutz *et al*., 1995
5,4′-Dihydroxy-[2"-(1-hydroxy-1-methylethyl) dihydrofurano]-(7,8:5",4") flavanone [**106**]	*M. conifera*	Leaves	Jang *et al*., 2002
5,7-Dihydroxy-4′-methoxy-8-(2-hydroxy-3-methylbut-3-enyl) flavanone [**107**]	*M. conifera*	Leaves	Jang *et al*., 2002
5,7-Dihydroxy-4′-methoxy-8-(3-methyl but-2-enyl) flavanone [**108**]	*M. conifera*	Leaves	Jang *et al*., 2002
6,7-Dimethoxy-3′,4′-methylenedioxy flavanone [**109**]	*M. indica*	Leaves	Sultana and Ilyas, 1987
Euchrestaflavanone A [**110**]	*M. pleiostemona*	Leaves	Schutz *et al*., 1995
5-Hydroxy-4′-methoxy-2",2"-dimethylpyrano-(7,8:6",5") flavanone [**111**]	*M. conifera*	Leaves	Jang *et al*., 2002

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Lonchocarpol A [**112**]	*M. conifera*	Leaves	Jang *et al*., 2002
Macaranga flavanone A [**113**]	*M. pleiostemona*	Leaves	Schutz *et al*., 1995
Macaranga flavanone B [**114**]	*M. pleiostemona*	Leaves	Schutz *et al*., 1995
Nymphaeol-A [**115**]	*M. alnifolia*	Fruits	Yoder *et al*., 2007
	M. tanarius	Leaves	Phommart *et al*., 2005
Nymphaeol-B [**116**]	*M. tanarius*	Leaves	Phommart *et al*., 2005
Nymphaeol-C [**117**]	*M. tanarius*	Leaves	Tseng *et al*., 2001; Phommart *et al*., 2005
Sophoraflavanone B [**118**]	*M. conifera*	Leaves	Jang *et al*., 2002
	M. denticulata	Leaves	Sutthivaiyakit *et al.*, 2002
Tanariflavanone A [**119**]	*M. tanarius*	Leaves	Tseng *et al*., 2001
Tanariflavanone B [**120**]	*M. tanarius*	Leaves	Tseng *et al*., 2001; Phommart *et al*., 2005
Tanariflavanone C [**121**]	*M. tanarius*	Leaves	Phommart *et al*., 2005
Tanariflavanone D [**122**]	*M. tanarius*	Leaves	Phommart *et al*., 2005
Tomentosanol D [**123**]	*M. conifera*	Leaves	Jang *et al*., 2002
2. Flavanonol			
Alnifoliol [**124**]	*M. alnifolia*	Fruits	Yoder *et al*., 2007
Bonanniol A [**125**]	*M. alnifolia*	Fruits	Yoder *et al*., 2007
Diplacol [**126**]	*M. alnifolia*	Fruits	Yoder *et al*., 2007
Lupinifolinol [**127**]	*M. conifera*	Leaves	Jang *et al*., 2002
3. Isoflavone			
7-Methyltectorigenin [**128**]	*M. indica*	Leaves	Sultana and Ilyas, 1987
4. Flavone			
Amentoflavone [**129**]	*Alchornea castaneaefolia*	Leaves	Lima *et al*., 2006
	Chrozophora brocchiana	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
Apigenin [**130**]	*Jatropa curcas*	Leaves	Subramanian, Nagarajan And Sulochana, 1971a

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Apigenin [**130**]	*J. gossypifolia*	Leaves	Subramanian, Nagarajan And Sulochana, 1971b
Artemetin [**131**]	*Croton brasiliensis*	Leaves and stems	Palmeira, Conserva and Silveira, 2005
Casticin [**132**]	*C. brasiliensis*	Leaves and stems	Palmeira *et al*., 2005
Chrysosplenol-D [**133**]	*C. brasiliensis*	Leaves and stems	Palmeira *et al*., 2005
Desmethoxykanugin [**134**]	*Gelonium multiflorum*	Roots	Das *et al*., 1994
Kanugin [**135**]	*G. multiflorum*	Roots	Das *et al*., 1994
Penduletin [**136**]	*Croton brasiliensis*	Leaves and stems	Palmeira *et al*., 2005
Pinnatin [**137**]	*Gelonium multiflorum*	Roots	Das *et al*., 1994
5. Flavone glycoside			
Apigenin-5-*O*-glucoside [**138**]	*Chrozophora brocchiana*	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	C. verbascifolia	Leaves and stems	Hashim *et al*., 1990
Apigenin-7-*O*-glucoside [**139**]	*C. brocchiana*	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Apigenin-7-*O*-glucoside [**139**]	*C. verbascifolia*	Leaves and stems	Hashim *et al*., 1990
	Euphorbia forskaolii	Leaves and stems	Kawashty *et al*., 1990
	E. prostrata	Leaves and stems	Kawashty *et al*., 1990
Isovitexin [**140**]	*Hevea brasiliensis*	Leaves	Subramanian *et al*., 1971a
	Jatropha curcas	Leaves	Subramanian *et al*., 1971a
	J. gossypifolia	Leaves	Subramanian *et al*., 1971b
	J. heynii	Leaves and stems	Subramanian *et al*., 1971a
Luteolin-3-*O*-glucoside [**141**]	*Chrozophora brocchiana*	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	C. verbascifolia	Leaves and stems	Hashim *et al*., 1990
Luteolin-7-*O*-glucoside [**142**]	*C. brocchiana*	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	Euphorbia forskaolii	Leaves and stems	Kawashty *et al*., 1990
	E. prostrata	Leaves and stems	Kawashty *et al*., 1990
	Senefelderopsis chiribiquetensis	Leaves and stems	Canelon *et al*., 2005
Vitexin [**143**]	*Croton hovarum*	Leaves	Krebs and Ramiarantsoa, 1997

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Vitexin [**143**]	*Hevea brasiliensis*	Leaves	Subramanian *et al*., 1971a
	Jatropha curcas	Leaves	Subramanian *et al*., 1971a
	J. gossypifolia	Leaves	Subramanian *et al*., 1971b
	J. heynii	Leaves and stems	Subramanian *et al*., 1971a
6. Flavonol Ayanin [**144**]	*Croton schiedeanus*	Aerial part	Guerrero *et al*., 2002
	Macaranga triloba	Leaves	Jang *et al*., 2004
Denticulaflavonol [**145**]	*Macaranga denticulata*	Leaves	Sutthivaiyakit *et al*., 2002
Ferrugin [**146**]	*Bridelia ferruginea*	Stem bark	Cimanga *et al*., 2001
Isolicoflavonol [**147**]	*Macaranga conifera*	Leaves	Jang *et al*., 2002
Isorhamnetin [**148**]	*Croton oblongifolius*	Leaves	Subramanian *et al*., 1971a
Kaempferol [**149**]	*Euphorbia paralias*	Leaves and stems	Rizk, Ahmad and Diab, 1979
	Phyllanthus androgynus	Aerial part	Miean and Mohamed, 2001
	P. emblica	Leaves	Subramanian *et al*., 1971a
Kaempferol-3,6-dimethyl ether [**150**]	*Chamaesyce prostrata*	Aerial part	Rojas *et al*., 1999
	Macaranga conifera	Leaves	Jang *et al*., 2002
Kaempferol-3,7-dimethyl ether [**151**]	*Croton cajucara*	Leaves	Maciel *et al*., 2000
Kaempferol-3,4′,7-trimethyl ether [**152**]	*C. cajucara*	Leaves	Maciel *et al*., 2000
Macarangin [**153**]	*Macaranga denticulata*	Leaves	Sutthivaiyakit *et al*., 2002
3-*O*-Methylmacarangin [**154**]	*M. denticulata*	Leaves	Sutthivaiyakit *et al*., 2002
3-*O*-Methylquercetin [**155**]	*Bridelia ferruginea*	Stem bark	Cimanga *et al*., 2001
Myricetin [**156**]	*B. ferruginea*	Stem bark	Cimanga *et al*., 2001
Quercetin [**157**]	*Alchornea castaneaefolia*	Leaves	Lima *et al*., 2006

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Quercetin [**157**]	*Bridelia ferruginea*	Leaves	Mensah and Achenbach, 1985
	Croton oblongifolius	Leaves	Subramanian *et al*., 1971a
	Euphorbia paralias	Leaves and stems	Rizk *et al*., 1979
	Jatropha heynii	Leaves	Subramanian *et al*., 1971a
	Manihot utilissima	Aerial part	Miean and Mohamed, 2001
	Ricinus communis	Leaves	Khafagy, Mahmoud and Salam, 1979
	Sauropus androgynus	Aerial part	Miean and Mohamed, 2001
Quercetin-3,7-dimethyl ether [**158**]	*Croton schiedeanus*	Aerial part	Guerrero *et al*., 2002
	Macaranga triloba	Leaves	Jang *et al*., 2004
Rutisin [**159**]	*Bridelia ferruginea*	Stem bark	Cimanga *et al*., 2001
	Macaranga conifera	Leaves	Jang *et al*., 2002
3,3′,4′,5′-Tetra-*O*-methyl myricetin [**160**]	*B. ferruginea*	Stem bark	Cimanga *et al*., 2001
6. Flavonol glycoside Astragalin [**161**]	*Adenopeltis colliguaya*	Leaves	Ugarte and Silva, 1972
	Chrozophora brocchiana	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	C. verbascifolia	Leaves and stems	Hashim *et al*., 1990

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Astragalin [**161**]	*Euphorbia arguta*	Leaves and stems	Kawashty *et al*., 1990
	E. chamaescye	Leaves and stems	Kawashty *et al*., 1990
	E. dentroides	Leaves and stems	Kawashty *et al*., 1990
	E. geniculata	Leaves and stems	Kawashty *et al*., 1990
	E. isthmian	Leaves and stems	Kawashty *et al*., 1990
	E. maculata	Aerial part	Agata *et al*., 1991
	E. paralias	Leaves and stems	Kawashty *et al*., 1990
	E. peplus	Leaves and stems	Kawashty *et al*., 1990
	E. supina	Aerial part	Agata *et al*., 1991
	Phyllanthus emblica	Leaves	Subramanian *et al*., 1971a
Biorobin [**162**]	*Acalypha indica*	Flowers and leaves	Nahrstedt, Hungeling and Petereit, 2006
Clitorin [**163**]	*A. indica*	Flowers and leaves	Nahrstedt *et al*., 2006
3-*O*-β-D-Glucosyl-(1→6)-β-D-glucosyl kaempferol [**164**]	*Sauropus androgynus*	Aerial part	Wang and Lee, 1997; Yu *et al*., 2006
3-*O*-β-D-Glucosyl-(1→6)-β-D-glucosyl-7-*O*-α-L-rhamnosyl kaempferol [**165**]	*S. androgynus*	Aerial part	Wang and Lee, 1997; Yu *et al*., 2006
3-*O*-β-D-Glucosyl-7-*O*-α-L-rhamnosyl kaempferol [**166**]	*S. androgynus*	Aerial part	Wang and Lee, 1997
6-Hydroxykaempferol-7-rutinoside [**167**]	*Sapium eugeniaefolium*	Leaves	Ahmad *et al*., 1991
Hyperoside [**168**]	*Croton oblongifolius*	Leaves	Subramanian *et al*., 1971a
	Euphorbia arguta	Leaves and stems	Kawashty *et al*., 1990

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Hyperoside [**168**]	*E. helioscopia*	Leaves and stems	Kawashty *et al*., 1990
	E. hypericifolia	Leaves and stems	Kawashty *et al*., 1990
	E. paralias	Leaves and stems	Rizk *et al*., 1979; Kawashty *et al*., 1990
	E. prostrata	Leaves and stems	Kawashty *et al*., 1990
	Jatropha heynii	Leaves	Subramanian *et al*., 1971a
Isoquercitrin [**169**]	*Acalypha indica*	Flowers and leaves	Nahrstedt *et al*., 2006
	Bridelia ferruginea	Stem bark	Cimanga *et al*., 2001
	Chrozophora brocchiana	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	C. verbascifolia	Leaves and stems	Hashim *et al*., 1990
	Euphorbia arabica	Leaves and stems	Kawashty *et al*., 1990
	E. arguta	Leaves and stems	Kawashty *et al*., 1990
	E. chamaescye	Leaves and stems	Kawashty *et al*., 1990
	E. dentroides	Leaves and stems	Kawashty *et al*., 1990
	E. dracunculoides	Leaves and stems	Kawashty *et al*., 1990

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Isoquercitrin [**169**]	*E. forskaolii*	Leaves and stems	Kawashty *et al*., 1990
	E. geniculata	Leaves and stems	Kawashty *et al*., 1990
	E. hirta	Leaves and stems	Kawashty *et al*., 1990
	E. hypericifolia	Leaves and stems	Kawashty *et al*., 1990
	E. hyssopifolia	Leaves and stems	Kawashty *et al*., 1990
	E. isthmia	Leaves and stems	Kawashty *et al*., 1990
	E. maculata	Aerial part	Agata *et al*., 1991
	E. paralias	Leaves and stems	Kawashty *et al*., 1990
	E. peplus	Leaves and stems	Kawashty *et al*., 1990
	E. prostrata	Leaves and stems	Kawashty *et al*., 1990
	E. retusa	Aerial part	Saleh, 1985
		Leaves and stems	Kawashty *et al*., 1990
	E. scordifolia	Leaves and stems	Kawashty *et al*., 1990
	E. supina	Aerial part	Agata *et al*., 1991
	Phyllanthus sellowianus	Stem bark	Hnatyszyn *et al*., 2002
Isorhamnetin-3-*O*-β-glucopyranoside-7-*O*-α-rhamnopyranoside [**170**]	*Chrozophora obliqua*	Aerial part	Mohamed, 2001
Kaempferol-3-arabinoside [**171**]	*Euphorbia paralias*	Leaves and stems	Kawashty *et al*., 1990

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Kaempferol-3-galactoside [**172**]	*E. paralias*	Leaves and stems	Kawashty *et al*., 1990
Kaempferol-3-*O*-(2′-*O*-galloyl)-*β*-D-glucoside [**173**]	*E. maculata*	Aerial part	Agata *et al*., 1991
Kaempferol-7-*O*-glucoside [**174**]	*Chymaesyce prostrata*	Aerial part	Rojas *et al*., 1999
	Euphorbia helioscopia	Leaves and stems	Kawashty *et al*., 1990
	E. isthmia	Leaves and stems	Kawashty *et al*., 1990
Kaempferol-3-*O*-rutinoside [**175**]	*Acalypha indica*	Flowers and leaves	Nahrstedt *et al*., 2006
	Chrozophora brocchiana	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	C. verbascifolia	Leaves and stems	Hashim *et al*., 1990
	Euphorbia chamaescye	Leaves and stems	Kawashty *et al*., 1990
	E. geniculata	Leaves and stems	Kawashty *et al*., 1990
	Mnihot esculenta	Leaves	Prawat *et al*., 1995
	Ricinus communis	Roots	Kang *et al*., 1985
Mauritianin [**176**]	*Acalypha indica*	Flowers and leaves	Nahrstedt *et al*., 2006
Myricetin-3-*O*-*α*-L-arabinopyranoside [**177**]	*Alchrnea castaneaefolia*	Leaves	Lima *et al*., 2006

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

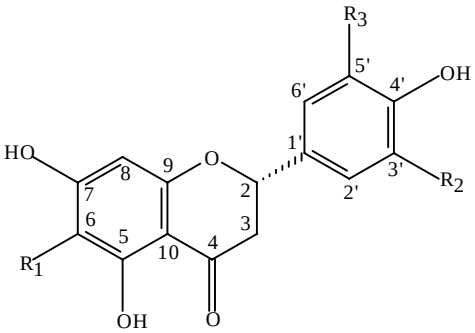
Compounds	Sources	Plant part	References
Myricetin-3-*O*-glucoside [**178**]	*Bridelia ferruginea*	Leaves	Mensah and Achenbach, 1985
Myricetin-3-*O*-rhamnoside [**179**]	*B. ferruginea*	Leaves	Mensah and Achenbach, 1985
Quercetin-3-arabinoside [**180**]	*Alchornea castaneaefolia*	Leaves	Lima *et al*., 2006
	Euphorbia hypericifolia	Leaves and stems	Kawashty *et al*., 1990
	E. paralias	Leaves and stems	Rizk *et al*., 1979; Kawashty *et al*., 1990
Quercetin-3-*O*-*β*-D-galacto pyranoside [**181**]	*Alchornea castaneaefolia*	Leaves	Lima *et al*., 2006
Quercetin-3-*O*-(2''-*O*-galloyl)-*β*-D-glucoside [**182**]	*Euphorbia maculata*	Aerial part	Agata *et al*., 1991
Quercetin-3-*O*-*β*-glucopyranoside-7-*O*-*α*-rhamnopyranoside [**183**]	*Chrozophora obliqua*	Aerial part	Mohamed, 2001
Quercetin-7-*O*-glucoside [**184**]	*Euphorbia helioscopia*	Leaves and stems	Kawashty *et al*., 1990
Quercetin-3-xyloside [**185**]	*E. paralias*	Leaves and stems	Kawashty *et al*., 1990
Quercitrin [**186**]	*Adenopeltis colliguaya*	Leaves	Ugarte and Silva, 1972
	Euphorbia arguta	Leaves and stems	Kawashty *et al*., 1990
	E. forskaolii	Leaves and stems	Kawashty *et al*., 1990
	E. hirta	Leaves	Yoshida *et al*., 1988
		Leaves and stems	Kawashty *et al*., 1990
	E. hypericifolia	Leaves and stems	Kawashty *et al*., 1990

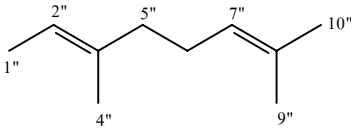
Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

Compounds	Sources	Plant part	References
Quercitrin [**186**]	*E. retusa*	Aerial part	Saleh, 1985
		Leaves and stems	Kawashty *et al*., 1990
	Senefelderopsis chiribiquetensis	Leaves and stems	Canelon *et al*., 2005
Rutin [**187**]	*Acalypha indica*	Flowers and leaves	Nahrstedt *et al*., 2006
	Bridelia ferruginea	Leaves	Mensah and Achenbach, 1985
	Chrozophora brocchiana	Leaves and stems	Hashim *et al*., 1990
	C. obliqua	Leaves and stems	Hashim *et al*., 1990
	C. plicata	Leaves and stems	Hashim *et al*., 1990
	C. tinctoria	Leaves and stems	Hashim *et al*., 1990
	C. verbascifolia	Leaves and stems	Hashim *et al*., 1990
	Euphorbia arguta	Leaves and stems	Kawashty *et al*., 1990
	E. chamaescye	Leaves and stems	Kawashty *et al*., 1990
	E. geniculata	Leaves and stems	Kawashty *et al*., 1990
	E. hyssopifolia	Leaves and stems	Kawashty *et al*., 1990
	E. peplus	Leaves and stems	Kawashty *et al*., 1990
	E. retusa	Aerial part	Saleh, 1985
		Leaves and stems	Kawashty *et al*., 1990
	Mcaranga triloba	Leaves	Jang *et al*., 2004

Table 2. Distribution of flavonoids in the family Euphorbiaceae (continued)

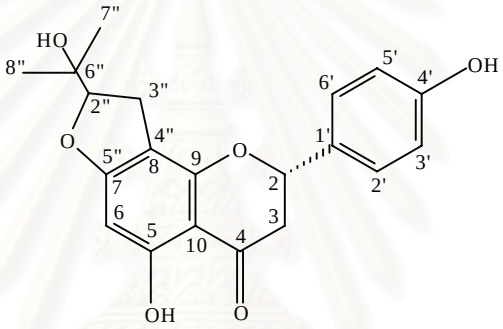
Compounds	Sources	Plant part	References
Rutin [**187**]	*Manihot esculenta*	Leaves	Prawat *et al*., 1995
	Phyllanthus sellowianus	Stem bark	Hnatyszyn *et al*., 2002
	Ricinus communis	Leaves	Khafagy *et al*., 1979
	Senefelderopsis chiribiquetensis	Leaves and stems	Canelon *et al*., 2005
8. Flavan Epicatechin [**188**]	*Sauropus hirsutus*	Aerial part	Lohakol, 2003
Gallocatechin-(4′-*O*-7)-epigallocatechin [**189**]	*Bridelia ferruginea*	Stem bark	Cimanga *et al*., 2001
9. Rotenoid 4,5-Dihydro-5′α-hydroxy-4′α-methoxy-6a,12a-dehydro-α-toxicarol [**190**]	*Macaranga triloba*	Leaves	Jang *et al*., 2004
Sumatrol [**191**]	*M. indica*	Leaves	Sultana and Ilyas, 1987



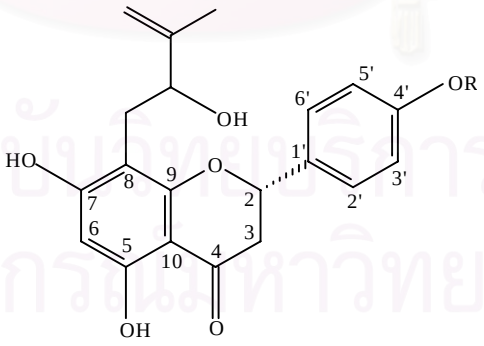


geranyl =

	R_1	R_2	R_3
Bonannione A [**105**]	geranyl	H	H
Macaranga flavanone A [**113**]	H	geranyl	H

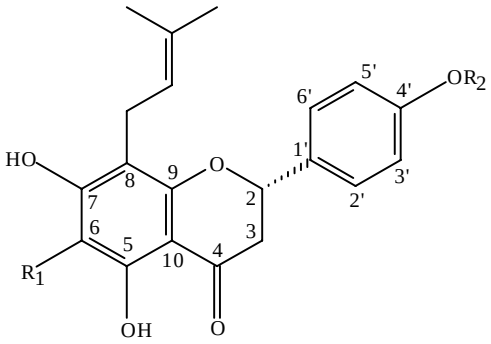


5,4′-Dihydroxy-[2″-(1-hydroxy-1-methylethyl) dihydrofurano]-(7,8:5″,4″) flavanone [**106**]

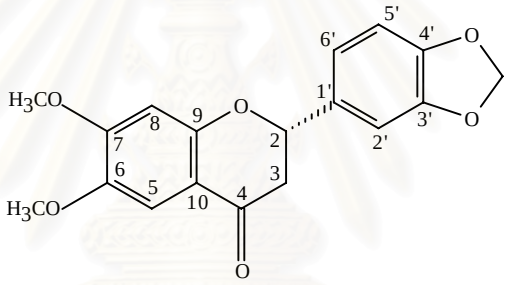


5,7-Dihydroxy-4′-methoxy-8-(2-hydroxy-3-methylbut-3-enyl) flavanone [**107**]	R = CH_3
Tomentosanol D [**123**]	R = H

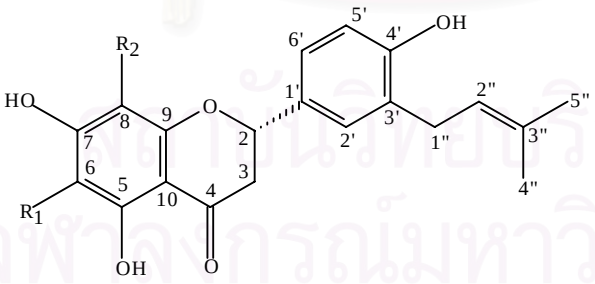
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae

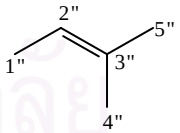


	R_1	R_2
5,7-Dihydroxy-4′-methoxy-8-(3-methyl but-2-enyl) flavanone [**108**]	H	CH_3
Lonchocarpol A [**112**]	Prenyl	H
Sophoraflavanone B [**118**]	H	H



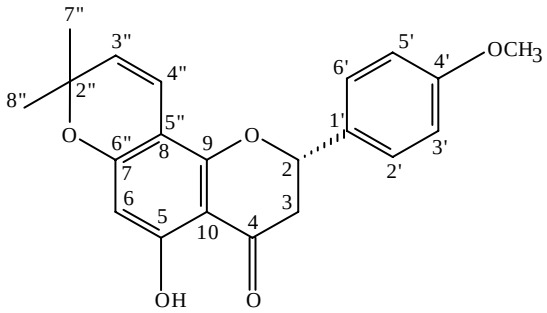
6,7-Dimethoxy-3′,4′-methylenedioxy flavanone [**109**]



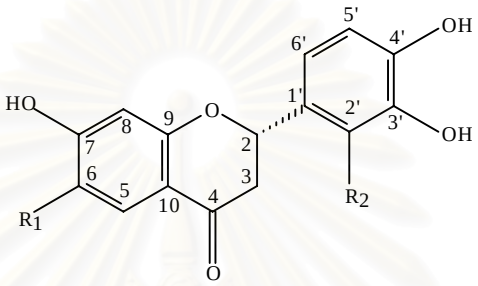
isoprenyl = 

	R_1	R_2
Euchrestaflavanone A [**110**]	H	isoprenyl
Macaranga flavanone B [**114**]	isoprenyl	H

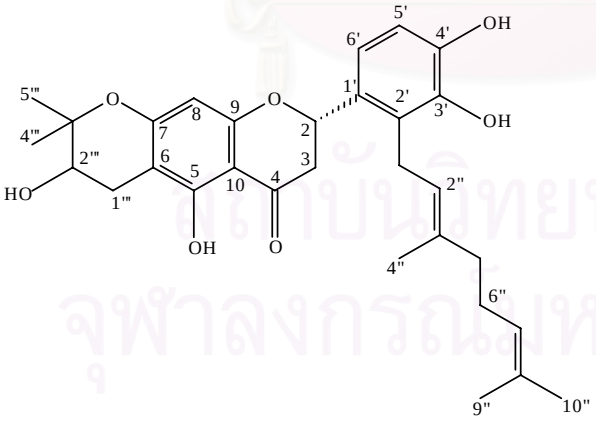
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



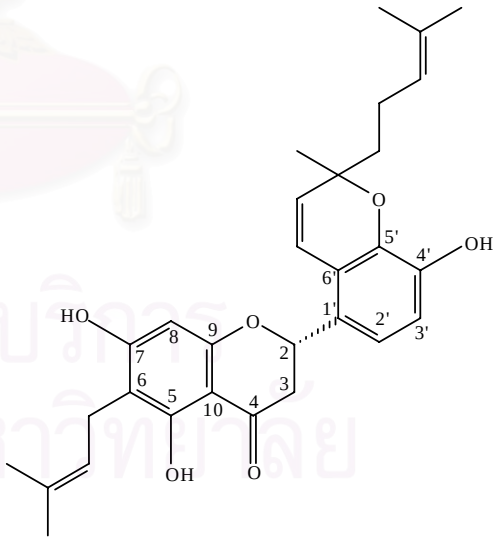
5-Hydroxy-4′-methoxy-2″,2″-dimethylpyrano-(7,8:6″,5″) flavanone [**111**]



	R_1	R_2
Nymphaeol-A [**115**]	geranyl	H
Nymphaeol-B [**116**]	H	geranyl
Nymphaeol-C [**117**]	prenyl	geranyl

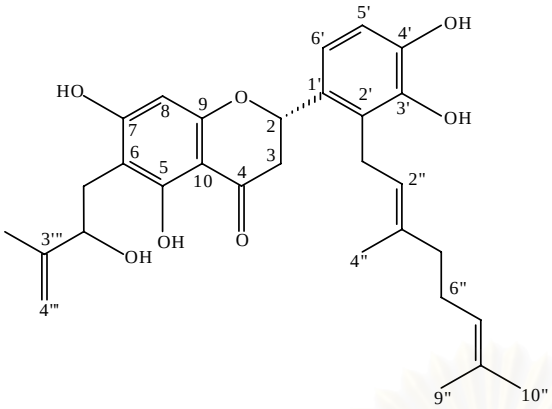


Tanariflavanone A [**119**]

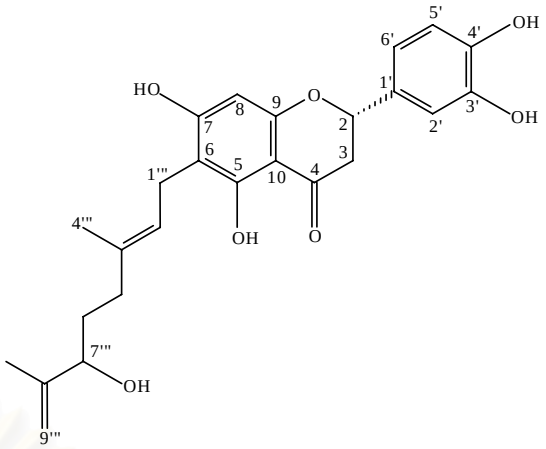


Tanariflavanone B [**120**]

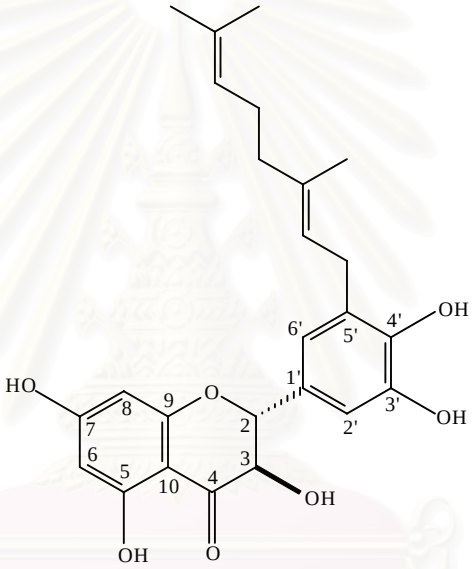
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



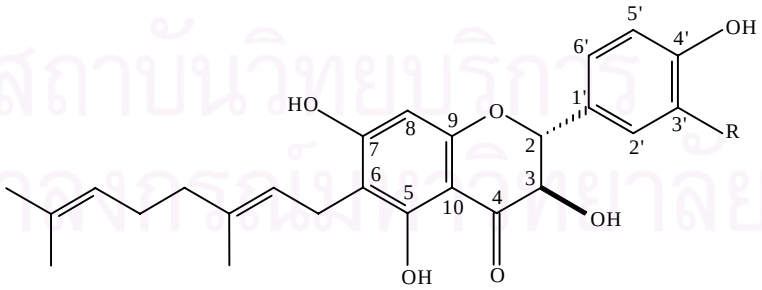
Tanariflavanone C [**121**]



Tanariflavanone D [**122**]



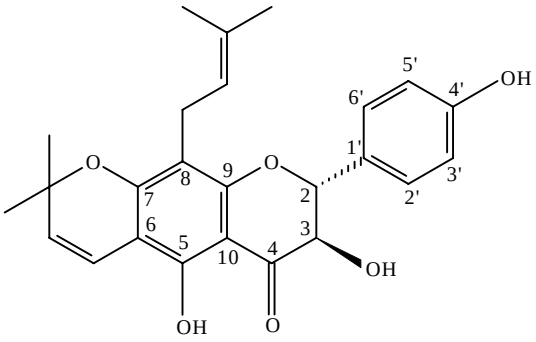
Alnifoliol [**124**]



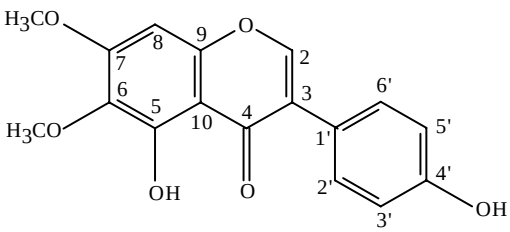
Bonanniol A [**125**] R = H

Diplacol [**126**] R = OH

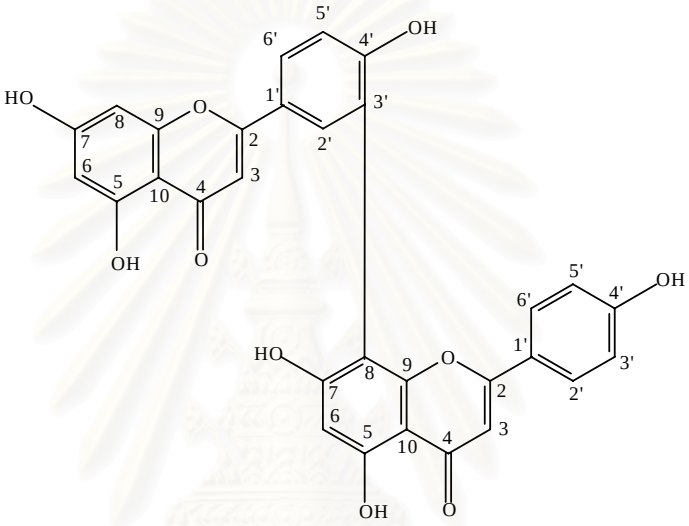
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



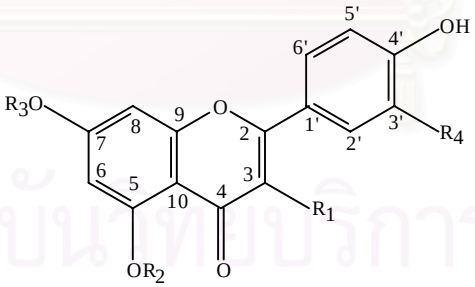
Lupinifolinol [**127**]



7-Methyltectorigenin [**128**]

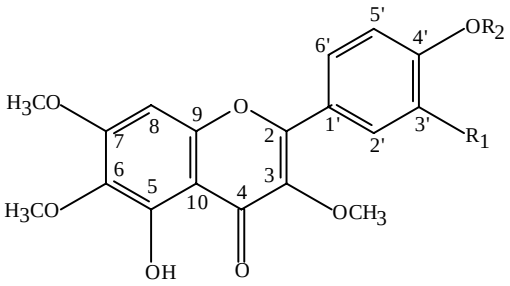


Amentoflavone [**129**]

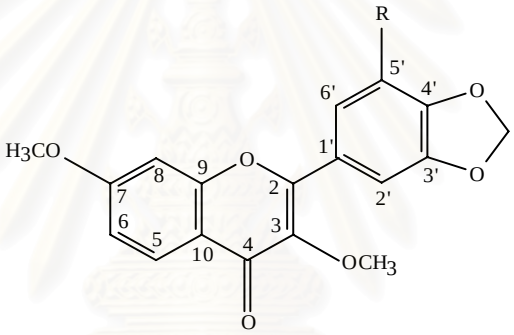


	R_1	R_2	R_3	R_4
Apigenin [**130**]	H	H	H	H
Apigenin-5-*O*-glucoside [**138**]	H	Glc	H	H
Apigenin-7-*O*-glucoside [**139**]	H	H	Glc	H
Luteolin-3-*O*-glucoside [**141**]	OGlc	H	H	OH
Luteolin-7-*O*-glucoside [**142**]	H	H	Glc	OH

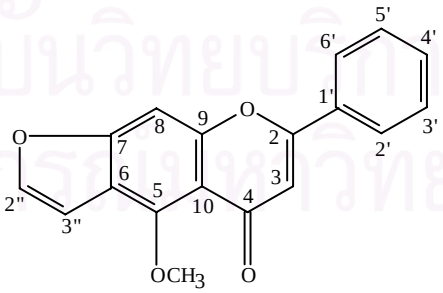
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



	R_1	R_2
Artemetin [**131**]	OCH_3	CH_3
Casticin [**132**]	OH	CH_3
Chrysosplenol-D [**133**]	OH	H
Penduletin [**136**]	H	H

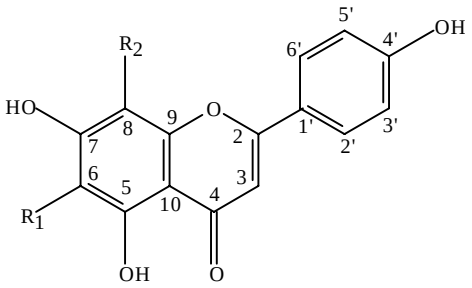


Desmethoxykanugin [**134**]	R = H
Kanugin [**135**]	R = OCH_3

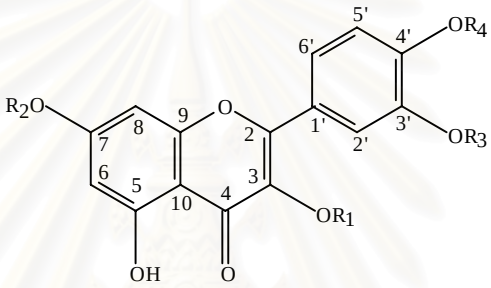


Pinnatin [**137**]

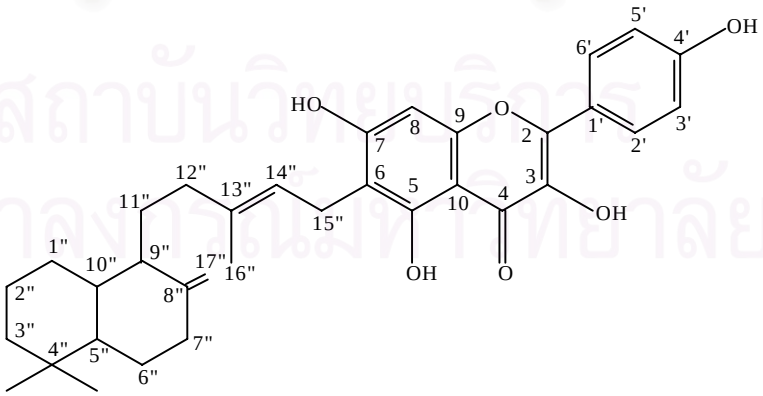
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



	R_1	R_2
Isovitexin [**140**]	Glc	H
Vitexin [**143**]	H	Glc

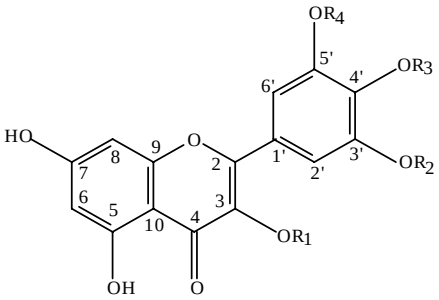


	R_1	R_2	R_3	R_4
Ayanin [**144**]	CH_3	CH_3	H	CH_3
Isolicoflavonol [**147**]	H	H	isoprenyl	H
Rutisin [**159**]	CH_3	CH_3	CH_3	CH_3

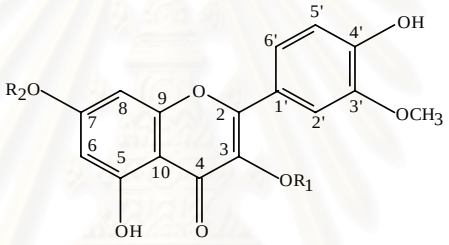


Denticulaflavonol [**145**]

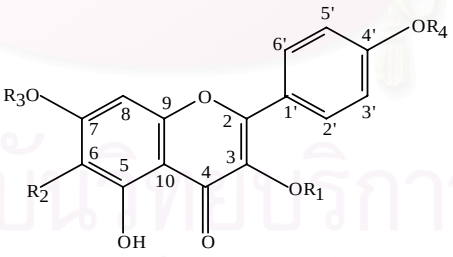
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



	R_1	R_2	R_3	R_4
Ferrugin [**146**]	H	CH_3	CH_3	CH_3
Myricetin [**156**]	H	H	H	H
Myricetin-3-*O*-α-arabinopyranoside [**177**]	α-Ara	H	H	H
Myricetin-3-*O*-glucoside [**178**]	Glc	H	H	H
Myricetin-3-*O*-rhamnoside [**179**]	Rha	H	H	H
3,3′,4′,5′-Tetra-*O*-methylmyricetin [**160**]	CH_3	CH_3	CH_3	CH_3

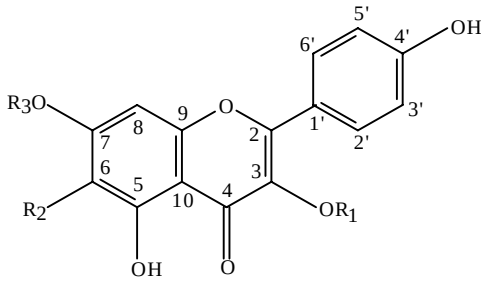


	R_1	R_2
Isorhamnetin [**148**]	H	H
Isorhamnetin-3-*O*-β-glucopyranoside-7-*O*-α-rhamnopyranoside [**170**]	β-Glc	α-Rha



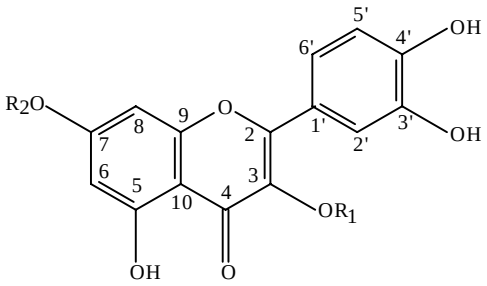
	R_1	R_2	R_3	R_4
Kaempferol [**149**]	H	H	H	H
Kaempferol-3,6-dimethyl ether [**150**]	CH_3	OCH_3	H	H
Kaempferol-3,7-dimethyl ether [**151**]	CH_3	H	CH_3	H
Kaempferol-3,4′,7-dimethyl ether [**152**]	CH_3	H	CH_3	CH_3
Macarangin [**153**]	H	geranyl	H	H
3-*O*-Methylmacarangin [**154**]	CH_3	geranyl	H	H

Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)

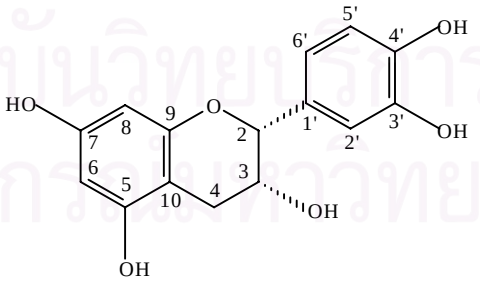


	R_1	R_2	R_3
Astragalin [**161**]	Glc	H	H
Biorobin [**162**]	α-L-Rha-(1→6)-β-D-Gal	H	H
Clitorin [**163**]	α-L-Rha-(1→2)-α-L-Rha-(1→6)-β-D-Glc	H	H
3-*O*-β-D-Glucosyl-(1→6)-β-D-glucosyl kaempferol [**164**]	β-Glc^6-β-Glc	H	H
3-*O*-β-D-Glucosyl-(1→6)-β-D-glucosyl-7-*O*-α-L-rhamnosyl kaempferol [**165**]	β-Glc^6-β-Glc	H	α-Rha
3-*O*-β-D-Glucosyl-7-*O*-α-L-rhamnosyl kaempferol [**166**]	β-Glc	H	α-Rha
6-Hydroxykaempferol-7-rutinoside [**167**]	H	OH	Glc^6-Rha
Kaempferol-3-arabinoside [**171**]	Ara	H	H
Kaempferol-3-galactoside [**172**]	Gal	H	H
Kaempferol-3-*O*-(2"-*O*-galloyl)-β-D-glucoside [**173**]	2"-*O*-galloyl-β-Glc	H	H
Kaempferol-7-*O*-glucoside [**174**]	H	H	Glc
Kaempferol-3-*O*-rutinoside [**175**]	Glc^6-Rha	H	H
Mauritianin [**176**]	α-L-Rha-(1→2)-α-L-Rha-(1→6)-β-D-Gal	H	H

Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)

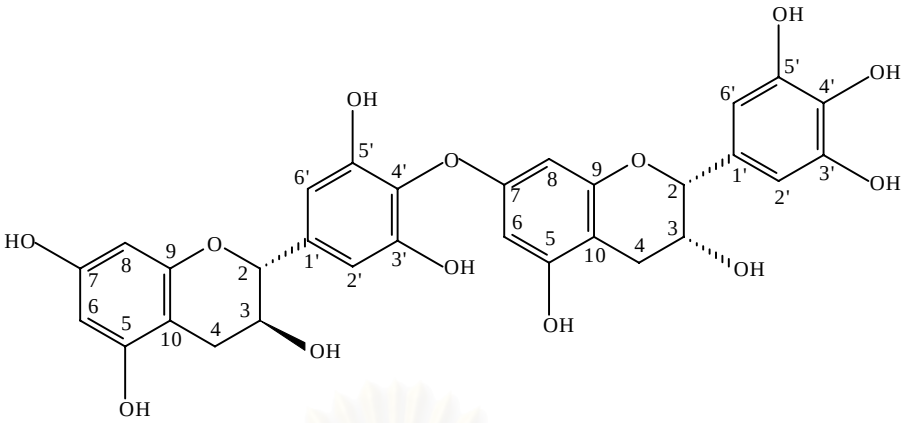


	R_1	R_2
Hyperoside [**168**]	Gal	H
Isoquercitrin [**169**]	Glc	H
3-*O*-Methylquercetin [**155**]	CH_3	H
Quercetin [**157**]	H	H
Quercetin-3,7-dimethyl ether [**158**]	CH_3	CH_3
Quercetin-3-arabinoside [**180**]	Ara	H
Quercetin-3-*O*-*β*-D-galactopyranoside [**181**]	*β*-Gal	H
Quercetin-3-*O*-(2"-*O*-galloyl)-*β*-D-glucoside [**182**]	2"-*O*-galloyl-*β*-Glc	H
Quercetin-3-*O*-*β*-D-glucopyranoside-7-*O*-*α*-rhamnopyranoside [**183**]	*β*-Glc	*α*-Rha
Quercetin-7-*O*-glucoside [**184**]	H	Glc
Quercetin-3-xyloside [**185**]	Xyl	H
Quercitrin [**186**]	Rha	H
Rutin [**187**]	Glc^6-Rha	H

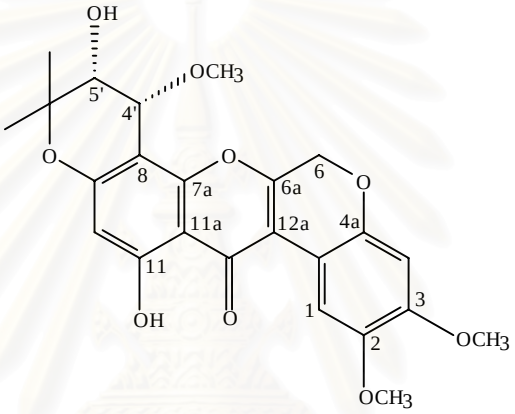


Epicatechin [**188**]

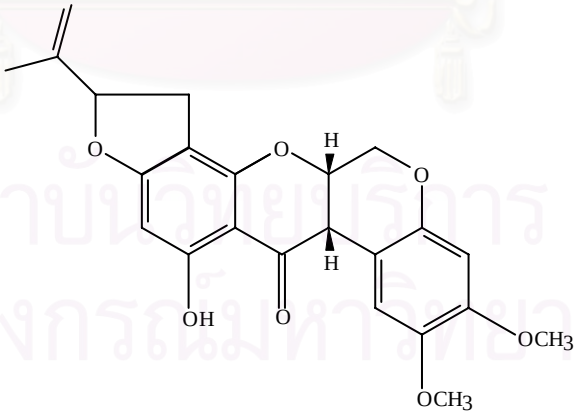
Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)



Gallocatechin-[4′-*O*-7]-epigallocatechin [**189**]



4,5-Dihydro-5′α-hydroxy-4′α-methoxy-6a,12a-dehydro-α-toxicarol [**190**]



Sumatrol [**191**]

Figure 4. Chemical structures of flavonoids in the family Euphorbiaceae (continued)

2. Chemical constituents of plants in the genus *Sauropus*

Of the 27 species of genus *Sauropus* found in Thailand, only 3 species, i.e. *Sauropus androgynus* (L.) Merr., *S. hirsutus* Beille and *S. quadrangularis* (Willd.) Mull. Arg., have been chemically investigated and a wide range of constituents, including terpenoids, steroids, alkaloids, flavonoids, lignans, lignan glycosides and nucleosides, have been reported as shown in **Table 3.**

Table 3. Chemical constituents of plants in the genus *Sauropus*

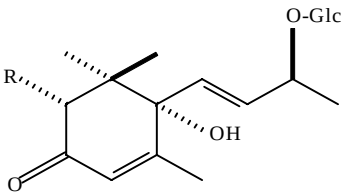
Plants	Plant part	Chemical type	Name	References
Sauropus androgynus (L.) Merr.	Aerial part	Terpenoids	Corchoionoside C [**192**]	Kanchanapoom *et al.*,2003
			Sauroposide [**193**]	Kanchanapoom *et al.*,2003
	Leaves	Alkaloids	Papaverine [**194**]	Bender and Ismail, 1973; Cordell *et al.*, 1989
	Aerial part	Flavonoids	3-*O*-β-D-Glucosyl-(1→6)-β-D-glucosyl kaempferol [**164**]	Wang and Lee, 1997; Yu *et al.*, 2006
			3-*O*-β-D-Glucosyl-(1→6)-β-D-glucosyl-7-*O*-α-L-rhamnosyl kaempferol [**165**]	Wang and Lee, 1997; Yu *et al.*, 2006
			3-*O*-β-D-Glucosyl-7-*O*-α-L-rhamnosyl kaempferol [**166**]	Wang and Lee, 1997
			Quercetin [**157**]	Miean and Mohamed, 2001
		Lignan glycosides	(+)-Isolariciresinol-3α-*O*-β-gluco pyranoside [**195**]	Kanchanapoom *et al.*,2003

Table 3. Chemical constituents of plants in the genus *Sauropus* (continued)

Plants	Plant part	Chemical type	Name	References
S. androgynus (L.) Merr.	Aerial part	Lignan glycosides	(-)-Isolariciresinol-3α-*O*-β-glucopyranoside [**196**]	Kanchanapoom *et al.*,2003
			(-)-Isolariciresinol-3α-*O*-β-apiofuranosyl-(1→2)-*O*-β-gluco pyranoside [**197**]	Kanchanapoom *et al.*,2003
			Liriodendrin [**198**]	Kanchanapoom *et al.*,2003
		Nucleosides	Adenosine [**199**]	Wang and Lee, 1997
			5′-Deoxy-5′-methyl sulphinyl adenosine [**200**]	Wang and Lee, 1997
			Guanosine [**201**]	Kanchanapoom *et al.*,2003
			Uridine [**202**]	Wang and Lee, 1997
S. hirsutus Beille	Aerial part	Steroids	β-Sitosterol [**203**]	Lohakol, 2003
		Alkaloids	4-Methoxy-2-methyl-7,8-methylenedioxy-1-isoquinolone [**204**]	Lohakol, 2003
			4,6-Dimethoxy-2-methyl-7,8-methylene dioxy-1-isoquinolone [**205**]	Lohakol, 2003
		Flavonoids	Epicatechin [**188**]	Lohakol, 2003
S. quadrangularis (Willd.) Mull. Arg.	Aerial part	Lignans	Diphyllin [**206**]	Satyanarayana and Ramu, 1995

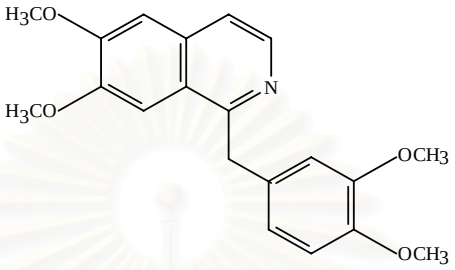
Table 3. Chemical constituents of plants in the genus *Sauropus* (continued)

Plants	Plant part	Chemical type	Name	References
S. quadrangularis (Willd.) Mull. Arg.	Aerial part	Lignans	Benzoyl diphyllin [**207**]	Satyanarayana and Ramu, 1995
			6-Bromo-3,4-dimethoxybenzoyl diphyllin [**208**]	Satyanarayana and Ramu, 1995
			6-Bromo-3,4-methylenedioxy benzoyl diphyllin [**209**]	Satyanarayana and Ramu, 1995
			Cinnamoyl diphyllin [**210**]	Satyanarayana and Ramu, 1995
			3,4-Methylenedioxy benzoyl diphyllin [**211**]	Satyanarayana and Ramu, 1995
			4-Nitro-benzoyl diphyllin [**212**]	Satyanarayana and Ramu, 1995
			3,4,5-Trimethyl benzoyl diphyllin [**213**]	Satyanarayana and Ramu, 1995
			Tran-(*3R*,*4S*) bis (3′,4′-methylenedioxy benzyl) tetrahydro furan [**214**]	Satyanarayana and Ramu, 1995

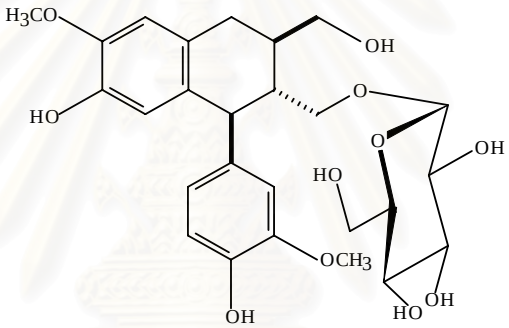


Corchoionoside C [**192**] R = H

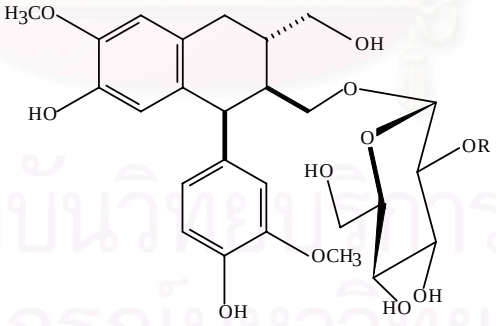
Sauroposide [**193**] R = OH



Papaverine [**194**]

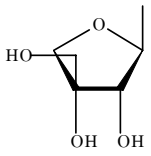


(+)-Isolariciresinol-3α-*O*-β-glucopyranoside [**195**]



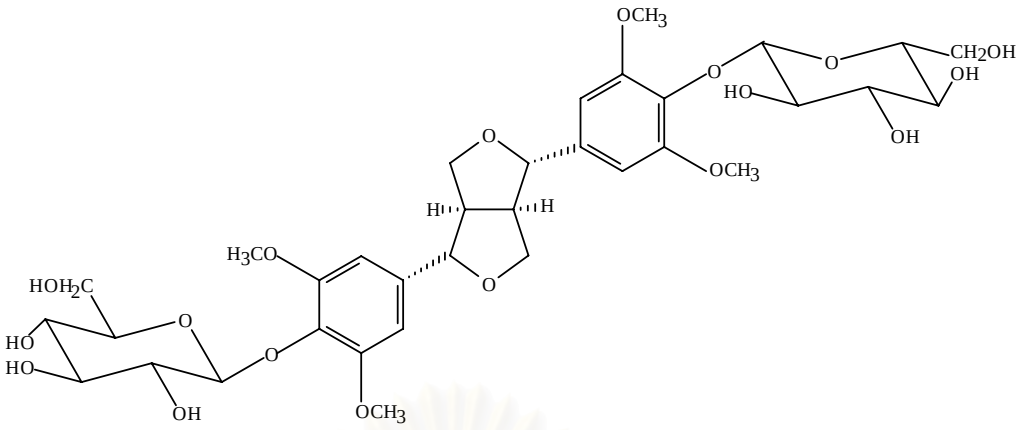
(-)-Isolariciresinol-3α-*O*-β-glucopyranoside [**196**] R = H

(-)-Isolariciresinol-3α-*O*-β-apiofuranosyl- R =

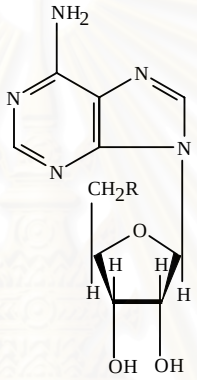


(1→2)-*O*-β-gluco pyranoside [**197**]

Figure 5. Chemical structures of plants in the genus *Sauropus*

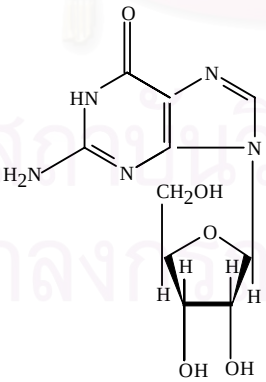


Liriodendrin [**198**]

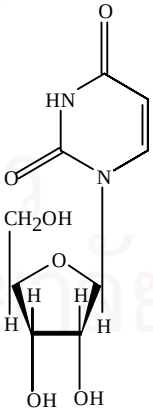


Adenosine [**199**] R = OH

5′-Deoxy-5′-methylsulphinyl adenosine [**200**] R = SCH_3

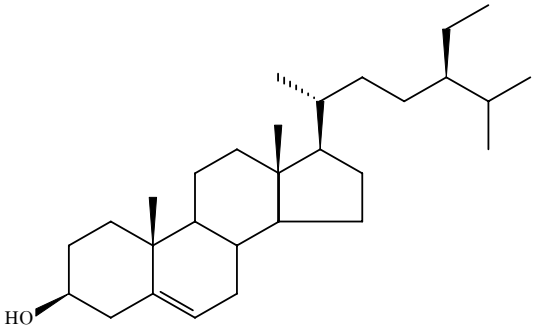


Guanosine [**201**]

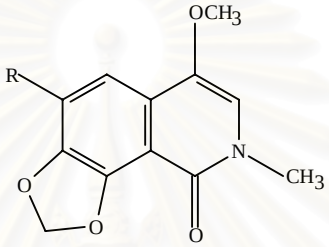


Uridine [**202**]

Figure 5. Chemical structures of plants in the genus *Sauropus* (continued)

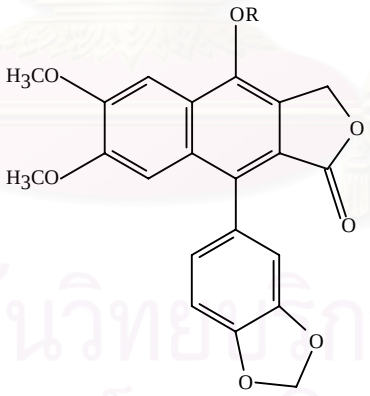


β-Sitosterol [**203**]

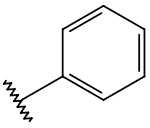


4-Methoxy-2-methyl-7,8-methylenedioxy-1-isoquinolone [**204**] R = H

4,6-Dimethoxy-2-methyl-7,8-methylene dioxy-1-isoquinolone [**205**] R = OCH_3

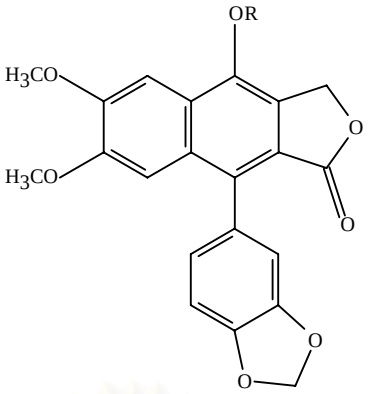


	R
Diphyllin [**206**]	H

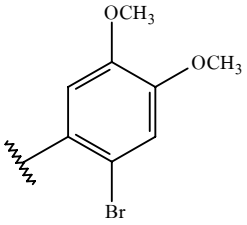


Benzoyl diphyllin [**207**]

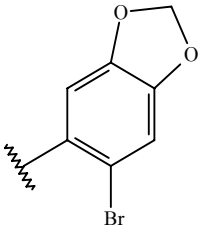
Figure 5. Chemical structures of plants in the genus *Sauropus* (continued)



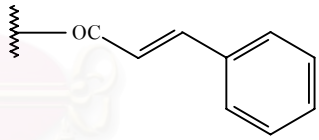
R



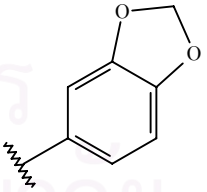
6-Bromo-3,4-dimethoxybenzoyl diphyllin [**208**]



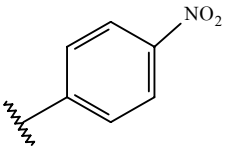
6-Bromo-3,4-methylenedioxybenzoyl diphyllin [**209**]



Cinnamoyl diphyllin [**210**]

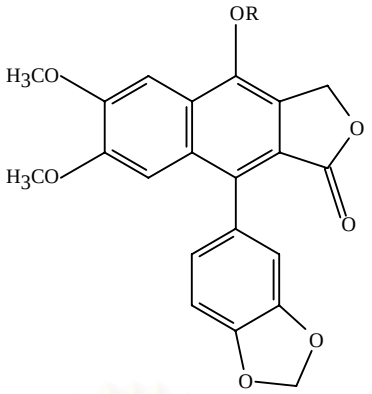


3,4-Methylenedioxybenzoyl diphyllin [**211**]

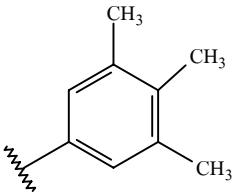


4-Nitro-benzoyl diphyllin [**212**]

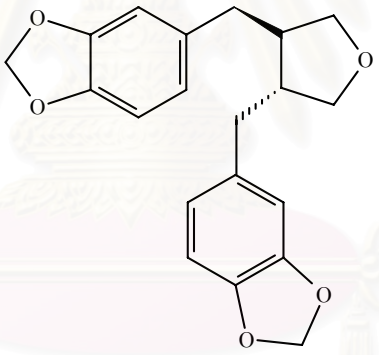
Figure 5. Chemical structures of plants in the genus *Sauropus* (continued)



R



3,4,5-Trimethylbenzoyl diphyllin [**213**]



Trans-(*3R,4S*) bis (3′,4′-methylenedioxy benzyl) tetrahydrofuran [**214**]

Figure 5. Chemical structures of plants in the genus *Sauropus* (continued)

CHAPTER III

EXPERIMENTAL

1. Source of plant material

Sauropus bacciformis (L.) Airy Shaw was collected from Sam Roi Yot National Park, Prachuap Khiri Khan province, Thailand in October 2006. The plant was identified by Professor Dr. Thawatchai Santisuk of Botanical Section, Royal Forest Department, Ministry of Agriculture and Co-operatives, Bangkok, Thailand. A voucher specimen, BKF. No. 148136, is deposited at the Forest Herbarium (BKF), Royal Forest Department, Ministry of Agriculture and Co-operative, Bangkok, Thailand.

2. General techniques

2.1 Chromatographic technique

2.1.1 Analytical thin-layer chromatography (TLC)

Technique	:	One dimension, ascending
Adsorbent	:	Silica gel 60 F_{254} (E. Merck) precoated plate
Layer thickness	:	0.2 mm
Solvent system	:	Various solvent systems depending on materials
Distance	:	5.0 cm
Temperature	:	Laboratory temperature 30-35 °C
Detection	:	1) UV light at the wavelengths of 254 and 365 nm
		2) 10% Sulfuric acid in ethanol, heating at 110 °C for 5-10 minutes

2.1.2 Column chromatography (CC)

Column	:	Flat bottom glass column (various diameters)
Adsorbent	:	1) Silica gel 60 (No. 7734, E. Merck) particle size 0.063 -0.200 nm (70-230 mesh ASTM)
	:	2) Silica gel 60 (No. 9385, E. Merck) particle size 0.040 -0.063 nm (230-400 mesh ASTM)
Packing method	:	Wet packing

Sample loading : 1) Dry packing

The sample was dissolved in a small volume of organic solvent, mixed with a small quantity of adsorbents, triturated, dried and then loaded on top of the column.

: 2) Wet packing

The sample was dissolved in a small volume of the eluent, then loaded on top of the column.

Solvent system : Various solvent systems depending on materials

Detection : Fractions were examined by TLC technique in the same manner as described in section 2.1.1

2.1.3 Gel filtration chromatography

Gel Filter : Sephadex LH-20

Packing method : Gel filter was suspended in the eluent and left standing to swell for 24 hours prior to use. It was then poured into the column and allowed to set tightly.

Sample loading : The sample was dissolved in a small volume of the eluent and then applied gently on top of the column.

Detection : Fractions were examined by TLC technique in the same manner as described in section 2.1.1

Solvent system : CH_2Cl_2-MeOH (1:1)

CH_2Cl_2-MeOH (1:4)

2.2 Crystallization technique

The compounds were crystallized from various solvents. Each compound was dissolve in selected solvent until saturated and left standing at room temperature until amorphous powder or crystals were formed.

2.3 Spectroscopy

2.3.1 Ultraviolet (UV) absorption spectra

UV spectra (in DMSO) were obtained on a Shimadzu UV-1601 spectrophotometer (Scientific Equipment Center, Prince of Songkla University).

2.3.2 Infrared (IR) absorption spectra

IR spectra (KBr disc and thin film) were recorded on a Perkin Elmer FT-IR1760X spectrophotometer (Scientific and Technological Research Equipment Center, Chulalongkorn University).

2.3.3 Mass spectra (MS)

Electron impact mass spectra (EIMS) were obtained on a Thermo Finnigan MAT 95 XL mass spectrometer (Scientific Equipment Center, Prince of Songkla University).

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

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

The ^{1}H-NMR (500 MHz) and ^{13}C-NMR (125 MHz) spectra were obtained on an INOVA-500 500 MHz NMR spectrometer (Scientific and Technological Research Equipment Center, Chulalongkorn University).

Solvents for NMR spectra were deuterated chloroform ($CDCl_3$) and deuterated dimethylsulfoxide (DMSO-d_6). Chemical shifts were reported in ppm scale using the chemical shift of the solvent as the reference signal.

2.4 Physical property

2.4.1 Melting points

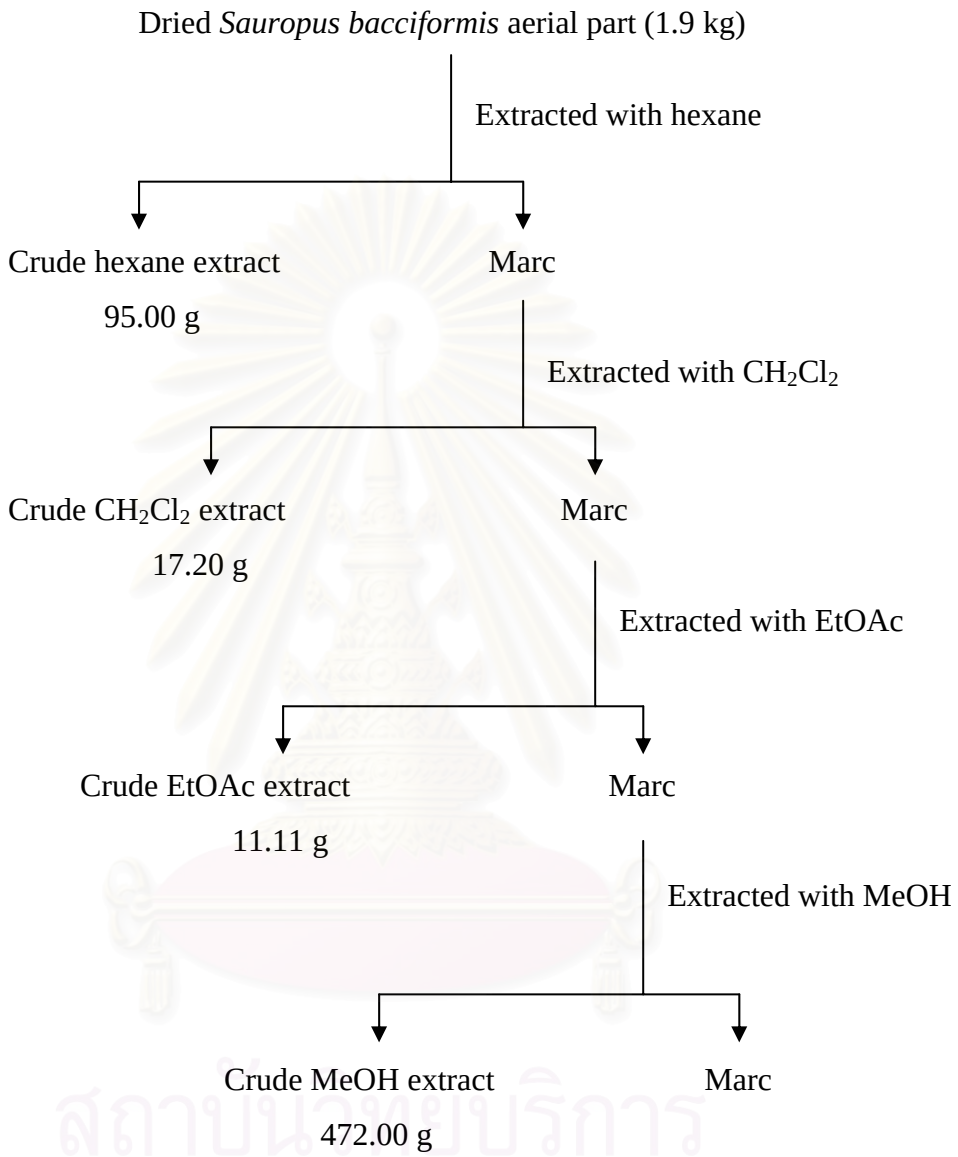
Melting points were obtained on a Fisher-John melting point apparatus (Department of Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University).

2.5 Solvents

Throughout this work, all organic solvents used in the extraction and isolation procedure were of commercial grade and were redistilled prior to use.

3. Extraction procedure

The dried aerial part of *Sauropus bacciformis* (1.9 kg) was ground and extracted with hexane (7 × 6 L) in a percolator to give, on evaporation, 95.00 g of crude hexane extract (5.00% of dried weight). The remaining marc was air-dried and consequently extracted with CH_2Cl_2 (7 × 6 L), EtOAc (7 × 6 L) and MeOH (7 × 6 L) in the same manner to give, on evaporation, 17.20 g of crude CH_2Cl_2 extract (0.91% of dried weight), 11.11 g of crude EtOAc extract (0.58% of dried weight) and 472.00 g of crude MeOH extract (24.84% of dried weight), respectively.



Scheme 2. Extraction of *Sauropus bacciformis* aerial part

4. Isolation procedure

4.1 Fractionation of the hexane extract

The hexane extract (15.00 g) was subjected to a silica gel column chromatography (450 g, 10 × 15 cm) eluted with hexane-acetone (49:1). Two hundred and forty-nine 30-ml fractions were collected and combined according to their TLC patterns into eleven major fractions (H01-H11) as shown in **Table 4.**

Table 4. Combined fractions from the hexane extract

Fraction	Number of eluates	Weight (g)
H01	1-16	0.38
H02	17-55	2.43
H03	56-62	0.39
H04	63-72	0.62
H05	73-83	0.52
H06	84-106	1.56
H07	107-129	1.13
H08	130-167	0.75
H09	168-215	0.82
H10	216-249	1.67
H11	MeOH eluate	4.23

4.1.1 Isolation of compound SB1

Fraction H03 (0.39 g), which showed one main spot on TLC plate, was further separated by gel filtration chromatography using a Sephadex LH-20 column (1.5 × 82 cm) eluted with CH_2Cl_2-MeOH (1:1). Twenty-four 2-ml fractions were collected and combined based on their TLC patterns into three major fractions (H12-H14). Fraction H13 (78.6 mg) was crystallized in MeOH to give compound SB1 as colorless needles (6.8 mg, 0.0004% yield). Fraction H04 (0.62 g), was subjected to a silica gel column chromatography (25 g, 2 × 28 cm) eluted with hexane-acetone (97:3), to give forty-six fractions (5 ml each). These fractions were combined based on their TLC pattern to afford four fractions (H15-H18). Fraction H16 (108.4 mg) was futher fractionated by gel filtration chromatography using a Sephadex LH-20 column (1.5 × 82 cm) eluted with CH_2Cl_2-MeOH (1:1) to give three combined

fractions (H19-H21). Fraction H20 (34.5 mg) was purified by crystallization in MeOH to give an additional amount of compound SB1 (2.9 mg, 0.0002% yield).

4.1.2 Isolation of compound SB2

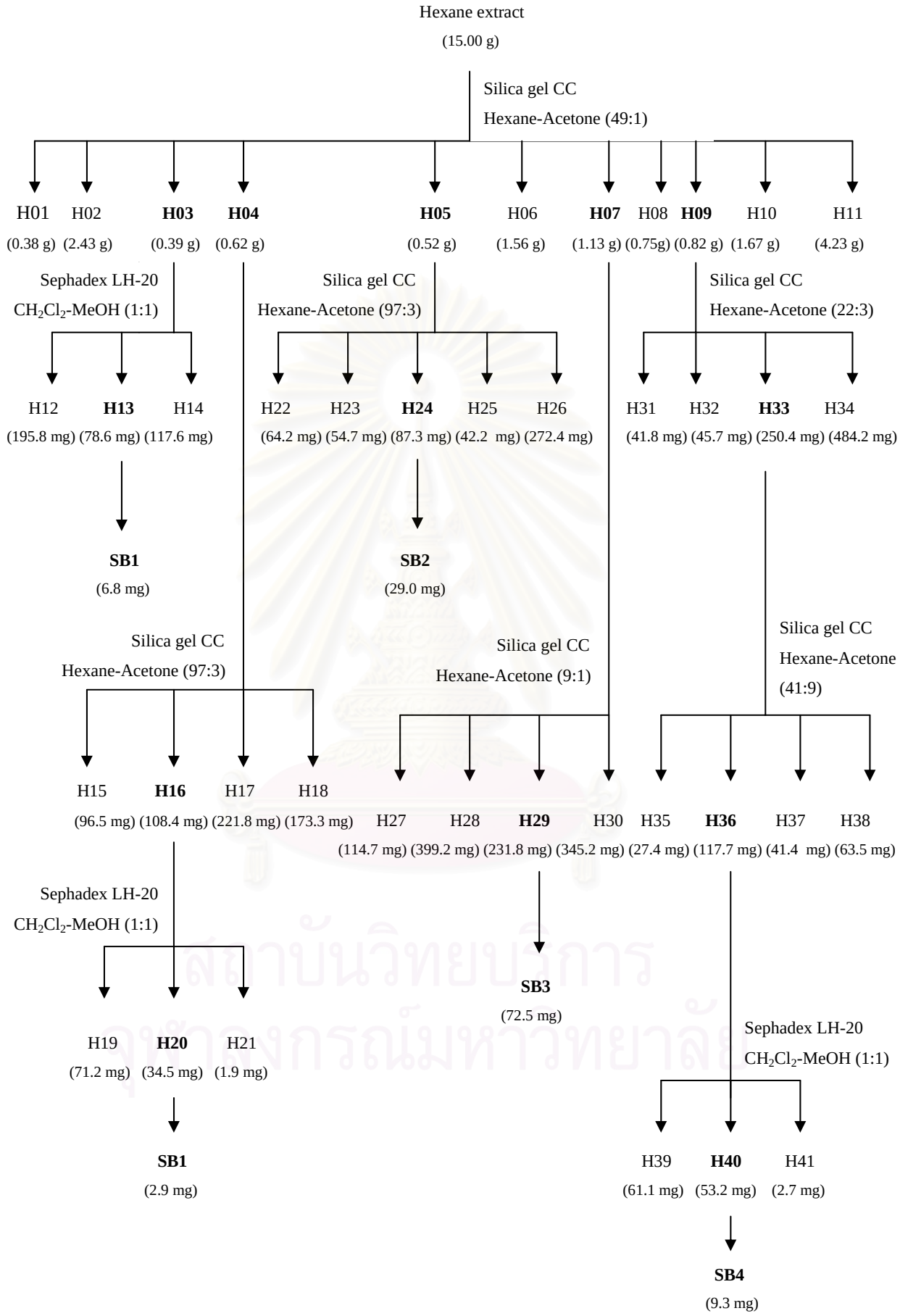
Fraction H05 (0.52 g) was chromatographed on a silica gel column (20 g, 2 × 22 cm) eluted with hexane-acetone (97:3). Twenty-six fractions (5 ml each) were combined based on their similar TLC pattern into five fractions (H22-H26). Fraction H25 (42.2 mg), which gave one pink-violet spot on TLC plate, was recrystallized in MeOH to give compound SB2 as white amorphous powder (29.0 mg, 0.002% yield)

4.1.3 Isolation of compound SB3

Fraction H07 (1.13 g) was separated on a silica gel column (50 g, 3 × 20 cm) eluted with hexane-acetone (9:1) to give fifty-nine fractions (5 ml each). Similarity of TLC pattern led to combination of these fractions into four combined fractions (H27-H30). Fraction H29 (231.8 mg), which gave one purple spot on TLC plate, was recrystallized in MeOH to give compound SB3 as colorless needles (72.5 mg, 0.004% yield).

4.1.4 Isolation of compound SB4

Fraction H09 (0.82 g) was separated on a silica gel column (30 g, 3 × 15 cm) eluted with hexane-acetone (22:3). Sixty-seven fractions (5 ml each) were collected and combined based on their TLC pattern to give four fractions (H31-H34). Fraction H33 (250.4 mg) was fractionated on a silica gel column (20 g, 2 × 22 cm) eluted with hexane-acetone (41:9) to give four combined fractions (H35-H38). Fraction H36 (117.7 mg) was further separated by gel filtration chromatography using a Sephadex LH-20 column (1.5 × 82 cm) eluted with CH_2Cl_2-MeOH (1:1) to give three combined fractions (H39-H41). Fraction H40 (53.2 mg), which showed one pink-violet spot on TLC plate, was further purified by crystallization in methanol. White amorphous powder (9.3 mg, 0.001% yield) was obtained and designated as compound SB4.



Sheme 3. Isolation of the hexane extract from *Sauropus bacciformis* aerial part

4.2 Fractionation of the EtOAc extract

The EtOAc extract (11.11 g) was subjected to a silica gel column (350 g, 10 × 10 cm) eluted with CH_2Cl_2-acetone (7:3). One hundred and forty-seven 30-ml fractions were collected and combined according to their TLC patterns into seven major fractions (E01-E07) as shown in **Table 5.**

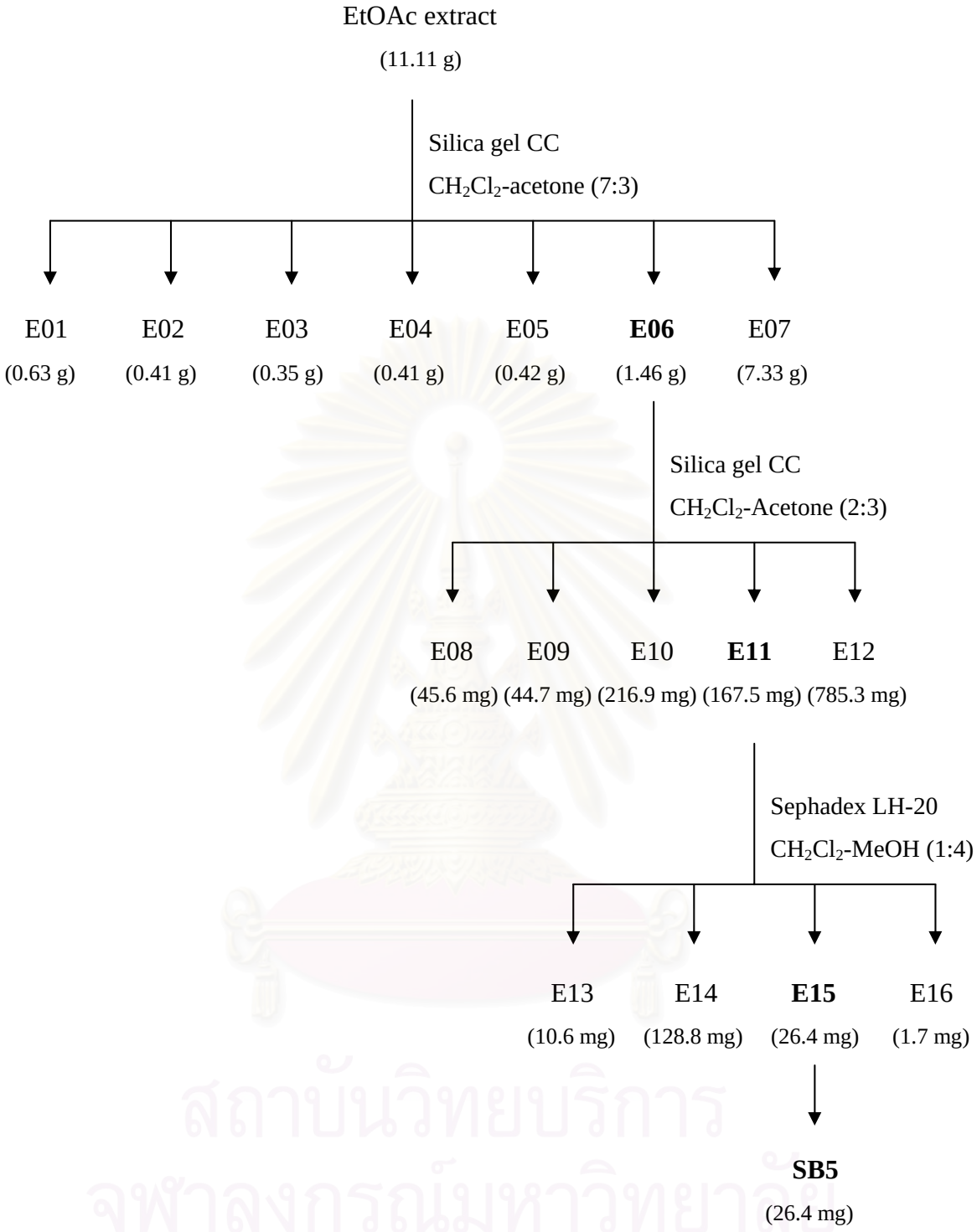
Table 5. Combined fractions from the EtOAc extract

Fraction	Number of eluates	Weight (g)
E01	1-6	0.63
E02	7-15	0.41
E03	16-36	0.35
E04	37-93	0.41
E05	94-119	0.42
E06	120-147	1.46
E07	MeOH eluate	7.33

4.2.1 Isolation of compound SB5

Fraction E06 (1.46 g), was separated on a silica gel column (70 g, 3 × 29 cm) eluted with CH_2Cl_2-acetone (2:3) to give seventy-five 2-ml fractions (10 ml each), which were then combined according to their TLC patterns into five fractions (E08-E12). Fraction E11 (167.5 mg), which exhibited one yellow spot when detected with 10% ethanolic sulfuric acid, was separated by gel filtration chromatography using a Sephadex LH-20 column (1.5 × 82 cm), with CH_2Cl_2-MeOH (1:4) as the eluent, to yield compound SB5 as yellowish amorphous powder (26.4 mg, 0.001% yield).

Compound SB5 was tested with Shinoda's reagent (0.5 ml HCl + Mg ribbon). Positive result (orange color bubble) was obtained.



Sheme 4. Isolation of the EtOAc extract from *Sauropus bacciformis* aerial part

5. Characterization of isolated compounds

5.1 Compound SB1

Appearance : Colorless needles

Solubility : Soluble in hexane and CH_2Cl_2

Melting point : 263-264 °C

IR υ_{max} (KBr disc) cm^{-1} (**Figure 6**, page 116)

: 2925, 2868, 2848, 1715, 1462, 1389, 1363, 1073, 1045 and 794

EIMS m/z (% relative intensity) (**Figure 7**, page 116)

: 426 (M^+, 75), 411 (27), 341 (15), 302 (48), 273 (80), 246 (49), 205 (76), 125 (100) and 109 (93)

^{1}H-NMR (δ ppm, 300 MHz, $CDCl_3$) (**Figure 8**, page 117)

: 0.70 (3H, *s*), 0.85 (3H, *s*), 0.86 (3H, *d*, *J* = 6.0 Hz), 0.93 (3H, *s*), 0.98 (6H, *s*), 1.03 (3H, *s*), 1.16 (3H, *s*), 1.26-1.75 (18H, *m*), 1.35 (1H, *dd*, *J* = 9.3, 4.8 Hz), 1.48 (1H, *dd*, *J* = 6.0, 3.0 Hz), 1.66 (1H, *dd*, *J* = 13.0, 5.7 Hz), 1.91-1.98 (2H, *m*), 2.21-2.36 (2H, *m*) and 2.27 (1H, *dt*, *J* = 18.6, 6.9 Hz)

^{13}C-NMR (δ ppm, 75 MHz, $CDCl_3$) (**Figure 9**, page 118)

: 6.8, 14.7, 17.9, 18.2, 18.6, 20.3, 22.3, 28.2, 30.0, 30.5, 31.8, 32.1, 32.4, 32.8, 35.0, 35.4, 35.6, 36.0, 37.5, 38.3, 39.3, 39.7, 41.3, 41.5, 42.1, 42.8, 53.1, 58.2, 59.5 and 213.1

5.2 Compound SB2

Appearance : White amorphous powder

Solubility : Soluble in hexane and CH_2Cl_2

Melting point : 213-214 °C

IR υ_{max} (KBr disc) cm^{-1} (**Figure 11**, page 120)

: 3511, 2929, 2868, 2850, 1732, 1463, 1455, 1384, 1364, 1173 and 738

EIMS m/z (% relative intensity) (**Figure 12**, page 120)

: 426 (M^+, 8), 411 (5), 393 (4), 274 (100), 259 (81), 245 (10), 231 (22), 205 (14), 189 (13), 152 (24) and 134 (34)

^{1}H-NMR (δ ppm, 500 MHz, $CDCl_3$) (**Figure 13**, page 121)

: 0.76 (3H, *s*), 0.81 (3H, *d*, *J* = 6.5 Hz), 0.87 (3H, *d*, *J* = 6.5 Hz), 0.87 (3H, *s*), 0.90 (3H, *s*), 0.98 (3H, *s*), 1.02 (3H, *s*), 1.12 (3H, *s*), 1.31-1.38 (1H, *m*), 1.42-1.47 (2H, *m*), 1.42-1.52 (6H, *m*), 1.52-1.59 (6H, *m*), 1.64-1.74 (2H, *m*), 1.79 (1H, *t*, *J* = 3.0 Hz), 1.86-1.96 (2H, *m*), 1.89 (1H, *dd*, *J* = 3.7, 2.0 Hz), 1.95 (1H, *dd*, *J* = 3.5, 2.0 Hz), 2.06 (1H, *ddd*, *J* = 12.4, 5.2, 3.5 Hz), 3.45 (1H, *br t*, *J* = 2.5 Hz) and 5.59 (1H, *dd*, *J* = 3.5, 2.0 Hz)

^{13}C-NMR (δ ppm, 125 MHz, $CDCl_3$) (**Figure 14**, page 121)

: 15.0, 15.7, 16.1, 17.8, 18.0, 19.9, 21.9, 22.9, 24.0, 25.5, 27.8, 28.3, 29.0, 29.0, 29.1, 30.8, 34.1, 34.8, 35.4, 38.6, 39.3, 40.8, 42.8, 44.2, 50.2, 51.7, 60.0, 76.3, 122.0 and 141.9

5.3 Compound SB3

Appearance : Colorless needles

Solubility : Soluble in hexane and CH_2Cl_2

IR υ_{max} (KBr disc) cm^{-1} (**Figure 18**, page 126)

: 3418, 2935, 2867, 2850, 1716, 1667, 1463, 1381, 1332, 1049, 1022, 800 and 738

^{1}H-NMR (δ ppm, 300 MHz, $CDCl_3$) (**Figure 19**, page 126)

: 0.66 (3H, *s*), 0.67 (3H, *d*, *J* = 5.4 Hz), 0.80 (3H, *t*, *J* = 6.3 Hz), 0.90 (3H, *d*, *J* = 6.3 Hz), 1.00 (3H, *d*, *J* = 6.9 Hz), 1.23 (3H, *s*), 3.47 (1H, *m*), 4.99 (1H, *dd*, *J* = 15.3, 8.4 Hz), 5.13 (1H, *dd*, *J* = 15.3, 8.4 Hz) and 5.33 (1H, *br s*)

^{13}C-NMR (δ ppm, 75 MHz, $CDCl_3$) (**Figure 20**, page 127)

: 11.9, 12.0, 12.0, 12.2, 18.8, 19.0, 19.0, 19.4, 19.8, 21.1, 21.2, 23.1, 24.3, 25.4, 26.1, 28.2, 28.9, 29.2, 31.7, 31.9, 34.0, 36.1, 36.5, 37.3, 39.7, 39.8, 40.5, 42.2, 42.3, 45.9, 50.1, 51.2, 56.0, 56.1, 56.8, 56.9, 71.8, 121.7, 129.3, 138.3 and 140.8

5.4 Compound SB4

Appearance : White amorphous powder

Solubility : Soluble in CH_2Cl_2

Melting point : 228-229 °C

IR υ_{max} (KBr disc) cm^{-1} (**Figure 22**, page 128)

: 3418, 2950, 2873, 2855, 1713, 1641, 1456, 1414, 1379, 1357, 1345, 1110, 883 and 739

EIMS m/z (% relative intensity) (**Figure 23**, page 129)

: 440 (M^+, 4), 422 (17), 407 (5), 327 (8), 285 (5), 229(18), 203 (12), 189 (13), 175 (9), 149 (13), 135 (16) and 114 (100)

^{1}H-NMR (δ ppm, 500 MHz, $CDCl_3$) (**Figure 24**, page 129)

: 0.78 (3H, *s*), 0.82 (3H, *s*), 0.96 (3H, *s*), 1.02 (3H, *s*), 1.04 (6H, *s*), 1.06-1.23 (4H, *m*), 1.33 (1H, *dd*, *J* = 10.0, 5.0 Hz), 1.35 (1H, *dd*, *J* = 4.5, 2.0 Hz), 1.46 (1H, *dd*, *J* = 4.5, 2.5 Hz), 1.48-1.53 (8H, *m*), 1.63-1.71 (1H, *m*), 1.64 (2H, *dd*, *J* = 6.2, 4.5 Hz), 1.79-1.93 (2H, *m*), 2.20 (1H, *dd*, *J* = 14.2, 4.0 Hz), 2.98 (1H, *dd*, *J* = 14.2, 8.0 Hz), 2.36 (1H, *td*, *J* = 11.0, 5.5 Hz), 3.88 (1H, *dd*, *J* = 8.0, 4.0 Hz), 4.54 (1H, *dd*, *J* = 2.5, 1.0 Hz), and 4.66 (1H, *d*, *J* = 2.5 Hz)

^{13}C-NMR (δ ppm, 125 MHz, $CDCl_3$) (**Figure 25**, page 130)

: 11.8, 14.4, 15.9, 18.0, 19.3, 19.6, 19.8, 23.0, 25.1, 27.5, 27.9, 29.8, 32.9, 35.5, 37.9, 40.0, 41.1, 42.9, 42.9, 42.9, 45.1, 47.1, 47.9, 48.2, 50.7, 51.3, 79.6, 109.5, 150.7 and 215.7

5.5 Compound SB5

Appearance : Yellowish amorphous powder

Solubility : Soluble in DMSO

Melting point : 176-177 °C

EIMS m/z (% relative intensity) (**Figure 31**, page 135)

: 478 (M^+, 1), 441 (2), 361 (6), 316 (100), 286 (11), 273 (12), 259 (3), 168 (7), 149 (7), 137 (14), 111 (4) and 73 (8)

UV λmax nm (log ε), in DMSO (**Figure 29**, page 134)

: 260 (3.88), 309 (3.51) and 372 (3.86)

IR υ_{max} (KBr disc) cm^{-1} (**Figure 30**, page 135)

: 3329, 2924, 2854, 1656, 1622, 1603, 1506, 1208 and 1071

^{1}H-NMR (δ ppm, 500 MHz, DMSO-d_6) (**Figure 32**, page 136)

: 3.86 (3H, OMe, *s*), 6.35 (1H, *d*, *J* = 2.5 Hz), 6.77 (1H, *d*, *J* = 2.5 Hz), 7.25 (1H, *d*, *J* = 9.0 Hz), 7.66 (1H, *dd*, *J* = 9.0, 2.0 Hz), 7.74 (1H, *d*, *J* = 2.0 Hz), 3.17 (1H, *dd*, *J* = 9.0, 3.0 Hz), 3.29 (1H, *dd*, *J* = 9.5, 5.0 Hz), 3.33 (1H, *s*), 3.37 (1H, *dt*, *J* = 7.9, 1.5 Hz), 3.48 (1H, *dd*, *J* = 12.0, 6.0 Hz), 3.73 (1H, *dd*, *J* = 11.7, 5.5 Hz) and 4.84 (1H, *d*, *J* = 7.5 Hz)

^{13}C-NMR (δ ppm, 125 MHz, DMSO-d_6) (**Figure 34**, page 137)

: 56.0, 92.0, 97.5, 104.1, 115.2, 115.8, 119.6, 125.0, 136.7, 146.3, 146.4, 146.9, 156.2, 160.3, 165.0, 176.2, 60.7, 69.8, 73.3, 75.9, 77.3 and 101.4

CHAPTER IV

RESULTS AND DISCUSSION

Chromatographic separation of the hexane and EtOAc extracts of *Sauropus bacciformis* aerial part led to the isolation of five chemical constituents. The identification and structure elucidation of these compounds were based on analysis of their spectroscopic data and comparison with the literature. The details can be discussed as follows.

1. Identification of compound SB1

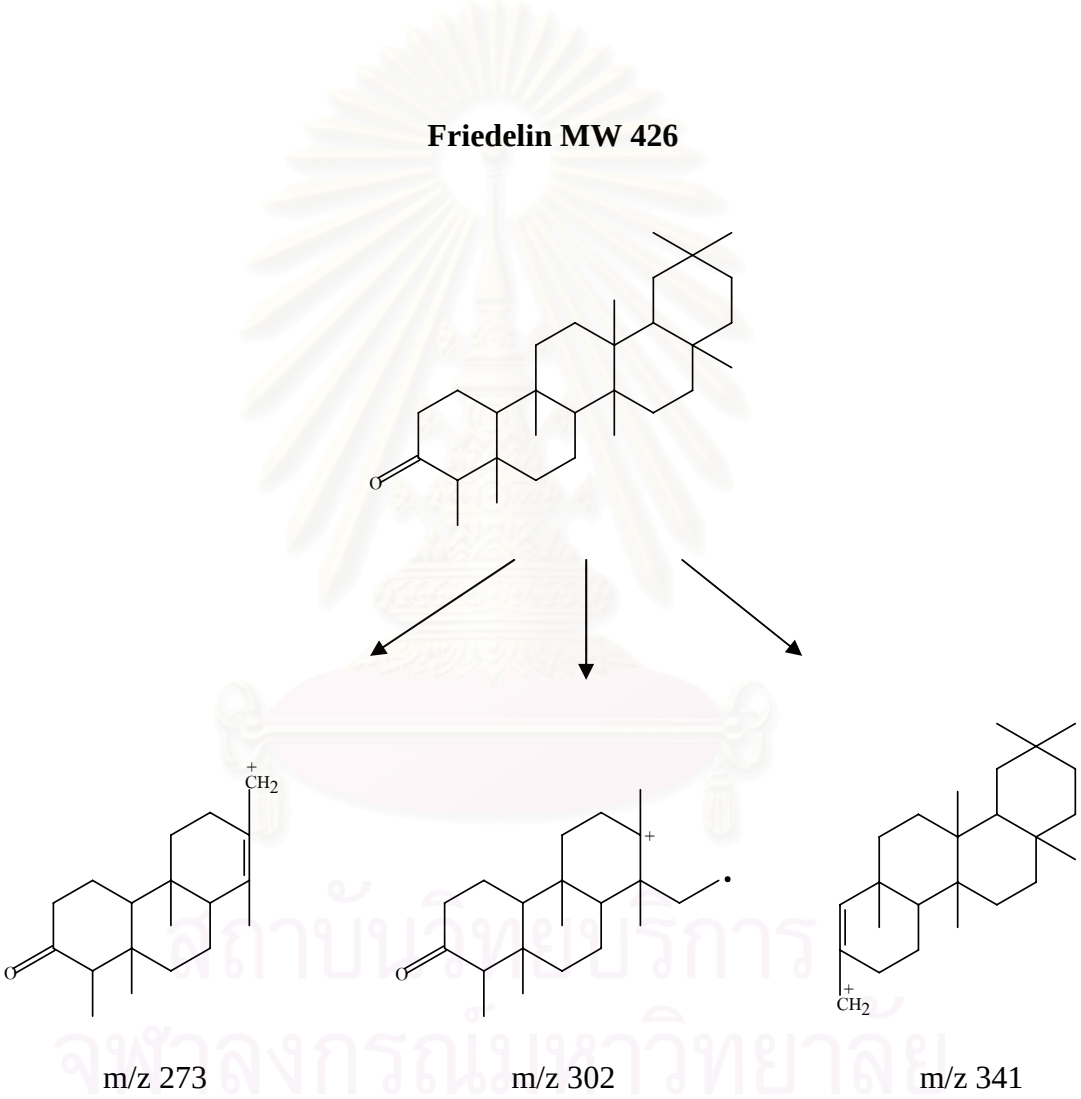
Compound SB1 was crystallized as colorless needles from methanol (9.7 mg, 0.001% yield). This compound gave purple color to Liebermann-Burchard reagent, suggesting that it is a triterpenoid. Its IR absorption band (**Figure 6**) at 1715 cm^{-1} was indicative of the presence of keto carbonyl group (C=O stretching). Its EIMS (**Figure 7**) exhibited the molecular ion peak at m/z 426, indicating the molecular formula of $C_{30}H_{50}O$. The index of hydrogen deficiency for this compound, which equals six, and the remaining index of one is attributed to the unsaturation in the keto carbonyl group in the structure.

The ^{1}H-NMR spectrum (**Figure 8**) exhibited the signals due to one doublet of secondary methyl at δ 0.86 ppm (3H, *J* = 6.0 Hz, H-23), and seven singlets of tertiary methyls at δ 0.70 (3H, H-24), 0.85 (3H, H-25), 0.93 (3H, H-29), 0.98 (6H, H-26, H-30), 1.03 (3H, H-27) and 1.16 ppm (3H, H-28).

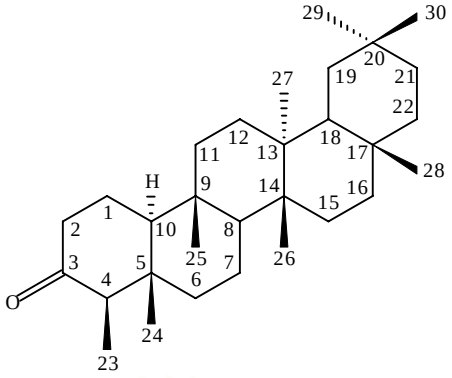
The ^{13}C-NMR spectrum (**Figure 9**) showed 30 carbon peaks, supportive of a triterpenoid structure. These peaks were classified, according to DEPT experiment (**Figure 10**), into those of eight methyl carbons at δ 6.8 (C-23), 14.7 (C-24), 17.9 (C-25), 18.6 (C 27), 20.3 (C-26), 31.8 (C-30), 32.1 (C-28) and 35.0 ppm (C-29), eleven methylene carbons at δ 18.2 (C-7), 22.3 (C-1), 30.5 (C-12), 32.4 (C-15), 32.8 (C-21), 35.4 (C-19), 35.6 (C-11), 36.0 (C-16), 39.3 (C-22), 41.3 (C-6) and 41.5 ppm (C-2), four methine carbons at δ 42.8 (C-18), 53.1 (C-8), 58.2 (C-4) and 59.5 ppm (C-10), and seven quaternary carbons at δ 28.2 (C-20), 30.0 (C-17), 37.5 (C-9), 38.3 (C-14), 39.7 (C-13), 42.1 (C-5) and 213.1 ppm (C-3). The last signal represented the keto carbonyl group in the molecule.

The mass fragment peaks at m/z 273, 302 and 341 were the results of cleavage at different positions across the skeleton, which have been shown to have the keto group on the ring A (**Scheme 5**) (Ogunkoya, 1981).

The ^{13}C-NMR data of compound SB1 (**Table 6**) were found to be in full agreement with those values previously reported for friedelin (Akihisa *et al*., 1992), a friedelane-type triterpenoid with 3-keto substituent.



Scheme 5. Mass fragmentation of compound SB1



Friedelin

Friedelin was previously isolated from 20 species out of 13 euphorbiaceous genera. However, this is the first report of its occurrence in the genus *Sauropus.*

Friedelin has been reported as possessing cytotoxic (Zheng, 1994; Chilpa *et al*., 2004), anti-inflammatory (Shimizu and Tomoo, 1994) and diuretic activities (Rizvi *et al*., 1980a).

Table 6. ^{1}H-NMR data and comparision of the ^{13}C-NMR assignments of compound SB1 and friedelin (in $CDCl_3$)

Position	Compound SB1		Friedelin
	δ H (ppm)	δ C (ppm)	δ C (ppm)
1	1.91-1.98 (*m*)	22.3	22.3
2	2.21-2.36 (*m*)	41.5	41.5
3	–	213.1	213.2
4	2.27 (*dt*, *J* = 18.6, 6.9 Hz)	58.2	58.2
5	–	42.1	42.1
6	1.26-1.75 (*m*)	41.3	41.3
7	1.26-1.75 (*m*)	18.2	18.2
8	1.35 (*dd*, *J* = 9.3, 4.8 Hz)	53.1	53.1
9	–	37.5	37.4
10	1.48 (*dd*, *J* = 6.0, 3.0 Hz)	59.5	59.4
11	1.26-1.75 (*m*)	35.6	35.6
12	1.26-1.75 (*m*)	30.5	30.5
13	–	39.7	39.7
14	–	38.3	38.3
15	1.26-1.75 (*m*)	32.4	32.4
16	1.26-1.75 (*m*)	36.0	36.0
17	–	30.0	30.0
18	1.66 (*dd*, *J* = 13.0, 5.7 Hz)	42.8	42.8
19	1.26-1.75 (*m*)	35.4	35.3
20	–	28.2	28.1
21	1.26-1.75 (*m*)	32.8	32.7
22	1.26-1.75 (*m*)	39.3	39.2
23	0.86 (*d*, *J* = 6.0 Hz)	6.8	6.8
24	0.70 (*s*)	14.7	14.6
25	0.85 (*s*)	17.9	17.9
26	0.98 (*s*)	20.3	20.2
27	1.03 (*s*)	18.6	18.6
28	1.16 (*s*)	32.1	32.1
29	0.93 (*s*)	35.0	35.0
30	0.98 (*s*)	31.8	31.8

2. Identification of compound SB2

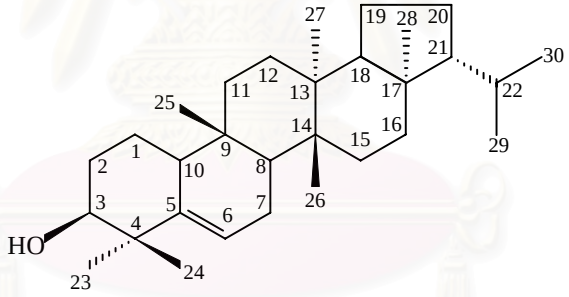
Compound SB2 was obtained as white amorphous powder (29.0 mg, 0.002% yield). The compound gave purple color to Liebermann-Burchard reagent, suggesting that it is a triterpenoid. The IR spectrum (**Figure 11**) exhibited absorption bands at 3511 (OH stretching) and 1173 (C-O stretching) cm^{-1}, suggesting the presence of hydroxyl substituent. Its EIMS (**Figure 12**) displayed a molecular ion peak at m/z 426 which corresponded to the molecular formula of $C_{30}H_{50}O$. The base peak at m/z 274 should be due to the ion resulting directly from retro-Diels-Alder fission of ring B, in which the charge remains with the monoalkene instead of the diene. This is suggestive of a C-5 unsaturated pentacyclic triterpenoid in which there is no substitution in ring C, D, or E and that the compound has a skeleton structure of the adianane type (Ogunkoya, 1981). The peaks at m/z 259 (274-CH_3) and 231 (274-Pr) for those with isopropyl group in ring E, and the $[M\text{-}CH_3]^+$ and $[M\text{-}CH_3\text{-}H_2O]^+$ peaks at m/z 411 and 393, respectively, were also observed (**Scheme 6**).

The ^{1}H-NMR spectrum (**Figure 13**) exhibited signals due to two doublet of secondary methyls at δ 0.81 (3H, *J* = 6.5 Hz, H-30), and δ 0.87 ppm (3H, *J* = 6.5 Hz, H-29), and six tertiary methyls singlets at δ 0.76 (3H, H-28), 0.87 (3H, H-25), 0.90 (3H, H-27), 0.98 (3H, H-26), 1.02 (3H, H-23) and 1.12 ppm (3H, H-24). The proton signal at δ 3.45 ppm (1H, *br t*, *J* = 2.5 Hz, H-3) confirmed the presence of hydroxyl substituent. The most downfield signal at δ 5.59 ppm (1H, *dd*, *J* = 3.5, 2.0 Hz), represents H-6 of a C-6 unsaturated triterpenoid.

The ^{13}C-NMR spectrum (**Figure 14**) showed 30 carbon signals, supportive of a triterpenoid structure. The DEPT (**Figure 15**) and HMQC (**Figure 16**) experiments were performed to differentiate these signals into eight methyl carbons at δ 15.0 (C-27), 15.7 (C-26), 16.1 (C-28), 17.8 (C-25), 21.9 (C-29), 22.9 (C-30), 25.5 (C-24) and 29.0 ppm (C-23), nine methylene carbons at δ 18.0 (C-1), 19.9 (C-19), 24.0 (C-7), 27.8 (C-2), 28.3 (C-20), 29.0 (C-12), 29.1 (C-15), 34.1 (C-11) and 35.4 ppm (C-16), seven methine carbons at δ 30.8 (C-22), 44.2 (C-8), 50.2 (C-10), 51.7 (C-18), 60.0 (C-21), 76.3 (C-3) and 122.0 ppm (C-6), and six quaternary carbons at δ 34.8 (C-9), 38.6 (C-13), 39.3 (C-14), 40.8 (C-4), 42.8 (C-17) and 141.9 ppm (C-5). The downfield carbon signals at δ 122.0 and 141.9 ppm represent the characteristic double bond between C-5 and C-6 in the adianane skeleton (Ahmad and Rahman, 1994).

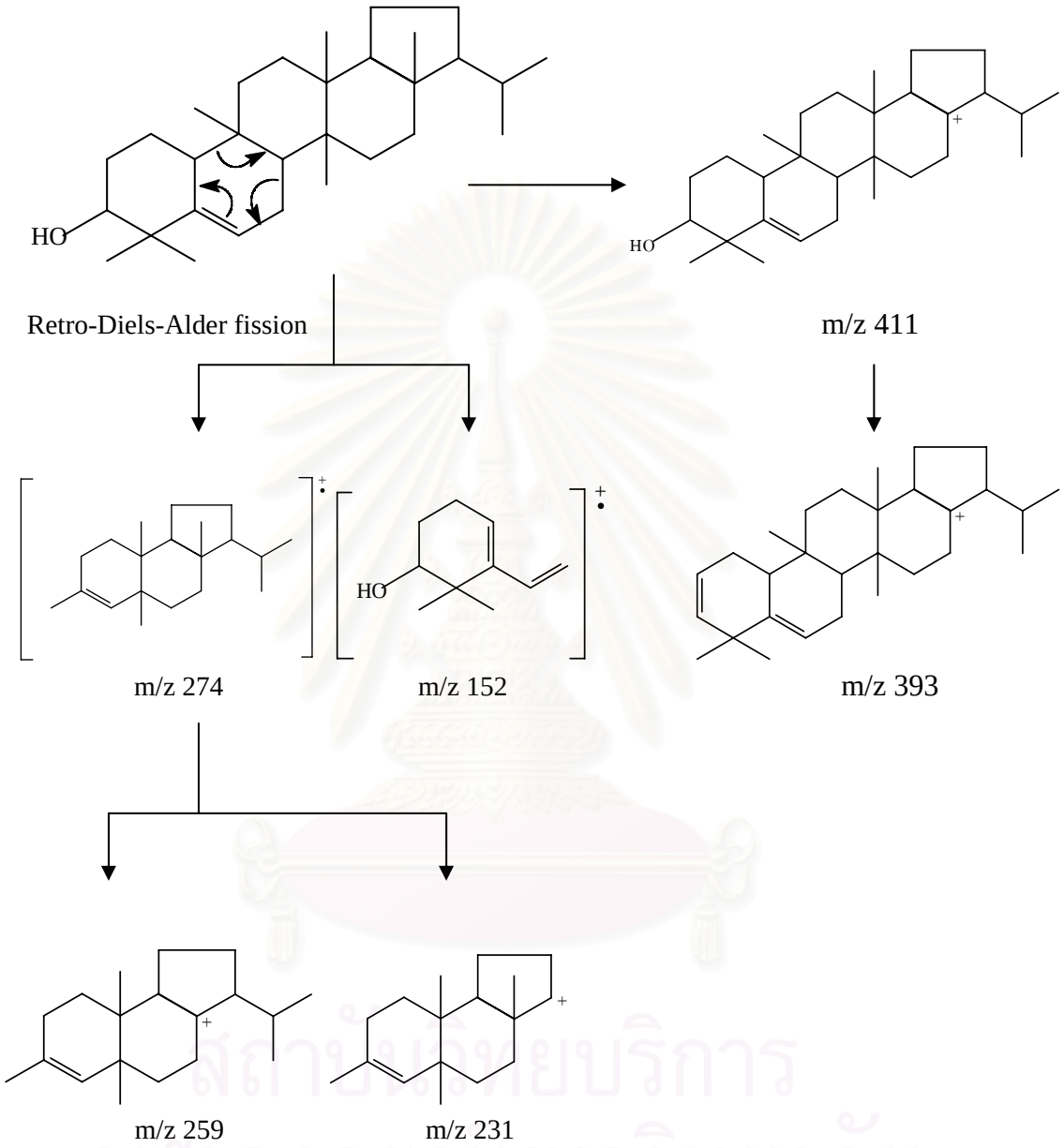
The HMBC experiment (**Figure 17**) was useful in confirming the structure of compound SB2. The proton signal at δ 3.45 ppm (H-3) displayed three-bond correlations with C-5 (δ 141.9 ppm) and C-1 (δ 18.0) (**Figure 17a**). HMBC correlations of H-23 (δ 1.02) and H-24 methyl signals (δ 1.12) with C-3 (δ 76.3 ppm) (**Figure 17b**), confirmed the presence of hydroxyl substituent at this carbon, while the signal of the olefinic H-6 (δ 5.59) showed three-bond correlations with C-10 (δ 50.2), C-8 (δ 44.2) and C-4 (δ 40.8 ppm) (**Figure 17c**), confirming the position of double bond as between C-5 and C-6.

Compound SB2 was therefore proven to be a C-5 unsaturated triterpenoid of the adianane type. Comparison of the ^{13}C-NMR data of compound SB2 with those reported for simiarenol (Tanaka *et al*, 1989), a known adian-5-ene, previously isolated from *Euphorbia supina*, indicated the structures of both compounds to be identical. The ^{1}H and ^{13}C-NMR assignments and HMBC (correlation with ^{13}C) of compound SB2 and the reported ^{13}C-NMR data of simiarenol are shown in **Table 7.**



Simiarenol

Simiarenol MW 426



Scheme 6. Mass fragmentation of compound SB2

Table 7. The ^{1}H and ^{13}C-NMR data, HMBC correlation of compound SB2 and comparison of the ^{13}C-NMR assignments with those simiarenol (in $CDCl_3$)

Position	Compound SB2		Simiarenol	HMBC
	δ H (ppm)	δ C (ppm)	δ C (ppm)	correlation with ^{13}C
1	1.42-1.47 (*m*)	18.0	18.1	C-2*, C-3, C-10*
2	1.64-1.74 (*m*)	27.8	27.8	C-1*
3	3.45 (*br t*, *J* = 2.5 Hz)	76.3	76.4	C-1, C-5
4	–	40.8	41.0	–
5	–	141.9	142.0	–
6	5.59 (*dd*, *J* = 3.5, 2.0 Hz)	122.0	122.0	C-4, C-7*, C-8, C-10
7	1.86-1.96 (*m*)	24.0	24.0	C-5, C-6*, C-8*
8	1.89 (*dd*, *J* = 3.7, 2.0 Hz)	44.2	44.3	C-7*
9	–	34.8	34.8	–
10	1.95 (*dd*, *J* = 3.5, 2.0 Hz)	50.2	50.0	C-5*, C-6, C-8
11	1.42-1.52 (*m*)	34.1	34.2	C-8, C-9*, C-10, C-12*, C-13
12	1.42-1.52 (*m*)	29.0	28.9	C-27
13	–	38.6	38.6	–
14	–	39.3	40.3	–
15	1.52-1.59 (*m*)	29.1	29.1	C-13, C-14*, C-17
16	1.52-1.59 (*m*)	35.4	35.4	C-14, C-17*
17	–	42.8	42.4	–
18	1.79 (*t*, *J* = 3.0 Hz)	51.7	51.8	C-17*, C-19*
19	1.42-1.52 (*m*)	19.9	19.9	C-18*
20	1.52-1.59 (*m*)	28.3	28.3	C-17, C-19*
21	2.06 (*ddd*, *J* = 12.4, 5.2, 3.5 Hz)	60.0	60.0	C-20*, C-22*
22	1.31-1.38 (*m*)	30.8	30.8	C-17, C-20
23	1.02 (*s*)	29.0	29.1	C-3, C-5
24	1.12 (*s*)	25.5	25.5	C-3, C-5
25	0.87 (*s*)	17.8	17.9	C-8, C-9*, C-10, C-11
26	0.98 (*s*)	15.7	15.8	C-8, C-14*, C-15
27	0.90 (*s*)	15.0	15.0	C-12, C-13*, C-14, C-18
28	0.76 (*s*)	16.1	16.1	C-16, C-17*, C-18, C-21
29	0.87 (*d*, *J* = 6.5 Hz)	21.9	21.9	C-21
30	0.81 (*d*, *J* = 6.5 Hz)	22.9	22.9	C-21

* Two-bond correlation

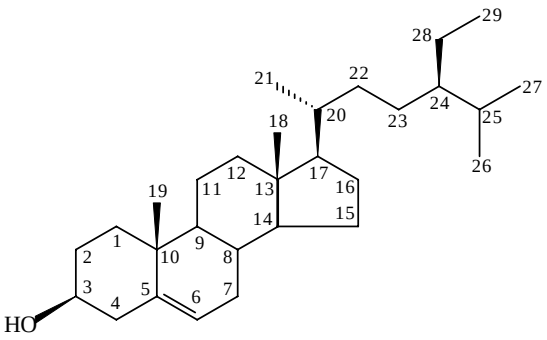
3. Identification of compound SB3

Compound SB3 was recrystallized as colorless needles from methanol (72.5 mg, 0.004% yield). This compound gave green color to Liebermann-Burchard reagent, suggesting the presence of the steroid nucleus. The IR spectrum (**Figure 18**) exhibited absorption bands at 3418 (OH stretching), 1049 and 1022 (C-O stretching) cm^{-1}, suggesting the presence of hydroxyl substituent .

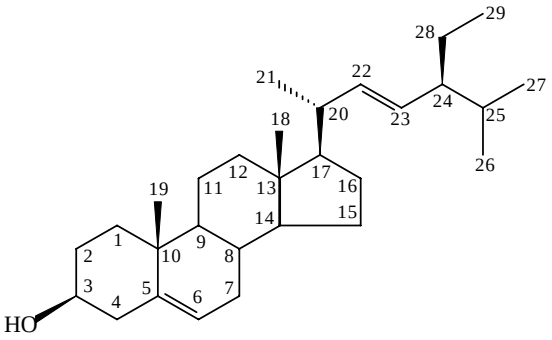
The ^{1}H-NMR spectrum (**Figure 19**) gave evidences which suggested this compound is a mixture of *β*-sitosterol (SB3B) and stigmasterol (SB3S). The olefinic proton at δ 5.33 ppm (2H, *d*, *J* = 4.5 Hz) was assignable to H-6 of both *β*-sitosterol and stigmasterol, while two signals at δ 4.99 (1H, *dd*, *J* = 15.3, 8.4 Hz) and 5.13 ppm (1H, *dd*, *J* = 15.3, 8.4 Hz) were assigned as olefinic protons at H-22 and H-23 of stigmasterol, respectively. The ratio of SB3B and SB3S in the mixture was deduced from the integration value between H-6 and H-22 or H-23 to be 1:0.5:0.4. The multiplet signal at δ 3.47 ppm was attributable to the methine proton of hydroxyl substituted position 3 of both *β*-sitosterol and stigmasterol. The ^{1}H-NMR spectrum of both *β*-sitosterol and stigmasterol displayed signals due to one primary methyl at δ 0.80 ppm (3H, *t*, *J* = 6.3 Hz, H-29), three secondary methyls doublets at δ 0.67 (3H, *J* = 5.4 Hz, H-21), 0.90 (3H, *J* = 6.3 Hz, H-27) and 1.00 ppm (3H, *J* = 6.9 Hz, H-26), and two tertiary methyls singlets at δ 0.66 (3H, H-18) and 1.23 ppm (3H, H-19), suggestive of the steroidal skeleton (De-Eknamkul and Potduang, 2003).

The ^{13}C-NMR (**Figure 20**) and DEPT spectrum (**Figure 21**) showed 29 carbon signals easily assigned to *β*-sitosterol. However, four olefinic carbon signals were observed at δ 140.8, 138.3, 129.3 and 121.7 ppm. The two signals at δ 140.8 and 121.7 ppm were assignable to C-5 and C-6 of both *β*-sitosterol and stigmasterol. The other two signals which resonated at δ 138.3 and 129.3 ppm were due to C-22 and C-23 of stigmasterol, respectively. The carbon signal at δ 71.8 ppm represents the oxygenated C-3 of both *β*-sitosterol and stigmasterol.

Comparison of the ^{13}C-NMR assignment of compound SB3 (a mixture of SB3B and SB3S) with those previously reported data for a mixture of *β*-sitosterol and stigmasterol (De Eknamkul and Potduang, 2003), is shown in **Table 8**.



β-sitosterol



stigmasterol

β-Sitosterol and stigmasterol were the most common phytosterols in plant kingdom (Li, Beveridge and Drover, 2007). *β*-Sitosterol has been reported as possessing antimicrobial (Ajaiyeoba *et al*., 2003), antihyperglycemic (Ivorra *et al*., 1988), anti-inflammatory and antipyretic activities (Gupta *et al*., 1980).

Table 8. Comparison of the ^{13}C-NMR assignment of compound SB3 (a mixture of SB3B and SB3S, β-sitosterol and stigmasterol (in $CDCl_3$)

Position	δ C (ppm)			
	SB3B	**SB3S**	**β-sitosterol**	**stigmasterol**
1	37.3	37.3	37.2	37.2
2	31.7	31.7	31.6	31.6
3	71.8	71.8	71.8	71.8
4	42.2	42.3	42.2	42.3
5	140.8	140.8	140.7	140.7
6	121.7	121.7	121.7	121.7
7	31.9	31.9	31.9	31.9
8	31.9	31.9	31.9	31.9
9	50.1	50.1	50.1	50.1
10	36.5	36.5	36.5	36.5
11	21.1	21.1	21.1	21.1
12	39.8	39.7	39.7	39.7
13	42.3	42.3	42.3	42.3
14	56.8	56.9	56.7	56.8
15	24.3	24.3	24.3	24.3
16	28.2	28.9	28.2	28.9
17	56.1	56.0	56.0	55.9
18	11.9	12.0	11.8	12.0
19	19.4	19.4	19.4	19.4
20	36.1	40.5	36.1	40.5
21	18.8	21.1	18.8	21.1
22	34.0	138.3	33.9	138.3
23	26.1	129.3	26.0	129.2
24	45.9	51.2	45.8	51.2
25	29.2	31.9	29.1	31.9
26	19.8	21.2	19.8	21.2
27	19.0	19.0	19.0	19.0
28	23.1	25.4	23.0	25.4
29	12.0	12.2	12.0	12.2

4. Identification of compound SB4

Compound SB4 was crystallized as white amorphous powder from methanol (9.3 mg, 0.001% yield). This compound gave purple color to Liebermann Burchard reagent, suggesting that it is a triterpenoid. Its IR spectrum (**Figure 22**) exhibited absorption bands at 3418 (OH stretching), 1110 (C-O stretching), suggesting the presence of hydroxyl substituent, and displayed keto carbonyl absorption (C=O stretching) at 1713 cm^{-1}. Its EIMS (**Figure 23**) showed a molecular ion peak at m/z 440 which corresponded to the molecular formula of $C_{30}H_{48}O_2$. The mass fragment peaks at m/z 285, 229, 203 and 189 were the results of cleavage at different positions across the lupane skeleton (Hui and Fung, 1969) as shown in **Scheme 7**.

The ^{1}H-NMR spectrum (**Figure 24**) showed signals due to seven tertiary methyls singlets at δ 0.78 (3H, H-28), 0.82 (3H, H-25), 0.96 (3H, H-27), 1.02 (3H, H-24), 1.04 (6H, H-23, H-26) and 1.66 ppm (3H, *br s*, H-30). The proton signal at δ 3.88 ppm (1H, *dd*, *J* = 8.0, 4.0 Hz, H-1) confirmed the presence of hydroxyl group substituent. The most downfield signals at δ 4.54 (1H, *dd*, *J* = 2.5, 1.0 Hz) and δ 4.66 ppm (1H, *d*, *J* = 2.5 Hz) could be assigned as those of exomethylene protons at position 29.

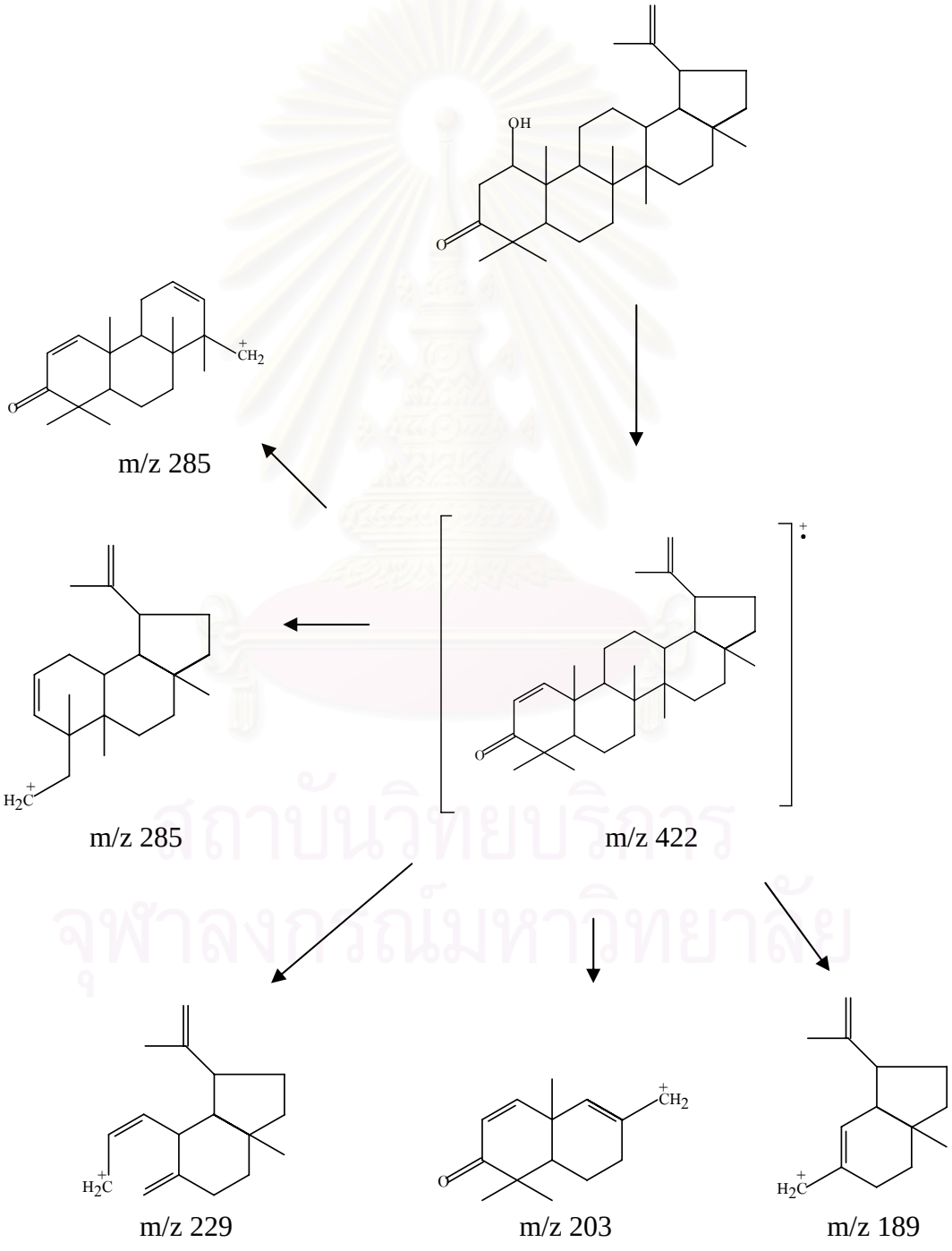
The ^{13}C-NMR spectrum (**Figure 25**) showed 30 carbon signals supportive of a triterpenoid structure. These peaks were classified, according to DEPT (**Figure 26**) and HMQC (**Figure 27**) experiments, into those of seven methyl carbons at δ 11.8 (C-25), 14.4 (C-27), 15.9 (C-26), 18.0 (C-28), 19.3 (C-30), 19.8 (C-24) and 27.9 ppm (C-23), ten methylene carbons at δ 19.6 (C-6), 23.0 (C-11), 25.1 (C-12), 27.5 (C-15), 29.8 (C-21), 32.9 (C-7), 35.5 (C-16), 40.0 (C-22), 45.1 (C-2) and 109.5 ppm (C-29), six methine carbons at δ 37.9 (C-13), 47.9 (C-19), 48.2 (C-18), 50.7 (C-9), 51.3 (C-5) and 79.6 ppm (C-1), seven quaternary carbons at δ 41.1 (C-8), 42.9 (C-10, C-14, C-17), 47.1 (C-4), 150.7 (C-20) and 215.7 ppm (C-3). The last signal represented keto carbonyl group in the molecule.

The HMBC experiment (**Figure 28**) was useful to confirm the structure of compound SB4. The proton signal at δ 3.88 ppm (H-1) displayed three-bond correlations with C-3 (δ 215.7) (**Figure 28a**), C-9 (δ 50.7) and C-25 (δ 11.8) (**Figure 28b**), confirming the presence of hydroxyl substituent at C-1. The proton signals at δ 1.02 (H-24), δ 1.04 (H-23) (**Figure 28c**), and δ 3.88 ppm (H-1) all exhibited three-bond correlations with C-3 (δ 215.7 ppm) (**Figure 28a**), confirming that the keto

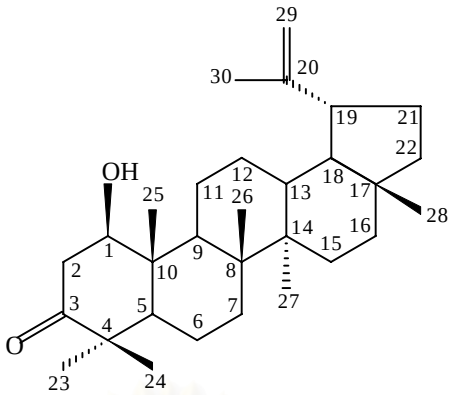
carbonyl was at position 3. Correlations between both exomethylene protons at position 29 with C-30 (δ 19.3) and between H-30 methyl protons and C-19 (δ 47.9) could also be observed (**Figure 28b**).

The ^{13}C-NMR data of compound SB4 were found to be in full agreement with those values previously reported for glochidonol (Ayer, Flanagan and Reffstrup, 1984), a lupane-type triterpenoid with 3-keto substituent, as shown in **Table 9.**

Glochidonol MW 440



Scheme 7. Mass fragmentation of compound SB4



Glochidonol

Glochidonol was previously isolated from 13 species out of 3 euphorbiaceous genera. However, this is the first report of its occurrence in the genus *Sauropus.*

Glochidonol has been reported as possessing anti-tumor activity against three human tumor cell lines, including MCF-7 (breast adenocarcinoma), NCI-H-460 (non-small cell lung cancer) and SF-268 (CNS cancer) (Puapairoj *et al.*, 2005).

Table 9. The ^{1}H and ^{13}C-NMR data, HMBC correlation of compound SB4 and comparison of the ^{13}C-NMR assignments with those glochidonol (in $CDCl_3$)

Position	Compound SB4		Glochidonol	HMBC
	δ H (ppm)	δ C (ppm)	δ C (ppm)	correlation with ^{13}C
1	3.88 (*dd*, *J* = 8.0, 4.0 Hz)	79.6	79.6	C-3, C-9, C-25
2a 2b	2.20 (*dd*, *J* = 14.2, 4.0 Hz) 2.98 (*dd*, *J* = 14.2, 8.0 Hz)	45.1	45.2	C-1*, C-3*, C-10
3	–	215.7	216.1	–
4	–	47.1	47.1	–
5	1.33 (*dd*, *J* = 10.0, 5.0 Hz)	51.3	51.4	C-1, C-6*, C-23, C-24, C-25
6	1.48-1.53 (*m*)	19.6	19.6	C-5*, C-7*, C-8, C-10
7	1.48-1.53 (*m*)	32.9	33.0	C-5, C-8*, C-14, C-26
8	–	41.1	41.2	–
9	1.46 (*dd*, *J* = 4.5, 2.5 Hz)	50.7	50.8	C-1, C-10*, C-25, C-26
10	–	42.9	43.0	–
11	1.48-1.53 (*m*)	23.0	23.0	C-8, C-10
12	1.48-1.53 (*m*)	25.1	25.2	C-11*, C-14
13	1.63-1.71 (*m*)	37.9	38.0	C-8, C-17, C-18*
14	–	42.9	43.0	–
15	1.64 (*dd*, *J* = 6.2, 4.5 Hz)	27.5	27.5	C-16*, C-17
16	1.06-1.23 (*m*)	35.5	35.6	C-17*, C-28
17	–	42.9	43.0	–
18	1.35 (*dd*, *J* = 4.5, 2.0 Hz)	48.2	48.3	C-13*, C-16, C-17*, C-19*, C-20
19	2.36 (*td*, *J* = 11.0, 6.0 Hz)	47.9	48.0	C-13, C-18*, C-21*, C-29, C-30
20	–	150.7	150.7	–
21	1.79-1.93 (*m*)	29.8	29.8	C-18, C-19*, C-22*
22	1.06-1.23 (*m*)	40.0	40.4	C-16, C-17*, C-28
23	1.04 (*s*)	27.9	28.0	C-3, C-4*, C-5, C-24
24	1.02 (*s*)	19.8	19.9	C-3, C-4*, C-5, C-23
25	0.82 (*s*)	11.8	11.8	C-1, C-5, C-9, C-10*
26	1.04 (*s*)	15.9	16.0	C-7, C-8*, C-14
27	0.96 (*s*)	14.4	14.5	C-8, C-13, C-14*, C-15
28	0.78 (*s*)	18.0	18.1	C-16, C-17*, C-18, C-22
29	4.54 (*dd*, *J* = 2.5, 1.0 Hz) 4.66 (*d*, *J* = 2.5 Hz)	109.5	109.5	C-19, C-30
30	0.81 (*d*, *J* = 6.5 Hz)	19.3	19.3	C-19, C-20* and C-29

* Two-bond correlation

5. Structure elucidation of compound SB5

Compound SB5 was obtained as yellowish amorphous powder (26.4 mg, 0.001% yield). This compound gave orange color bubble to Shinoda's reagent, suggesting that it is a flavonoid. The IR spectrum (**Figure 30**) displayed absorption bands at 3329 (OH stretching), 1071 (C-O stretching), suggesting the presence of hydroxyl substituent, at 1208 (CH_2 bending), 1506 (C=C aromatic), 1603 and 1622 (conjugated C=C), and at keto carbonyl absorption (C=O stretching) at 1656 cm^{-1}. Its EIMS (**Figure 31**) showed base peak at m/z 316 which suggested that SB5 has an aglycone of rhamnetin (Wagner and Chari, 1976). The UV absorption showed maxima (**Figure 29**) at 260, 309 and 372 nm [Band I 350-385, Band II 250-280 nm for flavonols (3-OH free)] and the presence of three carbon in the ^{13}C-NMR spectrum (**Figure 34**) at δ 146.3 (C-2), δ 136.7 (C-3) and δ 176.2 ppm (C-4) [C-2 (δ 140.0-151.2), C-3 (δ 133.5-140.0), C-4 (δ 167.9-179.6 ppm) for flavonols] were indicative of a flavonol skeleton (Agrawal, 1989).

The ^{1}H-NMR spectrum (**Figure 32**) exhibited a methoxyl signal at δ 3.86 (3H, *s*), three hydroxyl signals including one chelated hydroxyl was observed at δ 12.39 (5-OH) and two hydroxyl groups at δ 8.95 and δ 9.65 ppm. The presence of two doublets at δ 6.35 (1H, *J* = 2.5 Hz) and δ 6.77 ppm (1H, *J* = 2.5 Hz) were assignable to the two *meta*-coupled H-6 and H-8 aromatic protons of ring A.

Substitution pattern on ring B was deduced from the *meta*-coupling of aromatic proton signals at δ 7.74 (1H, *d*, *J* = 2.0 Hz, H-2′) and δ 7.66 ppm (1H, *dd*, *J* = 9.0, 2.0 Hz, H-6′), whereas the latter signal also *ortho*-coupled to a doublet at δ 7.25 ppm (1H, *J* = 9.0 Hz, H-5′) indicated a *meta* or *para*-substituted for ring B. A set of proton signal of a sugar moiety [δ 3.17 (1H, *dd*, *J* = 9.0, 3.0 Hz, H-4"), 3.29 (1H, *dd*, *J* = 9.5, 5.0 Hz, H-3"), 3.33 (1H, *s*, H-2"), 3.37 (1H, *dt*, *J* = 7.9, 1.5 Hz, H-5"), 3.48 (1H, *dd*, *J* = 12.0, 6.0 Hz, H-6a"), 3.73 (1H, *dd*, *J* = 11.7, 5.5 Hz, H-6b"), 4.84 (1H, *d*, *J* = 7.5 Hz, H-1") were also observed. In addition, the presence of one anomeric proton signal at δ 4.84 (1H, *d*, *J* = 7.5 Hz, H-1") suggested that compound SB5 should be a monoglycoside of rhamnetin.

The ^{13}C-NMR (**Figure 34**), DEPT (**Figure 35**) and HMQC (**Figure 36**) spectrum showed 22 carbon signals, supporting the assignment of this compound as a flavonoid glycoside, and exhibited 6 signals for sugar carbons including one anomeric carbon at δ 101.4 ppm (C-1″), in addition to fifteen carbons and one

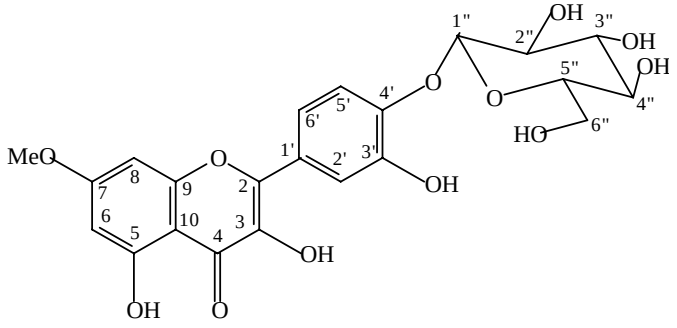
methoxyl at δ 56.0 ppm (7-OMe) of rhamnetin nucleus. The anomeric carbon was attached to rhamnetin with *O*-linkage (δ 59-110 ppm for *O*-glycoside and δ 60-85 ppm for *C*-glycoside) (Agrawal, 1989).

To identify the sugar unit, Compound SB5 was hydrolysed with 10% H_2SO_4 acid to give aglycone and sugar. These sugar was identified as *β*-D-glucose by TLC analysis, comparison with sugar standards, and the ^{13}C-NMR assignment with those previously reported data for *β*-D-glucose (Mahmoud *et al.*, 1989; Kojima *et al.*, 1990, Champavier *et al.*, 1999; Kim *et al.*, 2006; Mizushina *et al.*, 2006). The connectivity of these sugar protons and the assignment of ^{13}C-NMR signals were determined by ^{1}H-^{1}H COSY (**Figure 33**) and HMQC (**Figure 36**) experiments, as shown in **Table 10**. The observed vicinal coupling constants of J = 7.5 Hz between the *trans* diaxial H-1″ and H-2″ suggested that H-1″ (δ 4.84 ppm) was *β*-anomeric proton (Agrawal, 1992).

The HMBC experiment (**Table 10** and **Figure 37**) was useful to confirm the structure of compound SB5. The methoxyl signal at δ 3.86 ppm should be placed on ring A at C-7, as shown by the HMBC correlation with C-7 (δ 165.0 ppm) (**Figure 37a**), confirming that the rhamnetin nucleus. The anomeric proton signal at δ 4.84 ppm (*d*, J = 7.5 Hz, H-1″) displayed three-bond correlation with C-4′ (**Figure 37b**), suggesting that the *β*-D-glucose was at position 4′.

According to all information mentioned above, compound SB5 was proposed as a rhamnetin-4′-*O*-*β*-D-glucopyranoside. The ^{13}C-NMR data of compound SB5 were found to be in full agreement with those values previously reported for rhamnetin (Wagner and Chari, 1976), as shown in **Table 10.**

On the basis of the above spectroscopic studies, Compound SB5 was thus identified as a new compound and has been given the name Rhamnetin-4′-*O*-*β*-D-glucopyranoside, the structure of which is shown below.



Rhamnetin-4′-*O*-*β*-D-glucopyranoside

Table 10. The ^{1}H and ^{13}C-NMR data, HMBC correlation of compound SB5 and comparison of the ^{13}C-NMR assignments with those rhamnetin (in DMSO-d_6)

Position	Compound SB5		Rhamnetin	HMBC
	δ H (ppm)	δ C (ppm)	δ C (ppm)	correlation with ^{13}C
2	–	146.3	147.3	–
3	–	136.7	136.0	–
4	–	176.2	175.9	–
5	–	160.3	160.4	–
6	6.35 (*d*, *J* = 2.5 Hz)	97.5	97.4	C-8, C-10, C-5*, C-7*
7	–	165.0	164.9	–
8	6.77 (*d*, *J* = 2.5 Hz)	92.0	91.8	C-6, C-10, C-7*, C-9*
9	–	156.2	156.0	
10	–	104.1	103.7	
1′	–	125.0	124.9	
2′	7.74 (*d*, *J* = 2.0 Hz)	115.2	115.2	C-2, C-1′*, C-6′
3′	–	146.4	145.0	–
4′	–	146.9	147.8	–
5′	7.25 (*d*, *J* = 9.0 Hz)	115.8	115.6	C-1′, C-3′, C-4′*
6′	7.66 (*dd*, *J* = 9.0, 2.0 Hz)	119.6	120.1	C-2′ and C-2
1"	4.84 (*d*, *J* = 7.5 Hz)	101.4	–	C-4′, C-3″, C-5″
2"	3.33 (*s*)	73.3	–	C-1″*, C-3″*
3"	3.29 (*dd*, *J* = 9.5, 5.0 Hz)	75.9	–	C-2″*, C-4″*
4"	3.17 (*dd*, *J* = 9.0, 3.0 Hz)	69.8	–	C-3″*, C-5″*
5"	3.37 (*dt*, *J* = 7.9, 1.5 Hz)	77.3	–	C-1″, C-6″*
6a" 6b"	3.48 (*dd*, *J* = 12.0, 6.0 Hz) 3.73 (*dd*, *J* = 11.7, 5.5 Hz)	60.7	–	C-5″* C-4″
7-OMe	3.86 (*s*)	56.0	–	C-7
5-OH	12.39 (*s*)	–	–	C-5*, C-6, C-10

* Two-bond correlation

CHAPTER V

CONCLUSION

In this investigation, four compounds and a mixture of two compounds were isolated from the aerial part of *Sauropus bacciformis* (L.) Airy Shaw by chromatographic techniques. From the EtOAc extract, a new flavonol glycoside named rhamnetin-4′-*O*-*β*-D-glucopyranoside was isolated and its structure elucidated. From the hexane extract, three known triterpenoids, i.e. friedelin, simiarenol and glochidonol, and a mixture of *β*-sitosterol and stigmasterol were identified.

This is the first report of chemical constituents of *Sauropus bacciformis* (L.) Airy Shaw. Glochidonol is considered a chemotaxonomic marker found only in several genus of Euphorbiaceae Subtribe Flueggeinae such as *Fluggea*, *Glochidion* and *Phyllanthus*.

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APPENDIX

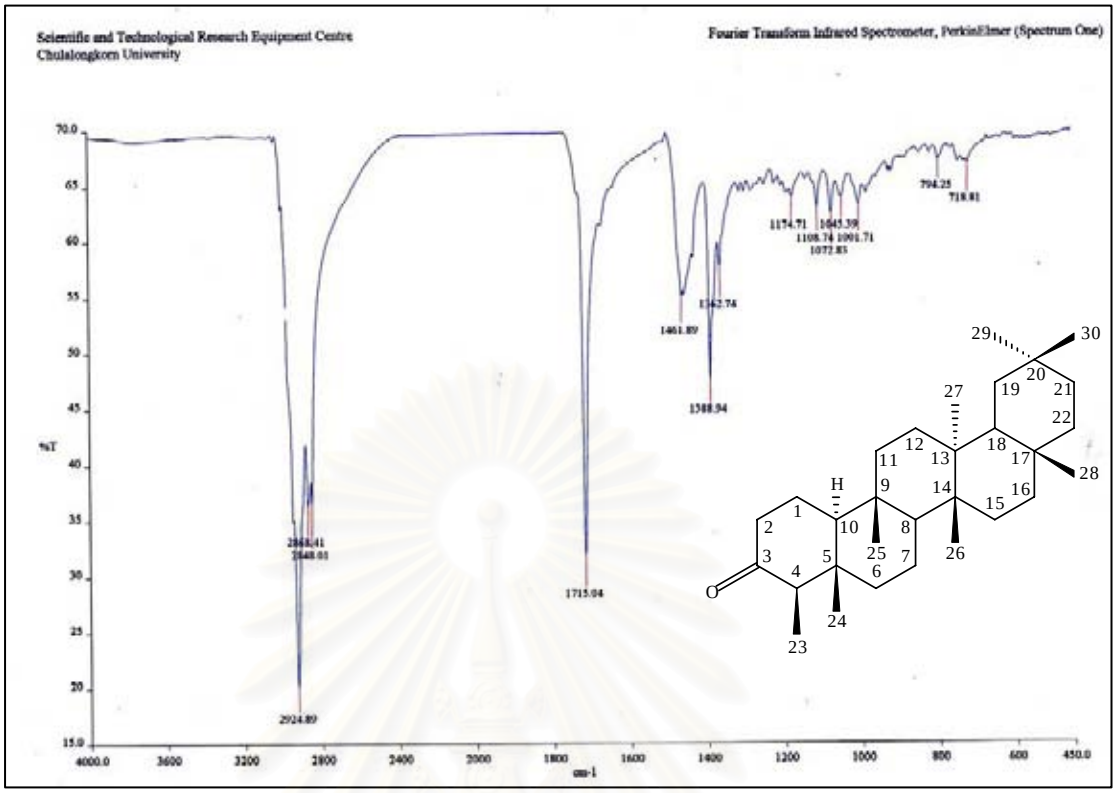

Figure 6. IR spectrum of compound SB1 (KBr disc)

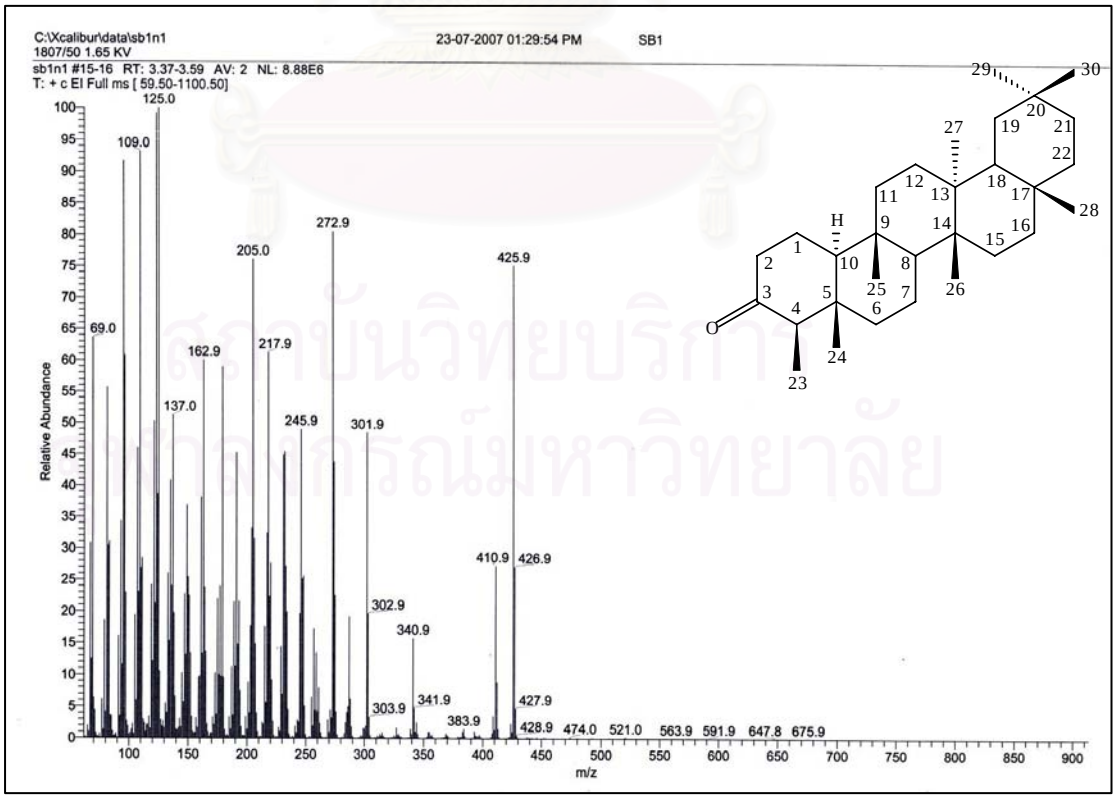

Figure 7. EIMS of compound SB1

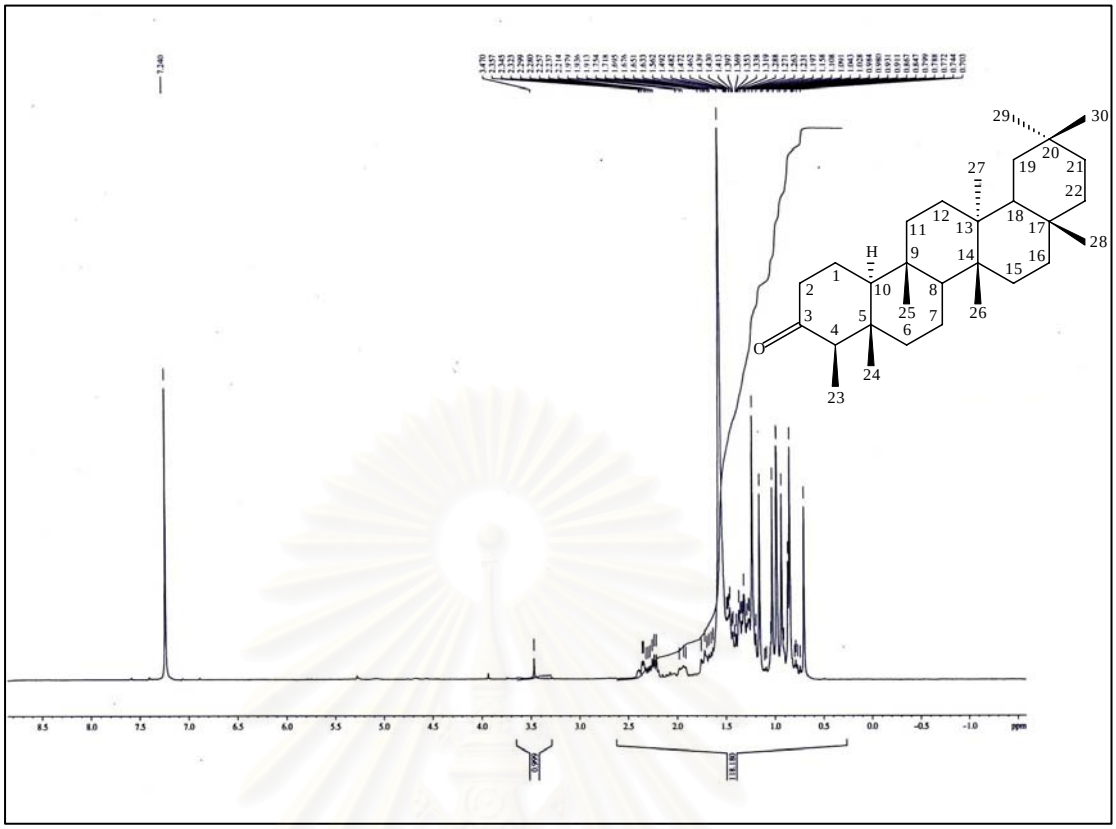

Figure 8a. The 300 MHz ^{1}H-NMR spectrum of compound SB1 (in $CDCl_3$)

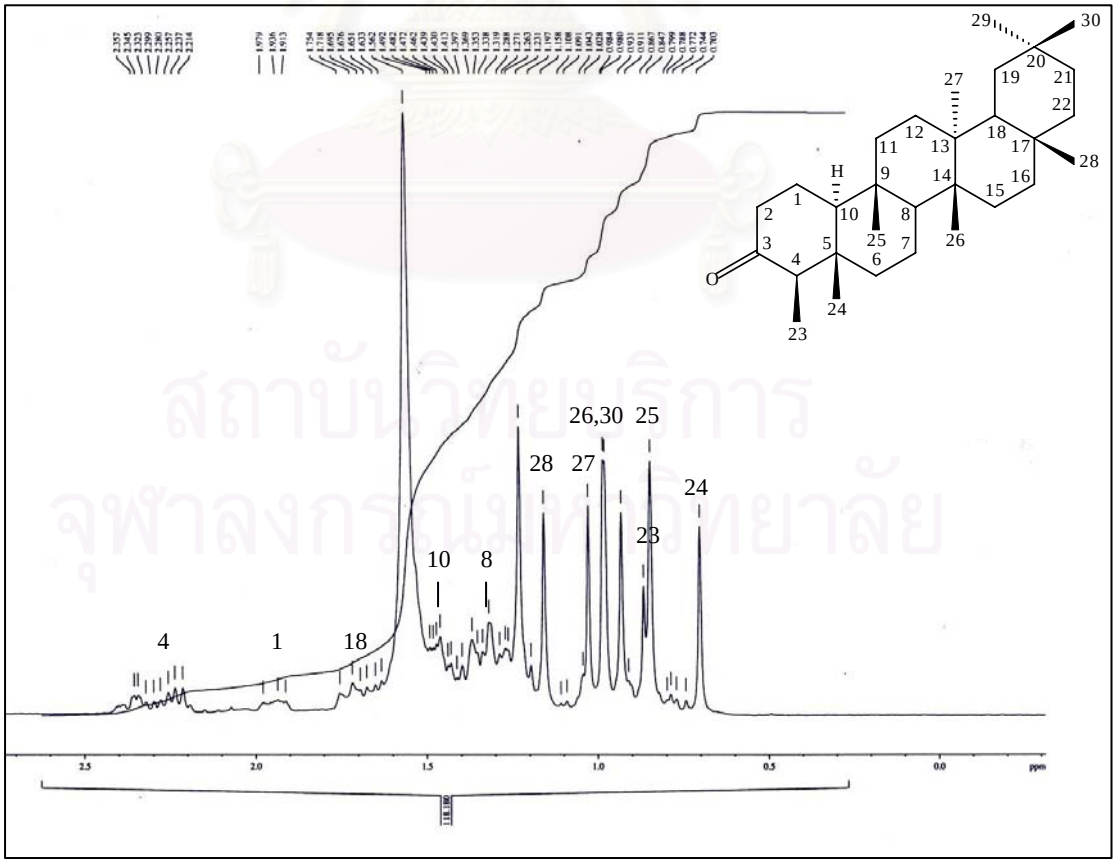

Figure 8b. The 300 MHz ^{1}H-NMR spectrum of compound SB1 (expanded)

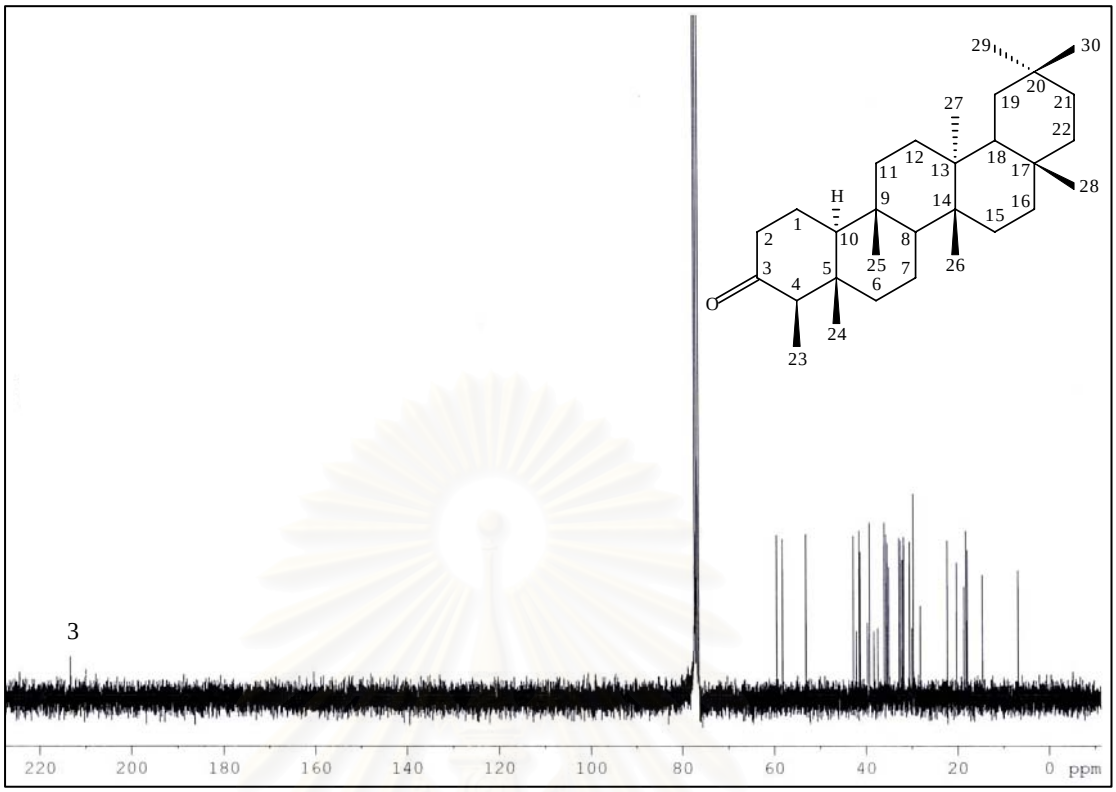

Figure 9a. The 75 MHz ^{13}C-NMR spectrum of compound SB1 (in $CDCl_3$)

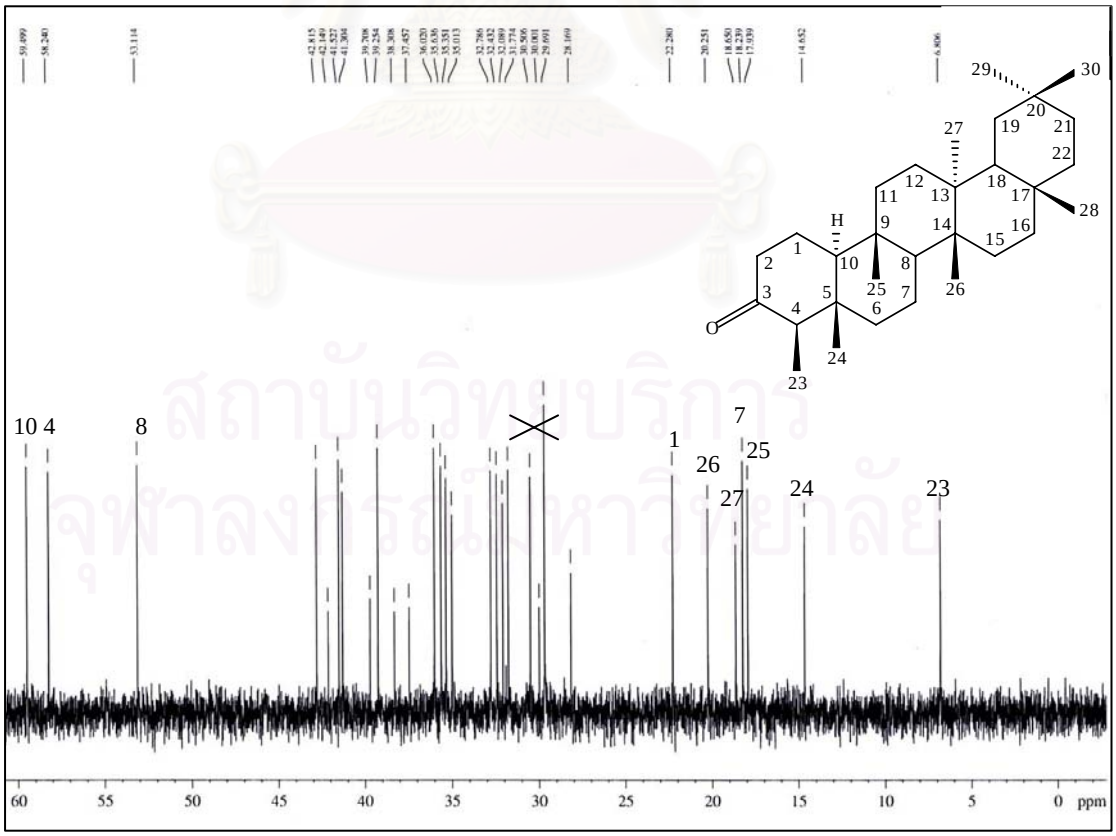

Figure 9b. The 75 MHz ^{13}C-NMR spectrum of compound SB1 (expanded)

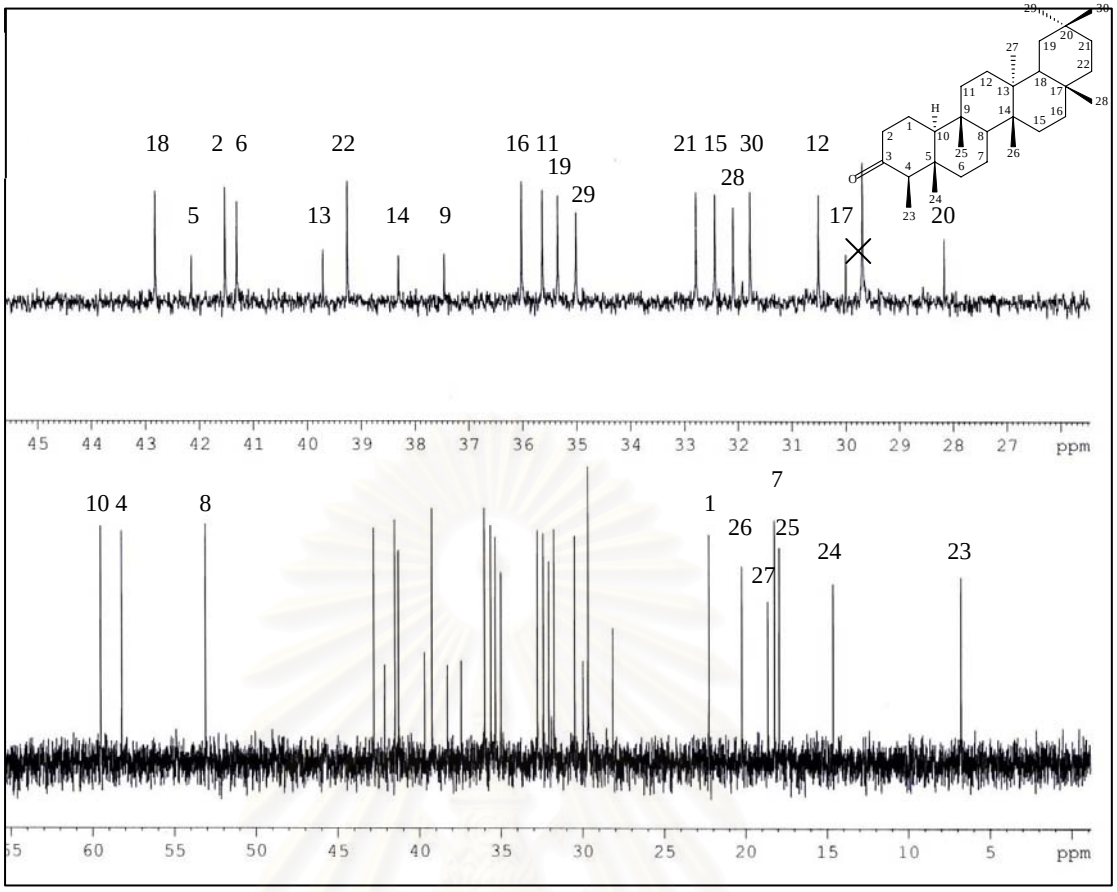

Figure 9c. The 75 MHz ^{13}C-NMR spectrum of compound SB1 (expanded)

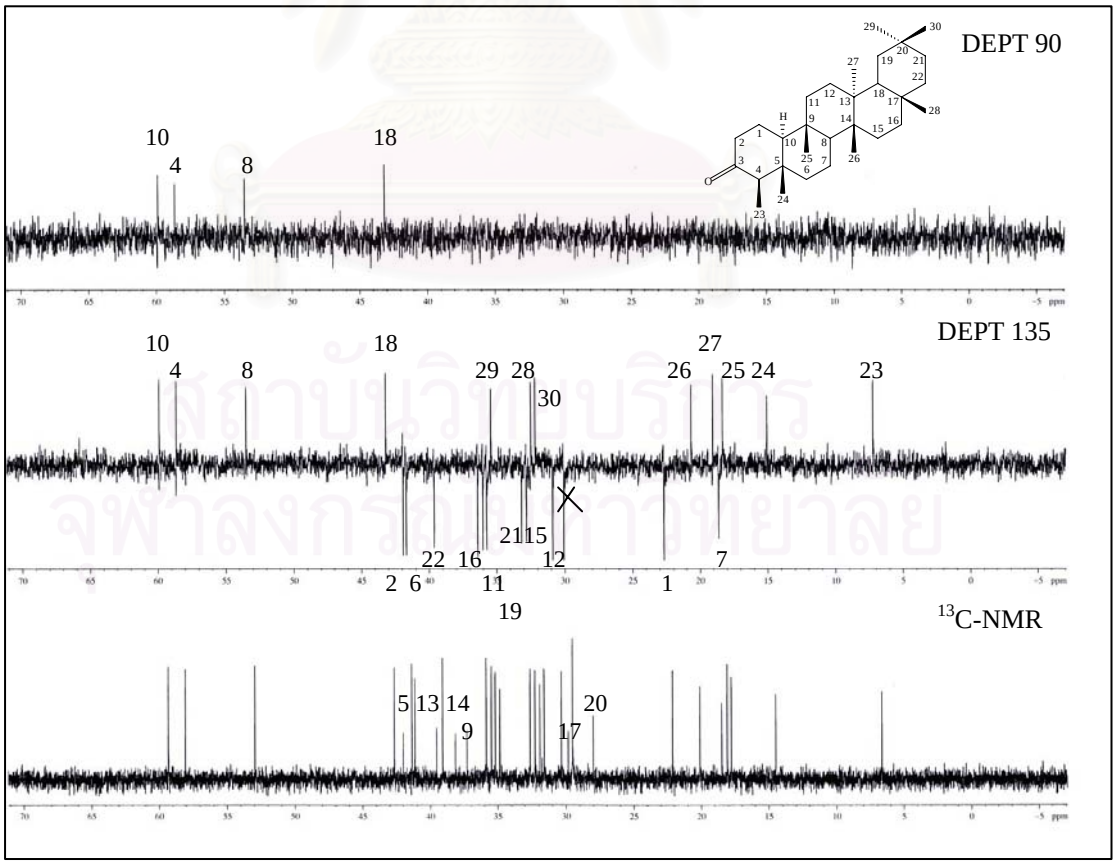

Figure 10. The 75 MHz ^{13}C-DEPT spectra of compound SB1 (in $CDCl_3$)

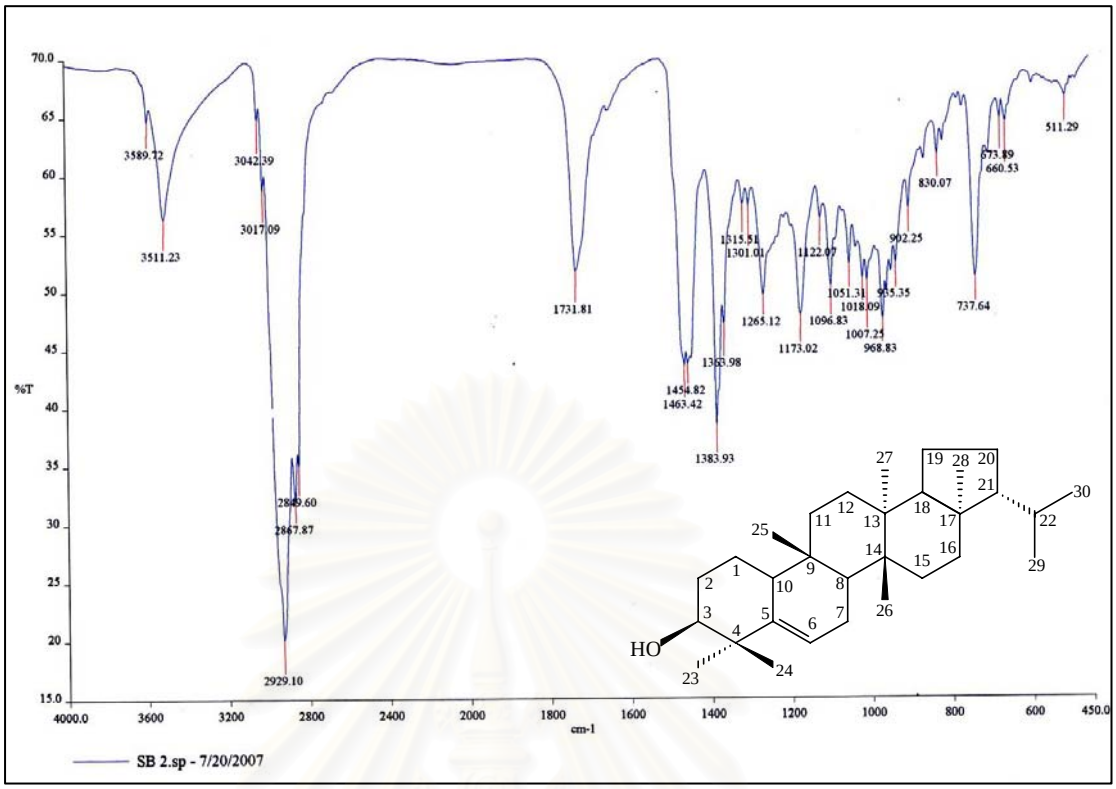

Figure 11. IR spectrum of compound SB2 (KBr disc)

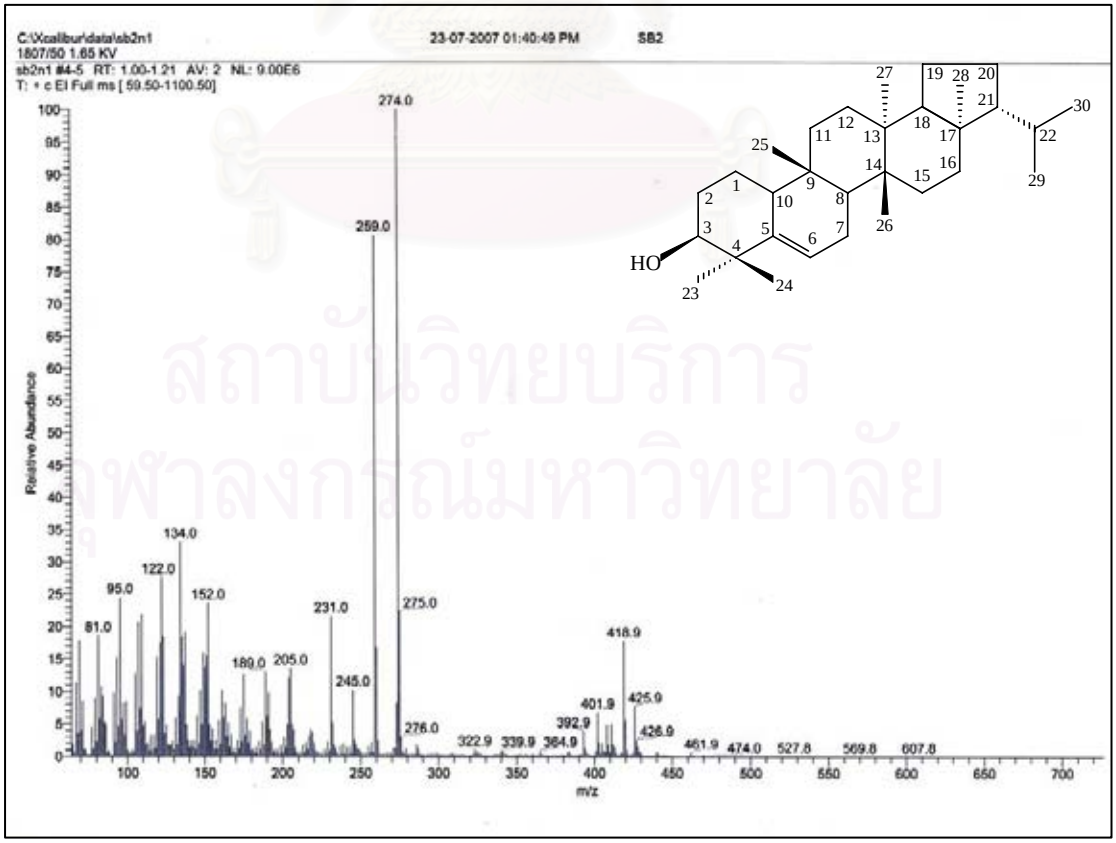

Figure 12. EIMS of compound SB2

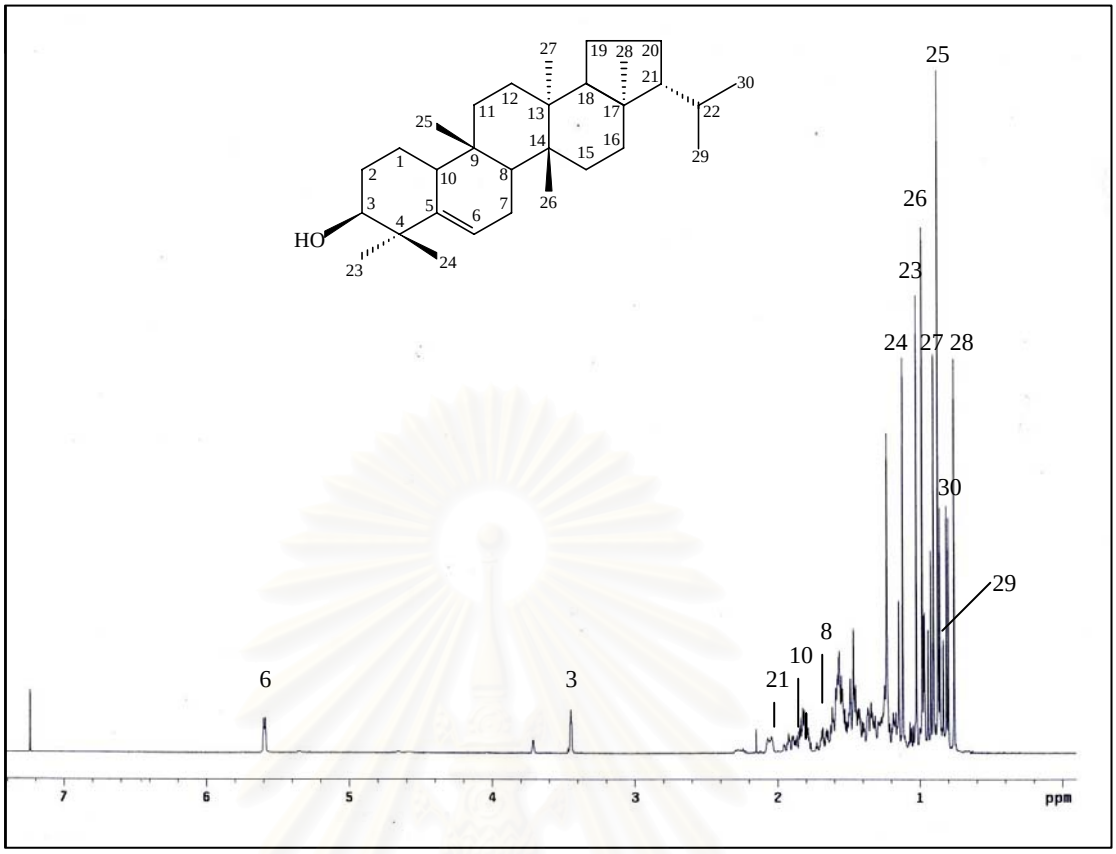

Figure 13. The 500 MHz ^{1}H-NMR spectrum of compound SB2 (in $CDCl_3$)

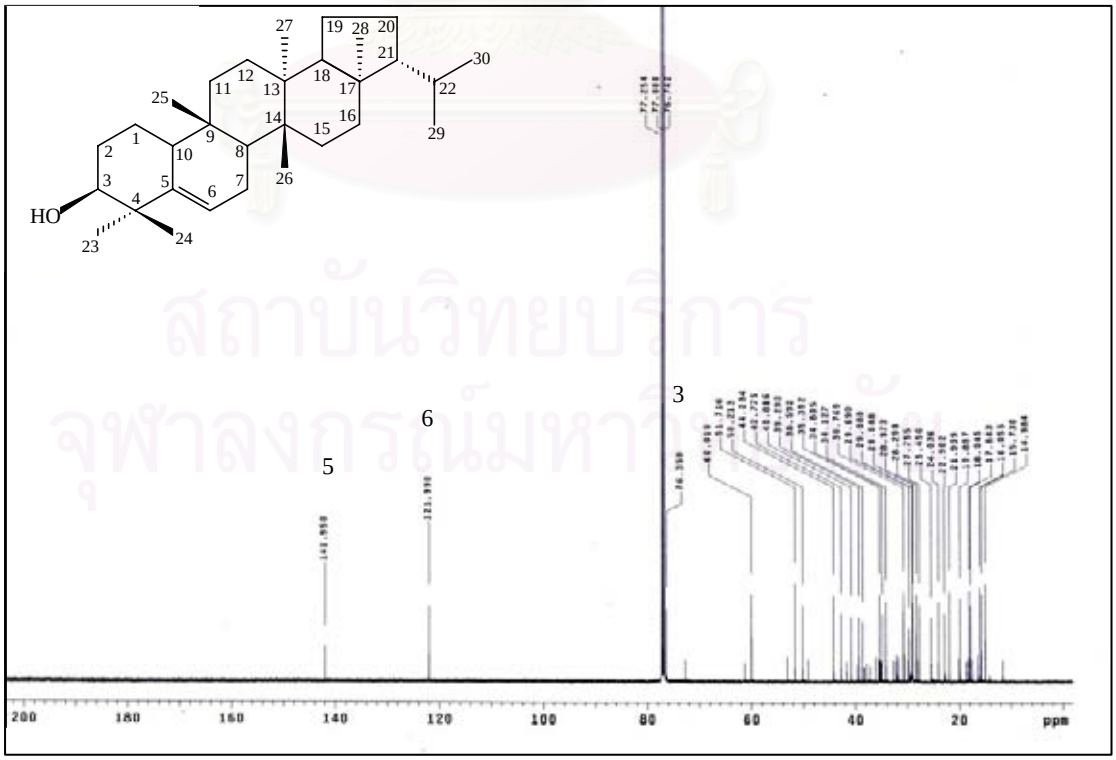

Figure 14a. The 125 MHz ^{13}C-NMR spectrum of compound SB2 (in $CDCl_3$)

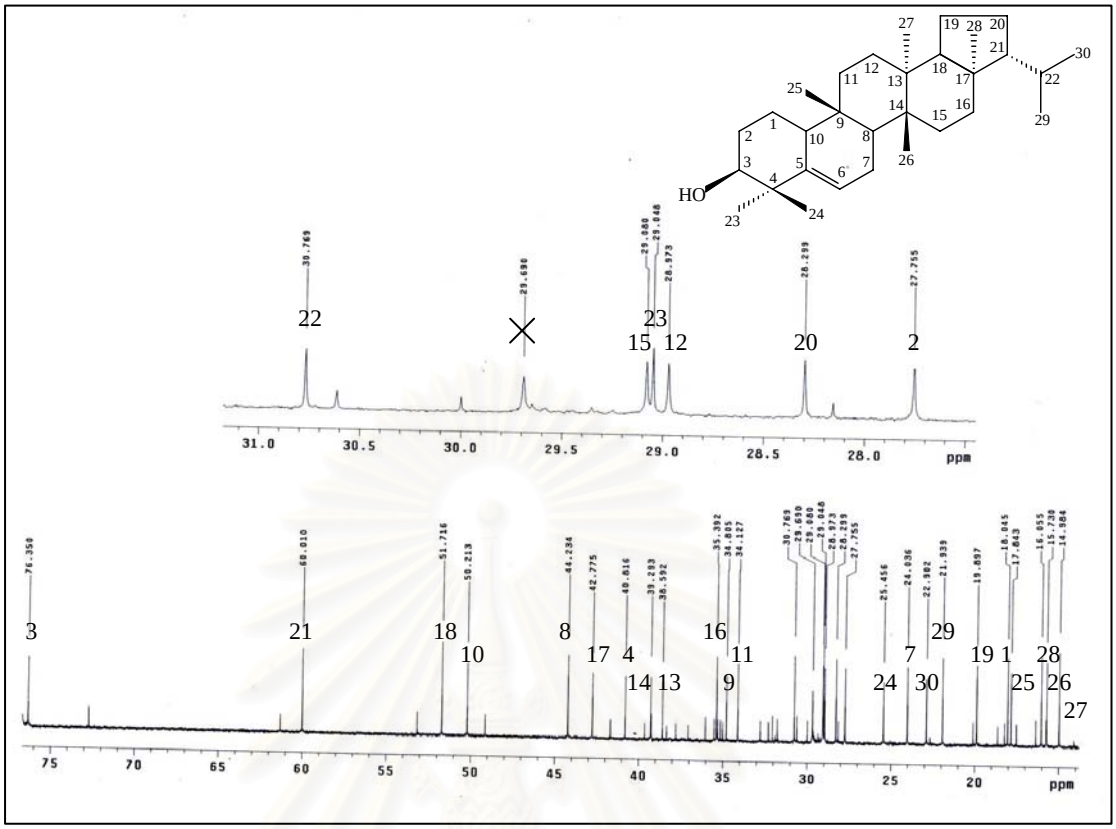

Figure 14b. The 125 MHz ^{13}C-NMR spectrum of compound SB2 (expanded)

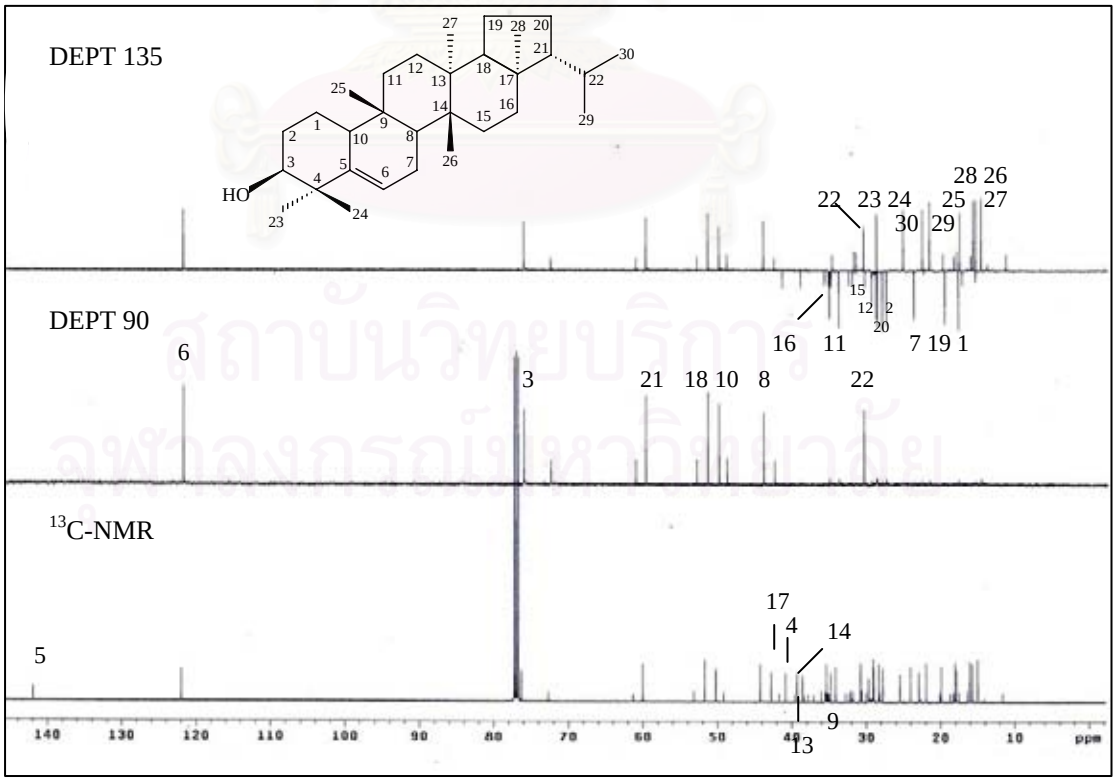

Figure 15. The 125 MHz ^{13}C-DEPT spectra of compound SB2 (in $CDCl_3$)

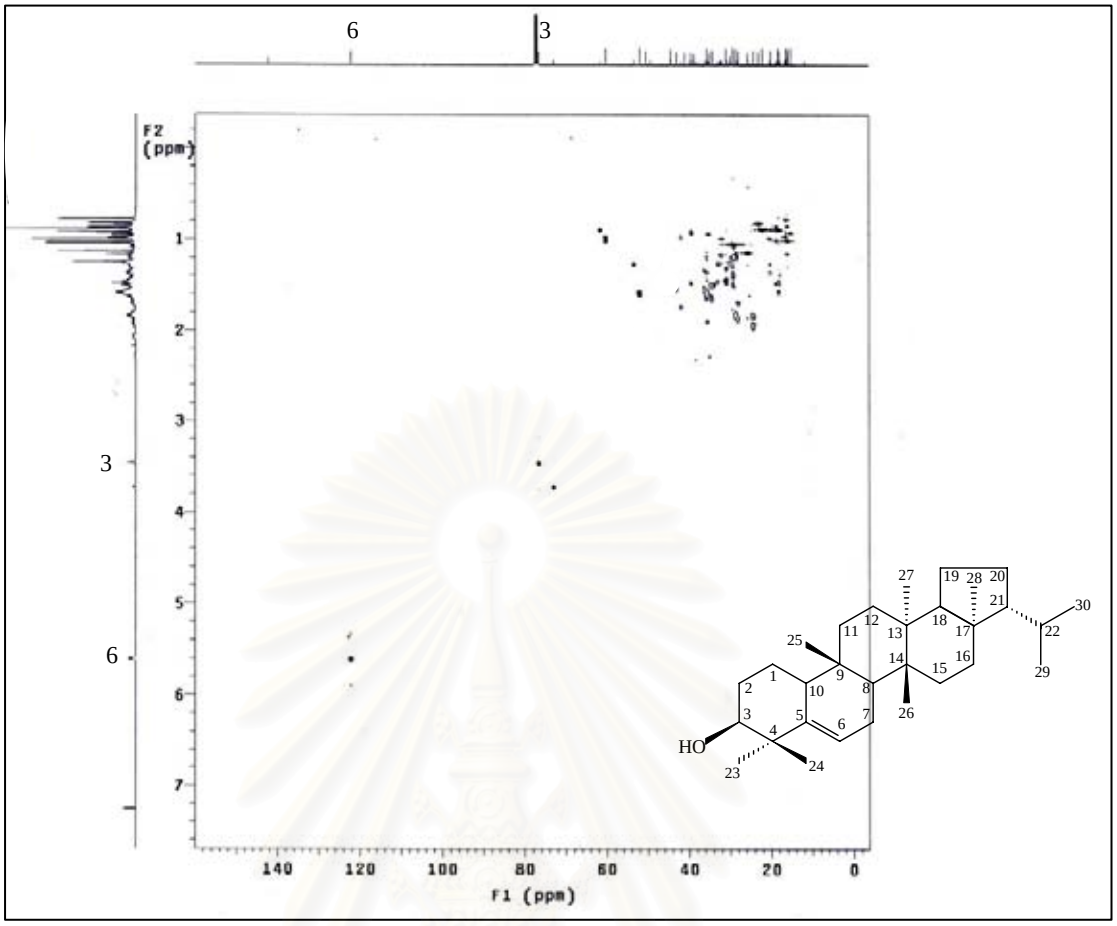

Figure 16a. The 500 MHz ^{1}H-^{13}C HMQC NMR spectrum of compound SB2 (in $CDCl_3$)

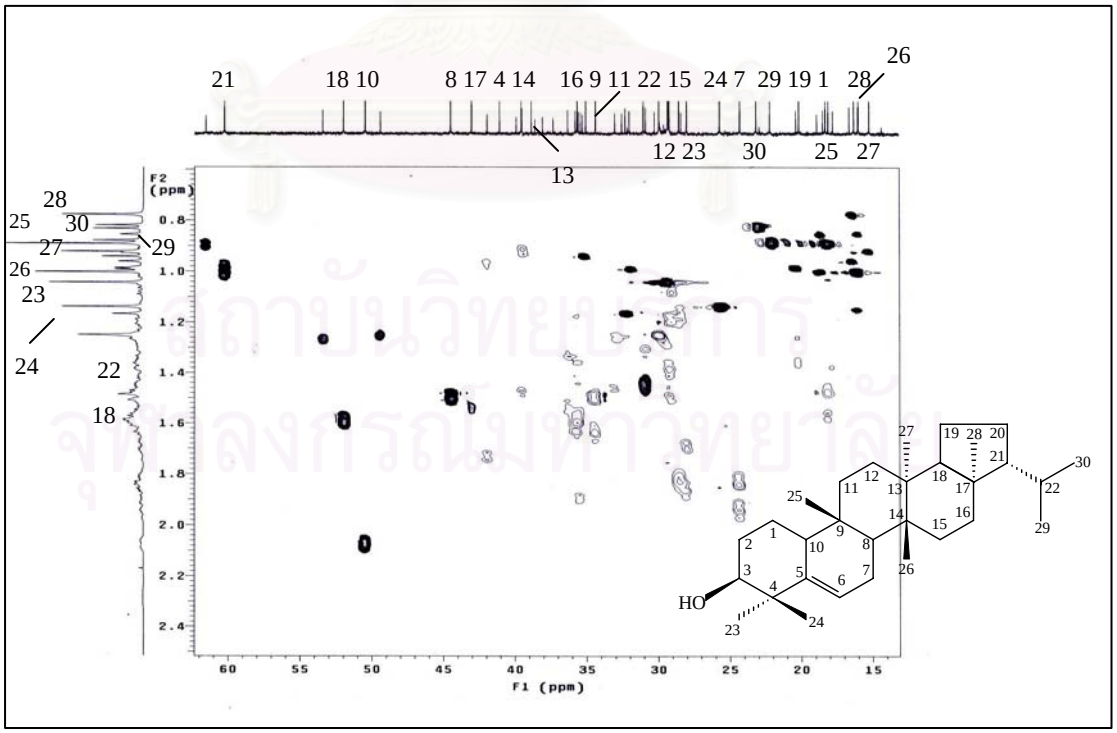

Figure 16b. The 500 MHz ^{1}H-^{13}C HMQC NMR spectrum of compound SB2 (expanded)

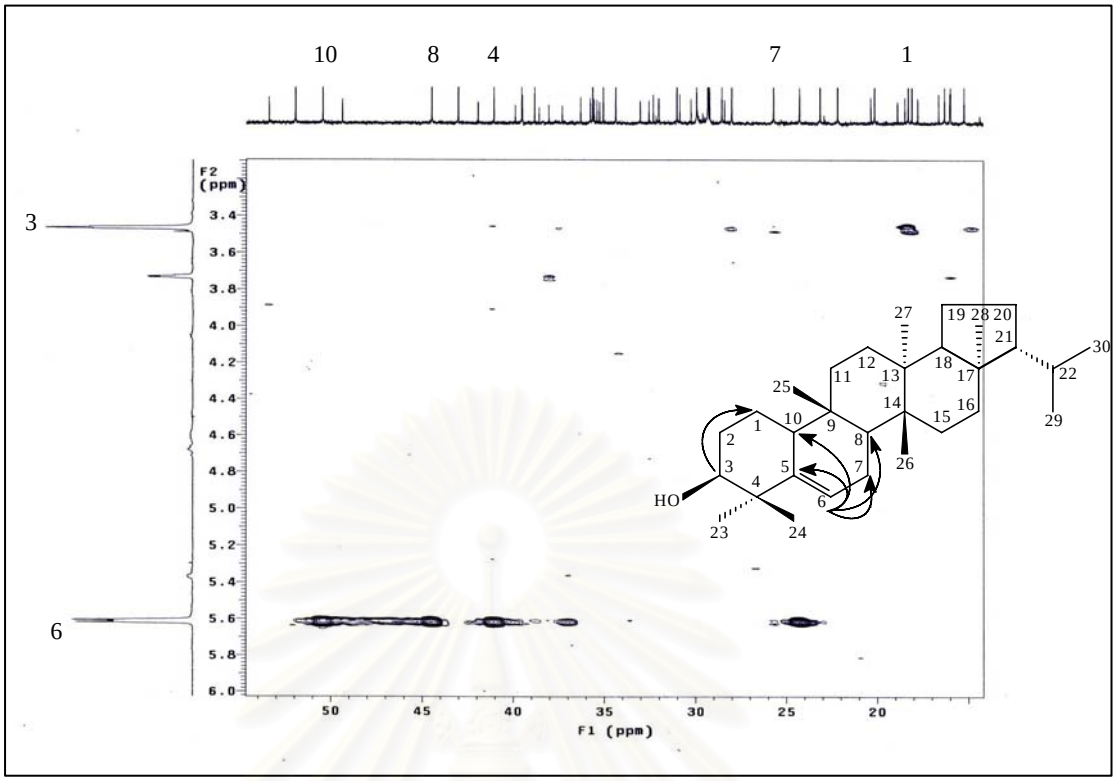

Figure 17a. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB2 (in $CDCl_3$)

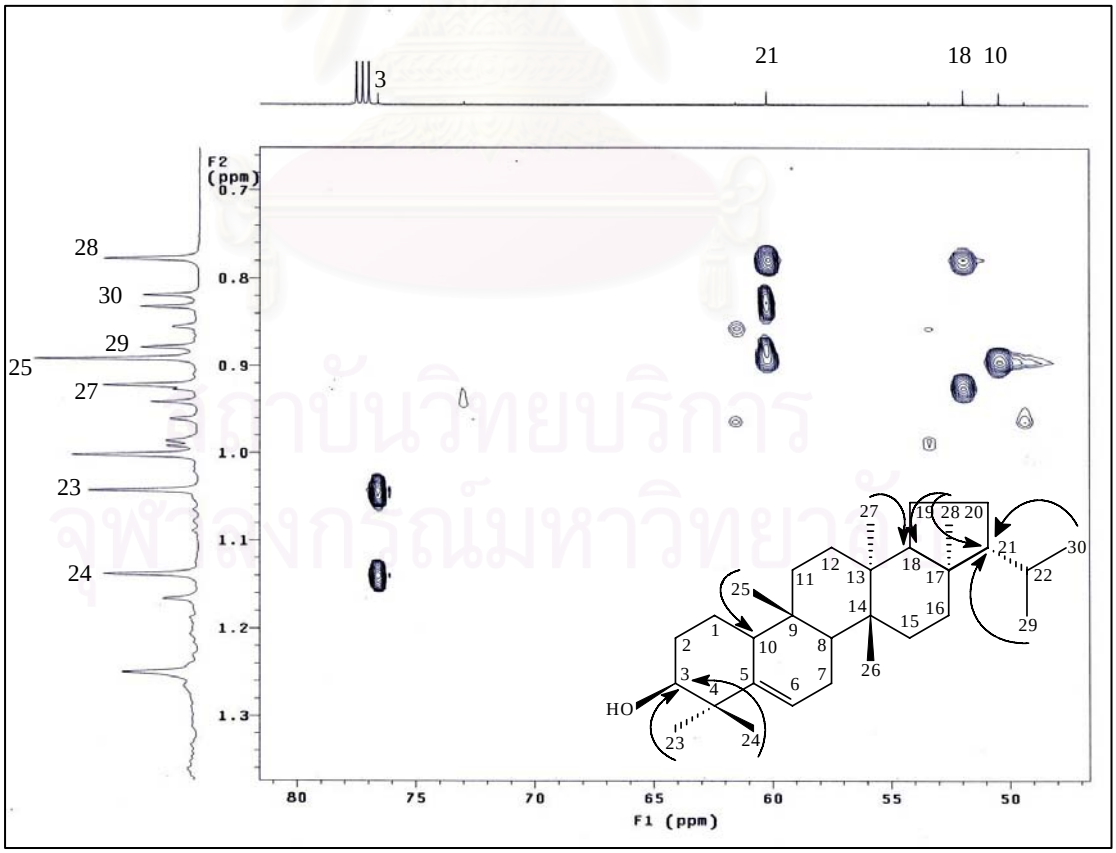

Figure 17b. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB2 (expanded)

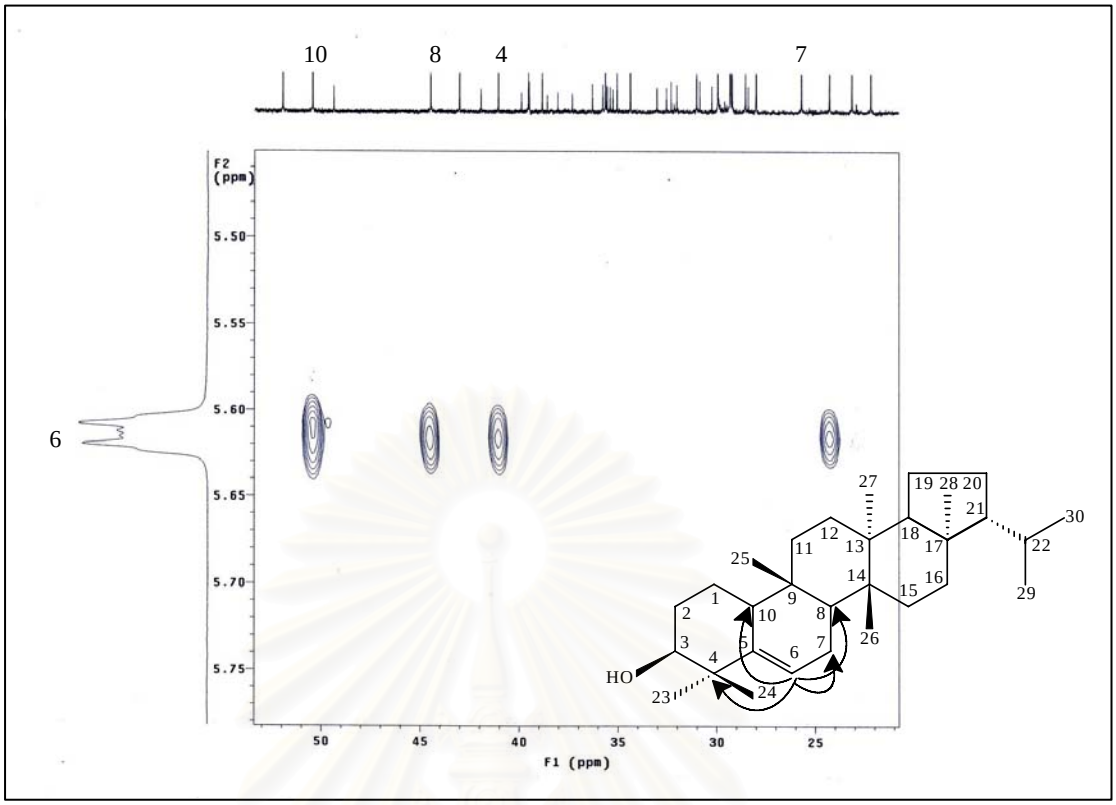

Figure 17c. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB2 (expanded)

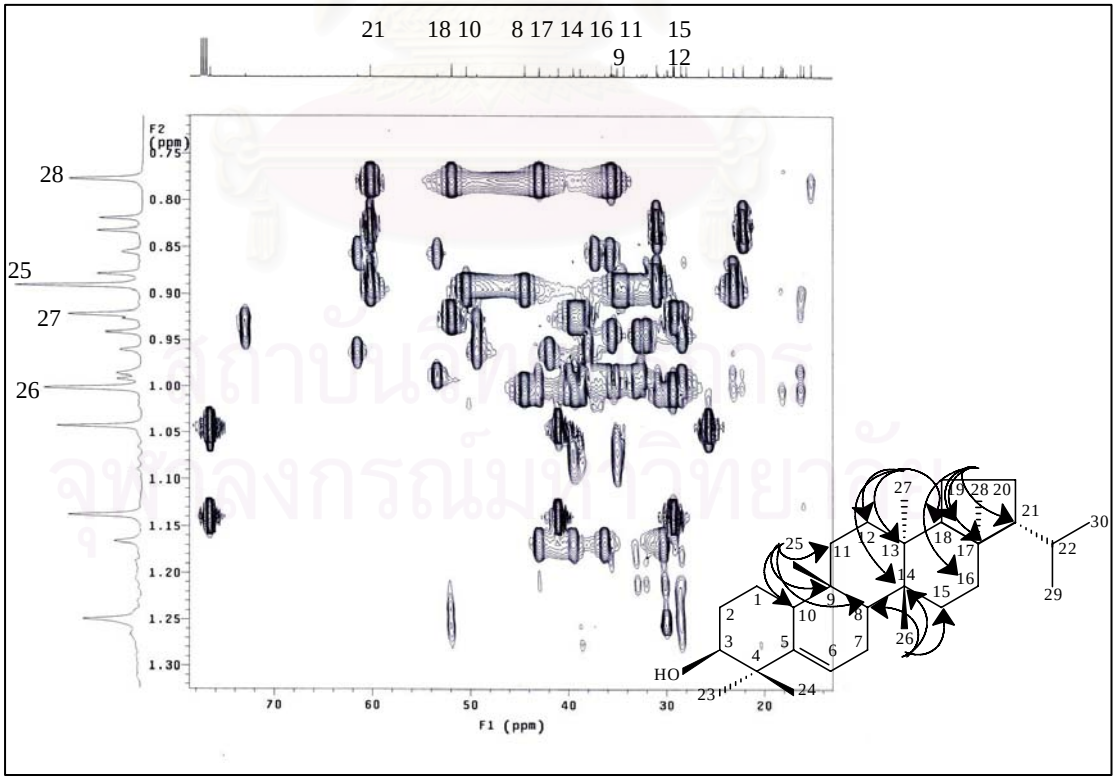

Figure 17d. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB2 (expanded)

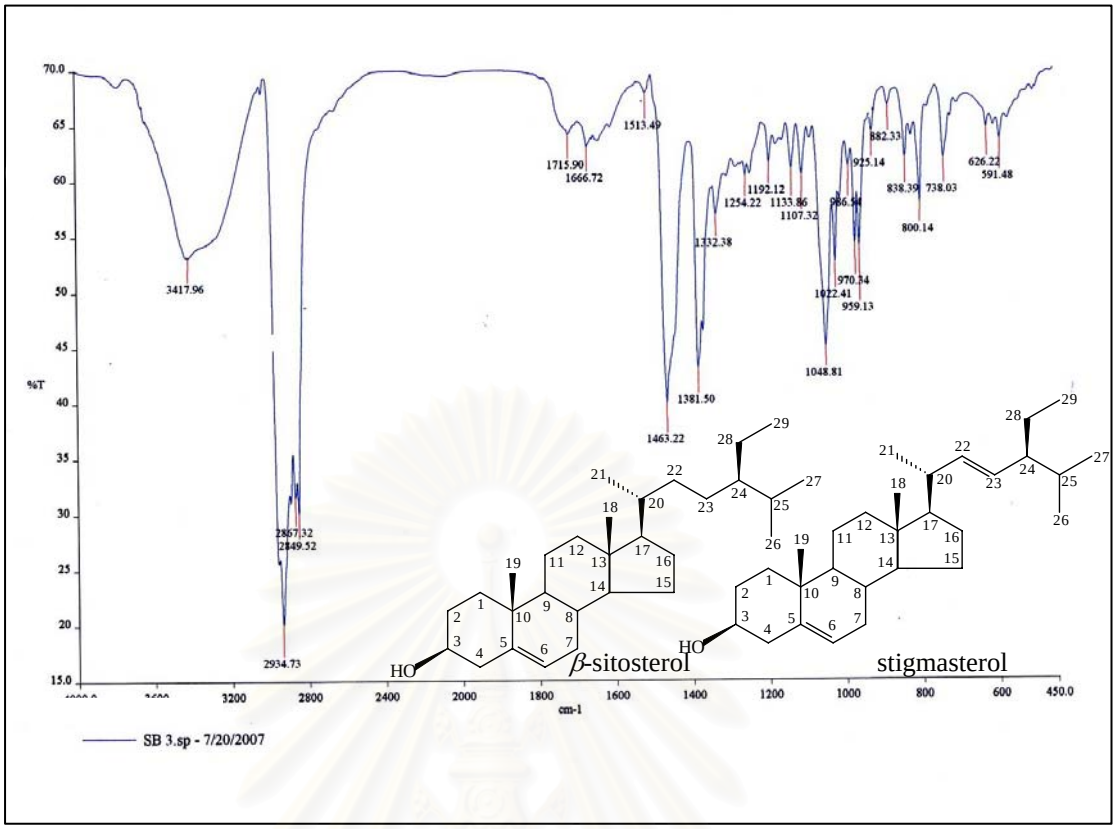

Figure 18. IR spectrum of compound SB3 (KBr disc)

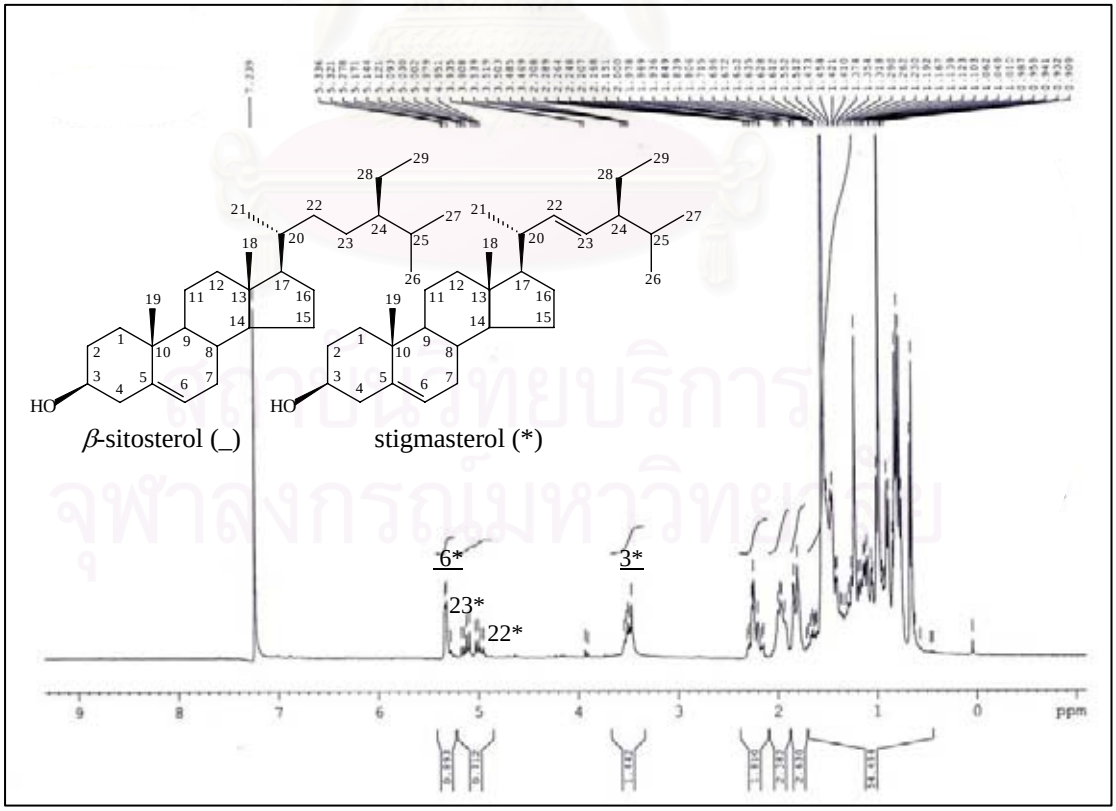

Figure 19a. The 300 MHz ^{1}H-NMR spectrum of compound SB3 (in $CDCl_3$)

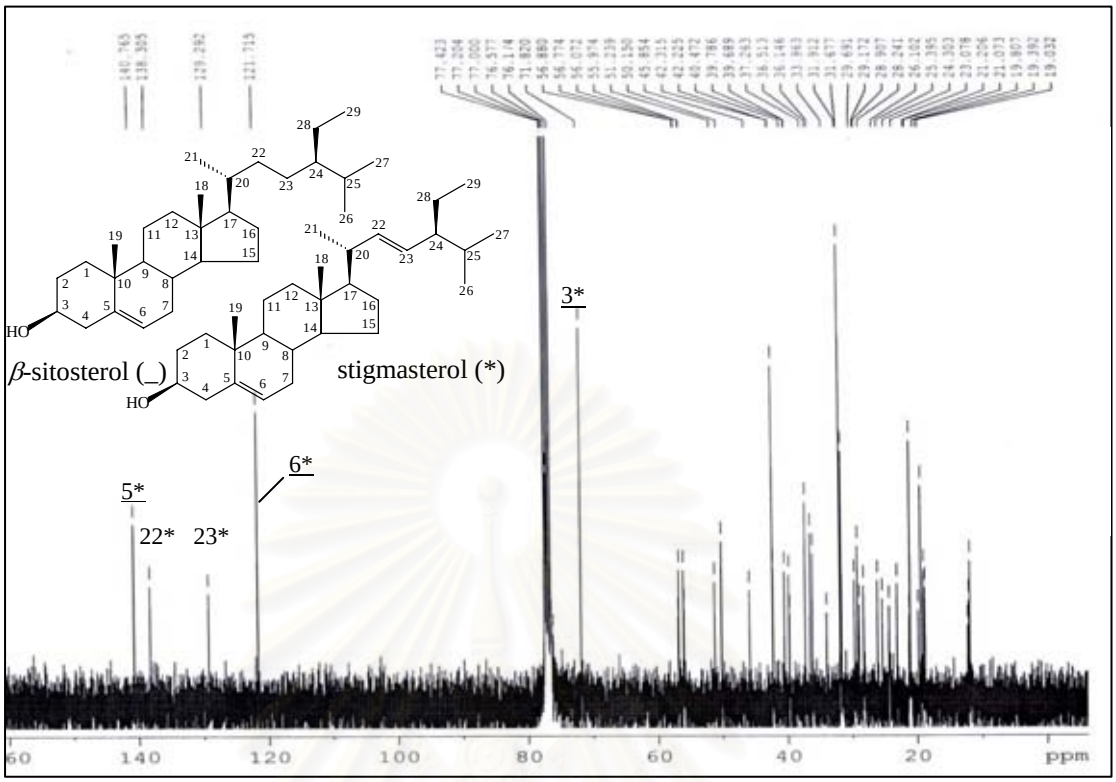

Figure 20a. The 75 MHz ^{13}C-NMR spectrum of compound SB3 (in $CDCl_3$)

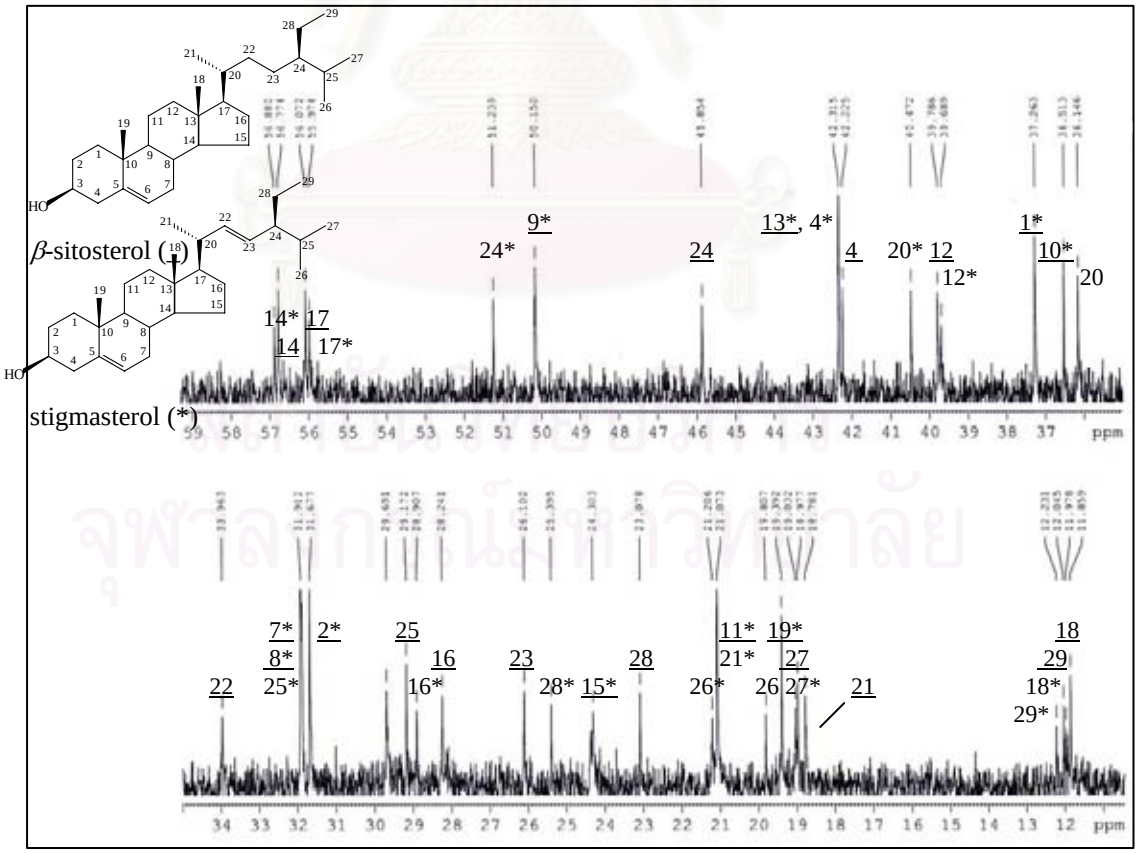

Figure 20b. The 75 MHz ^{13}C-NMR spectrum of compound SB3 (in $CDCl_3$)

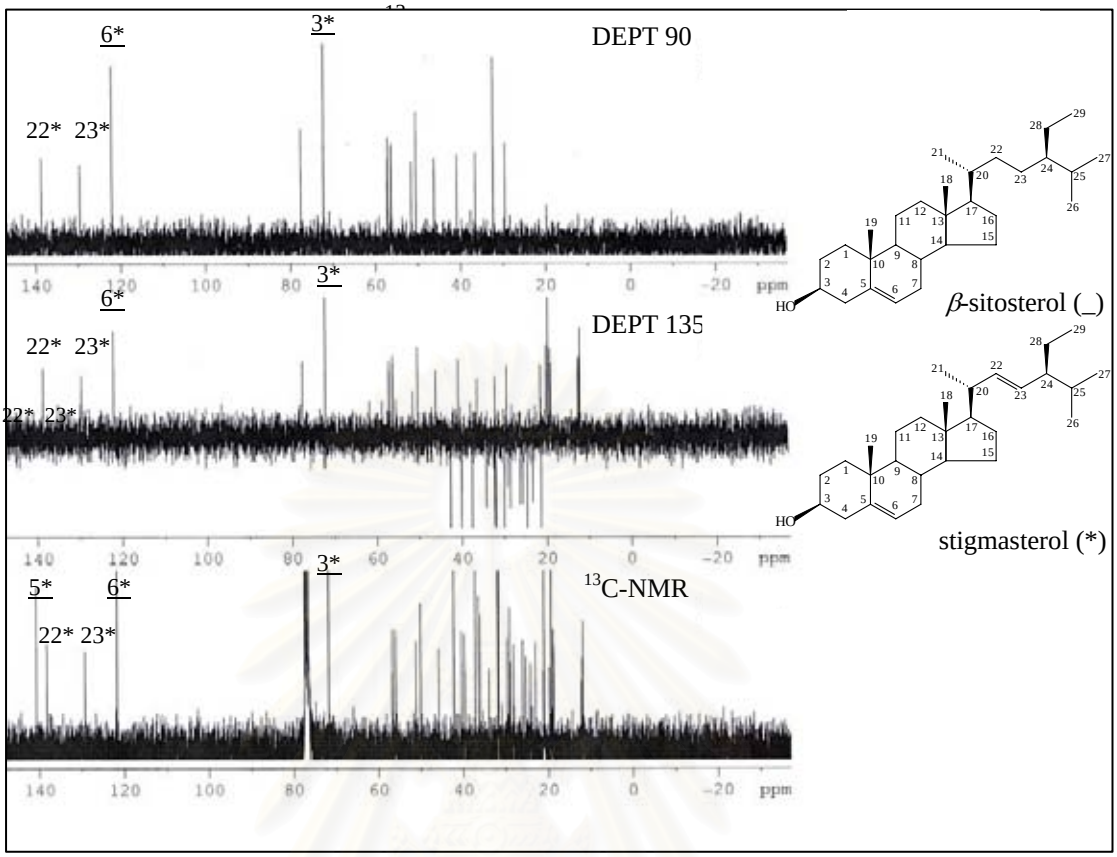

Figure 21. The 75 MHz ^{13}C-DEPT spectra of compound SB3 (in $CDCl_3$)

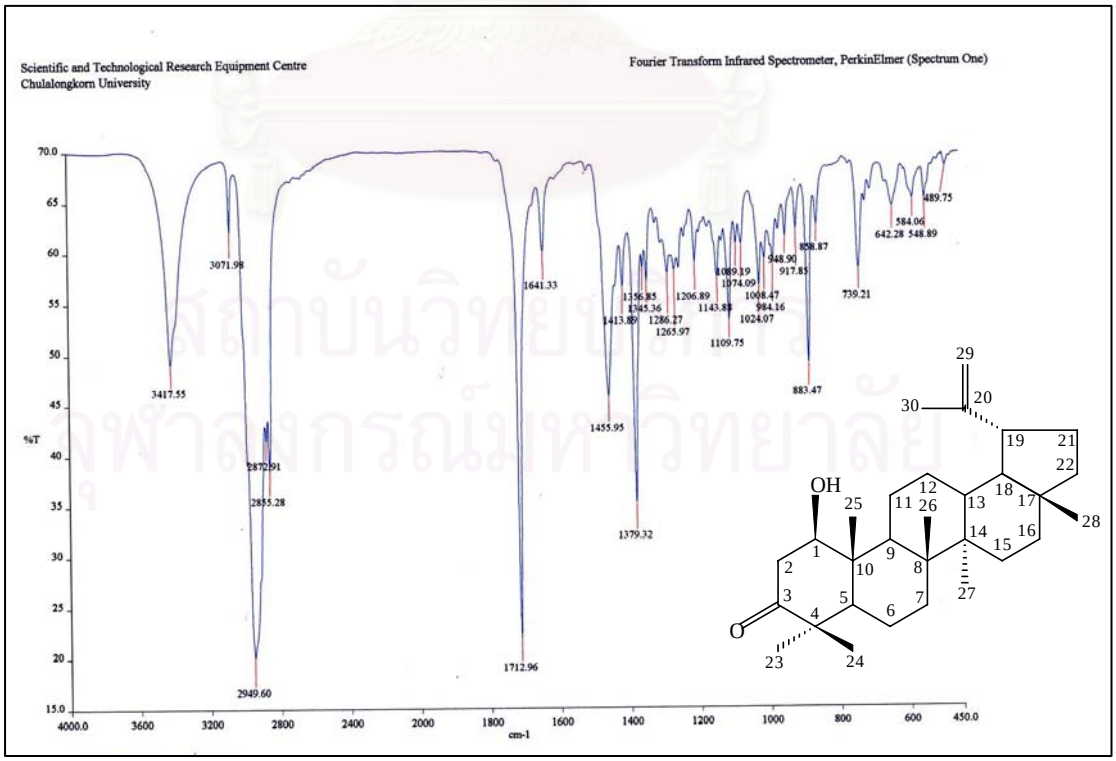

Figure 22. IR spectrum of compound SB4 (KBr disc)

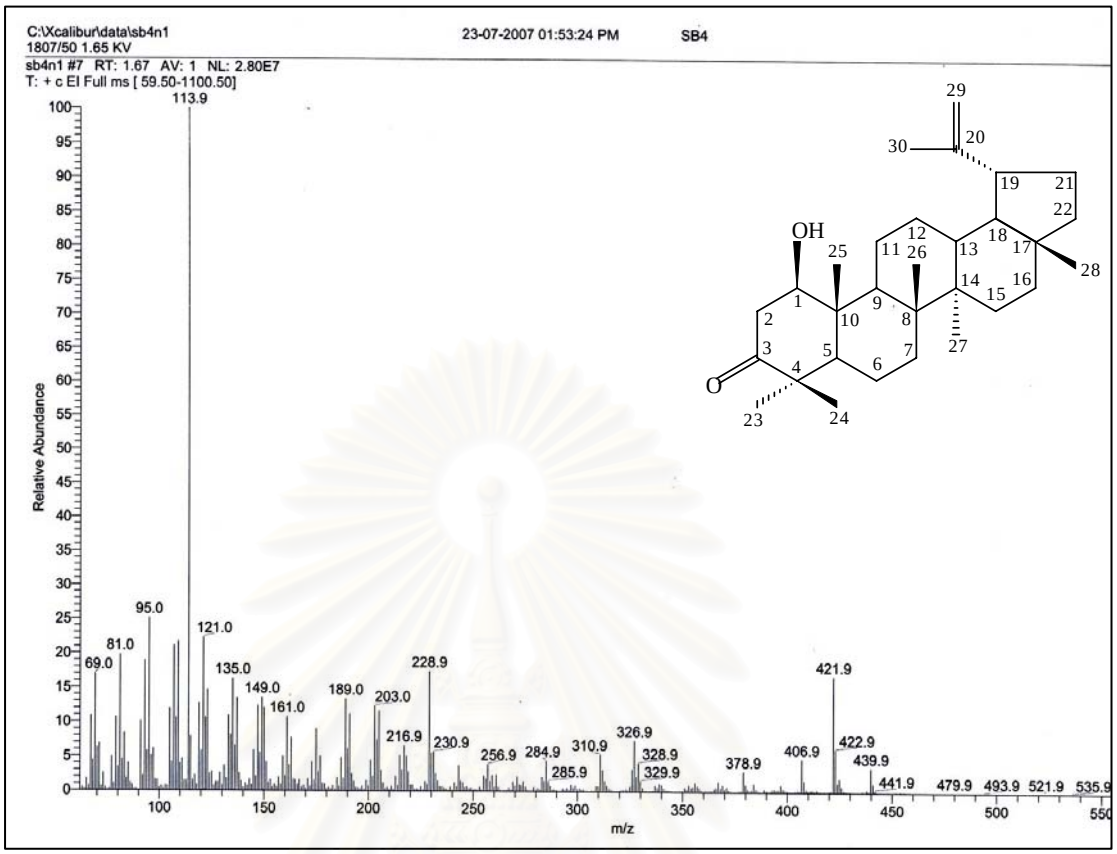

Figure 23. EIMS of compound SB4

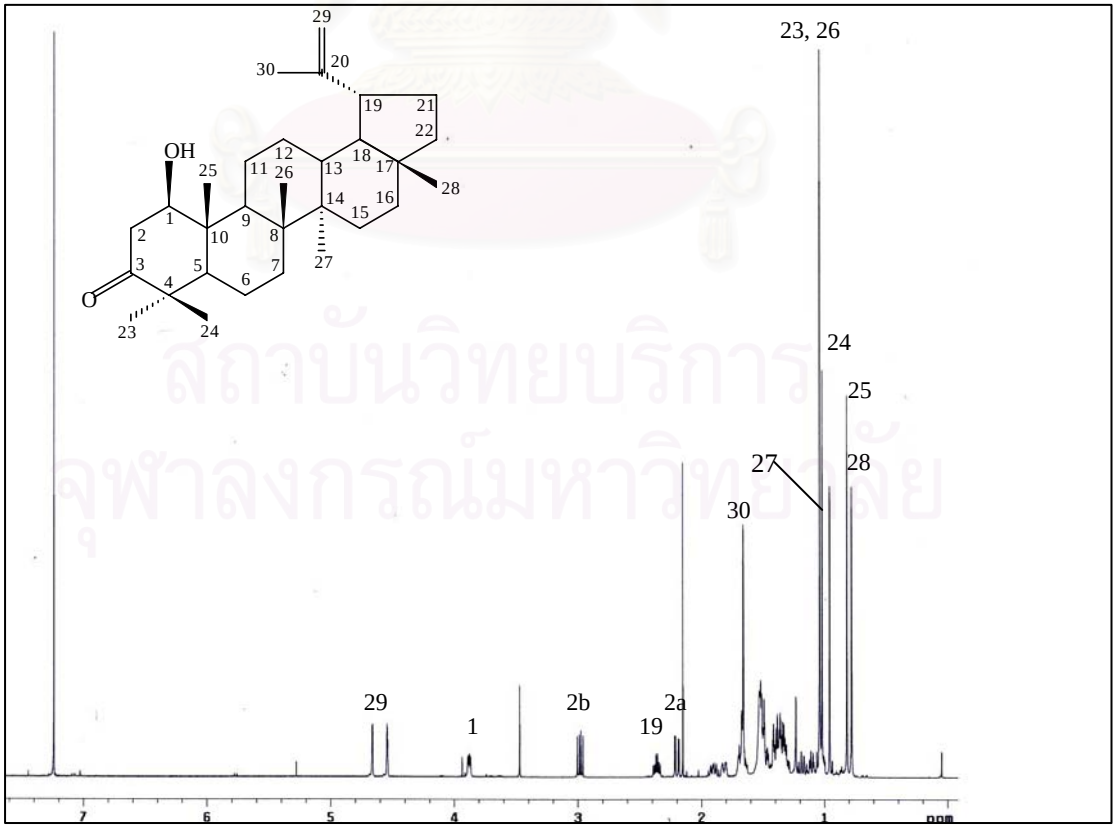

Figure 24. The 500 MHz ^{1}H-NMR spectrum of compound SB4 (in $CDCl_3$)

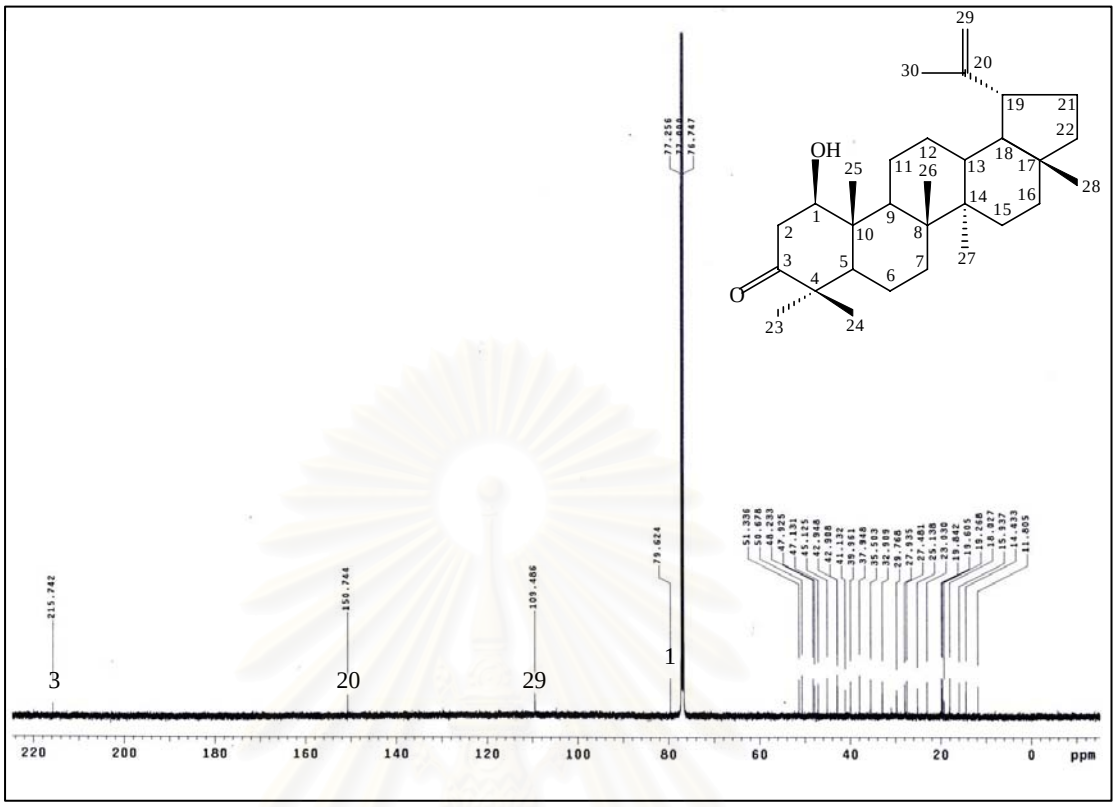

Figure 25a. The 125 MHz ^{13}C-NMR spectrum of compound SB4 (in $CDCl_3$)

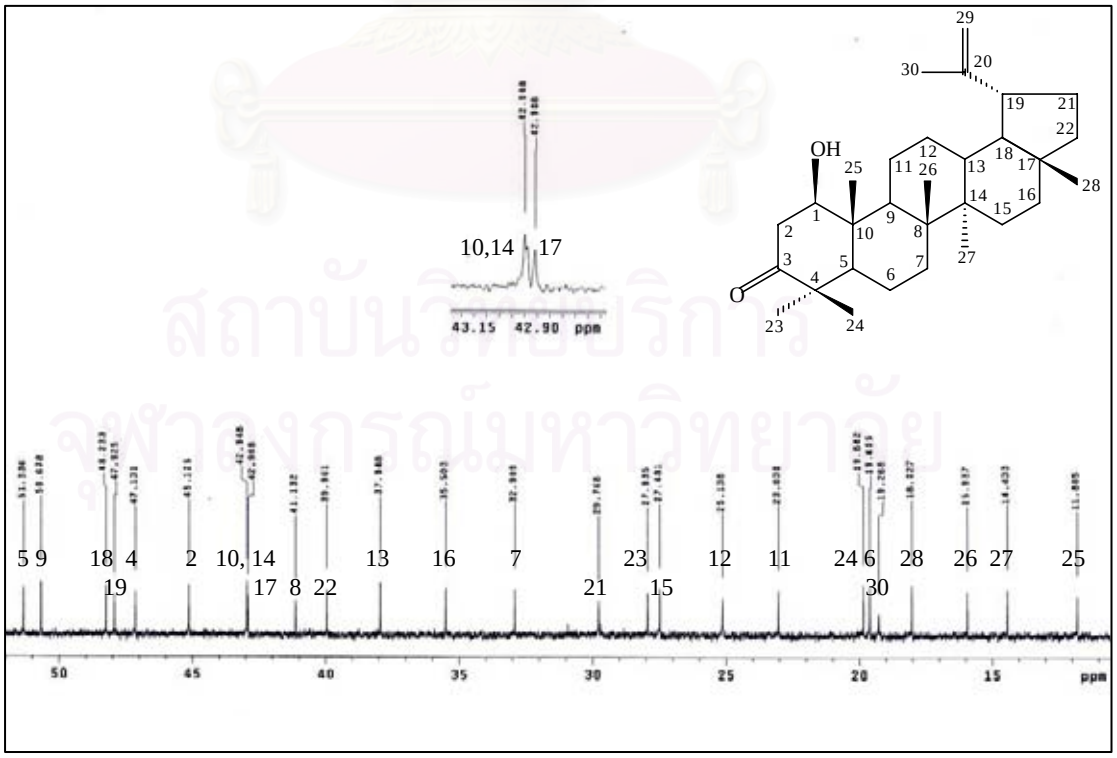

Figure 25b. The 125 MHz ^{13}C-NMR spectrum of compound SB4 (expanded)

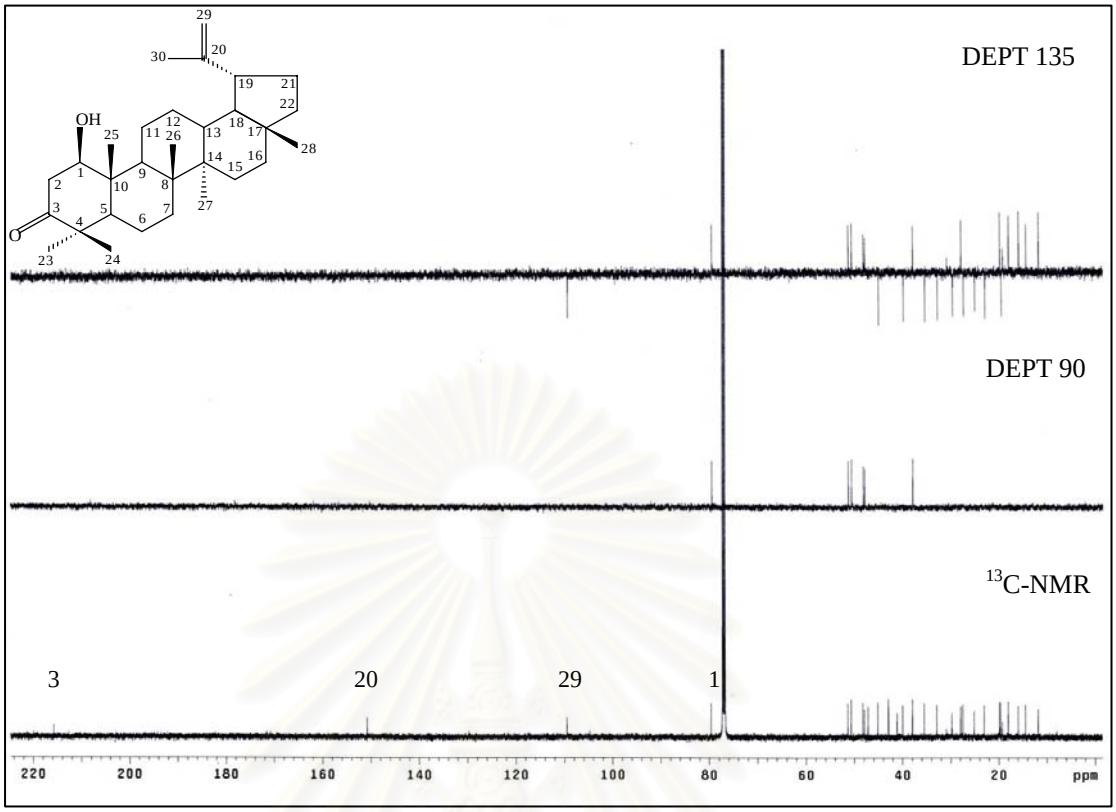

Figure 26a. The 125 MHz ^{13}C-DEPT spectra of compound SB4 (in $CDCl_3$)

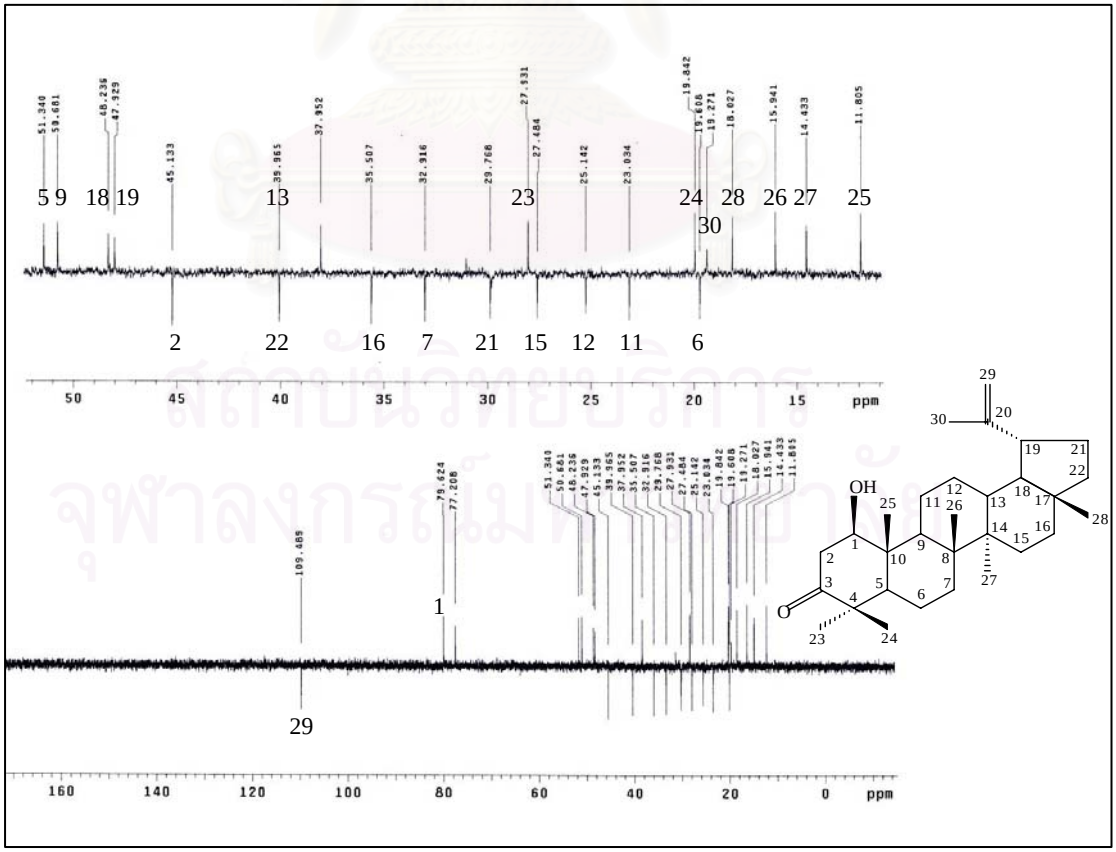

Figure 26b. The 125 MHz ^{13}C-DEPT spectra of compound SB4 (expanded)

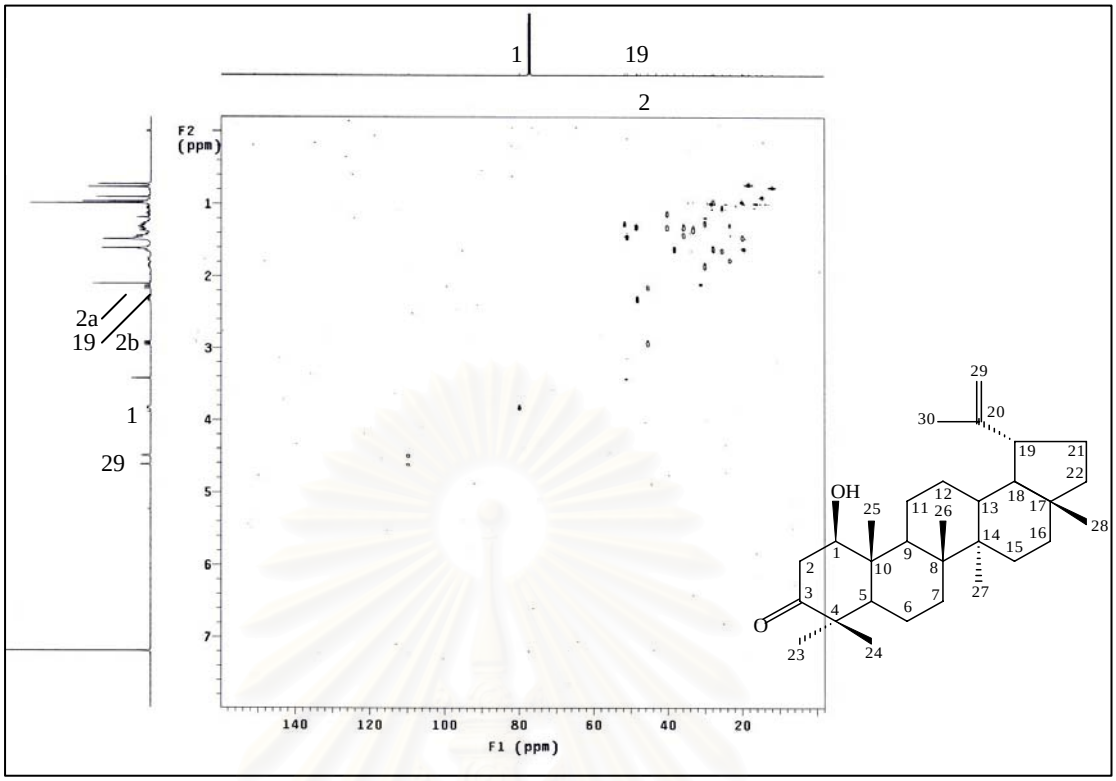

Figure 27a. The 500 MHz ^{1}H-^{13}C HMQC NMR spectrum of compound SB4 (in $CDCl_3$)

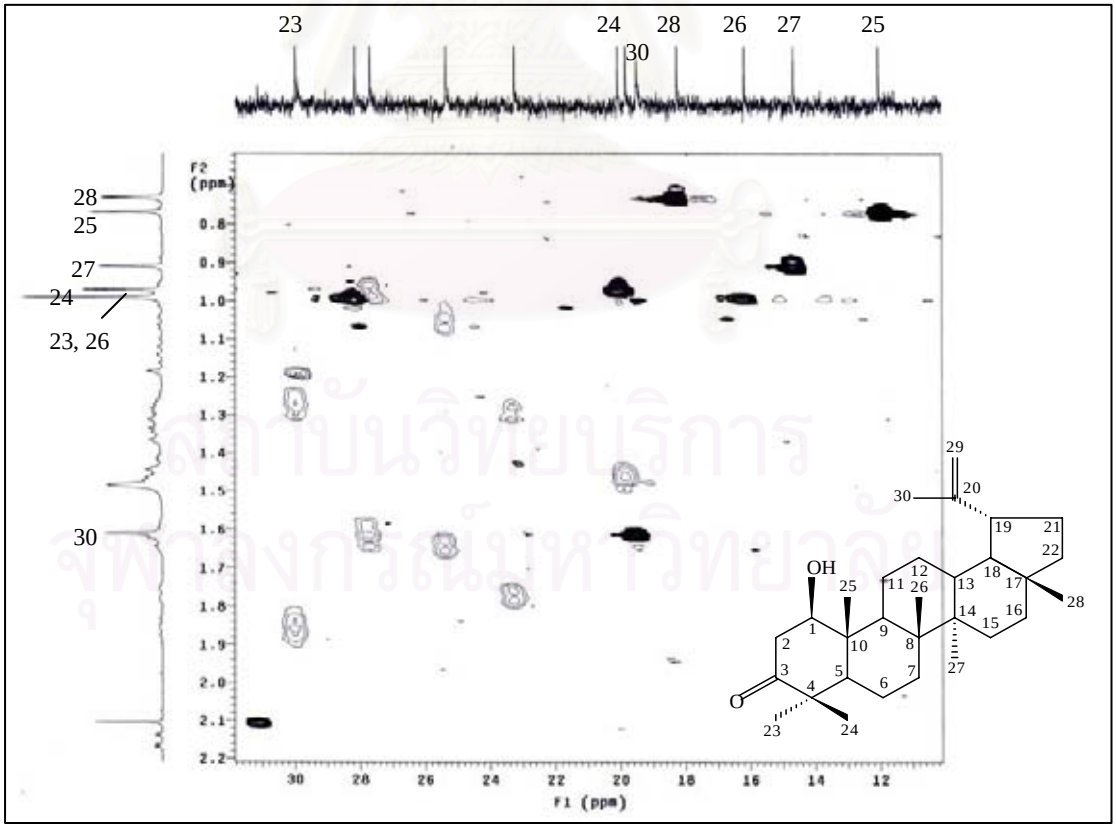

Figure 27b. The 500 MHz ^{1}H-^{13}C HMQC NMR spectrum of compound SB4 (expanded)

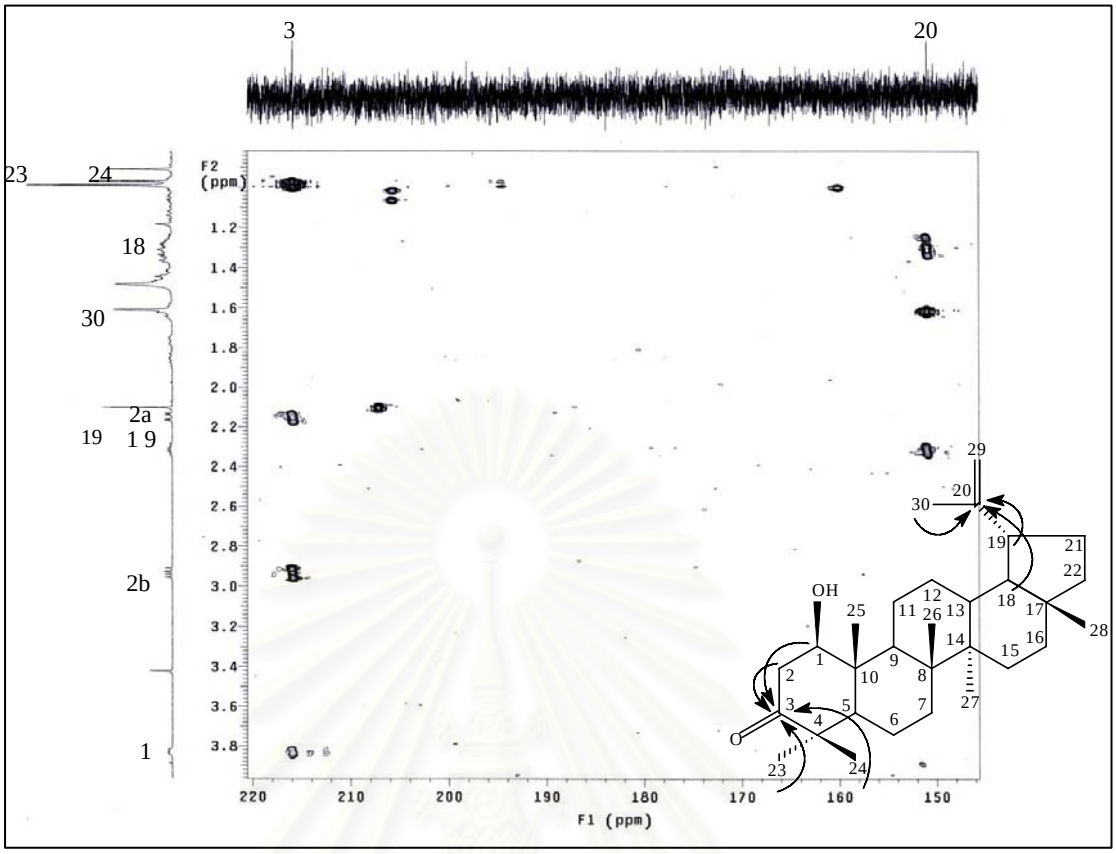

Figure 28a. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB4 (in $CDCl_3$)

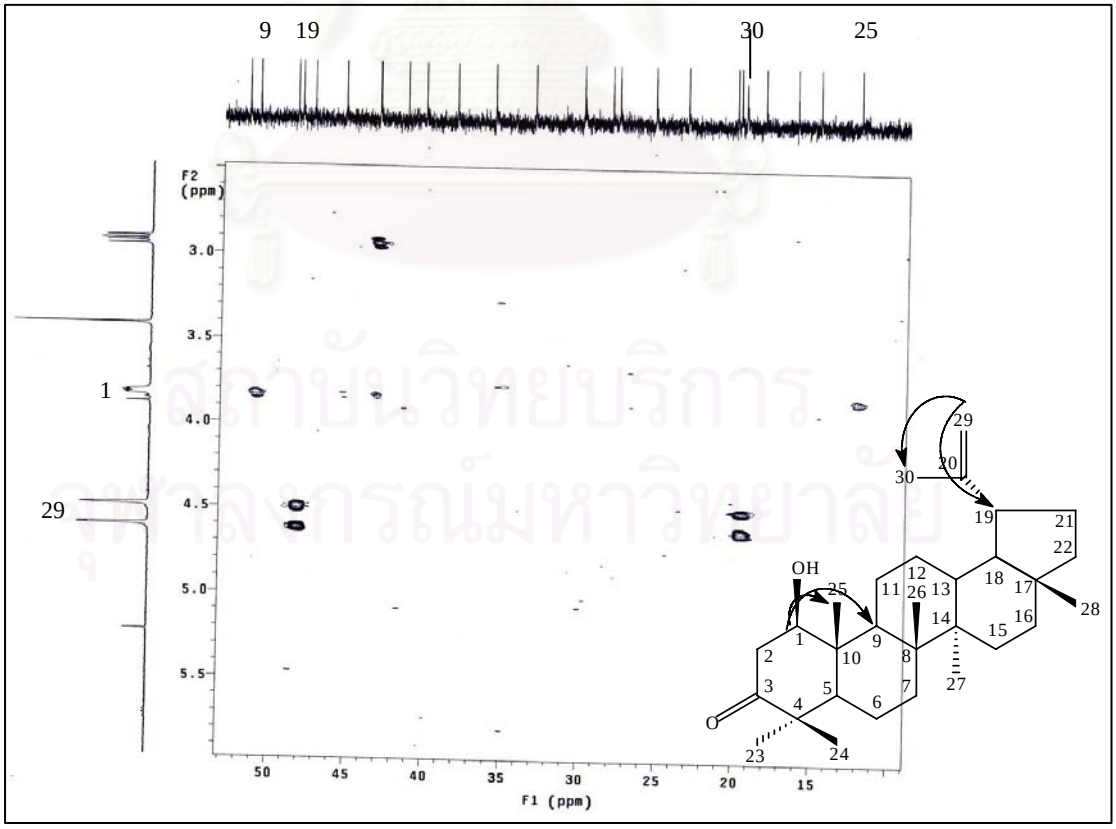

Figure 28b. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB4 (expanded)

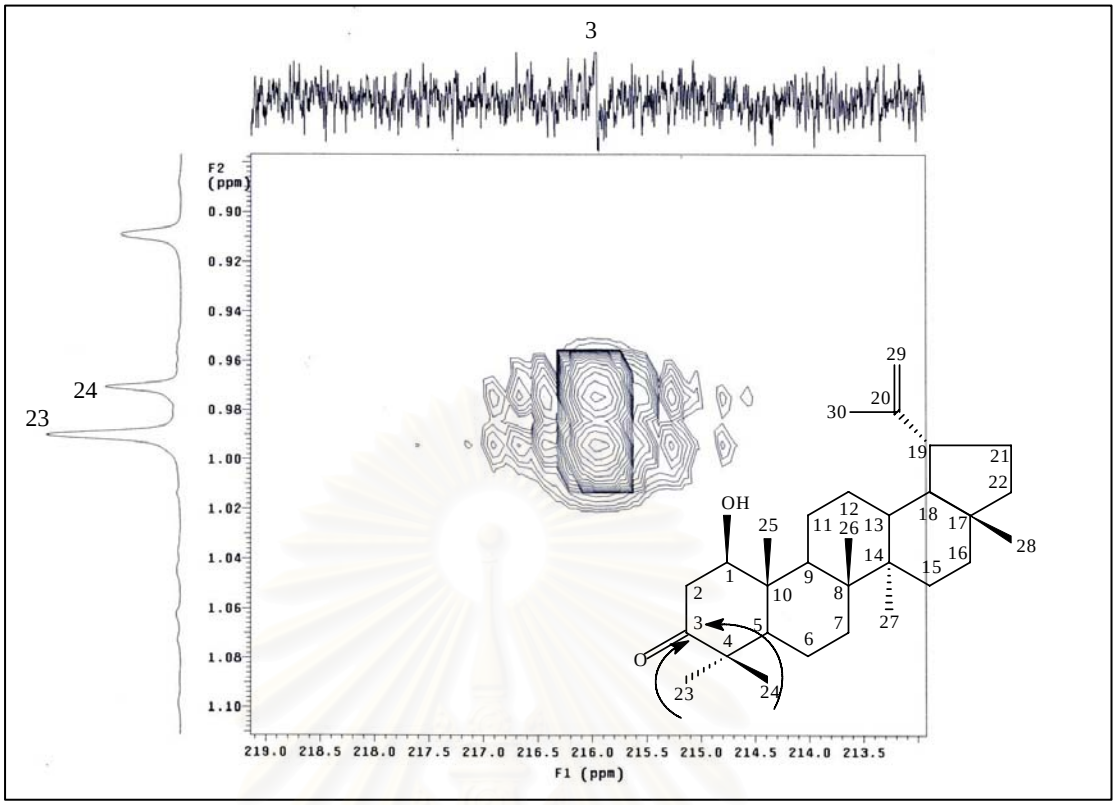

Figure 28c. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB4 (expanded)

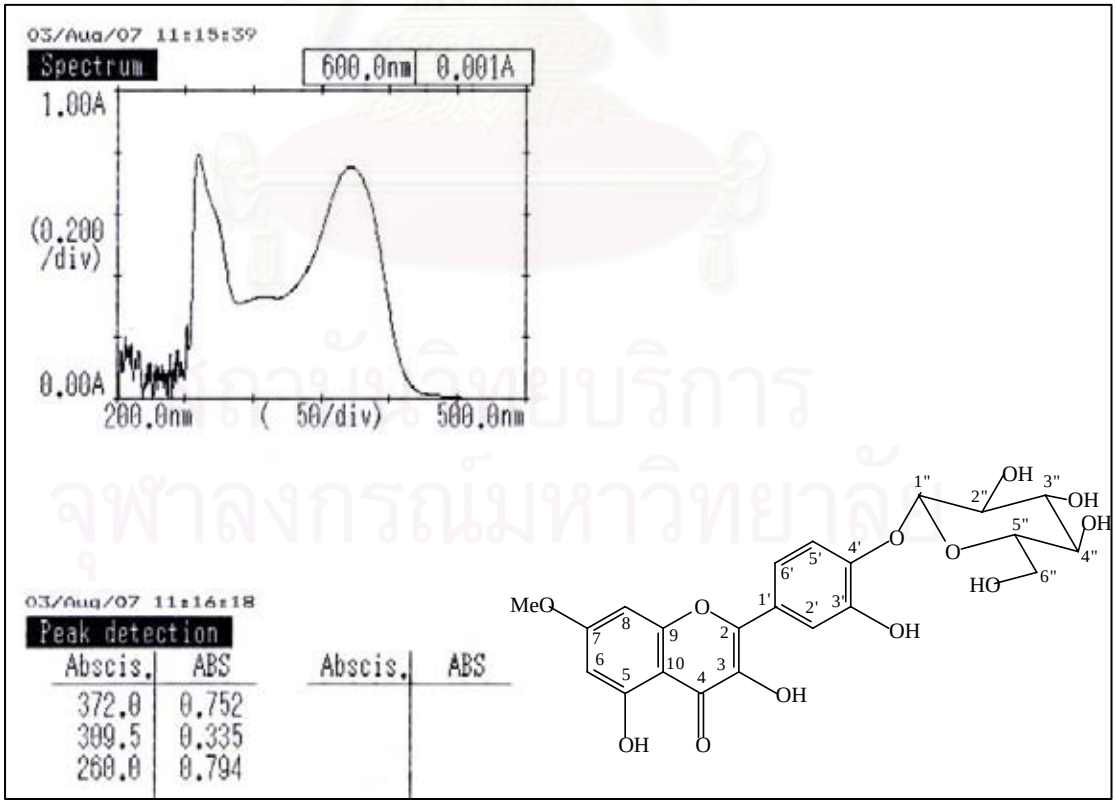

Figure 29. UV Spectrum of compound SB5 (in DMSO)

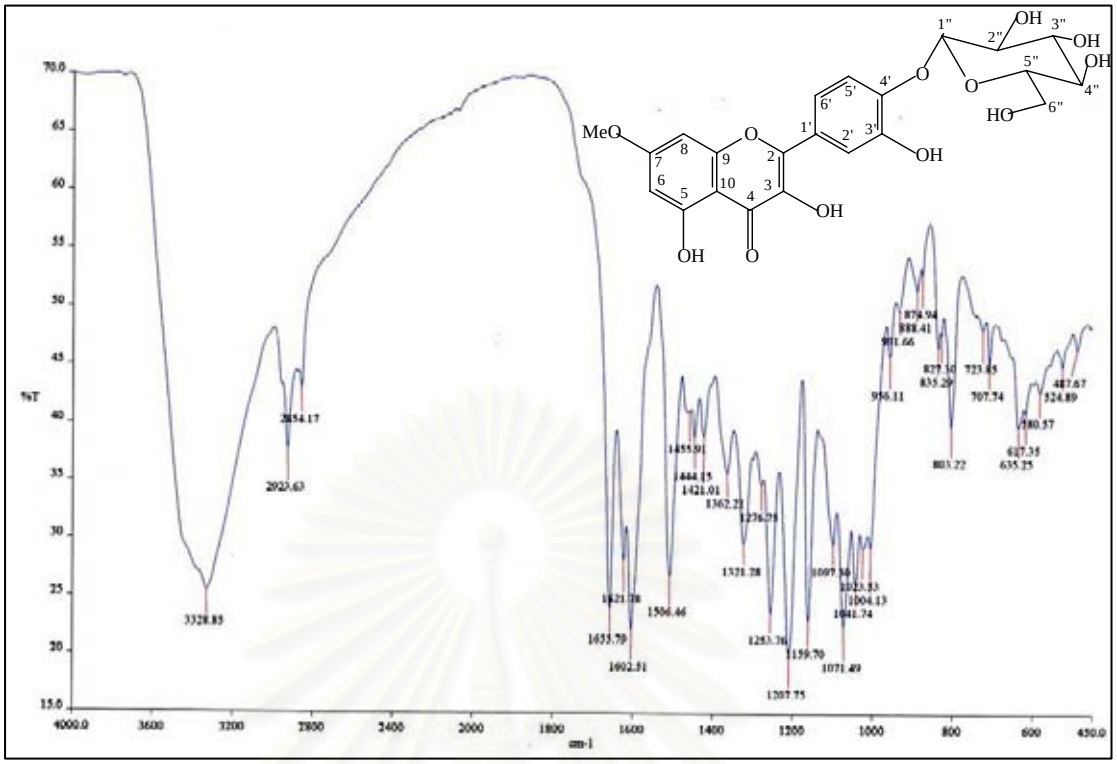

Figure 30. IR spectrum of compound SB5

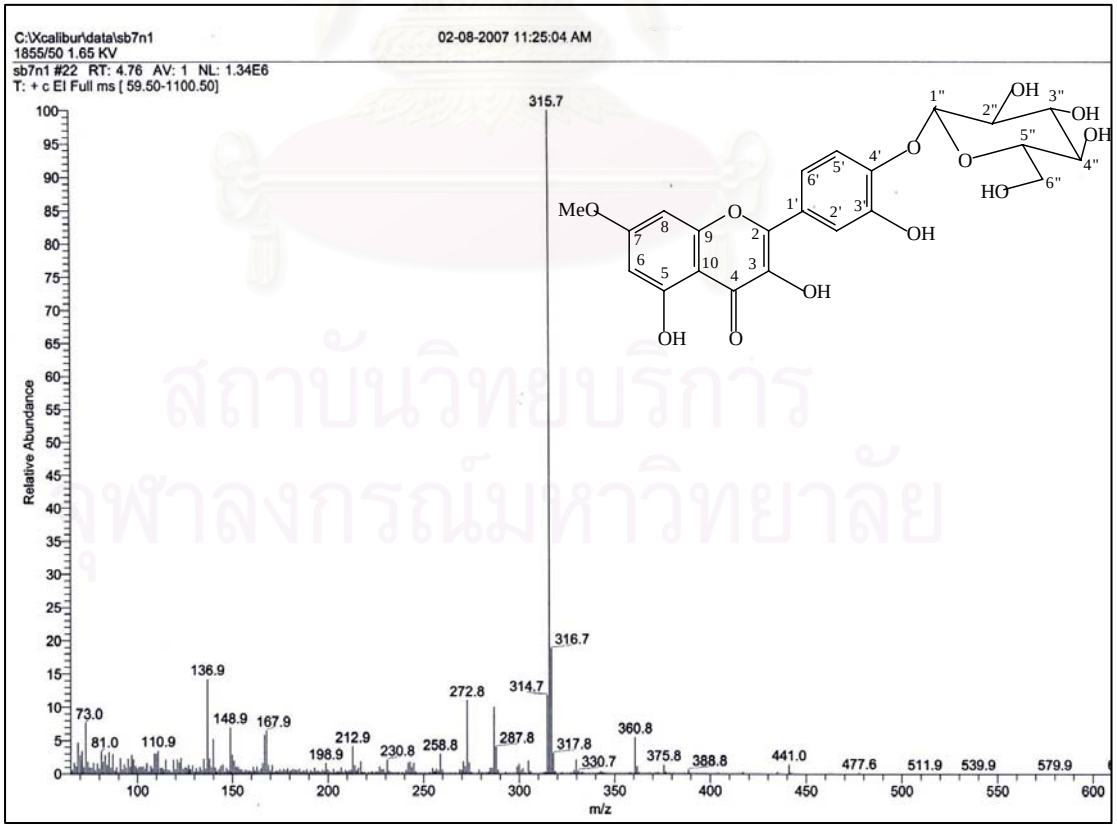

Figure 31. EIMS of compound SB5

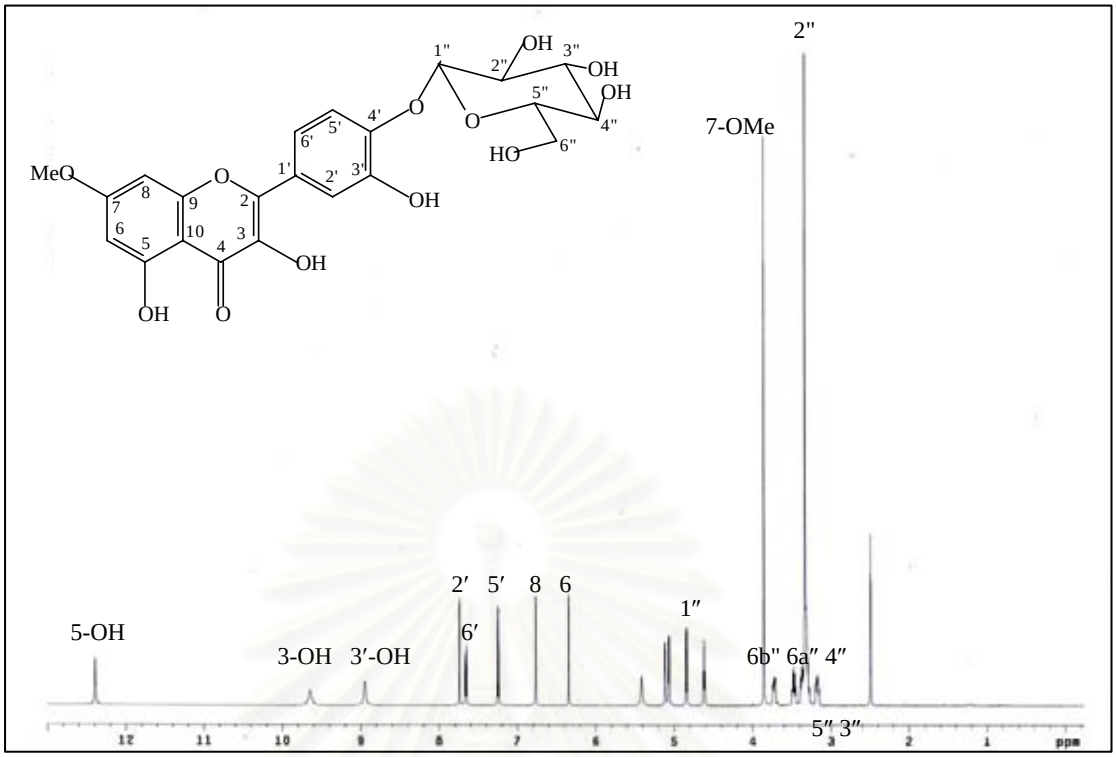

Figure 32. The 500 MHz ^{1}H-NMR spectrum of compound SB5 (in DMSO-d_6)

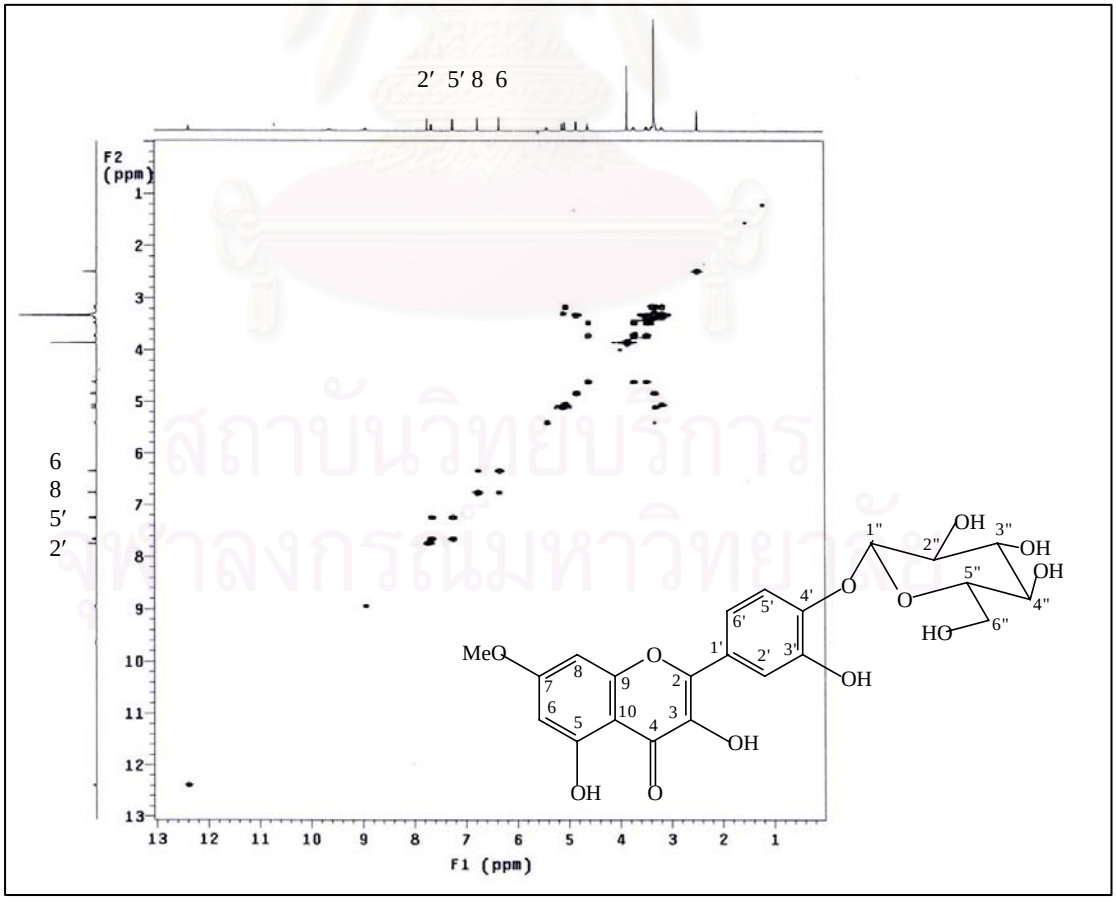

Figure 33a. The 500 MHz ^{1}H-^{1}H COSY spectrum of compound SB5 (in DMSO-d_6)

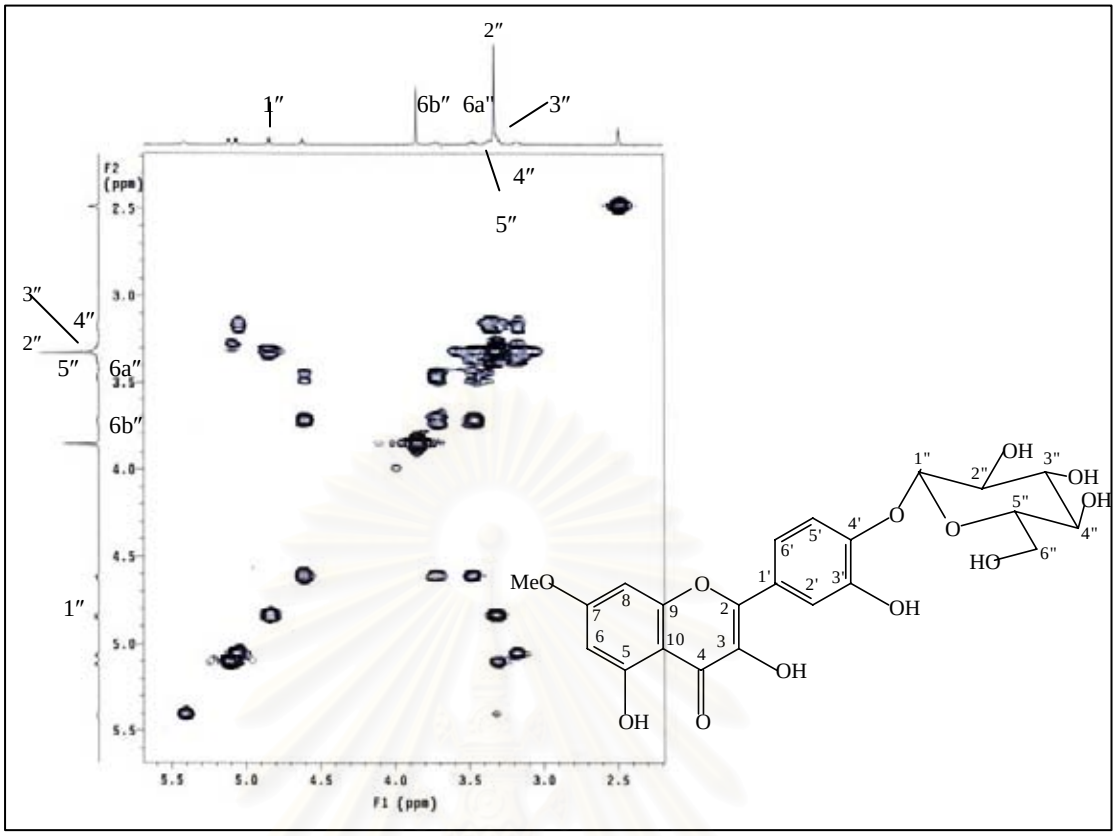

Figure 33b. The 500 MHz ^{1}H-^{1}H COSY spectrum of compound SB5 (expanded)

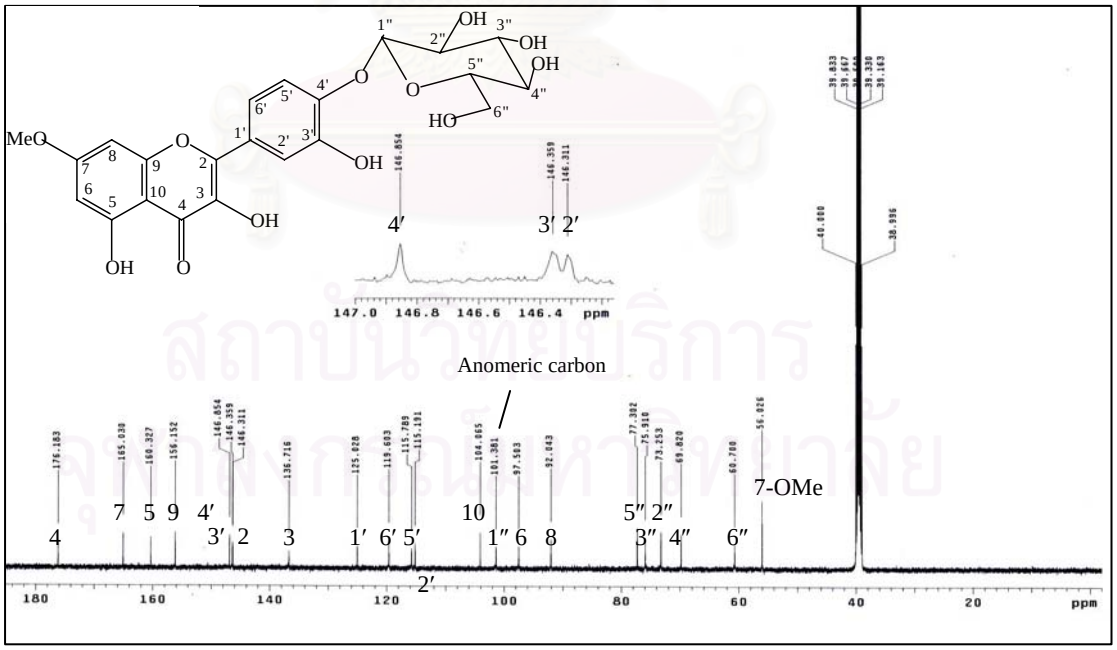

Figure 34. The 125 MHz ^{13}C-NMR spectrum of compound SB5 (in DMSO-d_6)

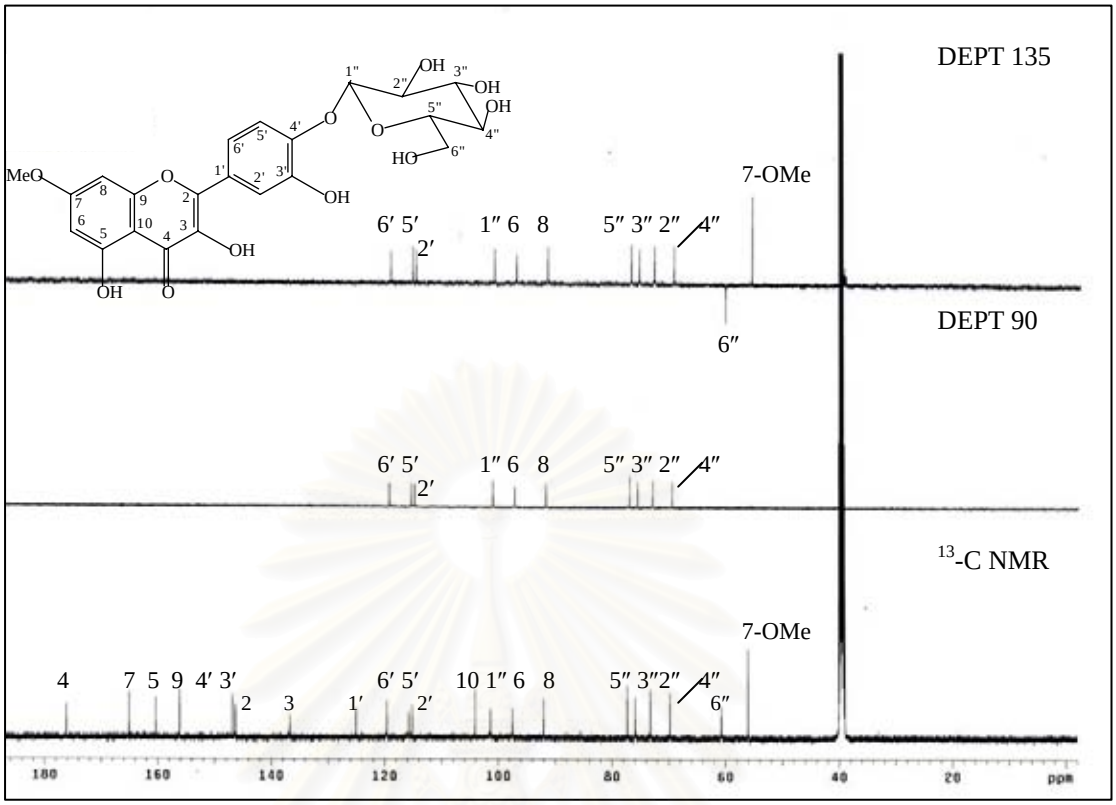

Figure 35. The 125 MHz ^{13}C-DEPT spectra of compound SB5 (in DMSO-d_6)

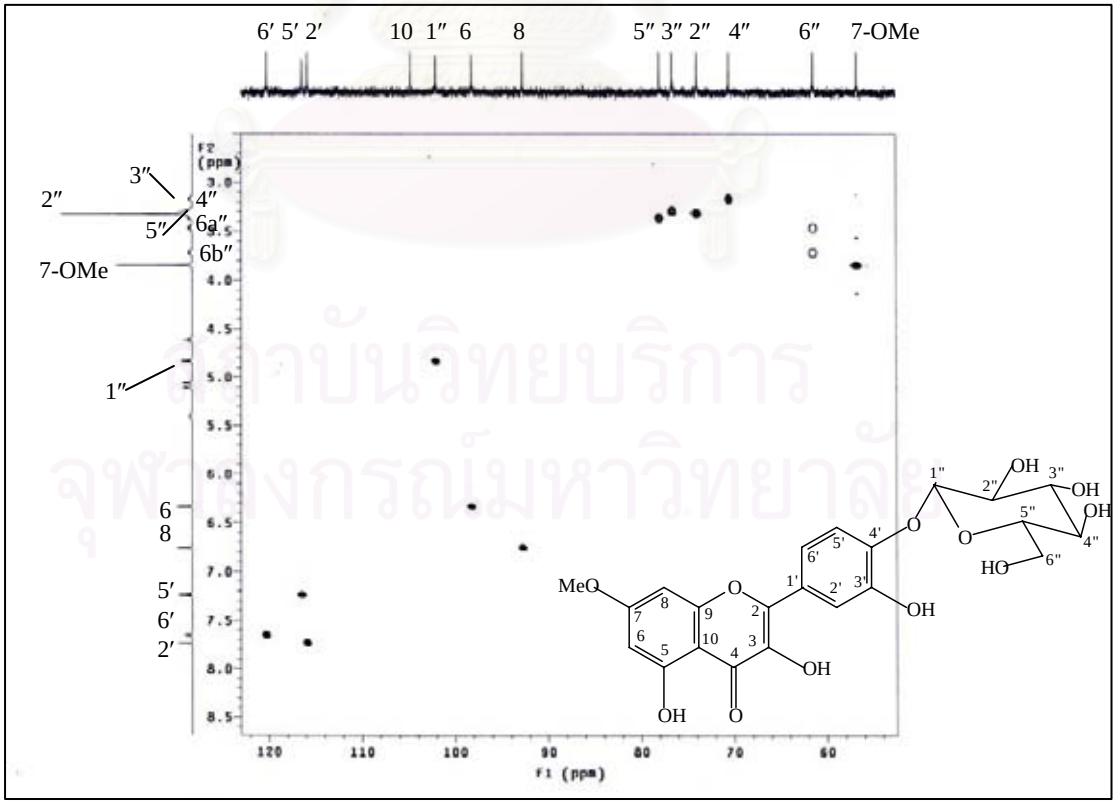

Figure 36. The 500 MHz ^{1}H-^{13}C HMQC NMR spectrum of compound SB5 (in DMSO-d_6)

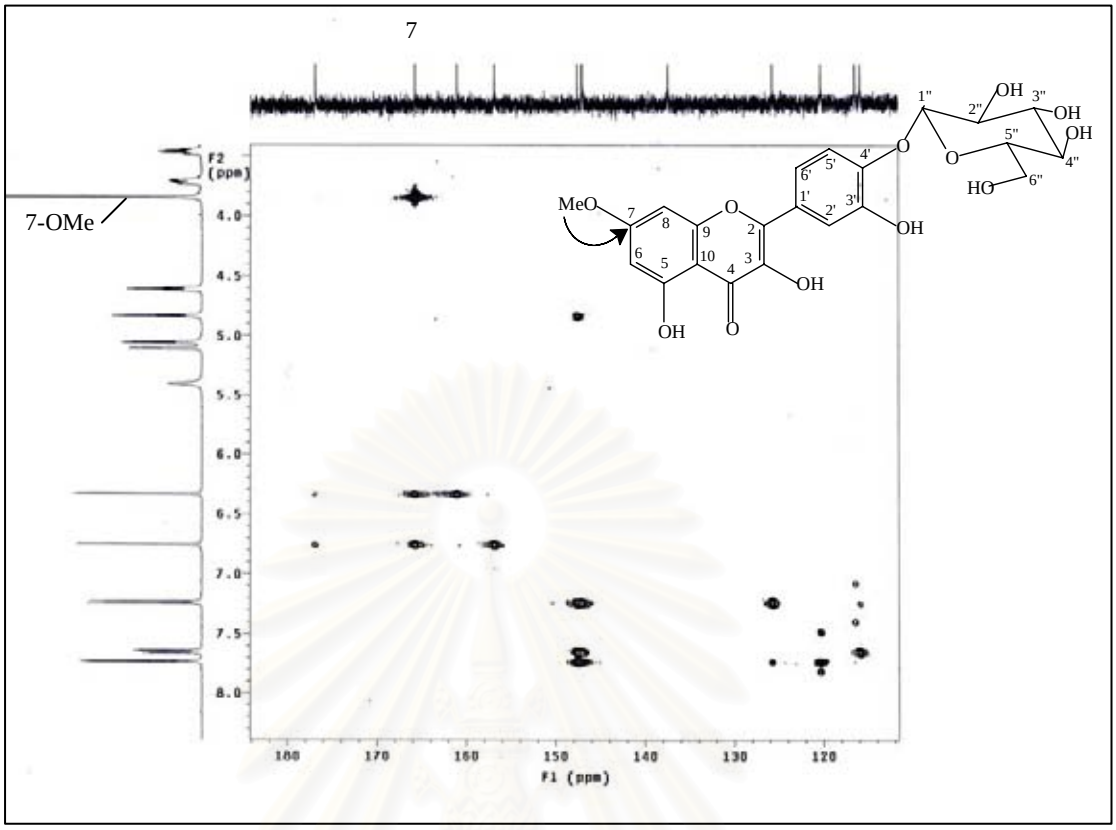

Figure 37a. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB5 (in DMSO-d_6)

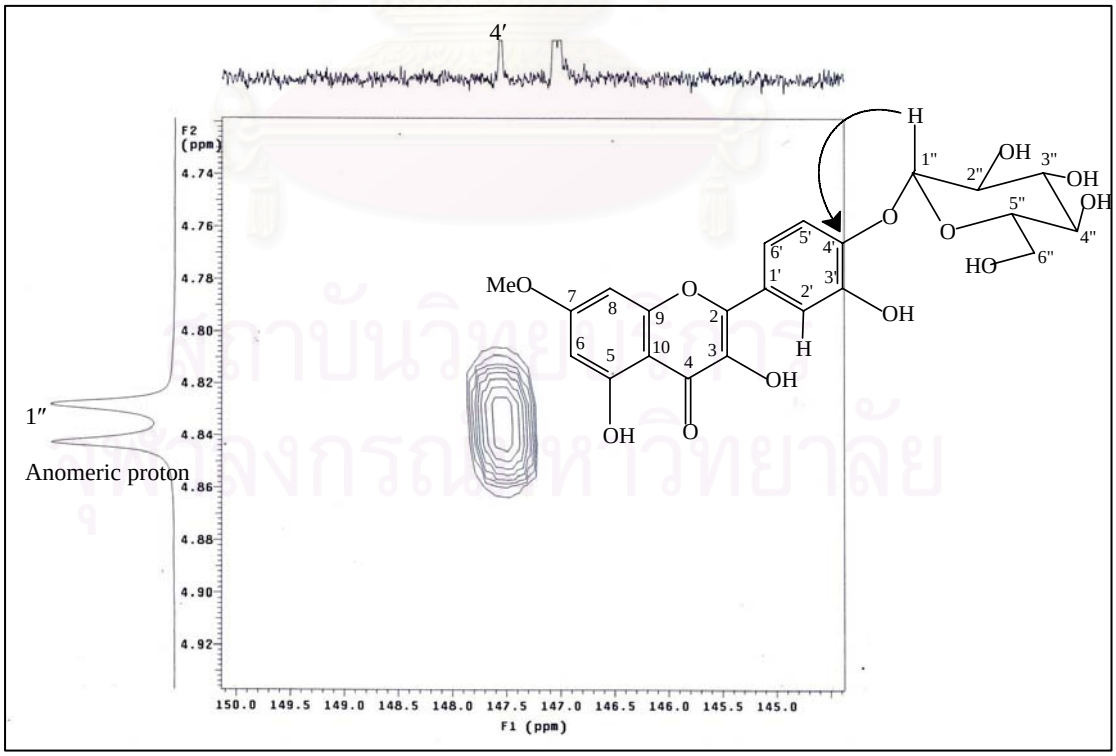

Figure 37b. The 500 MHz ^{1}H-^{13}C HMBC NMR spectrum of compound SB5 (expanded)

VITA

Miss Pattama Lekduwee was born on December 17, 1974 in Yala, Thailand. She received her Bachelor degree of Pharmaceutical Sciences from the Faculty of Pharmaceutical Sciences, Prince of Songkla University, Songkla, Thailand in 1997.

She has been working as a hospital pharmacist at Yaha Crown Prince Hospital in Yala, since 1997.