สารที่มีฤทธิ์ทางชีวภาพจากเปลือกรากมะหาด

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BIOACTIVE COMPOUNDS FROM THE ROOT BARK OF *ARTOCARPUS LAKOOCHA*

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A Thesis Submitted in Partial Fulfillment of the Requirements
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การศึกษาทางพฤกษเคมีของเปลือกรากมะหาด สามารถแยกสารบริสุทธิ์ได้ 5 ชนิด โดยเป็นสารกลุ่ม 2-arylbenzofurans ชนิดใหม่ 3 ชนิด คือ artolakoochol, 4-hydroxy artolakoochol และ cycloartolakoochol นอกจากนี้เป็นสารกลุ่ม prenylated flavones 2 ชนิด พบว่าเป็นสารใหม่ 1 ชนิด คือ 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone และอีก 1 ชนิดเป็นสารที่มีการรายงานมาแล้วคือ cudraflavone C การพิสูจน์โครงสร้างทางเคมีของสารที่แยกได้นี้ อาศัยการวิเคราะห์สเปกตรัมของ UV, IR, MS, NMR ร่วมกับการเปรียบเทียบข้อมูลของสารที่รายงานมาแล้ว และมีการนำสารบริสุทธิ์ทั้ง 5 ชนิด ที่แยกได้ไปทำการทดสอบฤทธิ์ในการจับสารอนุมูลอิสระ ฤทธิ์ยับยั้งเอนไซม์ tyrosinase และฤทธิ์ต้านไวรัสเริม พบว่า artolakoochol, cycloartolakoochol และ 4-hydroxyartolakoochol มีฤทธิ์แรงในการจับสารอนุมูลอิสระ ส่วน 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone และ cudraflavone C มีฤทธิ์ปานกลาง นอกจากนี้พบว่ามีเพียง 4-hydroxyartolakoochol ที่มีฤทธิ์ต่ำในการยับยั้งเอนไซม์ tyrosinase ในขณะที่สารชนิดอื่นไม่มีฤทธิ์ในการยับยั้งเอนไซม์ tyrosinase และในการทดสอบฤทธิ์ต้านเชื้อไวรัสเริม HSV-1 และ HSV-2 พบว่าเฉพาะสารในกลุ่ม prenylated flavones เท่านั้นที่มีฤทธิ์ โดย 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone มีฤทธิ์ปานกลางในการต้านไวรัสเริมทั้งสองชนิดโดยการทดสอบด้วยวิธี Inactivation และ Post-treatment และ cudraflavone C มีฤทธิ์ต่ำในการต้านเชื้อไวรัสเริมทั้งสองชนิดโดยการทดสอบด้วยวิธี Inactivation

ภาควิชา..เภสัชเวทและเภสัชพฤกษศาสตร์... ลายมือชื่อนิสิต.....

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ADVISOR : ASST. PROF. BOONCHOO SRITULARAK, Ph.D.,
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Phytochemical study of the root bark of *Artocarpus lakoocha* Roxb. led to the isolation of five pure compounds, including three new 2-arylbenzofurans, namely artolakoochol, cycloartolakoochol and 4-hydroxyartolakoochol and a new prenylated flavone named 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone, together with the known compound cudraflavone C. Their structures were elucidated through analysis of their spectroscopic data (UV, IR, MS, NMR) and by comparison with previously reported data. The isolated compounds were evaluated for free radical scavenging, antityrosinase and antiherpetic activities. Artolakoochol, cycloartolakoochol and 4-hydroxy artolakoochol showed potent free radical scavenging activity, where as 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone and cudraflavone C showed moderate activity. Furthermore, 4-hydroxyartolakoochol exhibited weak tyrosinase inhibitory activity. The prenylated flavones, 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone and cudraflavone C, showed activity against herpes simplex virus (HSV-1 and HSV-2). The compound 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone exhibited moderate activity against both types of herpes simplex virus in the Inactivation and Post-treatment assay, while cudraflavone C showed weak activity against both types of herpes simplex virus in the Inactivation assay.

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LIST OF ABBREVIATIONS AND SYMBOLS

$[\alpha]^{20}_{D}$	=	Specific rotation at 20ºC and Sodium D line (589 nm)
α	=	Alpha
Acetone-d_6	=	Deuterated acetone
ax	=	Axial
β	=	Beta
br	=	Broad (for NMR spectra)
C	=	Concentration
ºC	=	Degree Celsius
calcd	=	Calculated
CD	=	Circular Dichroism
$CDCl_3$	=	Deuterated chloroform
CH_2Cl_2	=	Dichloromethane
cm	=	Centimeter
^{13}C NMR	=	Carbon-13 Nuclear Magnetic Resonance
^{1}H-^{1}H COSY	=	Homonuclear (Proton-Proton) Correlation Spectroscopy
1-D	=	One dimensional (for NMR spectra)
2-D	=	Two dimensional (for NMR spectra)
d	=	Doublet (for NMR spectra)
dd	=	Doublet of doublets (for NMR spectra)
DPPH	=	1,1-Diphenyl-2-picrylhydrazyl
δ	=	Chemical shift
ED_{50}	=	50% Effective Dose
eq	=	Equatorial
ESI-MS	=	Electrospray Ionization Mass Spectrometry
EtOAc	=	Ethyl acetate
FCC	=	Flash Column Chromatography
g	=	Gram
GF	=	Gel Filtration Chromatography
hr	=	Hour
^{1}H-NMR	=	Proton Nuclear Magnetic Resonance

LIST OF ABBREVIATIONS AND SYMBOLS (continued)

HMBC = ^{1}H-detected Heteronuclear Multiple Bond Correlation
HMQC = ^{1}H-detected Heteronuclear Multiple Quantum Coherence
HR- ESI-MS = High Resolution Electrospray Ionization Mass Spectrometry
HSQC = Heteronuclear Single Quantum Coherence
HSV-1 = Herpes Simplex Virus type 1
HSV-2 = Herpes Simplex Virus type 2
Hz = Hertz
IC_{50} = Concentration showing 50% inhibition
IR = Infrared
J = Coupling constant
KBr = Potassium bromide
Kg = Kilogram
L = Liter
L-DOPA = L-3,4-dihydroxyphenylalanine
μg = microgram
μl = microliter
μM = micromolar
λ_{max} = Wavelength at maximal absorption
ε = Molar absorptivity
M^{+} = Molecular ion
m = Meta
m = Multiplet (for NMR spectra)
MeOH = Methanol
mg = Milligram
$[M+H]^{+}$ = Protonated molecular ion
MHz = Megahertz
min = Minute
ml = Milliliter
mm = Millimeter

LIST OF ABBREVIATIONS AND SYMBOLS (continued)

mM	=	Millimolar
m/z	=	Mass to charge ratio
MS	=	Mass spectrum
mult.	=	Multiplicity
MW	=	Molecular weight
NaH_2PO_4	=	Sodium dihydrogen phosphate
Na_2HPO_4	=	Disodium hydrogen phosphate
nm	=	Nanometer
NMR	=	Nuclear Magnetic Resonance
NOESY	=	Nuclear Overhauser Effect Spectroscopy
o	=	Ortho
p	=	Para
ppm	=	Part per million
q	=	Quartet (for NMR spectra)
s	=	Singlet (for NMR spectra)
spp.	=	Species
t	=	Triplet (for NMR spectra)
TLC	=	Thin Layer Chromatography
UV	=	Ultraviolet
UV-VIS	=	Ultraviolet and Visible spectrophotometry
VLC	=	Vacuum Liquid Column Chromatography
υ_{max}	=	Wave number at maximal absorption

CHAPTER I

INTRODUCTION

The genus *Artocarpus* belongs to the family Moraceae of the order Urticarles. This genus consists of 50 species worldwide, especially distributed in Sri Lanka, India, Pakistan, Myanmar, Thailand, Indo-china, South-China, Malaysia and Solomon Islands (Kochummen, 1978; Gardner, Sidisunthorn and Anusarnsunthorn, 2000).

Plants in the genus *Artocarpus* are small to large trees. They are mostly evergreen trees with abundant white latex in all parts. The leaves are alternate, lobe, pinnatifid or rarely pinnate. The leaves margin are entire. The leaves texture are leathery. They have only one leaves main vein from the base. The flowers are minute, tightly packed in oblong or globose heads. Male and female flowers are packed in separate heads. The male flowers have 2-4 sepals and 1 stamen. On the other hand, the female flowers have narrow tubular calyx fused with neighbouring flowers at the base. They consist of 1 slender style and 1 or 2 stigmas that are equal or unequal. The bracts are fused with the flowers to form a syncarp (fruit). The syncarps are irregulary globose or fistshaped with many oblong seeds. (Gardner *et al*., 2000; Wu, Raven and Hong, 2003).

The species of *Artocarpus* in Thailand according to Royal Forest Department (2001) are as follows.

Artocarpus altilis (Parkinson) Fosberg (*A*. *communis* J.R.& G. Forst., *A*. *incisa* Linn. f.)	ขนุนสำปะลอ Khanun sampalo (Central); สาเก Sake (Central); Bread fruit tree; Bread nut tree.
A. *altissimus* J.J. Smith	ไสน Sanai (Surat Thani).
A. *chaplasha* Roxb.	หาดส้าน Haat san (Chiang Rai).
A. *dadah* Miq.	ทังคัน Thang khan; ม่วงกวาง Muang kwang, (Yala); หาดรุม Hat rum, หาดลูกใหญ่, Hat luk yai (Trang); หาดขน Hat khon (Narathiwat).
A. *elasticus* Reinw. ex Blume	กะออก Ka ok, กะเอาะ Ka-o (Peninsular); ตือกะ Tue-ka (Malay-Yala); เอาะ O (Trang, Ranong).
A. *gomezianus* Wall. Ex Trécul	ตะปัง Ta pang, ตำปัง Tam-pang (Malay-Peninsular); หาดหนุน Hat nun (Northern); อีโป้ I po (Trang).

A. heterophyllus Lamk. (*A. integrifolia* Linn. f.)	ขนุน Khanun (General); ขะนู Kha-nu (Chong-Chanthaburi); ขะเนอ Kha-noe (Khmer); ซีคือ Si-khue, ปะหน่อย Pa-noi (Karen-Maehongson); นะยวยซะ Na-yuai-sa (Karen-Kanchanaburi); นากอ Na-ko (Malay-Pattani); เนน Nen (Chaobon-Nakhonratchasima); มะหนุน Manun (Northern, Peninsular); ล้าง, ลาง Lang (Shan-Northern); หมักหมี้ Makmi (Northeastern); หมากลาง Mak lang (Shan-Maehongson); Jack fruit tree.
A. kemando Miq.	ขนุนป่า Khanun pa (Narathiwat); ยาตู Yatu (Malay-Narathiwat)
A. integer (Thunb.) Merr.	จำปาดะ Champada (General); จำปาเดาะ Champado (Peninsular); Champedak
A. lacucha Roxb. (*A. lakoocha* Roxb.)	กาแย Kaa-yae, ตาแป Ta-pae, ตาแปง Ta-pang (Malay-Narathiwat); มะหาด Mahat (Peninsular); มะหาดใบใหญ่ Mahat bai yai (Trang); หาด
A. lanceifolius Roxb.	ขนุนป่า Khanun pa (Peninsular); หนังกาปิโต Nang-ka-pi-to, หนังกาปีปิ๊ต Nang-ka-pi-pit (Malay-Peninsular); นั่งกาปีแป๊ะ Nang-ka-pi-pae (Malay-Narathiwat).
A. nitidus Tréc subsp. *lingnanensis* Jarrett (*A. parva* Gagnep.)	มะหาดข่อย Mahat khoi (Surat Thani).
A. rigidus Blume subsp. *rigidus*	ขนุนป่า Khanun pa (Peninsular)
A. rigidus Bl. subsp. *asperulus Jarrett*. (*A. calophyllus* Kurz)	ขนุนปาน Khanun pan (Surat Thani)

Artocarpus lakoocha Roxb. is an indigenous plant known in Thai as Mahat. It is a large deciduous tree reaching 15-18 m. The bark are red brown to dark brown, which becomes rough and scaly with age. The branchets are 3-6 mm. thick. The stipules are ovate-lanceolate, 4-5 cm. in length. The leaves (5-15 cm. x 10-15 cm.) are alternate. Their shape is oval or obovate. The margin of leaves are untoothed or with minute teeth. They have 10-18 secondary veins on each side of the midvein. The leaves texture are leathery. The young red brown shoots are hairy. The stalks are finely hairy, 1.4-3.3 cm. long. The twigs are rather stout without ring scars. The flower heads, which grow from leaf axils, are dirty yellow to pale pink or orange. The male heads (0.8-2 cm.) with globular stalks, while the

female heads (1.2-2.3 cm.) are oval or oblong, with 2.5-3 cm. stalks. The fruits are 2.5-8 cm. with smooth velutin surface. Their flesh are pale yellow or orange that change to reddish brown when dried. The seeds are ellipsoid with bent bristles (Gardner *et al*., 2000; Wu *et al*., 2003).

Previous phytochemical studies of stem heartwood and root of this plant have revealed the presence of triterpenoids, flavonoids and stilbenes, some of which possessed biological activities such as antiherpetic, antioxidant and tyrosinase inhibitory activities (Jagtap and Bapat, 2010).

Our preliminary evaluation for biological activities of the root bark extract of *A. lakoocha* showed significant antiherpetic, antioxidant and tyrosinase inhibitory activities. Therefore, the following objectives were put forwards:

1. Isolation and purification of compounds from the root bark of *Artocarpus lakoocha*.

2. Determination of the chemical structure of each isolated compound.

3. Evaluation of each isolated compound for its free radical scavenging activity, anti-herpes simplex effect and tyrosinase inhibition potential.

A

B

C

D

Figure 1 *Artocarpus lakoocha* Roxb.

A) Tree, B) Leaves, C) Fruit, D) Roots

CHAPTER II

HISTORICAL

1. Chemical constituents of *Artocarpus* spp.

A number of compounds have been isolated from the genus *Artocarpus*. They can be classified as flavonoids, triterpenoids, steroids, stilbenes and miscellaneous substances (Tables 1-3).

Table 1 Distribution of flavonoids in the genus *Artocarpus*

Plant and chemical compound	Plant part	Reference
Artocarpus altilis		
Apigenin [**1**]	Heartwood	Shimizu *et al*., 1998
Artobiloxanthone [**2**] (artocarpus flavone KB-1)	Bark	Aida *et al*., 1997
Artocarpesin [**3**]	Heartwood	Shimizu *et al*., 1998
Artocarpin [**4**]	Heartwood	Venkataraman, 1972
Artocarpus chalcone AC-3-1 [**5**]	Flower Leaves	Fujimoto *et al*., 1987a Wang *et al*., 2007b
Artocarpus chalcone AC-3-3 [**6**]	Flower	Fujimoto *et al*., 1987a
Artocarpus chalcone AC-5-1 [**7**]	Flower Leaves	Fujimoto *et al*., 1987a Wang *et al*., 2007b
Artocarpus chalcone I [**8**]	Flower	Fujimoto, Agusutein, and Made, 1987b
Artocarpus flavanone AC-3-2 [**9**]	Flower	Fujimoto *et al*., 1987a
Artocarpus flavanone AC-5-2 [**10**]	Flower Leaves	Fujimoto *et al*., 1987a Wang *et al*., 2007b
Artocarpus flavone KB-1 [**2**] (Artobiloxanthone)	Bark	Fujimoto *et al*., 1990
Artocarpus flavone KB-2 [**11**]	Bark	Fujimoto *et al*., 1990
Artocarpus flavone KB-3 [**12**] (Artonin E)	Bark	Fujimoto *et al*., 1990
Artochamin B [**13**]	Root cortex	Lin *et al*., 2006
Artochamin D [**14**]	Root cortex	Lin *et al*., 2006

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Artocommunol CB [**15**]	Root cortex	Chan, Ko, and Lin, 2003
Artocommunol CC [**16**]	Root cortex	Lin *et al*., 2006
Artocommunol CD [**17**]	Root cortex	Chan *et al*., 2003
Artocommunol CE [**18**]	Root cortex	Chan *et al*., 2003
Artoflavone A [**19**]	Root cortex	Lin *et al*., 2009
Artomunoflavanone [**20**]	Root cortex	Lin *et al*., 2006
Artomunoisoxanthone [**21**]	Root cortex	Lin *et al*., 2006
Artomunoxanthentrione [**22**]	Root bark	Shieh and Lin, 1992
Artomunoxanthone [**23**]	Root bark	Shieh and Lin, 1992
Artomunoxanthotrione epoxide [**24**]	Root bark	Lin, Shieh and Jong, 1992
Artonin E [**12**] (Artocarpus flavone KB-3)	Bark	Hano *et al*., 1990d
Artonin F [**25**]	Bark	Hano *et al*., 1990d
Artonin K [**26**]	Bark	Aida *et al*., 1997
Artonin V [**27**]	Root bark	Hano, Inami and Nomura, 1994
Artonol A [**28**]	Bark	Aida *et al*., 1997
Artonol B [**29**]	Bark	Aida *et al*., 1997
Artonol C [**30**]	Bark	Aida *et al*., 1997
Artonol D [**31**]	Bark	Aida *et al*., 1997
Artonol E [**32**]	Bark	Aida *et al*., 1997
Cudraflavone A [**33**] (Isocyclomorusin)	Root bark Heartwood	Shieh and Lin, 1992 Han *et al*., 2006
Cudraflavone C [**34**]	Heartwood	Han *et al*., 2006

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Cycloaltilisin [**35**]	Stem Leaves	Chen *et al*., 1993 Wang *et al*., 2007b
Cycloaltilisin 6 [**36**]	Bud cover	Patil *et al*., 2002
Cycloaltilisin 7 [**37**]	Bud cover	Patil *et al*., 2002
Cycloartobiloxanthone [**38**]	Bark	Hano *et al*., 1990d
Cycloartocarpin [**39**]	Heartwood	Venkataraman, 1972
Cycloartomunin [**40**]	Root bark	Lin and Shieh, 1991
Cycloartomunoxanthone [**41**]	Root bark	Lin and Shieh, 1991
Cyclocommunin [**42**]	Root bark	Lin and Shieh, 1991
Cyclocommunol [**43**]	Root bark	Lin and Shieh, 1991
Cyclocommunomethonol [**44**]	Root cortex	Lin *et al*., 2006
Cyclogeracommunin [**45**]	Root cortex	Lin *et al*., 2009
Cyclomorusin [**46**]	Stem Root	Chen *et al*., 1993 Lin and Shieh, 1991
Cyclomulberrin [**47**]	Stem Root bark	Chen *et al*., 1993 Lin and Shieh, 1992
Dihydroartomunoxanthone [**48**]	Root cortex	Lin *et al*., 2006
Dihydrocycloartomunin [**49**]	Root bark	Lin and Shieh, 1991
Dihydroisocycloartomunin [**50**]	Root bark	Lin and Shieh, 1992
Dihydromorin [**51**]	Heartwood	Shimizu *et al*., 1998
Engeletin [**52**]	Stem	Chen *et al*., 1993
(2*S*)-Euchrenone a7 [**53**]	Heartwood	Han *et al*., 2006
Gemichalcone B [**54**]	Heartwood	Han *et al*., 2006
Gemichalcone C [**55**]	Heartwood	Han *et al*., 2006
3′-Geranyl-2′-3-4-4′- tetrahydroxy-chalcone [**56**]	Leaves	Shimizu *et al*., 2000

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Hydroxyartocarpin [**57**]	Stem bark	Shamaun *et al*., 2010
Isoartocarpesin [**58**]	Heartwood	Shimizu *et al*., 1998
Isobacachalcone [**59**]	Heartwood	Han *et al*., 2006
Isocyclomorusin [**33**] (Cudraflavone A)	Stem	Chen *et al*., 1993
Isocyclomulberrin [**42**] (Cyclocommunin)	Stem	Chen *et al*., 1993
Isolespeol [**60**]	Leaves	Fang *et al*., 2008b
Morin [**61**]	Heartwood	Venkataraman, 1972
Morachalcone A [**62**]	Heartwood	Han *et al*., 2006
Morusin [**63**]	Stem bark	Fujimoto *et al*., 1990
(+)-Norartocarpanone [**64**]	Heartwood	Shimizu *et al*., 1998
Norartocarpetin [**65**]	Heartwood	Venkataraman, 1972
1-(2,4-Dihydroxyphenyl)-3-[3,4-dihydro-3,8-dihydroxy-2-methyl-2-(4-methyl-3-pentenyl)-2H-1-benzopyran-5-yl]-1-propanone [**66**]	Leaves	Wang *et al*., 2007b
1-(2,4-Dihydroxyphenyl)-3-[8-hydroxy- 2-methyl-2-(3,4-epoxy-4-methyl-1-pentenyl)-2H-1-benzopyran-5-yl]-1-propanone [**67**]	Leaves	Wang *et al*., 2007b
1-(2,4-Dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(4-hydroxy-4-methyl-2-pentenyl)-2H-1-benzopyran-5-yl]-1-propanone [**68**]	Leaves	Wang *et al*., 2007b
1-(2,4-Dihydroxyphenyl)-3-{4-hydroxy-6,6,9-trimethyl-6a,7,8,10a tetrahydro-6H-dibenzo [b,d]pyran-5-yl}-1-propanone [**69**]	Leaves	Wang *et al*., 2007b
3″,3″-Dimethylpyrano[3′,4′]2,4,2′-trihydroxy chalcone [**70**]	Heartwood	Han *et al*., 2006

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
5′-Geranyl-2′,4′,4-trihydroxychalcone [**71**]	Leaves	Fang *et al*., 2008
2-[6-Hydroxy-3,7-dimethylocta-2(*E*),7-dienyl]-2′,3,4,4′-tetrahydroxy dihydrochalcone [**72**]	Leaves	Wang *et al*., 2007b
3,4,2′,4′-Tetrahydroxy-3′-geranyldihydrochalcone [**73**]	Leaves	Fang *et al*., 2008
Artocarpus bracteata		
Artoindonesianin J [**74**]	Root and stem bark	Ersam *et al*., 2002
Carpachromene [**75**]	Root and stem bark	Ersam *et al*., 2002
Kozonol C [**76**]	Root and stem bark	Ersam *et al*., 2002
6-Prenylalpigenin [**77**]	Root and stem bark	Ersam *et al*., 2002
Artocarpus champeden		
Artocarpone A [**78**]	Stem bark	Widyawaruyanti *et al*., 2007
Artocarpone B [**79**]	Stem bark	Widyawaruyanti *et al*., 2007
Artoindonesianin A [**80**]	Root	Hakim *et al*., 1999
Artoindonesianin A-2 [**81**]	Stem bark Heartwood	Syah *et al*., 2006b Widyawaruyanti *et al*., 2007
Artoindonesianin A-3 [**82**]	Heartwood	Syah *et al*., 2006b
Artoindonesianin B [**83**]	Root	Hakim *et al*., 1999
Artoindonesianin E [**84**]	Stem bark	Widyawaruyanti *et al*., 2007
Artoindonesianin M [**85**]	Heartwood	Syah *et al*., 2002a
Artoindonesianin Q [**86**]	Heartwood	Syah *et al*., 2002b

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Artoindonesianin R [**87**]	Heartwood	Syah *et al*., 2002b
Artoindonesianin S [**88**]	Heartwood	Syah *et al*., 2002b
Artoindonesianin T [**89**]	Heartwood	Syah *et al*., 2002b
Artoindonesianin U [**90**]	Heartwood	Syah *et al*., 2004
Artoindonesianin V [**91**]	Heartwood	Syah *et al*., 2004
Artonin A [**92**]	Root Stem bark	Hakim *et al*., 1999 Widyawaruyanti *et al*., 2007
Artonin B [**93**]	Heartwood	Syah *et al*., 2004
Artopeden A [**94**]	Bark	Wahyuni *et al*., 2009
Cyclochampedol [**95**]	Stem bark	Achmad *et al*., 1996 Parenti *et al*., 1998
Cyclocommunin [**42**]	Heartwood	Syah *et al*., 2004
Cycloheterophyllin [**96**]	Stem bark	Widyawaruyanti *et al*., 2007
Heteroflavanone C [**97**]	Stem bark	Widyawaruyanti *et al*., 2007
Heterophyllin [**98**]	Stem bark	Widyawaruyanti *et al*., 2007
5′-Hydroxycudraflavone A [**99**]	Heartwood	Syah *et al*., 2004
Artocarpus chaplasha (***A. chama***)		
Artocarpesin [**3**]	Heartwood	Rao, Rathi and Venkataraman, 1972
Artocarpin [**4**]	Heartwood Root	Rao *et al*., 1972 Wang *et al*., 2004
Artochamin A [**100**]	Root	Wang *et al*., 2004
Artochamin B [**13**]	Root	Wang *et al*., 2004
Artochamin C [**101**]	Root	Wang *et al*., 2004

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Artochamin D [**14**]	Root	Wang *et al*., 2004
Artochamin E [**102**]	Root	Wang *et al*., 2004
Artonin A [**92**]	Root	Wang *et al*., 2004
Artonin E [**12**] (Artocarpus flavone KB-3)	Root	Wang *et al*., 2004
Artonin U [**103**]	Root	Wang *et al*., 2004
Chaplashin [**104**]	Heartwood	Rao *et al*., 1972
Cudraflavone A [**33**] (Isocyclomorusin)	Root	Wang *et al*., 2004
Cycloartobiloxanthone [**38**]	Root	Wang *et al*., 2004
Cycloartocarpesin [**105**]	Heartwood	Rao *et al*., 1972
Cycloartocarpin [**39**]	Heartwood	Rao *et al*., 1972
Cycloartocarpin A [**106**]	Root	Wang *et al*., 2004
5′-Hydroxycudraflavone A [**99**]	Root	Wang *et al*., 2004
Artocarpus dadah		
Afzelechin-3-*O*-*α*-L-rhamnoside [**107**]	Stem bark Twig	Su *et al*., 2002
(+)-Catechin [**108**]	Stem bark Twig	Su *et al*., 2002
Dihydromorin [**51**]	Stem bark	Su *et al*., 2002
Engeletin [**52**]	Twig	Su *et al*., 2002
(+)-Epiafzelechin [**109**]	Stem bark	Su *et al*., 2002
(-)-Epiafzelechin-(4*β*→8)-epicatechin [**110**]	Stem bark	Su *et al*., 2002
Gemichalcone B [**54**]	Twig	Su *et al*., 2002
Isogemichalcone B [**111**]	Twig	Su *et al*., 2002

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Norartocarpetin [**65**]	Twig	Su *et al*., 2002
Steppogenin [**112**]	Twig	Su *et al*., 2002
Artocarpus elasticus		
Artelasticin [**113**]	Heartwood	Kijjoa *et al*., 1996
Artelasticinol [**114**]	Root bark	Ko *et al*., 2005
Artelastin [**115**]	Heartwood	Kijjoa *et al*., 1996
Artelastinin [**116**]	Heartwood	Kijjoa *et al*., 1998
Artelastocarpin [**117**]	Heartwood	Cidade *et al*., 2001
Artelastochromene [**118**]	Heartwood	Kijjoa *et al*., 1996
Artelastofuran [**119**]	Heartwood	Kijjoa *et al*., 1998
Artelastoheterol [**120**]	Root bark	Ko *et al*., 2005
Artelastoxanthone [**121**]	Root bark	Ko *et al*., 2005
Artocarpesin [**3**]	Heartwood	Kijjoa *et al*., 1996
Artocarpin [**4**]	Heartwood	Kijjoa *et al*., 1996
Artoindonesianin E1 [**122**]	Wood	Musthapa *et al*., 2009
Artonin F [**25**]	Root bark	Ko *et al*., 2005
Artonin S [**123**]	Root bark	Ko *et al*., 2005
Artonol A [**28**]	Root bark	Ko *et al*., 2005
Artonol B [**29**]	Root bark	Ko *et al*., 2005
Carpelastofuran [**124**]	Heartwood	Cidade *et al*., 2001
Cycloartelastoxanthendiol [**125**]	Root bark	Ko *et al*., 2005
Cycloartelastoxanthone [**126**]	Root bark	Ko *et al*., 2005
Cycloartobiloxanthone [**38**]	Root bark	Ko *et al*., 2005
Cycloartocarpesin [**105**]	Heartwood	Pendse *et al*., 1976

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Cycloartocarpin [**39**]	Heartwood	Pendse *et al*., 1976
Cyclomorusin [**46**]	Root bark	Ko *et al*., 2005
Integrin [**127**]	Heartwood	Pendse *et al*., 1976
Norartocarpin [**128**]	Heartwood	Pendse *et al*., 1976
Artocarpus fretessi		
Afzelechin [**129**]	Stem bark	Soekamto *et al*., 2003
Afzelechin-3-*O*-*α*-L-rhamnoside [**107**]	Stem bark	Soekamto *et al*., 2003
Artonin A [**92**]	Stem bark	Soekamto *et al*., 2003
Mulberrin [**130**]	Stem bark	Soekamto *et al*., 2003
Mulberrochromene [**131**]	Stem bark	Soekamto *et al*., 2003
Norartocarpetin [**65**]	Stem bark	Soekamto *et al*., 2003
Artocarpus glaucus		
Cudraflavone C [**34**]	Root bark	Hakim *et al*., 2006
Catechin [**108**]	Root bark	Hakim *et al*., 2006
Artocarpus gomezianus		
Albanin A [**132**]	Root	Likhitwitayawuid, Sritularak and De-Eknamkul, 2000
Artocarpesin [**3**]	Heartwood	Venkataraman, 1972
Artocarpin [**4**]	Heartwood Root	Venkataraman, 1972 Likhitwitayawuid *et al*., 2000
Cudraflavone C [**34**]	Root	Likhitwitayawuid *et al*., 2000
Cycloartocarpin [**39**]	Heartwood Root	Venkataraman, 1972 Likhitwitayawuid *et al*., 2000

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Isocyclomorusin [**33**]	Root	Likhitwitayawuid *et al*., 2000
Morin [**61**]	Heartwood	Venkataraman, 1972
Norartocarpetin [**65**]	Heartwood Root	Venkataraman, 1972 Likhitwitayawuid *et al*., 2000
Norcycloartocarpin [**133**]	Heartwood	Likhitwitayawuid *et al*., 2006
Artocarpus heterophyllus		
Afzelechin-(4α→8)-catechin [**134**]	Leaves	An *et al*., 1992
Albanin A [**132**]	Wood	Arung, Shimizu and Kondo, 2006b
Artocarpanone [**135**]	Heartwood	Radhakrishnan, Rao and Venkataraman, 1965
Artocarpanone A [**136**]	Root bark	Lin, Lu and Huang, 1995
Artocarpesin [**3**]	Heartwood	Radhakrishnan *et al*., 1965
Artocarpetin [**137**]	Heartwood	Venkataraman, 1972
Artocarpetin A [**138**]	Root bark	Lin *et al*., 1995
Artocarpetin B [**139**]	Root	Chung *et al*., 1995
Artocarpfuranol [**140**]	Wood	Zheng *et al*., 2008
Artocarpin [**4**]	Heartwood	Radhakrishnan *et al*., 1965
Artoflavanone [**141**]	Root	Dayal and Seshadri, 1974
Artoheterophyllin B [**142**]	Twig	Zheng *et al*., 2009
Artoheterophyllin C [**143**]	Twig	Zheng *et al*., 2009

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Artoheterophyllin D [**144**]	Twig	Zheng *et al*., 2009
Artonin A [**92**]	Root bark	Hano *et al*., 1989
Artonin B [**93**]	Root bark	Hano *et al*., 1989
Artonin C [**145**]	Root bark	Hano, Aida and Nomura, 1990a
Artonin D [**146**]	Root bark	Hano *et al*., 1990a
Artonin I [**147**]	Root bark	Hano *et al*., 1989
Artonin J [**148**]	Root bark	Aida *et al*., 1993
Artonin K [**26**]	Root bark	Aida *et al*., 1993
Artonin L [**149**]	Root bark	Aida *et al*., 1993
Artonin Q [**150**]	Bark	Aida *et al*., 1994
Artonin R [**151**]	Bark	Aida *et al*., 1994
Artonin S [**123**]	Bark	Aida *et al*., 1994
Artonin T [**152**]	Bark	Aida *et al*., 1994
Artonin U [**103**]	Bark	Aida *et al*., 1994
Artonin X [**153**]	Bark	Shinomiya *et al*., 1995
Catechin [**108**]	Leaves	Yamazaki *et al*., 1987
Cudraflavone A [**33**]	Root bark	Lin *et al*., 1995
Cudraflavone C [**34**]	Wood	Arung *et al*., 2006b
Cyanomaclurin [**154**]	Heartwood	Radhakrishnan *et al*., 1965
Cycloartocarpesin [**105**]	Heartwood	Pathasarathy *et al*., 1969
Cycloartocarpin [**39**]	Heartwood	Venkataraman, 1972
Cycloartocarpin A [**106**]	Root bark	Lu and Lin, 1994

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Cycloheterophyllin [**96**]	Bark	Rao, Varadan, and Venkataraman, 1971
	Root bark	Hano *et al*., 1989
Dihydromorin [**51**]	Heartwood	Venkataraman, 1972
Heteroartonin A [**155**]	Root bark	Chung *et al*., 1995
Heteroflavanone A [**156**]	Root bark	Lu and Lin, 1993
Heteroflavanone B [**157**]	Root bark	Lu and Lin, 1993
Heteroflavanone C [**97**]	Root bark	Lu and Lin, 1994
Heterophyllin [**98**]	Root bark	Hano *et al*., 1989
Heterophyllol [**158**]	Root bark	Lu and Lin, 1993
Isocycloheterophyllin [**159**]	Bark	Rao, Varadan and Venkataraman, 1973
Kuwanon C [**160**]	Wood	Arung *et al*., 2006b
Kuwanon R [**161**]	Root bark	Shinomiya *et al*., 1995
Kuwanon T [**162**]	Root bark	Shinomiya *et al*., 1995
Morin [**61**]	Heartwood	Radhakrishnan *et al*., 1965; Pathasarathy *et al*., 1969; Mu and Li, 1982
Norartocarpetin [**65**]	Heartwood	Radhakrishnan *et al*., 1965
Norartocarpin [**128**]	Heartwood	Venkataraman, 1972
	Wood	Arung *et al*., 2006b
Oxydihydroartocarpesin [**163**]	Heartwood	Pathasarathy *et al*., 1969
6-Prenylapigenin [**77**]	Wood	Arung *et al*., 2006b
3-Prenyl luteolin [**164**]	Wood	Arung *et al*., 2010
Procyanidin B-3 [**165**]	Leaves	An *et al*., 1992

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Procyanidin C-1 [**166**]	Leaves	An *et al*., 1992
Artocarpus hirsuta		
Artocarpanone [**135**]	Heartwood	Venkataraman, 1972
Artocarpesin [**3**]	Heartwood	Venkataraman, 1972
Artocarpetin [**137**]	Heartwood	Venkataraman, 1972
Artocarpin [**4**]	Heartwood	Venkataraman, 1972; Arung *et al*., 2006b
Cyanomaclurin [**154**]	Heartwood	Venkataraman, 1972
Cycloartocarpesin [**105**]	Heartwood	Venkataraman, 1972
Cycloartocarpin [**39**]	Heartwood	Venkataraman, 1972
Dihydromorin [**51**]	Heartwood	Venkataraman, 1972
Morin [**61**]	Heartwood	Venkataraman, 1972
Norartocarpetin [**65**]	Heartwood	Venkataraman, 1972
Oxydihydroartocarpesin [**163**]	Heartwood	Venkataraman, 1972
Artocarpus integer		
Artocarpanone [**135**]	Heartwood	Pendse *et al*., 1976
Artocarpesin [**3**]	Heartwood	Pendse *et al*., 1976
Artocarpetin [**137**]	Heartwood	Pendse *et al*., 1976
Catechin [**108**]	Leaves	Yamazaki *et al*., 1987
Chaplashin [**104**]	Heartwood	Pendse *et al*., 1976
Cycloartocarpesin [**105**]	Heartwood	Pendse *et al*., 1976
Cycloartocarpin [**39**]	Heartwood	Pendse *et al*., 1976
Cyclointegrin [**167**]	Heartwood	Pendse *et al*., 1976
Cyanomaclurin [**154**]	Heartwood	Pendse *et al*., 1976

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Dihydromorin [**51**]	Heartwood	Pendse *et al*., 1976
Integrin [**127**]	Heartwood	Pendse *et al*., 1976
Morin [**61**]	Heartwood	Pendse *et al*., 1976
Norartocarpetin [**65**]	Heartwood	Pendse *et al*., 1976
Oxydihydroartocarpesin [**163**]	Heartwood	Pendse *et al*., 1976
Oxyisocyclointegrin [**168**]	Heartwood	Pendse *et al*., 1976
Artocarpus kemando		
Artobiloxanthone [**2**] (artocarpus flavone KB-1)	Stem bark	Seo *et al*., 2003
Artocarpin [**4**]	Root	Hakim *et al*., 2006
Artoindonesianin B [**83**]	Root	Hakim *et al*., 2006
Artoindonesianin D [**169**]	Root	Hakim *et al*., 2006
Artonin E [**12**]	Stem bark	Seo *et al*., 2003
Artonin O [**170**]	Stem bark	Seo *et al*., 2003
Cycloartobiloxanthone [**38**]	Stem bark Root	Seo *et al*., 2003 Hakim *et al*., 2006
Cycloartocarpin [**39**]	Root	Hakim *et al*., 2006
Norartocarpetin [**65**]	Root	Hakim *et al*., 2006
Artocarpus lakoocha		
Artocarpin [**4**]	Heartwood	Venkataraman, 1972
Cycloartocarpin [**39**]	Heartwood	Venkataraman, 1972
5,7-Dihydroxyflavone-3-*O*-*α*-L-rhamnoside [**171**]	Root bark	Chauhan and Kumari, 1979
5-Hydroxy-7-2′-4′-trimetroxyflavone [**172**]	Stemwood	Pavaro and Reutrakul, 1976
Galangin-3-*O*-*α*-L-(-)-rhamnoside [**173**]	Root bark	Chauhan and Kumari, 1979
Galangin-3-*O*-*β*-D-galactopyranosyl-(1→4)-*α*-L-rhamnoside [**174**]	Root bark	Chauhan, Kumari and Saraswat, 1979

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Kaempferol-3-*O*- *β*-D-xyloside [**175**]	Root bark	Chauhan *et al*., 1982
Norartocarpin [**128**]	Heartwood	Venkataraman, 1972
Norcycloartocarpin [**176**]	Heartwood	Venkataraman, 1972
Quercetin-3-*O*-*α*-L-rhamnoside [**177**]	Root bark	Chauhan *et al*., 1982
Artocarpus lanceifolius		
Artelasticin [**113**]	Heartwood	Syah *et al*., 2001
Artelastofuran [**119**]	Heartwood	Syah *et al*., 2001
Artobiloxanthone [**2**]	Bark	Hakim *et al*., 2002a
Artoindonesianin G [**178**]	Heartwood	Syah *et al*., 2001
Artoindonesianin H [**179**]	Heartwood	Syah *et al*., 2001
Artoindonesianin I [**180**]	Heartwood	Syah *et al*., 2001
Artoindonesianin P [**181**]	Bark	Hakim *et al*., 2002a
Artoindonesianin Z-1 [**182**]	Stem bark	Syah *et al*., 2006a
Artoindonesianin Z-2 [**183**]	Stem bark	Syah *et al*., 2006a
Artoindonesianin Z-3 [**184**]	Stem bark	Hakim *et al*., 2006
Artoindonesianin Z-4 [**185**]	Stem bark	Musthapa *et al*., 2009
Artoindonesianin Z-5 [**186**]	Stem bark	Musthapa *et al*., 2009
Artonin E [**12**]	Stem	Cao, Butler, and Buss, 2003
Artonol B [**29**]	Bark	Hakim *et al*., 2002a
Cycloartobiloxanthone [**38**]	Bark	Hakim *et al*., 2002a
14-Hydroxyartonin E [**187**]	Stem	Cao *et al*., 2003
Artocarpus lowii		
2′,4′-Dihydroxy-4-methoxy-3′-prenyldihydrochalcone [**188**]	Leaves	Jamil *et al*., 2008

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Artocarpus maingayi		
Artocarpin [**4**]	Stem bark	Hakim *et al*., 2006
Artoindonesianin D [**169**]	Stem bark	Hakim *et al*., 2006
Chaplashin [**104**]	Stem bark	Hakim *et al*., 2006
Cudraflavone A [**33**]	Stem bark	Hakim *et al*., 2006
Cycloartocarpin **A** [**106**]	Stem bark	Hakim *et al*., 2006
Artocarpus nobilis		
Artobilochromen [**189**]	Bark	Pavanasasivam, Sultanbawa and Mageswaran, 1974; Kumar *et al*., 1977; Sultanbawa and Surendrakumar, 1989
Artobiloxanthone [**2**]	Bark	Sultanbawa and Surendrakumar, 1989
Artonin E2′-methylether [**190**]	Root bark	Jayasinghe *et al*., 2008
Artonin V2′-methylether [**191**]	Root bark	Jayasinghe *et al*., 2008
Chromanoartobilochromen A [**192**]	Stem bark	Kumar *et al*., 1977
Chromanoartobilochromen B [**193**]	Stem bark	Pavanasasivam *et al*., 1974; Kumar *et al*., 1977
Chromanoartobilochromene [**194**]	Bark	Pavanasasivam *et al*., 1974
Cycloartobiloxanthone [**38**]	Bark	Pavanasasivam *et al*., 1974
1-(3,4-Dihydro-3,5-dihydroxy-2-methyl-2-(3-methyl-2-butenyl)-2H-1-benzopyran-6-yl-3-(4-hydroxy phenyl)-2(*E*)-propen-1-one [**195**]	Fruit	Jayasinghe *et al*., 2006
(-)-Dihydrofuranoartobilochromen A [**196**]	Stem bark	Kumar *et al*., 1977
(-)-Dihydrofuranoartobilochromen B-1 [**197**]	Stem bark	Kumar *et al*., 1977

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
(-)-Dihydrofuranoartobilochromen B-2 [**198**]	Stem bark	Kumar *et al*., 1977
Dihydroisoartonin E2′-methylether [**199**]	Root bark	Jayasinghe *et al*., 2008
Furanoartobilochromen A [**200**]	Bark	Pavanasasivam *et al*., 1974
Furanoartobilochromen B-1 [**201**]	Bark	Pavanasasivam *et al*., 1974
Furanoartobilochromen B-2 [**202**]	Bark	Pavanasasivam *et al*., 1974
3′-Geranyl-2′,3,4,4′-tetrahydroxychalcone [**203**]	Leaves Fruit	Jayasinghe *et al*., 2004a Jayasinghe *et al*., 2006
3′-Geranyl-4′,5,7-trihydroxyflavanone [**204**]	Fruit	Jayasinghe *et al*., 2006
8-Geranyl-3′,4′,7-trihydroxyflavanone [**205**]	Fruit	Jayasinghe *et al*., 2006
8-Geranyl-4′,7-dihydroxyflavanone [**206**]	Fruit	Jayasinghe *et al*., 2006
Isoartonin E2′-methylether [**207**]	Root bark	Jayasinghe *et al*., 2008
Isonymphaeol-B [**208**]	Fruit	Jayasinghe *et al*., 2006
Lespeol [**209**]	Fruit	Jayasinghe *et al*., 2006
2,4,4′-Trihydroxy-3-[(2*E*)-5-methoxy-3,7-dimethylocta-2,6-dienyl]chalcone [**210**]	Fruit	Jayasinghe *et al*., 2006
2′,4′,4-Trihydroxy-3′-geranylchalcone [**211**]	Leaves	Fujimoto *et al*., 2004
2′,4′,4-Trihydroxy-3′-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadiethyl] chalcone [**212**]	Leaves	Fujimoto *et al*., 2004
2′,4′,4-Trihydroxy-3′-[2-hydroxy-7-methyl-3-methylene-6-octaethyl] chalcone [**213**]	Leaves	Fujimoto *et al*., 2004

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
2′,3,4,4′-Tetrahydroxy-3′-geranyl chalcone [**214**]	Leaves	Fujimoto *et al*., 2004
2′,3,4,4′-Tetrahydroxy-3′-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadiethyl] chalcone [**215**]	Leaves	Fujimoto *et al*., 2004
Oxydihydromorusin [**216**]	Stem bark	Kumar *et al*., 1977; Fukai and Nomura, 1993
Xanthoangelol [**217**]	Leaves Fruit	Jayasinghe *et al*., 2004a Jayasinghe *et al*., 2006
Xanthoangelol B [**218**]	Leaves Fruit	Jayasinghe *et al*., 2004a Jayasinghe *et al*., 2006
Artocarpus obtusus		
Dihydroartoindonesianin C [**219**]	Stem bark	Hashim *et al*., 2010
Pyranocycloartobiloxanthone A [**220**]	Stem bark	Hashim *et al*., 2010
Artocarpus odoratissimus		
Artosimmin [**221**]	-	Ee *et al*., 2010
Artocarpus pithecogallus		
Morin [**61**]	Heartwood	Mu and Li, 1982
Artocarpus rigida		
Artobiloxanthone [**2**]	Stem bark	Hano, Inami, and Nomura, 1990b
Artocarpol B [**222**]	Root bark	Ko, Lin, and Yang, 2000
Artocarpol H [**223**]	Root bark	Lu *et al*., 2002
Artonin E [**12**]	Stem bark	Hano *et al*., 1990b
Artonin G [**224**]	Stem bark	Hano *et al*., 1990b
Artonin H [**225**]	Stem bark	Hano *et al*., 1990b

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Artonin M [**226**]	Stem bark	Hano *et al*., 1990b
Artonin N [**227**]	Stem bark	Hano *et al*., 1990b
Artonin O [**170**]	Stem bark	Hano *et al*., 1990b
Artonin P [**228**]	Stem bark	Hano *et al*., 1990b
Cycloartobiloxanthone [**38**]	Stem bark	Hano *et al*., 1990b
Rubraflavone C [**229**]	Root bark	Lu *et al*., 2002
Artocarpus rotundo		
Artoindonesianin L [**230**]	Root bark	Suhartati *et al*., 2001
Artonin E [**12**]	Root bark	Suhartati *et al*., 2001
Artonin M [**226**]	Root bark	Suhartati *et al*., 2001
Artonin O [**170**]	Root bark	Suhartati *et al*., 2001
Cycloartobiloxanthone [**38**]	Root bark	Suhartati *et al*., 2001
Artocarpus scotehinii		
Artobiloxanthone [**2**] (artocarpus flavone KB-1)	Stem bark	Hakim *et al*., 2006
Artonin E [**12**] (artocarpus flavone KB-3)	Stem bark	Hakim *et al*., 2006
Cycloartobiloxanthone [**38**]	Stem bark	Hakim *et al*., 2006
Norartocarpetin [**65**]	Stem bark	Hakim *et al*., 2006
5′-Hydroxycudraflavone A [**99**]	Stem bark	Hakim *et al*., 2006
Artocarpus sepicanus		
Sepicanin A [**231**]	Leaves	Radwan *et al*., 2009
Artocarpus styracifolius		
Styracifolin A [**232**]	Stem bark	Bourjot *et al*., 2010

Table 1 (continued)

Plant and chemical compound	Plant part	Reference
Styracifolin B [**233**]	Stem bark	Bourjot *et al*., 2010
Artocarpus teysmanii		
Artoindonesianin C [**234**]	Root bark	Makmur *et al*., 2000
Artonin J [**148**]	Root bark	Makmur *et al*., 2000
Cycloartobiloxanthone [**38**]	Root bark	Makmur *et al*., 2000
Artocarpus tonkinensis		
Alphitonin-4-*O*-glucoside [**235**]	Leaves	Thuy *et al*., 2004
Artokin-4′-*O*-glucoside [**236**]	Leaves	Dang *et al*., 2009
Artotonin A [**237**]	Root	Ma *et al*., 2010
Artotonin B [**238**]	Root	Ma *et al*., 2010
Maesopsin-4-*O*-glucoside [**239**]	Leaves	Thuy *et al*., 2004
Artocarpus venenosa		
Paratocarpin A [**240**]	Stem bark	Nomura, Hano and Aida, 1998
Paratocarpin B [**241**]	Stem bark	Nomura *et al*., 1998
Paratocarpin C [**242**]	Stem bark	Nomura *et al*., 1998
Paratocarpin D [**243**]	Stem bark	Nomura *et al*., 1998
Paratocarpin E [**244**]	Stem bark	Nomura *et al*., 1998
Paratocarpin F [**245**]	Stem bark	Nomura *et al*., 1998
Paratocarpin G [**246**]	Stem bark	Nomura *et al*., 1998
Paratocarpin H [**247**]	Stem bark	Nomura *et al*., 1998
Paratocarpin I [**248**]	Stem bark	Nomura *et al*., 1998
Paratocarpin J [**249**]	Stem bark	Nomura *et al*., 1998
Paratocarpin K [**250**]	Stem bark	Nomura *et al*., 1998
Paratocarpin L [**251**]	Stem bark	Nomura *et al*., 1998

Table 2 Distribution of triterpenoids in the genus *Artocarpus*

Plant and chemical compound	Plant part	Reference
Artocarpus altilis		
α-Amyrin [**252**]	Latex	Ultee, 1949
α-Amyrin acetate [**253**]	Fruit	Altman and Zito, 1976
β-Amyrin acetate [**254**]	Latex	Ultee, 1949
Cycloart-23-ene-3β,25-diol [**255**]	Fruit	Altman and Zito, 1976
Cycloart-24-ene-3β-ol [**256**] (Cycloartenol)	Fruit Stem bark	Altman and Zito, 1976 Pavanasasivum and Sultanbawa, 1973
Cycloart-25-ene-3β,24-diol [**257**]	Fruit	Altman and Zito, 1976
Cycloartenone [**258**]	Stem bark	Pavanasasivum and Sultanbawa, 1973
Cycloartenyl acetate [**259**]	Stem bark	Pavanasasivum and Sultanbawa, 1973
Lupeol acetate [**260**]	Root bark	Shieh and Lin, 1992
Artocarpus champeden		
Cycloartenone [**258**]	Stem bark	Achmad *et al*., 1996
Cycloeucalenol [**261**]	Stem bark	Achmad *et al*., 1996
Glutinol [**262**]	Stem bark	Achmad *et al*., 1996
24-Methylenecycloartenone [**263**]	Stem bark	Achmad *et al*., 1996
Artocarpus chaplasha		
Cycloartenyl acetate [**259**]	Stem bark	Mahato, Banerjee and Chakravarti, 1971
Isocycloartenol acetate [**264**]	Stem bark	Mahato *et al*., 1971
Lupeol acetate [**260**]	Stem bark	Mahato *et al*., 1971

Table 2 (continued)

Plant and chemical compound	Plant part	Reference
Artocarpus elasticus		
β-Amyrin acetate [**254**]	Latex	Ultee, 1949
Lupeol acetate [**260**]	Latex	Ultee, 1949
Artocarpus gomezianus		
Lupeol acetate [**260**]	Leaves	Kingroungpet, 1994
Simiarenol [**265**]	Leaves	Kingroungpet, 1994
Artocarpus heterophyllus		
Betulin [**266**]	Root bark	Lu and Lin, 1994
Betulinic acid [**267**]	Root Root bark	Dayal and Seshadri, 1974 Lu and Lin, 1994
Butyrospermol [**268**]	Fruit	Barton, 1951
Cycloartenol [**256**] (Cycloart-24-ene-3*β*-ol)	Fruit Wood Stem bark Latex	Barton, 1951 Nogueira and Correia, 1958 Pavanasasivum and Sultanbawa, 1973 Barik *et al*., 1994
Cycloartenone [**258**]	Fruit Stem bark Root Latex	Nath and Mukherjee, 1939; Barton, 1951 Pavanasasivam and Sultanbawa, 1973 Dayal and Seshadri, 1974 Barik *et al*., 1994
Cycloartenyl acetate [**259**]	Stem bark	Pavanasasivam and Sultanbawa, 1973
9,19-Cyclolanost-23-ene-3*β*,25-diol (Cycloart-23-ene-3*β*,25-diol) [**255**]	Fruit	Kielland and Malterud, 1994
9,19-Cyclolanost-25-ene-3*β*,24-diol [**257**]	Fruit	Kielland and Malterud, 1994
9,19-Cyclolanost-3-one-24,25-diol [**269**]	Fruit	Kielland and Malterud, 1994

Table 2 (continued)

Plant and chemical compound	Plant part	Reference
Ursolic acid [**270**]	Root Root bark	Dayal and Seshadri, 1974 Lu and Lin, 1994
Artocarpus integer		
Cycloartenone [**258**]	Latex	Pant and Chaturvedi, 1989
Artocarpus lakoocha		
β-Amyrin acetate [**254**]	Stem Bark	Kapil and Joshi, 1960
Cycloartenol [**256**] (Cycloart-24-ene-3*β*-ol)	Stem Bark	Pavanasasivam and Sultanbawa, 1973
Cycloartenone [**258**]	Stem Bark	Pavanasasivam and Sultanbawa, 1973
Cycloartenyl acetate [**259**]	Stem Bark	Pavanasasivam and Sultanbawa, 1973
Lupeol [**271**]	Root Bark	Chauhan and Kumari, 1979
Lupeol acetate [**260**]	Stem Bark	Kapil and Joshi, 1960
Artocarpus nobilis		
Cycloartenol [**256**] (Cycloart-24-ene-3*β*-ol)	Stem Bark Heartwood	Pavanasasivam and Sultanbawa, 1973
Cycloartenone [**258**]	Stem Bark Heartwood	Pavanasasivam and Sultanbawa, 1973
Cycloartenyl acetate [**259**]	Stem Bark Heartwood	Pavanasasivam and Sultanbawa, 1973

Table 3 Distribution of miscellaneous constituents in the genus *Artocarpus*

Plant and chemical compound	Category	Plant part	Reference
Artocarpus altilis			
γ-Aminobutyric acid [**272**]	Amino acid	Leaves	Durand *et al*., 1962
Artocarbene [**273**]	Stilbene	Heartwood	Shimizu, Kondo, and Sakai, 1997
4-Prenyloxyresveratrol [**274**]	Stilbene	Heartwood	Shimizu *et al*., 1997
β-Sitosterol [**275**]	Steroid	Root bark	Shieh and Lin., 1992
Artocarpus chaplasha			
Artochamin H [**276**]	Stilbene	Stem	Wang *et al*., 2006
Artochamin I [**277**]	Stilbene	Stem	Wang *et al*., 2006
Artochamin J [**278**]	Stilbene	Stem	Wang *et al*., 2006
Artochamin K [**279**]	Stilbene	Stem	Wang *et al*., 2006
Artochamin F [**280**]	Stilbene	Stem	Wang *et al*., 2006
Artochamin G [**281**]	Stilbene	Stem	Wang *et al*., 2006
Artostilbene A [**282**]	Stilbene	Stem	Wang *et al*., 2007a
Artostilbene B [**283**]	Stilbene	Stem	Wang *et al*., 2007a
Oxyresveratrol [**284**]	Stilbene	Heartwood	Rao *et al*., 1972
Resorcinol [**285**]	Benzenoid	Heartwood	Rao *et al*., 1972
β-Resorcylaldehyde [**286**]	Benzenoid	Heartwood	Rao *et al*., 1972
Resveratrol [**287**]	Stilbene	Heartwood	Rao *et al*., 1972
β-Sitosterol [**275**]	Steroid	Stem bark	Mahato *et al*., 1971
Artocarpus dadah			
Dadahol A [**288**]	Neolignan	Twig	Su *et al*., 2002
Dadahol B [**289**]	Neolignan	Twig	Su *et al*., 2002
3-(2,3-Dihydroxy-3-methylbutyl)-resveratrol [**290**]	Stilbene	Stem bark	Su *et al*., 2002

Table 3 (continued)

Plant and chemical compound	Category	Plant part	Reference
3-(γ,γ-Dimethylallyl) oxyresveratrol [**291**]	Stilbene	Stem bark	Su *et al*., 2002
3-(γ,γ-Dimethylallyl) resveratrol [**292**]	Stilbene	Stem bark	Su *et al*., 2002
3-(γ,γ-Dimethylpropenyl) Moracin M [**293**]	Stilbene	Stem bark	Su *et al*., 2002
Moracin M [**294**]	Stilbene	Twig	Su *et al*., 2002
Oxyresveratrol [**284**]	Stilbene	Stem bark Twig	Su *et al*., 2002
Resveratrol [**287**]	Stilbene	Twig	Su *et al*., 2002
Artocarpus elasticus			
β-Sitosterol [**275**]	Steroid	Heartwood	Pendse *et al*., 1976
Artocarpus fretessi			
Artoindonesianin X [**295**]	Stilbene	Root bark	Soekamto *et al*., 2003
Artoindonesianin Y [**296**]	Stilbene	Root bark	Soekamto *et al*., 2003
Artocarpus gomezianus			
Andalasin [**297**]	Stilbene	Root	Likhitwitayawuid and Sritularak, 2001
Arbutin [**298**]	Phenolic glycoside	Leaves	Kingroungpet, 1994
Artogomezianol [**299**]	Stilbene	Root	Likhitwitayawuid and Sritularak, 2001
Artoindonesianin N [**300**]	Stilbene	Bark	Hakim *et al*., 2002b
Artoindonesianin O [**301**]	Stilbene	Bark	Hakim *et al*., 2002b
1-Dotriacontanol [**302**]	Alcohol	Leaves	Kingroungpet, 1994

Table 3 (continued)

Plant and chemical compound	Category	Plant part	Reference
Oxyresveratrol [**284**]	Stilbene	Heartwood	Likhitwitayawuid *et al*., 2006
Phenyl-*β*-naphthylamine [**303**]	Naphthalene	Root	Likhitwitayawuid and Sritularak, 2001
Resorcinol [**285**]	Benzenoid	Root	Sritularak, 1998
Resveratrol [**287**]	Stilbene	Root	Likhitwitayawuid *et al*., 2000
β-sitosterol [**275**]	Steroid	Leaves	Kingroungpet, 1994
Stigmasterol [**304**]	Steroid	Leaves	Kingroungpet, 1994
Artocarpus heterophyllus			
Acetylcholine [**305**]	Amine	Seed	Pereira, Medina and Bustos, 1962
Artocarpus integra *α* -D-Galactose specific lectin [**306**]	Lectin	Seed	Suresh, Appukuttan and Basu, 1982
Artocarpus integrifolia lectin [**307**]	Lectin	Seed	Chatterjee, Sarkar and Rao, 1982; Namjuntra and Culavatnatol, 1984
Artocarpus lectin CE-A-I [**308**]	Lectin	Seed	Ferreira *et al*., 1992
Artoheterophyllin A [**309**]	Stilbene	Twig	Zheng *et al*., 2009
Aurantiamide acetate [**310**]	Protein	Seed	Chakraborty and Mandal, 1981
9-Hydroxytridecyl docosanoate [**311**]	Fatty acid	Root bark	Lu and Lin, 1994
4-Hydroxyundecyl docosanoate [**312**]	Fatty acid	Latex	Pant and Chaturvedi, 1989
Jacalin [**313**]	Lectin	Seed	Hagiwara *et al*., 1988 Ferreira *et al*., 1992
Lymphoagglutinin [**314**]	Lectin	Seed	Arora *et al*., 1987

Table 3 (continued)

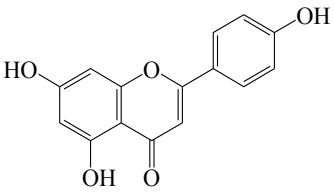
Plant and chemical compound	Category	Plant part	Reference
Recinoleic acid [**315**]	Fatty acid	Seed oil	Daulatabad and Mirajkar, 1989
β-Sitosterol [**275**]	Steroid	Heartwood	Pathasarathy *et al*., 1969
		Root	Dayal and Seshadri, 1974
		Root bark	Lu and Lin, 1994
Artocarpus hirsuta			
Lymphoagglutinin [**314**]	Lectin	Seed	Arora *et al*., 1987
Artocarpus integer			
Artocarbene [**273**]	Stilbene	Aerial part	Boonlaksiri *et al*., 2000
Artocarpus lectin C [**316**]	Lectin	Seed	Hashim, Gendeh and Jaafar, 1992
4-Hydroxyundecyl docosanoate [**312**]	Fatty acid	Latex	Pant and Chaturvedi, 1989
4-Methoxy-2,2-dimethyl-6-(2-(2,4-dihydroxy)phenyl-trans-ethenyl) chromene [**317**]	Stilbene	Aerial part	Boonlaksiri *et al*., 2000
4-Prenyloxyresveratrol [**274**] *(trans*-4-Isopentenyl-3,5,2′,4′ tetrahydroxy stilbene)	Stilbene	Aerial part	Boonlaksiri *et al*., 2000
β-Sitosterol [**275**]	Steroid	Heartwood	Pendse *et al*., 1976
trans-4-(3-Methyl-*E*-but-1-enyl)-3,5,2′,4′-tetrahydroxystilbene [**318**] (Artoindonesianin F)	Stilbene	Aerial part	Boonlaksiri *et al*., 2000
Artocarpus lakoocha			
ALA-I [**319**]	Isolectin	Seed	Wongkham *et al*., 1995
ALA-II [**320**]	Isolectin	Seed	Wongkham *et al*., 1995
ALA-III [**321**]	Isolectin	Seed	Promdee, 1996

Table 3 (continued)

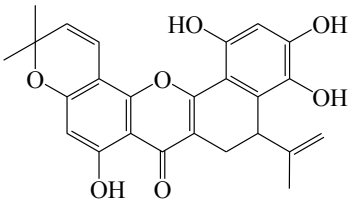
Plant and chemical compound	Category	Plant part	Reference
Artocarpus lakoocha lectin [**322**]	Lectin	Seed	Chatterjee *et al*., 1982
Lakoochin A [**323**]	Stilbene	Root	Puntumchai *et al*., 2004
Lakoochin B [**324**]	Stilbene	Root	Puntumchai *et al*., 2004
Lymphoagglutinin [**314**]	Lectin	Seed	Arora *et al*., 1987
Oxyresveratrol [**284**]	Stilbene	Heartwood	Venkataraman, 1972; Likhitwitayawuid and Sritularak, 2001
Resorcinol [**285**]	Benzenoid	Heartwood	Venkataraman, 1972
Resveratrol [**287**]	Stilbene	Heartwood	Venkataraman, 1972
β-Sitosterol [**275**]	Steroid	Root bark	Chaunhan and Kumari, 1979
Artocarpus lignanensis			
Artocarpus lectin [**325**]	Lectin	Seed	Zhang *et al*., 1999
Artocarpus masticatus			
Artocarpus lectin AM [**326**]	Lectin	Seed	Blasco *et al*., 1996
Artocarpus melinoxylus			
Artocarpus lectin AME [**327**]	Lectin	Seed	Blasco *et al*., 1996
Artocarpus nitidus			
Artonitidin A [**328**]	Stilbene	Stem	Zhao *et al*., 2009
Artonitidin B [**329**]	Stilbene	Stem	Zhao *et al*., 2009
Artocarpus nobilis			
trans-4-(3-Methyl-E-but-1-enyl)-3,5,2′,4′-tetrahydroxystilbene [**318**] (Artoindonesianin F)	Stilbene	Stem bark	Jayasinghe *et al*., 2004b

Table 3 (continued)

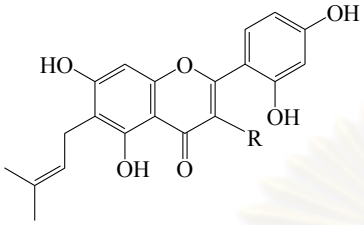
Plant and chemical compound	Category	Plant part	Reference
trans-4-Isopentenyl-3,5,2',4'-tetra hydroxy stilbene [**274**] (4-prenyloxyresveratrol)	Stilbene	Stem bark	Jayasinghe *et al*., 2004b
Artocarpus petelotii			
Artopetelin L [**330**]	Stilbene	Root bark	Shen and Hou, 2008
Artopetelin M [**331**]	Stilbene	Root bark	Shen and Hou, 2008
Artocarpus rigida			
Artocarpol A [**332**]	Stilbene	Root bark	Ko, Lin and Yang, 2001
Artocarpol C [**333**]	Stilbene	Root bark	Ko *et al*., 2001
Artocarpol D [**334**]	Stilbene	Root bark	Ko *et al*., 2001
Artocarpol E [**335**]	Stilbene	Root bark	Ko *et al*., 2001
Artocarpol F [**336**]	Stilbene	Root bark	Ko *et al*., 2001
Artocarpus tonkinensis			
Artotonkin [**337**]	Stilbene	Stem bark	Lien *et al*., 1998



[**1**] Apigenin

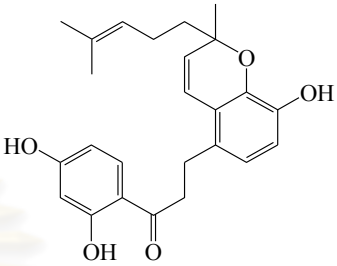


[**2**] Artobiloxanthone
(artocarpus flavone KB-1)

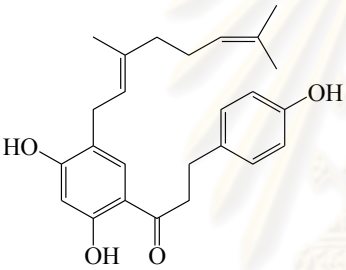


[**3**] Artocarpesin R=H

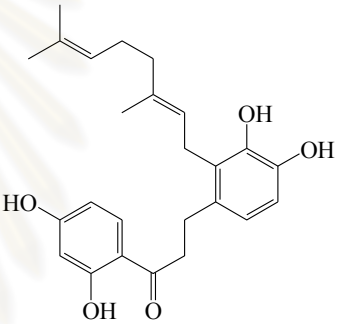
[**4**] Artocarpin R=



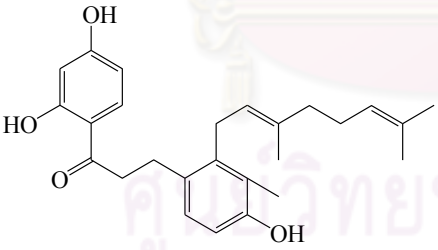
[**5**] Artocarpus chalcone AC-3-1



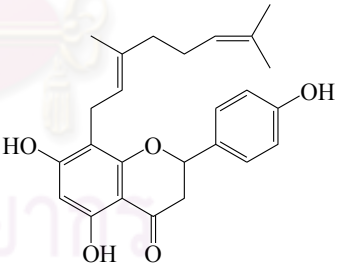
[**6**] Artocarpus chalcone AC-3-3



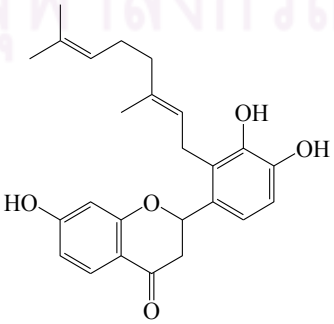
[**7**] Artocarpus chalcone AC-5-1



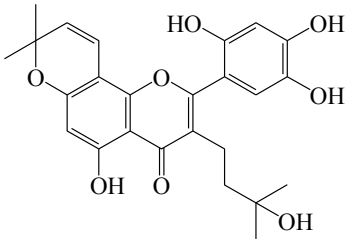
[**8**] Artocarpus chalcone I



[**9**] Artocarpus flavanone AC-3-2

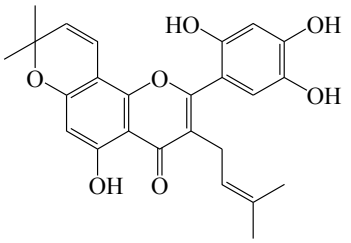


[**10**] Artocarpus flavanone AC-5-2

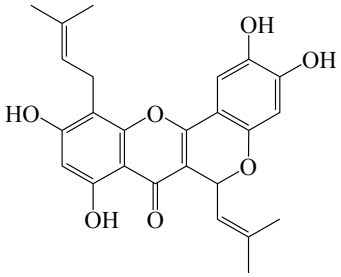


[**11**] Artocarpus flavone KB-2

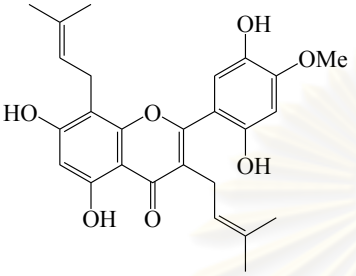
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp.



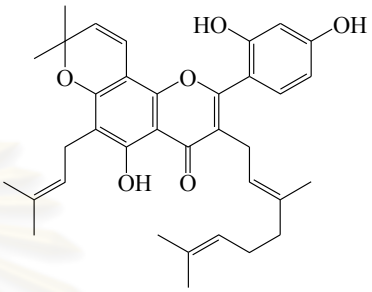
[**12**] Artocarpus flavone KB-3 (Artonin E)



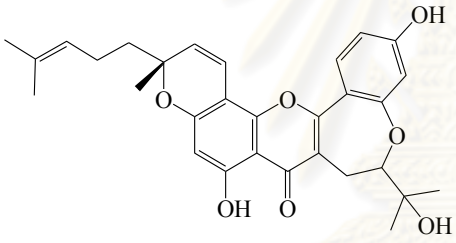
[**13**] Artochamin B



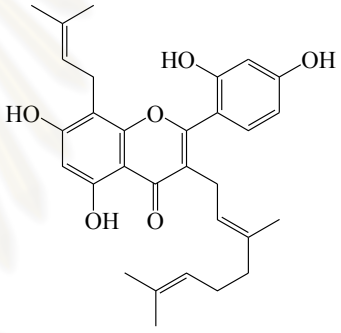
[**14**] Artochamin D



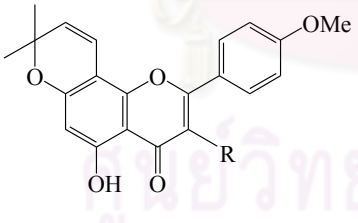
[**15**] Artocommunol CB



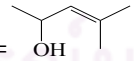
[**16**] Artocommunol CC



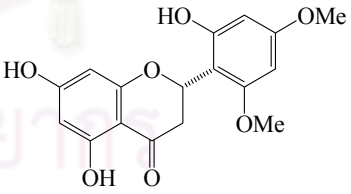
[**17**] Artocommunol CD



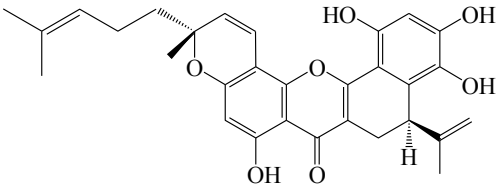
[**18**] Artocommunol CE R=



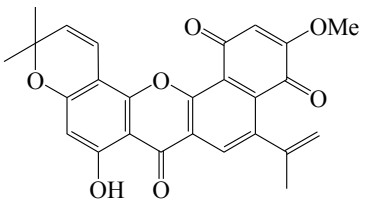
[**19**] Artoflavone A R=



[**20**] Artomunoflavanone

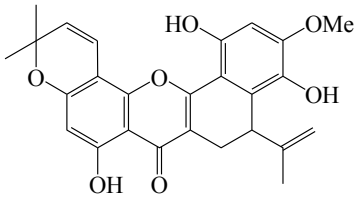


[**21**] Artomunoisoxanthone

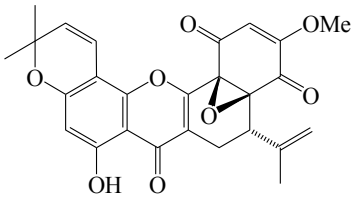


[**22**] Artomunoxanthentrione

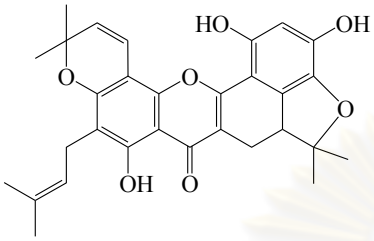
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



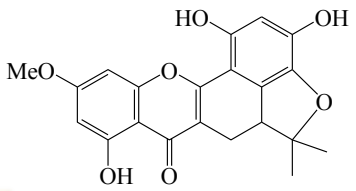
[**23**] Artomunoxanthone



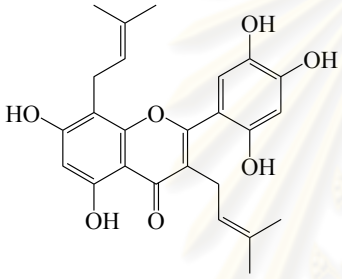
[**24**] Artomunoxanthotrione epoxide



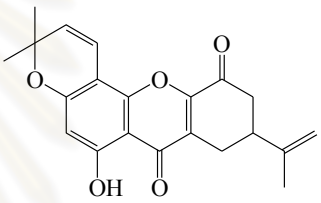
[**25**] Artonin F



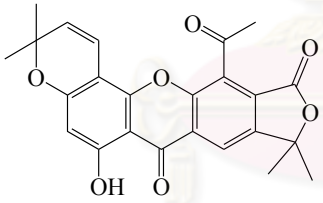
[**26**] Artonin K



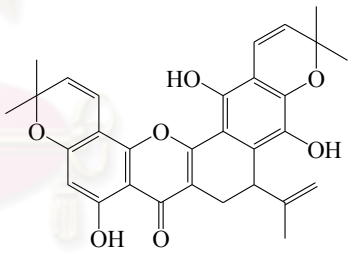
[**27**] Artonin V



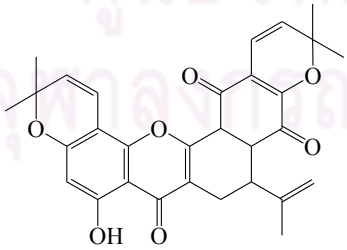
[**28**] Artonol A



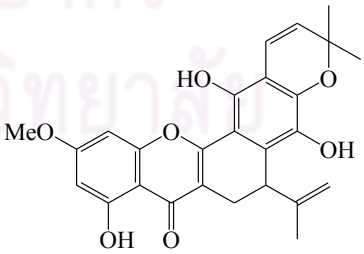
[**29**] Artonol B



[**30**] Artonol C

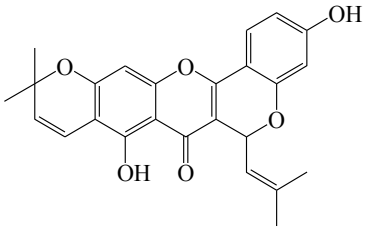


[**31**] Artonol D

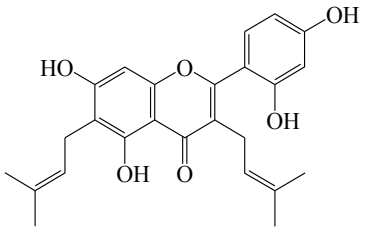


[**32**] Artonol E

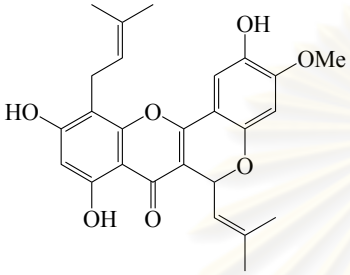
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



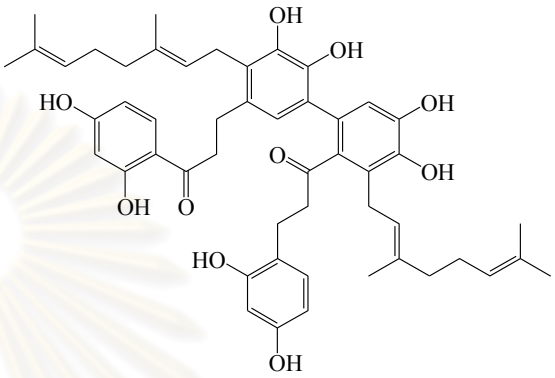
[**33**] Cudraflavone A
(Isocyclomorusin)



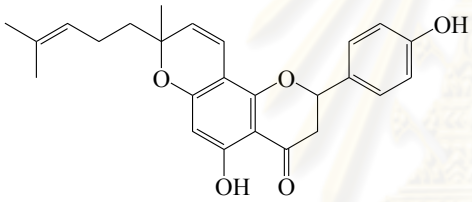
[**34**] Cudraflavone C



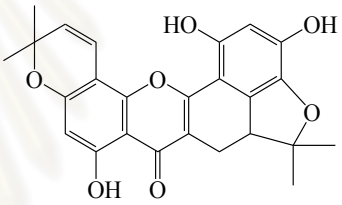
[**35**] Cycloaltilisin



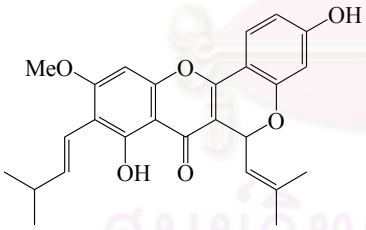
[**36**] Cycloaltilisin 6



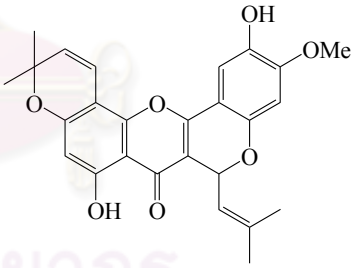
[**37**] Cycloaltilisin 7



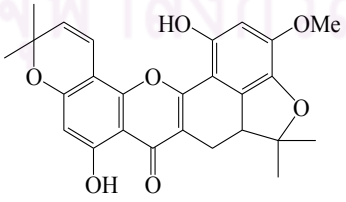
[**38**] Cycloartobiloxanthone



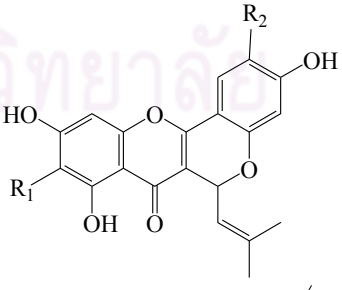
[**39**] Cycloartocarpin



[**40**] Cycloartomunin

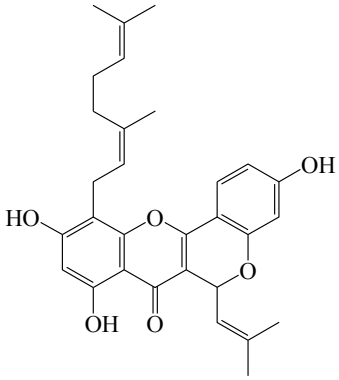


[**41**] Cycloartomunoxanthone

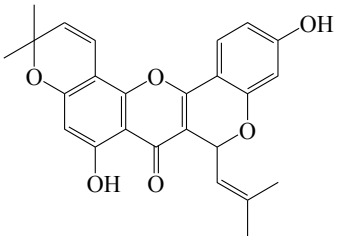


[**42**] Cyclocommunin R_1 =  R_2= H
[**43**] Cyclocommunol $R_1 = R_2 = H$
[**44**] Cyclocommunomethonol R_1=H R_2=OMe

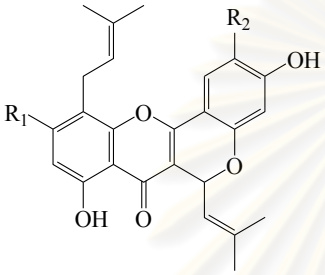
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



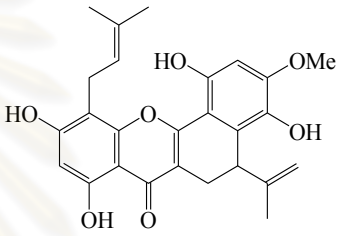
[**45**] Cyclogeracommunin



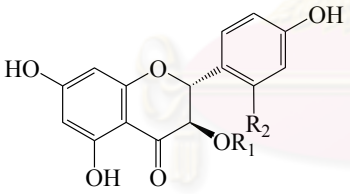
[**46**] Cyclomorusin



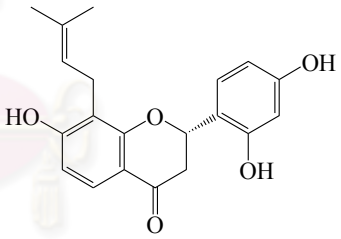
[**47**] Cyclomulberrin R_1=OH R_2=H
[**49**] Dihydrocycloartomunin
R_1=OMe R_2=OH
[**50**] Dihydroisocycloartomunin
R_1=OH R_2=OMe



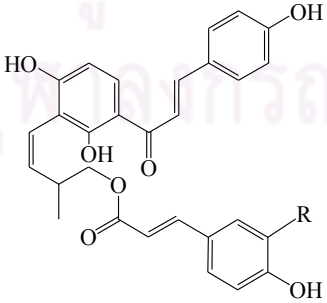
[**48**] Dihydroartomunoxanthone



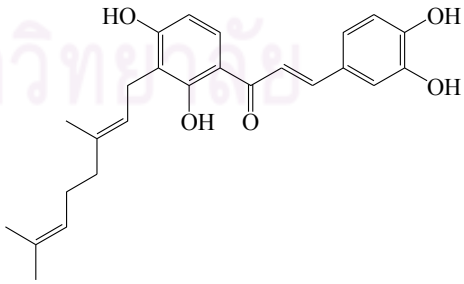
[**51**] Dihydromorin R_1=H R_2=OH
[**52**] Engeletin R_1=rhamnose R_2=H



[**53**] (2*S*)-Euchrenone a7

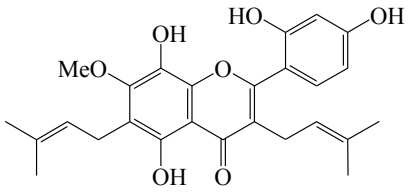


[**54**] Gemichalcone B R=H
[**55**] Gemichalcone C R=OMe

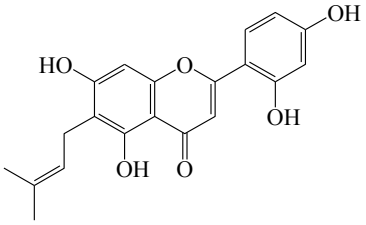


[**56**] 3′-Geranyl-2′-3-4-4′- tetrahydroxy-chalcone

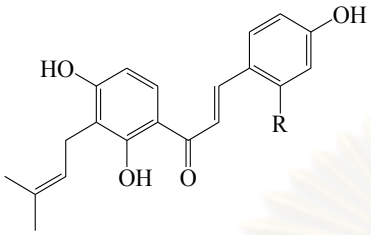
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



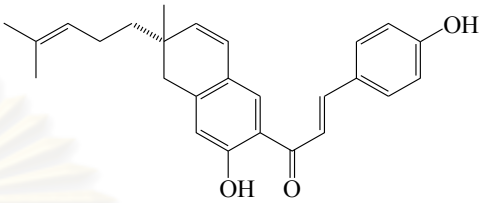
[**57**] Hydroxyartocarpin



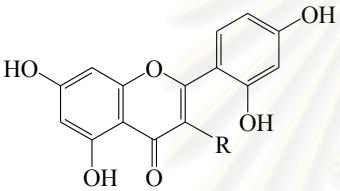
[**58**] Isoartocarpesin



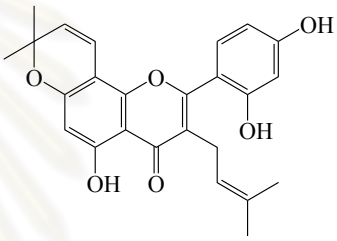
[**59**] Isobacachalcone R=H
[**62**] Morachalcone A R=OH



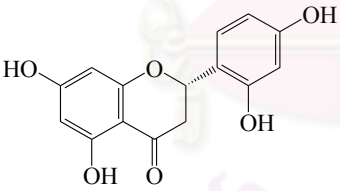
[**60**] Isolespeol



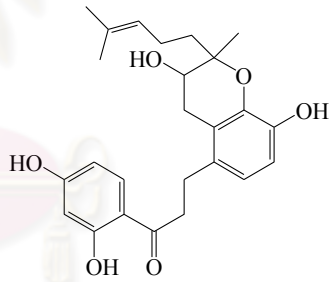
[**61**] Morin R=OH
[**65**] Norartocarpetin R=H



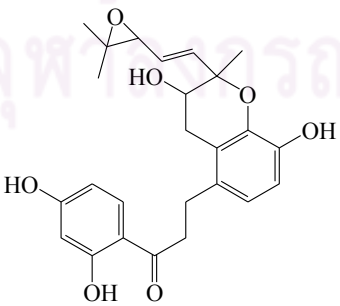
[**63**] Morusin



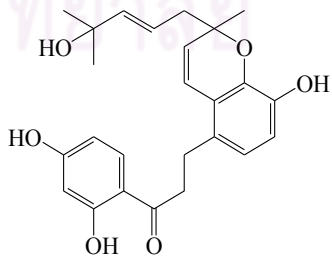
[**64**] (+)-Norartocarpanone



[**66**]1-(2,4-Dihydroxyphenyl)-3-[3,4-dihydro -3,8-dihydroxy-2-methyl-2-(4-methyl-3-pentenyl)-2H-1-benzopyran-5-yl]-1-propanone

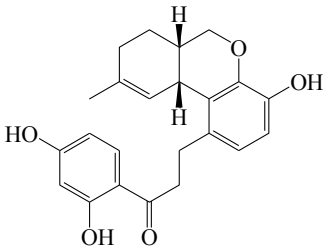


[**67**] 1-(2,4-Dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(3,4-epoxy-4-methyl-1-pentenyl)-2H-1-benzopyran-5-yl]-1-propanone

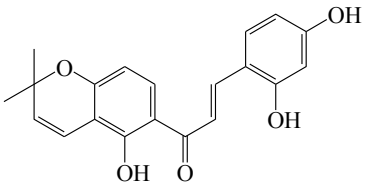


[**68**] 1-(2,4-Dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(4-hydroxy-4-methyl-2-pentenyl)-2H-1-benzopyran-5-yl]-1-propanone

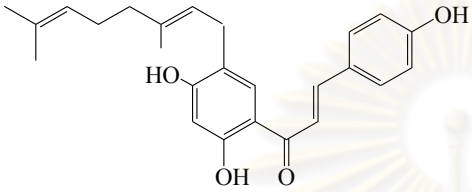
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



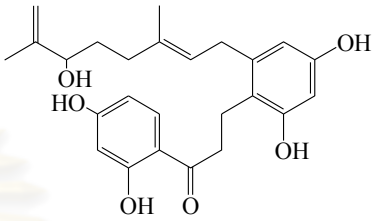
[**69**] 1-(2,4-Dihydroxyphenyl)-3-{4-hydroxy-6,6,9-trimethyl-6a,7,8,10a-tetrahydro-6H-dibenzo [b,d]pyran-5-yl}-1-propanone



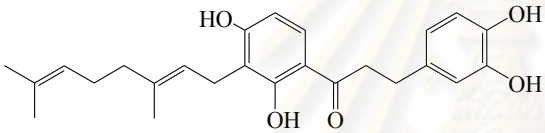
[**70**] 3″,3″-Dimethylpyrano[3′,4′]2,4,2′-trihydroxychalcone



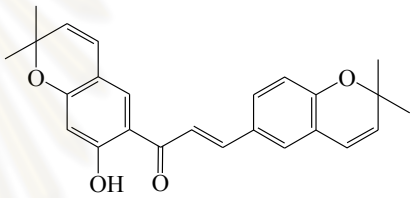
[**71**] 5′-Geranyl-2′,4′,4-trihydroxychalcone



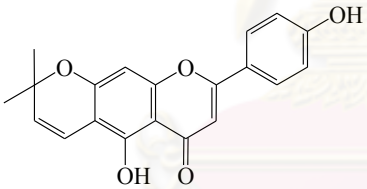
[**72**] 2-[6-Hydroxy-3,7-dimethylocta-2(E),7-dienyl]-2′,3,4,4′ tetrahydroxy dihydrochalcone



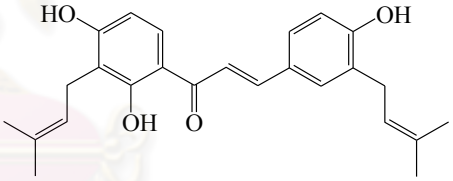
[**73**] 3,4,2′,4′-Tetrahydroxy-3′-geranyl dihydrochalcone



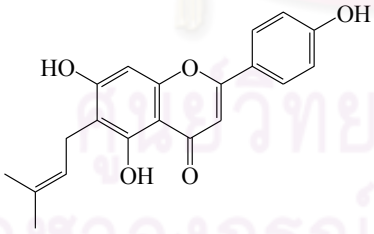
[**74**] Artoindonesianin J



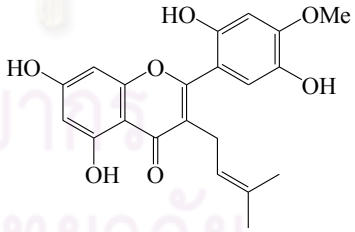
[**75**] Carpachromene



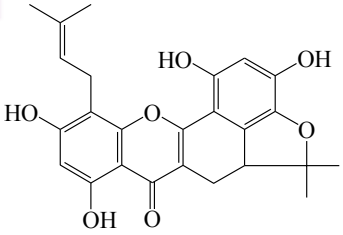
[**76**] Kozonol C



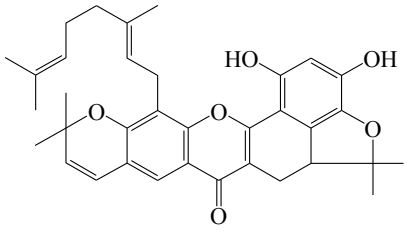
[**77**] 6-Prenylalpigenin



[**78**] Artocarpone A

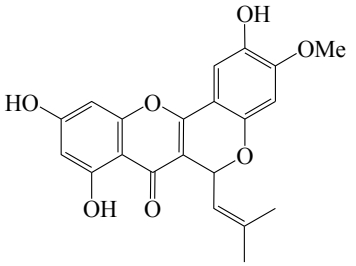


[**79**] Artocarpone B

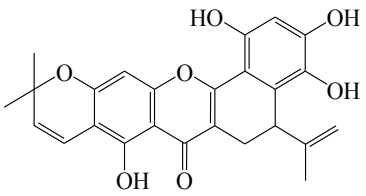


[**80**] Artoindonesianin A

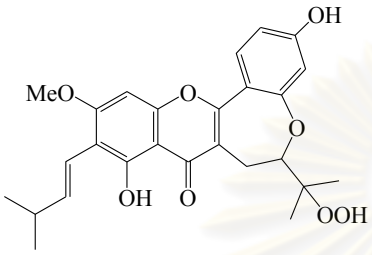
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



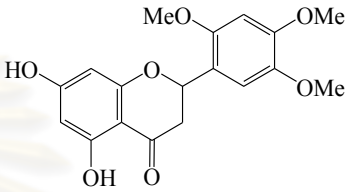
[**81**] Artoindonesianin A-2



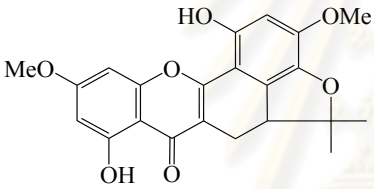
[**82**] Artoindonesianin A-3



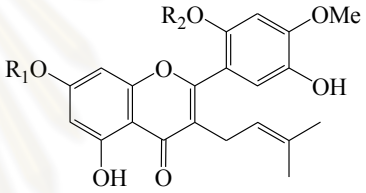
[**83**] Artoindonesianin B



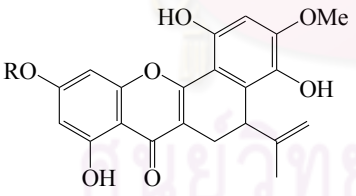
[**84**] Artoindonesianin E



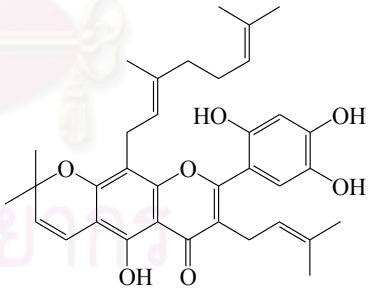
[**85**] Artoindonesianin M



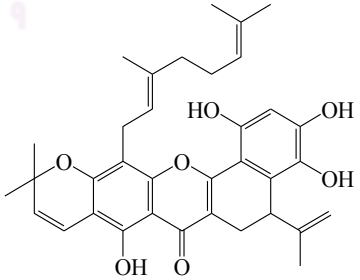
[**86**] Artoindonesianin Q R_1=Me R_2=H
[**87**] Artoindonesianin R R_1=H R_2=Me



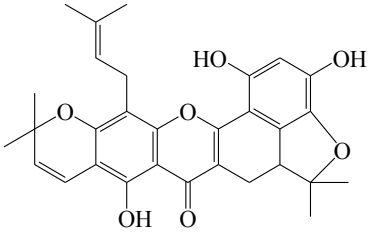
[**88**] Artoindonesianin S R=Me
[**89**] Artoindonesianin T R=H



[**90**] Artoindonesianin U

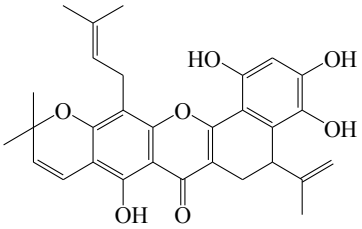


[**91**] Artoindonesianin V

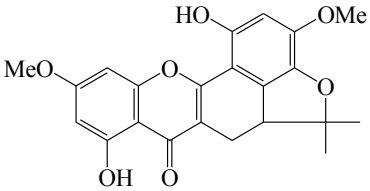


[**92**] Artonin A

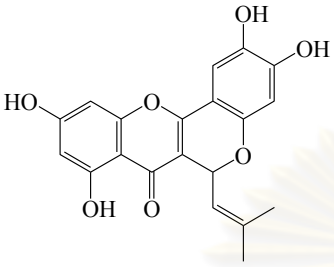
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



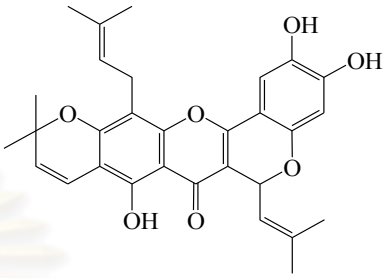
[**93**] Artonin B



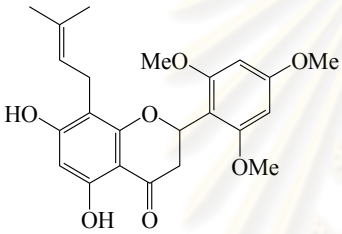
[**94**] Artopeden A



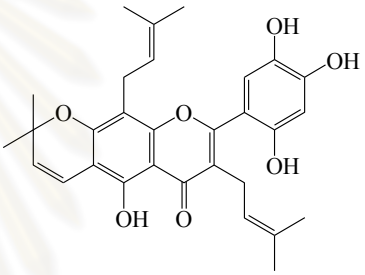
[**95**] Cyclochampedol



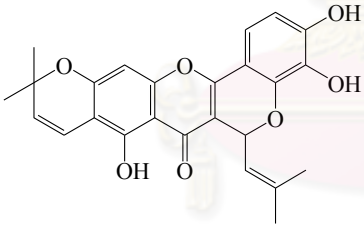
[**96**] Cycloheterophyllin



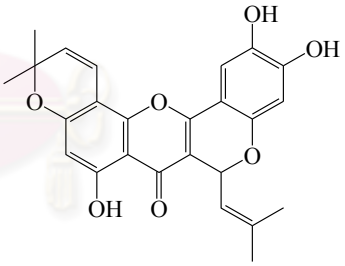
[**97**] Heteroflavanone C



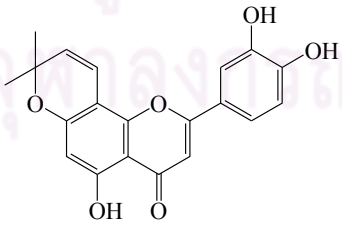
[**98**] Heterophyllin



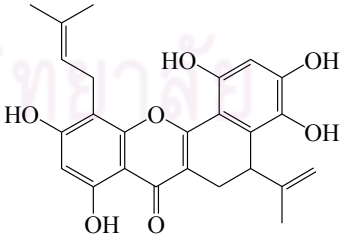
[**99**] 5′-Hydroxycudraflavone A



[**100**] Artochamin A

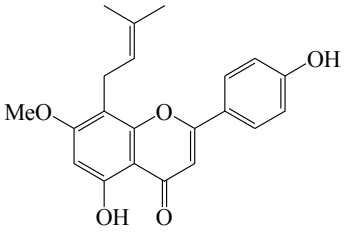


[**101**] Artochamin C

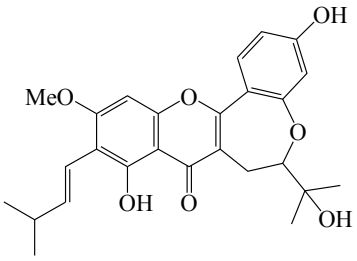


[**102**] Artochamin E

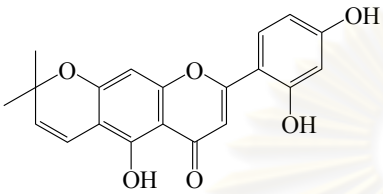
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



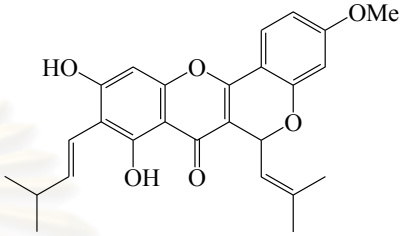
[**103**] Artonin U



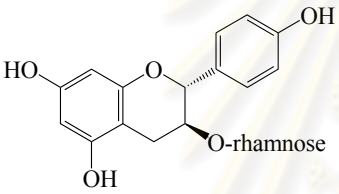
[**104**] Chaplashin



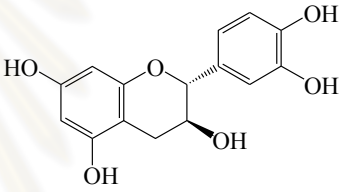
[**105**] Cycloartocarpesin



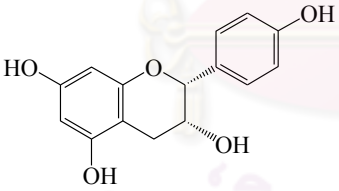
[**106**] Cycloartocarpin A



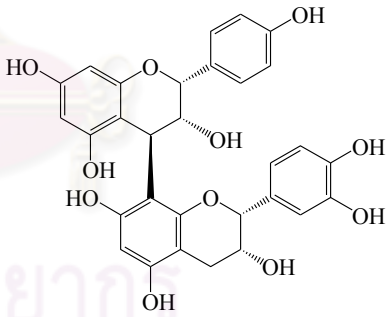
[**107**] Afzelechin-3-O-*α*-L-rhamnoside



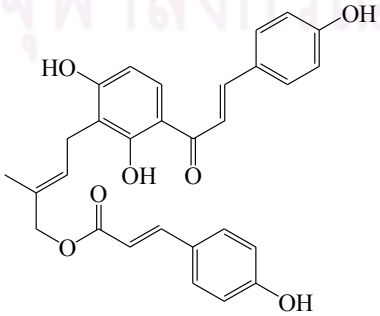
[**108**] (+)-Catechin



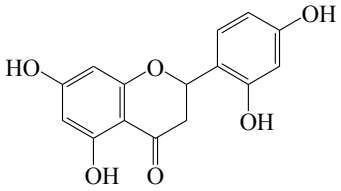
[**109**] (+)-Epiafzelechin



[**110**] (-)-Epiafzelechin-(4*β*→8)-epicatechin

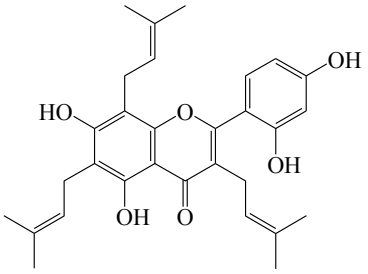


[**111**] Isogemichalcone B

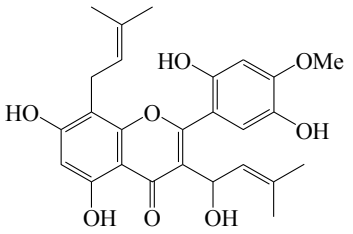


[**112**] Steppogenin

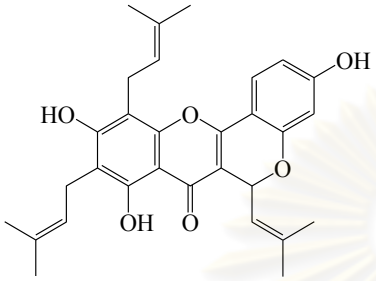
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



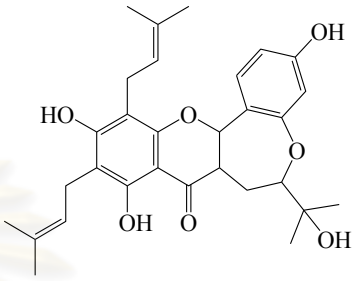
[**113**] Artelasticin



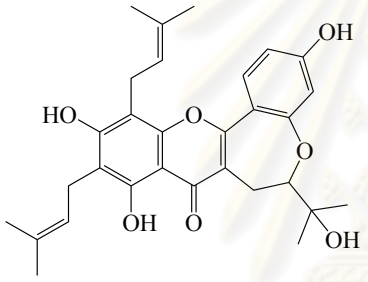
[**114**] Artelasticinol



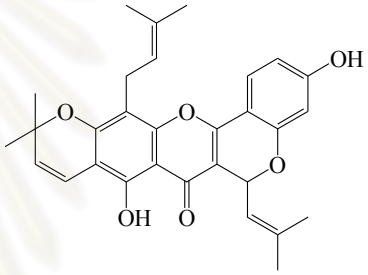
[**115**] Artelastin



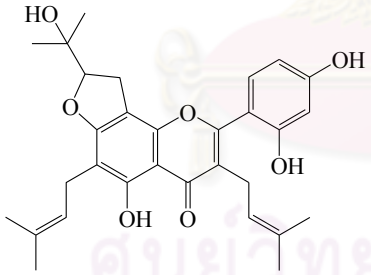
[**116**] Artelastinin



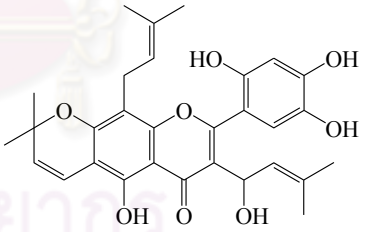
[**117**] Artelastocarpin



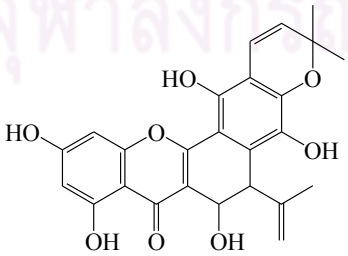
[**118**] Artelastochromene



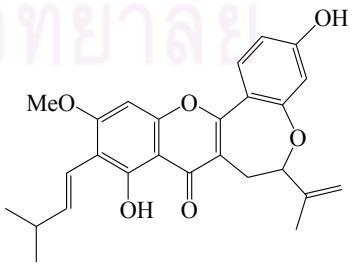
[**119**] Artelastofuran



[**120**] Artelastoheterol

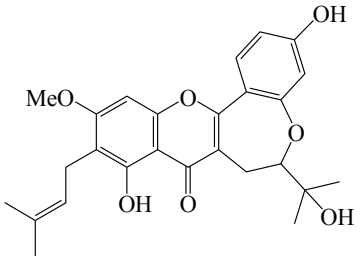


[**121**] Artelastoxanthone

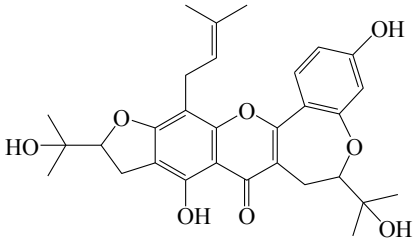


[**122**] Artoindonesianin E1

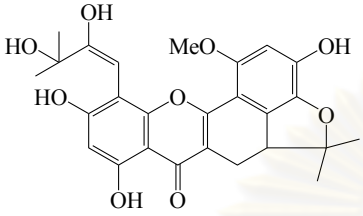
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



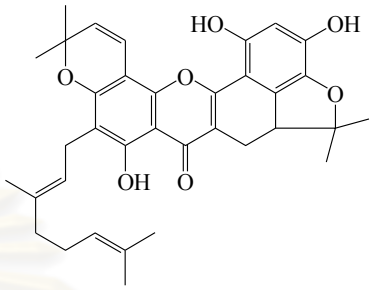
[**123**] Artonin S



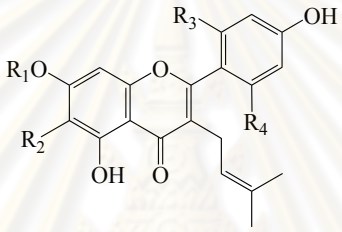
[**124**] Carpelastofuran



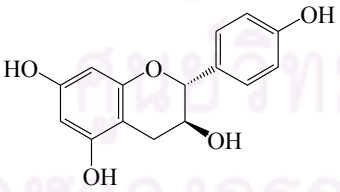
[**125**] Cycloartelastoxanthendiol



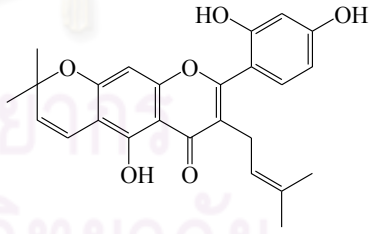
[**126**] Cycloartelastoxanthone



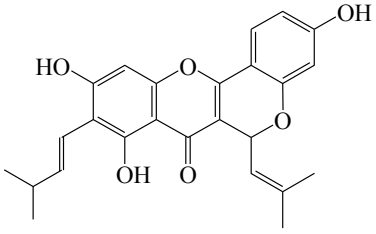
	R_1	R_2	R_3	R_4
[**127**] Integrin	Me	H	H	OH
[**128**] Norartocarpin	H		H	OH
[**130**] Mulberrin	H		OH	H
[**132**] Albanin A	H	H	H	OH



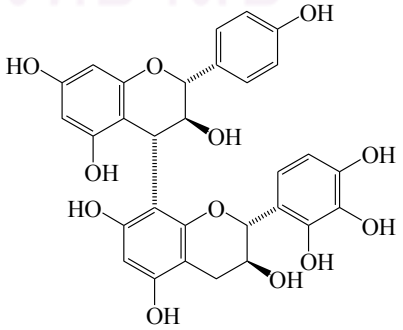
[**129**] Afzelechin



[**131**] Mulberrochromene

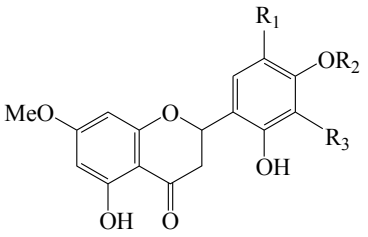


[**133**] Norcycloartocarpin

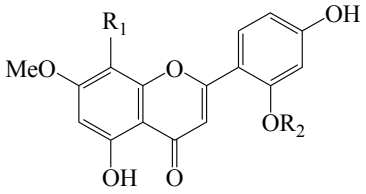


[**134**] Afzelechin-(4α→8)-catechin

Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



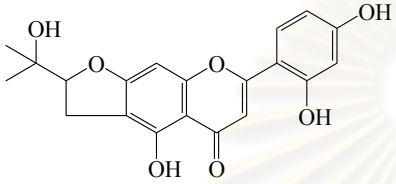
[**135**] Artocarpanone R_1=R_2=R_3=H
[**136**] Artocarpanone A R_1=R_3=H R_2=Me
[**141**] Artoflavanone R_1=R_3=OMe R_2=Me



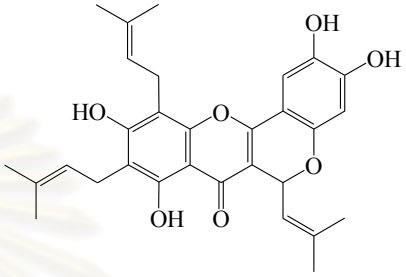
[**137**] Artocarpetin R_1=H R_2=H

[**138**] Artocarpetin A R_1= R_2=H

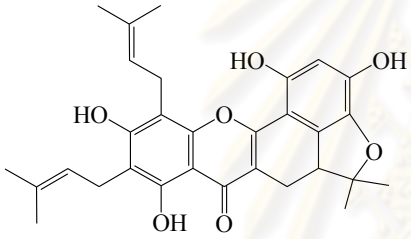
[**139**] Artocarpetin B R_1= R_2=Me



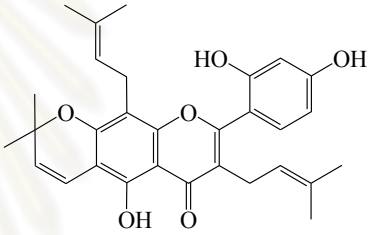
[**140**] Artocarpfuranol



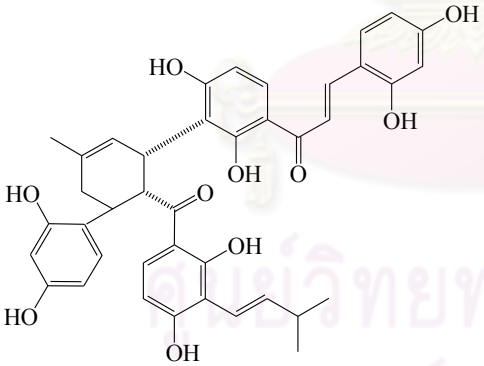
[**142**] Artoheterophyllin B



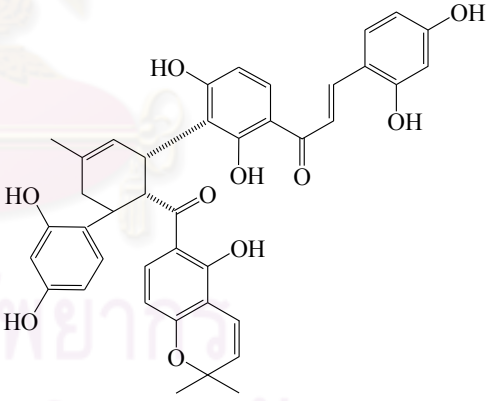
[**143**] Artoheterophyllin C



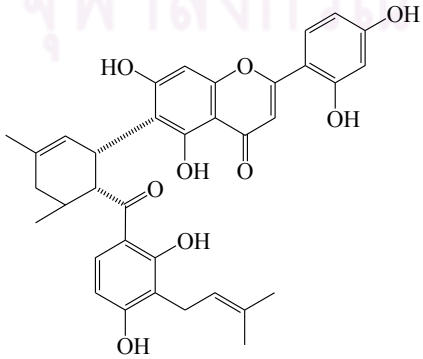
[**144**] Artoheterophyllin D



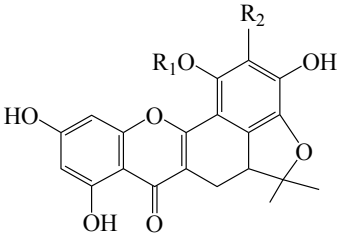
[**145**] Artonin C



[**146**] Artonin D



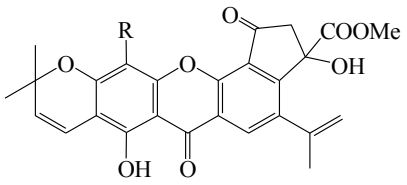
[**147**] Artonin I



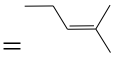
[**148**] Artonin J R_1=H R_2=

[**149**] Artonin L R_1=Me R_2=H

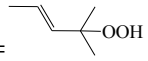
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)

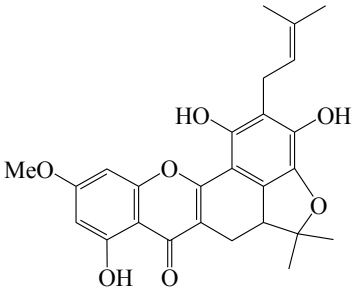


[**150**] Artonin Q R =

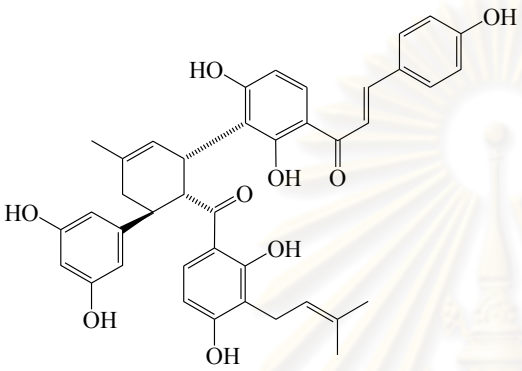


[**151**] Artonin R R=

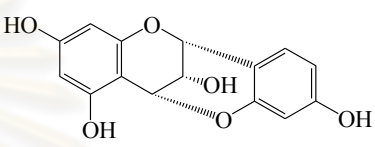




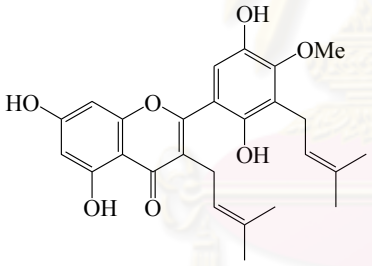
[**152**] Artonin T



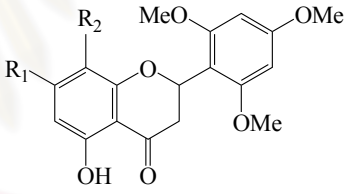
[**153**] Artonin X



[**154**] Cyanomaclurin



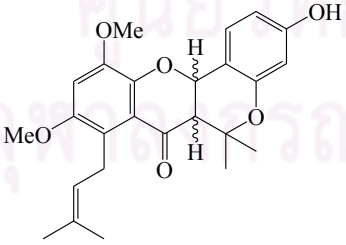
[**155**] Heteroartonin A



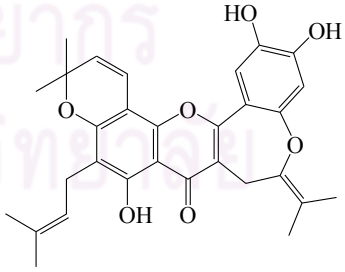
[**156**] Heteroflavanone A R_1=OH R_2=H

[**157**] Heteroflavanone B R_1=OMe

R_2=

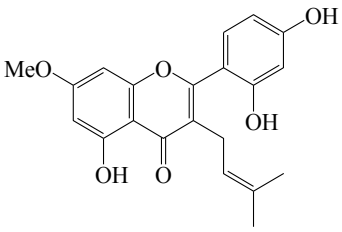


[**158**] Heterophyllol

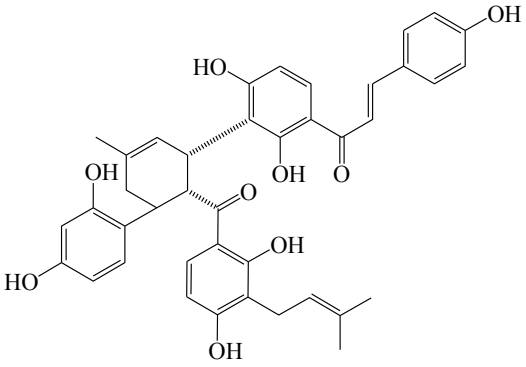


[**159**] Isocycloheterophyllin

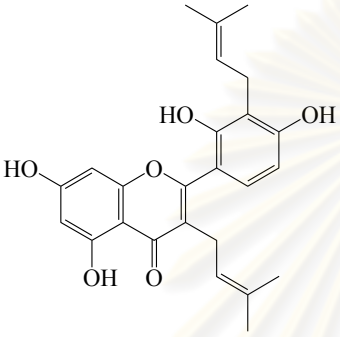
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



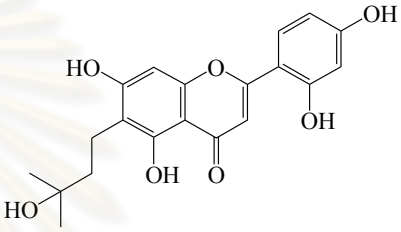
[**160**] Kuwanon C



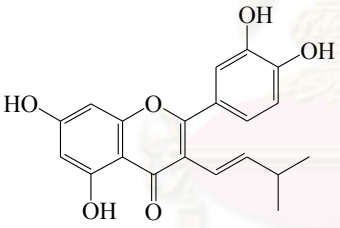
[**161**] Kuwanon R



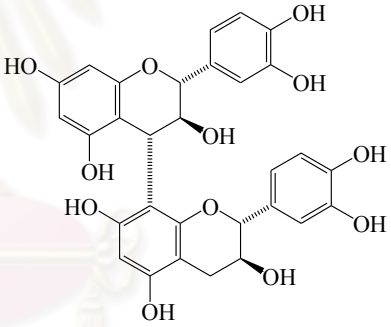
[**162**] Kuwanon T



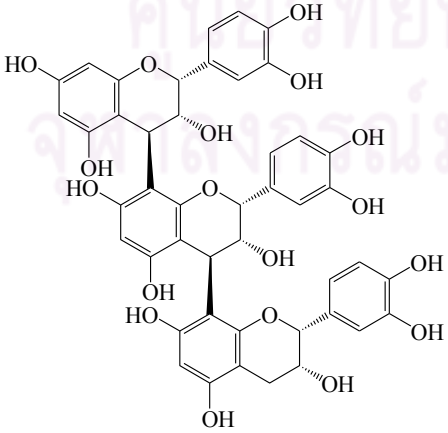
[**163**] Oxydihydroartocarpesin



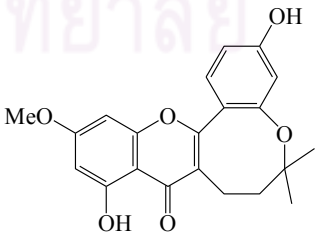
[**164**] 3-Prenyl luteolin



[**165**] Procyanidin B-3

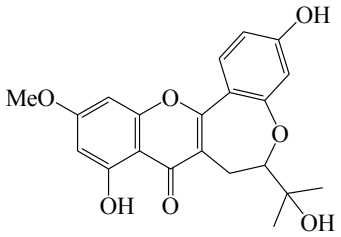


[**166**] Procyanidin C-1

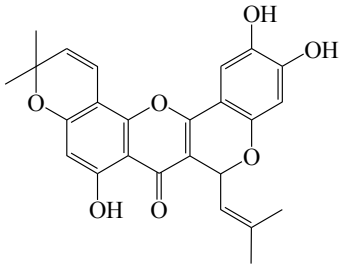


[**167**] Cyclointegrin

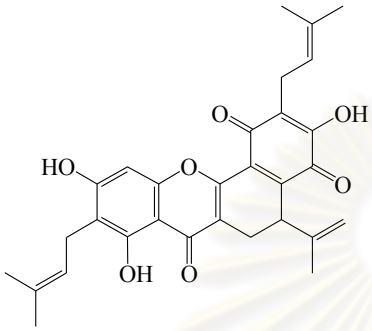
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



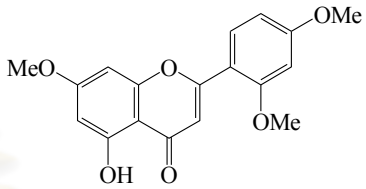
[**168**] Oxyisocyclointegrin



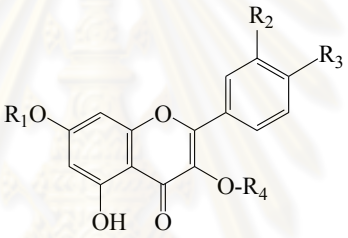
[**169**] Artoindonesianin D



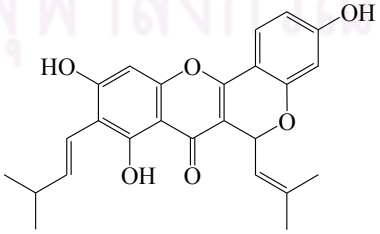
[**170**] Artonin O



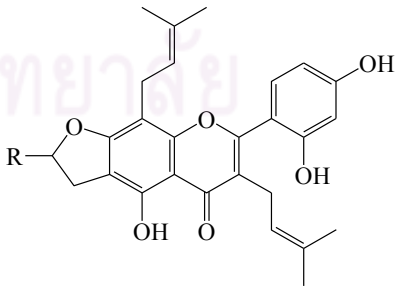
[**172**] 5-Hydroxy-7,2′,4′-trimethoxyflavone



	R_1	R_2	R_3	R_4
[**171**] 5,7-Dihydroxyflavone-3-*O*-*α*-L-rhamnoside	H	H	H	rhamnose
[**173**] Galangin-3-*O*-*α*-L-(-)-rhamnoside	Me	H	H	rhamnose
[**174**] Galangin-3-*O*-*β*-D-galactopyranosyl-(1→4)-*α*-L-rhamnoside	Me	H	H	galactose-rhamnose
[**175**] Kaempferol-3-*O*- *β*-D-xyloside	H	H	OH	xylose
[**177**] Quercetin-3-*O*-*α*-L-rhamnoside	H	OH	OH	rhamnose



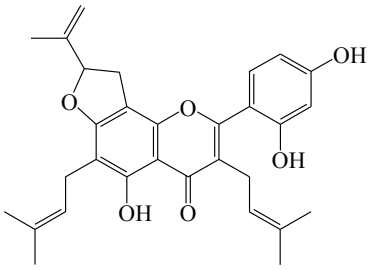
[**176**] Norcycloartocarpin



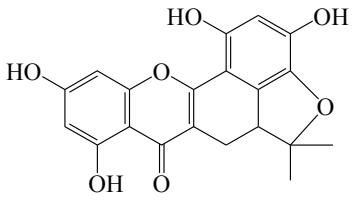
[**178**] Artoindonesianin G R=

[**180**] Artoindonesianin I R=

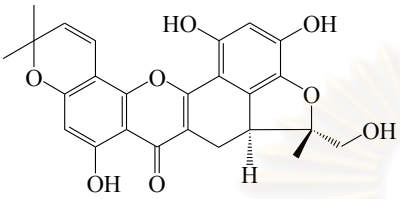
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



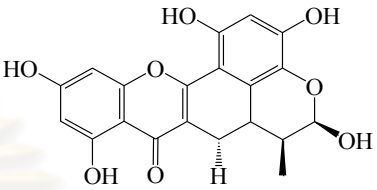
[**179**] Artoindonesianin H



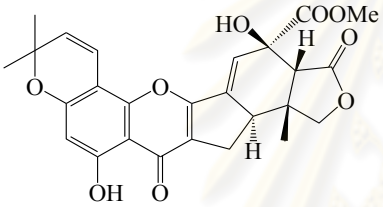
[**181**] Artoindonesianin P



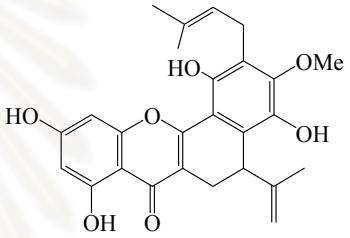
[**182**] Artoindonesianin Z-1



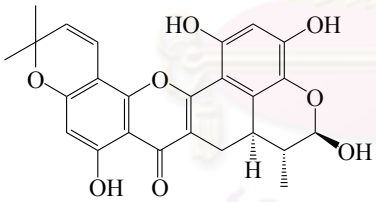
[**183**] Artoindonesianin Z-2



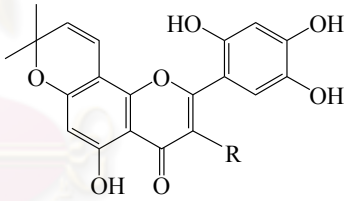
[**184**] Artoindonesianin Z-3



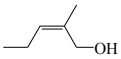
[**185**] Artoindonesianin Z-4



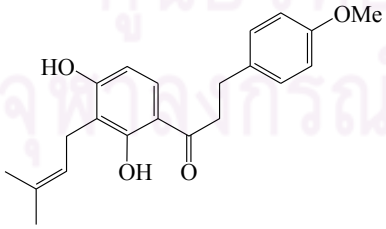
[**186**] Artoindonesianin Z-5



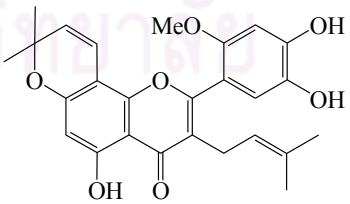
[**187**] 14-Hydroxyartonin E R=



[**189**] Artobilochromen R=

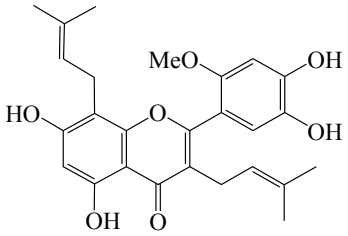


[**188**] 2′,4′-dihydroxy-4-methoxy-3′-prenyl dihydrochalcone

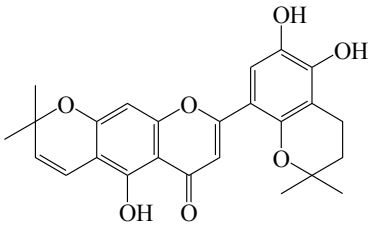


[**190**] Artonin E2′-methylether

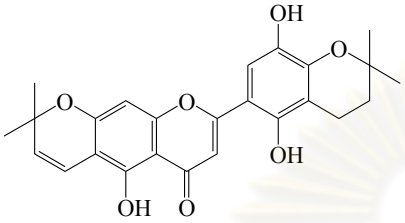
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



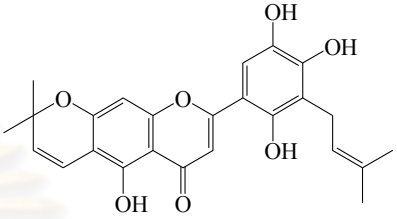
[**191**] Artonin V2′-methylether



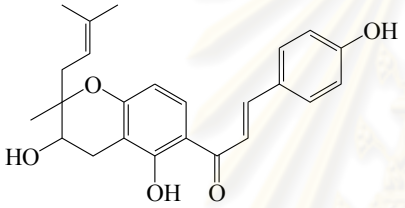
[**192**] Chromanoartobilochromen A



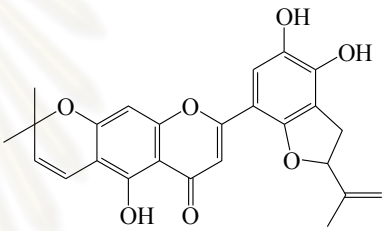
[**193**] Chromanoartobilochromen B



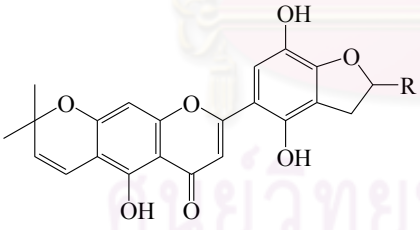
[**194**] Chromanoartobilochromene



[**195**]1-(3,4-Dihydro-3,5-dihydroxy-2-methyl-2-(3-methyl-2-butenyl)-2H-1-benzopyran-6-yl-3-(4-hydroxy phenyl)-2(*E*)-propen-1-one



[**196**] (-)-Dihydrofuranoartobilochromen A

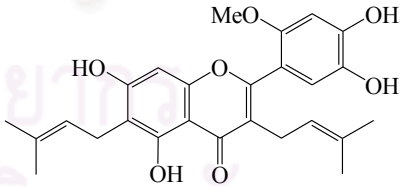


[**197**] (-)-Dihydrofuranoartobilochromen B-1

R=

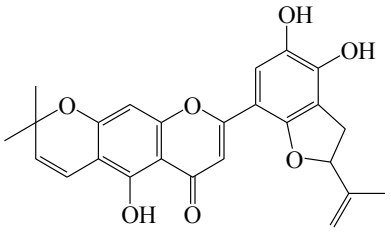
[**198**](-)-Dihydrofuranoartobilochromen B-2

R=

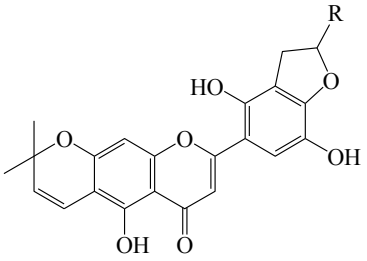


[**199**] Dihydroisoartonin E2′-methylether

Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)

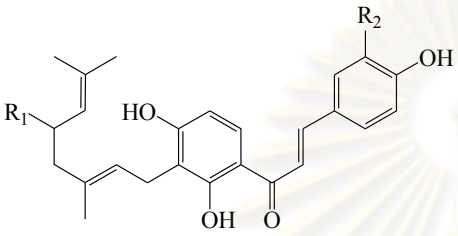


[**200**] Furanoartobilochromen A



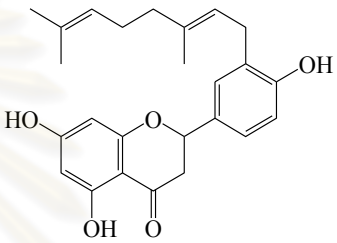
[**201**] Furanoartobilochromen B-1 R=

[**202**] Furanoartobilochromen B-2 R=

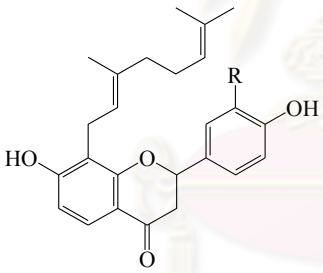


[**203**] 3′-Geranyl-2′,3,4,4′-tetrahydroxy chalcone R_1=H R_2=OH

[**210**] 2,4,4'-Trihydroxy-3-[(2*E*)-5-methoxy-3,7-dimethylocta-2,6-dienyl]chalcone R_1=OMe R_2=H

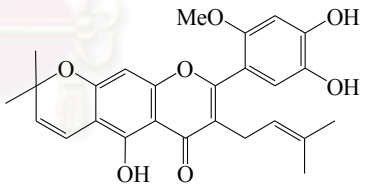


[**204**] 3′-Geranyl-4′,5,7-trihydroxyflavanone

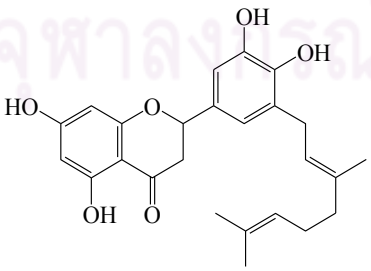


[**205**] 8-Geranyl-3′,4′,7-trihydroxy flavanone R=OH

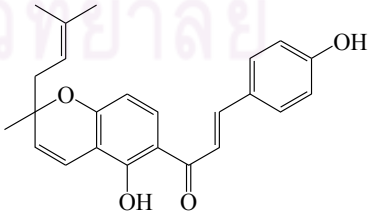
[**206**] 8-Geranyl-4′,7-dihydroxyflavanone R=H



[**207**] Isoartonin E2′-methylether

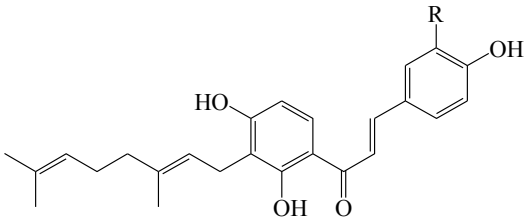


[**208**] Isonymphaeol-B



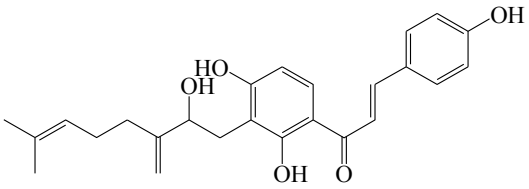
[**209**] Lespeol

Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)

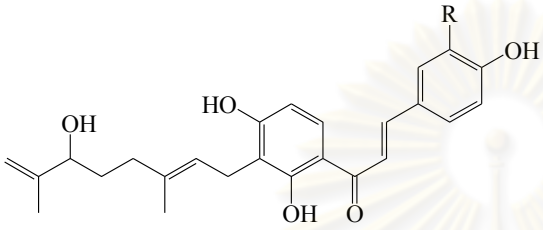


[**211**] 2′,4′,4-Trihydroxy-3′-geranylchalcone R= H

[**214**] 2′,3,4,4′-Tetrahydroxy-3′-geranyl chalcone R= OH

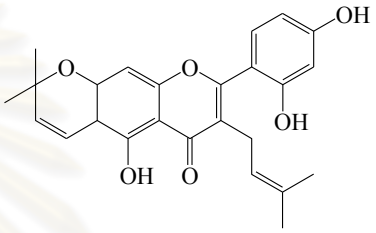


[**212**] 2′,4′,4-Trihydroxy-3′-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadiethyl]chalcone

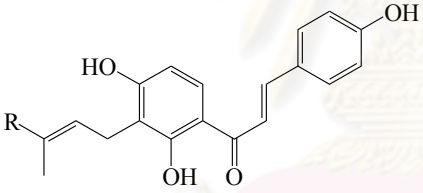


[**213**] 2′,4′,4-Trihydroxy-3′-[2-hydroxy-7-methyl-3-methylene-6-octaethyl] chalcone R=H

[**215**] 2′,3,4,4′-Tetrahydroxy-3′-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadiethyl] chalcone R= OH

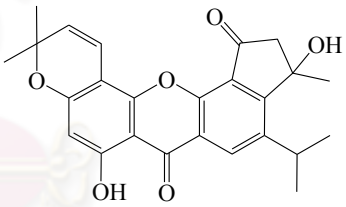


[**216**] Oxydihydromorusin

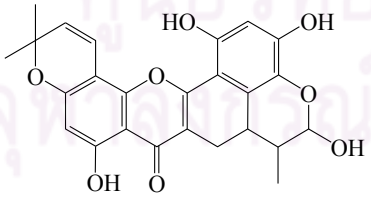


[**217**] Xanthoangelol R=

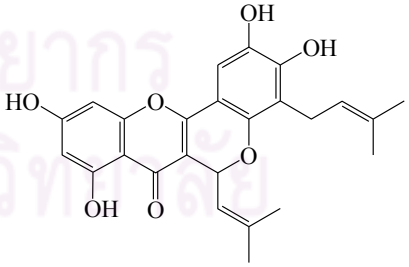
[**218**] Xanthoangelol B R=



[**219**] Dihydroartoindonesianin C

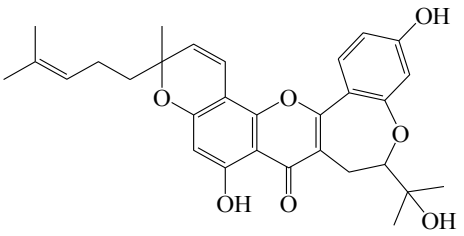


[**220**] Pyranocycloartobiloxanthone A

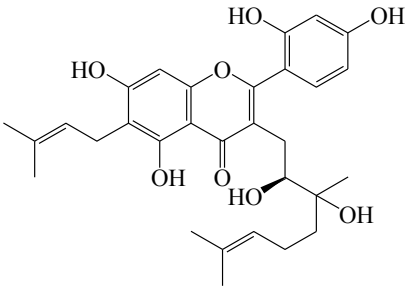


[**221**] Artosimmin

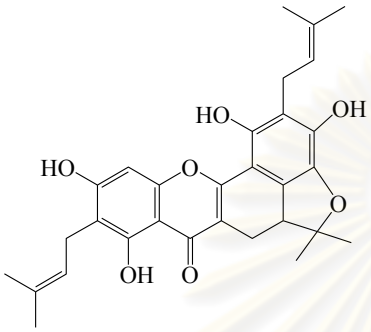
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



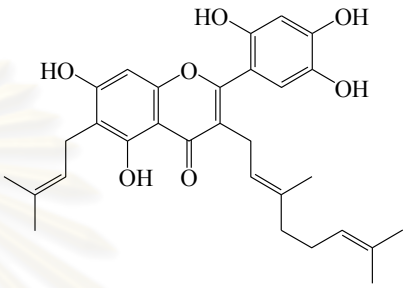
[**222**] Artocarpol B



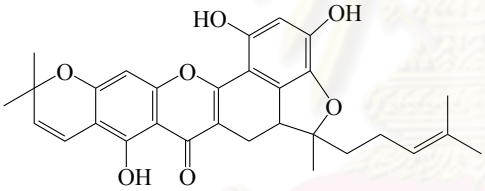
[**223**] Artocarpol H



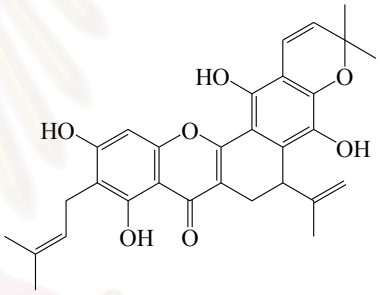
[**224**] Artonin G



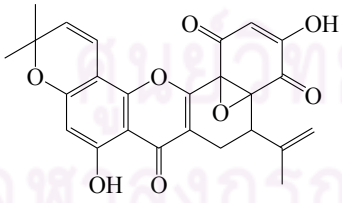
[**225**] Artonin H



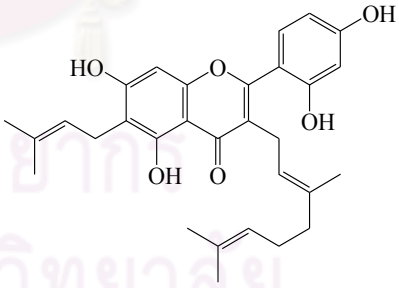
[**226**] Artonin M



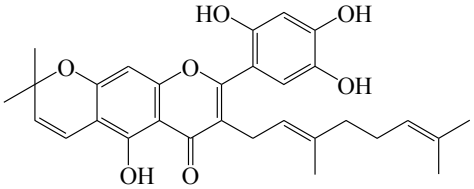
[**227**] Artonin N



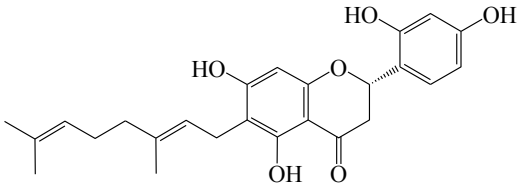
[**228**] Artonin P



[**229**] Rubraflavone C

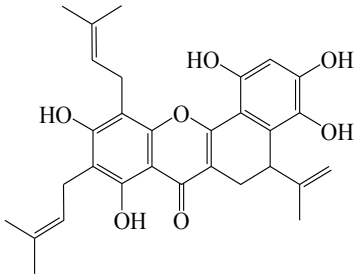


[**230**] Artoindonesianin L

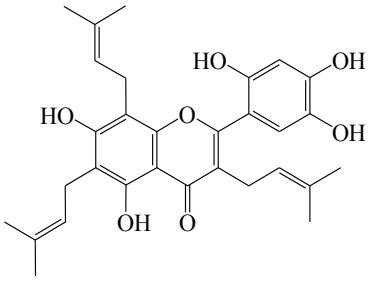


[**231**] Sepicanin A

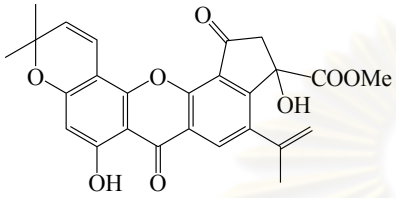
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



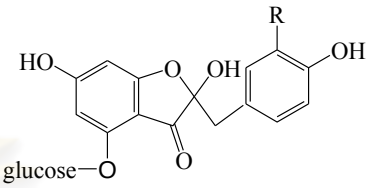
[**232**] Styracifolin A



[**233**] Styracifolin B

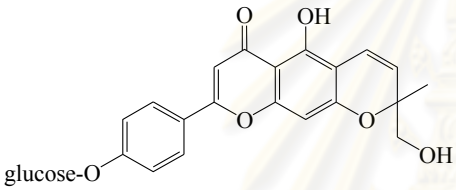


[**234**] Artoindonesianin C

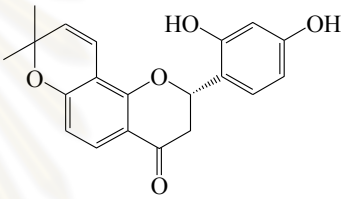


[**235**] Alphitonin-4-*O*-glucoside R=H

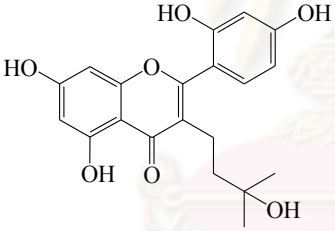
[**239**] Maesopsin-4-*O*-glucoside R=OH



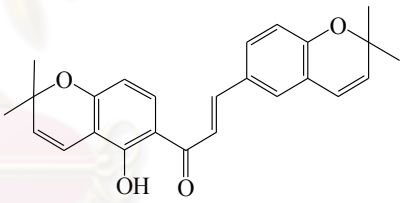
[**236**] Artokin-4′-*O*-glucoside



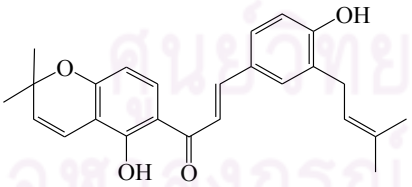
[**237**] Artotonin A



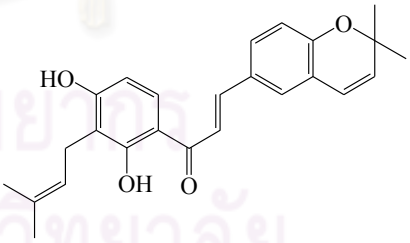
[**238**] Artotonin B



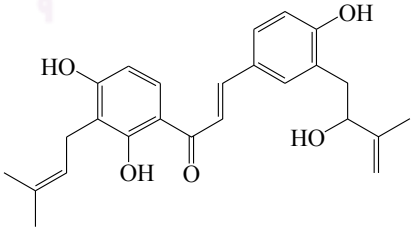
[**240**] Paratocarpin A



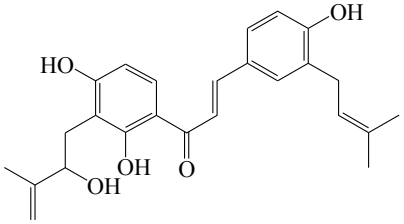
[**241**] Paratocarpin B



[**242**] Paratocarpin C

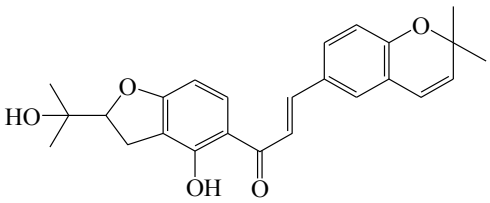


[**243**] Paratocarpin D

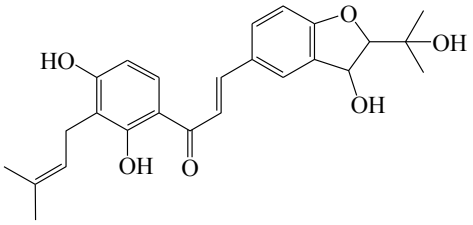


[**244**] Paratocarpin E

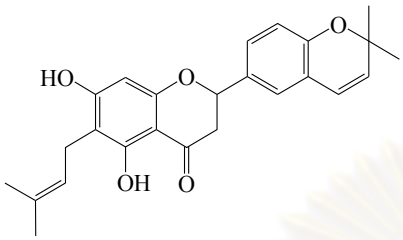
Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)



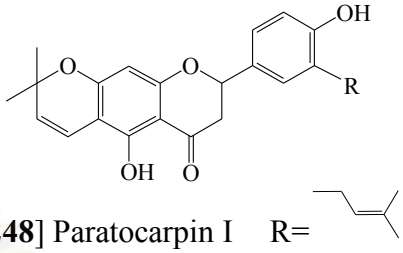
[**245**] Paratocarpin F



[**246**] Paratocarpin G

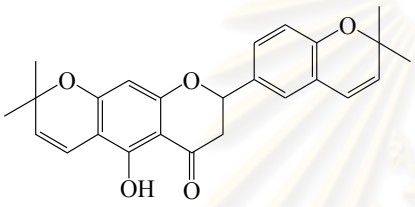


[**247**] Paratocarpin H

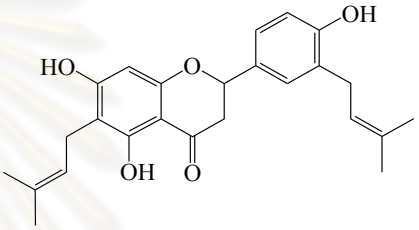


[**248**] Paratocarpin I R=

[**250**] Paratocarpin K R=H

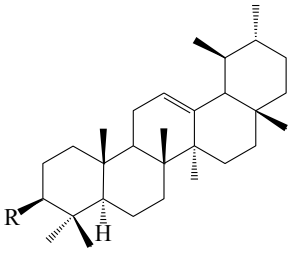


[**249**] Paratocarpin J

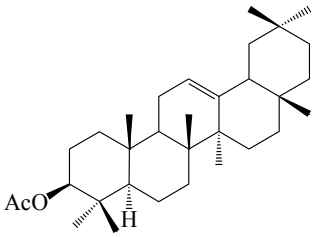


[**251**] Paratocarpin L

Figure 2 Structures of flavonoids previously isolated from *Artocarpus* spp. (continued)

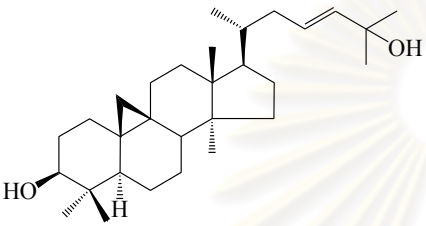


[**252**] α-Amyrin R=OH

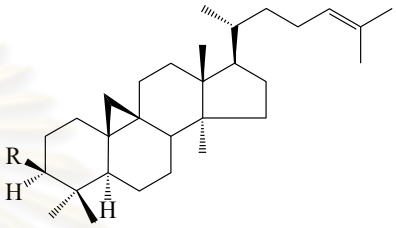


[**254**] β-Amyrin acetate

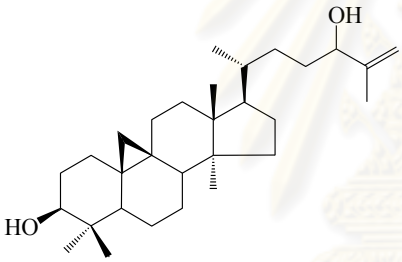
[**253**] α-Amyrin acetate R=OAc



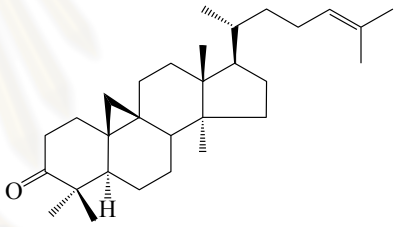
[**255**] Cycloart-23-ene-3β,25-diol
(9,19-Cyclolanost-3-one-24,25-diol)



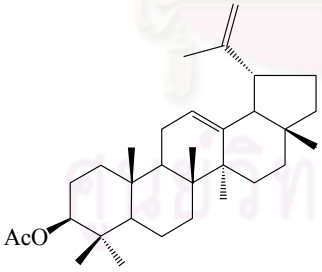
[**256**] Cycloartenol
(Cycloart-24-ene-3β-ol) R=OH
[**259**] Cycloartenyl acetate R=OAc



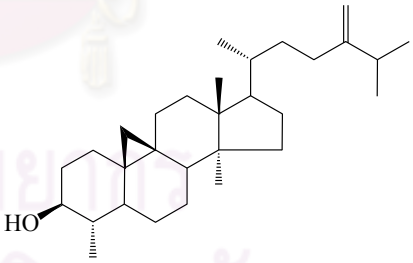
[**257**] Cycloart-25-ene-3β,24-diol
(9,19-Cyclolanost-23-ene-3β,25-diol)



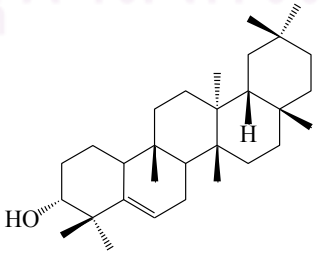
[**258**] Cycloartenone



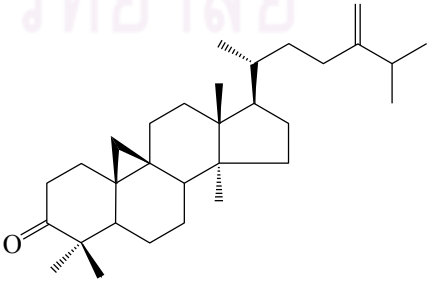
[**260**] Lupeol acetate



[**261**] Cycloeucalenol

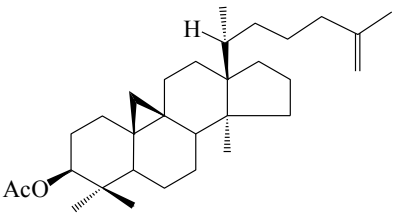


[**262**] Glutinol

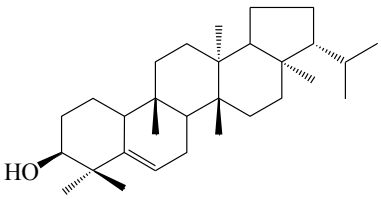


[**263**] 24-Methylenecycloartenone

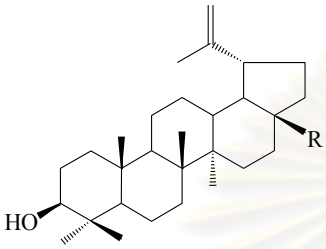
Figure 3 Structures of triterpenoids previously isolated from *Artocarpus* spp.



[**264**] Isocycloartenol acetate



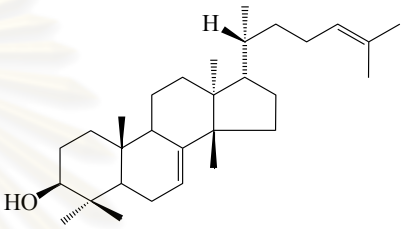
[**265**] Simiarenol



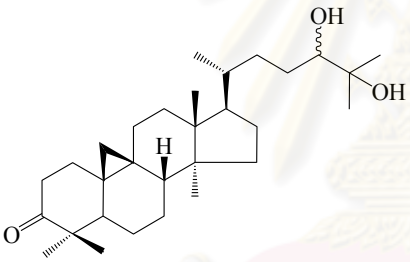
[**266**] Betulin R=CH_2OH

[**267**] Betulinic acid R=COOH

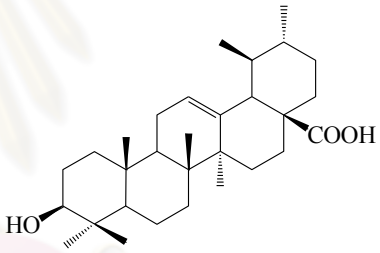
[**271**] Lupeol R=CH_3



[**268**] Butyrospermol

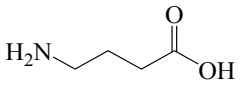


[**269**] (9,19-Cyclolanost-3-one-24,25-diol)

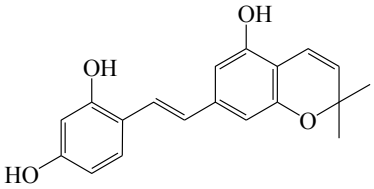


[**270**] Ursolic acid

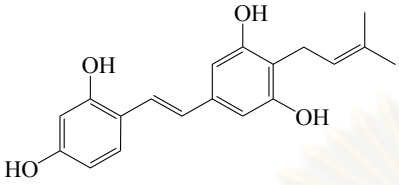
Figure 3 Structures of triterpenoids previously isolated from *Artocarpus* spp. (continued)



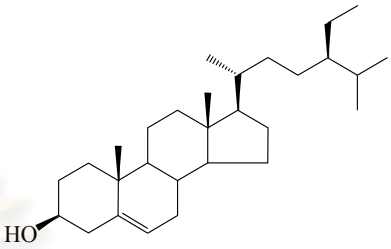
[**272**] γ-Aminobutyric acid



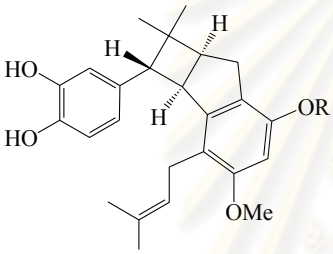
[**273**] Artocarbene



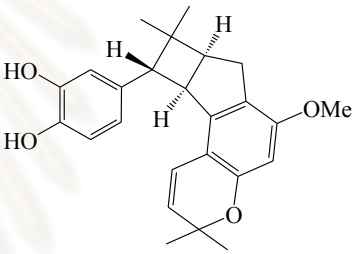
[**274**] 4-Prenyloxyresveratrol (*trans*-4-Isopentenyl-3,5,2′,4′tetrahydroxystilbene)



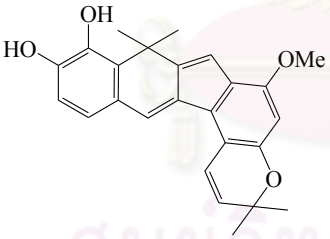
[**275**] *β*-Sitosterol



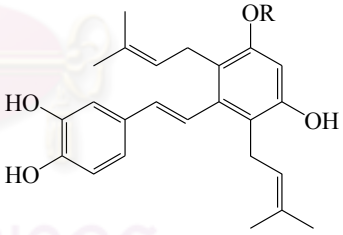
[**276**] Artochamin H R=H
[**277**] Artochamin I R=Me



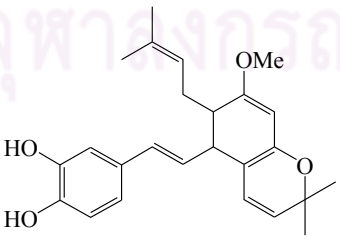
[**278**] Artochamin J



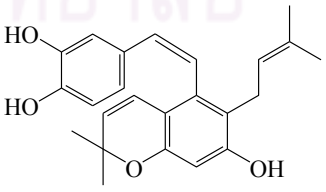
[**279**] Artochamin K



[**280**] Artochamin F R=H
[**281**] Artochamin G R=Me

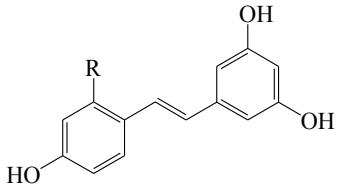


[**282**] Artostilbene A

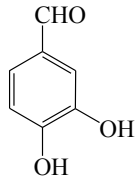


[**283**] Artostilbene B

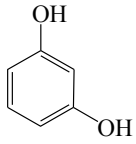
Figure 4 Structures of miscellaneous compounds previously isolated from *Artocarpus* spp.



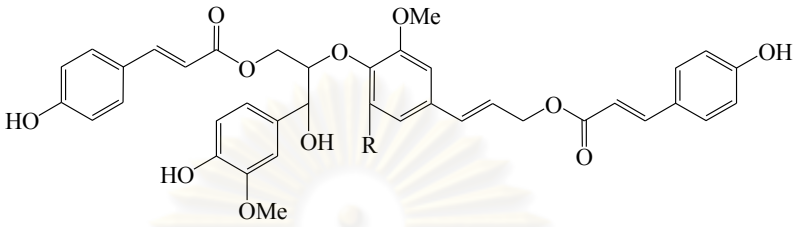
[**284**] Oxyresveratrol R=OH
[**287**] Resveratrol R=H



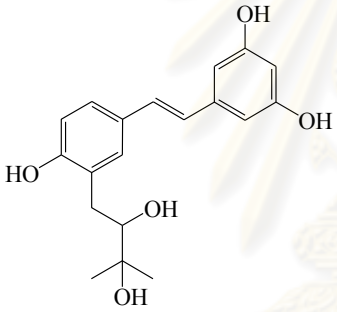
[**285**] Resorcinol



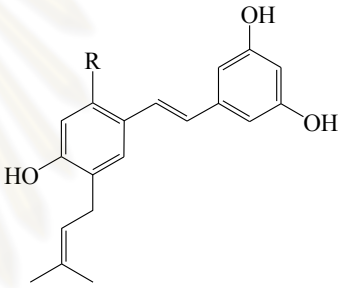
[**286**] *β*-Resorcylaldehyde



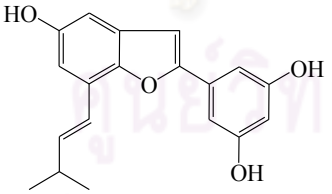
[**288**] Dadahol A R=OMe
[**289**] Dadahol B R=H



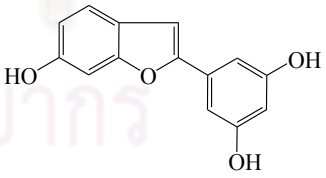
[**290**] 3-(2,3-Dihydroxy-3-methylbutyl)-resveratrol



[**291**] 3-(*γ*,*γ*-Dimethylallyl) oxyresveratrol R=OH
[**292**] 3-(*γ*,*γ*-Dimethylallyl) resveratrol R=H

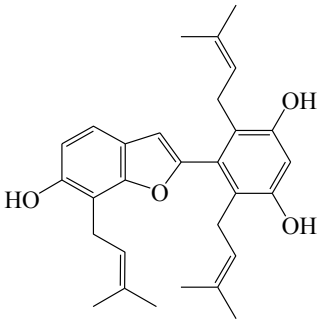


[**293**] 3-(*γ*,*γ*-Dimethylpropenyl) Moracin M

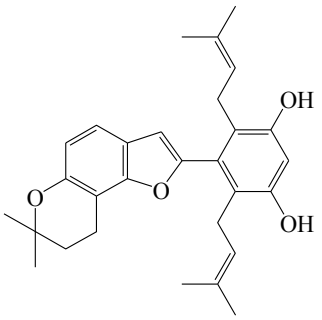


[**294**] Moracin M

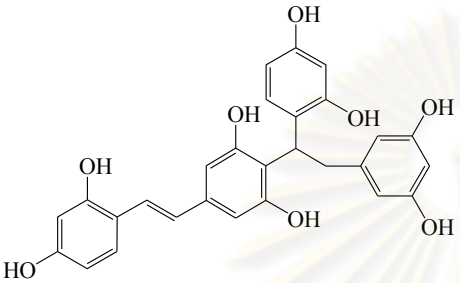
Figure 4 Structures of miscellaneous compounds previously isolated from *Artocarpus* spp. (continued)



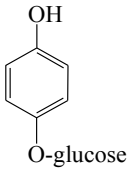
[**295**] Artoindonesianin X



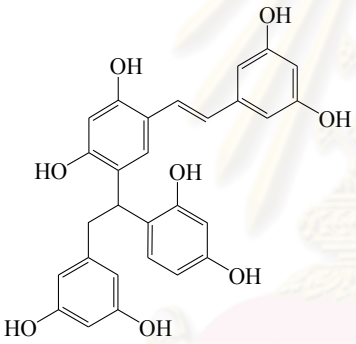
[**296**] Artoindonesianin Y



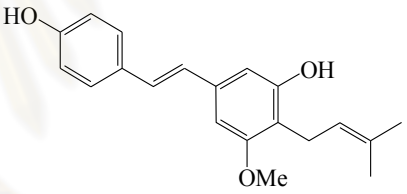
[**297**] Andalasin



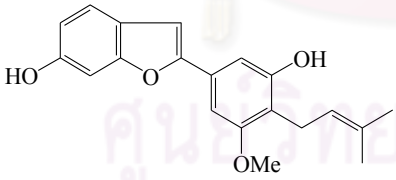
[**298**] Arbutin



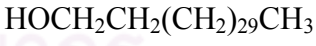
[**299**] Artogomezianol



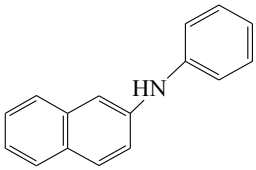
[**300**] Artoindonesianin N



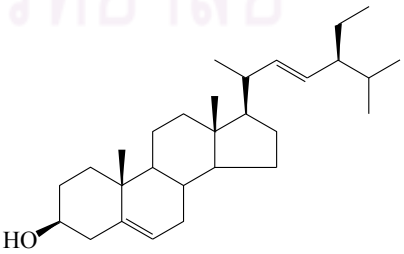
[**301**] Artoindonesianin O



[**302**] 1-Dotriacontanol

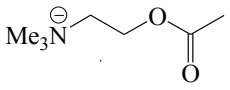


[**303**] Phenyl- β-naphthylamine

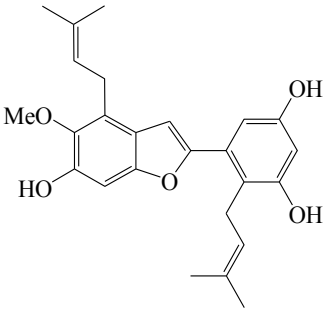


[**304**] Stigmasterol

Figure 4 Structures of miscellaneous compounds previously isolated from *Artocarpus* spp. (continued)



[**305**] Acetylcholine



[**309**] Artoheterophyllin A

$CH_3(CH_2)_{20}COO(CH_2)_8CH(OH)(CH_2)_3CH_3$

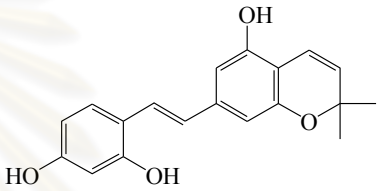
[**311**] 9-Hydroxytridecyl docosanoate

$CH_3(CH_2)_{20}COO(CH_2)_3CH(OH)(CH_2)_6CH_3$

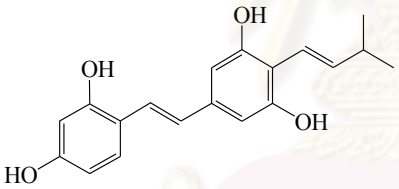
[**312**] 4-Hydroxyundecyl docosanoate

$CH_3(CH_2)_5CH(OH)CH_2CH{=}CH(CH_2)_7COOH$

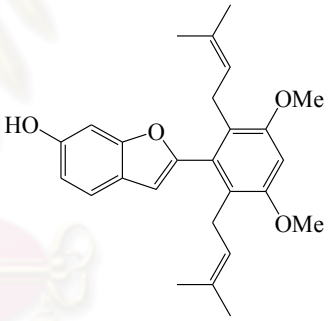
[**315**] Ricinoleic acid



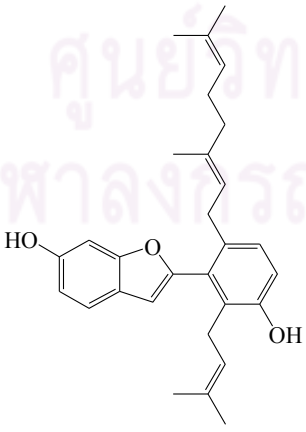
[**317**]4-Methoxy-2,2-dimethyl-6-(2-(2,4-dihydroxy) phenyl-*trans*-ethenyl) chromene



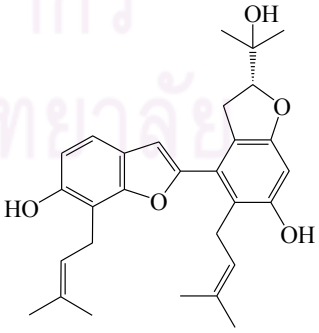
[**318**] *trans*-4-(3-Methyl-*E*-but-1-enyl)-3,5,2′,4′-tetrahydroxystilbene (Artoindonesianin F)



[**323**] Lakoochin A

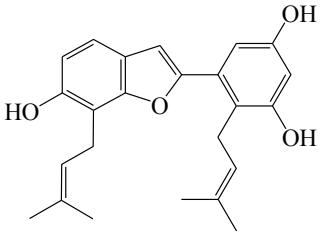


[**324**] Lakoochin B

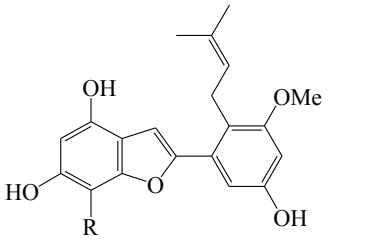


[**328**] Artonitidin A

Figure 4 Structures of miscellaneous compounds previously isolated from *Artocarpus* spp. (continued)

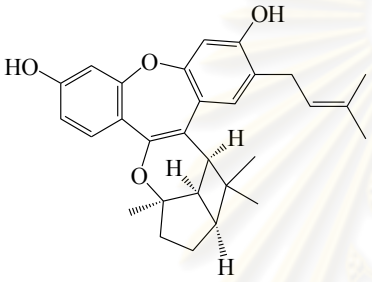


[**329**] Artonitidin B

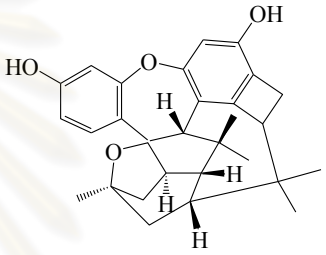


[**330**] Artopetelin L R=

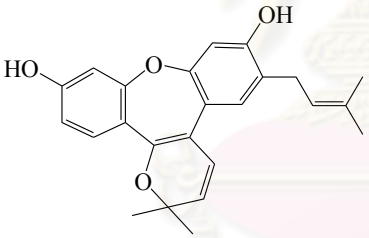
[**331**] Artopetelin M R=



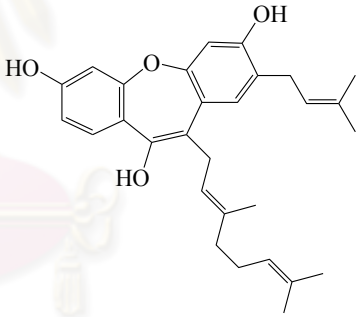
[**332**] Artocarpol A



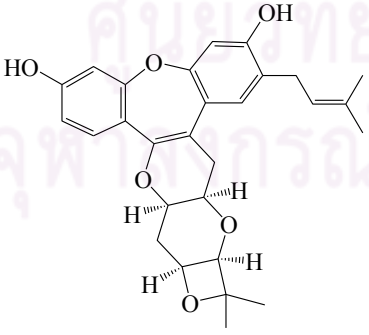
[**333**] Artocarpol C



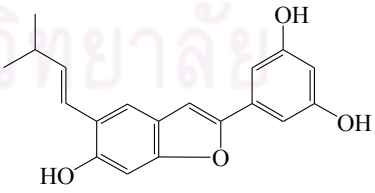
[**334**] Artocarpol D



[**335**] Artocarpol E



[**336**] Artocarpol F



[**337**] Artotonkin

Figure 4 Structures of miscellaneous compounds previously isolated from *Artocarpus* spp. (continued)

2. Traditional uses and biological activities of *Artocarpus* spp.

2.1 Traditional uses of *Artocarpus* spp.

Many members of the genus *Artocarpus* have been used as traditional folk medicine in South-East Asia for the treatment of inflammation, malarial fever, ulcer, abscess and diarrhea. *A. heterophyllus* is used in the treatment of various symptoms. For example, the pulp and seeds are used as a cooling tonic and pectoral, the roots are used to treat diarrhea and skin disease, whereas its leaves are used to promote lactation in women. Its latex is mixed with vinegar as a treatment for abscess, and the wood which is used by monks to dye their robes, has sedative effect in convulsions. (Jagtap and Bapat, 2010). The leaves of *A. altilis* have been used for the treatment of liver cirrhosis, hypertention and diabetes (Wang *et al*., 2006). In Indonesia, the seeds of *A. champeden* have been used against diarrhea while its roots are used against malaria fever. In western Java, *A. elasticus* has been used to treat inflammation. The bark of this plant is used as a contraceptive, while the young leaves are used to treat tuberculosis (Jagtap and Bapat, 2010). The sap from *A. lowii* is traditionally used as an ointment and as cooking oil (Jamil *et al*., 2008).

The edible fruit pulp of *A. lakoocha* is believed to act as a tonic for the liver, while its tannin-containing tree bark is used to treat skin ailments. The brown powder from aqueous extraction of its wood, called Puag-Haad in Thai, has been used as a traditional anthelmintic drug to treat tapeworm infection. In addition, *A. lakoocha* roots yield a color dye (Charoenlarp *et al*., 1981; Jagtap and Bapat, 2010).

2.2 Biological activities of *Artocarpus* spp.

Compounds from *Artocarpus* plants showed various activities such as antimicrobial, cytotoxic, anti-platelet aggregration and antioxidant.

Artocarpin [**4**] and artocarpesin [**3**], isolated from *A. heterophyllus*, inhibited the growth of cariogenic bacteria such as *Streptococci mutans*, *Actinomyces viscosus*, *Lactobacillus casei* (Sato *et al*., 1996). Artonin E [**12**], isolated from the bark of *A. rigida*, showed antimicrobial activity against the gram-negative bacteria *Escherichia coli* and *Bacillus subtilis* (Suhartati and Yandri, 2008). Lakoochins A [**323**] and B [**324**], from the root of *A. lakoocha*, displayed anti-tuberculosis activity by inhibiting the growth of *Mycobacterium tuberculosis* (Puntumchai *et al*., 2004). Oxyresveratrol [**284**] from *A. lakoocha* possessed moderate activity against herpes simplex virus (HSV) type I and

type II and against a wild-type human immunodeficiency virus type I (HIV-1/LAI) (Likhitwitayawuid *et al*., 2005). Morusin [**63**], cycloartobiloxanthone [**38**] and artonin E [**12**] from the root bark of *A. altilis* exhibited moderate antiplasmodial activity against *Plasmodium falciparum* (Boonphong *et al*., 2007). Cycloartocarpin [**39**], isocyclomorusin [**33**] and norartocarpetin [**65**], isolated compounds from *A. gomezianus*, were moderately active against both types of HSV (Likhitwitayawuid *et al*., 2006).

Prenylated flavones such as artoindonesianins U [**90**] and V [**91**] (Syah *et al*., 2004), artoindonesianins A-2 [**81**] A-3 [**82**] and T [**89**], heterophyllin [**98**] and cudraflavone C [**34**] from the heartwood of *A. champeden* (Syah *et al*., 2006b) or cycloartobiloxanthone [**38**] and artonin E [**12**] from *A. rigida* (Suhartati and Yandri, 2008) showed strong cytotoxicity against the murine leukemia P-388 cell line. In another report , artosimmin [**221**], isolated from *A. odoratissimus*, exhibited significant cytotoxicity against HL-60 and MCF-7 cancer cell lines (Ee *et al*., 2010).

Dihydroartomunoxanthone [**48**], artochamin B [**13**] and artocommunol CC [**16**], isolated from the roots of *A. communis*, significanty inhibited secondary platelet aggregation induced by adrenaline, resulting in the inhibitory effect on thromboxane formation (Weng *et al*., 2006).

The anti-inflammatory activity of artocarpesin [**3**], norartocarpetin [**65**] and oxyresveratrol [**284**] from *A. heterophyllus* have been demonstrated against production of proinflamatory mediators in lipopolysaccharide (LPS)-activated RAW 264.7 murine macrophage cells (Fang, Hsu, and Yen, 2008a).

Artocarpin [**4**] isolated from a diethyl ether extract of heartwood of *A. incisus*. possessed potent 5α- reductase inhibitory effect resulting in the inhibiton of the conversion of testosterone into 5α-dihydrotestosterone. The 5α-reductase inhibitors acts on androgen receptors which are found in both preputial skin and nongenital skin. Therefore artocarpin might be useful in selective treatment of androgen-dependent disorders such as male pattern alopecia and achne (Shimizu *et al*., 2000).

Norartocarpin [**128**], cudraflavone C [**34**], artotonkin [**337**], albanin A [**132**] and artopetelin M [**331**], isolated from *A. nitidus*, showed inhibitory effect on pancreatic lipase with IC_{50} values ranging from 1.8 ± 0.1 to 63.8 ± 3.6 μM (Zhao *et al*., 2009).

Several phenolic compounds found in plants of this genus was shown to be inhibitors of tyrosinase activity. For example, norartocarpetin [**65**] and resveratrol [**287**] from *A. gomezianus* exhibited potent tyrosinase inhibitory activity (Likhitwitayawuid *et al*., 2000). Artocarpanone [**135**] inhibited both mushroom tyrosinase enzyme activity and

melanin production in B16 melanoma cells (Arung *et al*., 2006a). Artocarpin [**4**], cudraflavone C [**34**], 6-prenylapigenin [**77**], kuwanon C [**160**], norartocarpin [**128**] and albanin A [**132**] inhibited melanin biosynthesis in B16 melanoma cells without inhibiting the tyrosinase enzyme (Arung *et al*., 2006b). The heartwood extract of *A. lakoocha* showed both tyrosinase-inhibitory activity *in vitro* and melanin-reducing efficacy *in vivo* (Tengamnuay *et al*., 2006).

The prenylated flavones, cycloheterophyllin [**96**] and artonins A [**92**] and B [**93**], inhibited lipid peroxidation and were antioxidant against DPPH, peroxyl and hydroxyl radicals and H_2O_2 (Ko *et al*., 1998). Artelastin [**115**], another prenylated flavone isolated from *A. elasticus,* showed strong $O_2^{\bullet-}$ scavenging activity (Cerqueira *et al*., 2008). In another study, cyclogeracommunin [**45**], artoflavone A [**19**], artomunoisoxanthone [**21**], artocommunol CC [**16**], artochamin D [**14**], artochamin B [**13**], dihydroartomunoxanthone [**48**], isolated from the root cortex of *A. communis* and cycloartelastoxanthone [**126**], artelastoheterol [**120**], cycloartobiloxanthone [**38**] and artonol A [**28**] isolated from *A. elasticus*, all showed inhibition of oxidative DNA damage. Compounds [**19**], [**126**], [**120**] and [**38**] showed significant DPPH-scavenging activity, while compounds [**45**] and [**28**] significantly inhibited xanthine oxidase (XO) activity (Lin *et al*., 2009). A xanthone, pyranocycloartobiloxanthone A [**220**], isolated from the stem bark of *A. obtusus*, showed strong DPPH-scavenging activity (Hashim *et al*., 2010).

CHAPTER III

EXPERIMENTAL

1. Source of Plant Materials

The root bark of *A. lakoocha* Roxb. was collected from the botanical garden of the Faculty of Pharmaceutical Sciences, Chulalongkorn University, Bangkok, Thailand, in June 2009. Authentication was performed by comparison with herbarium specimens at the Royal Forest Department, Ministry of Agriculture and Co-operatives. A voucher specimen (BS-062552) has been deposit at the Department of Pharmacognosy and Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University.

2. General Techniques

2.1 Analytical Thin-Layer Chromatography (TLC)

Technique	:	One dimension, ascending
Absorbent	:	Silica gel 60 F_{254} (Merck) precoated plate
Layer thickness	:	0.2 mm
Distance	:	6 cm
Temperature	:	Laboratory temperature (30-35ºC)
Detection	:	1. Ultraviolet light at wavelengths of 254 and 365 nm. 2. Sprayed with anisaldehyde in 10% sulfuric acid and heating at 105°C for 10 min.

2.2 Column Chromatography

2.2.1 Vacuum Liquid Column Chromatography

Adsorbent	:	Silica gel 60 (No.7734) particle size 0.063-0.200 mm (70-230 mesh ASTM) (Merck)
Packing method	:	Dry packing
Sample loading	:	The sample was dissolved in a small amount of organic solvent, mixed with a small quantity of the adsorbent, triturated, dried and then placed gently on top of the column.
Detection	:	Fractions were examined by TLC under UV light at the wavelengths of 254 and 365 nm.

2.2.2 Flash Column Chromatography

Adsorbent	:	Silica gel 60 (No.9385) particle size 0.040-0.063 mm (230-400 mesh ASTM) (Merck)
	:	Silica gel 60 RP-18 (No.0167) particle size 40-63 μm (Merck)
Packing method	:	Wet packing
Sample loading	:	The sample was dissolved in a small amount of the eluent and then applied gently on top of the column.
Detection	:	Fractions were examined in the same way as described in section 2.2.1

2.2.3 Gel Filtration Chromatography

Gel filter	:	Sephadex LH 20 (Pharmacia)
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 into the column and allowed to set tightly
Sample loading	:	The sample was dissolved in a small amount of the eluent and then applied gently on top of the column.

2.3 Spectroscopy

2.3.1 Ultraviolet (UV) Absorption Spectra

UV spectra (in methanol) were obtained on a Shimadzu UV-160A UV/vis spectrophotometer (Pharmaceutical Research Instrument Center, Faculty of Pharmaceutical Sciences, Chulalongkorn University).

2.3.2 Infrared (IR) Absorption Spectra

IR spectra (film) were recorded on a Perkin Elmer FT-IR 1760X spectrometer (Scientific and Technological Research Equipment Center, Chulalongkorn University)

2.3.3 Mass Spectra

Mass spectra were recorded on a Bruker microTOF mass spectrometer (National Center for Genetic Engineering and Biotechnology).

2.3.4 Proton and Carbon-13 Nuclear Magnetic Resonance (^{1}H and ^{13}C-NMR) Spectra

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

^{1}H NMR (500 MHz) and ^{13}C NMR (125 MHz) spectra were obtained with a JEOL JMN-A 500 NMR spectrometer (Scientific and Technological Research Equipment Center, Chulalongkorn University).

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

2.4 Physical Properties

2.4.1 Optical Rotation

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

2.4.2 Circular Dichroism (CD) Spectra

CD Spectra were recorded on a JASCO J-715 spectropolarimeter (Pharmaceutical Research Instrument Center, Faculty of Pharmaceutical Sciences, Chulalongkorn University)

2.5 Solvents

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

3. Extraction and Isolation

3.1 Extraction

Air-dried and powdered root bark of *Artocarpus lakoocha* (2.4 kg) was successively extracted with EtOAc and MeOH (2 × 15 L, 2 days each) at room temperature, yielding an EtOAc extract (111 g, 4.62% based on dried weight of root bark) and a MeOH extract (369 g, 15.37% based on dried weight of root bark), respectively.

3.2 Separation of Compounds from the EtOAc Extract

The EtOAc extract (111 g) was separated by vacuum liquid column chromatography using a sintered glass filter column of silica gel (No.7734, 400 g). Elution was performed in a polarity gradient manner with mixtures of hexane and EtOAc (1:0 to 0:1). The eluates (500 ml per fraction) were collected and examined by TLC (silica gel, EtOAc-hexane 3:7) to yield 52 fractions. Fractions with similar chromatographic manner were combined to give 13 fractions: A (0.30 g), B (39.09 g), C (2.76 g), D (4.29 g), E (3.89 g), F (9.99 g), G (3.60 g), H (0.56 g), I (7.76 g), J (1.09 g), K (1.76 g), L (8.90 g), M (5.41 g).

3.2.1 Isolation of Compound AL1 (artolakoochol)

Fraction E (3.89 g) was re-chromatographed on a silica gel 60 (No. 9385, 78 g) column. Gradient elution (mixtures of hexane and EtOAc, 17:3 to 16:4) was performed (50 ml per fracion) to give 13 fractions: fraction E1 (23.8 mg), E2 (73.4 mg), E3 (104.2 mg), E4 (144.7 mg), E5 (251.3 mg), E6 (513.2 mg), E7 (1.53 g), E8 (101.0 mg), E9 (356.8 mg), E10 (50.3 mg), E11 (47.5 mg), E12 (30.3 mg) and E13 (24.7 mg).

Fraction E8 (101.0 mg) was purified on a Sephadex LH20 column (acetone) to give compound AL1 as a yellow amorphous solid (40 mg, R_f 0.26, silica gel, EtOAc-hexane 1:4). This compound was later characterized as a new prenylated 2-arylbenzofuran, which was subsequently named artolakoochol [**338**].

3.2.2 Isolation of Compound AL2 (cycloartolakoochol)

Fraction G (3.6 g) was re-chromatographed on a silica gel 60 (No. 9385, 78 g) column. Elution (EtOAc-hexane 1:9) was performed (50 ml per fracion) to give 24 fractions: fraction G1 (115.1 mg), G2 (131.7 mg), G3 (116.4 mg), G4 (46.5 mg), G5 (10.1 mg), G6 (18.6 mg), G7 (5.7 mg), G8 (9.5 mg), G9 (22.8 mg), G10 (6.5 mg), G11 (6.7 mg), G12 (18.9 mg), G13 (164.7 mg), G14 (395.9 mg), G15 (138.8 mg), G16 (148.2 mg), G17 (218.2 mg), G18 (188.4 mg), G19 (147.9 mg), G20 (141.9 mg), G21 (205.1 mg), G22 (260 mg), G23 (305.1 mg) and G24 (212.4 mg).

Fraction G9 (22.8 mg) was purified on a Sephadex LH20 column (acetone) to give compound AL2 as a yellow amorphous solid (6 mg, R_f 0.36, silica gel, EtOAc-hexane 1:4). This compound was later characterized as a new prenylated 2-arylbenzofuran, subsequently named cycloartolakoochol [**339**].

3.2.3 Isolation of Compound AL3 (4-hydroxyartolakoochol)

Fraction K (1.76 g) was subjected to flash column chromatography (silica gel, No. 9385, 78 g , EtOAc-hexane 3:7). Eighteen fractions were collected (50 ml each): fraction K1 (30.2 mg), K2 (1.9 mg), K3 (1.6 mg), K4 (2 mg), K5 (1.7 mg), K6 (1.7 mg), K7 (7.2 mg), K8 (3.2 mg), K9 (9.8 mg), K10 (51.6 mg), K11 (286.2 mg), K12 (278.8 mg), K13 (200.3 mg), K14 (254 mg), K15 (24.6 mg), K16 (34.7 mg), K17 (292.3 mg), and K18 (158 mg). Fraction K14 (254 mg) was then subjected to another silica gel column (MeOH-CH_2Cl_2, 1:99 to 3:97) to give 10 fractions: fraction 1 (0.6 mg), 2 (29.6 mg), 3 (6.9 mg), 4 (8.3 mg), 5 (71.3 mg), 6 (31.6 mg), 7 (7.3 mg), 8 (9.2 mg), 9 (7.9 mg) and 10 (36.6 mg). Fraction 7 was recrystallized in CH_2Cl_2 to give compound AL3 as a white powder (2.5 mg, R_f 0.21, silica gel, MeOH-CH_2Cl_2 1:19).

This compound was later characterized as a new prenylated 2-arylbenzofuran, which named 4-hydroxyartolakoochol [**340**].

3.2.4 Isolation of compound AL4 (5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone)

Fraction L (8.9 g) was further fractionated on a vacuum sintered glass filter column of silica gel (No.7734, 400 g). Elution was performed in a polarity gradient manner with mixtures of CH_2Cl_2 and methanol (1:0 to 0:1). The eluates (500 ml per fraction) were collected and examined by TLC (silica gel, MeOH-CH_2Cl_2 1:19). Fractions with similar chromatographic pattern were combined into six fractions: fraction L1 (161.1 mg), L2 (33.5 mg), L3 (2.88 g), L4 (1.66 g), L5 (3.5 g), and L6 (525.6 g). Fraction L5 (3.5 g) was then subjected to flash column chromatography (silica gel, MeOH-CH_2Cl_2 3:97). Seven fractions were collected (50 ml each): fraction L5A (38.6 mg), L5B (528 mg), L5C (187.5 mg), L5D (253.4 mg), L5E (594.7 mg), L5F (727.7 mg) and L5G (823 mg).

Fraction L5B (528 mg) was separated on a Sephadex LH20 column (MeOH: CH_2Cl_2, 1:1). The eluates (30 ml per fraction) were collected and examined by TLC (silica gel, acetone-CH_2Cl_2 3:17). Fractions with similar chromatographic pattern were combined into seven fractions: fraction L5B1 (22.2 mg), L5B2 (44.9 mg), L5B3 (108.3 mg), L5B4 (140.6 mg), L5B5 (85.3 mg), L5B6 (78.4 mg) and L5B7 (9.5 mg).

Fraction L5B4 (140.6 mg) was further separated on a flash column (silica gel, acetone-CH_2Cl_2 7:93). The eluates (30 ml per fraction) were collected and examined by TLC (silica gel, acetone-CH_2Cl_2 3:17). Fractions with similar chromatographic pattern were combined into twelve fractions: fraction 1 (0.8 mg), 2 (15.3 mg), 3 (21.6 mg), 4 (32.8 mg), 5 (6 mg), 6 (7.8 mg), 7 (6.8 mg), 8 (7.3 mg), 9 (5.8 mg), 10 (4 mg), 11 (12.4 mg) and 12 (14.5 mg).

Combination of fractions 3 (21.6 mg) and 4 (32.8 mg) gave compound AL4 as an orange amorphous solid (54.4 mg, R_f 0.29, silica gel, acetone-CH_2Cl_2 3:17). This compound was later shown to be a new prenylated flavone, which was subsequently named 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone [**341**].

3.2.5 Isolation of Compound AL5 (cudraflavone C)

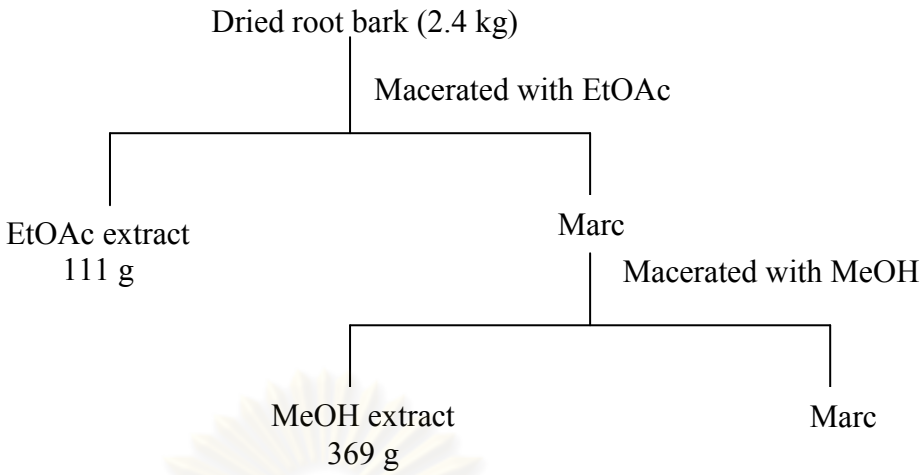
Fraction L5C (187.5 mg) was separated on a Sephadex LH20 column (MeOH: CH_2Cl_2, 1:1). The eluates (30 ml per fraction) were collected and examined by TLC (silica gel, acetone-CH_2Cl_2 3:17). Fractions were pooled according to their TLC pattern

into seven major fractions: fraction L5C1 (8.3 mg), L5C2 (15.3 mg), L5C3 (23.4 mg), L5C4 (36.3 mg), L5C5 (24.7 mg), L5C6 (66.5 mg) and L5C7 (8.9 mg).

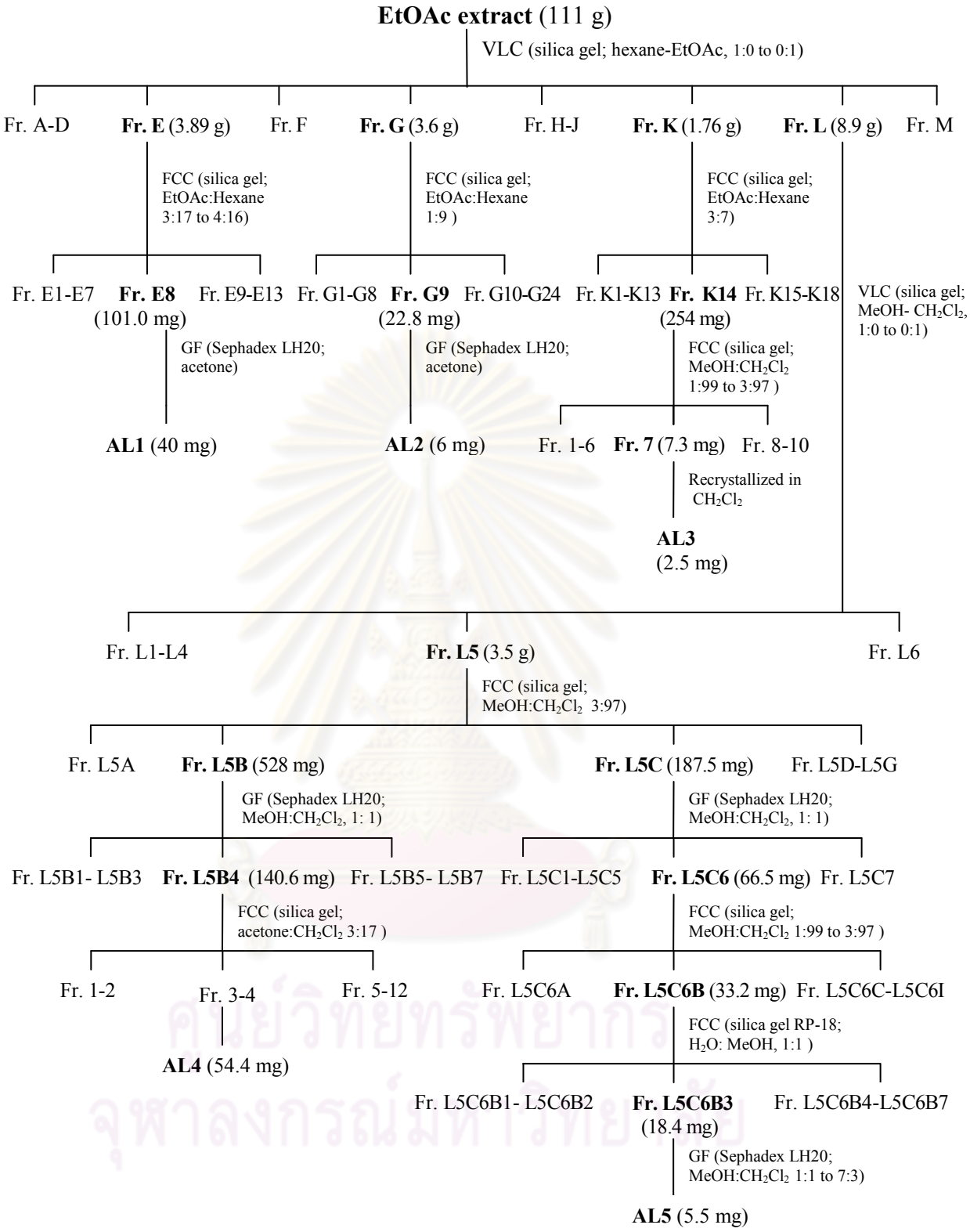
Fraction L5C6 (66.5 mg) was subjected to flash column chromatography (silica gel, MeOH-CH_2Cl_2 1:99 to 3:97). The eluates (30 ml per fraction) were collected and examined by TLC (silica gel, MeOH-CH_2Cl_2 1:19) in order to combine fractions with similar TLC pattern into nine fractions: fraction L5C6A (3.5 mg), L5C6B (33.2 mg), L5C6C (5.8 mg), L5C6D (5.2 mg), L5C6E (1.8 mg), L5C6F (3.8 mg), L5C6G (5 mg), L5C6H (4.9 mg) and L5C6I (1.1 mg).

Fraction L5C6B (33.2 mg) was further fractionated on a reverse-phase flash column (silica gel RP-18, H_2O:MeOH 1:1). The eluates (30 ml per fraction) were collected and examined by TLC (silica gel, MeOH-CH_2Cl_2 1:19). Fractions with similar chromatographic pattern were then combined into seven fractions: fraction L5C6B1 (0.5 mg), L5C6B2 (1.1 mg), L5C6B3 (18.4 mg), L5C6B4 (5 mg), L5C6B5 (2.3 mg), L5C6B6 (1.6 mg) and L5C6B7 (0.3 mg).

Fraction L5C6B3 (18.4 mg) was purified on a Sephadex LH20 column (MeOH-CH_2Cl_2 1:1 to 7:3) to give compound AL5 as a yellow amorphous solid (5.5 mg, R_f 0.21, silica gel, MeOH-CH_2Cl_2 1:19). It was later identified as cudraflavone C [**34**].



Scheme 1 Extraction of the root bark of *Artocarpus lakoocha*



Scheme 2 Separation of the EtOAc extract of the root bark of *Artocarpus lakoocha*

4. Physical and spectral data of isolated compounds

4.1 Compound AL1 (artolakoochol)

Compound AL1 was obtained as a yellow amorphous solid, soluble in CH_2Cl_2 (40 mg, 1.67 x 10^{-3} % based on dried weight of root bark).

HREIMS : $[M+H]^+$ at *m/z* 445.2381 (calcd for $C_{29}H_{33}O_4$ 445.2379) Figure 9

UV : λ_{max} nm (log ε), in methanol; Figure 11
234 (3.23), 339 (3.16)

IR : ν_{max} cm^{-1}, film; Figure 10
3377, 2966, 2924, 2854, 1623, 1607, 1489, 1445

$[\alpha]^{20}_D$: -86.1 ° (*c* 0.03; MeOH)

CD : $[\theta]_{193.5}$ -3101, $[\theta]_{199}$ +30266, $[\theta]_{209}$ +2431, $[\theta]_{230}$ -12013, $[\theta]_{333.5}$ -8337; (*c* 0.03; MeOH); Figure 24

^{1}H NMR : δ ppm, 500 MHz, in $CDCl_3$; see Table 4, Figure 12

^{13}C NMR : δ ppm, 125 MHz, in $CDCl_3$; see Table 4, Figure 13

4.2 Compound AL2 (cycloartolakoochol)

Compound AL2 was obtained as a yellow amorphous solid, soluble in CH_2Cl_2 (6 mg, 2.5 x 10^{-4} % based on dried weight of root bark).

HREIMS : $[M+H]^+$ at *m/z* 445.2391 (calcd for $C_{29}H_{33}O_4$ 445.2379) Figure 25

UV : λ_{max} nm (log ε), in methanol; Figure 26
226 (2.5), 316 (2.35)

IR : ν_{max} cm^{-1}, film; Figure 27
3365, 2925, 2873, 2854, 1622, 1489, 1445

$[\alpha]^{20}_D$: +19.2 ° (*c* 0.02; MeOH)

CD : $[\theta]_{194}$ +18734, $[\theta]_{199}$ +2273, $[\theta]_{202}$ +3549, $[\theta]_{214.5}$ +447, $[\theta]_{229}$ -3300, $[\theta]_{243}$ - 4939; (*c* 0.02; MeOH); Figure 40

^{1}H NMR : δ ppm, 500 MHz, in $CDCl_3$; see Table 5, Figure 28

^{13}C NMR : δ ppm, 125 MHz, in $CDCl_3$; see Table 5, Figure 30

4.3 Compound AL3 (4-hydroxyartolakoochol)

Compound AL3 was obtained as a white powder, soluble in acetone (2.5 mg, 1.04 x 10^{-4} % based on dried weight of root bark).

HREIMS : $[M+H]^+$ at *m/z* 461.2328 (calcd for $C_{29}H_{33}O_5$ 461.2332) Figure 41

UV : λ_{max} nm (log ε), in methanol; Figure 42
240 (3.04), 316 (3.02)

IR : ν_{max} cm^{-1}, film; Figure 43
3417, 2965, 2920, 1633, 1609, 1447, 1418, 1129, 1065

$[\alpha]^{20}_D$: -117.6 ° (*c* 0.03; MeOH)

CD : $[\theta]_{193.5}$ -14285, $[\theta]_{198.5}$ +11842, $[\theta]_{207}$ +2242, $[\theta]_{227}$ -14326, $[\theta]_{331}$ -9227, (*c* 0.03; MeOH); Figure 48

^{1}H NMR : δ ppm, 500 MHz, in $CDCl_3$; see Table 6, Figure 44

^{13}C NMR : δ ppm, 125 MHz, in $CDCl_3$; see Table 6, Figure 46

4.4 Compound AL4 (5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone)

Compound AL4 was obtained as an orange amorphous solid, soluble in acetone (54.4 mg, 2.27 x 10^{-3} % based on dried weight of root bark).

HREIMS : $[M+H]^+$ at *m/z* 491.2430 (calcd for $C_{30}H_{35}O_6$ 491.2434) Figure 51

UV : λ_{max} nm (log ε), in methanol; Figure 53
220.5 (3.83), 262.5 (3.69), 308.5 (3.44),

IR : ν_{max} cm^{-1}, film; Figure 52
3329, 2968, 2873, 1701, 1648, 1619, 1560, 1459, 1360, 1309

^{1}H NMR : δ ppm, 500 MHz, in acetone-d_6; see Table 7, Figure 54

^{13}C NMR : δ ppm, 125 MHz, in acetone-d_6; see Table 7, Figure 55

4.6 Compound AL5 (Cudraflavone C)

Compound AL5 was obtained as a yellow amorphous solid, soluble in acetone (5.5 mg, 2.29 x 10^{-4} % based on dried weight of root bark).

ESIMS : $[M+Na]^+$ at *m/z* 445.16 Figure 58

UV : λ_{max} nm (log ε), in methanol; Figure 59
223 (4.20), 260 (4.12), 314 (3.95)

IR : ν_{max} cm^{-1}, film; Figure 60
3336, 2966, 2917, 2855, 1648, 1620, 1564, 1464, 1359,1309

^{1}H NMR : δ ppm, 300 MHz, in acetone- d_6; see Table 8, Figure 61

^{13}C NMR : δ ppm, 75 MHz, in acetone- d_6; see Table 8, Figure 62

5. Determination of free radical scavenging activity

5.1 TLC screening assay (Takao *et al*., 1994**)**

The samples were spotted and developed on TLC plate with suitable developing solvent. After drying, the TLC plate was sprayed with 0.2% solution of 1,1-diphenyl-2-picrylhydrazyl (DPPH) in methanol. After 30 min, active compounds appeared as yellow spots on the purple background.

5.2 Free radical scavenging activity assay (Braca *et al*., 2002)

5.2.1 Preparation of test sample

The test compound (0.5 mg) was dissolved in 1 ml of methanol (or suitable solvent) and diluted with methanol until a suitable range of concentration (mg/ml) was obtained. The concentration was expressed as μM in final concentration. For example, AL1 (MW 444) at 0.5 mg/1ml was equal to 1126 μM [(0.5 mg x 10^3 x 1000 ml) /444]. For each well, 20 μl of test solution was added to the reaction mixture to furnish the total volume of 200 μl. The final concentration was calculated by the formula below.

$N_1V_1 = N_2V_2$

N_1 = Beginning concentration (μM)

V_1 = Beginning volume (μl)

N_2 = Final concentration (μM)

V_2 = Final volume (μl)

Thus, the final concentration of AL1 solution = 1126 μM x 20 μl / 200 μl

= 112.6 μM

5.2.2 Preparation of DPPH solution (100 μM)

DPPH (2 mg) was dissolved in 100 ml of methanol, and the solution was stirred for 30 min.

5.2.3 Measurement of activity

The test sample (20 μl) was added to 180 μl of DPPH solution (100 μM) in 96-well plate. The solution mixture was incubated at 37ºC for 30 min and then the absorbance of each well was measured at 510 nm. The DPPH solution (180 μl) mixed with methanol (20 μl) was used as negative control and quercetin as a reference compound.

5.2.4 Calculation of percent inhibition of DPPH free radical scavenging activity

The percentage of DPPH reduction was calculated as follows.

% DPPH reduction = (A-B) x 100 / A

A = The absorbance of DPPH solution after incubation at 510 nm

B = The absorbance of the reaction mixture after incubation at 510 nm

For IC_{50} evaluation of pure compounds, a graph showing concentration versus % DPPH reduction was plotted. The IC_{50} was calculated from the graph.

6. Determination of tyrosinase inhibitory activity

In this study, tyrosinase inhibitory activity is determined by the dopachrome method using L-DOPA as the substrate (Iida *et al*., 1995). Dopachrome is one of the intermediate substances in the melanin biosynthesis. The red color of dopachrome can be detected by visible light. In this experiment a microplate reader (BIO-RAD, model 450) with 492 nm interference filter was used for detection. The potential tyrosinase inhibitor would show minimal dopachrome absorption. This method was modified from the methods of Masamoto (Masamoto, Iida, and Kubo, 1980), Iida (Iida *et al*., 1995) and Morita (Morita *et al*., 1994)

6.1 Preparation of the reaction mixture

6.1.1 Preparation of 20 mM phosphate buffer (pH 6.8)

Solution A: $NaH_2PO_4.2H_2O$ (312 mg) was dissolved in 100 ml of H_2O.

Solution B: Na_2HPO_4 (284 mg) was dissolved in 100 ml of H_2O.

Then, solutions A and B were mixed until pH 6.8 was reached.

6.1.2 Preparation of 0.8 mM L-DOPA

L-DOPA (0.8 mg) was dissolved in 5 ml of 20 mM phosphate buffer (pH 6.8).

6.1.3 Preparation of tyrosinase solution

Tyrosinase enzyme (0.5 mg) was dissolved in 5 ml of 20 mM phosphate buffer (pH 6.8).

6.1.4 Preparation of the test sample

One milligram of the test compound was dissolved in 3 ml of ethanol (or suitable solvent) and diluted with ethanol until a suitable range of concentrations (mg/ml) was obtained. The concentration was expressed as μM in the final calculation. For example, the concentration of compound AL1 (MW 444) at 1 mg/3ml was equal to 751 μM [(1 mg x 10^3 x 1000 ml) /(3 x 444)]. For each well, 20 μl of test solution was added to the reaction mixture to furnish the total volume of 200 μl. The final concentration was calculated by the formular below.

$$N_1V_1 = N_2V_2$$

N_1 = Beginning concentration (μM)

V_1 = Beginning volume (μl)

N_2 = Final concentration (μM)

V_2 = Final volume (μl)

Thus, the final concentration of AL1 solution = 751 μM x 20 μl / 200 μl = 75.1 μM

6.2 Measurement of activity

The reaction mixture (200 μl) was measured in four wells (A, B, C and D). In each well, the substance was added in the order of mixing, as follows;

A (control)	20 μl of mushroom tyrosinase solution (48 unit/ml)
	140 μl of 20 mM phosphate buffer (pH 6.8)
	20 μl of ethanol
B (blank of A)	160 μl of 20 mM phosphate buffer (pH 6.8)
	20 μl of ethanol
C (test sample)	20 μl of mushroom tyrosinase solution (48 unit/ml)
	140 μl of 20 mM phosphate buffer (pH 6.8)
	20 μl of test sample in ethanol
D (blank of C)	160 μl of 20 mM phosphate buffer (pH 6.8)
	20 μl of test sample in ethanol

After each well was mixed and preincubated at 25 ^{o}C for 10 minutes, 20 μl of 0.85 μM L-DOPA were added, and the mixture was incubated at 25 ^{o}C for 20 min. The absorbance of each well was measured at 492 nm with the microplate reader both before and after incubation.

6.3 Calculation of the percent inhibition of tyrosinase enzyme

The percent inhibition of tyrosinase reaction was calculated as follows.

% Tyrosinase inhibition = 100 x [(A-B)-(C-D)] / (A-B)

A = The difference of optical density before and afer incubation at 492 nm without test sample

B = The difference of optical density before and afer incubation at 492 nm without test sample and enzyme

C = The difference of optical density before and afer incubation at 492 nm with test sample

D = The difference of optical density before and afer incubation at 492 nm with test sample, but without enzyme

6.4 Calculation of IC_{50}

After the % tyrosinase inhibition of the test solution in each concentration was obtained, a graph showing concentration against % tyrosinase inhibition was plotted. The IC_{50} (concentration at 50% tyrosinase inhibition) of each pure compound was then obtained from the graph.

7. Determination of anti-herpes simplex virus (HSV) activity

In this study, plaque reduction assay (PRA) was performed against HSV-1 and HSV-2 for all isolated compounds (Abou-karam and Shier,1990). Acyclovir was used as positive control for both inactivation and post-treatment assays.

7.1 Inactivation

Virus (30 PFU/25 μl) was mixed with 25 μl of test compound and incubated at 37 ^{o}C in humidified CO_2 incubator for an hour. The mixtures were added into Vero cells ($6x10^5$ cells/ml, 50 μl/well) in 96-well microtiter plates and incubated at 37 ^{o}C for 2 hours. The overlay medium containing various concentrations of test compound (100 μl/well) was added to the Vero cells and incubated at 37 ^{o}C in humidified CO_2 incubator for 2 days. After incubation, the cells were fixed in 10% formalin and stained with 1% crystal violet for an hour. The number of plaques was counted under an inverted microscope. The percentage of plaque inhibition was determined. The graph plotted between values of various concentrations and % plaque inhibition was used for IC_{50} (inhibitory concentration at 50% of virus growth) determination.

7.2 Post-treatment

Virus (30 PFU/25 μl) was added into Vero cells ($6x10^5$ cells/ml, 50 μl/well) in 96-well microtiter plates and incubated at 37 ^{o}C for 2 hours. Fifty μl of the dilution of each test compound and overlay medium (100 μl/well) were added to the 96-well microtiter plates and incubated at 37 ^{o}C in humidified CO_2 incubator for 2 days. The cells were fixed in 10% formalin and stained with 1% crystal violet for an hour. The plaques were counted under an inverted microscope. The % plaque inhibition and IC_{50} values were determined as described in 7.1.

CHAPTER IV

RESULTS AND DISCUSSION

The dried powdered root bark of *Artocarpus lakoocha* (2.4 kg) was extracted with EtOAc to give an EtOAc extract (111 g), which was then separated using several chromatographic techniques to yield five pure compounds (AL1 to AL5).

The structure determination of all isolates was performed by interpretation of their UV, IR, MS and NMR data, and then comfirmed by comparison with previously reported values.

1. Structure determination of isolated compounds

1.1 Structure determination of compound AL1

Compound **AL1** was isolated as a yellow amorphous solid. The positive HR-ESI-MS exhibited an $[M+H]^+$ ion at *m/z* 445.2381 (calcd. for $C_{29}H_{33}O_4$: 445.2379), suggesting the molecular formula $C_{29}H_{32}O_4$ (Figure 9). The IR spectrum showed absorption bands for hydroxyl (3,377 cm^{-1}), aliphatic (2,966, 2,924 and 2,854 cm^{-1}) and aromatic (1,445-1,623 cm^{-1}) groups (Figure 10). The UV absorption maxima at 234 and 339 nm (Figure 11) were indicative of a 2-arylbenzofuran skeleton (Yenesew *et al*., 2002; Kapche *et al*., 2009), and this was supported by the ^{1}H-NMR signal at δ 6.72 (1H, d, *J* = 0.5 Hz, H-3) (Figure 12), and the ^{13}C-NMR signals at δ 105.0 (C-3) and δ 154.4 (C-2) (Table 4, Figure 13) (Yenesew *et al*., 2002). The ^{13}C-NMR and HSQC spectra of AL1 displayed 29 carbon signals, corresponding to five methyls, three methylenes, nine methines, and twelve quaternary carbons (Figures 13-16). The presence of a phenolic group at C-6 on ring A of the 2-arylbenzofuran nucleus was indicated by the OH signal at δ 5.29 (br s, 1H, OH-6, D_2O exchangable) and the ABM aromatic proton spin system [δ 6.75 (dd, *J* = 8.5, 2.0 Hz, H-5), 6.95 (d, *J* = 2.0 Hz, H-7) and 7.36 (d, *J* = 8.5 Hz, H-4) (Puntumchai *et al*., 2004). This was supported by the NOESY interactions between H-4 and H-5, H-7 and OH-6 (Figure 17), and further confirmed by the HMBC correlations from the OH-6 proton to C-5 (δ111.9) and C-7 (δ 98.2) (Table 4 and Figure 18).

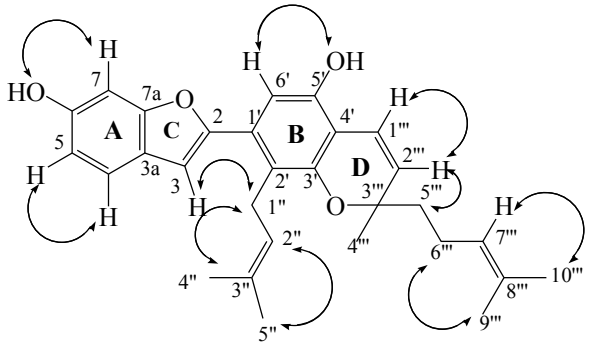


Figure 5 Important NOESY correlations of AL1

In ring B, one of the *ortho*-position carbon atoms was unsubstituted, as evidenced by the HMBC correlation from C-2 to an aromatic proton singlet at δ 6.70 (H-6′) (Figure 19). Further analysis of the ^{1}H and ^{13}C-NMR data revealed that a 3,3-dimethylallyl group was present on the other *ortho*-position (C-2′), [^{1}H: δ 3.45 (2H, d, J = 6.5 Hz, H_2-1″), 5.17 (1H, br t, J = 6.5 Hz, H-2″), 1.67 (3H, s, H_3-5″) and 1.72 (3H, s, H_3-4″); ^{13}C: δ 25.6 (C-1″), 123.6 (C-2″), 131.2 (C-3″), 18.1 (C-4″) and 25.7 (C-5″)]. In support of this, C-2′ (δ 120.1) showed HMBC correlations to H-6′ and H-2″ (Figures 20-21), and H-3 displayed NOESY interactions with H_2-1″ (Figure 22). The ^{1}H-NMR spectrum of AL1 also showed an additional phenolic proton (δ 5.19, 1H, br s, D_2O exchangeable), which could be assigned to OH-5′ from its 3-bond connectivity to C-6′ and its NOESY correlation to H-6′ (Figures 18 and 22). Further examination of the remaining ^{1}H- and ^{13}C-NMR signals suggested that AL1 also contained a modified geranyl group that formed a 2-methyl-2-(4-methylpent-3-enyl) chromene structure on ring B [^{1}H: δ 1.36 (3H, s, H_3-4‴), 1.57 (3H, s, H_3-9‴), 1.65 (3H, s, H_3-10‴), 1.71 (2H, m, H_2-5‴), 2.10 (2H, m, H_2-6‴), 5.10 (1H, br t, J = 7.0 Hz, H-7‴), 5.57 (1H, d, J = 10.0 Hz, H-2‴) and 6.68 (1H, d, J = 10.0 Hz, H-1‴); ^{13}C: δ 117.0 (C-1‴), 128.6 (C-2‴), 78.5 (C-3‴), 26.2 (C-4‴), 41.3 (C-5‴), 22.9 (C-6‴), 124.2 (C-7‴), 131.7 (C-8‴), 17.6 (C-9‴) and 25.6 (C-10‴)] (Asakawa *et al*., 1991; Ko *et al.*, 1997). This unit should be situated at C-3′ and C-4′, and its placement was corroborated by the HMBC correlations from H-1‴ to C-3′ and C-5′, and from H-2‴ to C-4′ (Figures 19 and 23).

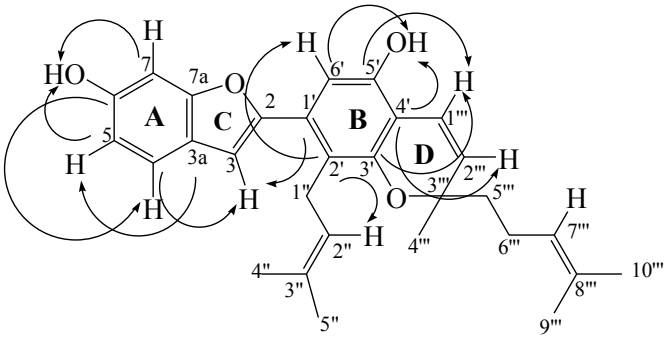
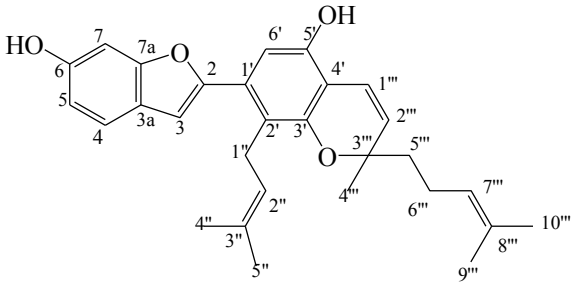


Figure 6 Important HMBC (C→H) correlations of AL1

Based on the above spectral evidence, the structure of AL1 was established as shown, and the compound was given the trivial name artolakoochol.



Artolakoochol [**338**]

Table 4 NMR Spectral data of compound AL1 ($CDCl_3$)

position	Compound AL1		HMBC
	^{1}H (mult., *J* in Hz)	^{13}C (mult.)	(correlation with ^{1}H)
2	-	154.4 (s)	6′
3	6.72 (d, 0.5)	105.0 (d)	4
3a	-	122.9 (s)	3*, 5
4	7.36 (d, 8.5)	121.2 (d)	3
5	6.75 (dd, 8.5, 2.0)	111.9 (d)	7, OH-6
6	-	153.4 (s)	4, 7*, OH-6*
7	6.95 (d, 2.0)	98.2 (d)	5, OH-6
7a	-	155.2 (s)	3, 4, 7*
1′	-	130.2 (s)	3, 6′*
2′	-	120.1 (s)	6′, 1″*, 2″
3′	-	152.3 (s)	1″, 1‴
4′	-	109.6 (s)	6′, 1‴*, 2‴, OH-5′
5′	-	149.1 (s)	6′*,1‴, OH-5′*
6′	6.70 (s)	106.9 (d)	OH-5′
1″	3.45 (d, 6.5)	25.6 (t)	2″*
2″	5.17 (br t, 6.5)	123.6 (d)	1″*, 4″, 5″
3″	-	131.2 (s)	1″, 4″*, 5″*
4″	1.72 (s)	18.1 (q)	2″, 5″
5″	1.67 (s)	25.7 (q)	2″, 4″
1‴	6.68 (d, 10.0)	117.0 (d)	-
2‴	5.57 (d, 10.0)	128.6 (d)	4‴, 5‴
3‴	-	78.5 (s)	1‴,2‴*, 4‴*,5‴*, 6‴
4‴	1.36 (s)	26.2 (q)	2‴, 5‴
5‴	1.71 (m)	41.3 (t)	2‴, 4‴,6‴*, 7‴
6‴	2.10 (m)	22.9 (t)	5‴*, 7‴*
7‴	5.10 (br t, 7.0)	124.2 (d)	5‴, 6‴*, 9‴, 10‴
8‴	-	131.7 (s)	6‴, 9‴*, 10‴*
9‴	1.57 (s)	17.6 (q)	7‴, 10‴
10‴	1.65 (s)	25.6 (q)	7‴, 9‴
OH-6	5.29 (br s)	-	-
OH-5′	5.19 (br s)	-	-

* Two-bond coupling.

1.2 Structure determination of AL2

Compound AL2 was obtained as a yellow amorphous solid. A molecular formula of $C_{29}H_{32}O_4$ was deduced from its $[M+H]^+$ ion at *m/z* 445.2391 (calcd. for $C_{29}H_{33}O_4$: 445.2379) (Figure 25). The UV absorption maxima and IR bands of AL2 were similar to those of AL1 (Figures 26 and 27), suggesting a 2-arylbenzofuran skeleton. The benzofuran unit (rings A and C) of AL2 should have a structure similar to that of AL1, as indicated from the ^{1}H-NMR signals of an ABM splitting pattern at δ 6.73 (1H, dd, *J* = 8.0, 2.0 Hz, H-5), δ 6.96 (1H, d, *J* = 2.0 Hz, H-7) and δ 7.36 (1H, d, *J* = 8.0 Hz, H-4), and a doublet signal at δ 6.68 (*J* = 1.0 Hz) assignable to proton H-3 (Table 5 and Figure 28). The HMBC correlations of H-4 with C-3 (δ 104.3) and C-6 (δ 153.3) confirmed the presence of a phenolic group at C-6. Similar to AL1, compound AL2 was unsubstituted at position 6′, as evidenced by the ^3J coupling between H-6′ (δ 6.81, 1H, s) and C-2 (δ 155.4) (Figure 29).

The ^{1}H-NMR and ^{13}C-NMR spectra (Figure 30) of AL2 also exhibited signals for a 3,3-dimethylallyl group [^{1}H: δ 3.40 (1H, dd, *J* = 14.5, 7.0 Hz, H-1″α), 3.54 (1H, dd, *J* = 14.5, 7.0 Hz, H-1″β), 5.19 (1H, t, *J* = 7.0 Hz, H-2″), 1.66 (3H, s, H_3-5″) and 1.69 (3H, s, H_3-4″); ^{13}C: δ 25.5 (C-1″), 123.9 (C-2″), 130.9 (C-3″), 18.1 (C-4″) and 25.8 (C-5″)] which should be placed at C-2′ due to the HMBC correlation of C-2′ (δ 120.8) with H-1″ (Figure 31). The ^{13}C-NMR, HSQC (Figures 32-33) and HMBC spectra of AL2 displayed, in addition to the signals for the 2-arylbenzofuran nucleus and the prenyl group, ten carbon signals corresponding to three angular methyls, three methylenes, two methines and two oxygenated quarternary carbons. This indicated that compound AL2 also had a monoterpene unit which was attached to C-4′ and appeared to form a tricylic structure with the oxygen functionalities on C-3′ and C-5′. The conjugation of a 10-carbon moiety to a di-*ortho* oxygenated aromatic structure to produce a pyran-cyclohexane-pyran system (rings D, E and F) has been recently observed in isorubraine, a monoterpene-chalcone conjugate isolated from the seeds of *Alpinia katsumadai* (Hua *et al*., 2009). Comparison of the ^{1}H- and ^{13}C-NMR data of AL2 with those of isorubraine (Hua *et al*., 2009), particularly on the tricyclic partial structure, revealed their close similarity. Therefore the monoterpene unit should be connected to ring B by a direct linkage between C-4′ (δ 117.2) and C-1‴ (δ 28.6) with two ether bridges between C-3′ and C-3‴, and C-5′ and C-8‴. This was supported by the HMBC correlation between H_2-2‴ (δ 1.82) and C-4′ (Figure 31).

The arrangement of this monoterpene unit was confirmed by HMBC correlations from C-7‴ (δ 46.9) to H_2-2‴ (δ 1.82, 1H, dd, *J* = 13.0, 1.5 Hz; δ 2.21, 1H, m), H_2-6‴ (δ 1.25, 1H, m; δ 0.70, 1H, m), H_3-9‴ (δ 1.52, 3H, s) and H_3-10‴ (δ 1.04, 3H, s), and from C-3‴ (δ 74.6) to H_2-2‴, H_3-4‴ (δ 1.39, 3H, s) and H_2-6‴ (Figures 34 and 35).

The F ring of AL2 appeared to have a chair conformation. Its relative configuration and NMR assignments were obtained from detailed analysis of the COSY, NOESY, HSQC and HMBC spectra. At C-2‴, the double doublet at δ 1.82 (*J* = 13.0, 1.5 Hz) was assigned to the axial proton from its NOESY interaction with H-7‴, whereas the multiplet at δ 2.21 was assigned to the equatorial, consistent with its long-range (W-type) coupling with equatorial H-5‴ (δ 1.42, m) observed in the COSY spectrum. The axial proton at C-5‴(δ 1.71, m), as expected, showed NOESY correlation with H_3-4‴. The equatorial proton at C-6‴ (δ 1.25, m) displayed a NOESY cross peak with H-7‴ (Figures 36-39).

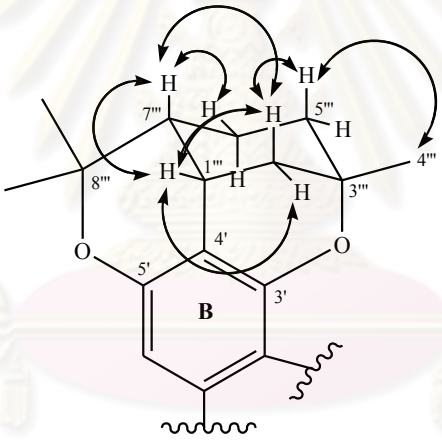
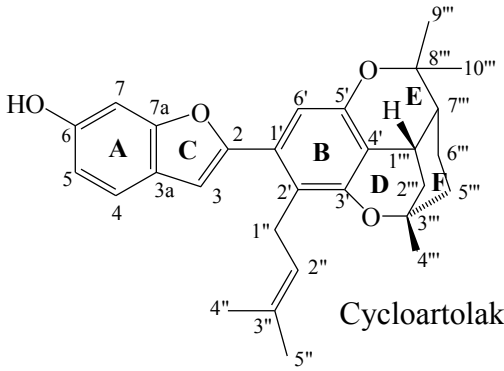


Figure 7 Important NOESY correlation of AL2

Regarding its optical activity, AL2 was found to be dextrorotatory ($[\alpha]^{20}_D$ +19.2). In the CD spectrum (Figure 40), it appeared to show a negative cotton effect at 243 nm, although two small positive peaks at 320 and 370 nm were observed. These findings reflected the influence of the stereochemistry at C-1‴, which determined the arrangement of the tricyclic (D/E/F) ring system, on the optical properties of AL2 as compared with those of AL1 and AL3.

Based on the above spectral evidence, compound AL2 was elucidated as a new 2-arylbenzofuran, named cycloartolakoochol.



Cycloartolakoochol [**339**]

Table 5 NMR Spectral data of compound AL2 ($CDCl_3$)

position	Compound AL2		HMBC
	^{1}H (mult., *J* in Hz)	^{13} C (mult.)	(correlation with ^{1}H)
2	-	155.4 (s)	3*, 6′
3	6.68 (d, 1.0)	104.3 (d)	4
3a	-	123.0 (s)	3*, 5, 7
4	7.36 (d, 8.0)	120.9 (d)	3
5	6.73 (dd, 8.0, 2.0)	116.6 (d)	7
6	-	153.3 (s)	4, 7*
7	6.96 (d, 2.0)	98.2 (d)	5
7a	-	155.5 (s)	3, 4, 7*
1′	-	128.4 (s)	3, 1″
2′	-	120.8 (s)	6′, 1″*
3′	-	154.9 (s)	1″
4′	-	117.2 (s)	6′, 2‴
5′	-	154.5 (s)	-
6′	6.81 (s)	109.2 (d)	-
1″α	3.40 (dd, 14.5, 7.0)	25.5 (t)	2″*
1″β	3.54 (dd, 14.5, 7.0)		
2″	5.19 (t, 7.0)	123.9 (s)	1″*, 4″, 5″
3″	-	130.9 (s)	1″, 4″*, 5″*
4″	1.69 (s)	18.1 (q)	2″, 5″
5″	1.66 (s)	25.8 (d)	2″, 4″
1‴	2.89 (br t, 2.0)	28.6 (d)	2‴*, 6‴
2‴ax	1.82 (dd, 13.0, 1.5)	35.1 (t)	4‴
2‴eq	2.21 (m)		
3‴	-	74.6 (s)	2‴*, 4‴*, 6‴
4‴	1.39 (s)	29.2 (q)	-
5‴ax	1.42 (m)	37.5 (t)	4‴, 6‴*
5‴eq	1.71 (m)		
6‴ax	0.70 (m)	22.3 (t)	5‴*
6‴eq	1.25 (m)		
7‴	2.05 (m)	46.9 (d)	2‴, 6‴*, 9‴, 10‴
8‴	-	83.5 (s)	6‴, 9‴*, 10‴*
9‴	1.52 (s)	29.8 (q)	10‴
10‴	1.04 (s)	23.8 (q)	9‴
OH-6	4.83 (s)	-	-

* Two-bond coupling.

1.3 Structure determination of AL3

The molecular formula of compound AL3, a white powder, was analyzed to be $C_{29}H_{32}O_5$ from its $[M+H]^+$ ion at *m/z* 461.2328 (calcd. for $C_{29}H_{33}O_5$: 461.2332) in the HR-ESI-MS (Figure 41). Its UV and IR properties were similar to those of AL1, suggesting another 2-arylbenzofuran skeleton (Figure 42 and 43). Comparison of its molecular formula with that of AL1 showed that AL3 should be a derivative of AL1 with an additional hydroxyl group. This hydroxyl group should be located at C-4 of ring A, due to the absence of the H-4 resonance and the appearance of signals for H-5 and H-7, each appeared as a doublet (J = 2.0 Hz) at δ 6.29 and δ 6.49, respectively, in the ^{1}H-NMR spectrum (Figure 44). This was confirmed by the HMBC correlations from C-3a (δ 112.3) to OH-4 (δ 8.83, 1H, br s) and H-3 (δ 6.86, 1H, d, J = 1.0 Hz) and C-4 to H-5 (Table 6 and Figure 45).

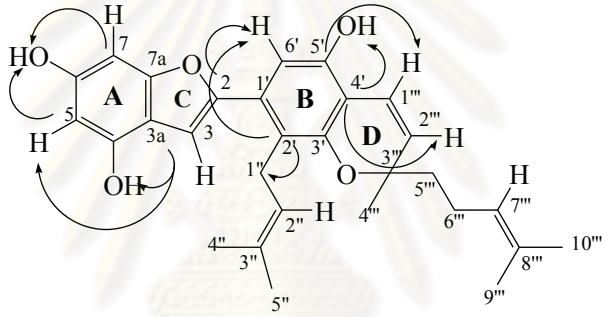
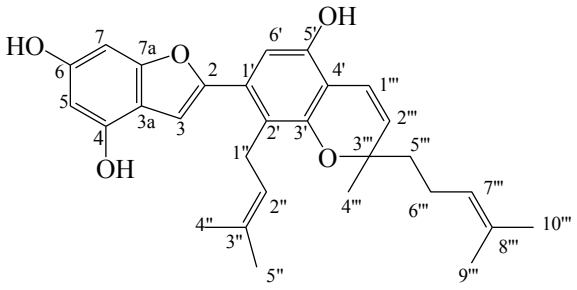


Figure 8 Important HMBC (C→H) correlations of AL3

The ^{1}H- and ^{13}C-NMR signals for rings B and D of AL3 resembled those of AL1 (Figures 44 and 46). Ring B of AL3 was unsubstituted at C-6′, as indicated by the three-bond coupling between H-6′ (δ 6.80, s) and C-2 (δ 153.2) in the HMBC spectrum. The presence of a 3,3-dimethylallyl group at C-2′ of ring B was supported by the HMBC correlations of C-2′ (δ 119.0) with H-6′ and H-1″ (δ 3.47, 2H, d, J = 6.5 Hz) (Figures 46 and 47). The HMBC correlation between C-4′ (δ 110.2) and H-2‴ (δ 5.65, 1H, d, J = 10.5 Hz) (Figure 46) confirmed the attachement of a monoterpene unit at C-4′ that was arranged to form a 2-methyl-2-(4-methylpent-3-enyl) chromene structure.

Compounds AL1 and AL3 were optically active with levorotation ($[\alpha]^{20}_D$ −86.1 and −117.6, respectively). Both shared similar CD properties, displaying a negative Cotton effect at 331−334 nm and a negative peak at 227−230 nm (Figures 24 and 48), and therefore should have the same stereochemistry at C-3‴.

Compound AL3 was given the trivial name 4-hydroxyartolakoochol.



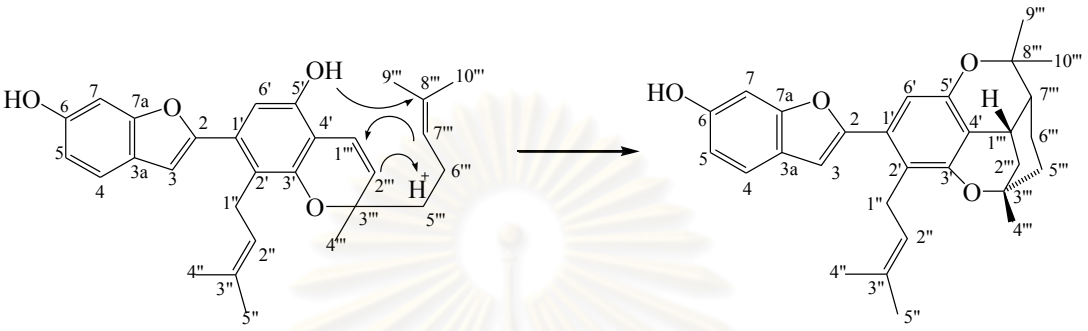
4-Hydroxyartolakoochol [**340**]

Table 6 NMR Spectral data of compound AL3 (acetone-d_6)

position	Compound AL3		HMBC
	^{1}H (mult., *J* in Hz)	^{13}C (mult.)	(correlation with ^{1}H)
2	-	153.2 (s)	3*, 6′
3	6.86 (d, 1.0)	103.1 (d)	-
3a	-	112.3 (s)	3*, 5, 7, OH-4
4	-	152.0 (s)	5*
5	6.29 (d, 2.0)	98.6 (d)	7, OH-6
6	-	157.6 (s)	5*, 7*, OH-6*
7	6.49 (d, 2.0)	90.4 (d)	5, OH-6
7a	-	157.7 (s)	3, 7*
1′	-	131.9 (s)	6′*
2′	-	119.0 (s)	6′, 1″*
3′	-	153.0 (s)	1″, 1‴
4′	-	110.2 (s)	6′, 1‴*, 2‴, OH-5′
5′	-	151.8 (s)	6′*, 1‴, OH-5′*
6′	6.80 (s)	107.6 (d)	-
1″	3.47 (d, 6.5)	26.2 (t)	2″*
2″	5.17 (br t, 6.5)	124.8 (d)	1″*, 4″, 5″
3″	-	131.1 (s)	1″, 4″*, 5″*
4″	1.74 (s)	18.3 (q)	2″, 5″
5″	1.65 (s)	25.9 (q)	2″, 4″
1‴	6.74 (d, 10.5)	118.4 (d)	-
2‴	5.65 (d, 10.5)	128.5 (d)	4‴, 5‴
3‴	-	79.0 (s)	1‴, 2‴*, 4‴*, 5‴*
4‴	1.37 (s)	26.6 (q)	2‴
5‴	1.75 (m)	42.0 (t)	2‴, 4‴, 6‴*
6‴	2.07 (m)	23.6 (t)	7‴*
7‴	5.13 (br t, 7.0)	125.1 (d)	5‴, 9‴, 10‴
8‴	-	131.4 (s)	9‴*, 10‴*
9‴	1.57 (s)	17.7 (q)	7‴, 10‴
10‴	1.64 (s)	25.8 (q)	7‴, 9‴
OH-4	8.83 (br s)	-	-
OH-6	8.38 (br s)	-	-
OH-5′	8.48 (br s)	-	-

* Two-bond coupling.

Biogenetically, the 2-arylbenzofuran nucleus of AL1 and AL2 might be derived from 4,3′,5′-trihydroxystilbene (resveratrol), whereas that of AL3 could be originated from 2,4,3′,5′-tetrahydroxystilbene (oxyresveratrol) (Reuß and König 2004; Likhitwitayawuid *et al*., 2005; 2006;). Compound AL2 appears to be a cyclization product of AL1.

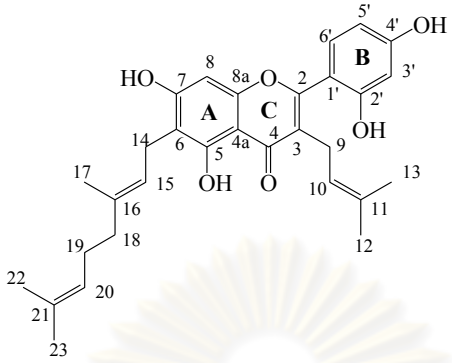


AL 1 AL 2

1.4 Structure determination of Compound AL4

Compound AL4 was obtained as an orange amorphous solid. The positive HR-ESI-MS exhibited the $[M+H]^+$ ion at *m/z* 491.2430 (calcd. for $C_{30}H_{35}O_6$, 491.2434), suggesting the molecular formula $C_{30}H_{34}O_6$ (Figure 51). The IR bands at 3328 (hydroxyl), 1701 (conjugated carbonyl) and 1459-1648 (aromatic ring) cm^{-1} (Figure 52) and the UV absorption maxima at 220, 262 and 308 nm (Figure 53) were suggestive of a flavone skeleton (Markham, 1982). The ^{1}H-NMR spectrum (Figure 54) exhibited signal for a prenyl group at δ 1.41 (3H, s, H_3-13), δ 1.55 (3H, s, H_3-12), δ 3.09 (2H, d, J = 7.0 Hz, H_2-9) and δ 5.11 (1H, t, J = 7.0 Hz, H-10), a geranyl group at δ 1.55 (3H, s, H_3-22), δ 1.60 (3H, s, H_3-23), 1.78 (3H, s, H_3-17), δ 1.95 (2H, m, H_2-18), δ 2.04 (2H, m, H_2-19), δ 3.36 (2H, d, J = 7.0 Hz, H_2-14), 5.07 (1H, t, J = 7.0 Hz, H-20) and δ 5.28 (1H, d, J = 7.0 Hz, H-15), an aromatic proton at δ 6.38 (1H, s, H-8), and a chelated hydroxyl signal at δ 13.42 (OH-5). The prenyl group was attached at C-3 (δ 121.4) of ring C, as supported by the HMBC correlations of H_2-9 with C-2 (δ 161.9) and C-4 (δ 182.9) (Figures 55-56). The HMBC correlations of H_2-14 with C-6 (δ 111.7) and C-5 (δ 160.0) placed the geranyl group at C-6 of ring A (Figures 56 and 57). For ring B, the presence of an ABM spin system at δ 6.48 (1H, dd, J = 8.5, 2.5 Hz, H-5′), δ 6.54 (1H, d, J = 2.5 Hz, H-3′) and δ 7.16 (1H, d, J = 8.5 Hz, H-6′) indicated 2′,4′-dihydroxy substitution. This was confirmed by the HMBC correlation of H-6′ with C-2 (δ 161.9) (Figure 56). From the above observations, it appears that AL4 should have a structure similar to rubraflavone C [**229**], a prenylated

flavonoid reported from *Morus rubra* and *Artocarpus rigida* (Lu *et al*., 2002), except for the alternate positions of the prenyl and geranyl groups. Based on the above spectral evidence, compound AL4 was identified as 5,7,2′,4′-tetrahydroxy-3-prenyl-6-geranylflavone.



5,7,2′,4′,-Tetrahydroxy-6-geranyl-3-prenylflavone [**341**]

Table 7 NMR Spectral data of compound AL4 (acetone-d_6)

position	Compound AL4		HMBC
	^{1}H (mult., *J* in Hz)	^{13}C (mult.)	(correlation with ^{1}H)
2	-	161.9 (s)	9, 6′
3	-	121.4 (s)	10
4	-	182.9 (s)	9
4a	-	104.9 (s)	8, OH-5
5	-	160.0 (s)	14, OH-5*
6	-	111.7 (s)	8, 14*, 15, OH-5
7	-	162.4 (s)	8*, 14
8	6.38 (s)	93.4 (d)	-
8a	-	157.0 (s)	8*
9	3.09 (d, 7.0)	24.6 (t)	10*
10	5.11 (t, 7.0)	122.7 (d)	9*, 12, 13
11	-	131.9 (s)	9, 12*, 13*
12	1.55 (s)	25.7 (q)	10, 13
13	1.41 (s)	17.6 (q)	10, 12
14	3.36 (d, 7.0)	21.8 (t)	15*
15	5.28 (t, 7.0)	123.2 (d)	14*, 17, 18
16	-	135.1 (s)	14, 17*, 18*, 19
17	1.78 (s)	16.2 (q)	15, 18
18	1.95 (m)	40.4 (t)	15, 17, 19*, 20
19	2.04 (m)	27.3 (t)	18*, 20*
20	5.07 (t, 7.0)	125.1 (d)	18, 19*,22, 23
21	-	131.5 (s)	19, 22*, 23*
22	1.55 (s)	17.6 (q)	20, 23
23	1.60 (s)	25.7 (q)	20, 22
1′	-	113.0 (s)	3′, 5′
2′	-	157.1 (s)	3′*, 6′
3′	6.54 (d, 2.5)	103.8 (d)	5′
4′	-	161.3 (s)	3′*, 5′*, 6′
5′	6.48 (dd, 8.5, 2.5)	107.9 (d)	3′
6′	7.16 (8.5)	132.2 (d)	-
OH-5	13.42 (s)	-	-

* Two-bond coupling.

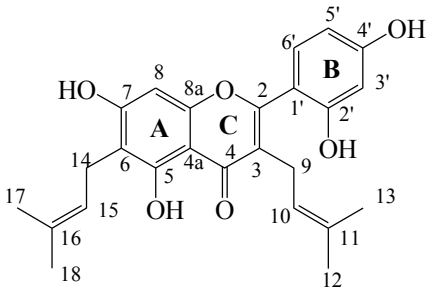
1.5 Structure determination of compound AL5

Compound AL5 was obtained as a yellow amorphous solid and its molecular formula was analyzed as $C_{25}H_{26}O_6$ from its $[M+Na]^+$ ion at *m/z* 445.16 in the ESI-MS (Figure 58). The UV spectrum exhibited maxima at 223, 262 and 314 nm (Figure 59) and the IR bands at 3336 (hydroxyl), 1648 (conjugated carbonyl) and 1464-1621 (aromatic ring) cm^{-1} (Figure 60) were suggestive of a flavone skeleton and was similar to the spectrum of AL4

The ^{1}H-NMR spectrum exhibited the signals of two prenyl groups. The first prenyl group [δ 1.76 (3H, br s, H_3-17), δ 1.63 (3H, br s, H_3-18), δ 3.34 (2H, br d, *J* = 6.9 Hz, H_2-14) and δ 5.27 (1H, br t, H-15)] was located on C-6 of ring A. The second prenyl group [δ 1.41 (3H, br s, H_3-12), δ 1.55 (3H, br s, H_3-13), δ 3.09 (2H, br d, *J* = 6.9 Hz, H_2-9) and δ 5.11 (1H, br t, H-10)] substituted on C-3 of ring C. An aromatic singlet signal appeared at δ 6.38 (1H, s, H-8), and a chelated hydroxyl signal at δ 13.42 (1H, s, OH-5). For ring B, the presence of an ABM spin system at δ 6.48 (1H, br d, *J* = 8.4 Hz, H-5′), δ 6.54 (1H, br s, H-3′), 7.16 (1H, d, *J* = 8.1 Hz, H-6′) indicated 2′, 4′-dihydroxy substitution (Figure 61). From the above ^{1}H-NMR data, it appears that compound AL5 should have a structure similar to that of AL4, except for the substituted group at C-6 of ring A which was a prenyl group instead of a geranyl group as in AL4.

The ^{13}C-NMR spectrum displayed 25 signals, including those of one carbonyl group, four methyl groups, six methine carbon, two methylene carbons and twelve quaternary carbons (Figure 62). The signals [δ 162.0 (C-2), δ 121.5 (C-3) and δ 183.0 (C-4) were confirmed flavone structure.

This compound was identified as cudraflavone C [**34**] through comparison of its ^{1}H-and ^{13}C-NMR and MS data with those reported in the literature (Table 8). The flavonoid was first isolated and reported from *Cudrania tricuspidata* (Moraceae) (Hano *et al*., 1990c)



Cudraflavone C [**34**]

Table 8 NMR Spectral data of compound AL5 and cudraflavone C (acetone-d_6)

Position	Compound AL5		Cudraflavone C (Hano *et al*., 1990)	
	^{1}H (mult., *J* in Hz)	^{13}C (mult)	^{1}H (mult., *J* in Hz)	^{13}C (mult)
2	-	162.0 (s)	-	162.0 (s)
3	-	121.5 (s)	-	121.5 (s)
4	-	183.0 (s)	-	183.0 (s)
4a	-	105.0 (s)	-	105.0 (s)
5	-	160.1 (s)	-	160.0 (s)
6	-	111.8 (s)	-	111.8 (s)
7	-	162.6 (s)	-	162.3 (s)
8	6.38 (s)	93.6 (d)	6.40 (s)	93.5 (d)
8a	-	157.1 (s)	-	157.0 (s)
9	3.09 (d, 6.9)	24.6 (t)	3.12 (d, 6.9)	24.6 (t)
10	5.11 (br t)	122.8 (d)	5.14 (m)	122.7 (d)
11	-	131.9 (s)	-	132.0 (s)
12	1.41 (br s)	17.9 (q)	1.43 (br s)	17.9 (q)
13	1.55 (br s)	25.8 (q)	1.57 (br s)	25.8 (q)
14	3.34 (d, 6.9)	22.0 (t)	3.41 (d, 6.9)	22.0 (t)
15	5.27 (br t)	123.5 (d)	5.29 (m)	123.3 (d)
16	-	131.4 (s)	-	131.4 (s)
17	1.76 (br s)	17.6 (q)	1.78 (br s)	17.6 (q)
18	1.63 (br s)	25.8 (q)	1.65 (br s)	25.9 (q)
1′	-	113.1 (s)	-	113.1 (s)
2′	-	157.2 (s)	-	157.1 (s)
3′	6.54 (br s)	103.9 (d)	6.57 (d, 2.0)	103.9 (d)
4′	-	161.4 (s)	-	161.3 (s)
5′	6.48 (br d, 8.4)	108.0 (d)	6.52 (dd, 8.0, 2.0)	108.1 (d)
6′	7.16 (d, 8.1)	132.2 (d)	7.19 (d, 8.0)	132.2 (d)
5-OH	13.42 (s)	-	13.43 (s)	-

2. Free radical scavenging activity

Free radicals are products of normal cellular metabolism that can be defined as an atom or molecules containing one or more unpaired electrons in its atomic or molecular orbitals. Reactive oxygen species (ROS) represent the most important class of radical species generated in living systems. They include superoxide ($O_2^{\bullet-}$), peroxyl ($ROO^{\bullet}$), alkoxyl ($RO^{\bullet}$), hydroxyl ($HO^{\bullet}$) and hydrogen peroxide (H_2O_2). ROS can be either deleterious or beneficial, but the excess ROS can damage cellular lipids, proteins and DNA (Valko *et al*., 2007). These pathophysiological conditions can cause violent chronic diseases including cancer, artherosclerosis, stroke, rheumatoid arthritis, neurodegeneration and diabetes (Fang, Yang, and Wu, 2002).

Upon TLC screening assay, the ethyl acetate extract of *A. lakoocha* exhibited free radical scavenging activity. Isolated compounds from the extract were first tested at 100 μg/ml. Compounds exhibiting more than 50% DPPH reduction were further evaluated for their IC_{50} values. Quercetin was employed as positive control. The results are summarized in Table 9.

Table 9 Percentage of DPPH reduction by compounds isolated from *A. lakoocha* root bark

Compounds	% DPPH reduction at 100 μg/ml	IC_{50} (μM)
Artolakoochol [**338**]	93.0	6.8
Cycloartolakoochol [**339**]	84.9	8.2
4-Hydroxyartolakoochol [**340**]	86.6	3.9
5,7,2′,4′,-Tetrahydroxy-3-prenyl-6-geranylflavone [**341**]	87.1	45.0
Cudraflavone C [**34**]	83.7	68.5
Quercetin*	96.4	2.0

* positive control

As shown in table 9, five pure compounds were tested for their free radical scavenging activity. It can be seen that all compounds exhibited DPPH scavenging activity. The most active compound was 4-hydroxyartolakoochol [**340**], but its activity was lower than that of the positive control quercetin.

3. Tyrosinase inhibitory activity

Tyrosinase is a copper monooxygenase enzyme widely distributed in nature. It has been found in plants, fungi, insects and animals. A number of physiological functions of this enzyme have been studied (Gelder *et al*., 1997). Tyrosinase is one of the important key enzymes involved in the molting process of insects (Kubo, Yokokawa and Kinst-Hori, 1995). A search for its inhibitors may therefore lead to discovery of insect control agents. In plants, tyrosinase has been found to be responsible for browning in fruits and vegetables. In mammals and humans, the biosynthesis of melanin has been studied intensively by Raper, and subsequently by Manson (Britton, 1983), which led to the proposal of Raper-Manson scheme of melanogenesis and the function of tyrosinase in the biosynthesis of the skin pigment melanin is well-established (Gelder *et al*., 1997). Thus, the study of tyrosinase inhibitors should be useful for the treatment of localized hyperpigmentation in human. Moreover, tyrosinase inhibitors are becoming more popular in the development of cosmetic products (Kubo *et al*., 1995).

In this study, the tyrosinase inhibitory activity of each pure compound and each crude extract was determined by the dopachrome method modified from the procedures described by Masamoto (Masamoto *et al*., 1980), Iida (Iida *et al*., 1995) and Morita (Morita *et al*., 1994). The activity of these compounds was expressed as IC_{50} values (concentration of 50% inhibition) in comparison with oxyresveratrol, a known inhibitor of tyrosinase. The results are summarized in Table 10.

Table 10 Percentage of tyrosinase inhibition by compounds isolated from *A. lakoocha* root bark

Compounds	% tyrosinase reduction at 100 μg/ml	IC_{50} (μM)
Artolakoochol [**338**]	46.4	-
Cycloartolakoochol [**339**]	47.4	-
4-Hydroxyartolakoochol [**340**]	81.9	120.4
5,7,2′,4′,-Tetrahydroxy-3-prenyl-6-geranylflavone [**341**]	10.8	-
Cudraflavone C [**34**]	22.5	-
Oxyresveratrol*	87.8	11.7

* positive control

Among the five pure compounds tested for tyrosinase inhibitory activity, it can be seen that only 4-hydroxyartolakoochol [**340**] showed tyrosinase inhibitory activity, whereas other compounds were devoid of this activity.

4. Anti-herpes simplex activity

Evaluation of anti-herpes simplex activity of all five compounds isolated from the root bark of *A. lakoocha* was performed by the plaque reduction assay (post-treatment and inactivation). Compounds exhibiting more than 50% inhibition without cytotoxicity at 25 μg/ml were further evaluated for their IC_{50} values. Acyclovir was employed as positive control. The results are summarized in Table 11.

Table 11 Percentage of HSV inhibition by isolated compounds from *A. lakoocha* root bark

Compounds	Post-treatment		Inactivation	
	IC_{50} (μM)		IC_{50} (μM)	
	HSV-1	HSV-2	HSV-1	HSV-2
Artolakoochol [**338**]	-	-	-	-
Cycloartolakoochol [**339**]	-	-	-	-
4-Hydroxyartolakoochol [**340**]	-	-	-	-
5,7,2′,4′,-Tetrahydroxy-3-prenyl - 6-geranylflavone [**341**]	22.5	22.5	22.5	22.5
Cudraflavone C [**34**]	-	-	237.0	237.0
Acyclovir*	2.2	4.4	0.25	2.24

* positive control

As shown above, 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone [**341**] displayed moderate activity against both types of virus in the post-treatment and inactivation assays. Cudraflvone C [**34**] showed weak activity against both types of herpes simplex virus in the inactivation assay. Other compounds were devoid of this activity as compared with acyclovir.

CHAPTER V

CONCLUSION

In this study, a chemical investigation focusing on the root bark of *Artocarpus lakoocha* was undertaken, and this led to the isolation of three new prenylated 2-arylbenzofurans, namely artolakoochol [**338**], cycloartolakoochol [**339**] and 4-hydroxy artolakoochol [**340**] and a new prenylated flavone 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone [**341**] together with the known compound, cudraflavone C [**34**]. The isolated compounds were evaluated for their free radical scavenging, antityrosinase and antiherpetic activities.

Artolakoochol, cycloartolakoochol and 4-hydroxy artolakoochol showed potent free radical scavenging activity, while the other compounds were moderately active. Furthermore, 4-hydroxyartolakoochol exhibited weak tyrosinase inhibitory activity. The prenylated flavones, 5,7,2′,4′,-tetrahydroxy-3-prenyl-6-geranylflavone and cudraflavone C, were active against herpes simplex virus (HSV-1 and HSV-2). 5,7,2′,4′,-Tetrahydroxy-3-prenyl-6-geranylflavone exhibited moderate activity against both types of herpes simplex virus in the inactivation and post-treatment assays, while cudraflavone C showed weak activity against both types of virus in the inactivation assay only. These bioactive compounds from *A. lakoocha* provide possibilities for application in medicine and cosmetics.

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APPENDIX

High resolution report

Acquisition Date 2/19/2010 11:21:08 AM

Analysis Name D:\Data\customer
Method NaFormate_pos_infusion.m

Operator Sutichai Ext: 3560
Instrument micrOTOF Bruker
Calibrate by Sodium Formate

Acquisition Parameter

Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	1.0 Bar
Focus	Not active			Set Dry Heater	150 °C
Scan Begin	100 m/z	Set Capillary	4000 V	Set Dry Gas	6.0 l/min
Scan End	1000 m/z	Set End Plate Offset	-500 V	Set Divert Valve	Source

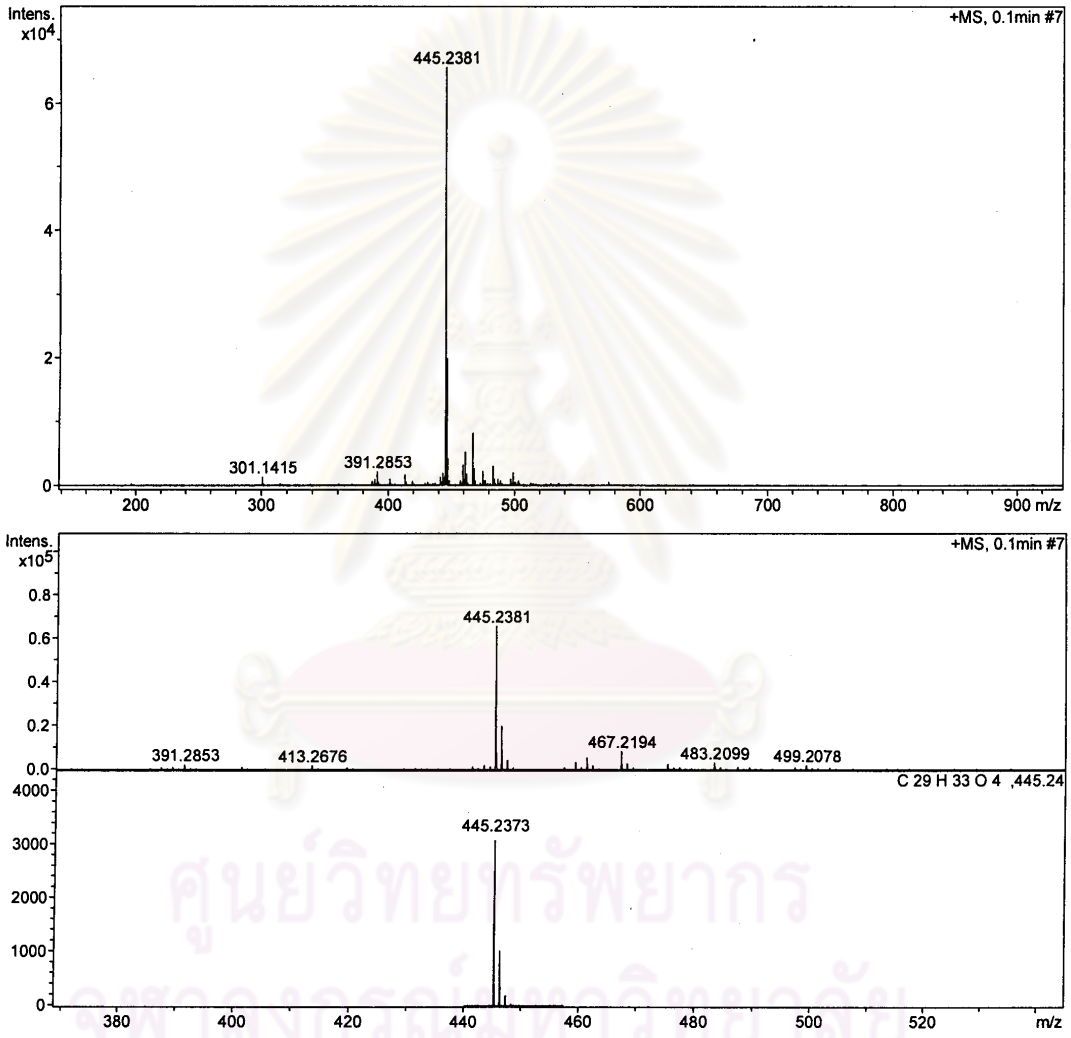

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Figure 9 HRESI Mass Spectrum of compound AL1

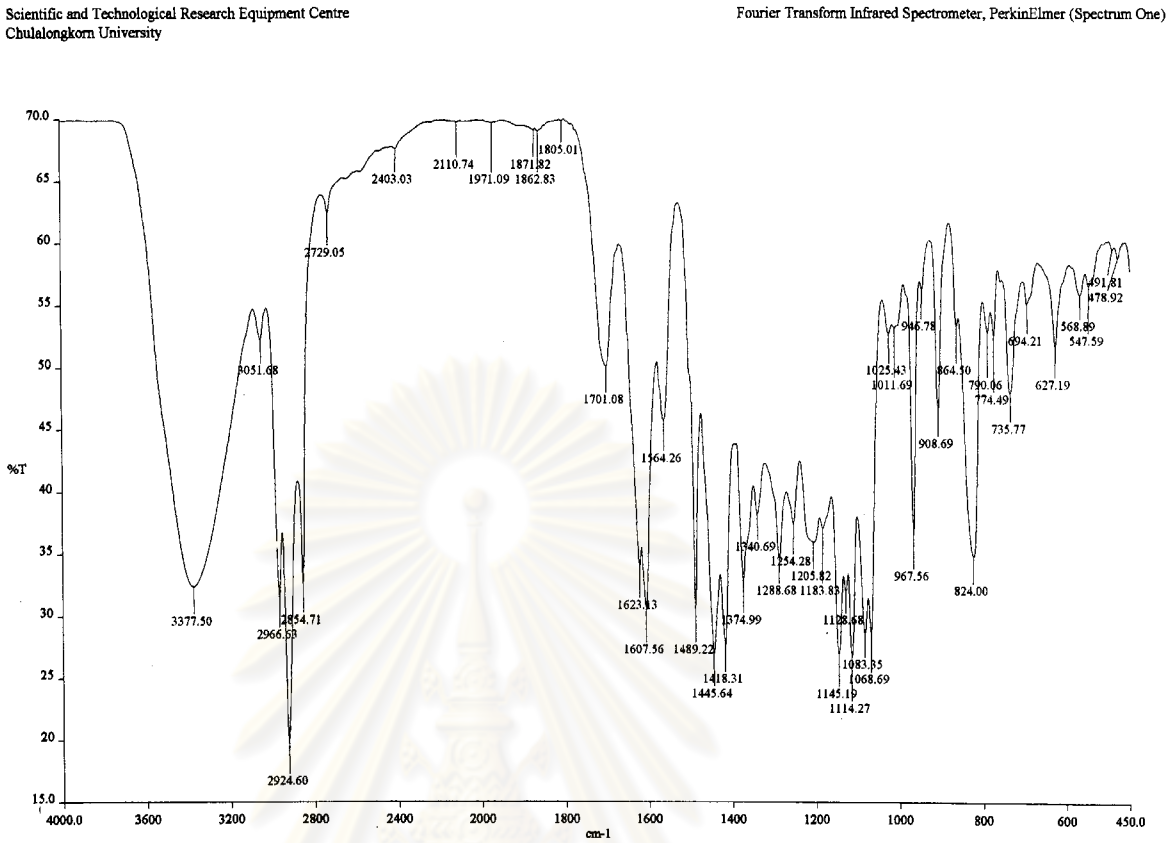


Figure 10 IR Spectrum of compound AL1 (film)

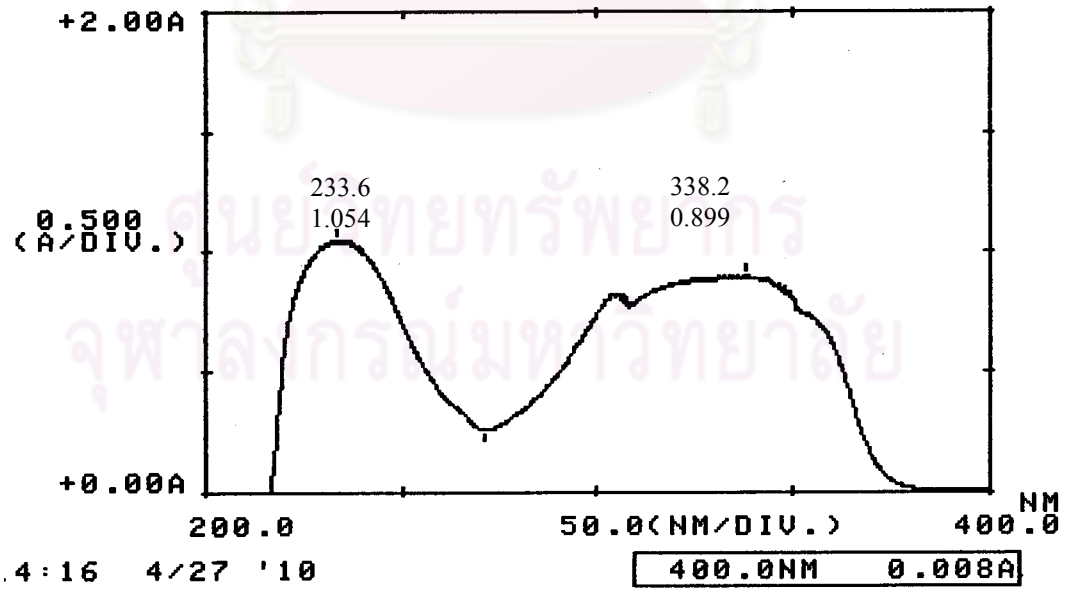


Figure 11 UV Spectrum of compound AL1 (methanol)

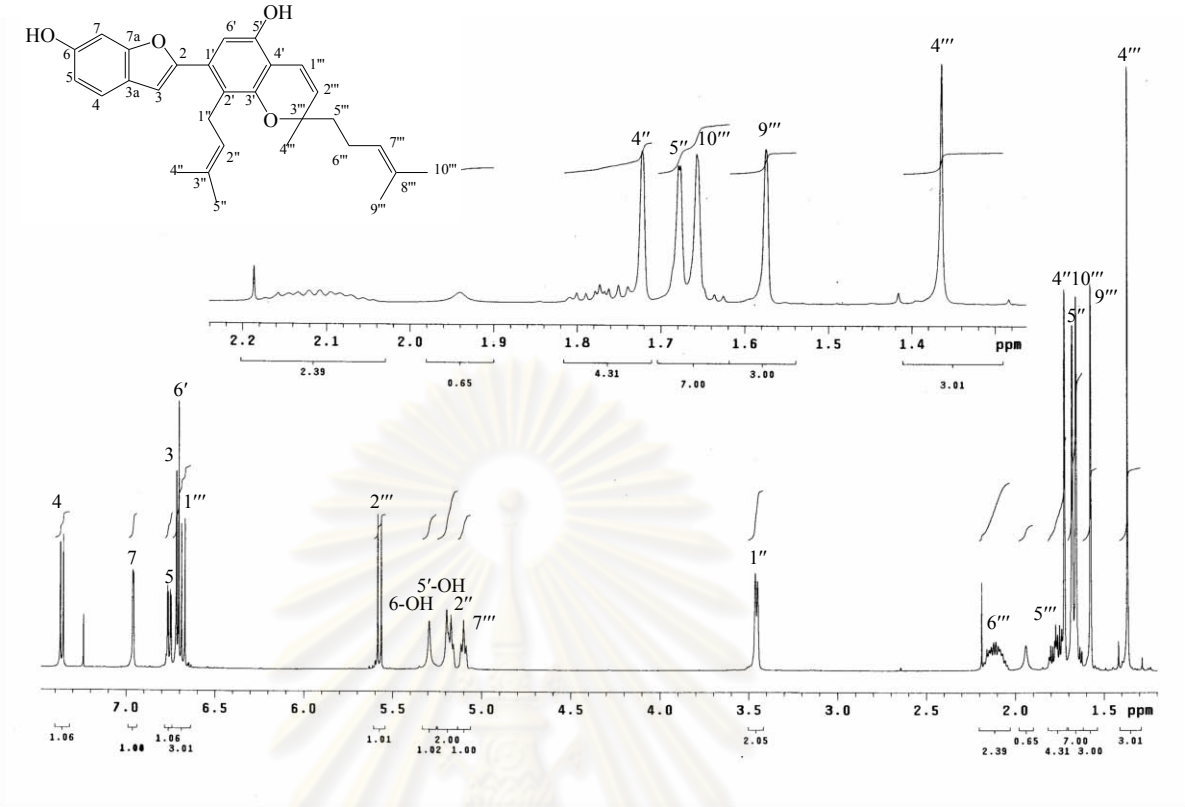


Figure 12 ^{1}H-NMR (500 MHz) Spectrum of compound AL1 ($CDCl_3$)

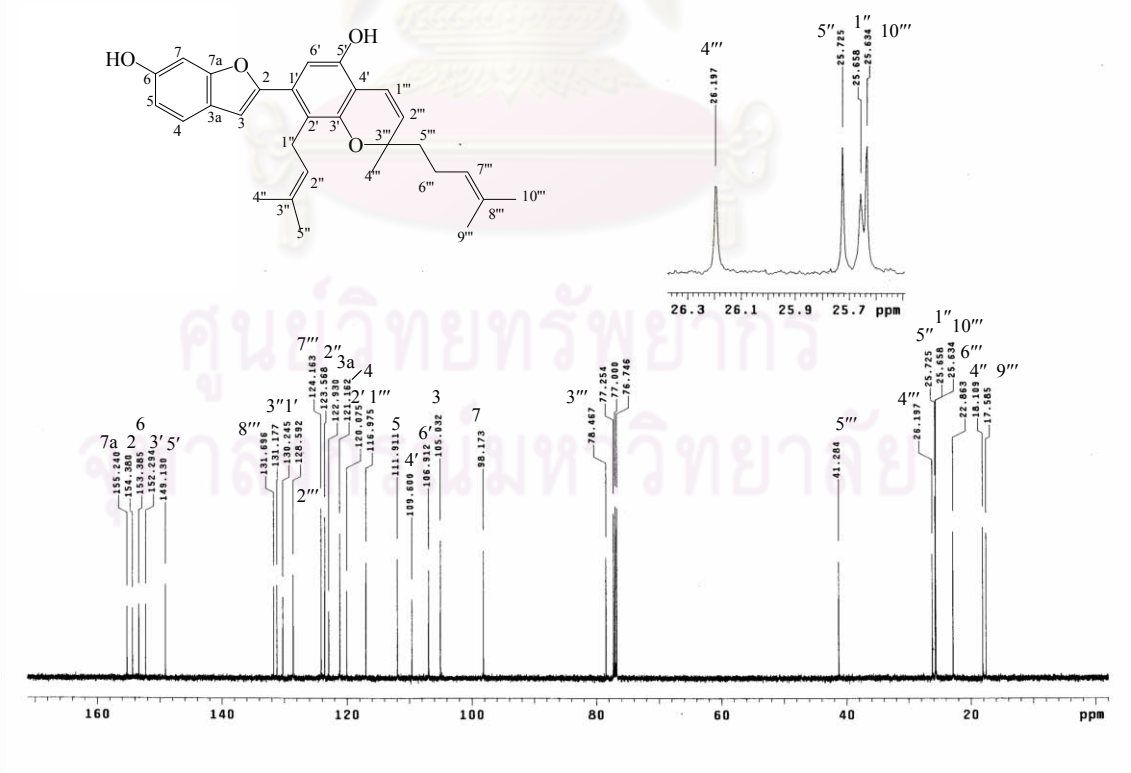


Figure 13 ^{13}C-NMR (125 MHz) Spectrum of compound AL1 ($CDCl_3$)

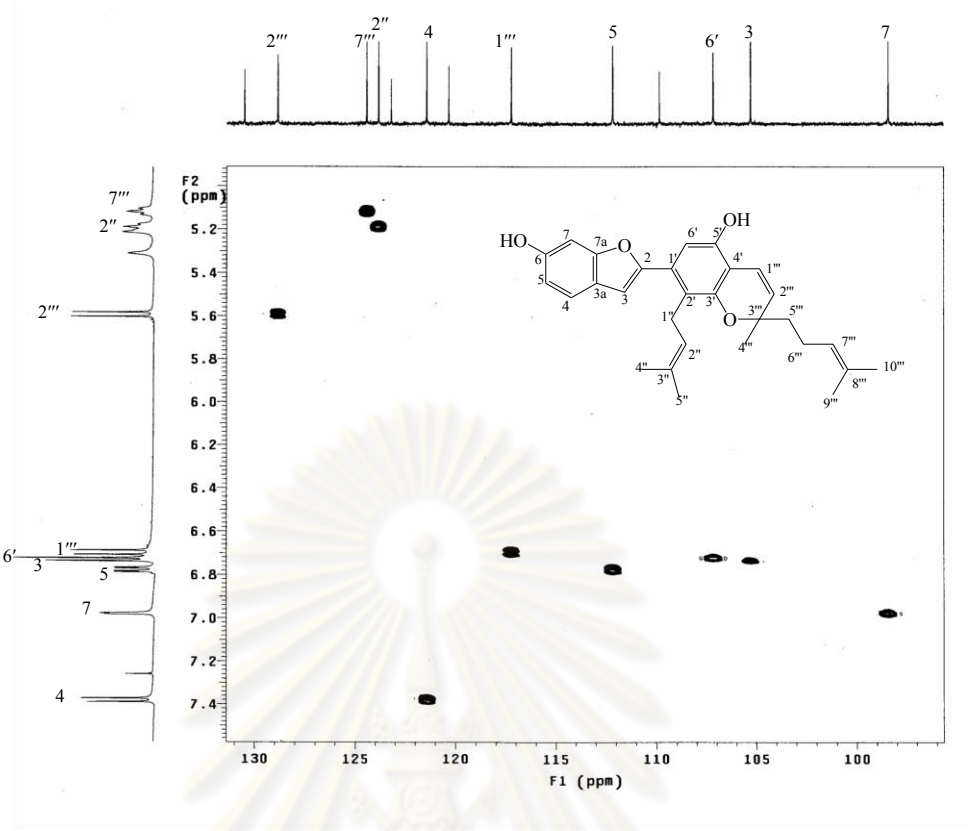


Figure 14 HSQC Spectrum of compound AL1 ($CDCl_3$)

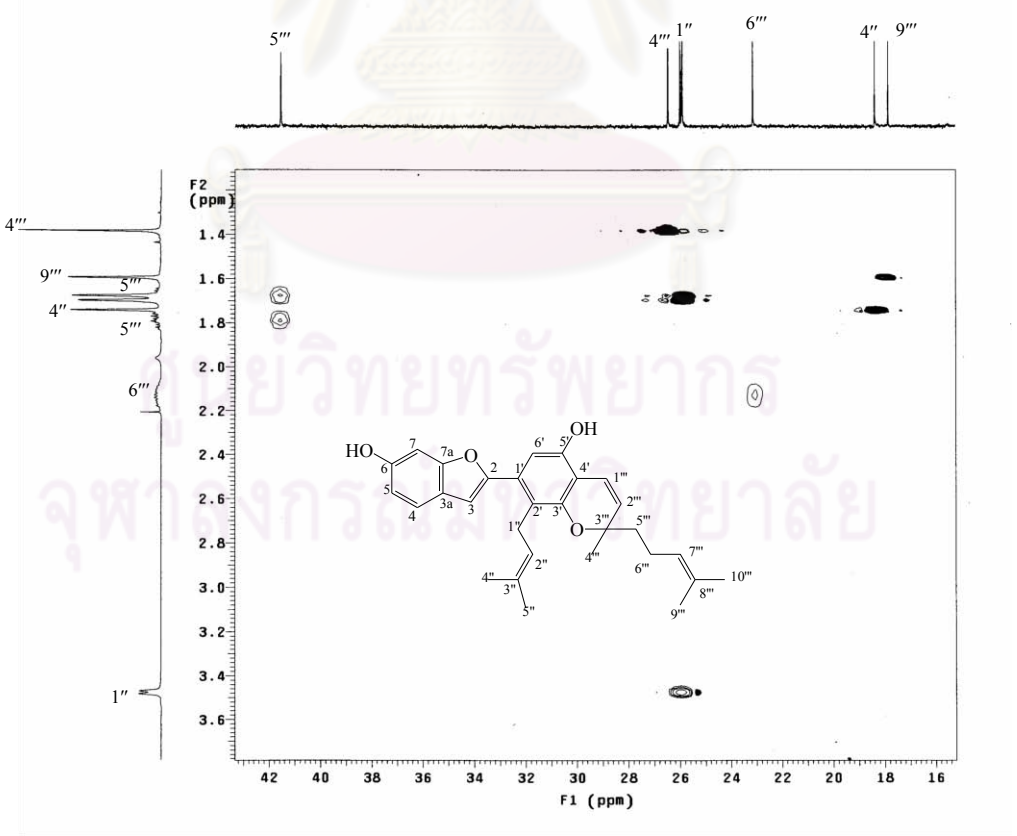


Figure 15 HSQC Spectrum of compound AL1 ($CDCl_3$)

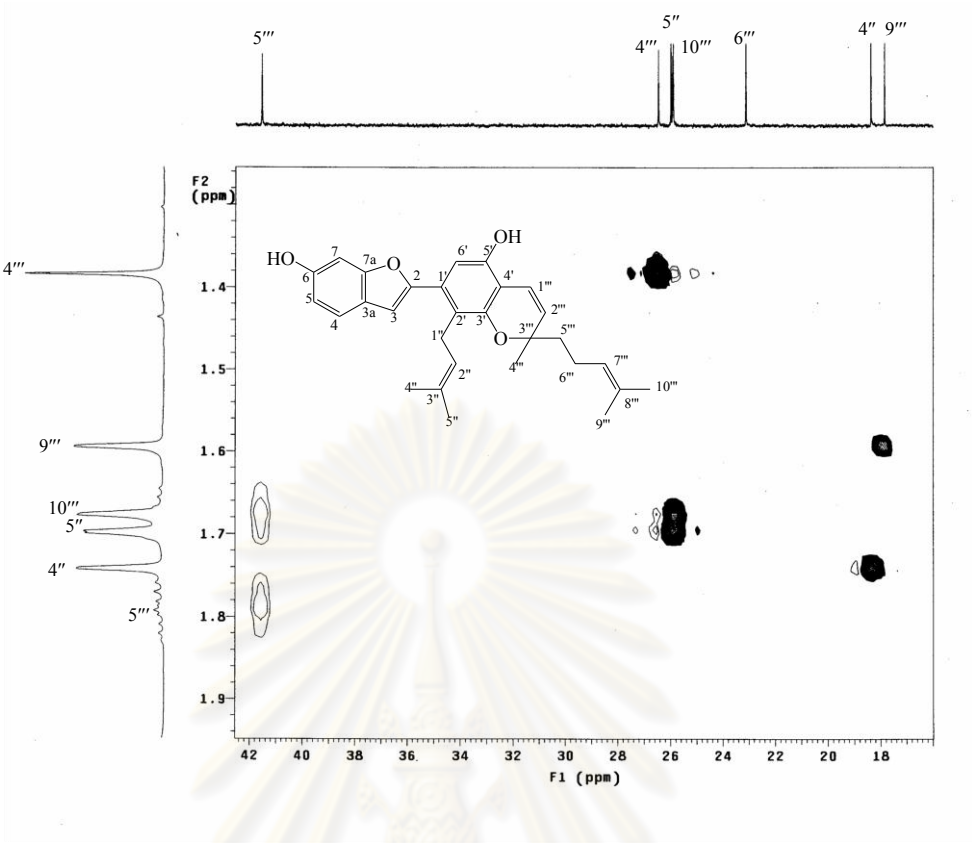


Figure 16 HSQC Spectrum of compound AL1 ($CDCl_3$)

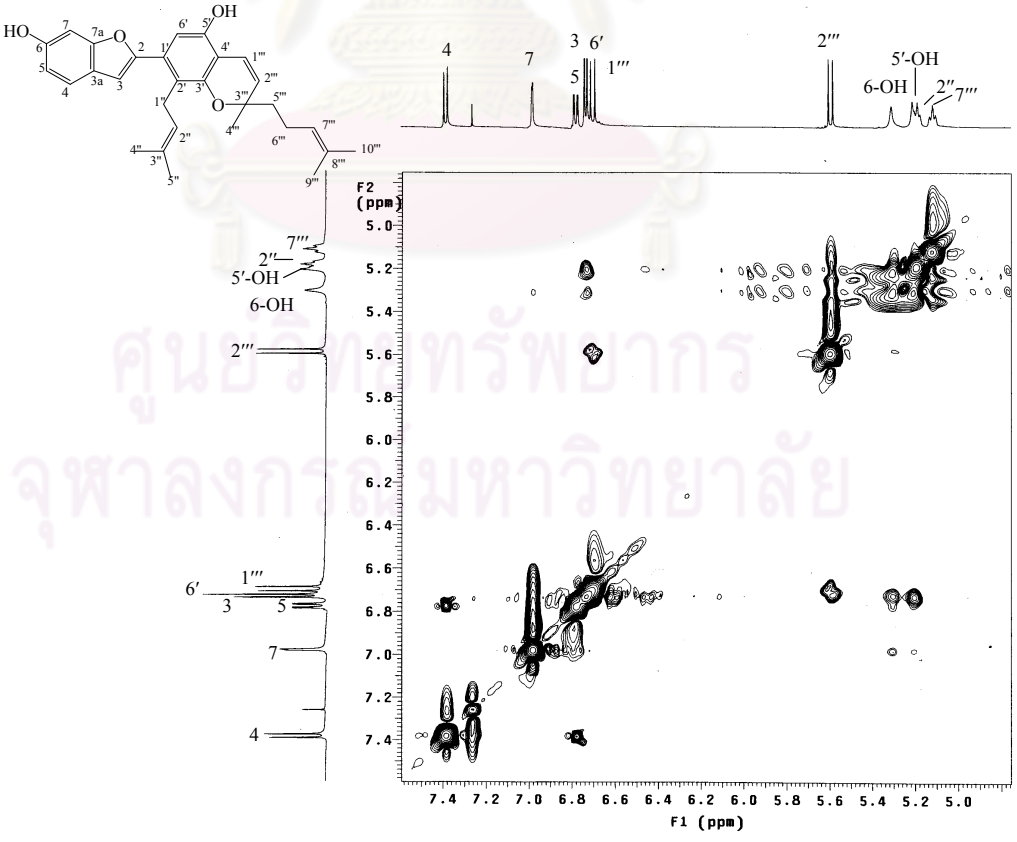


Figure 17 NOESY Spectrum of compound AL1 ($CDCl_3$)

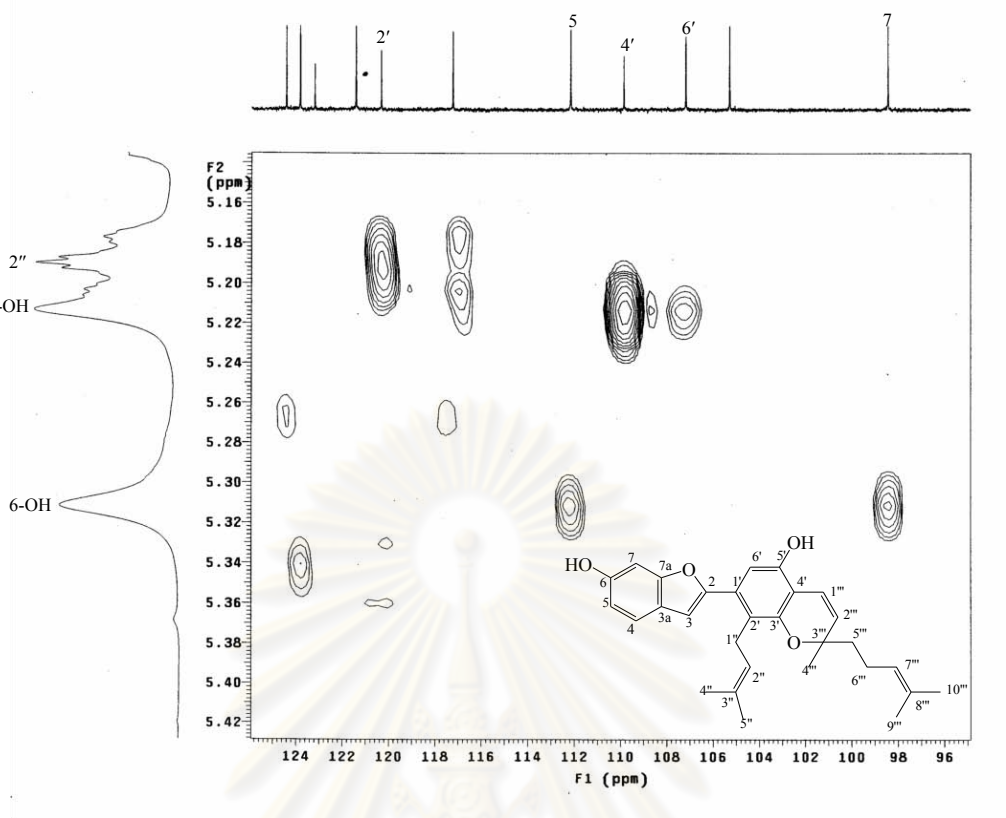


Figure 18 HMBC Spectrum of compound AL1 ($CDCl_3$)

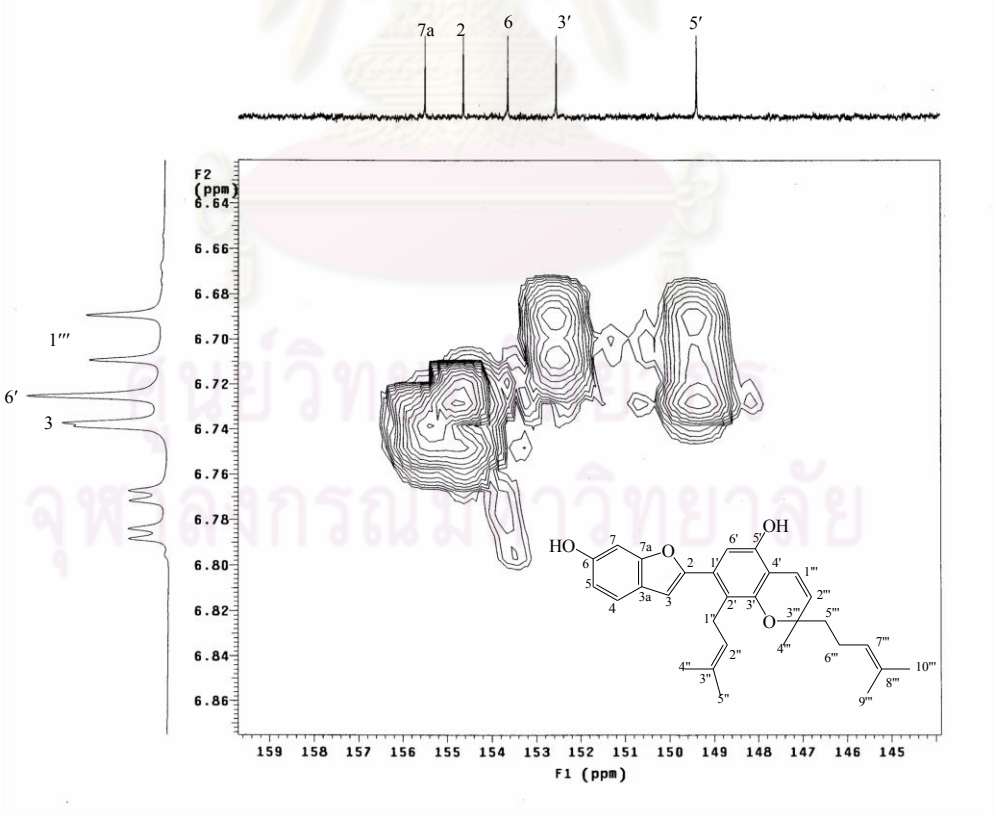


Figure 19 HMBC Spectrum of compound AL1 ($CDCl_3$)

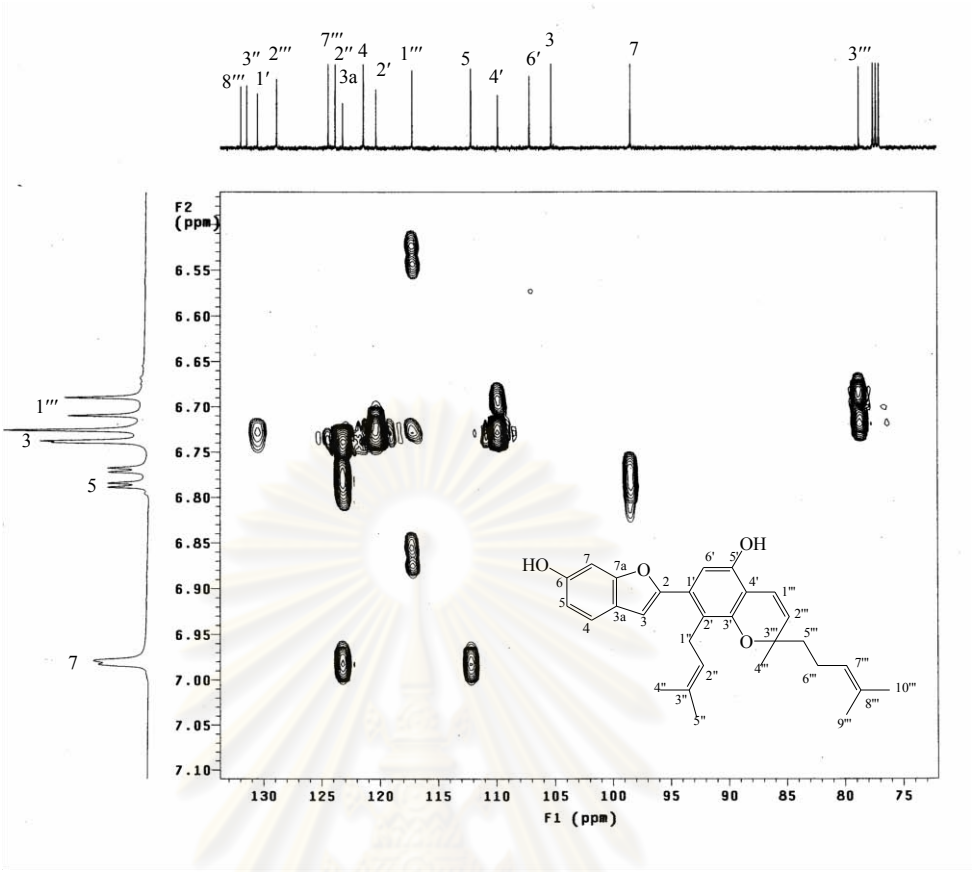


Figure 20 HMBC Spectrum of compound AL1 ($CDCl_3$)

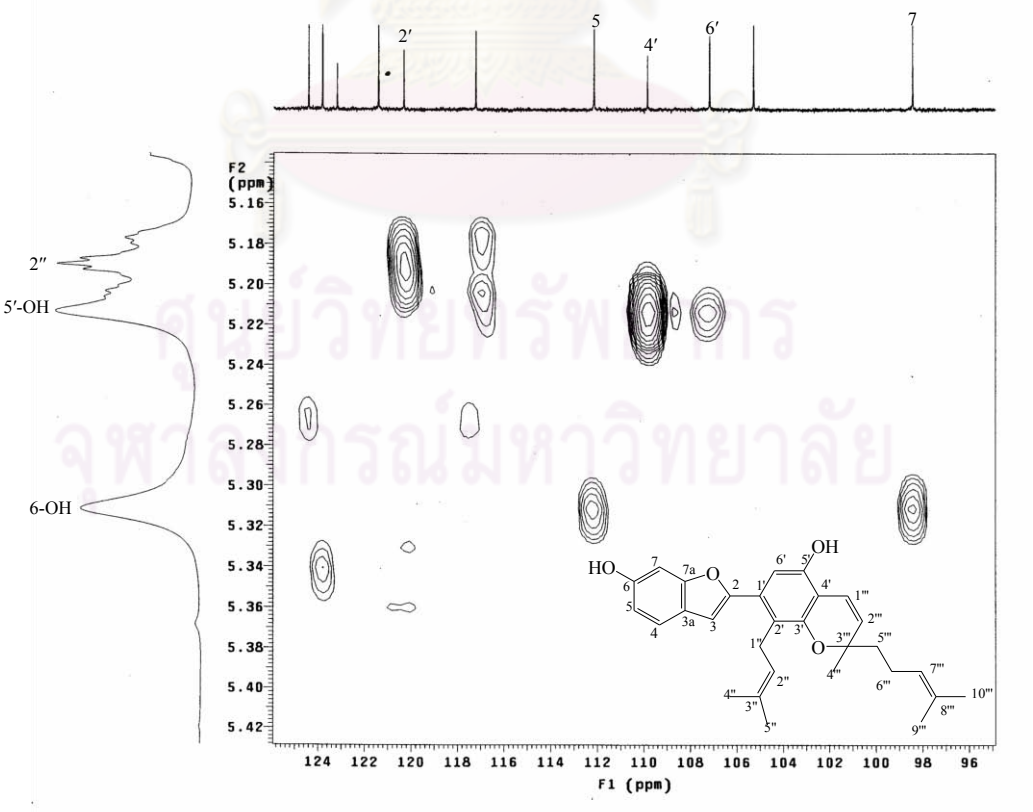


Figure 21 HMBC Spectrum of compound AL1 ($CDCl_3$)

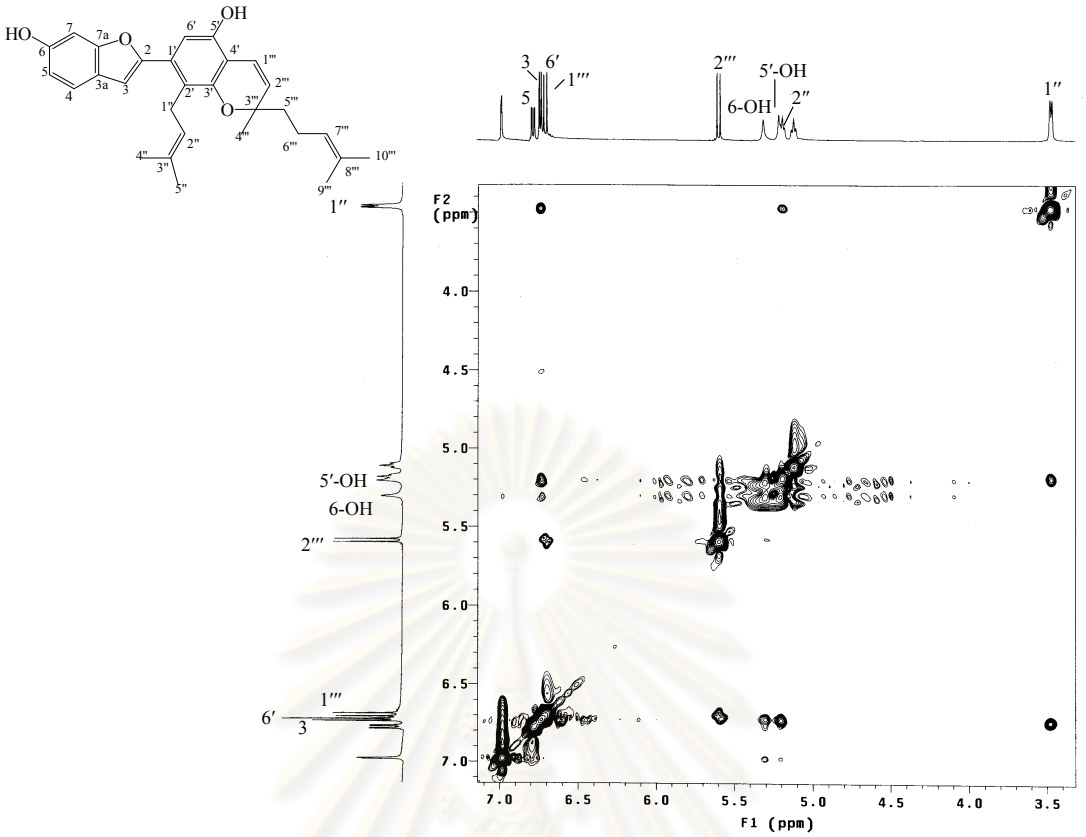


Figure 22 NOESY Spectrum of compound AL1 ($CDCl_3$)

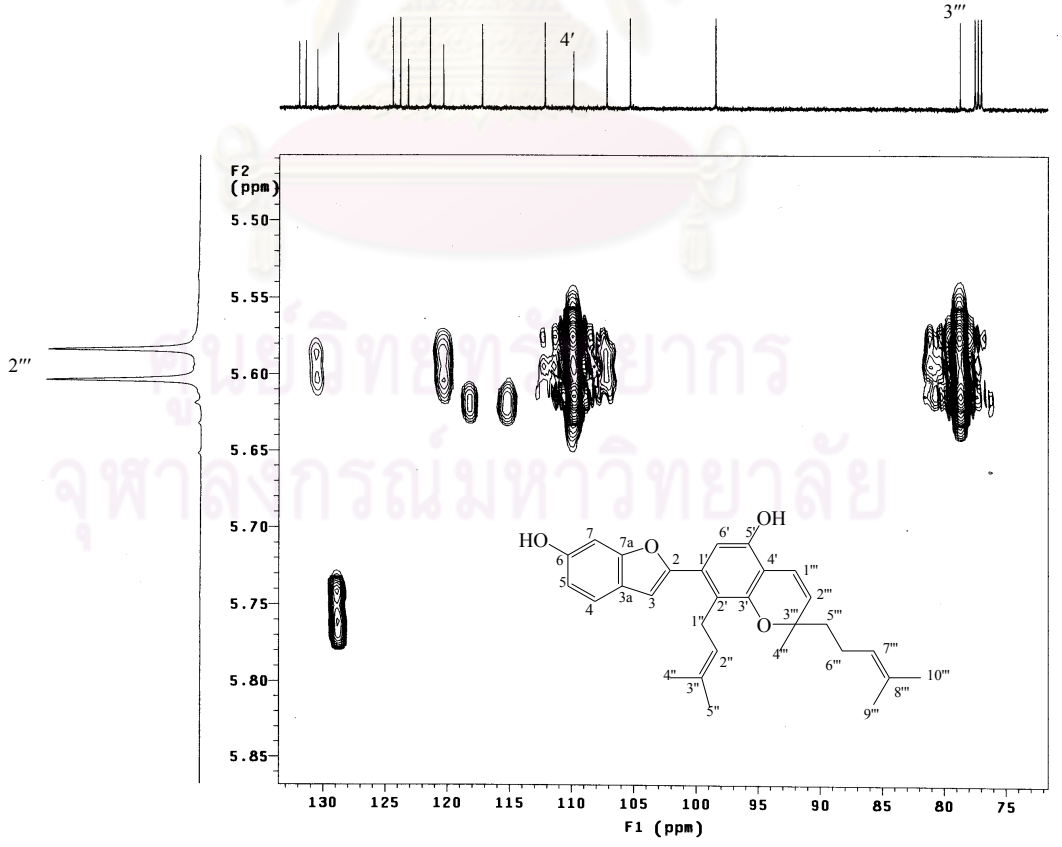
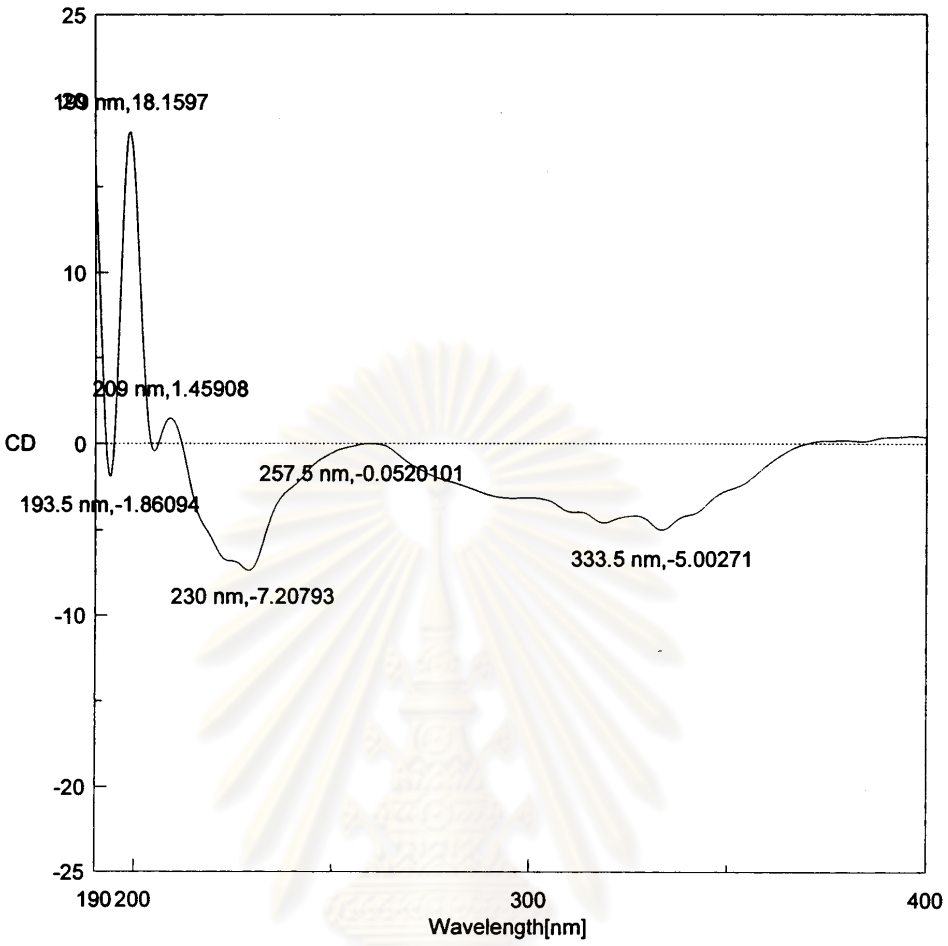


Figure 23 HMBC Spectrum of compound AL1 ($CDCl_3$)



Tris

Cell Length :	0.1 cm
Concentration :	
Solvent :	20mM Tris
Temperature :	Room Temp.
Operator :	Amnart
Organization :	
Comment :	Tris
Data mode :	CD
Ch2-mode :	HT
Range :	400 - 190 nm
Band width :	2.0 nm
Resolution :	0.5 nm
Accumulation :	3
Sensitivity :	20 mdeg
Response :	2 sec
Speed :	50 nm/min

Figure 24 CD Spectrum of compound AL1 (methanol)

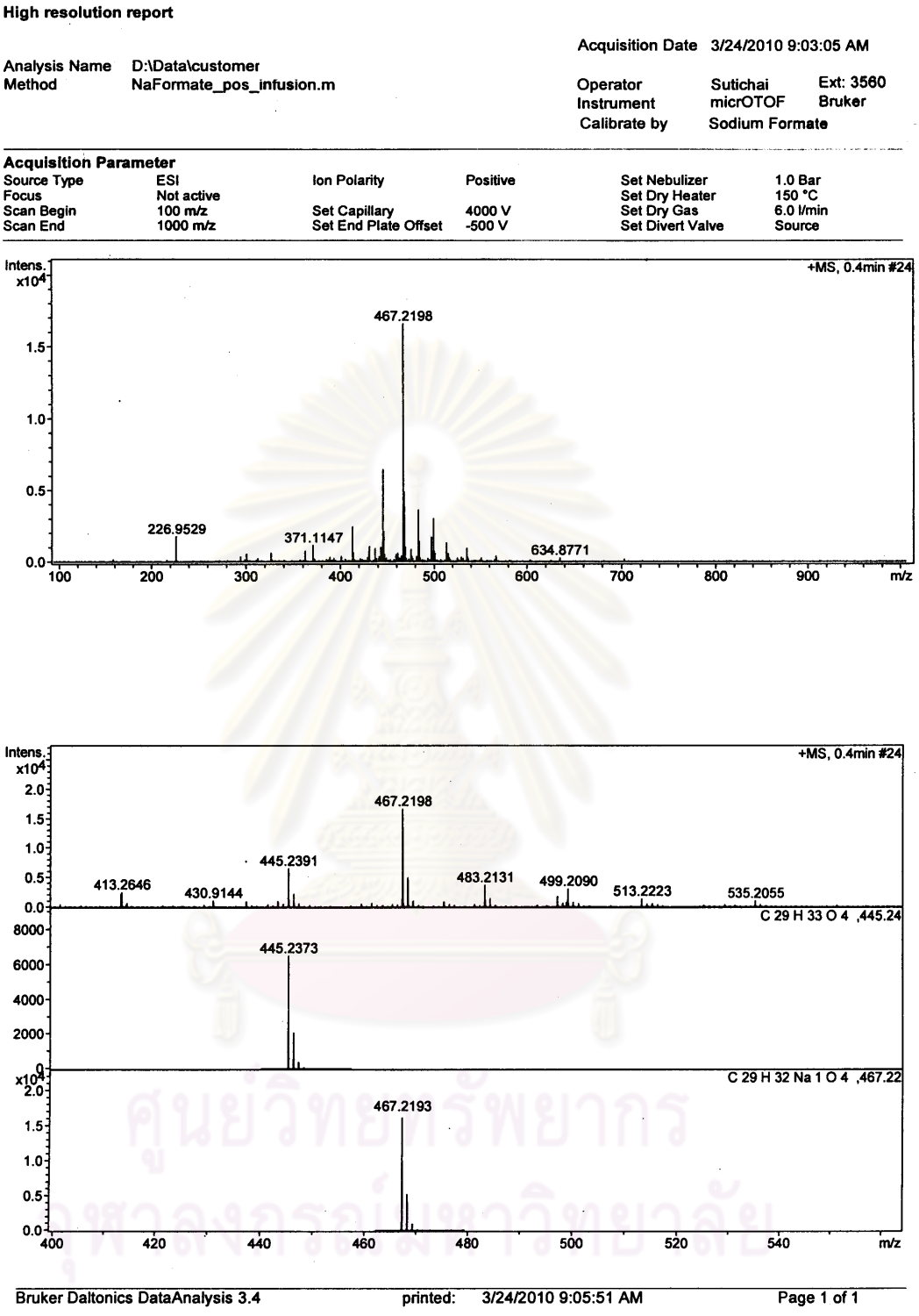


Figure 25 HRESI Mass Spectrum of compound AL2

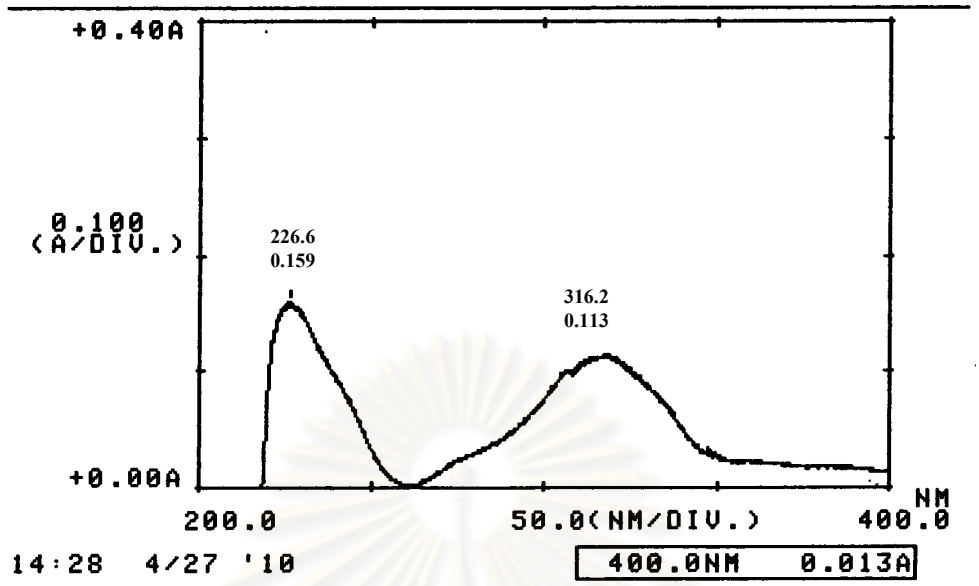


Figure 26 UV Spectrum of compound AL2 (methanol)

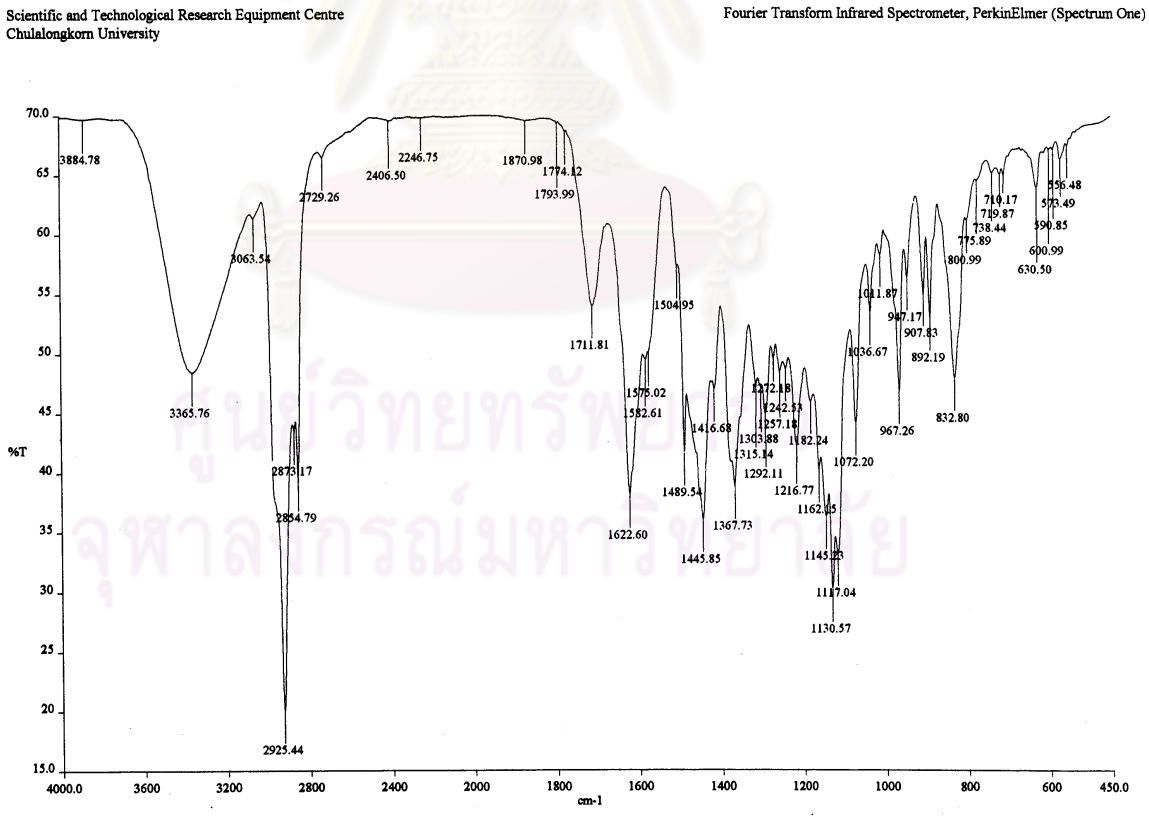


Figure 27 IR Spectrum of compound AL2 (film)

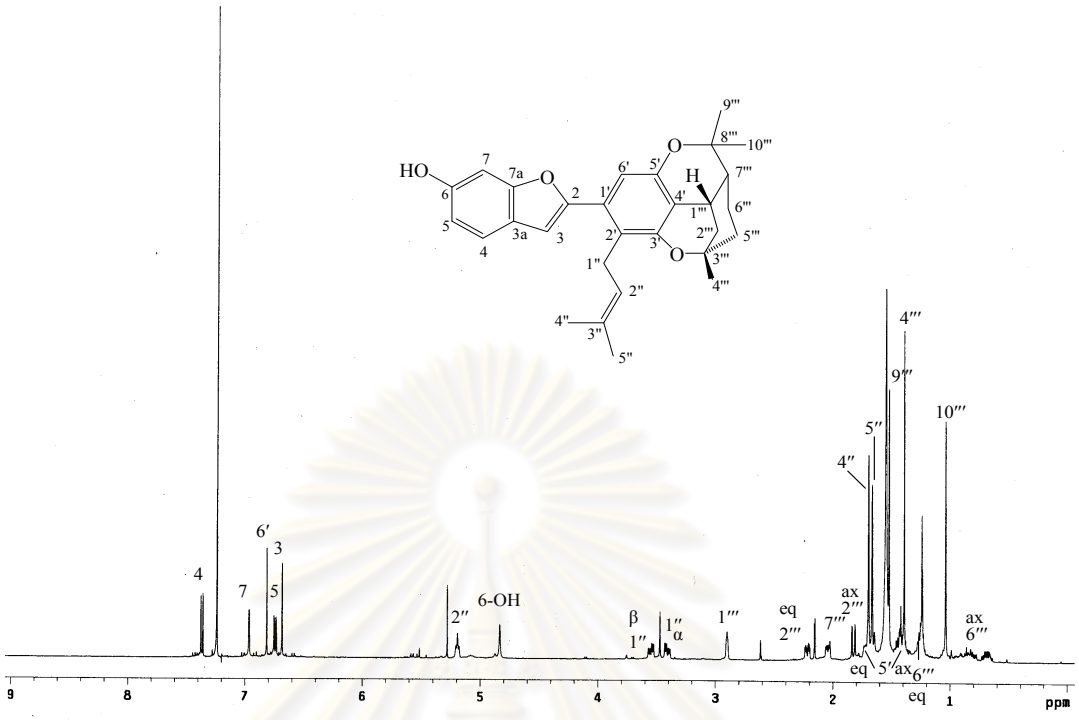


Figure 28 ^{1}H-NMR (500 MHz) Spectrum of compound AL2 ($CDCl_3$)

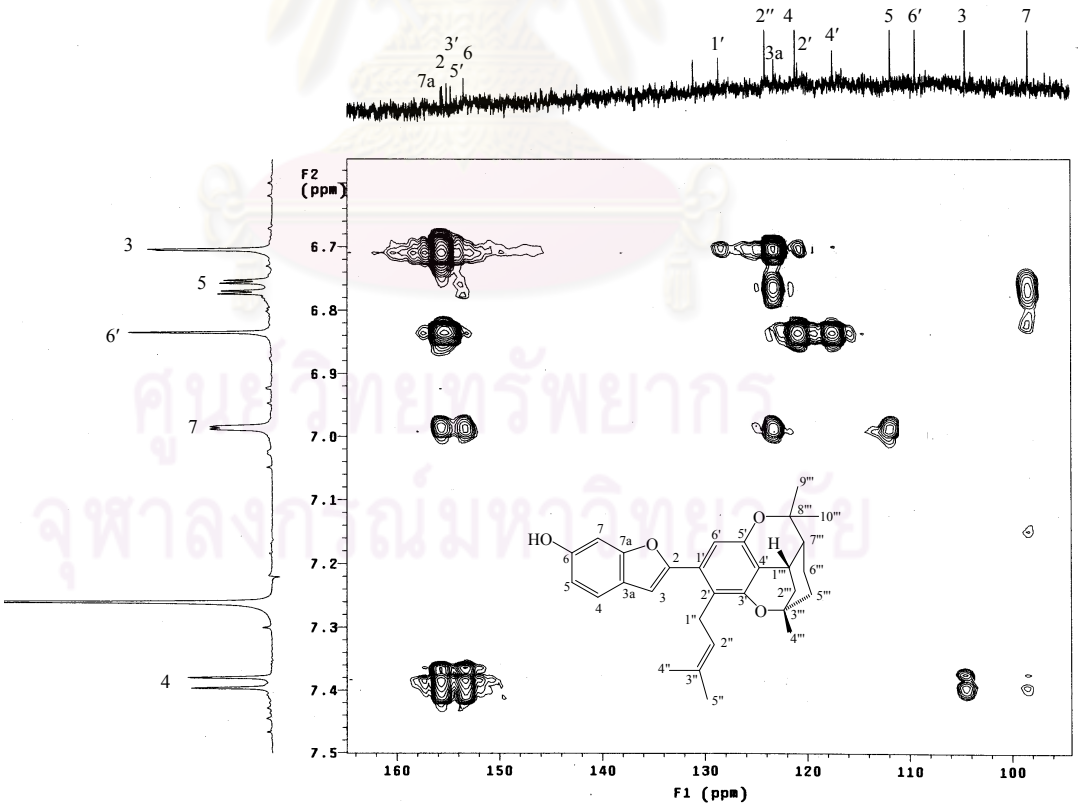


Figure 29 HMBC Spectrum of compound AL2 ($CDCl_3$)

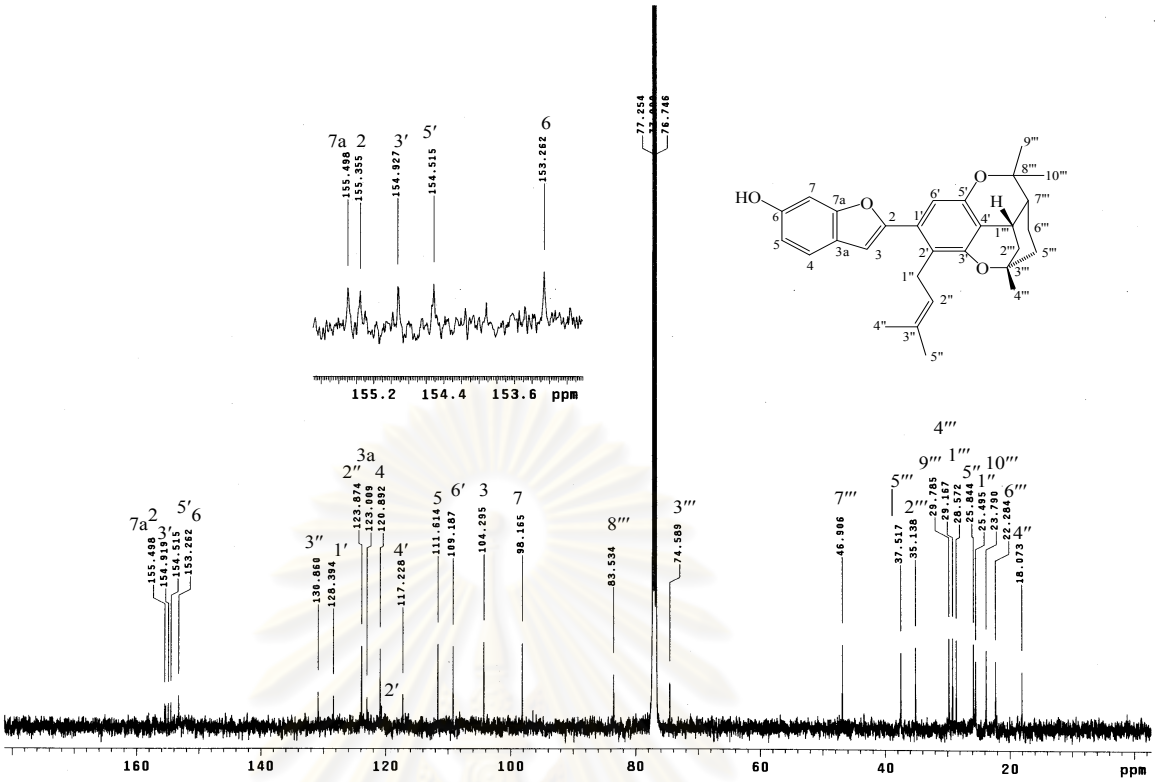


Figure 30 ^{13}C-NMR (125 MHz) Spectrum of compound AL2 ($CDCl_3$)

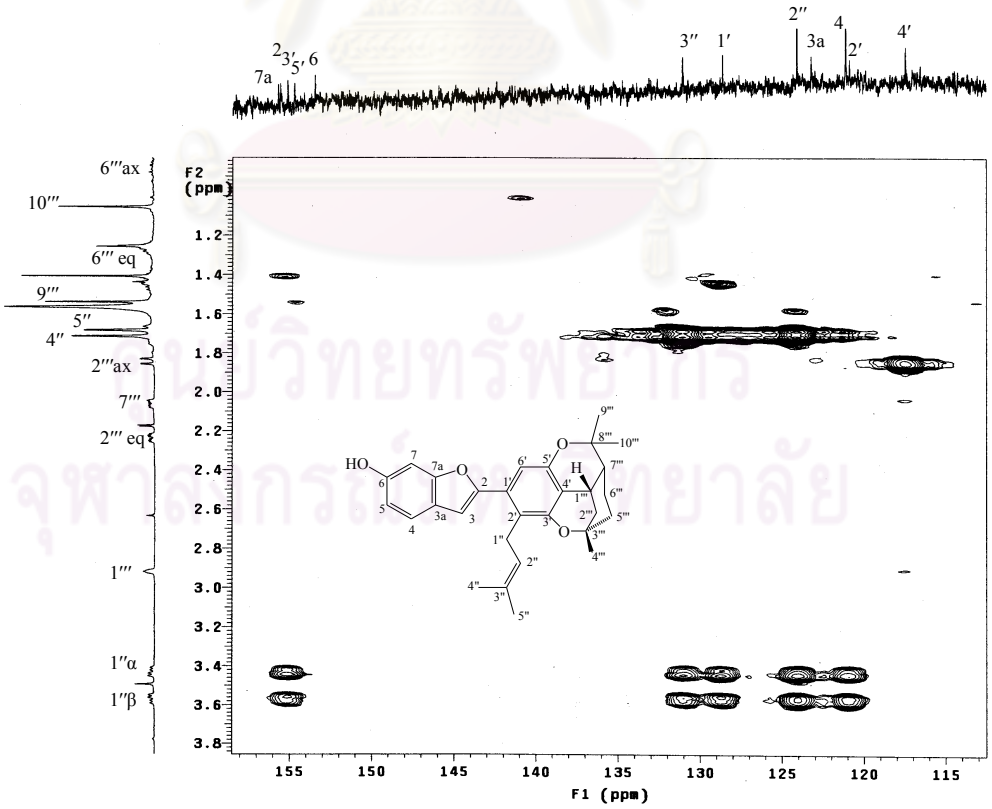


Figure 31 HMBC Spectrum of compound AL2 ($CDCl_3$)

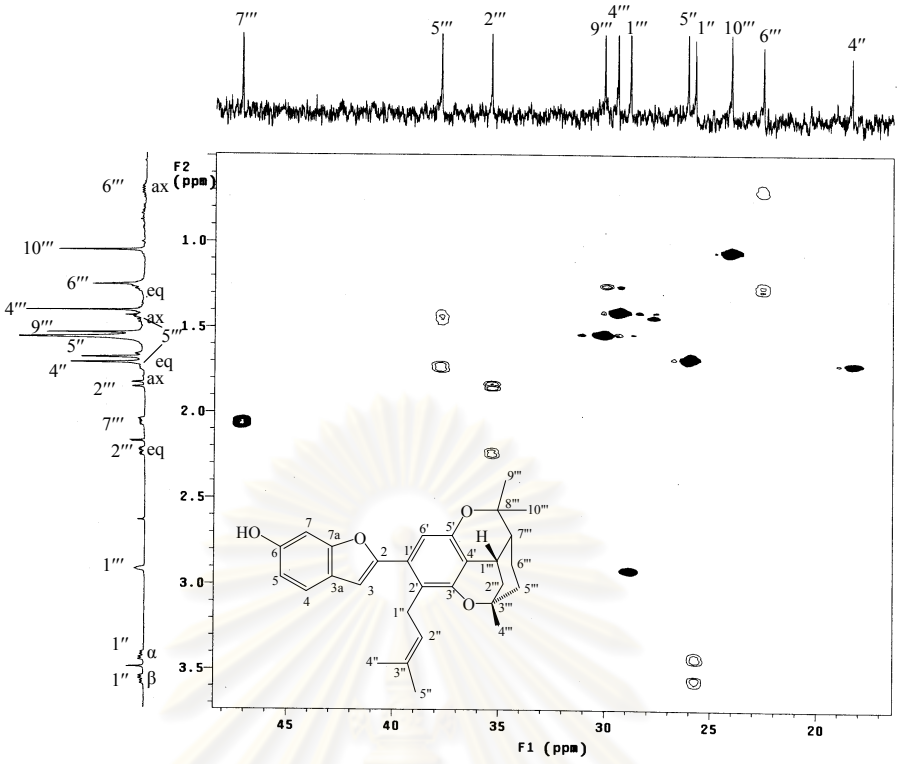


Figure 32 HSQC Spectrum of compound AL2 ($CDCl_3$)

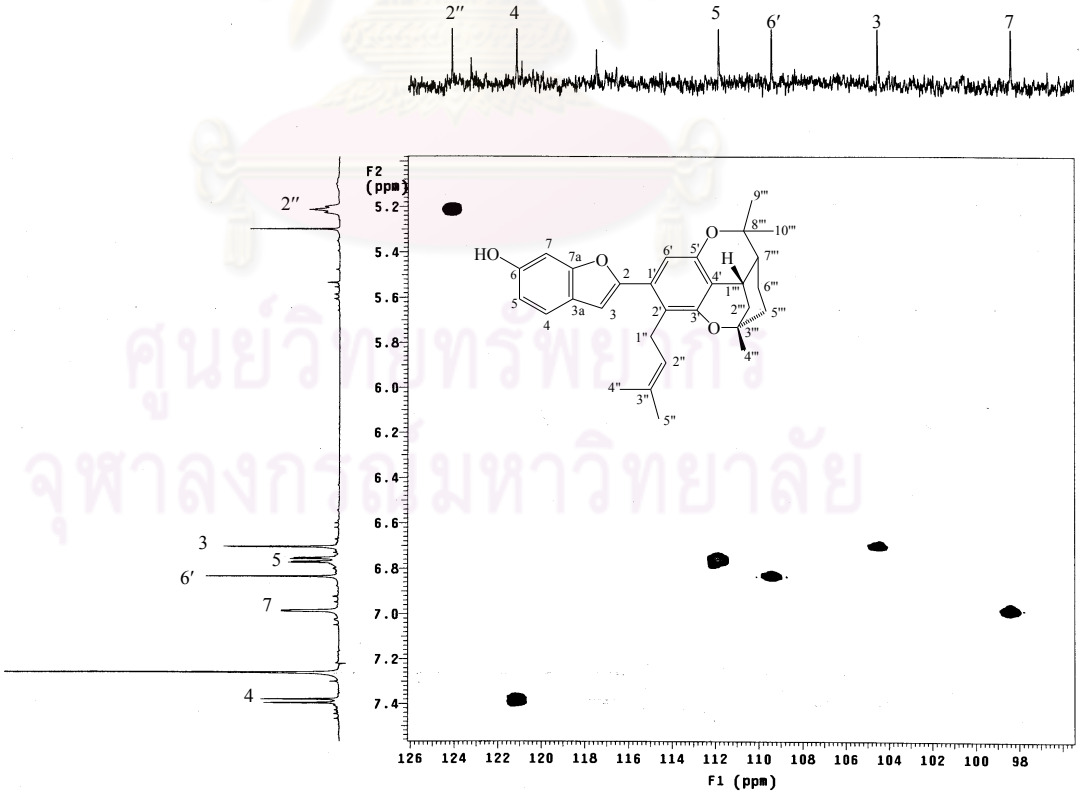


Figure 33 HSQC Spectrum of compound AL2 ($CDCl_3$)

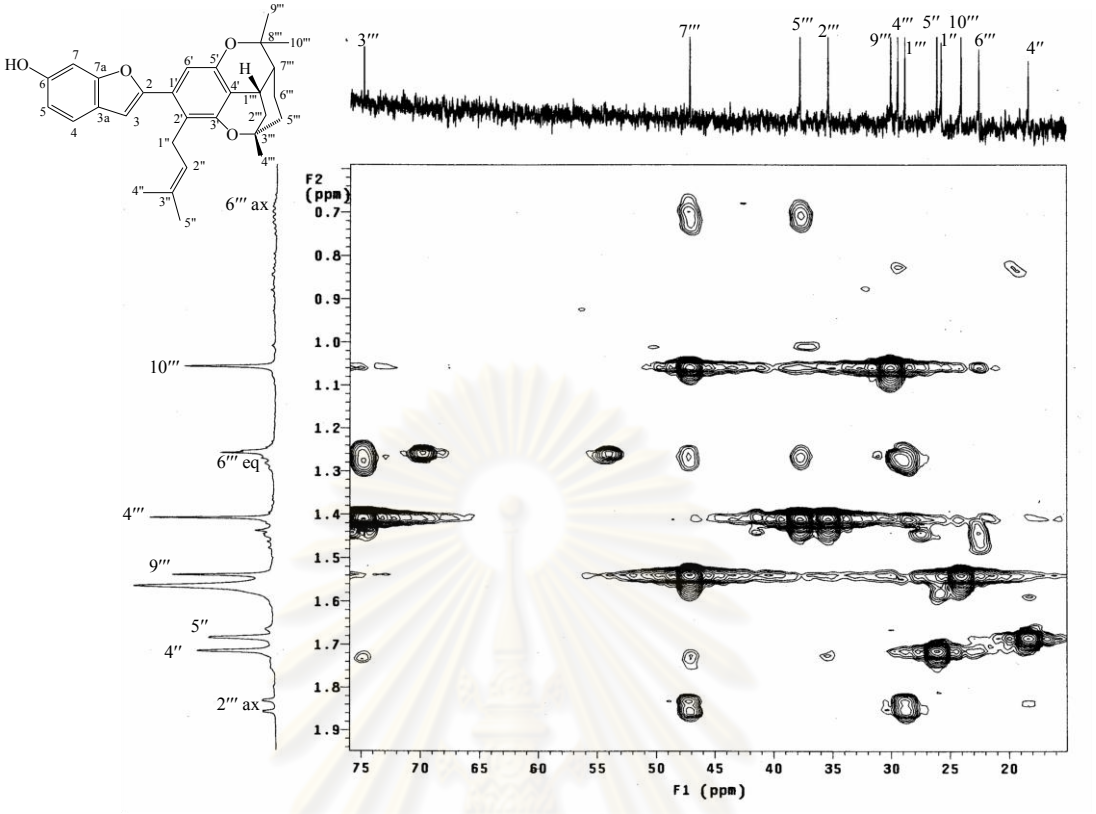


Figure 34 HMBC Spectrum of compound AL2 ($CDCl_3$)

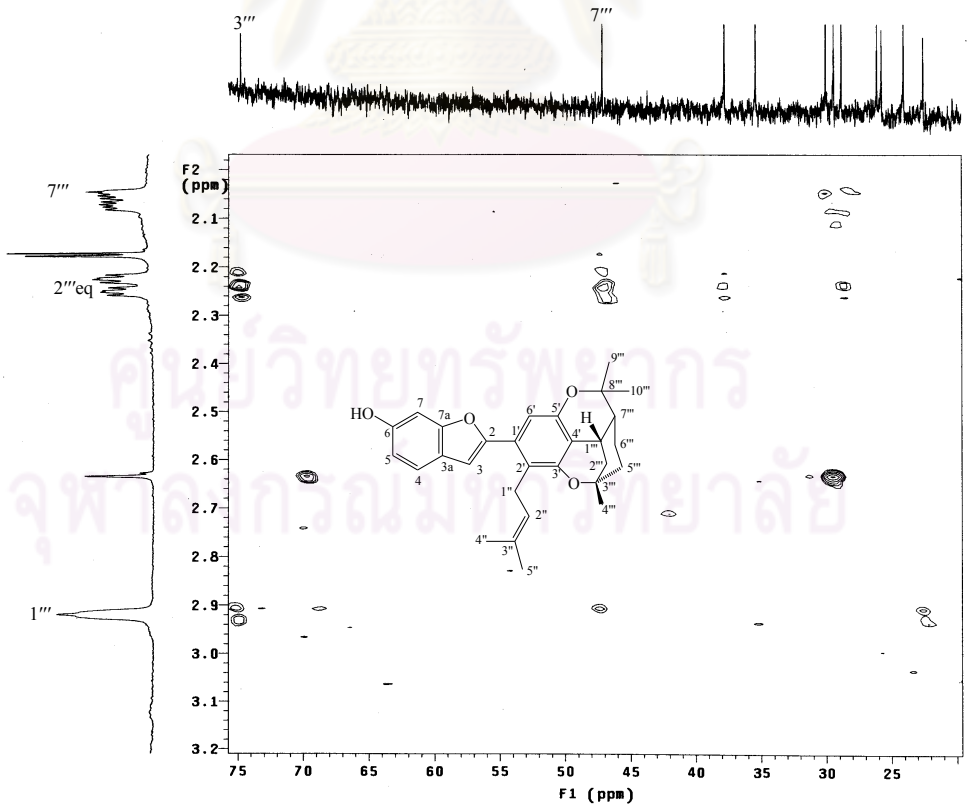


Figure 35 HMBC Spectrum of compound AL2 ($CDCl_3$)

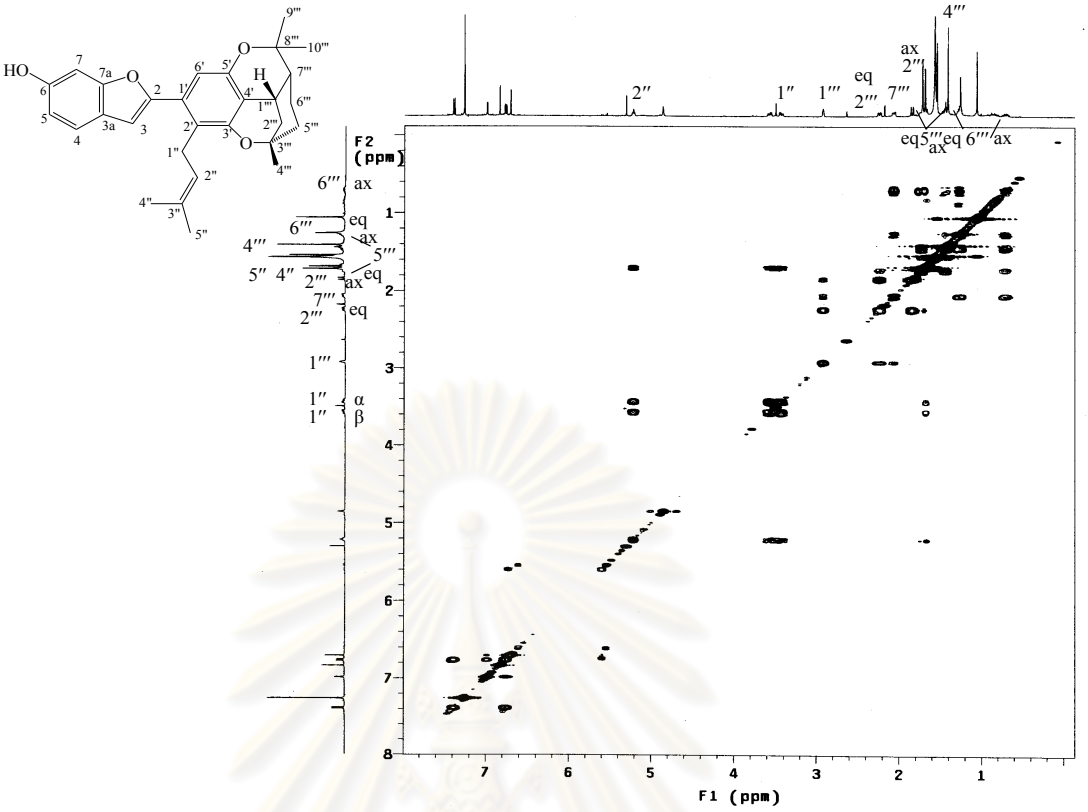


Figure 36 COSY Spectrum of compound AL2 ($CDCl_3$)

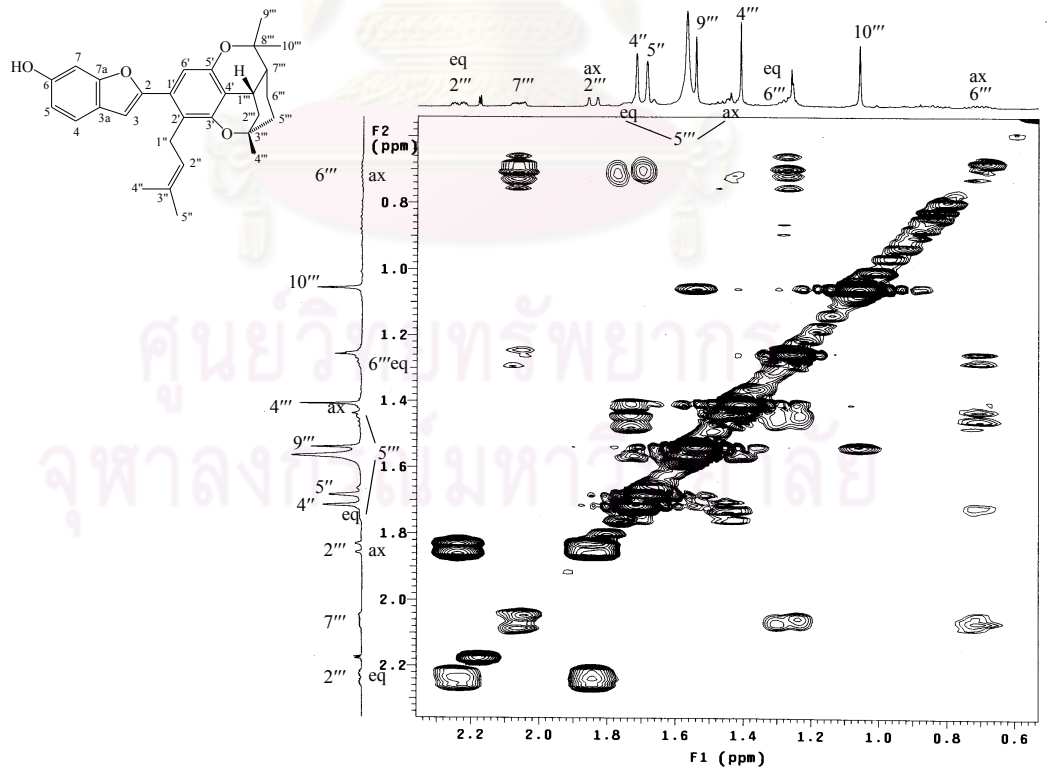


Figure 37 COSY Spectrum of compound AL2 ($CDCl_3$)

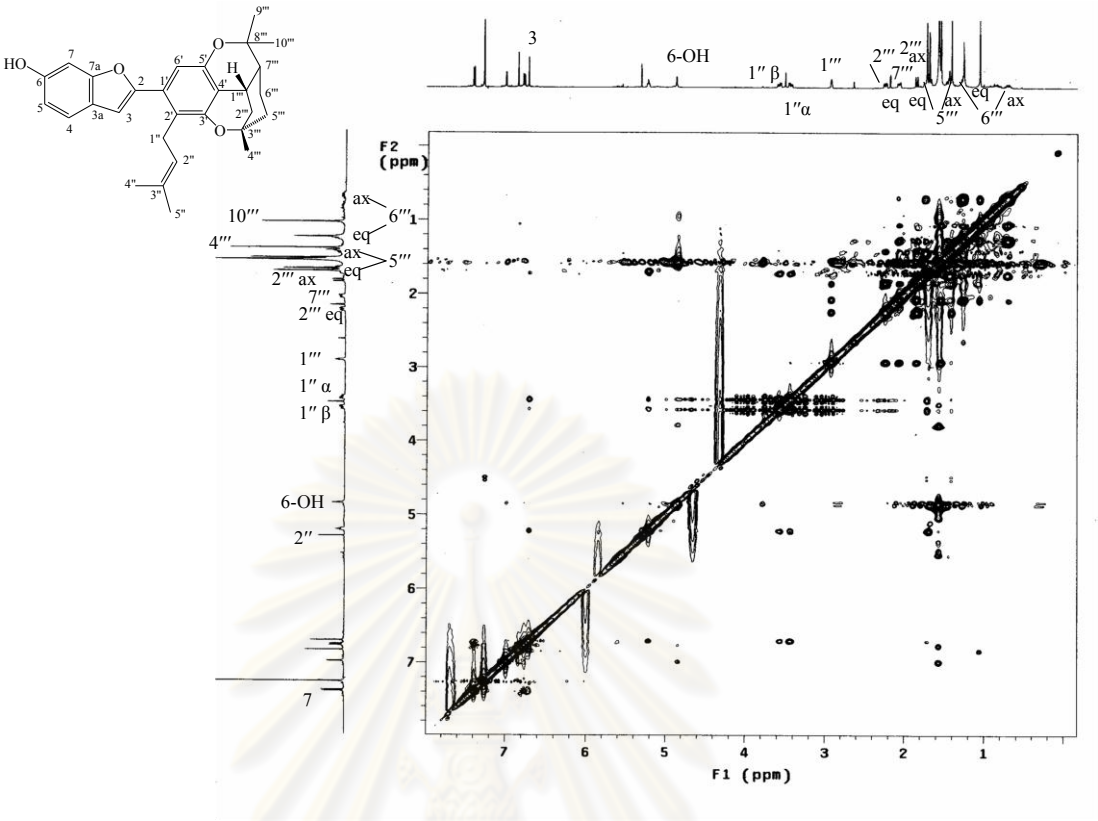


Figure 38 NOESY Spectrum of compound AL2 ($CDCl_3$)

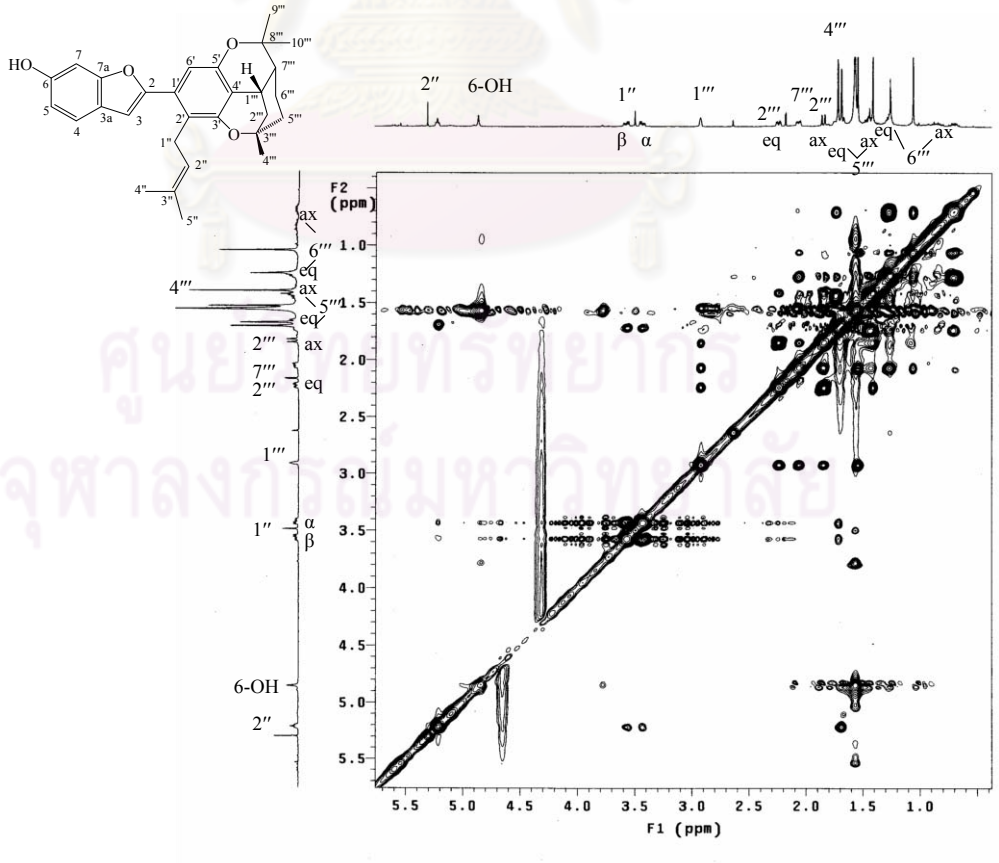
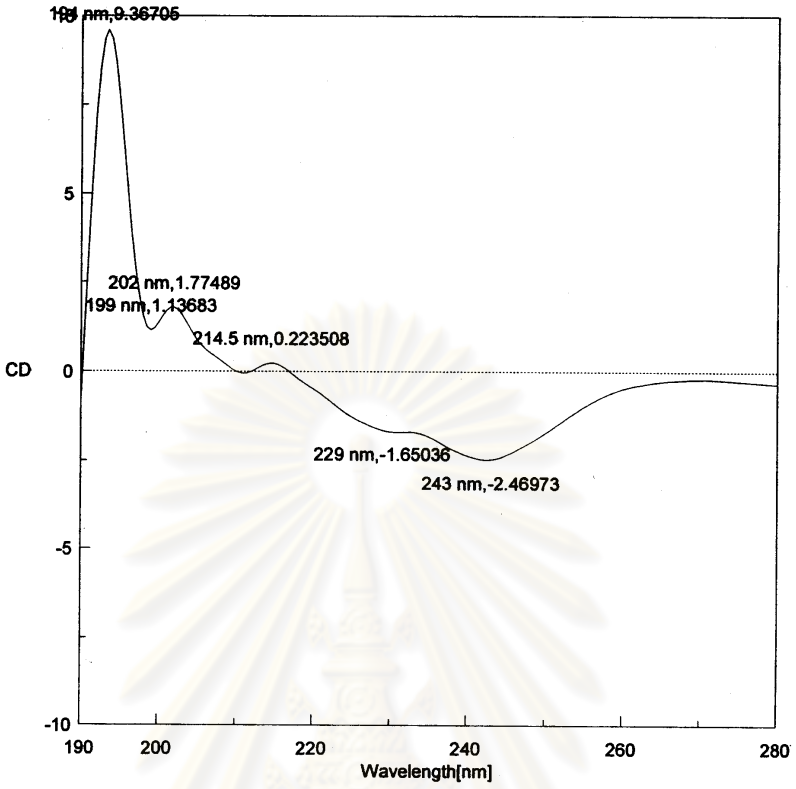


Figure 39 NOESY Spectrum of compound AL2 ($CDCl_3$)



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Cell Length :	0.1 cm
Concentration :	
Solvent :	20mM Tris
Temperature :	Room Temp.
Operator :	Amnart
Organization :	
Comment :	Tris

Data mode :	CD		
Ch2-mode :	HT		
Range :	400 - 190 nm		
Band width :	2.0 nm	Sensitivity :	20 mdeg
Resolution :	0.5 nm	Response :	2 sec
Accumulation :	3	Speed :	50 nm/min

Figure 40 CD Spectrum of compound AL2 (methanol)

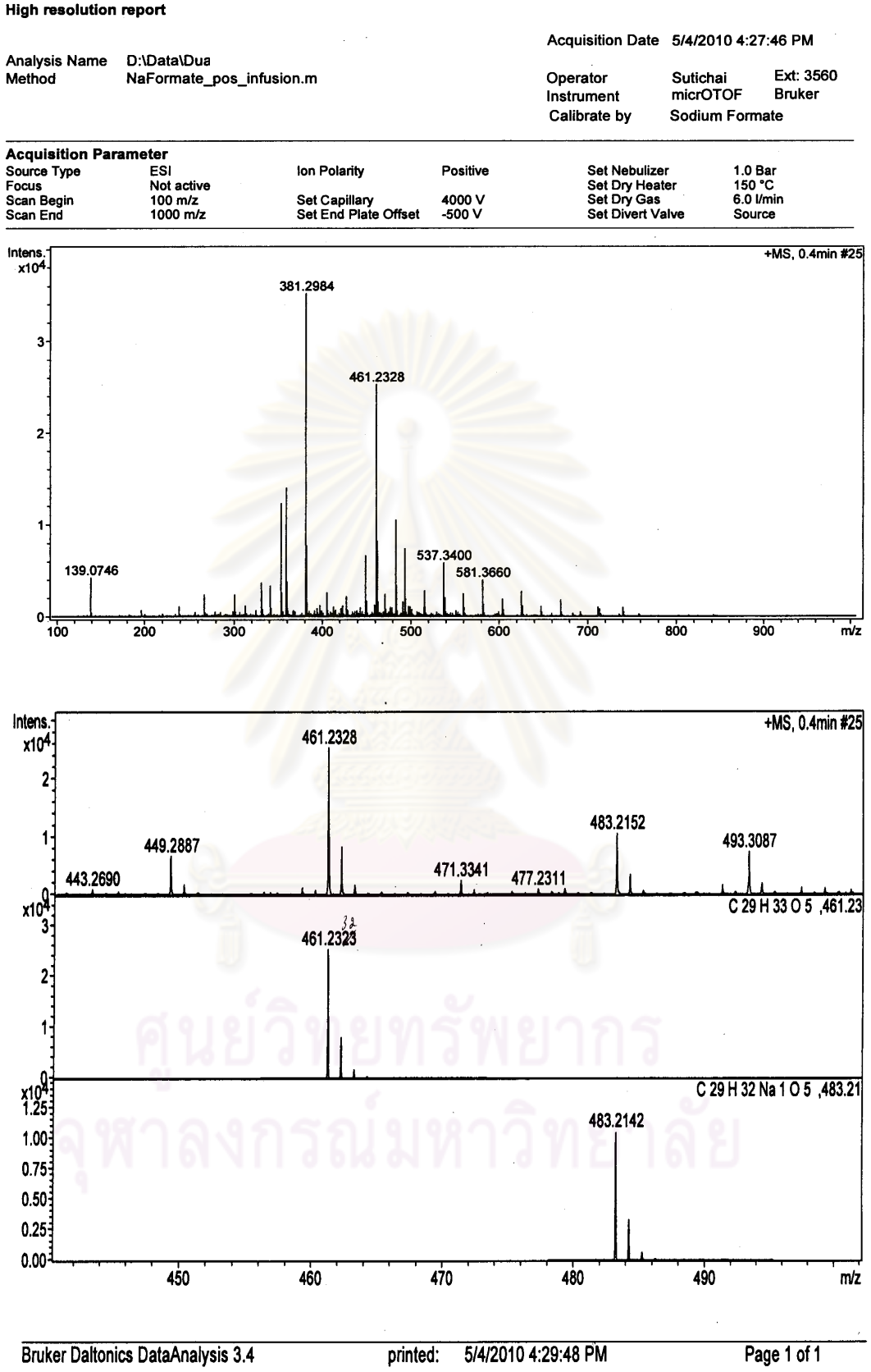


Figure 41 HRESI Mass Spectrum of compound AL3

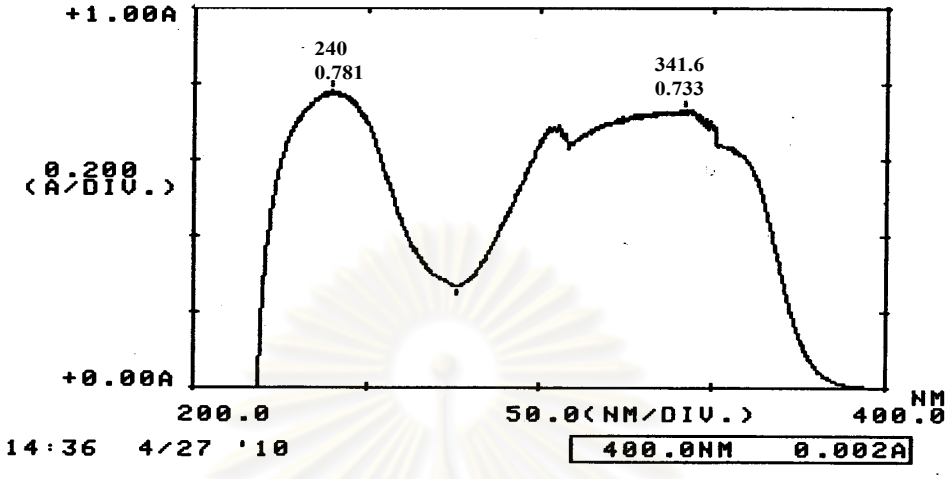


Figure 42 UV Spectrum of compound AL3 (methanol)

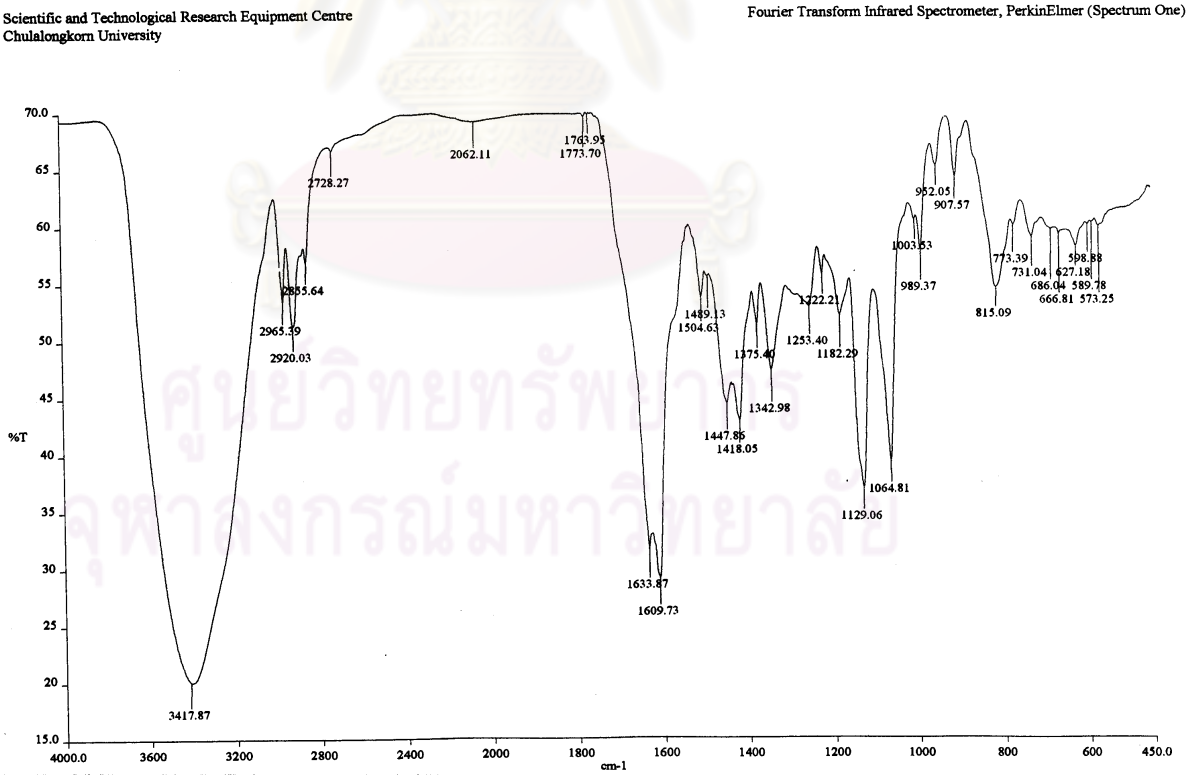


Figure 43 IR Spectrum of compound AL3 (film)

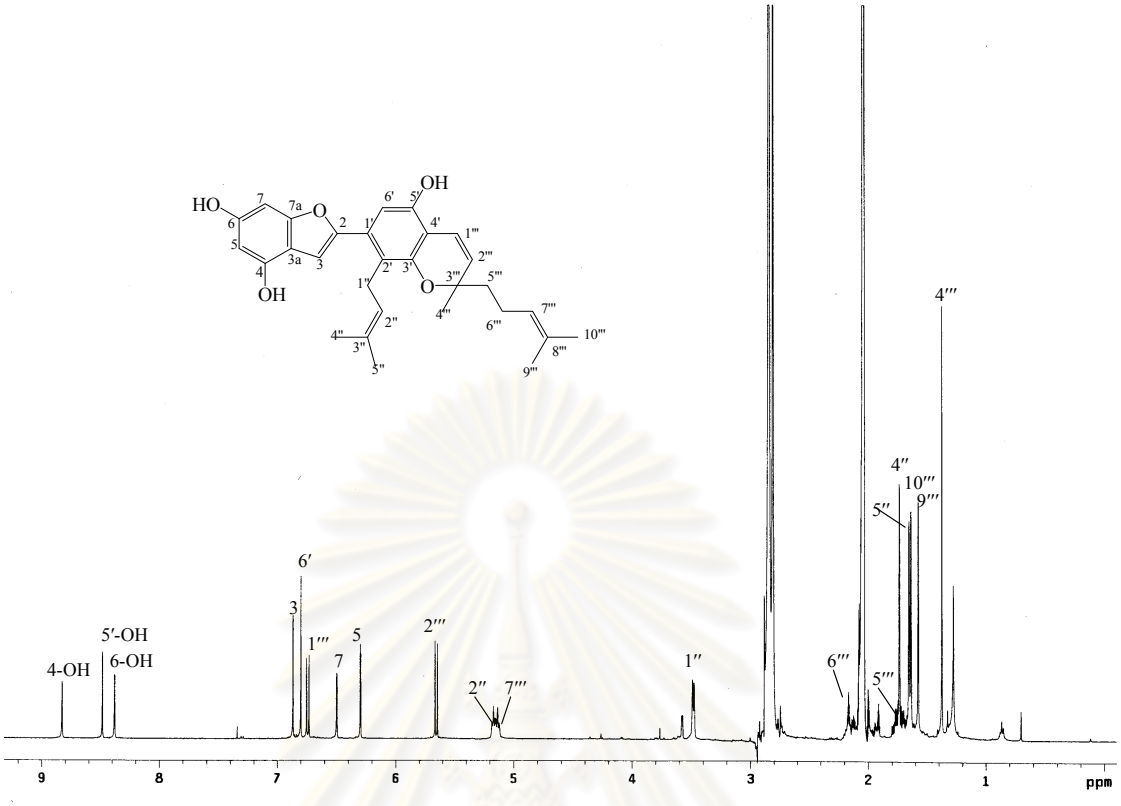


Figure 44 ^{1}H-NMR (500 MHz) Spectrum of compound AL3 ($CDCl_3$)

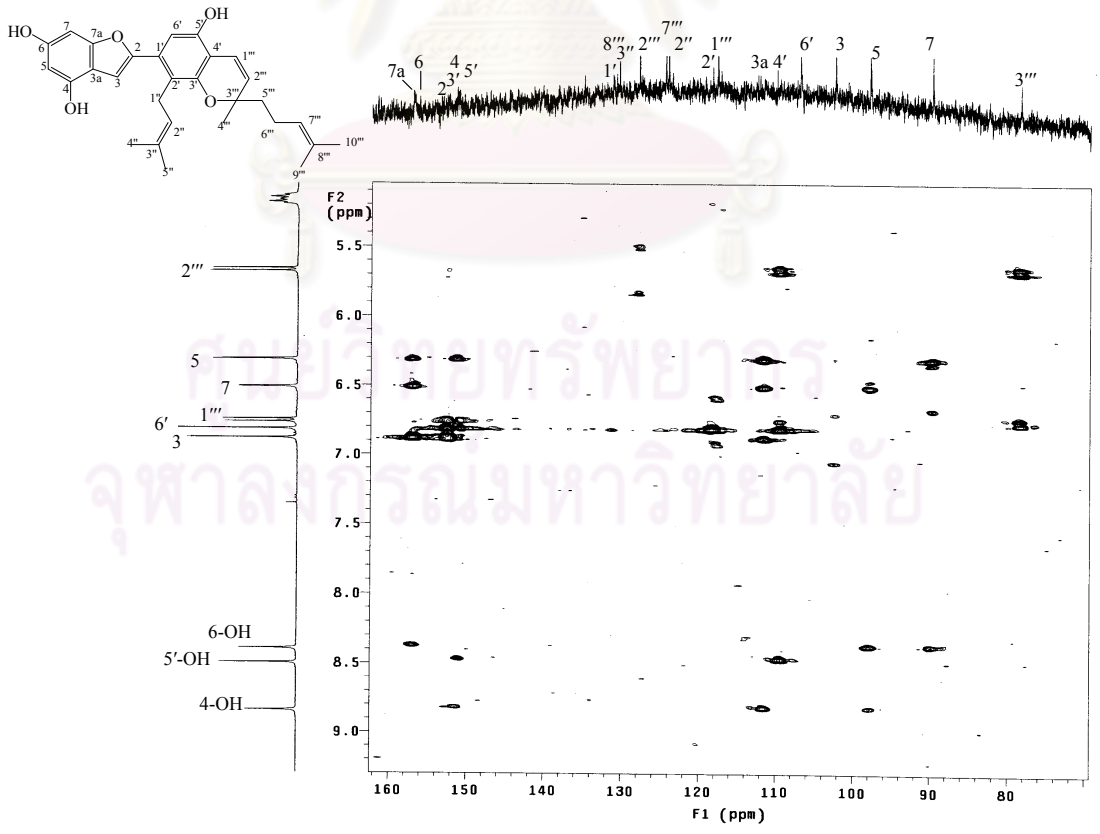


Figure 45 HMBC Spectrum of compound AL3 ($CDCl_3$)

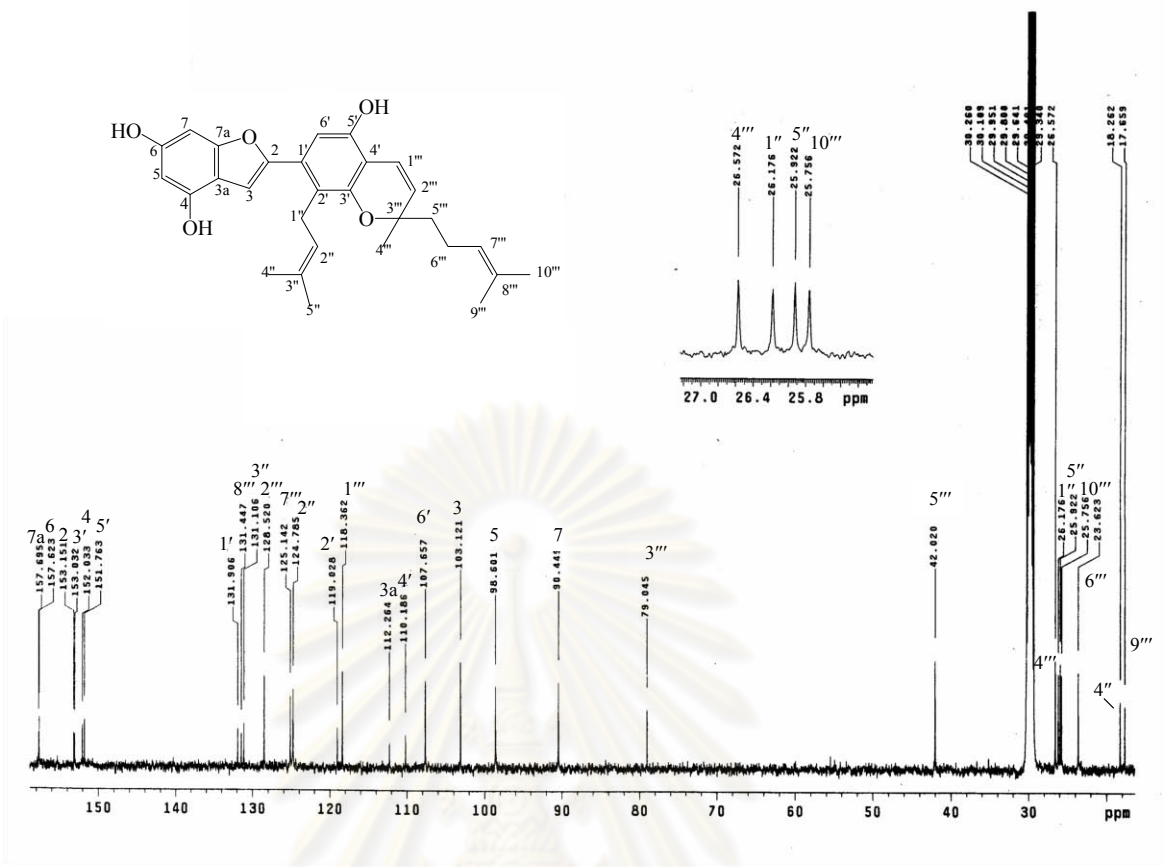


Figure 46 ^{13}C-NMR (125 MHz) Spectrum of compound AL3 ($CDCl_3$)

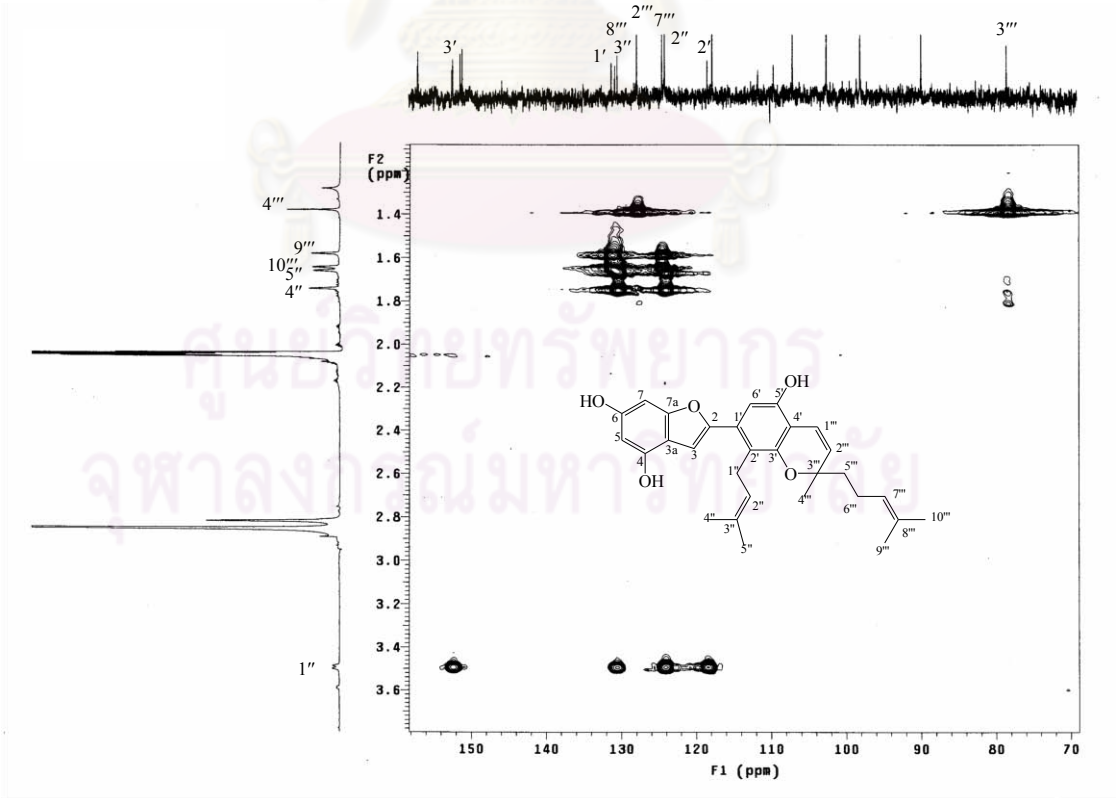
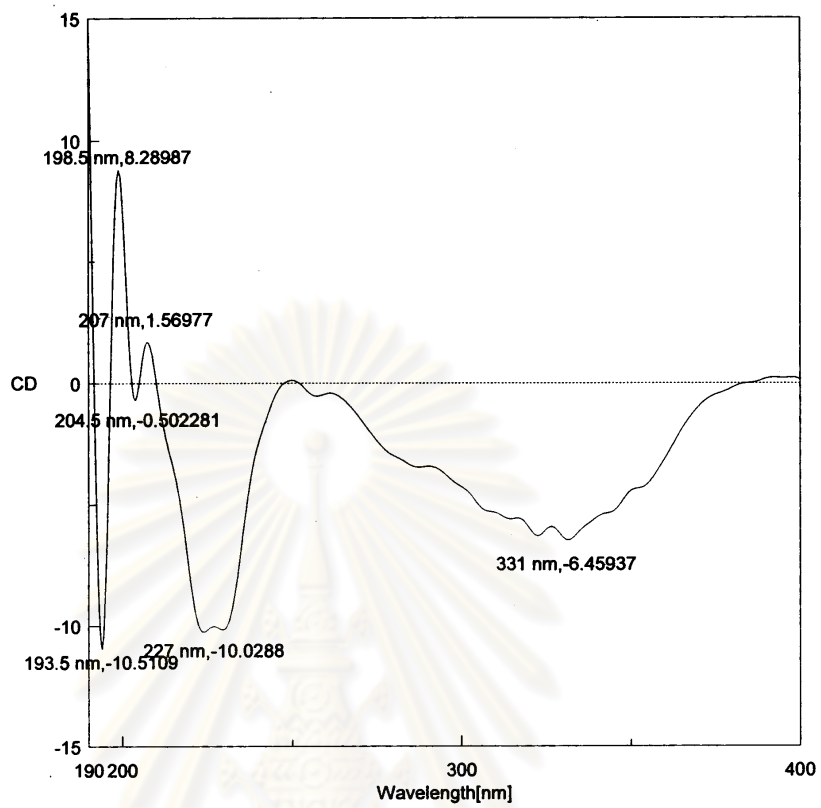


Figure 47 HMBC Spectrum of compound AL3 ($CDCl_3$)



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Concentration :			
Solvent :	20mM Tris		
Temperature :	Room Temp.		
Operator :	Amnart		
Organization :			
Comment :	Tris		
Data mode :	CD		
Ch2-mode :	HT		
Range :	400 - 190 nm		
Band width :	2.0 nm	Sensitivity :	20 mdeg
Resolution :	0.5 nm	Response :	2 sec
Accumulation :	3	Speed :	50 nm/min

Figure 48 CD Spectrum of compound AL3 (methanol)

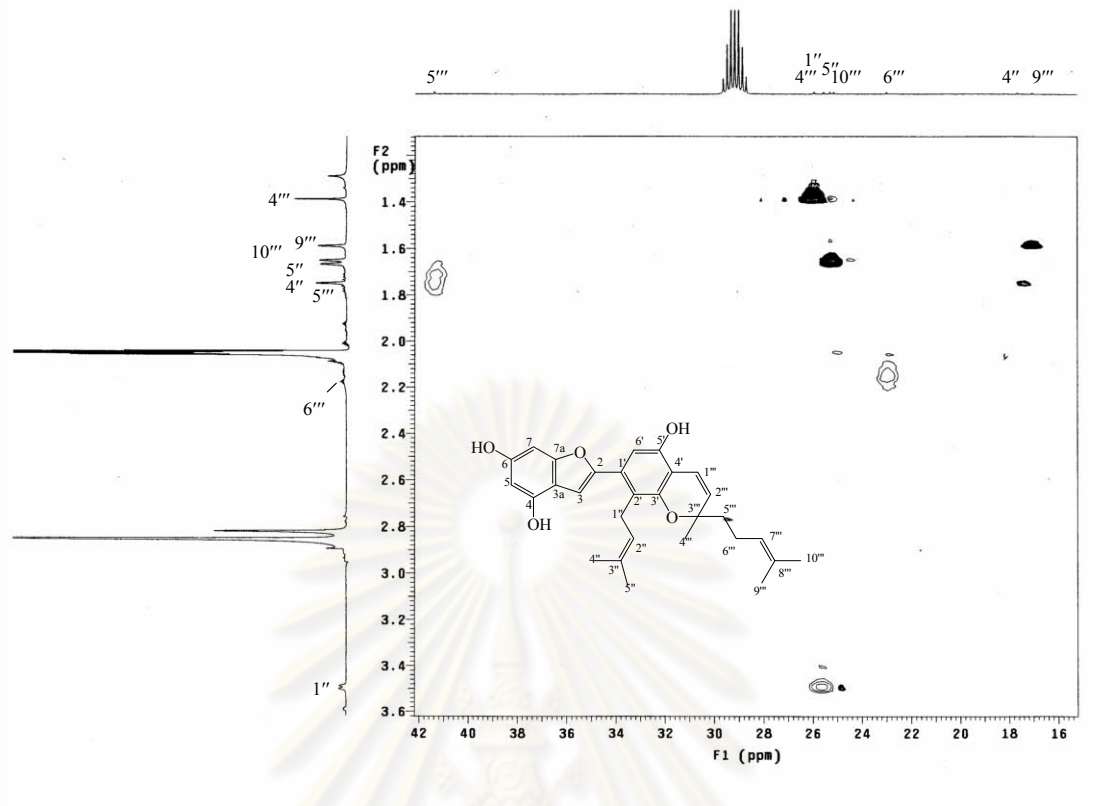

Figure 49 HSQC Spectrum of compound AL3 ($CDCl_3$)

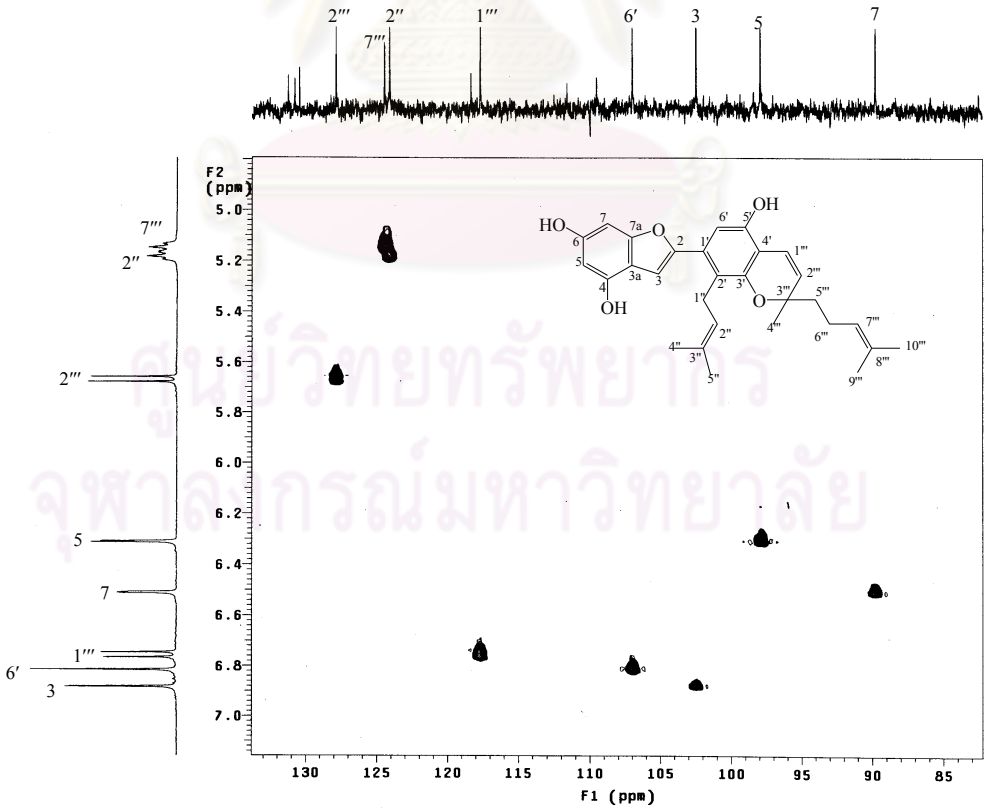

Figure 50 HSQC Spectrum of compound AL3 ($CDCl_3$)

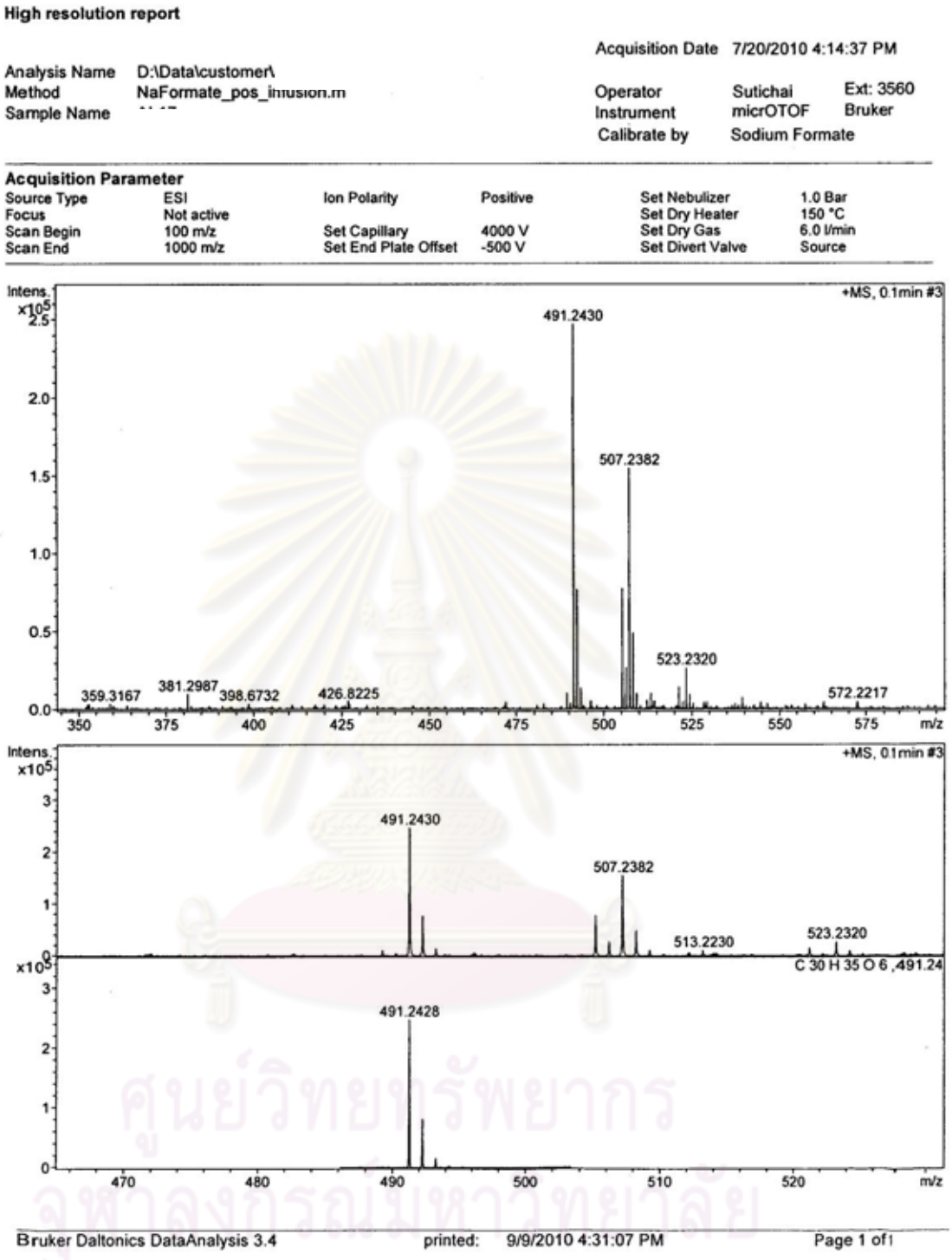

Figure 51 HRESI Mass Spectrum of compound AL4

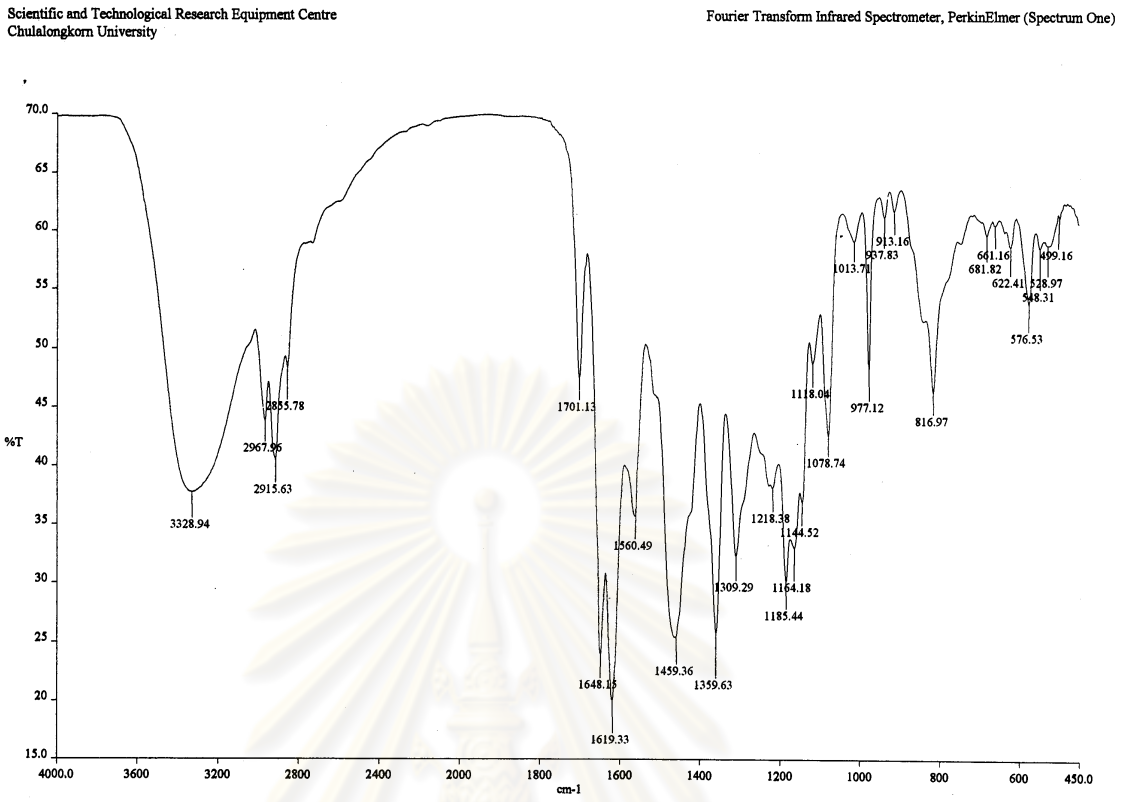

Figure 52 IR Spectrum of compound AL4 (film)

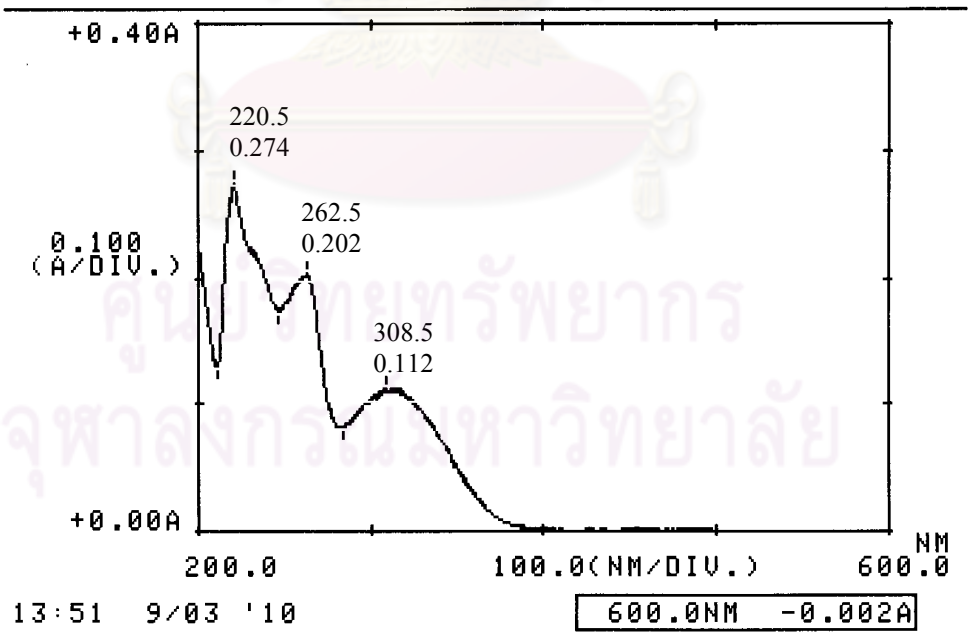

Figure 53 UV Spectrum of compound AL4 (methanol)

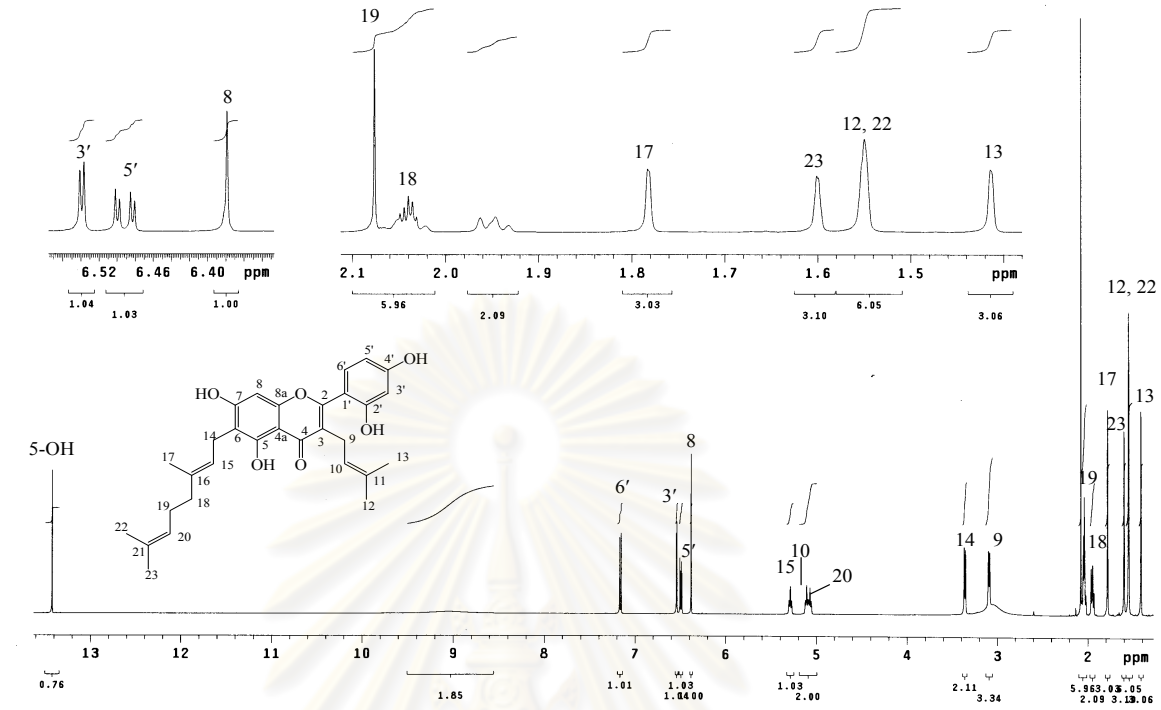

Figure 54 ^{1}H-NMR (500 MHz) Spectrum of compound AL4 (Acetone-d_6)

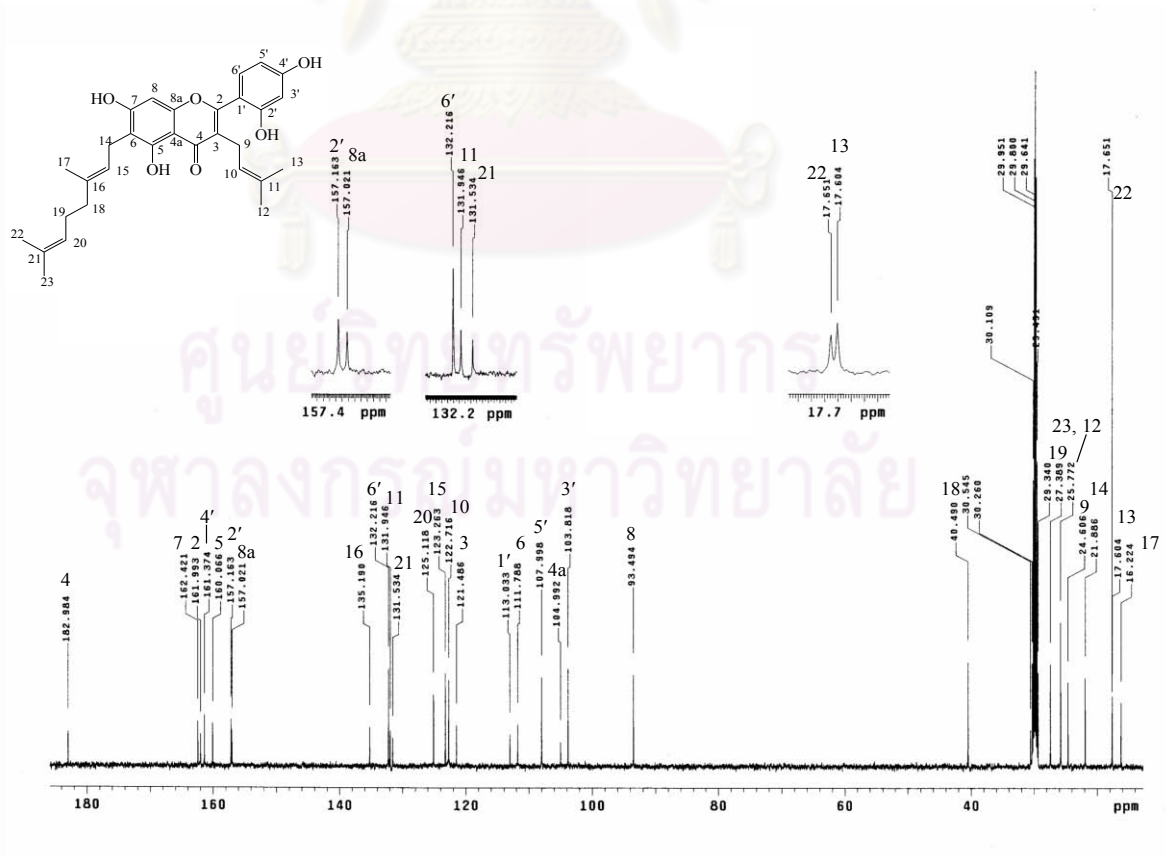

Figure 55 ^{13}C-NMR (125 MHz) Spectrum of compound AL4 (Acetone-d_6)

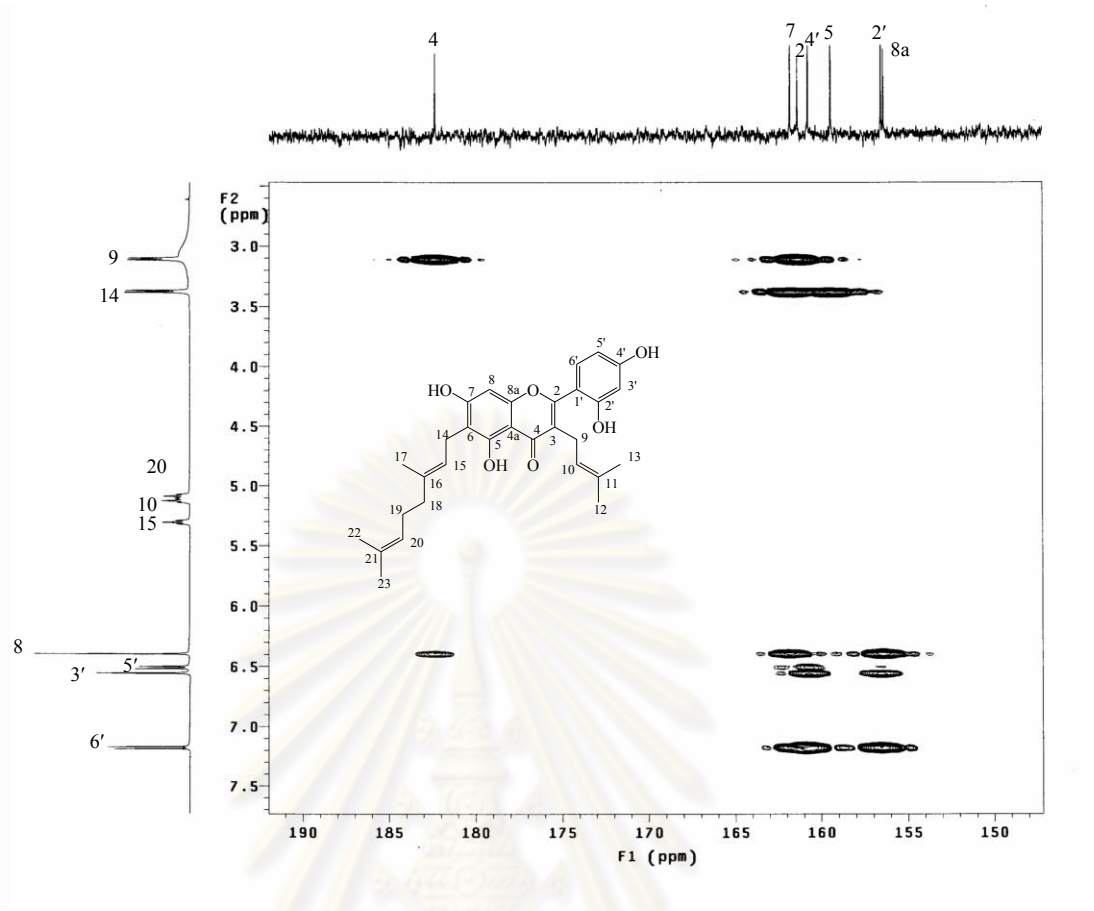

Figure 56 HMBC Spectrum of compound AL4 (Acetone-d_6)

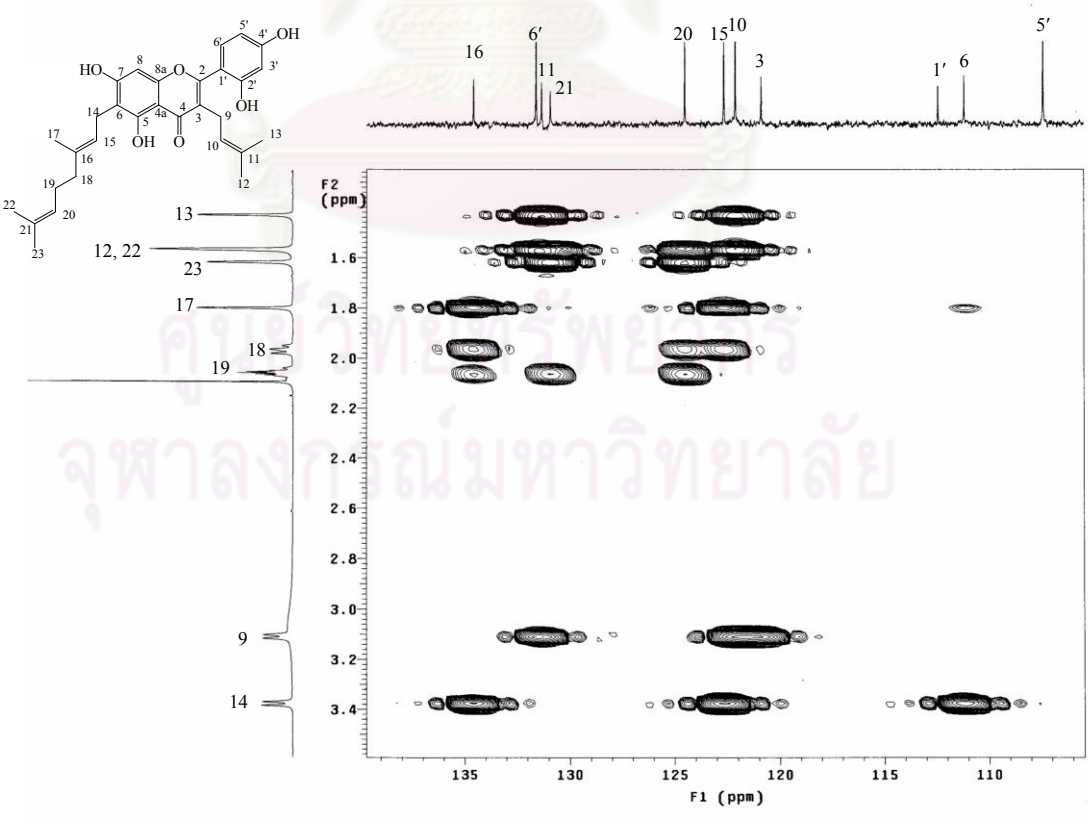

Figure 57 HMBC Spectrum of compound AL4 (Acetone-d_6)

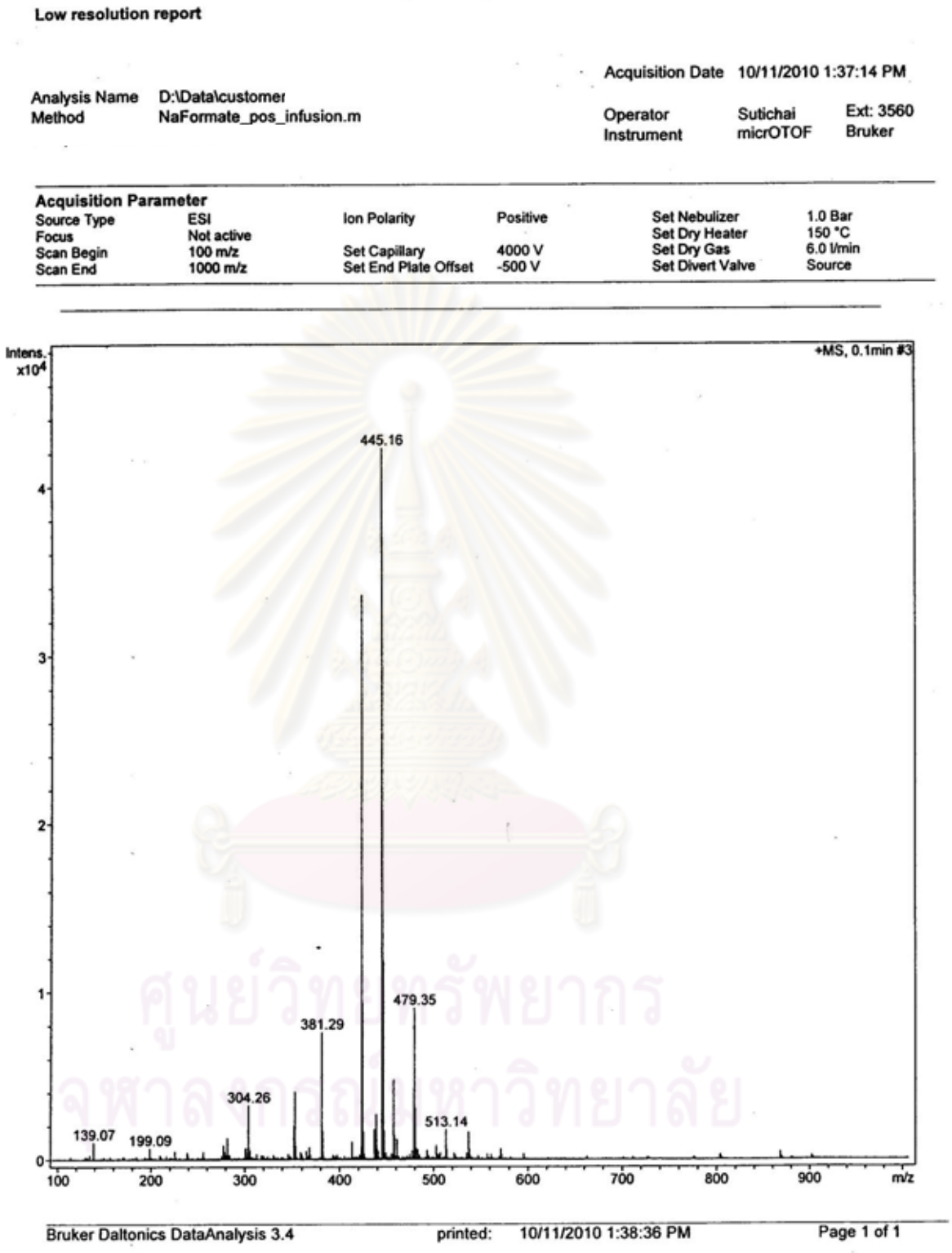

Figure 58 LR-ESI Mass Spectrum of compound AL5

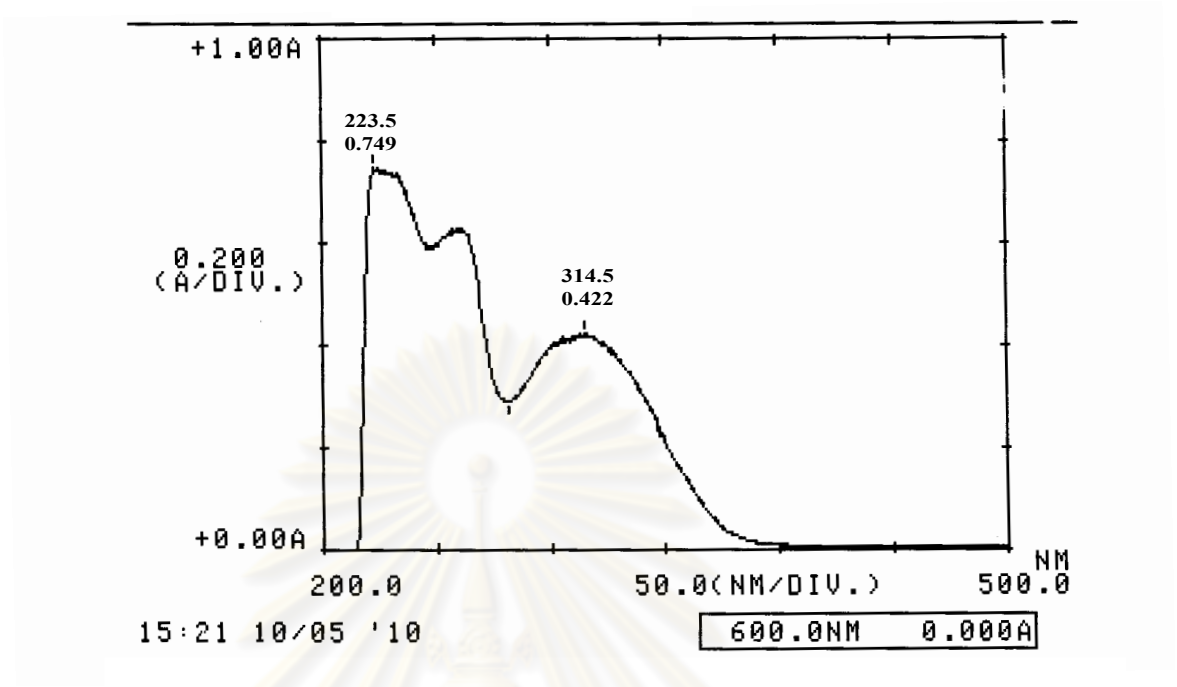

Figure 59 UV Spectrum of compound AL5 (methanol)

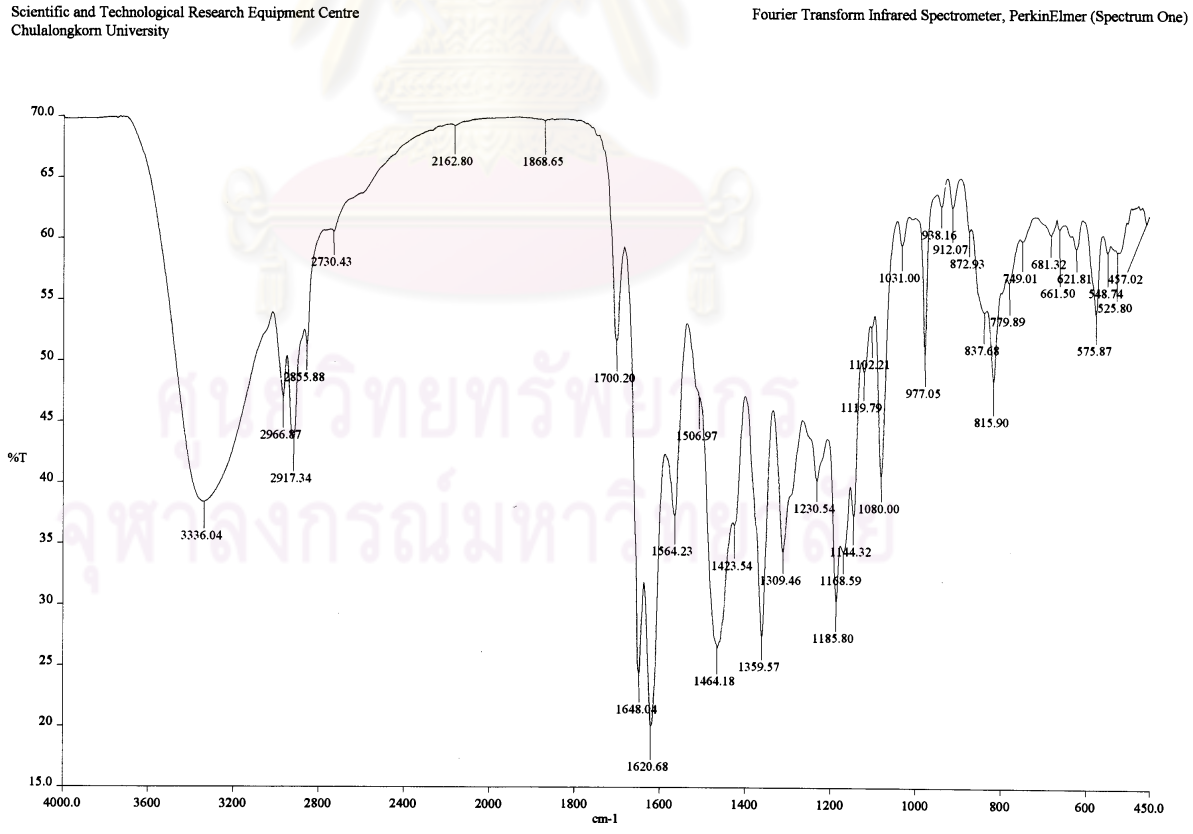

Figure 60 IR Spectrum of compound AL5 (film)

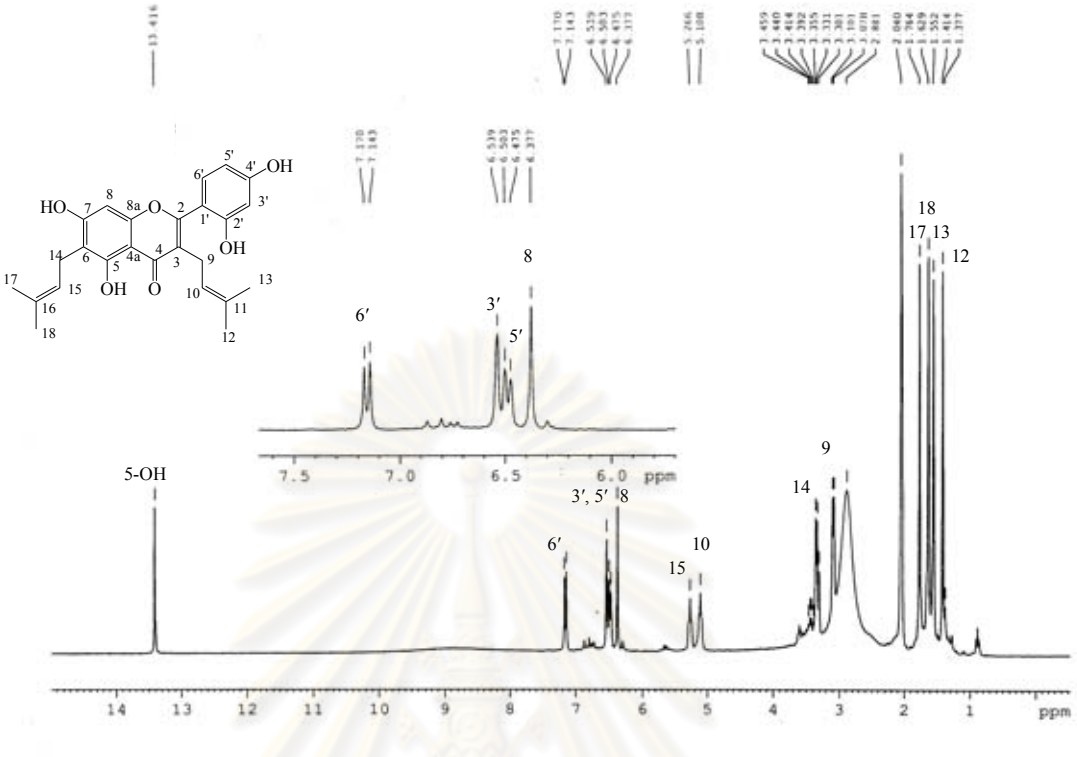

Figure 61 ^{1}H-NMR (300 MHz) Spectrum of compound AL5 (Acetone-d_6)

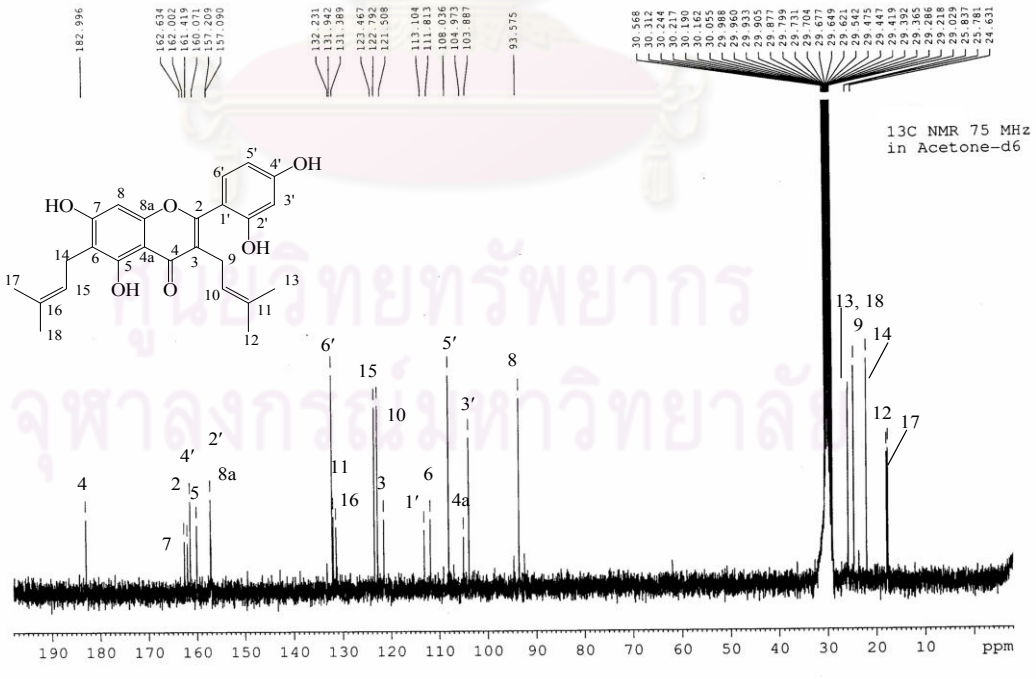

Figure 62 ^{13}C-NMR (75 MHz) Spectrum of compound AL5 (Acetone-d_6)

VITA

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Publications

Sritularak, B., Kullasap, T., Likhitwitayawuid, K. and Lipipun, V. 2010. New 2-arylbenzofurans from the root bark of *Artocarpus lakoocha*. Molecules 15 : 6548-6558.

Poster Presentation

Kullasap, T., Sritularak, B., and Likhitwitayawuid, K. 2-Arylbenzofurans with free radical scavenging activity from the root bark of *Artocarpus lakoocha*. p.113. NRCT-JSPS Core University Program on Natural Medicine in Pharmaceutical Sciences The 9th Joint Seminar Natural Medicine Research for the Next Decade: New Challenges and Future Collaboration, December 15-17, 2010, Faculty of Pharmaceutical Sciences, Chulalongkorn University, Bangkok.