Chemical Constituents from the Bark of *Artocarpus elasticus*

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Organic Chemistry
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Thesis Title	Chemical Constituents from the Bark of *Artocarpus elasticus*
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(Assoc. Prof. Dr. Krerkchai Thongnoo)

Dean of Graduate School

ชื่อวิทยานิพนธ์ องค์ประกอบทางเคมีจากเปลือกต้นกะออก (*Artocarpus elasticus*)

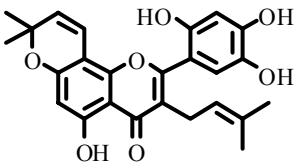
ผู้เขียน นางสาวอาอีเซาะส์ ยานยา

สาขาวิชา เคมีอินทรีย์

ปีการศึกษา 2551

บทคัดย่อ

การศึกษาองค์ประกอบทางเคมีของเปลือกต้นกะออก (*Artocarpus elasticus*) แยกได้สารประกอบที่ยังไม่มีรายงานการวิจัย 6 สาร ซึ่งเป็นสารประกอบที่เกิดจากการเรียงตัวใหม่ของสารประเภท prenylated flavone คือ 5-hydroxy-2-(4-hydroxy-2,5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one (**AE3**) อนุพันธ์ของสารประกอบประเภท furanodihydrobenzoxanthone (**AE7**) อนุพันธ์ของสารประกอบประเภท quinonobenzoxanthone (**AE11** และ **AE13**) 1,3,4,8-tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*]xanthen-7-(6*H*)-one (**AE12**) 5-hydroxy-8,8-dimethyl-2-(2,4-dihydroxyphenyl)-4*H*,8*H*-benzo[1,2-*b*′]dipyran-4-one (**AE15**) นอกจากนี้ยังได้สารที่มีรายงานวิจัยแล้ว 10 สาร ได้แก่ 5-hydroxy-8,8-dimethyl-3-(3-methyl-2-butenyl)-2-(2,4,5-trihydroxyphenyl)-4*H*,8*H*-benzo[1,2-b:3,4-*b*′]dipyran-4-one (**AE1**) 8-hydroxy-3-methylisochroman-1-one (**AE2**) 6,7-dihydro-5,9,14-trihydroxy-11-methoxy-3,3-dimethyl-6-(1-methylethyl)-3*H*,8*H*-[1]benzopyrano[7,6-*c*]xanthen-8-one (**AE4**) 12-acetyl-6-hydroxy-3,3,9,9-tetramethyl-3*H*,7*H*,furo[3,4-*b*]pyrano[3,2-*h*]xanthene-7,11(9*H*)-dione (**AE5**) 6,7-dihydro-5,9,11,14-tetrahydroxy-3,3-dimethyl-6-(1-methylethenyl)-(-)-3*H*,8*H*-pyrano[3′,2′:4,5]benzo[1,2-*c*]xanthen-8-one (**AE6**) 5a,6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-9-(3-methyl-2-buten-1-yl)-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (**AE8**) (3,4,5-trimethoxyphenyl)methanol (**AE9**) 5a,6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (**AE10**) 5a,6-dihydro-1,3,8-trihydroxy-10-methoxy-5,5-dimethyl-5*H*,7*H*-benzofuro[3,4-*bc*]xanthen-7-one (**AE14**) และ 2-(2,4-dihydroxyphenyl)-5,7-dihydroxy-4*H*-chromen-4-one (**AE16**) โครงสร้างของสารประกอบเหล่านี้วิเคราะห์โดยใช้ข้อมูลทางสเปกโทรสโกปี UV IR NMR MS และ เปรียบเทียบกับสารที่มีรายงานการวิจัยแล้ว



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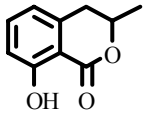

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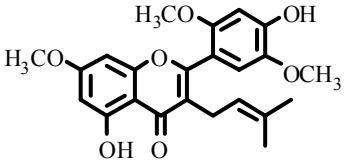

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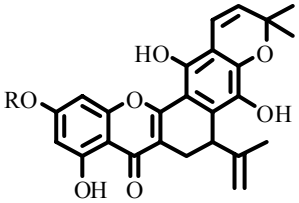
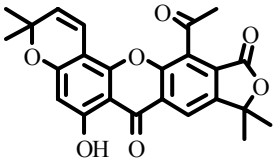


AE4: R = CH_3

AE6: R = H



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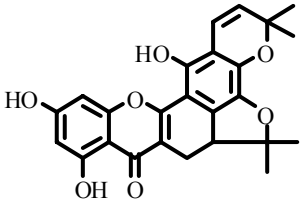

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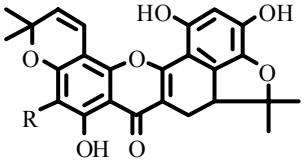
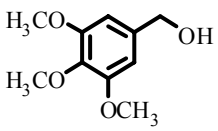


AE8 : R = prenyl

AE10: R = H



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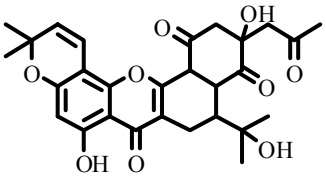

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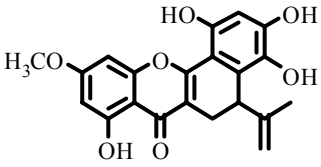

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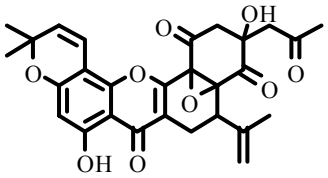

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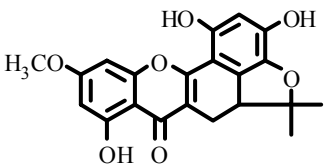

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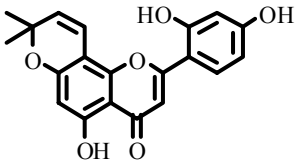

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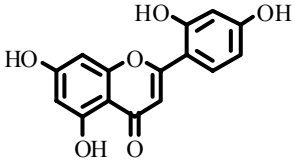


AE16

Thesis Title Chemical Constituents from the Bark of *Artocarpus elasticus*

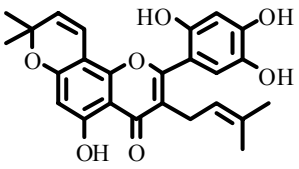
Author Miss Aeesoh Yanya

Major Program Organic Chemistry

Acedemic Year 2008

ABSTRACT

Investigation of the chemical constituents from the bark of *Artocarpus elasticus* yielded six modified prenylated flavones: 5-hydroxy-2-(4-hydroxy-2,5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one (**AE3**), furanodihydrobenzoxanthone derivative (**AE7**), quinonobenzoxanthone derivatives (**AE11** and **AE13**), 1,3,4,8-tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*] xanthen-7-(6*H*)-one (**AE12**), 5-hydroxy-8,8-dimethyl-2-(2,4-dihydroxyphenyl)-4*H*, 8*H*-benzo[1,2-*b*′]dipyran-4-one (**AE15**). Ten known compounds were also obtained: 5-hydroxy-8,8-dimethyl-3-(3-methyl-2-butenyl)-2-(2,4,5-trihydroxyphenyl)-4*H*,8*H* benzo[1,2-b:3,4-*b*′]dipyran-4-one (**AE1**), 8-hydroxy-3-methylisochroman-1-one (**AE2**), 6,7-dihydro-5,9,14-trihydroxy-11-methoxy-3,3-dimethyl-6-(1-methylethyl)-3*H*,8*H*-[1]benzopyrano[7,6-*c*]xanthen-8-one (**AE4**), 12-acetyl-6-hydroxy-3,3,9,9-tetramethyl-3*H*,7*H*,furo[3,4-*b*]pyrano[3,2-*h*]xanthen-7,11(9*H*)-dione (**AE5**), 6,7-dihydro-5,9,11,14-tetrahydroxy-3,3-dimethyl-6-(1-methylethenyl)-(-)-3*H*,8*H*-pyrano [3′,2′:4,5]benzo[1,2-*c*]xanthen-8-one (**AE6**), 5a,6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-9-(3-methyl-2-buten-1-yl)-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*] xanthen-7-one (**AE8**), (3,4,5-trimethoxyphenyl)methanol (**AE9**), 5a,6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2*h*]xanthen-7-one (**AE10**), 5a,6-dihydro-1,3,8-trihydroxy-10-methoxy-5,5-dimethyl-5*H*,7*H*-benzo furo[3,4-*bc*]xanthen-7-one (**AE14**) and 2-(2,4-dihydroxyphenyl)-5,7-dihydroxy-4*H*-chromen-4-one (**AE16**). Their structures were determined on the basis of UV, IR, NMR MS and by comparison of their spectroscopic data with those reported.



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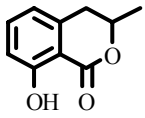

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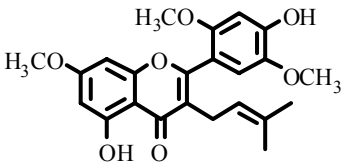

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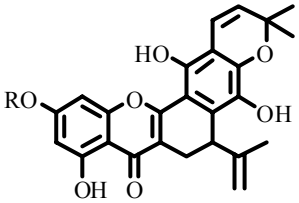

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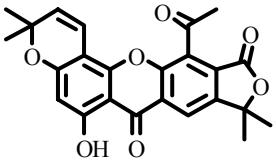

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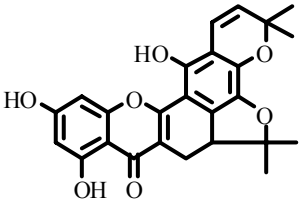

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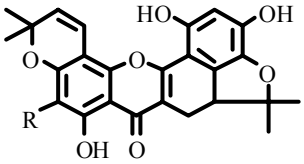

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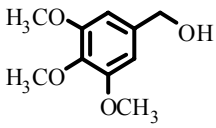

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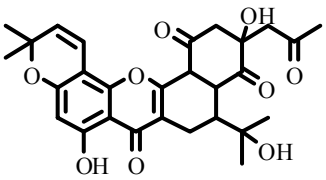

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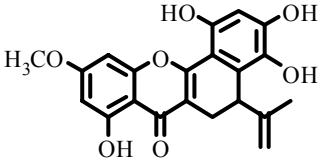

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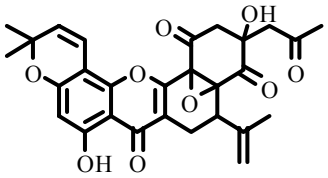

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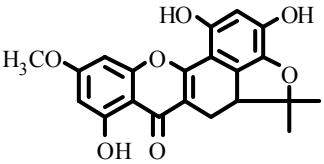

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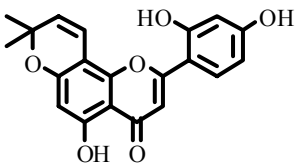

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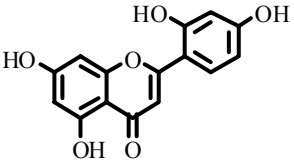

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Aeesoh Yanya

THE RELEVANCE OF THE RESEARCH WORK TO THAILAND

The purpose of this research is to investigate the chemical constituents of *Artocarpus elasticus*. It is a part of the basic research on the utilization of Thai medicinal plants. This research will contribute significantly to scientific basis of traditional medicine. Fourteen prenylated flavones type pure compounds, mullein and (3,4,5-trimethoxyphenyl)methanol have been isolated from this plant. Artonin E showed strong anti-*S. aureus* ATCC25923 and MRSA SK1 with MIC 4 and 8 μg/ml, respectively. Moreover, many compounds of prenylated flavones type have been reported to have cytotoxic, antimicrobial and antioxidation activities. Further study on the biological activity of the isolated compounds should be performed which can lead to active compounds. Therefore Thai plant can be utilized as a natural resource of potential drugs.

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LIST OF ABBREVIATIONS AND SYMBOLS

s	=	singlet
d	=	doublet
t	=	triplet
m	=	multiplet
dd	=	doublet of doublet
br s	=	broad singlet
g	=	gram
kg	=	kilogram
mg	=	milligram
%	=	percent
nm	=	nanometer
m.p.	=	melting point
cm^{-1}	=	reciprocal centimeter (wave number)
δ	=	chemical shift relative to TMS
J	=	coupling constant
λ_{max}	=	maximum wavelength
ν	=	absorption frequencies
ε	=	molar extinction coefficient
$^{\circ}C$	=	degree celcius
MHz	=	Megahertz
ppm	=	part per million
IR	=	Infrared
UV	=	Ultraviolet-Visible
NMR	=	Nuclear Magnetic Resonance
2D NMR	=	Two Dimentional Nuclear Magnetic Resonance
COSY	=	Correlated Spectroscopy

LIST OF ABBREVIATIONS AND SYMBOLS (Continued)

DEPT	=	Distortionless Enhancement by Polarization Transfer

HMBC	=	Heteronuclear Multiple Bond Correlation
HMQC	=	Heteronuclear Multiple Quantum Coherence
CC	=	column chromatography
TMS	=	tetramethylsilane
Acetone-d_6	=	deuteroacetone
DMSO-d_6	=	deuterodimethylsulphoxide
$CDCl_3$	=	deuterochloroform
MeOH	=	Methanol
CH_2Cl_2	=	Dichloromethane
TLC	=	Thin-Layer Chromatography
MIC	=	Minimum Inhibition Concentration

CHAPTER 1
INTRODUCTION

1.1 Introduction

Nowadays, most of people have extensively concern about their health due to various types of pollutions which occur through atmosphere, food, water and also unhealthy eating habits which result in many types of diseases such as coronary thrombosis, diabetes, hypertension, cancer, alzheimer, cataract, rheumatism, progeria syndrome *etc*.. Thus, the discovery of new drug or the development in nutrient supplement has very high competition between the suppliers within country and also abroad. Thailand is a tropical country which contains many kinds of herbal plants that promise to cure many diseases, therefore Thai scientists have realized that it is necessary to conduct a research and analyze on new substances from the herbal plant which have pharmacological and biological activities. The study of the chemical composition in Thai herbal plant is really important. The information from the study show that the plant in the genus *Artocarpus* contains really high percentage of flavonoid groups which is categorized as one type of phenolic compound. This compound is known to potentially have antioxidant, antimutagen, antitumor, anti-inflammatory and anticarcinogenic properties. Previous study by Euis H. Hakim reported that "*Artocarpus* species contain phenolic compounds, including isoprenylated flavonoids, stilbenoids and 2-arylbenzofurans" (Hakim, *et al*., 2006). Therefore, we were interested to study the chemical composition of the herbal plant in the genus *Artocarpus* which have been traditionally used by local people in many areas of Thailand and many other countries in Southeast Asia. Even though, the chemical composition, biological activity as well as pharmacological activity of *Artocarpus* genus have been studied worldwide in the past but only few researches about *Artocarpus elasticus* are conducted. Hence, the search for new bioactive compounds is really important as it can provide basic information for future study.

The *Artocarpus* genus is widely distributed throughout Thailand. It belongs to the mulberry family Moraceae and several members of the genus encompass approximately 60 species of trees that thrive throughout tropical Asia. This genus is known to be rich in prenylated flavonoids and their derivatives (Aida, *et al*., 1997). A number of these trees are historically reputed to possess medicinal properties and are utilized as folk medicines in Taiwan, Thailand, and Indonesia (Nicolaou, *et al*., 2008). *Artocarpus elasticus*, is locally known as 'Ka-ok' in Thailand. The use of ground-bark to allay backache and the latex to treat dysentery prompted us to examine *Artocarpus* species further for bioactive substances. However, there are only a few reports on the chemical constituents, we are therefore motivated to investigate its constituents in detail.

Artocarpus elasticus are found wild in the southern part of Thailand. *A. elasticus* is a large tree, grow to a height of 25-40 metre, spreading branches and a straight trunk with bark, outer bark is smooth and dark brown color while inner bark is light brown. The leaves are large 12-30 c.m., wide 20-55 c.m., bright-green and glossy on the upper surface, stiff hair on the underside, the petiole 5-10 c.m. long. Flowers bear a multitude of tiny flowers. Fruits are cylindrical-shaped, 5.5 c.m. wide, 12 c.m. long, have harsh, sand paper-like rind; generally the rind is green at first, turning yellow-brown when ripe. It produce flower during December-March, fruit will be mature during July-October. For geographic distribution it is found in the forest which located near canal and is also found in the southern area of Thailand. Moreover, it has also been found in other countries such as Myanmar, Malaysia, Indonesia. It has the sticky, milky latex which has a property like glue so it is used for trapping animal such as birds.

Figure 1 *Artocarpus elasticus*

1.2 Review of Literatures

1.2.1 The Chemical Constituents and Biological Activity of *Artocarpus* genus.

Prenylated flavonoids, stilbenoids and 2-arylbenzofuran were the major components isolated from *Artocarpus* genus. The flavonoid constituents may be further classified according to their skeletons, as chalcones, flavanones, flavones, flavan-3-ol, and 3-prenylflavones. Furthermore, there are classes of modified flavonoids, which can be regarded as cyclized derivatives of 3-prenylflavones: oxepinoflavones, pyranoflavones, dihydrobenzoxanthones, furanodihydrobenzoxanthones, and pyranodihydrobenzoxanthones, and classes of flavonoid-derived xanthones, which can be regarded as rearranged flavonoids: quinonobenzoxanthones, cyclopentenoxanthones, xanthonolides, dihydroxanthone, and cyclopentenochromone (Hakim, *et al*., 2006). The structures of various classes of the regular, modified, and rearranged flavonoids were summarized in **Figures 2**, **3** and **4**.

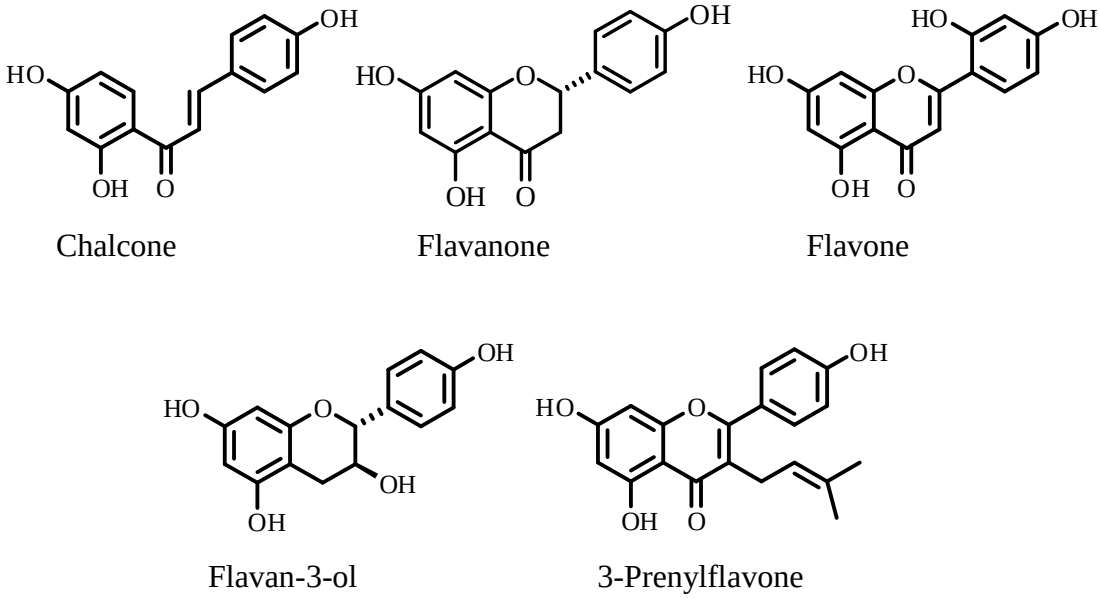


Figure 2 The structures of regular flavonoids in *Artocarpus*

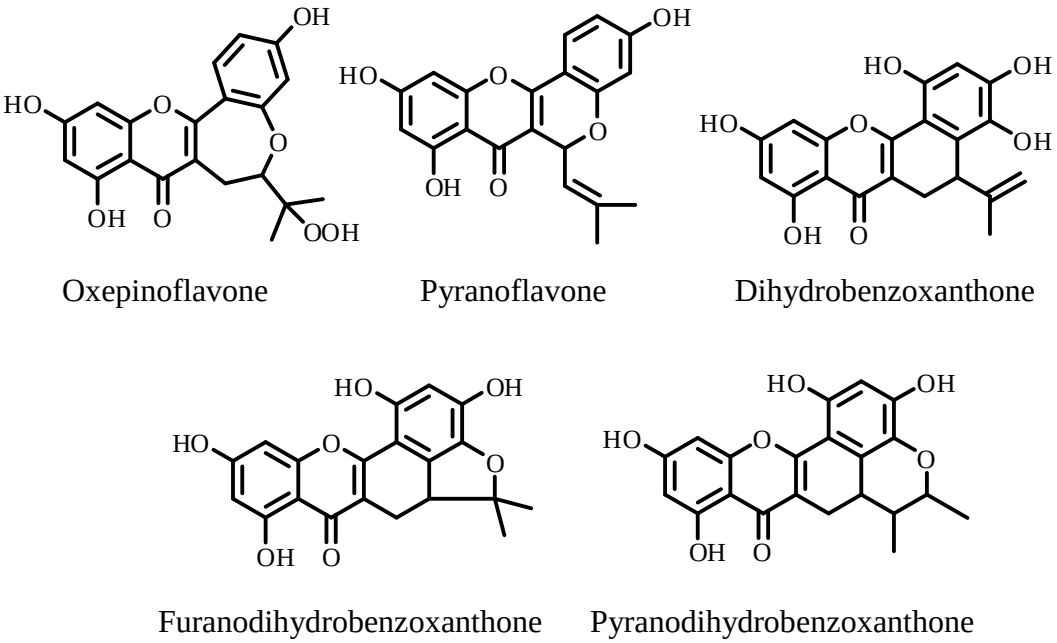


Figure 3 The structures of modified flavonoids in *Artocarpus*

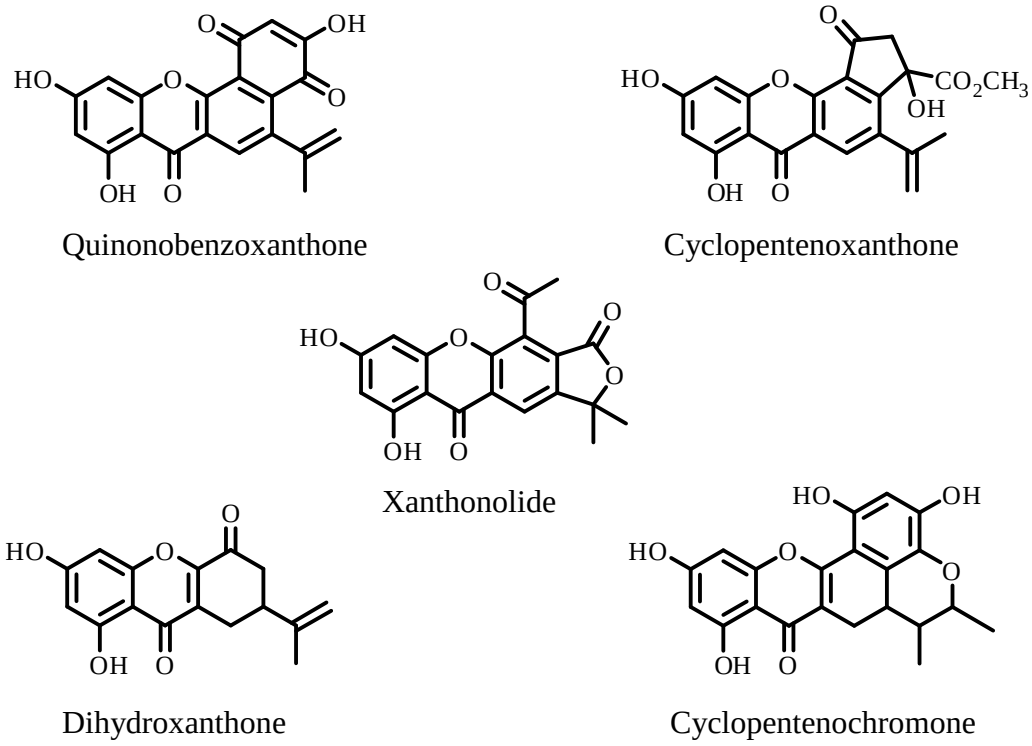


Figure 4 The structures of flavonoid-derived xanthones in *Artocarpus*

In the previous report, prenylated flavones which have been found in *Artocarpus* genus, most frequently the hydroxyl groups are replaced (occasionally with methoxyl groups) in the C-5,7,2′,4′ or C-5,7,2′,4′,5′ positions, and the isoprenyl group (occasionally geranyl group) at C-3, C-3,6, or C-3,6,8 positions in the A-ring. In the modified flavonoids, the isoprenyl substituent at C-3 position is always found in the form of a carbocyclic ring or an oxygen-bearing ring fused with rings B and C. In the rearranged-flavonoid group of compounds, the original ring B of the modified-flavonoid skeleton is found in the form of quinonoid moiety, or a five-membered ring, or in an opened, rearranged product.

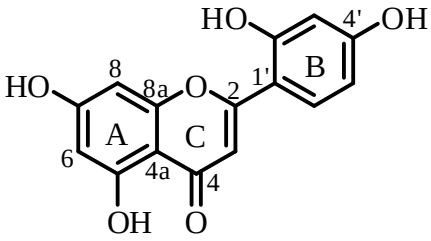


Figure 5 Flavone structure

Previously, a series of prenylated flavonoids were isolated from *Artocarpus* species, some of which showed interesting biological activities. These include cytotoxicity, antiplatelet action, antibacterial activities (Sultanbawa, *et al*., 1989), strong radical scavenging properties towards the DPPH radical (Jayasinghe, *et al*., 2008), and inhibitors of ROS and NO production (Cerqueira, *et al*., 2008). A series of weakly cytotoxic (Wang, *et al*., 2004) and antimalarial (Boonlaksiri, *et al*., 2000) prenylated stilbenes and their derivatives were revealed.

The chemical constituents isolated from the *Artocarpus* genus were summarized in **Table 1** (The literature survey from SciFinder Scholar database).

Table 1 Compounds from the *Artocarpus* genus

Compounds	Bibliography
1. A. altilis	
bud covers	
cycloaltilisin 6; **6b**	Patil, *et al*.,
cycloaltilisin 7; **1d**	2002
root bark	
friedelan-3β-ol; **1i**	Fun, *et al*., 2007
friedelin; **2i**	
artocarpin; **15e**	Chantrapromma, *et al*., 2007
leaves	
1-(2,4-dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(4-methyl-3-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone; **1b**	Wang, *et al*., 2007
1-(2,4-dihydroxyphenyl)-3-{4-hydroxy-6,6,9-trimethyl-6a,7,8,10a-tetrahydro-6*H*-dibenzo[*b*,*d*]pyran-5-yl}-1-propanone; **2b**	
2-geranyl-2′,3,4,4′-tetrahydroxydihydrochalcone; **3b**	
1-(2,4-dihydroxyphenyl)-3-[3,4-dihydro-3,8-dihydroxy-2-methyl-2-(4-methyl-3-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone; **4b**	
1-(2,4-dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(3,4-epoxy-4-methyl-1-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone; **5b**	
2′-geranyl-3′,4′,7-trihydroxyflavanone; **2d**	
cycloaltilisin 6; **6b**	
1-(2,4-dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(4-hydroxy-4-methyl-2-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone; **7b**	
2-[6-hydroxy-3,7-dimethylocta-2(*E*),7-dienyl]-2′,3,4,4′-tetrahydroxydihydrochalcone; **8b**	
fruits	
oxyresveratrol; **6g**	Amarasinghe, *et al*., 2008
artocarbene; **7g**	

Table 1 (continue)

Compounds	Bibliography
fruits moracin M; **4a** norartocarpanone; **10d** norartocarpetin; **4e** isoartocarpesin; **2e** 3β-acetoxyolean-12-en-11-one; **4i** cycloartenyl acetate; **3i** sitosterol β-D-glucopyranoside; **1h**	Amarasinghe, *et al*., 2008
2. *A. chama* **roots** artochamin A; **49e** artochamin B; **45e** artochamin C; **26e** artochamin D; **19e** artochamin E; **56e** artocarpin; **15e** cycloartocarpin; **43e** cudraflavone A; **54e** artonin A; **75e** artonin U; **8e** cycloartobiloxanthone; **76e** artonin E; **24e** artocarpetin A; **5e**	Wang, *et al*., 2004
3. *A. champeden* **tree bark** cyclochampedol; **41e** cycloeucalenol; **5i** cycloartenone; **6i**	Achmad, *et al*., 1996

Table 1 (continue)

Compounds	Bibliography
tree bark	
artocarpin; **15e**	Parenti, *et al*., 1998
heteroflavanone A; **9d**	
root bark	
artoindonesianin A; **79e**	Hakim, *et al*., 1999
artonin A; **75e**	
root trunk	
artoindonesianin B; **84e**	Hakim, *et al*., 1999
heartwood	
artoindonesianin Q; **14e**	Syah, *et al*., 2002
artoindonesianin R; **13e**	
artoindonesianin S; **57e**	
artoindonesianin T; **58e**	
artoindonesianin A-2; **39e**	
artoindonesianin A-3; **61e**	
artonin B; **63e**	Syah, *et al*., 2006
heterophyllin; **28e**	
cudraflavone C; **16e**	
4. *A. communis*	
bark	
artonin E; **24e**	Hano, *et al*., 1990
artonin F; **77e**	
cycloartobiloxanthone; **76e**	
artonol A; **2c**	Aida, *et al*., 1997
artonol B; **1j**	
artonol C; **67e**	
artonol D; **68e**	
artonol E; **65e**	

Table 1 (continue)

Compounds	Bibliography
bark	
artonin K; **73e**	Aida, *et al*., 1997
artobiloxanthone; **60e**	
roots	
artocommunol CA; **52e**	Chan, *et al*., 2003
artocommunol CB; **38e**	
artocommunol CC; **88e**	
artocommunol CD; **37e**	
artocommunol CE; **32e**	
cyclomorusin; **51e**	
root bark	
cycloartomunin; **50e**	Lin, *et al*., 1991
cycloartomunoxanthone; **78e**	
dihydrocycloartomunin; **47e**	
cudraflavone A; **54e**	
artomunoxanthone; **59e**	Shieh, *et al*., 1992
artomunoxanthentrione; **3j**	
cyclomulberrin; **46e**	
cyclocommunol; **40e**	
cyclocommunin; **44e**	
dihydroisocycloartomunin; **48e**	Lin, *et al*., 1992
heartwood	
3′′,3′′-dimethylpyrano[1′,4′]2,4,2′-trihydroxychalcone; **9b**	Han, *et al*., 2006
cycloartocarpin; **43e**	
cudraflavone A; **54e**	
isobacachalcone; **10b**	
morachalcone A; **11b**	
gemichalcone B; **20b**	
artoindonesianin E; **11d**	

Table 1 (continue)

Compounds	Bibliography
heartwood	
gemichalcone C; **21b**	Han, *et al*., 2006
artocarpin; **15e**	
cudraflavone C; **16e**	
licoflavone C; **6e**	
(2*S*)-euchrenone a_7; **4d**	
5. *A. elasticus*	
heartwood	
artocarpone A; **12e**	Kijjoa, *et al*., 1996
norartocarpin; **18e**	
artocarpin; **15e**	
artocarpone B; **71e**	
cycloartocarpin; **43e**	
wood	
artelastin; **42e**	Kijjoa, *et al*., 1996
artelastochromene; **53e**	
artelasticin; **20e**	
artelastinin; **86e**	Kijjoa, *et al*., 1998
artelastofuran; **36e**	
cyclocommunin; **44e**	
carpelastofuran; **87e**	
roots bark	
artelastocarpin; **85e**	Ko, *et al*., 2005
artelasticinol; **30e**	
cycloartelastoxanthendiol; **81e**	
cycloartelastoxanthone; **82e**	
artelastoxanthone (7-demethylartonol E); **66e**	
artonol A; **2c**	
artelastoheterol; **31e**	

Table 1 (continue)

Compounds	Bibliography
6. *A. gomezianus*	
not specified	
cyclomorusin; **51e**	Likhitwitayawuid, *et al*., 2000
cycloartocarpin; **43e**	
artocarpin; **15e**	
norartocarpetin; **4e**	
cudraflavone C; **16e**	
roots	
artogomezianol; **2g**	Likhitwitayawuid, *et al*., 2001
andalasin A; **1g**	
tree bark	
artoindonesianin N; **3g**	Hakim, *et al*., 2002
artoindonesianin O; **3a**	
oxyresveratrol; **6g**	
7. *A. heterophyllus*	
root bark	Lu, *et al*., 1993
heteroflavanone A; **9d**	
heteroflavanone B; **5d**	
artonin A; **75e**	Aida, *et al*., 1993
artonin B; **63e**	
artonin C; **22b**	
artonin D; **23b**	
artonin I; **11e**	Aida, *et al*., 1993
artonin J; **72e**	
artonin K; **73e**	
artonin L; **74e**	
heterophylol; **8g**	Lin, *et al*., 1993
heteroflavanone C; **6d**	Lin, *et al*., 1995
cudraflavone A; **54e**	

Table 1 (continue)

Compounds	Bibliography
root bark	
cycloheterophyllin; **55e**	Chung, *et al*., 1995
artocarpetin B; **7e**	
heteroartonin A; **22e**	
kuwanon T; **23e**	
heartwood of the root	
artocapanone A; **8d**	Lin, *et al*., 1995
cycloartocarpin; **43e**	
artocarpanone; **7d**	
artocarpetin; **3e**	
norartocarpetin; **4e**	
artocarpin; **15e**	
artocarpesin; **1e**	
dihydromorin; **14d**	
8. *A. incisus*	
heartwood	
artocarbene; **7g**	Shimizu, *et al*., 1997
leaves	
3-geranyl-2,3′,4,4′-tetrahydroxychalcone; **13b**	Shimizu, *et al*., 1997
9. *A. lakoocha*	
roots	
lakoochin A; **1a**	Puntumchai, *et al*., 2004
lakoochin B; **2a**	
10. *A. lanceifolius*	
heartwood	
artoindonesianin G; **33e**	Syah, *et al*., 2001
artoindonesianin H; **35e**	
artoindonesianin I; **34e**	
artelastofuran; **36e**	

Table 1 (continue)

Compounds	Bibliography
artelasticin; **20e** **tree bark** artoindonesianin P; **80e** artoindonesianin V; **62e** artobiloxanthone; **60e** cycloartobiloxanthone; **76e** artonol B; **1j**	Hakim, *et al*., 2002
11. *A. nobilis* **bark** artobiloxanthone; **60e** cycloartobiloxanthone; **76e** artobilochromen; **10e** **leaves** xanthoangelol; **12b** xanthoangelol B**; 15b** 2′,4′,4-trihydroxy-3′-[2-hydroxy-7-methyl-3-methylene-6-octaenyl]chalcone; **17b** 3-geranyl-2,3′,4,4′-tetrahydroxychalcone; **13b** 2′,3,4,4′-tetrahydroxy-3′-[6-hydroxy-3,7-dimethyl-2(*E*),7-octadienyl]chalcone; **16b** **fruits** 2,4,4′-trihydroxy-3-[(2*E*)-5-methoxy-3,7-dimethylocta-2,6-dienyl]chalcone; **14b** 1-(3,4-dihydro-3,5-dihydroxy-2-methyl-2(3-methyl-2-butenyl)-2*H*-1-benzopyran-6-yl-3-(4-hydroxyphenyl)-2(*E*)-propen-1-one; **18b** 8-geranyl-3′,4′,7-trihydroxyflavone; **9e** 3′-geranyl-4′,5,7-trihydroxyflavanone; **12d**	Sultanbawa, *et al*., 1989 Jayasinghe, *et al*., 2004 Jayasinghe, *et al*., 2006

Table 1 (continue)

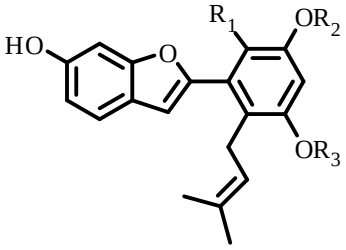
Compounds	Bibliography
fruits	
xanthoangelol; **12b**	Jayasinghe, *et al*., 2006
xanthoangelol B; **15b**	
3-geranyl-2,3′,4,4′-tetrahydroxychalcone; **13b**	
lespeol; **19b**	
8-geranyl-4′,7-dihydroxyflavone; **3d**	
isonymphaeol-B; **13d**	
root bark	
artonin E 2′-methylether; **25e**	Jayasinghe, *et al*., 2008
isoartonin E 2′-methylether; **29e**	
dihydroisoartonin E 2′-methylether; **17e**	
artonin V 2′-methylether; **21e**	
artobiloxanthone; **60e**	
artonin E; **24e**	
cycloartobiloxanthone; **76e**	
12. *A. rigida*	
bark	Hano, *et al*., 1993
artonin M; **83e**	
artonin N; **64e**	
artonin O; **69e**	
artonin P; **70e**	
13. *A. rigidus* subsp. *rigidus*	
root bark	
7-demethylartonol E; **66e**	Namdaung, *et al*., 2006
artorigidusin; **1c**	
artonol B; **1j**	
artonin F; **77e**	
cycloartobiloxanthone; **76e**	

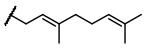
Table 1 (continue)

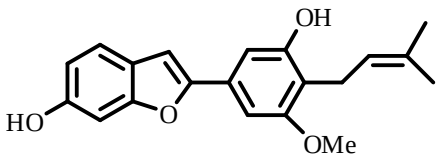
Compounds	Bibliography
morin; **1f** **14. *A. teysmanii*** **root bark** artoindonesianin C; **2j** artoindonesianin U; **27e** cycloartobiloxanthone; **76e** artonin J; **72e** *trans*-4-isopentenyl-3,5,2′,4′-tetrahydroxystilbene; **4g** trans-4-(3-methyl-E-but-1-enyl)-3,5,2′,4′-tetrahydroxystilbene; **5g**	Makmur, *et al*., 1999

Structures of compounds from *Artocarpus* genus

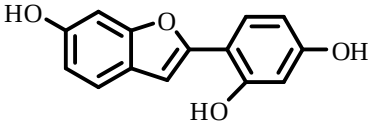
a. 2-arylbenzofurans



	R_1	R_2	R_3	
1a:		CH_3	CH_3	: lakoochin A
2a:		H	H	: lakoochin B

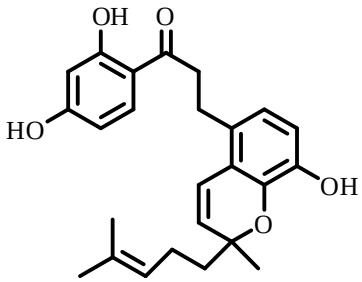


3a: artoindonesianin O

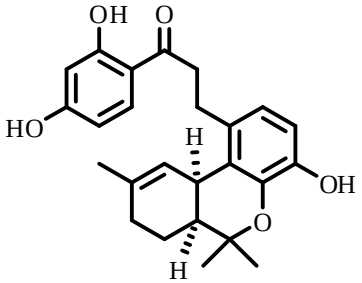


4a: moracin M

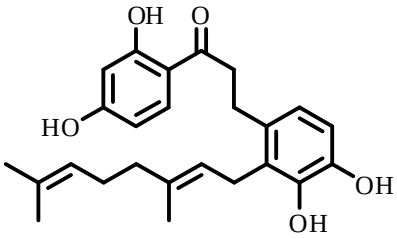
b. Chalcones



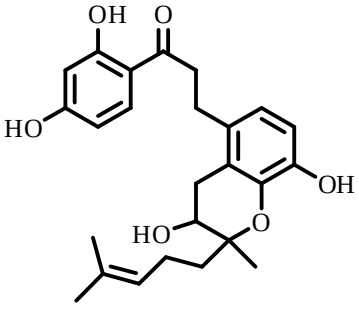
1b: 1-(2,4-dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(4-methyl-3-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone



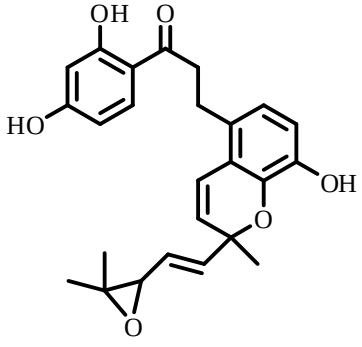
2b: 1-(2,4-dihydroxyphenyl)-3-{4-hydroxy-6,6,9-trimethyl-6a,7,8,10a-tetrahydro-6*H*-dibenzo[*b*,*d*]pyran-5-yl}-1-propanone



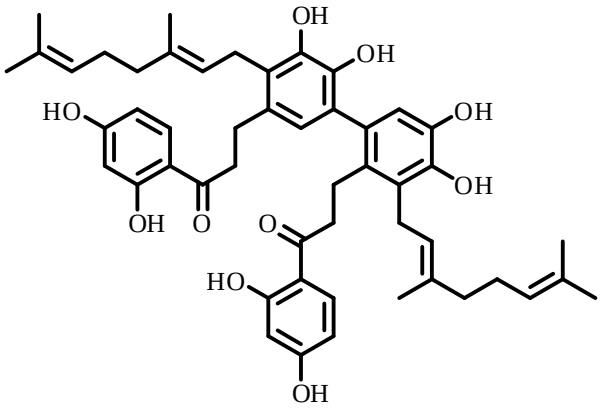
3b: 2-geranyl-2′,3,4,4′-tetrahydroxydihydrochalcone



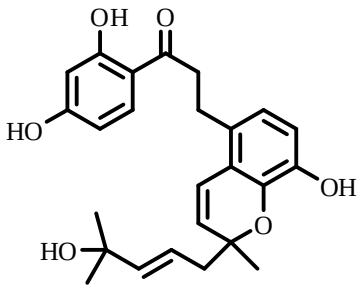
4b: 1-(2,4-dihydroxyphenyl)-3-[3,4-dihydro-3,8-dihydroxy-2-methyl-2-(4-methyl-3-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone



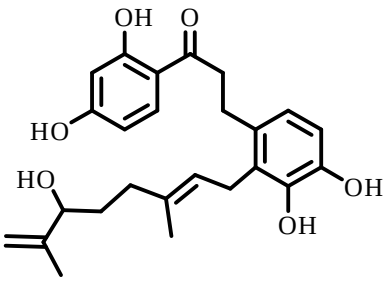
5b: 1-(2,4-dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(3,4-epoxy-4-methyl-1-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone



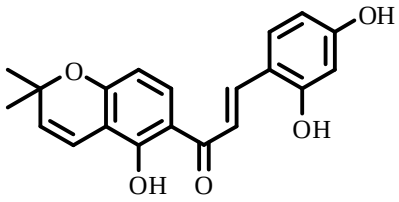
6b: cycloaltilisin 6



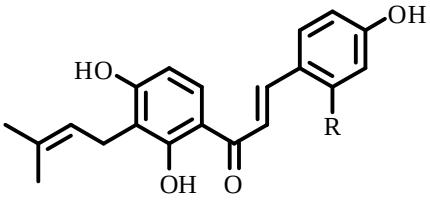
7b: 1-(2,4-dihydroxyphenyl)-3-[8-hydroxy-2-methyl-2-(4-hydroxy-4-methyl-2-pentenyl)-2*H*-1-benzopyran-5-yl]-1-propanone



8b: 2-[6-hydroxy-3,7-dimethylocta-2(*E*),7-dienyl]-2′,3,4,4′-tetrahydroxydihydrochalcone

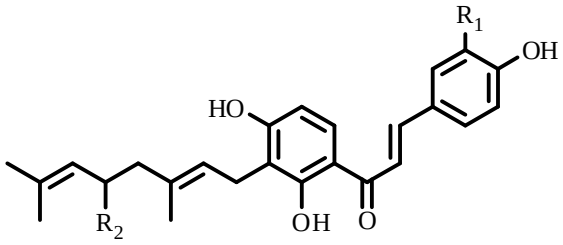


9b: 3′′, 3′′-dimethylpyrano[3′,4′]2,4,2′-trihydroxychalcone

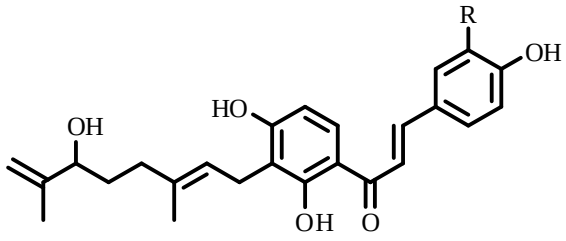


10b: R = H : isobacachalcone

11b: R = OH : morachalcone A

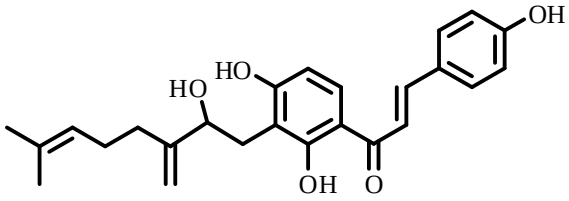


	R_1	R_2	
12b:	H	H	: xanthonangelol
13b:	OH	H	: 3-geranyl-2,3′,4,4′-tetrahydroxychalcone
14b:	H	OCH_3	: 2,4,4′-trihydroxy-3-[(2*E*)-5-methoxy-3,7-dimethyl octa-2,6-dienyl]chalcone

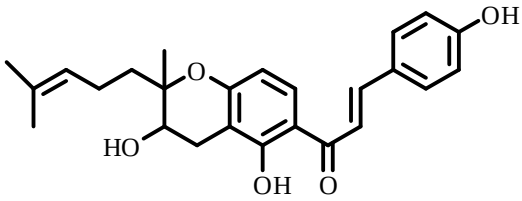


15b: R = H : xanthoangelol B

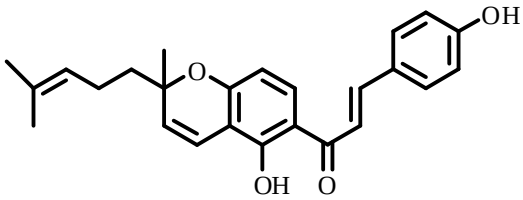
16b: R = OH : 2′,3,4,4′-tetrahydroxy-3′-[6-hydroxy-3,7-dimethyl-2(*E*), 7-octadienyl]chalcone



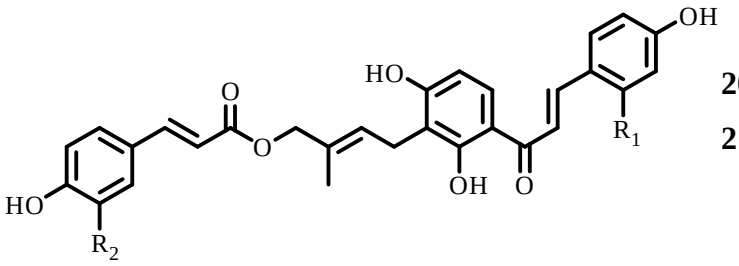
17b: 2′,4′,4-trihydroxy-3′-[2-hydroxy-7-methyl-3-methylene-6-octaenyl]-chalcone



18b: 1-(3,4-dihydro-3,5-dihydroxy-2-methyl-2-(3-methyl-2-butenyl)-2*H*-1-benzopyran-6-yl-3-(4-hydroxyphenyl) -2(*E*)-propen-1-one



19b: lespeol

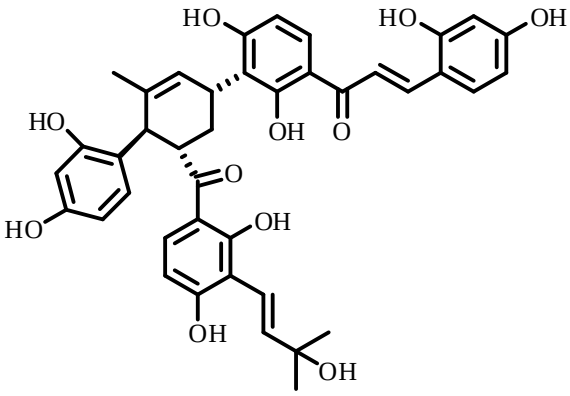


R_1 R_2

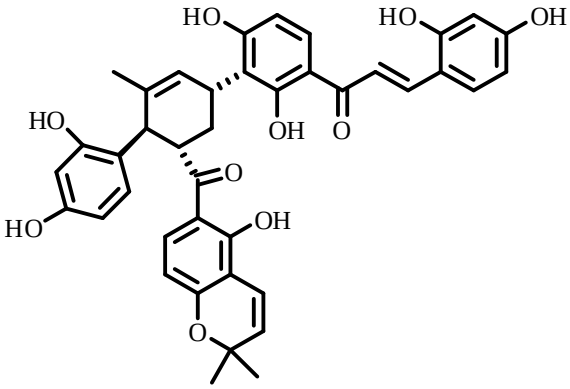
20b: H H : gemichalcone B

21b: OH OCH_3

: gemichalcone C

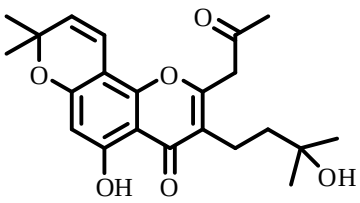


22b: artonin C

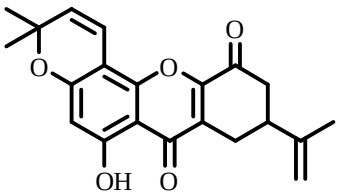


23b: artonin D

c. Chromones

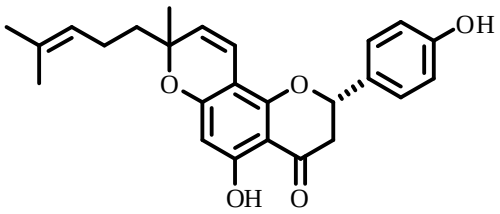


1c: artorigidusin

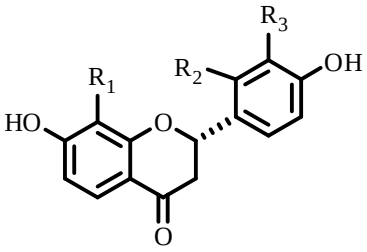


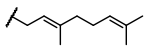
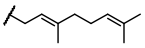
2c: artonol A

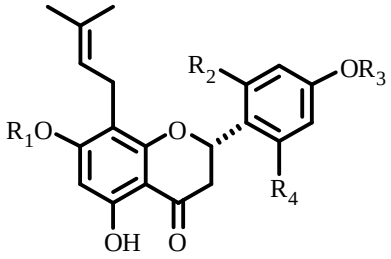
d. Flavanones



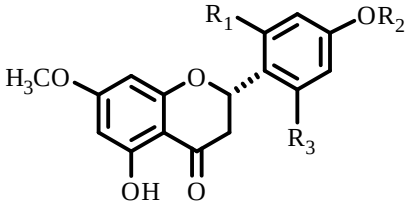
1d : cycloaltilisin 7



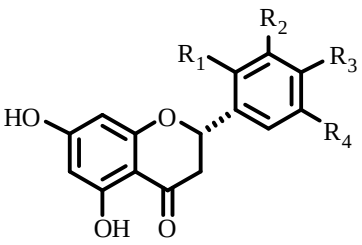
	R_1	R_2	R_3	
2d:	H		OH	: 2′-geranyl-3′,4′,7-trihydroxyflavanone
3d:		H	H	: 8-geranyl-4′,7-dihydroxyflavanone

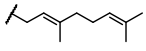
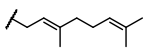


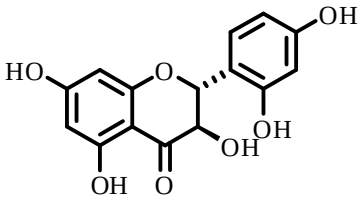
	R_1	R_2	R_3	R_4	
4d:	H	OH	H	H	: (2*S*)-euchrenone a_7
5d:	CH_3	OCH_3	CH_3	OCH_3	: heteroflavanone B
6d:	H	OCH_3	CH_3	OCH_3	: heteroflavanone C



	R_1	R_2	R_3	
7d:	H	H	H	: artocarpanone
8d:	H	CH_3	H	: artocarpanone A
9d:	CH_3	CH_3	OCH_3	: heteroflavanone A

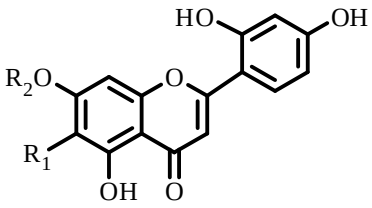


	R_1	R_2	R_3	R_4	
10d:	OH	H	OH	H	: norartocarpanone
11d:	OCH_3	H	CH_3	OCH_3	: artoindonesianin E
12d:	H		H	H	: 3′-geranyl-4′,5,7-trihydroxyflavanone
13d:	OH	OH	OH		: isonymphaeol-B

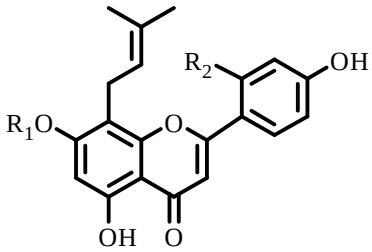


14d: dihydromorin

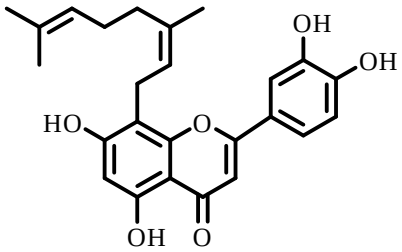
e. Flavones



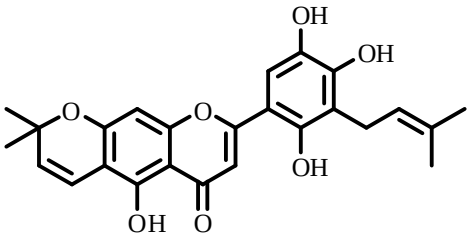
	R_1	R_2		
1e:		H	:	artocarpesin
2e:		H	:	isoartocarpesin
3e:	H	CH_3	:	artocarpetin
4e:	H	H	:	norartocarpetin



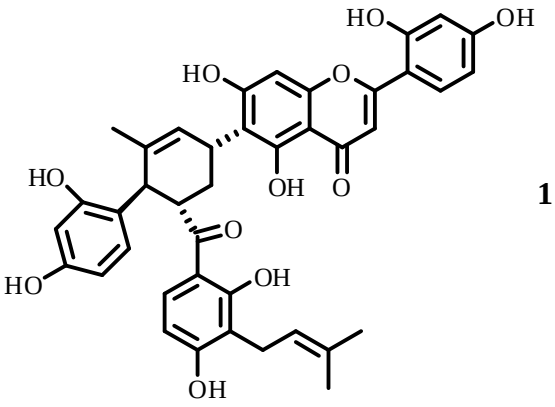
	R_1	R_2		
5e:	CH_3	OH	:	artocarpetin A
6e:	H	H	:	licoflavone C
7e:	CH_3	OCH_3	:	artocarpetin B
8e:	CH_3	H	:	artonin U



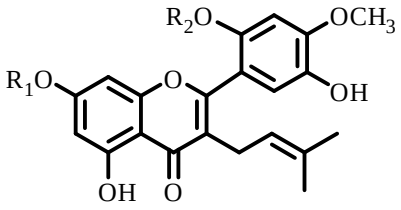
9e: 8-geranyl-3′,4′,7-trihydroxyflavone



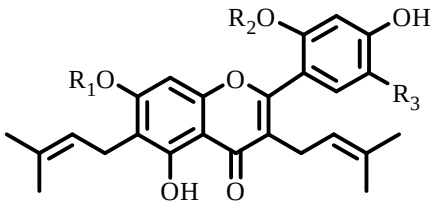
10e: artobilochromen



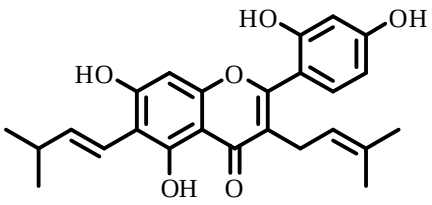
11e: artonin I



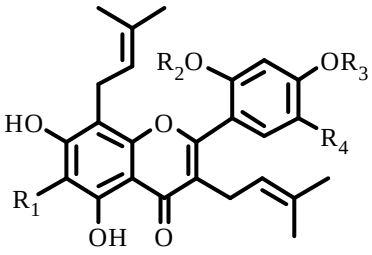
	R_1	R_2	
12e:	H	H	: artocarpone A
13e:	H	CH_3	: artoindonesianin R
14e:	CH_3	H	: artoindonesianin Q



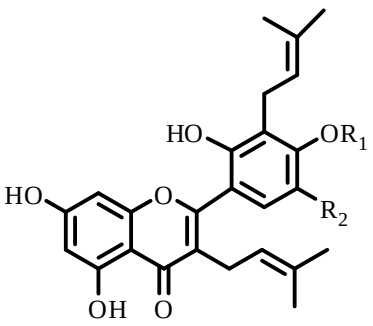
	R_1	R_2	R_3	
15e:	CH_3	H	H	: artocarpin
16e:	H	H	H	: cudraflavone C
17e:	CH_3	CH_3	OH	:dihydroisoartonin E 2′-methylether



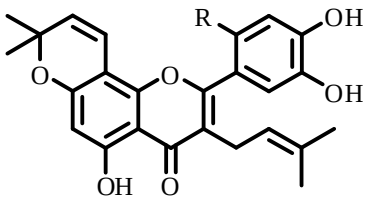
18e: norartocarpin



	R_1	R_2	R_3	R_4	
19e:	H	H	CH_3	OH	: artochamin D
20e:		H	H	H	: artelasticin
21e:	H	CH_3	H	OH	: artonin V 2′-methylether



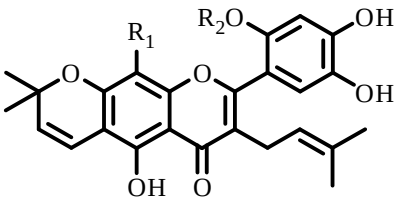
	R_1	R_2	
22e:	CH_3	OH	: heteroartonin A
23e:	H	H	: kuwanon T

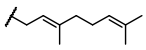


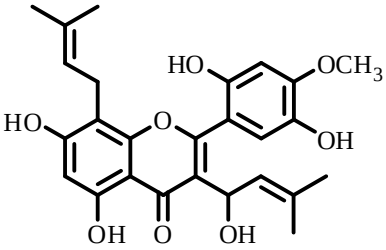
24e: R = OH : artonin E

25e: R = OCH_3 : artonin E 2′-methylether

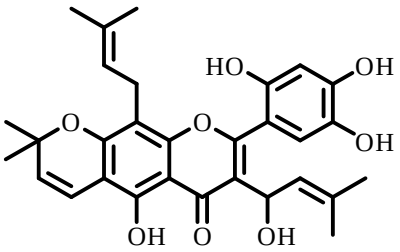
26e: R = H : artochamin C



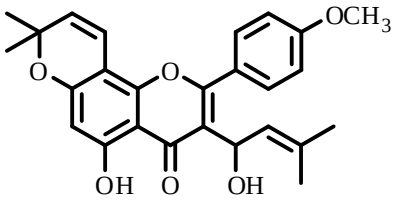
	R_1	R_2	
27e:		H	: artoindonesianin U
28e:		H	: heterophyllin
29e:	H	CH_3	: isoartonin E 2′-methylether



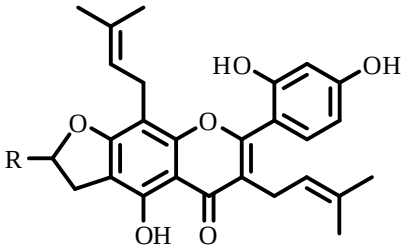
30e: artelasticinol



31e: artelasheterol

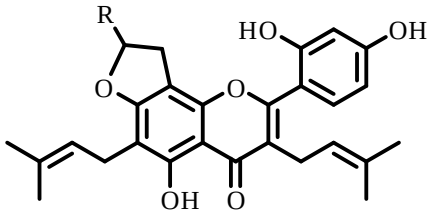


32e: artocommunol CE



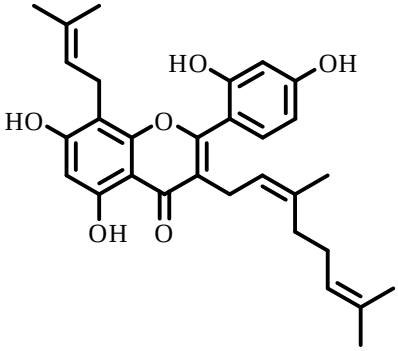
33e: R =  : artoindonesianin G

34e: R =  : artoindonesianin I

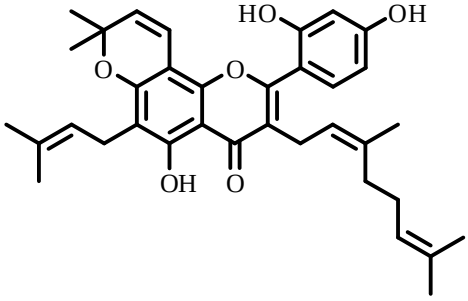


35e: R =  : artoindonesianin H

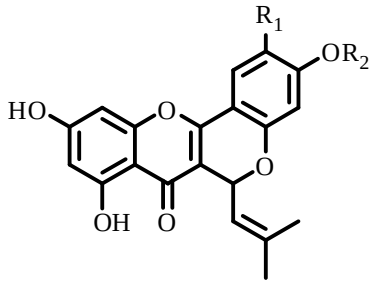
36e: R =  : artelastofuran



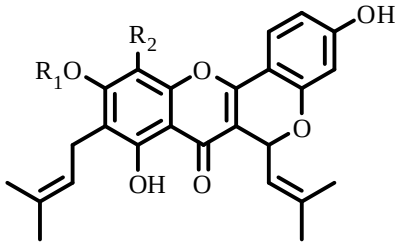
37e: artocommunol CD



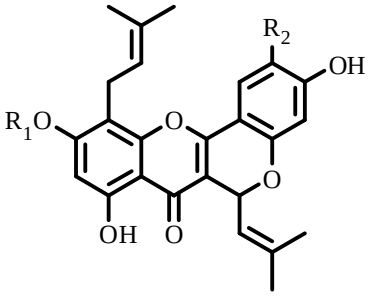
38e: artocommunol CB



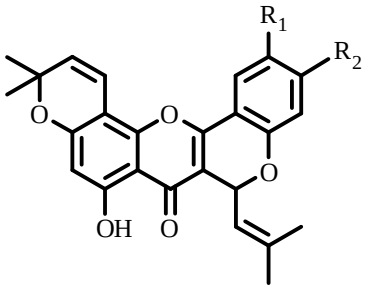
	R_1	R_2	
39e:	OH	CH_3	: artoindonesianin A-2
40e:	H	H	: cyclocommunol
41e:	H	OH	: cyclochampedol



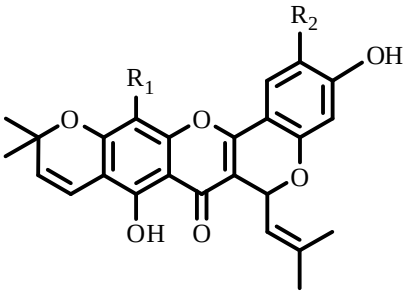
	R_1	R_2	
42e:	H		: artelastin
43e:	CH_3	H	: cycloartocarpin
44e:	H	H	: cyclocommunin



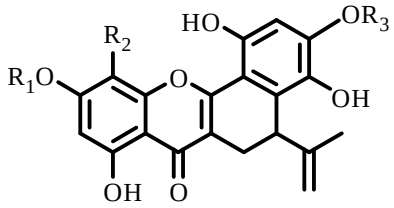
	R_1	R_2	
45e:	H	H	: artochamin B
46e:	H	H	: cyclomulberrin
47e:	CH_3	H	: dihydrocycloartomunin
48e:	H	OCH_3	: dihydroisocycloartomunin



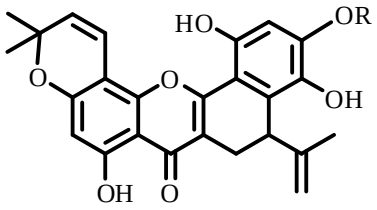
	R_1	R_2	
49e:	OH	OH	: artochamin A
50e:	OH	OCH_3	: cycloartomunin
51e:	H	OH	: cyclomorusin
52e:	H	OCH_3	: artocommunol CA



	R_1	R_2	
53e:		H	: artelastochromene
54e:	H	H	: cudraflavone A
55e:		OH	: cycloheterophyllin

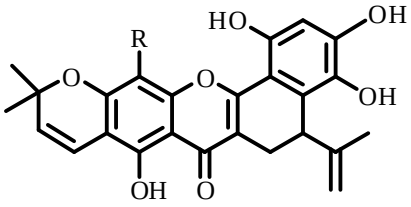


	R_1	R_2	R_3	
56e:	H		H	: artochamin E
57e:	CH_3	H	CH_3	: artoindonesianin S
58e:	H	H	CH_3	: artoindonesianin T

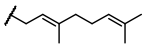


59e: R = CH_3 : artomunoxanthone

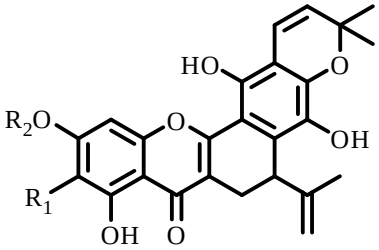
60e: R = OH : artobiloxanthone



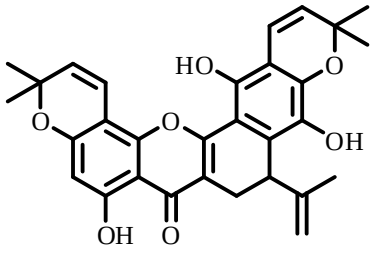
61e: R = H : artoindonesianin A-3

62e: R =  : artoindonesianin V

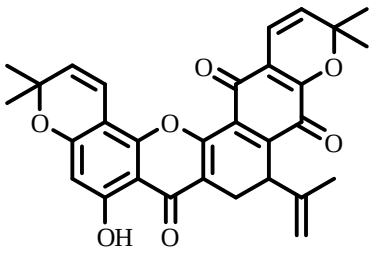
63e: R =  : artonin B



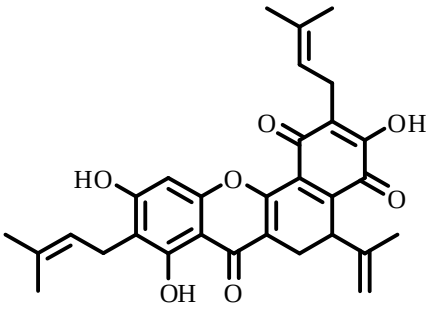
	R_1	R_2	
64e:	H		: artonin N
65e:	H	OH	: artonol E
66e:	H	H	: 7-demethylartonol E



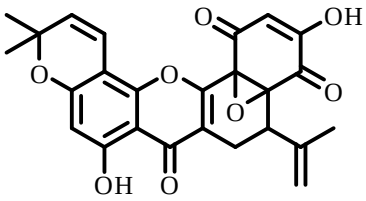
67e: artonol C



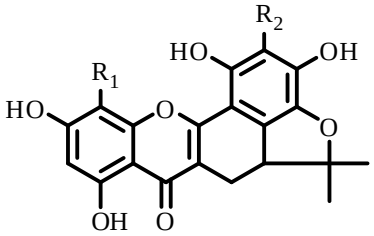
68e: artonol D



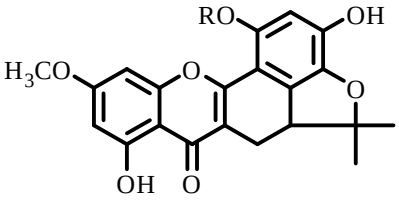
69e: artonin O



70e: artonin P

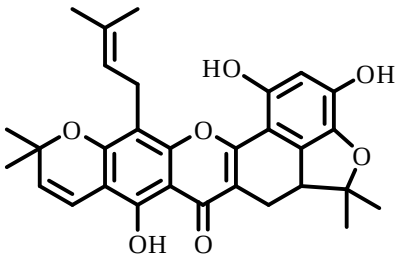


	R_1	R_2	
71e:		H	: artocarpone B
72e:	H		: artonin J

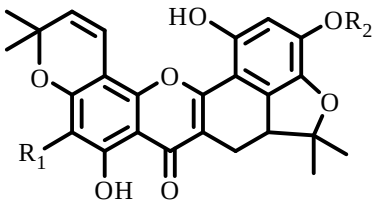


73e: R = H : artonin K

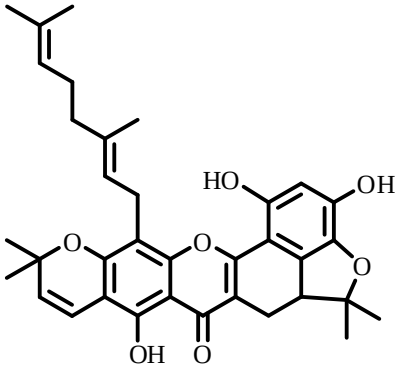
74e: R = CH_3 : artonin L



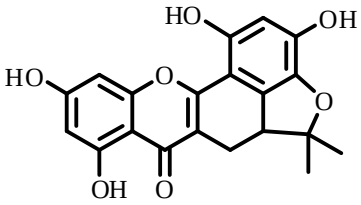
75e: artonin A



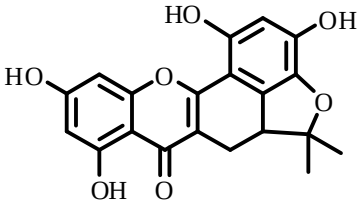
	R_1	R_2	
76e:	H	H	: cycloartobiloxanthone
77e:		H	: artonin F
78e:	H	CH_3	: cycloartomunoxanthone



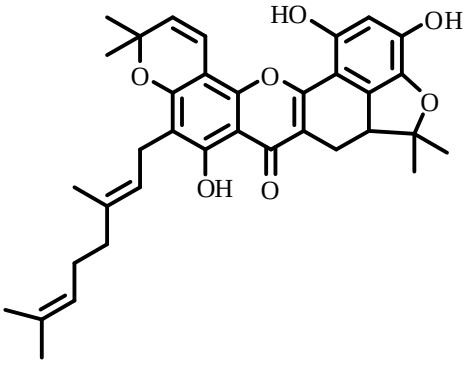
79e: artoindonesianin A



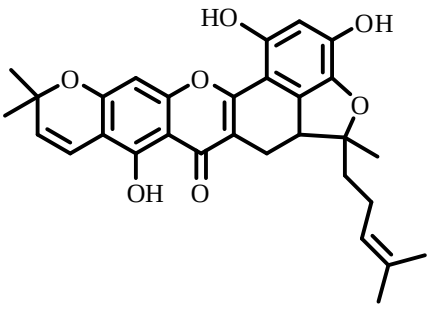
80e: artoindonesianin P



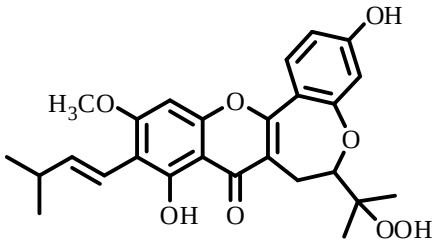
81e: cycloartelastoxanthendiol



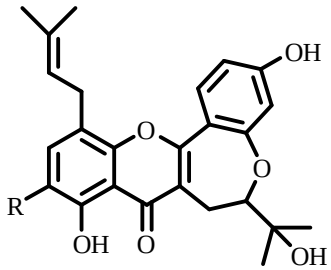
82e: cycloartelastoxanthone

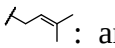


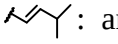
83e: artonin M

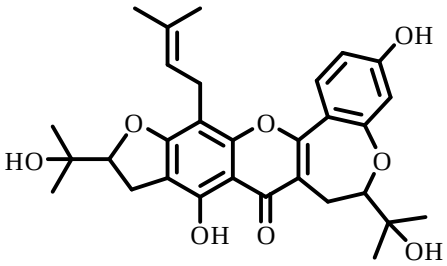


84e: artoindonesianin B

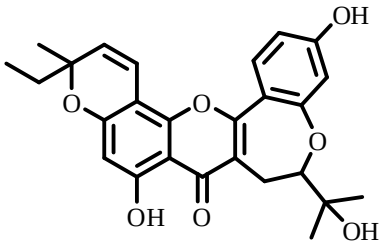


85e: R =  : artelastocarpin

86e: R =  : artelastinin

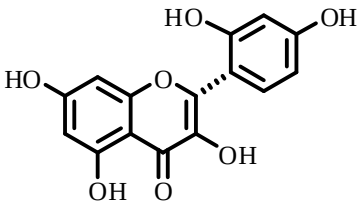


87e: carpelastofuran



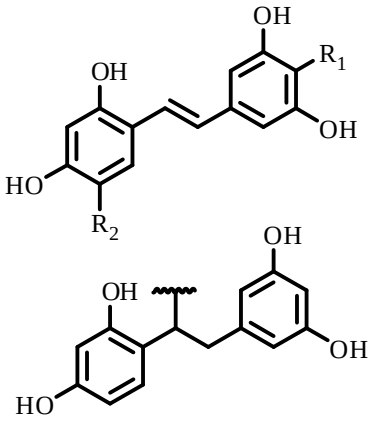
88e: artocommunol CC

f. Flavonol

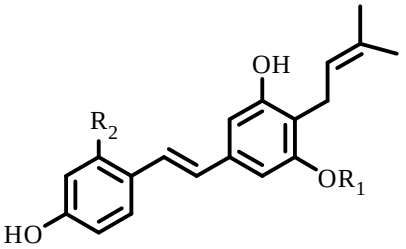


1f: morin

g. Stilbenes

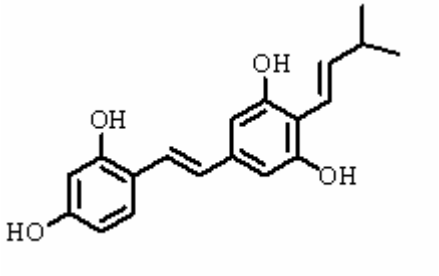


	R_1	R_2	
1g:	X	H	: andalasin A
2g:	H	X	: artogomezianol

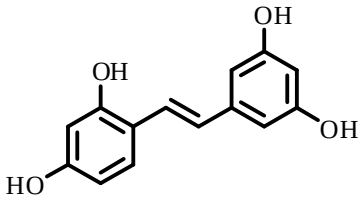


	R_1	R_2	
3g:	CH_3	H	: artoindonesianin N
4g:	H	OH	

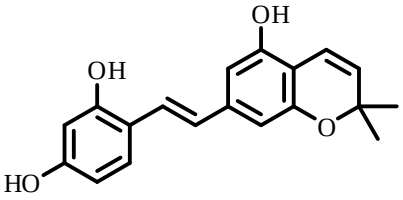
: *trans*-4-isopentenyl-3,5,2′,4′-tetrahydroxystilbene



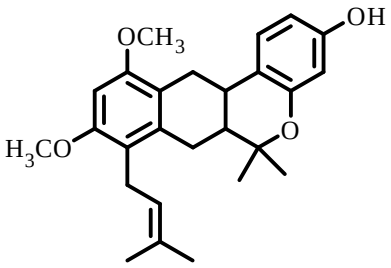
5g: *trans*-4-(3-methyl-*E*-but-1-enyl)-3,5,2′,4′-tetrahydroxystilbene



6g: oxyresveratrol

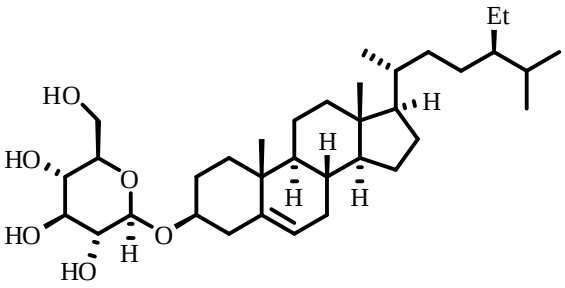


7g: artocarbene



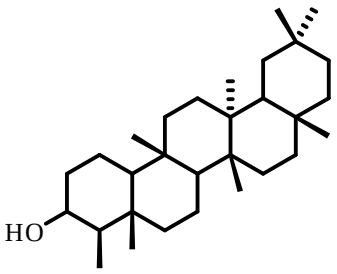
8g: heterophylol

h. Steroids

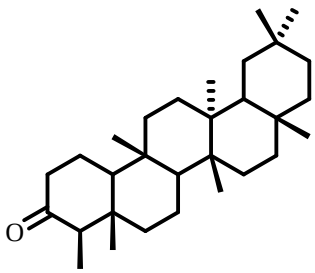


1h: sitosterol *β*-D-glucopyranoside

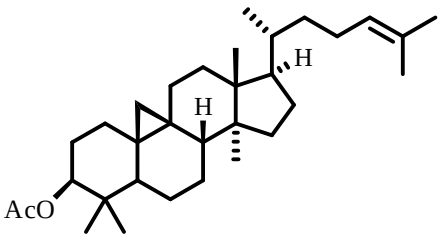
i. Triterpenes



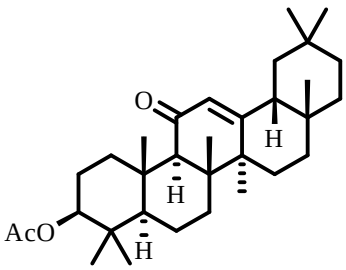
1i: friedelan-3*β*-ol



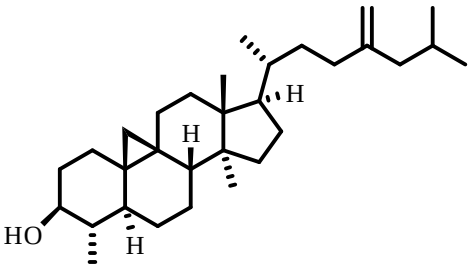
2i: friedelin



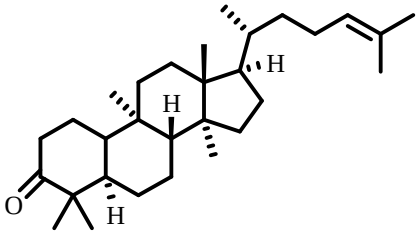
3i: cycloartenyl acetate



4i: 3β-acetoxyolean-12-en-11-one

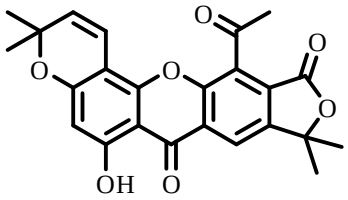


5i: cycloeucalenol

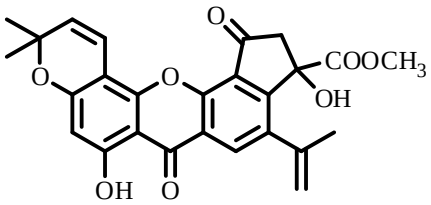


6i: cycloartenone

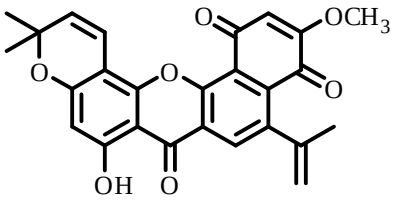
j. Xanthones



1j: artonol B



2j: artoindonesianin C



3j: artomunoxanthentrione

1.3 Objective

The objective of this work was to investigate the chemical constituents from the bark of *A. elasticus*.

CHAPTER 2

EXPERIMENTAL

2.1 General Method

Column chromatography was performed on silica gel 100 (70-230 Mesh ASTM, Merck) or Sephadex^{TM} LH-20 (Amersham Biosciences, Sweden). Quick column chromatography utilized silica gel 60 (230-400 Mesh ASTM, Merck). Aluminum sheets of silica gel 60 F_{254} (layer thickness 0.2 mm, Merck) were used for thin-layer chromatography (TLC) and the compounds were visualized under ultraviolet light. Solvents for extraction and chromatography were distilled at their boiling ranges prior to use. Melting points were determined on the Fisher-John melting point apparatus. Ultraviolet spectra were measured with UV-160A spectrophotometer (SHIMADZU). Principle bands (λ_{max}) were recorded as wavelengths (nm) and log ε in MeOH and CH_2Cl_2 solution. Infrared spectra (IR) were obtained on a FT-IR spectrum BX spectrophotometer and were recorded in wave number (cm^{-1}). ^{1}H- and ^{13}C-Nuclear magnetic resonance spectra were recorded on an FT-NMR Bruker Ultra Shield^{TM} 300 MHz spectrometer. Spectra were recorded in $CDCl_3$, DMSO and were recorded as δ value in ppm downfield from TMS (internal standard δ 0.00). Low and high resolution mass spectra were recorded on a MAT 95 XL at Scientific Equipment Center, Prince of Songkla University.

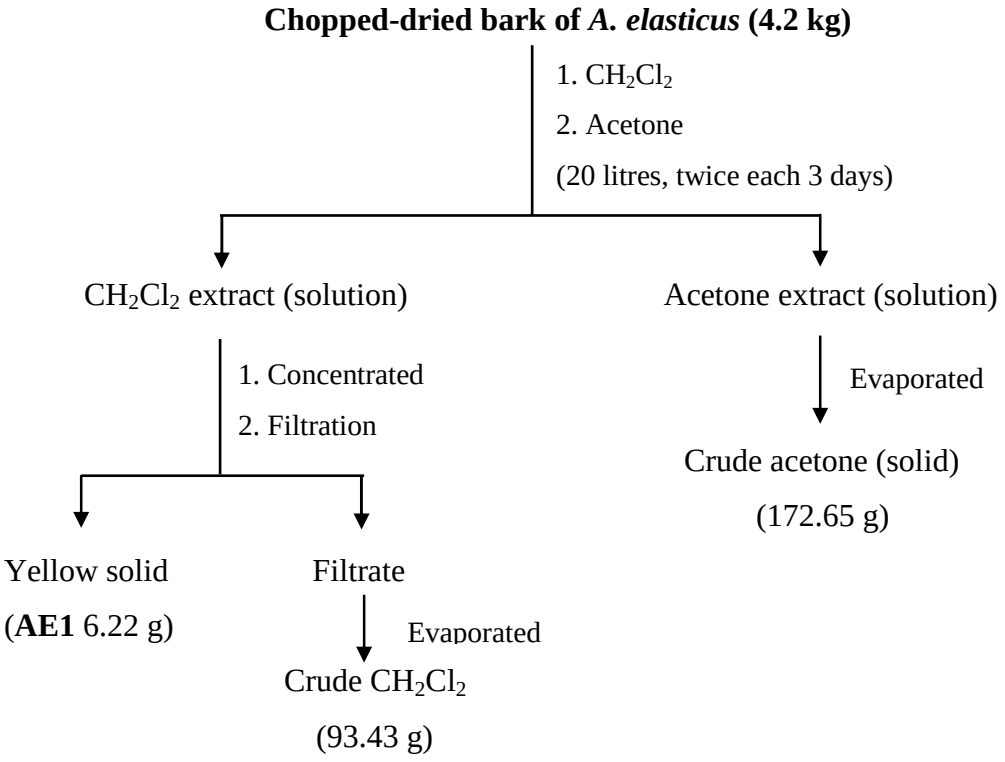
2.2 Plant Material

The bark of *A. elasticus* (Moraceae) was collected from Amphur Kuraburi, Phang Nga Province in the southern part of Thailand, in July 2007. Identification was made by Mr. Charernsak Saewai, Department of Biology, Faculty of Science, Prince of Songkla University. The specimen (A. Yanya 1Phang-nga: Kuraburi 2/4/2009) have been deposited in the Herbarium of Department of Biology,

Faculty of Science, Prince of Songkla University, Hatyai, Songkhla, Thailand.

2.3 Extraction and isolation

Chopped-dried bark of *A. elasticus* (4.2 kg) was immersed at room temperature in dichloromethane and acetone (each extract 3 days), successively. The solution of dichloromethane extract was concentrated under reduced pressure to produce a yellow solid upon standing overnight at room temperature. The solid **AE1** (6.22 g) was collected by filtration and the filtrate was further evaporated to give the dark-red viscous liquid (93.43 g). The solution of acetone extract was evaporated to give dark-red solid (172.65 g). The process of extraction was shown in **Scheme 1**.



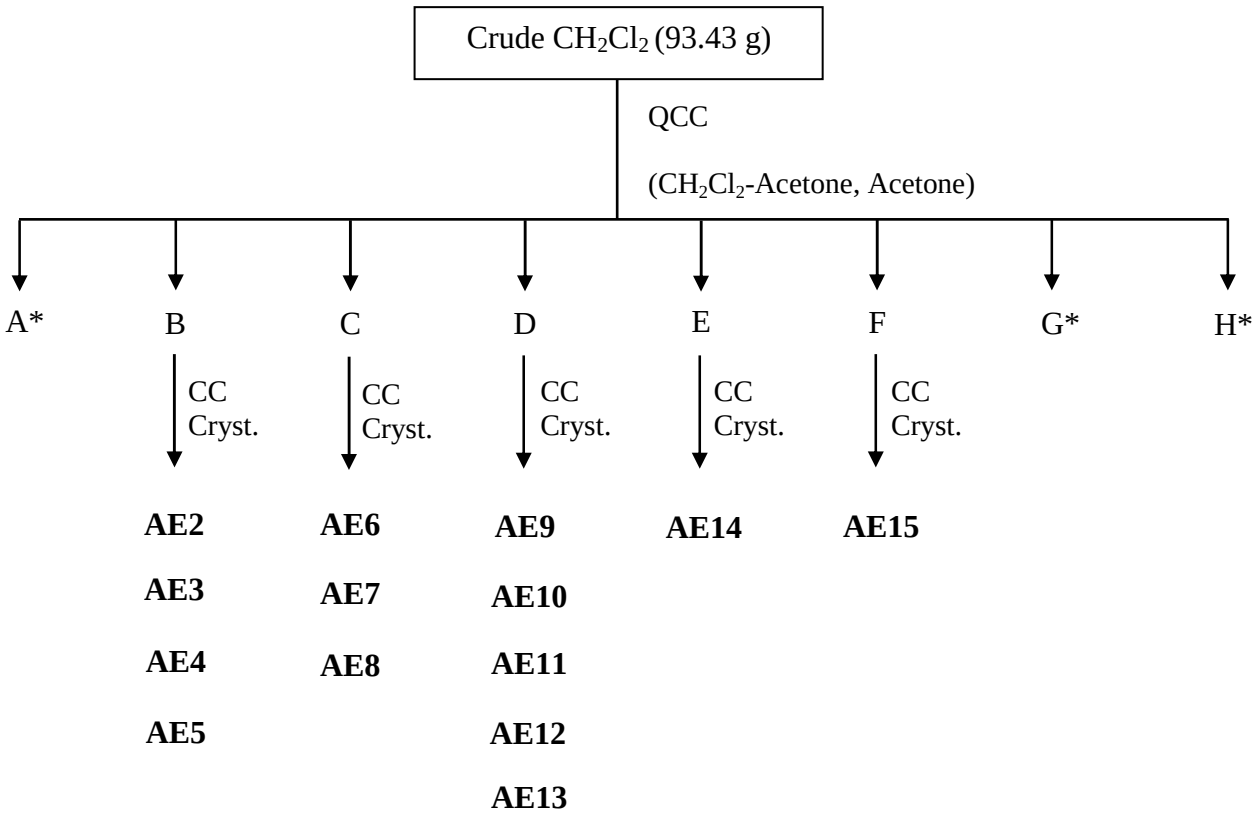
Scheme 1 Extraction of the crude extracts from the bark of *A. elasticus*

2.3.1 Purification of dichloromethane extract of the bark of *A. elasticus*

The solution of dichloromethane extract was concentrated under reduced pressure to produce a yellow solid upon standing overnight at room temperature. The solid **AE1** (6.22 g) was collected by filtration and the filtrate was further evaporated to give the dark-red viscous liquid (93.43 g). Which was subjected to quick column chromatography on silica gel, and eluted with CH_2Cl_2-acetone (13:1), and acetone (300 ml each). The fractions that showed the same major components on TLC were combined to yield fractions A-H. Further purification of each fraction gave fourteen pure compounds (**Scheme 2**).

Table 2 Physical characteristic and weight of fractions obtained from QCC of the crude CH_2Cl_2 extract

Fraction	Weight (g)	Appearance
A	15.8796	yellow gel
B	16.7920	brown gel
C	29.8941	dark-red viscous liquid
D	9.0987	dark-red viscous liquid
E	1.7163	dark-red viscous liquid
F	2.8492	dark-red viscous liquid
G	2.8205	brown solid
H	3.2393	brown solid



*No further investigation

Scheme 2 Isolation of compounds **AE2-AE15** from dichloromethane extract of the bark of *A. elasticus*

Isolation of AE1

The solution of the dichloromethane extract was concentrated under reduced pressure to produce a yellow solid upon standing overnight at room temperature. The solid **AE1** (6.22 g) was collected by filtration.

AE1

5-Hydroxy-8,8-dimethyl-3-(3-methyl-2-butenyl)-2-(2,4,5-trihydroxyphenyl)-4*H*,8*H*-benzo[1,2-b:3,4-*b*′]dipyran-4-one (artonin E)

Melting point: 217-219 °C

UV (CH_3OH) λ_{max} nm (log ε): 224 (4.34), 258 (4.41), 266 (4.47), 271 (4.47), 302 (3.90), 352 (3.89)

IR (Neat) ν_{max} (cm^{-1}): 3359 (O-H stretching), 1653 (C=O stretching)

^{1}H-NMR ($CDCl_3$+DMSO-d_6, 300 MHz) δ (ppm): 13.21 (1H, *s*, 5-OH), 8.56 (1H, *s*, OH), 8.38 (1H, *s*, OH), 7.54 (1H, *s*, OH), 6.79 (1H, *s*, H-6′), 6.62 (1H, *d*, *J* = 9.9 Hz, H-14), 6.19 (1H, *s*, H-6), 6.58 (1H, *s*, H-3′), 5.48 (1H, *d*, *J* = 9.9 Hz, H-15), 5.12 (1H, *t*, *J* = 6.6 Hz, H-10), 3.14 (2H, *d*, *J* = 6.6 Hz, H-9), 1.61 (3H, *s*, 13-CH_3), 1.47 (3H, *s*, 12-CH_3), 1.44 (6H, *s*, 17-CH_3 and 18-CH_3)

^{13}C NMR ($CDCl_3$+DMSO-d_6, 75 MHz) δ (ppm): δ 182.5 (C-4), 161.5 (C-5), 161.2 (C-2), 158.8 (C-7), 152.4 (C-8a), 148.8 (C-2′), 147.9 (C-4′), 137.6 (C-5′), 132.0 (C-11), 126.5 (C-15), 121.5 (C-10), 120.8 (C-3), 116.2 (C-6′), 115.2 (C-14), 110.7 (C-1′), 105.0 (C-4a), 104.0 (C-3′), 100.8 (C-8), 99.2 (C-6), 17.5 (C-12), 77.7 (C-16), 28.0 (C-17 and C-18), 25.7 (C-13), 24.2 (C-9)

2.3.1.1 Purification of fraction B

Fraction B (16.7920 g) was chromatographed on silica gel 100 (hexane-dichloromethane, 3:1) to give fractions B1-B14.

Table 3 Physical characteristic and weight of fractions obtained from CC of fraction B

Fraction	Weight (g)	Appearance
B1	0.1571	white solid mixed with cream gel
B2	0.0209	colorless gel
B3	0.4449	yellow gel
B4	1.1679	yellow gel
B5	2.9514	yellow gel
B6	8.6561	yellow gel
B7	0.1761	orange viscous liquid
B8	0.4108	yellow-brown viscous liquid
B9	0.3249	brown solid mixed with yellow viscous liquid
B10	0.2635	brown viscous liquid
B11	0.4416	brown viscous liquid
B12	0.2287	dark red viscous liquid
B13	0.2754	dark red viscous liquid
B14	0.2177	dark red viscous liquid

Isolation of AE2

Fraction B8 (0.4108 g) was further purified by column chromatography over silica gel and eluted with hexane-acetone (20:1) solvent system. The subfractions containing similar components were combined to give fractions B8.1-B8.6. **AE2** (55.8 mg) was obtained as an yellow gum from fraction B8.4.

AE2

8-Hydroxy-3-methylisochroman-1-one (mullein)

$[\alpha]^{31}{}_{D}$ -72 ° (*c* 0.07, $CHCl_3$)

IR (Neat) ν_{max} (cm^{-1}): 3438 (O-H stretching), 1680 (C=O stretching)

^{1}H-NMR ($CDCl_3$, 300 MHz) δ (ppm): 10.95 (1H, *s*, 8-OH), 7.32 (1H, *t*, *J* = 7.9 Hz, H-6), 6.80 (1H, *d*, *J* = 7.9 Hz, H-7), 6.61 (1H, *d*, *J* =7.9 Hz, H-5), 4.65 (1H, *sext*, *J* = 6.6 Hz, H-3), 2.85 (2H, *d*, *J* = 6.6 Hz, H-4), 1.47 (3H, *d*, *J* = 6.6 Hz, 9-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): δ 169.9 (C-1), 162.2 (C-8), 139.4 (C-4a), 136.1 (C-6), 117.9 (C-5), 116.2 (C-7), 108.3 (C-8a), 76.1 (C-3), 34.6 (C-4), 20.7 (C-9)

Isolation of AE3

Fraction B12 (0.2287 g) was purified by a silica gel column with hexane-acetone (7:1) as an eluent to provide six fractions (B12.1-B12.6). A yellow gum of **AE3** (6.6 mg) was obtained from the fraction B12.6.

AE3

5-Hydroxy-2-(4-hydroxy-2,5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one

IR (Neat) ν_{max} (cm^{-1}): 3445 (O-H stretching), 1653 (C=O stretching)

^{1}H NMR ($CDCl_3$, 300 MHz) δ (ppm): 13.00 (1H, *s*, 5-OH), 6.83 (1H, *s*, H-6′), 6.67 (1H, *s*, H-3′), 6.35 (2H, *s*, H-6 and H-8), 5.93 (1H, *s*, 4′-OH), 5.11 (1H, *t*, *J* = 6.6 Hz, H-10), 3.86 (3H, *s*, 5′-OCH_3), 3.83 (3H, *s*, 7-OCH_3), 3.75 (3H, *s*, 2′-OCH_3), 3.04 (2H, *d*, *J* = 6.6 Hz, H-9), 1.62 (3H, *s*, 13-CH_3), 1.42 (3H, *s*, 12-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 182.4 (C-4), 165.3 (C-7), 162.2 (C-5), 160.7 (C-2), 158.2 (C-8a), 148.5 (C-4′), 140.3 (C-5′), 132.0 (C-11), 121.7 (C-10), 121.4 (C-3), 112.9 (C-6′), 112.7 (C-1′), 105.5 (C-4a), 99.7 (C-3′), 97.8 (C-6), 92.0 (C-8), 56.7 (7-OCH_3), 56.2 (5′-OCH_3), 55.7 (2′-OCH_3), 25.7 (C-13), 24.2 (C-9), 17.6 (C-12)

EI-MS *m/z* (% relative intensity): 412 [M^+] (13), 411 (47), 396 (4), 381 (35), 368 (100), 356 (8), 338 (19), 324 (36), 296 (10), 282 (3), 256 (2), 242 (2), 190 (3), 180 (5), 166 (17), 163 (4), 149 (3), 128 (2), 69 (6)

HREI-MS *m/z*: 412.1542 for $C_{23}H_{24}O_7$ (calcd. 412.1522)

Isolation of AE4 and AE5

Fraction B13 (0.2754 g) was further purified by crystallization from hexane-dichloromethane (1:1) to give a yellow solid of **AE4** (11.9 mg) upon standing at room temperature. The filtrate of B13 was rechromatographed using hexane-acetone (7:1) as eluent to give eight fractions (B13.1-B13.8). The fraction B13.6 gave an orange solid of **AE5** (3.8 mg).

AE4

6,7-Dihydro-5,9,14-trihydroxy-11-methoxy-3,3-dimethyl-6-(1-methylethyl)-3*H*,8*H*-[1]benzopyrano[7,6-*c*]xanthen-8-one (artonol E)

Melting point: 205-207 °C

UV (EtOH) λ_{max} nm (log ε): 214 (2.81), 271 (2.79), 304 (2.41), 378 (2.58)

IR (Neat) ν_{max} (cm^{-1}): 3406 (O-H stretching), 1653 (C=O stretching)

^{1}H NMR ($CDCl_3$, 300 MHz) δ (ppm): 12.99 (1H, *s*, 5-OH), 7.76 (1H, *s*, 2′-OH), 6.74 (1H, *d*, *J* = 10.0 Hz, H-14), 6.37 (2H, *s*, H-6 and H-8), 5.64 (1H, *d*,

J = 10.0 Hz, H-15), 5.27 (1H, *s*, 5′-OH), 4.71 (1H, *s*, H_β-12), 4.35 (1H, *s*, H_α-12), 3.96 (1H, *d*, *J* = 6.9 Hz, H-10), 3.86 (3H, *s*, 7-OCH_3), 3.40 (1H, *dd*, *J* = 16.2, 1.5 Hz, H_β-9), 2.54 (1H, *dd*, *J* = 16.2, 6.9 Hz, H_α-9), 1.85 (3H, *s*, 13-CH_3), 1.52 (3H, *s*, 17-CH_3), 1.49 (3H, *s*, 18-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 180.1 (C-4), 165.1 (C-7), 162.4 (C-5), 159.9 (C-2), 155.7 (C-8a), 145.0 (C-2′), 144.3 (C-11), 143.9 (C-4′), 135.6 (C-5′), 128.6 (C-15), 126.7 (C-6′), 116.3 (C-14), 111.9 (C-12), 111.7 (C-3), 108.8 (C-3′), 105.1 (C-1′), 105.0 (C-4a), 98.2 (C-6), 92.1 (C-8), 78.5 (C-16), 55.8 (7-OCH_3), 36.6 (C-10), 28.3 (C-17), 28.2 (C-18), 21.6 (C-9, C-13)

AE5

12-Acetyl-6-hydroxy-3,3,9,9-tetramethyl-3*H*,7*H*,furo[3,4-*b*]pyrano[3,2-*h*]xanthen 7,11(9*H*)-dione (artonol B)

Melting point: 190-193 °C

UV (EtOH) λ_{max} nm (log ε): 207 (2.49), 241 (2.41), 275 (2.25), 285 (2.24), 314 (1.92), 338 (1.89), 411 (1.54)

IR (Neat) ν_{max} (cm^{-1}): 3455 (O-H stretching), 1731, 1653 (C=O stretching)

^{1}H NMR ($CDCl_3$, 300 MHz) δ (ppm): 12.50 (1H, *s*, 1-OH), 8.31(1H, *s*, H-8), 6.60 (1H, *d*, *J* = 10.1 Hz, H-10), 6.32 (1H, *s*, H-2), 5.63 (1H, *d*, *J* = 10.1 Hz, H-11), 2.82 (3H, *s*, 5-$COCH_3$), 1.76 (6H, *s*, 17-CH_3 and 18-CH_3), 1.50 (6H, *s*, 13-CH_3 and 14-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 198.5 (5-$\underline{C}OCH_3$), 179.1 (C-9), 169.4 (C-15), 163.2 (C-1), 162.3 (C-3), 152.5 (C-4a and C-4b), 148.6 (C-7), 131.0 (C-5), 128.2 (C-11), 125.2 (C-6 and 8a), 119.2 (C-8), 114.2 (C-10), 103.5 (C-9a), 101.4 (C-4), 100.2 (C-2), 86.6 (C-16), 79.1 (C-12), 32.3 (5-CO$\underline{C}H_3$), 28.5 (C-13 and C-14), 27.6 (C-17 and C-18)

2.3.1.2 Purification of fraction C

Fraction C (29.8941 g) was chromatographed on silica gel 100 (hexane-acetone, 20:1 to 2.5:1) to give fractions C1-C12.

Table 4 Physical characteristic and weight of fractions obtained from CC of fraction C

Fraction	Weight (g)	Appearance
C1	3.6894	yellow gel
C2	3.0701	green gel
C3	3.6262	yellow viscous liquid
C4	3.2734	green viscous liquid
C5	0.6268	red-brown viscous liquid
C6	0.3340	red-brown viscous liquid
C7	1.3897	red-brown viscous liquid
C8	2.3683	red-brown viscous liquid
C9	2.4563	red-brown viscous liquid
C10	1.6307	red-brown viscous liquid
C11	1.6454	dark brown viscous liquid
C12	0.3377	dark-brown viscous solid

Isolation of AE6

Fraction C7 (1.3897 g) was chromatographed on column chromatography and elution was conducted with hexane-acetone (7:1) to afford 10 portions (C7.1-C7.10). Fraction C7.2 was rechromatograped on column chromatography and eluted with hexane-acetone (7:1) to give a red-brown gum **AE6** (9.1 mg).

AE6

6,7-Dihydro-5,9,11,14-tetrahydroxy-3,3-dimethyl-6-(1-methylethenyl)-(-)-3*H*,8*H*-pyrano[3′,2′:4,5]benzo[1,2-*c*]xanthen-8-one (artelastoxanthone or 7-demethylartonol E)

UV (CH_3OH) λ_{max} nm (log ε): 263 (4.39), 269 (4.36), 307 (3.71), 379 (4.11)

IR (Neat) ν_{max} (cm^{-1}): 3402 (O-H stretching), 1655 (C=O stretching)

^{1}H NMR ($CDCl_3$+Acetone-d_6, 300 MHz) δ (ppm): 12.98 (1H, *s*, 5-OH), 7.78 (1H, *s*, 2′-OH), 6.74 (1H, *d*, *J* = 10.0 Hz, H-14), 6.40 (1H, *d*, *J* = 1.8 Hz, H-8), 6.35 (1H, *d*, *J* = 1.8 Hz, H-6), 5.64 (1H, *d*, *J* = 10.0 Hz, H-15), 5.46 (1H, *s*, 5′-OH), 4.71 (1H, *s*, H_β-12), 4.34 (1H, *s*, H_α-12), 3.96 (1H, *d*, *J* = 6.9 Hz, H-10), 3.39 (1H, *dd*, *J* = 16.2, 1.5 Hz, H_β-9), 2.53 (1H, *dd*, *J* = 16.2, 6.9 Hz, H_α-9), 1.81 (3H, *s*, 13-CH_3), 1.52 (3H, *s*, 17-CH_3), 1.49 (3H, *s*, 18-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 180.0 (C-4), 163.0 (C-7), 162.4 (C-5), 159.7 (C-2), 155.9 (C-8a), 144.9 (C-2′), 144.3 (C-11), 143.8 (C-4′), 135.6 (C-5′), 128.5 (C-15), 126.7 (C-6′), 116.3 (C-14), 111.7 (C-12), 111.5 (C-3), 108.8 (C-3′), 105.2 (C-1′), 104.5 (C-4a), 99.8 (C-6), 93.6 (C-8), 78.3 (C-16), 36.5 (C-10), 28.2 (C-17), 28.1 (C-18), 21.6 (C-13), 21.5 (C-9)

Isolation of AE7

Fraction C7.3 was further purified by crystallization from hexane-dichloromethane-acetone (1:1:1) upon standing at room temperature to give yellow solid of **AE7** (4.9 mg).

AE7

New furanodihydrobenzoxanthone derivative

$[\alpha]^{26.7}_{D}$ -18.5 ° (*c* 0.03, MeOH)

Melting point: 287-289 °C

UV (EtOH) λ_{max} nm (log ε): 214 (2.81), 253 (2.70), 273 (2.82), 288 (2.69), 308 (2.45), 375 (2.62)

IR (Neat) ν_{max} (cm^{-1}): 3442 (O-H stretching), 1630 (C=O stretching)

^{1}H NMR ($CDCl_3$+Acetone-d_6, 300 MHz) δ (ppm): 13.00 (1H, *s*, 5-OH), 9.42 (1H, *s*, 7-OH), 7.17 (1H, *s*, 2′-OH), 6.69 (1H, *d*, *J* = 10.2 Hz, H-14), 6.47 (1H, *d*, *J* = 2.1 Hz, H-8), 6.31 (1H, *d*, *J* = 2.1 Hz, H-6), 5.57 (1H, *d*, *J* = 10.2 Hz, H-15), 3.39 (1H, *dd*, *J* = 15.3, 7.2 Hz, H-10), 3.21 (1H, *dd*, *J* = 15.3, 7.2 Hz, H_β-9), 2.40 (1H, *t*, *J* = 15.3 Hz, H_α-9), 1.68 (1H, *s*, 13-CH_3), 1.50 (3H, *s*, 17-CH_3), 1.47 (3H, *s*, 18-CH_3), 1.35 (3H, *s*, 12-CH_3)

^{13}C NMR ($CDCl_3$+DMSO-d_6, 75 MHz) δ (ppm): 185.4 (C-4), 168.7 (C-7), 167.5 (C-5), 165.1 (C-2), 161.5 (C-8a), 149.6 (C-2′), 147.2 (C-4′), 142.6 (C-5′), 136.4 (C-6′), 133.2 (C-15), 121.9 (C-14), 117.4 (C-3), 116.1 (C-3′), 109.4 (C-4a), 108.5 (C-1′), 104.9 (C-6), 99.0 (C-8), 98.7 (C-11), 82.7 (C-16), 51.5 (C-10), 33.2 (C-13), 33.1 (C-17), 33.0 (C-18), 27.6 (C-12), 24.9 (C-9)

EI-MS *m/z* (% relative intensity): 434 [M^+] (15), 433 (50), 418 (100), 416 (17), 391 (7), 390 (23), 375 (22), 372 (8), 348 (16), 344 (5), 330 (4), 292 (3), 254 (4), 209 (3), 188 (7), 164 (3), 152 (4), 138 (1), 115 (2), 69 (2)

HREI-MS *m/z*: 434.1377 for $C_{25}H_{22}O_7$ (calcd. 434.1366)

Isolation of AE8

Fraction C7.4 containing one major component was further purified by crystallization from hexane-dichloromethane-acetone (1:1:1). A yellow solid of **AE8** (18.8 mg) which formed was filtered.

AE8

5a,6-Dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-9-(3-methyl-2-buten-1-yl)-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (artonin F)

Melting point: 249-251 °C

UV (CH_3OH) λ_{max} nm (log ε): 236 (4.46), 256 (4.42), 265 (4.41), 278 (4.50), 335 (4.09), 390 (4.27)

IR (Neat) ν_{max} (cm^{-1}): 3371 (O-H stretching), 1629 (C=O stretching)

^{1}H NMR ($CDCl_3$+DMSO-d_6, 300 MHz) δ (ppm): 13.42 (1H, *s*, 5-OH), 9.23 (1H, *s*, 4′-OH), 7.78 (1H, *s*, 2′-OH), 6.76 (1H, *d*, *J* = 9.9 Hz, H-19), 6.38 (1H, *s*, H-3′), 5.57 (1H, *d*, *J* = 9.9 Hz, H-20), 5.24 (1H, *t*, *J* = 7.2 Hz, H-15), 3.41 (1H, *dd*, *J* = 15.0, 7.2 Hz, H-10), 3.33 (1H, *d*, *J* = 7.2 Hz, H-14), 3.23 (1H, *dd*, *J* = 15.0, 7.2 Hz, H_β-9), 2.40 (1H, *t*, *J* = 15.0 Hz, H_α-9), 1.81 (3H, *s*, 18-CH_3), 1.68 (3H, *s*, 17-CH_3), 1.66 (3H, *s*, 13-CH_3), 1.46 (6H, *s*, 22-CH_3 and 23-CH_3), 1.35 (3H, *s*, 12-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 180.7 (C-4), 160.3 (C-2), 158.7 (C-5), 156.4 (C-7), 150.1 (C-2′), 149.2 (C-8a), 146.4 (C-4′), 137.2 (C-5′), 131.8 (C-6′), 131.3 (C-16), 127.1 (C-20), 122.1 (C-15), 115.3 (C-19), 112.5 (C-6), 111.5 (C-3), 104.6 (C-3′), 104.3 (C-4a), 103.4 (C-1′), 100.5 (C-8), 93.5 (C-11), 77.3 (C-21), 46.6 (C-10), 28.1 (C-13), 28.0 (C-22 and C-23), 25.8 (C-18), 22.7 (C-12), 21.3 (C-14), 19.9 (C-9), 17.9 (C-17)

2.3.1.3 Purification of fraction D

Fraction D (9.0987 g) was chromatographed on silica gel 100 (hexane-acetone, 20:1 to 2:1) to give fractions D1-D15.

Table 5 Physical characteristic and weight of fractions obtained from CC of fraction D

Fraction	Weight (g)	Appearance
D1	0.2134	yellow gel
D2	0.1456	orange gel
D3	0.0961	orange gel
D4	0.2567	orange gel
D5	0.3564	yellow gel
D6	0.2689	brown-yellow viscous liquid
D7	0.0670	brown viscous liquid
D8	0.0921	brown viscous liquid
D9	0.1587	black-brown viscous liquid
D10	0.1109	black-brown viscous liquid
D11	0.4822	black-brown viscous liquid
D12	0.8762	black-brown viscous liquid
D13	2.2525	black-brown viscous liquid
D14	1.5685	black-brown solid
D15	0.6456	black solid

Isolation of AE9 and AE10

Fraction D11 (0.4822 g) was further separated by column chromatography over silica gel and eluted with hexane-acetone (7:1) solvent system. The fractions containing similar components were combined into eleven fractions (D11.1-D11-11). The fraction D11.8 was rechromatographed using hexane-acetone (5:1) as an eluent to afford red-brown gum **AE9** (1.7 mg). The fraction D11.9 which contained one major component was further purified by crystallization from hexane-acetone (7:1). A yellow solid of **AE10** (22.5 mg) which formed was filtered.

AE9

(3,4,5-Trimethoxyphenyl)methanol

^{1}H NMR ($CDCl_3$, 500 MHz) δ (ppm): 6.61 (2H, *s*, H-2 and H-6), 4.65 (2H, *s*, H-7), 3.88 (6H, *s*, 3-OCH_3 and 5-OCH_3), 3.85 (3H, *s*, 4-OCH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 153.5 (C-3 and C-5), 137.5 (C-4), 135.5 (C-1), 103.9 (C-2 and C-6), 65.6 (C-7), 60.9 (4-OCH_3), 56.1 (3-OCH_3 and 5- OCH_3)

AE10

5a,6-Dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*] pyrano[3,2-*h*]xanthen-7-one (cycloartobiloxanthone)

Melting point: 284-285 °C

UV (EtOH) λ_{max} nm (log ε): 228 (2.92), 257 (2.88), 273 (2.94), 312 (2.56), 330 (2.52), 391 (2.72)

IR (Neat) ν_{max} (cm^{-1}): 3405 (O-H stretching), 1642 (C=O stretching)

^{1}H NMR ($CDCl_3$+DMSO-d_6, 300 MHz) δ (ppm): 13.22 (1H, *s*, 5-OH) , 9.26 (1H, *s*, 4′-OH), 8.00 (1H, *s*, 2′-OH), 6.78 (1H, *d*, *J* = 10.0 Hz, H-14), 6.38 (1H, *s*, H-3′), 6.23 (1H, *s*, H-6), 5.56 (1H, *d*, *J* = 10.0 Hz, H-15), 3.38 (1H, *dd*, *J* = 15.0, 7.2 Hz, H-10), 3.21 (1H, *dd*, *J* = 15.0, 7.2 Hz, H_β-9), 2.40 (1H, *t*, *J* = 15.0 Hz, H_α-9), 1.66 (3H, *s*, 13-CH_3), 1.46 (6H, *s*, 17-CH_3 and 18-CH_3), 1.34 (3H, *s*, 12-CH_3)

^{13}C NMR ($CDCl_3$+DMSO-d_6, 75 MHz) δ (ppm): 180.6 (C-4), 161.5 (C-5), 160.7 (C-2), 158.7 (C-7), 150.9 (C-8a), 150.3 (C-2′), 146.5 (C-4′), 137.2

(C-5′), 131.9 (C-6′), 127.3 (C-15), 115.0 (C-14), 111.6 (C-3), 104.7 (C-4a and C-3′), 103.4 (C-1′), 101.0 (C-8), 99.9 (C-6), 93.5 (C-11), 77.8 (C-16), 46.6 (C-10), 28.1 (C-13, C-17 and C-18), 22.6 (C-12),19.8 (C-9)

Isolation of AE11

Fraction D12 (0.8762 g) was further purified by column chromatography over silica gel and eluted with hexane-acetone (4:1) solvent system. The fractions containing similar components were combined into thirteen fractions. Crystallization of the eighth fraction from hexane-acetone gave a yellow solid of **AE11** (3.1 mg).

AE11

New quinonobenzoxanthone derivative

$[\alpha]^{26.3}_{D}$ -18.2 ° (*c* 0.045, MeOH)

Melting point: 179-180 °C

UV (EtOH) λ_{max} nm (log ε): 217 (2.84), 229 (2.86), 245 (2.88), 267 (2.98), 303 (2.47), 354 (2.28)

IR (Neat) ν_{max} (cm^{-1}): 3433 (O-H stretching), 1720, 1647, 1584 (C=O stretching)

^{1}H NMR ($CDCl_3$, 300 MHz) δ(ppm): 12.56 (1H, *s*, H-5), 6.77 (1H, *d*, *J* = 10.0 Hz, H-14), 6.27 (1H, *s*, H-6), 5.59 (1H, *d*, *J* = 10.0 Hz, H-15), 4.30 (1H, *s*, 4′-OH), 3.49 (1H, *s*, 11-OH), 3.50 (1H, *t*, *J* = 2.1 Hz, H-6′), 3.00 (1H, *bs*, H-19), 2.96 (1H, *dd*, *J* = 16.8, 5.7 Hz, H-9), 2.93 (1H, *bs*, H-19), 2.92 (1H, *m*, H-10), 2.67 (1H, *bs*, H-3′), 2.63 (1H, *bs*, H-3′), 2.62 (1H, *d*, *J* = 2.1 Hz, H-1′), 2.58 (1H, *dd*, *J* = 16.8, 5.7 Hz, H-9), 2.27 (1H, *s*, H-21), 1.48 (3H, *s*, 17-CH_3), 1.46 (3H, *s*, 18-CH_3), 1.20 (3H, *s*, 13-CH_3), 0.90 (3H, *s*, 12-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ(ppm): 207.6 (C-20), 205.5 (C-5′), 198.8 (C-2′), 180.9 (C-4), 161.6 (C-5), 159.7 (C-7), 156.9 (C-2), 151.8 (C-8a), 127.4 (C-15), 115.9

(C-3), 114.8 (C-14), 104.9 (C-4a), 101.2 (C-8), 100.3 (C-6), 78.2 (C-16), 75.6 (C-4′), 74.5 (C-11), 47.8 (C-6′), 46.9 (C-19), 46.9 (C-1′), 43.5 (C-3′), 32.0 (C-21), 32.8 (C-10), 31.9 (C-13), 28.3 (C-17), 28.2 (C-18), 25.3 (C-12), 22.6 (C-9)

Isolation of AE12 and AE13

Fraction D13 (2.2525 g) was further purified by crystallization from hexane-acetone (1:1) upon standing at room temperature to give a brown-yellow solid of **AE12** (29.5 mg) and the filtrate (2.2230 g). The filtrate was purified by column chromatography over silica gel and eluted with mixed solvent of hexane-acetone (7:1 to 3:1) to give thirteen fractions (D13.1-D13.13). Fraction D13.12 was further purified by crystallization from acetone to give a yellow solid of **AE13** (18.8 mg) upon standing at room temperature.

AE12

1,3,4,8-Tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*]xanthen-7-(6*H*)-one

$[\alpha]^{26}_{D}$ -22 ° (*c* 0.045, MeOH)

Melting point: 242-243 °C

UV (EtOH) λ_{max} nm (log ε): 214 (2.77), 228 (2.67), 261 (2.77), 314 (2.36), 380 (2.66)

IR (Neat) ν_{max} (cm^{-1}): 3180 (O-H stretching), 1653 (C=O stretching)

^{1}H NMR (Acetone d_6, 300 MHz) δ (ppm): 13.23 (1H, *s*, 5-OH), 8.27 (1H, *s*, OH), 6.65 (1H, *d*, *J* = 2.4 Hz, H-8), 6.52 (1H, *s*, H-3′), 6.30 (1H, *d*, *J* = 2.4 Hz, H-6), 4.65 (1H, *s*, H_{β}-12), 4.29 (1H, *s*, H_{α}-12), 4.00 (1H, *d*, *J* = 6.3 Hz, H-10), 3.89 (3H, *s*, 7-OCH_3), 3.41 (1H, *dd*, *J* = 15.9, 1.8 Hz, H_{β}-9), 2.46 (1H, *dd*, *J* = 15.9, 6.3 Hz, H_{α}-9), 1.78 (3H, *s*, 13-CH_3)

^{13}C NMR (Acetone d_6, 75 MHz) δ (ppm): 180.1 (C-4), 165.1 (C-7), 161.9 (C-5), 161.0 (C-2), 156.7 (C-8a), 150.5 (C-2′), 150.3 (C-4′), 144.4 (C-11), 136.0 (C-5′),

128.3 (C-6′), 110.9 (C-12), 110.6 (C-3), 105.5 (C-1′), 104.7 (C-4a), 102.9 (C-3′), 97.7 (C-6), 92.2 (C-8), 55.4 (7-OCH_3), 37.0 (C-10), 21.4 (C-9), 21.0 (C-13)

EI-MS *m/z* (% relative intensity): 382 [M^+] (18), 381 (68), 366 (20), 364 (18), 353 (5), 341 (13), 340 (56), 338 (100), 311 (6), 310 (25), 294 (7), 266 (4), 241 (5), 217 (3), 200 (4), 188 (4), 166 (10), 161 (3), 115 (3), 91 (1), 77 (1), 68 (4)

HREI-MS *m/z*: 382.1068 for $C_{21}H_{18}O_7$ (calcd. 382.1053)

AE13

New quinonobenzoxanthone derivative

$[\alpha]^{25.8}_D$ -32 ° (*c* 0.025, MeOH)

Melting point: 202-203 °C

UV (EtOH) λ_{max} nm (log ε): 212 (2.73), 232 (2.83), 269 (2.97), 308 (2.35), 327 (2.20), 361 (2.07)

IR (Neat) ν_{max} (cm^{-1}): 3426 (O-H stretching), 1753, 1722, 1697, 1657 (C=O stretching)

^{1}H NMR ($CDCl_3$, 300 MHz) δ (ppm): 12.42 (1H, *s*, 5-OH), 6.78 (1H, *d*, *J* = 10.2 Hz, H-14), 6.28 (1H, *s*, H-6), 5.64 (1H, *s*, 4′-OH), 5.60 (1H, *d*, *J* = 10.2 Hz, H-15), 4.98 (1H, *s*, H_β-12), 4.91 (1H, *d*, *J* = 0.9 Hz, H_α-12), 3.57 (1H, *d*, *J* = 19.4 Hz, H-3′), 3.47 (1H, *d*, *J* = 19.4 Hz, H-3′), 3.38 (1H, *d*, *J* = 7.2 Hz, H-10), 3.25 (1H, *d*, *J* = 15.8 Hz, H_β-19), 3.03 (1H, *d*, H_α-19), 2.89 (1H, *d*, *J* = 17.1 Hz, H_β-9), 2.49 (1H, *dd*, *J* = 17.1, 7.2 Hz, H_α-9), 2.43 (3H, *s*, 21-CH_3), 1.67 (3H, *s*, 13-CH_3), 1.49 (3H, *s*, 17-CH_3), 1.46 (3H, *s*, 18-CH_3)

^{13}C NMR ($CDCl_3$, 75 MHz) δ (ppm): 213.3 (C-20), 198.7 (C-5′), 195.6 (C-2′), 181.4 (C-4), 162.8 (C-5), 161.3 (C-7), 155.2 (C-2), 153.4 (C-8a),145.1 (C-11), 129.1 (C-15), 117.8 (C-12), 117.3 (C-3), 116.3 (C-14), 106.6 (C-4a), 103.1 (C-8), 102.0 (C-6), 83.6 (C-4′), 79.9 (C-16), 72.0 (C-6′), 61.9 (C-1′), 50.9 (C-3′), 41.7 (C-19), 41.1 (C-10), 33.3 (C-21), 29.9 (C-17), 29.7 (C-18), 24.3 (C-9), 22.5 (C-13)

EI-MS *m/z* (% relative intensity): 506 [M^+] (9), 505 (27), 490 (100), 462 (3), 446 (6), 433 (13), 432 (34), 418 (14), 362 (19), 336 (7), 306 (3), 292 (6), 280 (2), 203 (1), 202 (13), 176 (2), 134 (2), 68 (2)

HREI-MS *m/z*: 506.1572 for $C_{28}H_{26}O_9$ (calcd. 506.1577)

Isolation of AE14

Fraction E (1.7163 g) was further separated by column chromatography over silica gel and eluted with hexane-acetone (4:1) solvent system. The fractions containing similar components were combined into twenty fractions (E1-E20). Crystallization of the fraction E13 from acetone gave yellow solid of **AE14** (4.3 mg).

AE14

5a,6-Dihydro-1,3,8-trihydroxy-10-methoxy-5,5-dimethyl-5*H*,7*H*-benzofuro[3,4-*bc*] xanthen-7-one (artonin K)

Melting point: 287-288 °C

UV (CH_3OH) λ_{max} nm (log ε): 225 (4.55), 266 (4.84), 270 (4.83), 304 (4.15), 362 (4.15)

IR (Neat) ν_{max} (cm^{-1}): 3369 (O-H stretching), 1629 (C=O stretching)

^{1}H NMR ($CDCl_3$+DMSO-d_6, 300 MHz) δ (ppm): 13.17 (1H, *s*, 5-OH), 9.71 (1H, *s*, 4′-OH), 8.38 (1H, *s*, 2′-OH), 6.56 (1H, *d*, *J* = 2.1 Hz, H-8), 6.39 (1H, *s*, H-3′), 6.32 (1H, *d*, *J* = 2.1 Hz, H-6), 3.88 (3H, *s*, 7-OCH_3), 3.38 (1H, *dd*, *J* = 15.0, 6.9 Hz, H-10), 3.22 (1H, *dd*, *J* = 15.0, 6.9 Hz, H_β-9), 2.40 (1H, *t*, *J* = 15.0 Hz, H_α-9), 1.67 (3H, *s*, 13-CH_3), 1.35 (3H, *s*, 12-CH_3)

^{13}C NMR ($CDCl_3$+DMSO-d_6, 75 MHz) δ (ppm): 185.2 (C-4), 169.6 (C-7), 166.5 (C-5), 165.9 (C-2), 161.3 (C-8a), 155.3 (C-2′), 151.5 (C-4′), 141.9 (C-5′), 136.6 (C-6′), 116.4 (C-3), 110.5 (C-4a), 109.6 (C-3′), 108.2 (C-1′), 102.8 (C-6), 97.8 (C-11), 97.1 (C-8), 60.5 (7-OCH_3), 51.4 (C-10), 32.9 (C-13), 27.4 (C-12), 24.6 (C-9)

Isolation of AE15

Fraction F (2.8492 g) was further separated by column chromatography over Sephadex^{TM} LH-20 and eluted with methanol. The fractions containing similar components were combined into sixteen fractions (F1-F16). The fraction F11 was further purified by column chromatography over silica gel and eluted with hexane-acetone (3:1) solvent system to give **AE15** as a pale yellow solid (7.0 mg).

AE15

5-Hydroxy-8,8-dimethyl-2-(2,4-dihydroxyphenyl)-4*H*,8*H*-benzo[1,2-*b*′]dipyran-4-one

Melting point: 189-191 °C

UV (EtOH) λ_{max} nm (log ε): 212 (2.66), 230 (2.58), 254 (2.44), 273 (2.52), 287 (2.51), 307 (2.38), 357 (2.54)

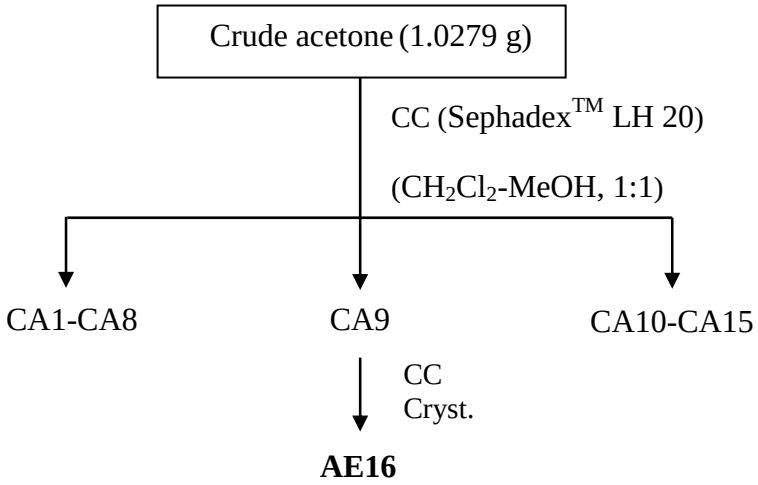
IR (Neat) ν_{max} (cm^{-1}): 3379 (O-H stretching), 1651 (C=O stretching)

^{1}H NMR (Acetone-d_6, 300 MHz) δ (ppm): 13.53 (1H, *s*, 5-OH), 7.83 (1H, *d*, *J* = 8.7 Hz, H-6′), 7.15 (1H, *s*, H-3), 6.67 (1H, *d*, *J* = 10.2 Hz, H-9), 6.58 (1H, *d*, *J* = 2.1 Hz, H-3′), 6.54 (1H, *dd*, *J* = 8.7, 2.1 Hz, H-5′), 6.44 (1H, *s*, H-6), 5.74 (1H, *d*, *J* = 10.2 Hz, H-10), 1.47 (6H, *s*, 12-CH_3 and 13-CH_3)

^{13}C NMR (Acetone-d_6, 75 MHz) δ (ppm): 182.8 (C-4), 162.3 (C-2), 161.9 (C-4′), 159.1 (C-7), 158.8 (C-2′), 157.1 (C-5), 156.3 (C-8a), 129.9 (C-6′), 128.1 (C-10), 115.0 (C-9), 108.2 (C-5′), 107.5 (C-3), 104.9 (C-4a, C-8, C-1′), 103.5 (C-3′), 94.6 (C-6), 78.3 (C-11), 27.6 (C-12 and C-13).

2.3.2 Purification of acetone extract

Acetone extract (1.0279 g) was separated by column chromatography over Sephadex^{TM} LH 20 and eluted with CH_2Cl_2-MeOH (1:1) solvent system. On the basis of their TLC characteristic, fractions which contained the same major component were combined to give fractions (CA1-CA15). Fraction CA9 was rechromatographed on column chromatography and eluted with the mixed solvent of hexane-acetone (2.5:1) to give five fractions. Crystallization of the third fraction in hexane-acetone (2.5:1) gave a pale creamy solid of **AE16** (1.8 mg).



Scheme 3 Isolation of compounds **AE16** from acetone extract of the bark of *A. elasticus*

AE16

2-(2,4-Dihydroxyphenyl)-5,7-dihydroxy-4*H*-chromen-4-one

^{1}H NMR (Acetone-d_6, 500 MHz) δ (ppm): 13.00 (1H, *s*, 5-OH), 9.95 (1H, *s*, OH), 9.90 (1H, *s*, OH), 9.42 (1H, *s*, OH), 7.70 (1H, *d*, *J* = 8.5 Hz, H-6′), 6.96 (1H, *s*, H-3), 6.48 (1H, *d*, *J* = 2.5 Hz, H-3′), 6.42 (1H, *dd*, *J* = 8.5, 2.5 Hz, H-5′), 6.36 (1H, *d*, *J* = 2.5 Hz, H-6), 6.10 (1H, *d*, *J* = 2.5 Hz, H-8)

^{13}C NMR (Acetone-d_6, 125 MHz) δ (ppm): 182.6 (C-4), 164.0 (C-7), 162.4 (C-8a), 162.0 (C-5), 161.8 (C-2′), 158.5 (C-2), 158.0 (C-4′), 129.9 (C-6′), 108.2 (C-3), 107.7 (C-5′), 107.6 (C-1′), 103.5 (C-4a), 103.4 (C-3′), 98.5 (C-8), 93.6 (C-6)

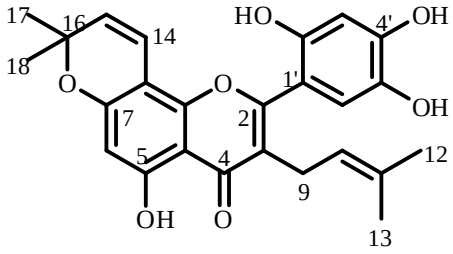
CHAPTER 3
RESULTS AND DISCUSSION

3.1 Structural Determination

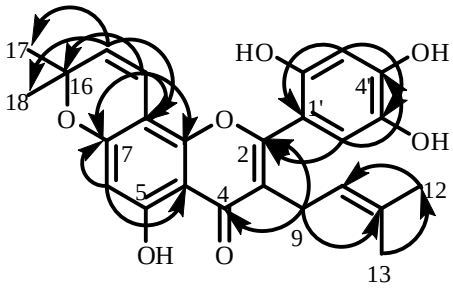
The bark of *Artocarpus elasticus* was extracted with dichloromethane and acetone, successively. Separation of the dichloromethane extract by column chromatography produced 5-hydroxy-8,8-dimethyl-3-(3-methyl-2-butenyl)-2-(2,4,5-trihydroxyphenyl)-4*H*,8*H*-benzo[1,2-b:3,4-*b*′]dipyran-4-one (**AE1**), 8-hydroxy-3-methylisochroman-1-one (**AE2**), 5-hydroxy-2-(4-hydroxy-2,5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one (**AE3**), 6,7-dihydro-5,9,14-trihydroxy-11-methoxy-3,3-dimethyl-6-(1-methylethyl)-3*H*,8*H*-[1]benzopyrano[7,6-*c*]xathen-8-one (**AE4**), 12-acetyl-6-hydroxy-3,3,9,9-tetramethyl-3*H*,7*H*,furo[3,4-*b*]pyrano[3,2-*h*]xanthene-7,11(9*H*)-dione (**AE5**), 6,7-dihydro-5,9,11,14-tetrahydroxy-3,3-dimethyl-6-(1-methylethenyl)-(-)-3*H*,8*H*-pyrano[3′,2′:4,5]benzo[1,2-*c*]xanthen-8-one (**AE6**), new furanodihydrobenzoxanthone derivative (**AE7**), 5a,6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-9-(3-methyl-2-buten-1-yl)-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (**AE8**), (3,4,5-trimethoxyphenyl)methanol (**AE9**), 5a, 6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (**AE10**), new quinonobenzoxanthone derivative (**AE11**), 1,3,4,8-tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*]xanthen-7-(6*H*)-one (**AE12**), new quinonobenzoxanthone derivative (**AE13**), 5a,6-dihydro-1,3,8-trihydroxy-10-methoxy-5,5-dimethyl-5*H*,7*H*-benzofuro[3,4-*bc*]xanthen-7-one (**AE14**) and 5-hydroxy-8,8-di-methyl-2-(2,4-dihydroxyphenyl)-4*H*,8*H*-benzo[1,2-*b*′]dipyran-4-one (**AE15**), whereas purification of acetone extract gave one compound: 2-(2,4-dihydroxy phenyl)-5,7-dihydroxy-4*H*-chromen-4-one (**AE16**). Their structures were elucidated by 1D and 2D NMR spectroscopic data.

AE1

5-Hydroxy-8,8-dimethyl-3-(3-methyl-2-butenyl)-2-(2,4,5-trihydroxyphenyl)-4*H*,8*H*-benzo[1,2-b:3,4-*b*′]dipyran-4-one



AE1 is a brown-yellow solid, m.p. 217-219 °C. The UV spectrum exhibited the absorption bands at 224, 258, 266, 271, 302 and 352 nm. The IR spectrum showed the absorption bands of a hydroxyl group at 3359 cm^{-1} and carbonyl group at 1653 cm^{-1}. The ^{1}H NMR spectrum (**Table 6**) showed signals of a hydrogen-bonded hydroxyl group (δ 13.21, *s*, 5-OH), three non-bonded hydroxyl groups (δ 8.56, 8.38, and 7.54), and three isolated aromatic protons (δ 6.19, *s*, H-6; δ 6.58, *s*, H-3′ and δ 6.79, *s*, H-6′). The doublet signals of vinylic protons at δ 5.48 (H-15) and δ 6.62 (H-14) and singlet signal of methyl groups at δ 1.44 (CH_3-17 and CH_3-18) were assigned for those of a 2, 2-dimethylchromene ring. The correlations of H-14 to C-7, C-8, C-8a; H-15 to C-8 and H-6 to C-7, C-8 correctly determined that the chromene ring was at C-7 and C-8 position. The presence of a prenyl group was observed from the characteristic signals at δ 3.14 (*d*, H-9); δ 5.12 (*t*, H-10); δ 1.47 (*s*, CH_3-12) and δ 1.61 (*s*, CH_3-13). This side chain was placed at C-3 according to the HMBC correlation of H-9 to C=O (δ 182.5) and C-2. These assignments were in agreement with a previously isolated compound, **artonin E** (Hano, *et al*., 1990).



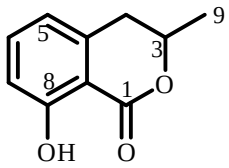
Major HMBC of **AE1**

Table 6 ^{13}C, ^{1}H and HMBC spectral data of **AE1**

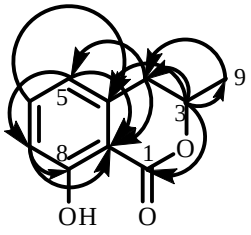
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	161.2 (C)	-	-
3	120.8 (C)	-	-
4	182.5 (C=O)	-	-
4a	105.0 (C)	-	-
5	161.5 (C)	-	-
6	99.2 (CH)	6.19 (1H, *s*)	C-4a, C-5, C-7, C-8
7	158.8 (C)	-	-
8	100.8 (C)	-	-
8a	152.4 (C)	-	-
9	24.2 (CH_2)	3.14 (2H, *d*, 6.6)	C-2, C-3, C-4, C-10, C-11
10	121.5 (CH)	5.12 (1H, *t*, 6.6)	-
11	132.0 (C)	-	-
12	17.5 (CH_3)	1.47 (3H, *s*)	C-10, C-11, C-13
13	25.7 (CH_3)	1.61 (3H, *s*)	C-10, C-11, C-12
14	115.2 (CH)	6.62 (1H, *d*, 9.9)	C-7, C-8, C-8a, C-16
15	126.5 (CH)	5.48 (1H, *d*, 9.9)	C-8, C-16, C-17, C-18
16	77.7 (C)	-	-
17	28.0 (CH_3)	1.44 (3H, *s*)	C-15, C-16, C-18
18	28.0 (CH_3)	1.44 (3H, *s*)	C-15, C-16, C-17
1′	110.7 (C)	-	-
2′	148.8 (C)	-	-
3′	104.0 (CH)	6.58 (1H, *s*)	C-1′, C-2′, C-5′
4′	147.9 (C)	-	-
5′	137.6 (C)	-	-
6′	116.2 (CH)	6.79 (1H, *s*)	C-2, C-4′, C-5′
5-OH	-	13.21 (1H, *s*)	C-4a, C-5, C-6
*OH	-	8.56 (1H, *s*)	-
*OH	-	8.38 (1H, *s*)	-
*OH	-	7.54 (1H, *s*)	-

* the position not identified

AE2: **8-Hydroxy-3-methylisochroman-1-one**



AE2 is a yellow gum, $[\alpha]^{31}{}_{D}$ -72 ° (*c* 0.07, $CHCl_3$). The IR spectrum indicated the presence of O-H stretching at 3438 cm^{-1} and C=O stretching at 1680 cm^{-1}. The ^{1}H NMR spectral data (**Table 7**) showed signals of a chelated hydroxyl proton at δ 10.95 (8-OH, *s*), and three coupled aromatic protons H-7, H-6 and H-5 at δ 6.80 (*d*), δ 7.32 (*t*), δ 6.61 (*d*). The spectrum further showed a doublet signal of methylene protons at δ 2.85 (H-4), a sextet signal of a methine proton at δ 4.65 (H-3) and a doublet signal of methyl protons at δ 1.47 (H-9). The ^{1}H-^{1}H COSY correlation of H-3 to H-4 and H-3 to CH_3-9 confirmed the connection of partial structure (CH_2-C<u>H</u>-CH_3). The HMBC correlations of H-3 to C-4a and H-4 to C-8a, C-5 suggested the point of attachment of C-3, C-4 and C-4a of aromatic ring. Moreover, the HMBC spectral data also showed the correlation of H-3 to 1-C=O. The ^{13}C NMR spectrum showed signals of carbonyl carbon at δ 169.9 (1-C=O), methyl carbon at δ 20.7, methylene carbons at δ 34.6, four methine carbons at δ 136.1, 117.9, 116.2 and 76.1, and three quaternary carbons at δ 162.2, 139.4 and 108.3. The chemical shift value of carbonyl carbon (δ 169.9) indicated that it was carbonyl of ester group. The HMBC experiment also confirmed the assignments structure of **AE2** as 8-hydroxy-3-methylisochroman-1-one, its optical rotation was corresponded to the R-(-)-mellein (Dimitriadis, *et al*., 1997).



Major HMBC of **AE2**

Table 7 ^{13}C, ^{1}H and HMBC spectral data of **AE2**

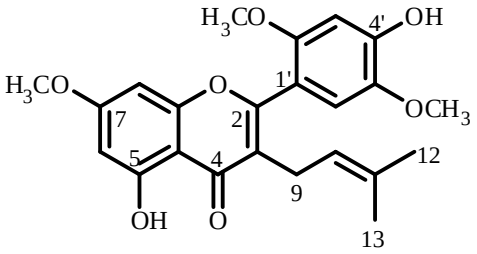
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
1	169.9 (C=O)	-	-
3	76.1 (CH)	4.65 (1H, *sext*, 6.6)	C-1, C-4, C-4a, C-9
4	34.6 (CH_2)	2.85 (2H, *d*, 6.6)	C-3, C-5, C-8a, C-9
4a	139.4 (C)	-	-
5	117.9 (CH)	6.61 (1H, *d*, 7.9)	C-4a, C-6, C-7, C-8a
6	136.1 (CH)	7.32 (1H, *t*, 7.9)	C-4a
7	116.2 (CH)	6.80 (1H, *d*, 7.9)	C-5, C-8, C-8a
8	162.2 (C)	-	-
8a	108.3 (C)	-	-
9	20.7 (CH_3)	1.47 (3H, *d*, 6.6)	C-3, C-4
8-OH	-	10.9 (OH, *s*)	C-6, C-7, C-8, C-8a

Table 8 ^{1}H-^{1}H COSY spectral data of **AE2**

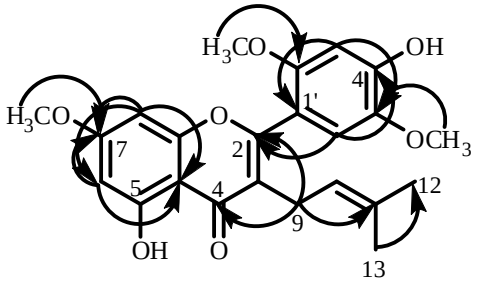
Proton ($\boldsymbol{\delta}_{ppm}$)	⟺	Correlated proton ($\boldsymbol{\delta}_{ppm}$)
H-3 (4.65)		H-4 (2.85), H-9 (1.47)
H-4 (2.85)		H-3 (4.65)
H-5 (6.61)		H-6 (7.32)
H-6 (7.32)		H-5 (6.61), H-7 (6.80)
H-7 (6.80)		H-6 (7.32)
H-9 (1.47)		H-3 (4.65)

AE3

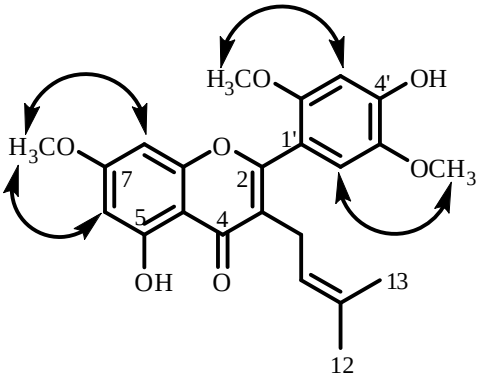
5-Hydroxy-2-(4-hydroxy-2, 5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one



AE3 is a yellow gum. Its molecular formula of $C_{23}H_{24}O_7$ was established on the basis of mass spectrum, EI-MS ($[M]^+$ *m/z* 412.1542). The IR spectrum showed the absorption bands of a hydroxyl group at 3445 cm^{-1} and carbonyl group at 1653 cm^{-1}. The ^1H NMR showed singlet signals of a hydrogen-bonded hydroxyl group (5-OH) at δ 13.00, non-bonded hydroxyl group (4′-OH) at δ 5.93 and three methoxyl groups (7-OCH_3, 2′-OCH_3, and 5′-OCH_3) at δ 3.83, 3.75, and 3.86. The singlet signals at δ 6.67 and 6.83 were assigned for aromatic protons H-3′ and H-6′ whereas singlet signals at δ 6.35 with integration of two protons was proposed for *meta*-aromatic protons H-6 and H-8. The presence of a prenyl group was observed from the characteristic signals of methylene protons (H-9, δ 3.04, *d*), a methine proton (H-10, δ 5.11, *t*, 6.6 Hz), methyl protons (CH_3-12, δ 1.42, *s* and CH_3-13, δ 1.62, *s*). This side chain was placed at C-3 position due to the HMBC correlation of H-9 to the C=O (δ 182.4) and C-2 (δ 160.7). The position of 7-OCH_3 was confirmed by HMBC correlation of methyl protons at δ 3.83, H-6 and H-8 to C-7 and the differential NOE technique by irradiation of the signal of H-6 and H-8 which enhanced the signal of 7-OCH_3. Furthermore, the locations of two methoxyl groups were assigned at C-2′ and C-5′ which were supported by the differential NOE technique; irradiation of a H-3′ and H-6′ enhanced the signals of 2′-OCH_3 and 5′-OCH_3. The HMBC experiment confirmed the structure of **AE3** as a new 3-prenylflavone derivative, 5-hydroxy-2-(4-hydroxy-2,5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one.



Major HMBC of **AE3**



NOE of **AE3**

Table 9 ^{13}C, ^{1}H and HMBC spectral data of **AE3**

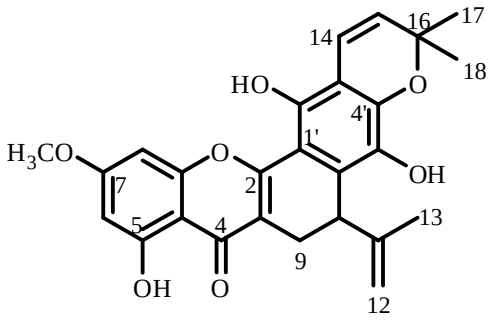
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	160.7 (C)	-	-
3	121.4 (C)	-	-
4	182.4 (C=O)	-	-
4a	105.5 (C)	-	-
5	162.2 (C)	-	-
6	97.8 (CH)	6.35 (1H, *s*)	C-4, C-4a, C-5, C-7, C-8
7	165.3 (C)	-	-
8	92.0 (CH)	6.35 (1H, *s*)	C-4, C-4a, C-7, C-6, C-8a
8a	158.2 (C)	-	-
9	24.2 (CH_2)	3.04 (2H, *d*, 6.6)	C-2, C-3, C-4, C-11
10	121.7 (CH)	5.11 (1H, *t*, 6.6)	-
11	132.0 (C)	-	-
12	17.6 (CH_3)	1.42 (3H, *s*)	C-9, C-10, C-11, C-13
13	25.7 (CH_3)	1.62 (3H, *s*)	C-10, C-11, C12
1′	112.7 (C)	-	-
2′	152.3 (C)	-	-
3′	99.7 (CH)	6.67 (1H, *s*)	C-1′, C-2′, C-4′, C-5′
4′	148.5 (C)	-	-
5′	140.3 (C)	-	-
6′	112.9 (CH)	6.83 (1H, *s*)	C-2, C-4′, C-5′
5-OH	-	13.00 (1H, *s*)	C-4a, C-5, C-6
4′-OH	-	5.93 (1H, *s*)	C-4′, C-5′
7-OCH_3	56.7 (OCH_3)	3.83 (3H, *s*)	C-7
2′-OCH_3	55.7 (OCH_3)	3.75 (3H, *s*)	C-2′
5′-OCH_3	56.2 (OCH_3)	3.86 (3H, *s*)	C-5′

Table 10 ^{1}H-^{1}H COSY spectral data of **AE3**

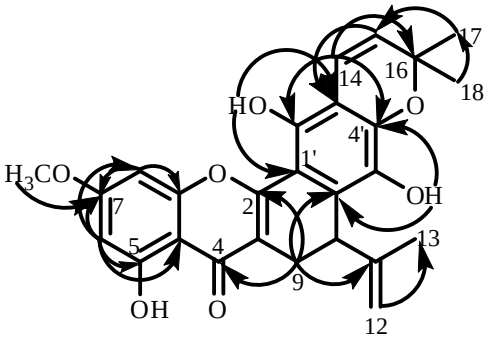
Proton (δ_{ppm})	⟷	Correlated proton (δ_{ppm})
H-9 (3.04)		H-10 (5.11)

AE4

6,7-Dihydro-5,9,14-trihydroxy-11-methoxy-3,3-dimethyl-6-(1-methylethyl)-3*H*,8*H*-[1]benzopyrano[7,6-*c*]xanthen-8-one



AE4 is a yellow solid, mp 205-207 °C. The UV spectrum exhibited absorption maxima at 214, 271, 304 and 378 nm. The IR spectrum showed the stretching band of O-H at 3406 cm^{-1} and C=O at 1653 cm^{-1}. The ^{1}H NMR showed signals of three hydroxyl groups (δ 12.99, 5-OH; δ 7.76, 2′-OH; δ 5.27, 5′-OH), two *meta* aromatic protons (δ 6.37, H-6 and H-8), and a methoxyl group (δ 3.86, 7-OCH_3). The characteristic signals of a 2,2-dimethylchromene ring were shown at δ 5.64 (*d*, H-15), δ 6.74 (*d*, H-14), δ 1.49 (*s*, CH_3-18), and δ 1.52 (*s*, CH_3-17). It was placed at C-3′ and C-4′ position due to the HMBC correlation (**Table 11**) of H-14 to C-2′, C-3′, C-4′ and of H-15 to C-3′. The ^{1}H NMR spectrum further showed an ABX system signal of non-equivalent methylene protons H_α-9 (δ 2.54, *dd*, J = 16.2, 6.9 Hz), H_β-9 (δ 3.40, *dd*, J = 16.2, 1.5 Hz) and a methine proton H-10 (δ 3.96, *d*, J = 6.9 Hz). The signal of non-equivalent vinylic protons (δ 4.35, *s*, H_α-12 and δ 4.71, *s*, H_β-12) and methyl protons (δ 1.85, *s*, H-13), corresponding to an isopropenyl group, were shown in the spectrum. The ^{3}J HMBC correlations of H-10 to C-3, C-12, C-1′, C-5′ suggested the point of attachment of C-10 to isoproprenyl group and to C-6′ of the aromatic ring. This evidence indicated that the cyclic was formed between C-3 and C-6′ position, whereas the isoprenyl group was linked at C-10. The constant value 6.9 Hz of H_β-9 and H-10 suggested the trans-axial position of these two protons, consequently the isopropenyl group was in agreement. These signals are the characteristic signals of a dihydrobenzoxanthone skeleton (Hakim, *et al.*, 2006). The spectral data and assignments corresponded to the previously isolated, **artonol E** (Aida, *et al*., 1997).



Major HMBC of **AE4**

Table 11 ^{13}C, ^{1}H and HMBC spectral data of **AE4**

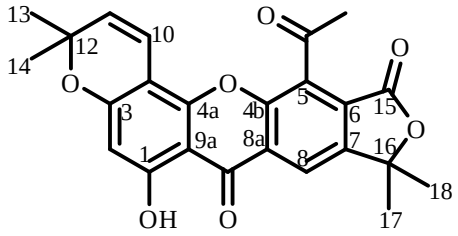
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	159.9 (C)	-	-
3	111.7 (C)	-	-
4	180.1 (C=O)	-	-
4a	105.0 (C)	-	-
5	162.4 (C)	-	-
6	98.2 (CH)	6.37 (1H, *s*)	C-4, C-4a, C-5, C-7, C-8
7	165.1 (C)	-	-
8	92.1 (CH)	6.37 (1H, *s*)	C-4, C-4a, C-5, C-6, C-7, C-8a
8a	155.7 (C)	-	-
9	21.6 (CH_2)	3.40 ($1H_\beta$, *dd*, 16.2, 1.5)	C-2, C-3, C-4, C-6′, C-10, C-11
		2.54 ($1H_\alpha$, *dd*, 16.2, 6.9)	C-2, C-3, C-4, C-6′, C-10, C-11
10	36.6 (CH)	3.96 (1H, *d*, 6.9)	C-1′, C-5′, C-6′, C-9, C-11, C-12
11	144.3 (C)	-	-
12	111.9 (CH_2)	4.71 ($1H_\beta$, *s*)	C-9
		4.35 ($1H_\alpha$, *s*)	C-9, C-10, C-11
13	21.6 (CH_3)	1.85 (3H, *s*)	C-10, C-11, C-12
14	116.3 (CH)	6.74 (1H, *d*, 10.0)	C-2′, C-3′, C-4′, C-16
15	128.6 (CH)	5.64 (1H, *d*, 10.0)	C-3′, C-16, C-17
16	78.5 (C)	-	-
17	28.3 (CH_3)	1.52 (3H, *s*)	C-15, C-16, C-18
18	28.2 (CH_3)	1.49 (3H, *s*)	C-15, C-16, C-17
1′	105.1 (C)	-	-
2′	145.0 (C)	-	-
3′	108.8 (C)	-	-
4′	143.9 (C)	-	-
5′	135.6 (C)	-	-
6′	126.7 (C)	-	-
5-OH	-	12.99 (1H, *s*)	C-4a, C-5, C-6
2′-OH	-	7.76 (1H, *s*)	C-1′, C-2′, C-3′
5′-OH	-	5.27 (1H, *s*)	C-4′, C-5′, C-6′
7-OCH_3	55.8 (OCH_3)	3.86 (3H, *s*)	C-7

Table 12 ^{1}H-^{1}H COSY spectral data of **AE4**

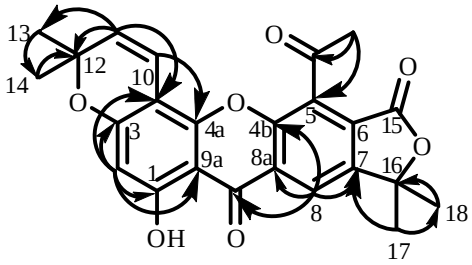
Proton (δ_{ppm})	⟺	Correlated proton (δ_{ppm})
H_{α}-9 (2.54)		H_{β}-9 (3.40), H-10 (3.96)
H_{β}-9 (3.40)		H_{α}-9 (2.54), H-10 (3.96)
H-10 (3.96)		H_{α}-9 (2.54), H_{β}-9 (3.40)
H-14 (6.74)		H-15 (5.64)

AE5

12-Acetyl-6-hydroxy-3,3,9,9-tetramethyl-3*H*,7*H*,furo[3,4-*b*]pyrano[3,2-*h*] xanthene-7,11(9*H*)-dione



AE5 is an orange solid, m.p. 190-193 °C. The UV spectrum showed specific absorptions with maxima at 207, 240, 275, 285, 314, 338 and 411 nm. The IR spectrum showed the stretching bands of O-H at 3455 cm^{-1} and C=O at 1731 and 1653 cm^{-1}. The ^{1}H NMR spectrum exhibited a sharp singlet signal of a hydroxyl proton which formed an intramolecular hydrogen bond to a carbonyl group at δ 12.50 and signals of two isolated aromatic protons at δ 6.32 (*s*, H-2) and δ 8.31 (*s*, H-8). The HMBC correlations of H-2 to C-1, C-3, C-4, C-9a and of H-8 to C-4b, C-6, C-8a, C-9, C-16 confirmed the location of aromatic protons at C-2 and C-8 position, respectively. The presence of characteristic signals of 2,2-dimethylchromene ring were observed from doublet signal of methylene protons at δ 6.60 (H-10) and 5.63 (H-11) and a singlet signal with integration of six protons at δ 1.50 (CH_3-13 and CH_3-14). The location of the chromene moiety at C-3 and C-4 was supported by HMBC correlations of H-11 to C-3, C-4, C-4a; H-12 to C-4, and of H-2 to C-1, C-3, C-4. The methyl protons of an acetyl group were indicated from the proton signal at δ 2.82 (*s*) and carbon signal of C=O at δ 198.5. It was placed at C-5 position due to HMBC correlation of –COC<u>H</u>$_3$ to C-5. Moreover, the signals of two equivalent methyl groups at δ 1.76 (*s*, CH_3-17 and CH_3-18) and the presence of a carbonyl carbon resonance in lactone moiety at δ 169.4 suggested the xanthonolide skeleton. The HMBC correlations of H_3-17 (H_3-18) to C-16 and C-7 suggested the point of attachment of C-16, C-17 (C-18) and C-7 of aromatic ring. The lactone functionality was assigned from the carbonyl carbon signal at δ 169.4. These spectral data corresponded to those of **artonol B**, which was first isolated from *Artocarpus communis* (Aida, *et al*., 1997).



Major HMBC of **AE5**

Table 13 ^{13}C, ^{1}H and HMBC spectral data of **AE5**

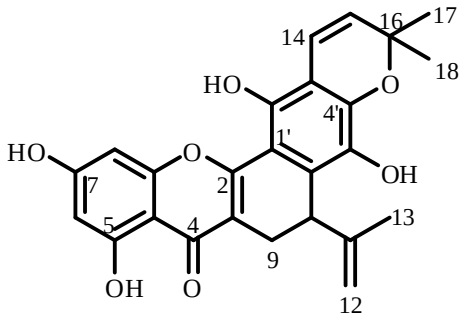
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
1	163.2 (C)	-	-
2	100.2 (CH)	6.32 (1H, *s*)	C-1, C-3, C-4, C-9a
3	162.3 (C)	-	-
4	101.4 (C)	-	-
4a	152.5 (C)	-	-
4b	152.5 (C)	-	-
5	131.0 (C)	-	-
6	125.2 (C)	-	-
7	148.6 (C)	-	-
8	119.2 (CH)	8.31 (1H, *s*)	C-4b, C-6, C-8a, C-9, C-16
8a	125.2 (C)	-	-
9	179.1 (C=O)	-	-
9a	103.5 (C)	-	-
10	114.2 (CH)	6.60 (1H, *d*, 10.1)	C-3, C-4, C-4a, C-12
11	128.2 (CH)	5.63 (1H, *d*, 10.1)	C-4, C-12, C13, C-14
12	79.1 (C)	-	-
13	28.5 (CH_3)	1.50 (3H, *s*)	C-11, C-12, C-14
14	28.5 (CH_3)	1.50 (3H, *s*)	C-11, C-12, C-13
15	169.4 (C=O)	-	-
16	86.6 (C)	-	-
17	27.6 (CH_3)	1.76 (3H, *s*)	C-7, C-16, C-18
18	27.6 (CH_3)	1.76 (3H, *s*)	C-7, C-16, C-17
5-$\underline{C}OCH_3$	198.5 (C=O)	-	-
5-CO$\underline{C}H_3$	32.3 (CH_3)	2.82 (3H, *s*)	C-5, 5-$\underline{C}OCH_3$
1-OH	-	12.50 (1H, *s*)	C-1, C-2, C-9a

Table 14 ^{13}C and ^{1}H spectral data of **artonol B**

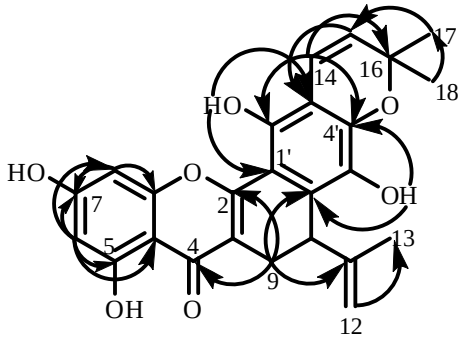
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})
1	163.2 (C)	-
2	100.2 (CH)	6.31 (*s*)
3	162.3 (C)	-
4	101.4 (C)	-
4a	151.3 (C)	-
4b	151.1 (C)	-
5	130.2 (C)	-
6	126.5 (C)	-
7	148.6 (C)	-
8	119.2 (CH)	8.30 (*s*)
8a	125.2 (C)	-
9	179.2 (C=O)	-
9a	103.6 (C)	-
10	114.2 (CH)	6.60 (1H, *d*, 10.1)
11	128.2 (CH)	5.63 (1H, *d*, 10.1)
12	79.1 (C)	-
13	28.5 (CH)	1.50 (3H, *s*)
14	28.5 (CH)	1.50 (3H, *s*)
15	166.7 (C=O)	-
16	86.6 (C)	-
17	27.6 (CH_3)	1.76 (3H, *s*)
18	27.6 (CH_3)	1.76 (3H, *s*)
5-$\underline{C}OCH_3$	198.5 (C)	-
5-CO$\underline{C}H_3$	32.3 (CH)	2.81 (3H, *s*)
1-OH	-	12.49 (1H, *s*)

AE6

6,7-Dihydro-5,9,11,14-tetrahydroxy-3,3-dimethyl-6-(1-methylethenyl)-(-)-3*H*,8*H*-Pyrano[3′,2′:4,5]benzo[1,2-*c*]xanthen-8-one



AE6 is a red-brown gum. The UV spectrum showed the absorption bands at 263, 269, 307 and 379. The IR spectrum indicated the presence of O-H stretching at 3402 cm^{-1} and C=O stretching at 1655 cm^{-1}. The ^{1}H NMR spectral data showed the signals of a chelated hydroxyl proton 5-OH (δ 12.98), two phenolic hydroxyl groups 2′-OH and 5′-OH (δ 7.78 and 5.46), and meta-coupled aromatic protons H-6 and H-8 (δ 6.35 and 6.40) and the signals of protons of the 2,2-dimethylchromene ring (δ 1.52, 17-CH_3; δ 1.49, 18-CH_3; δ 5.64, H-15 and δ 6.74, H-14). The spectrum also showed the characteristic signals of a dihydrobenzoxanthone skeleton (H_α-9, δ 2.53; H_β-9, δ 3.39; H-10, δ 3.96; H_α-12, δ 4.34; H_β-12, δ 4.71 and 13-CH_3, δ 1.81). The chemical shift values and coupling patterns of all proton signals were similar to those of relevant protons of **artonol E**, The difference was the disappearance of a singlet signal of a methoxyl group at δ 3.86 in **AE6**. It was then proposed as **7-demethylartonol E** (Namdaung, *et al*., 2006) or **artelastoxanthone** (Ko, *et al*., 2005). The assignment was also confirmed by the HMBC experiment (**Table 15**).



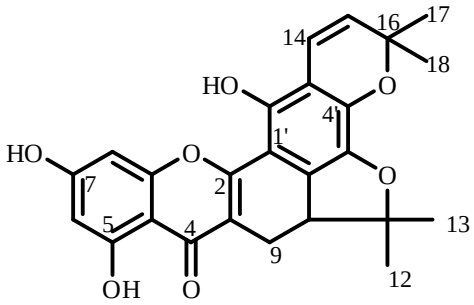
Major HMBC of **AE6**

Table 15 ^{13}C, ^{1}H and HMBC spectral data of **AE6**

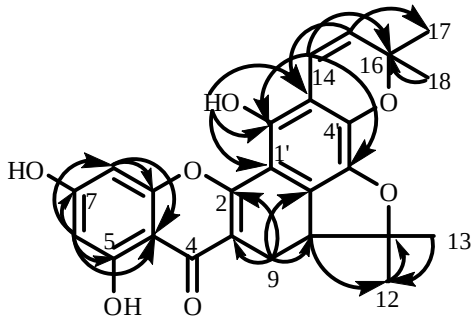
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	159.7 (C)	-	-
3	111.5 (C)	-	-
4	180.0 (C=O)	-	-
4a	104.5 (C)	-	-
5	162.4 (C)	-	-
6	99.8 (CH)	6.35 (1H, *d*, 1.8 Hz)	C-4a, C-5, C-7, C-8
7	163.0 (C)	-	-
8	93.6 (CH)	6.40 (1H, *d*, 1.8 Hz)	C-4a, C-6, C-7, C-8a
8a	155.9 (C)	-	-
9	21.5 (CH_2)	3.39 ($1H_\beta$, *dd*, 16.2, 1.5)	C-2, C-3, C-4, C-6′, C-10, C-11
		2.53 ($1H_\alpha$, *dd*, 16.2, 6.9)	C-2, C-3, C-10, C-11
10	36.5 (CH)	3.96 (1H, *d*, 6.9)	C-1′, C-3, C-5′, C-6′, C-9, C-11, C-12, C-13
11	144.3 (C)	-	-
12	111.7 (CH_2)	4.71 ($1H_\beta$, *s*)	C-10, C-13
		4.34 ($1H_\alpha$, *s*)	C-10, C-13
13	21.6 (CH_3)	1.81 (3H, *s*)	C-10, C-11, C-12
14	116.3 (CH)	6.74 (1H, *d*, 10.0)	C-2′, C-3′, C-4′, C-16
15	128.5 (CH)	5.64 (1H, *d*, 10.0)	C-3′, C-16, C-17, C-18
16	78.3 (C)	-	-
17	28.2 (CH_3)	1.52 (3H, *s*)	C-15, C-16, C-18
18	28.1 (CH_3)	1.49 (3H, *s*)	C-15, C-16, C-17
1′	105.2 (C)	-	-
2′	144.9 (C)	-	-
3′	108.8 (C)	-	-
4′	143.8 (C)	-	-
5′	135.6 (C)	-	-
6′	126.7 (C)	-	-
5-OH	-	12.98 (1H, *s*)	C-4, C-4a, C-5, C-6
2′-OH	-	7.78 (1H, *s*)	C-1′, C-2′, C-3′
5′-OH	-	5.46 (1H, *s*)	C-4′, C-5′, C-6′

AE7

New furanodihydrobenzoxanthone derivative



AE7 is a yellow solid, m.p. 287-289 °C. The molecular formula, $C_{25}H_{22}O_7$, was deduced from the mass spectrum, EI-MS ($[M]^+$ *m/z* 434.1377). The UV spectrum showed maximum absorption bands at 214, 253, 273, 289, 308 and 375 nm. The IR spectrum showed the stretching of O-H (3442 cm^{-1}) and C=O (1630 cm^{-1}). The ^1H NMR spectrum exhibited a singlet signal of a chelated hydroxyl proton (δ 13.00, 5-OH) and two singlet signals of non-chelated hydroxyl protons (δ 9.42, 7-OH) and δ 7.17 (2′-OH). The appearance of two meta-coupled signals at δ 6.31 and 6.47 with coupling constant of 2.1 Hz were assigned for aromatic protons H-6 and H-8. The HMBC correlation of H-6 to C-4a, C-5, C-7, C-8, and H-8 to C-4a, C-6, C-7, C-8a were also confirmed the positions of H-6 and H-8. Two singlet signals of two methyl groups (δ 1.35, *s*, CH_3-12 and δ 1.68, *s*, CH_3-13), ABX system signals of a methine proton (δ 3.39, *dd*, H-10) and methylene protons (δ 3.21, *dd*, H_β-9 and 2.40, *t*, H_α-9) were in agreement with the characteristic signals of a furanodihydrobenzoxanthone skeleton (Hakim, *et al*., 2006). The HMBC correlations of H-10 to C-3, C-9, C-11, C-12, C-13, C-6′ suggested that the cyclic was formed between C-3 and C-6′ whereas the furan moiety was formed at C-5′ and C-6′ of the aromatic ring. The remaining signals were assigned for 2,2-dimethylchromene ring of which two vicinal protons H-14 and H-15 appeared as two doublet signals at δ 6.69 and 5.57, and two germinal methyl groups resonating at δ 1.50 (H_3-17) and δ 1.47 (H_3-18). The correlations of H-14 to C-2′, C-5′; of H-15 to C-3′, and of 2′-OH to C-1′, C-2′, C-3′ correctly determined that the chromene ring was at C-3′ and C-4′ position. Therefore a new furanodihydrobenzo- xanthone derivative was assigned for **AE7**.



Major HMBC of **AE7**

Table 16 ^{13}C, ^{1}H and HMBC spectral data of **AE7**

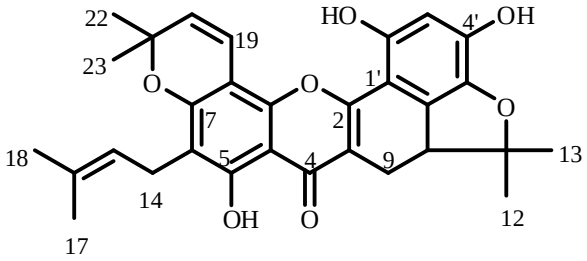
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	165.1 (C)	-	-
3	117.4 (C)	-	-
4	185.4 (C=O)	-	-
4a	109.4 (C)	-	-
5	167.5 (C)	-	-
6	104.9 (CH)	6.31 (1H, *d*, 2.1)	C-4a, C-5, C-7, C-8
7	168.7 (C)	-	-
8	99.0 (CH)	6.47 (1H, *d*, 2.1)	C-4a, C-6, C-7, C-8a
8a	161.5 (C)	-	-
9	24.9 (CH_2)	3.21 ($1H_\beta$, *dd*, 15.3, 7.2)	C-2, C-3, C-4, C-6′, C-10
		2.40 ($1H_\omega$, *t*, 15.3)	C-2, C-3, C-10, C-11
10	51.5 (CH)	3.39 (1H, *dd*, 15.3, 7.2)	C-5′, C-6′, C-9, C-11, C-12, C-13
11	98.7 (C)	-	-
12	27.6 (CH_3)	1.35 (3H, *s*)	C-10, C-11
13	33.2 (CH_3)	1.68 (3H, *s*)	C-10, C-11, C-12
14	121.9 (CH)	6.69 (1H, *d*, 10.2)	C-2′, C-5′, C-16
15	133.2 (CH)	5.57 (1H, *d*, 10.2)	C-3′, C-16, C-17, C-18
16	82.7 (C)	-	-
17	33.1 (CH_3)	1.50 (3H, *s*)	C-16, C-18
18	33.0 (CH_3)	1.47 (3H, *s*)	C-16, C-17
1′	108.5 (C)	-	-
2′	149.6 (C)	-	-
3′	116.1 (C)	-	-
4′	147.2 (C)	-	-
5′	142.6 (C)	-	-
6′	136.4 (C)	-	-
5-OH	-	13.00 (1H, *s*)	C-4a, C-5, C-6
7-OH	-	9.42 (1H, *s*)	-
2′-OH	-	7.17 (1H, *s*)	C-1′, C-2′, C-3′

Table 17 ^{1}H-^{1}H COSY spectral data of **AE7**

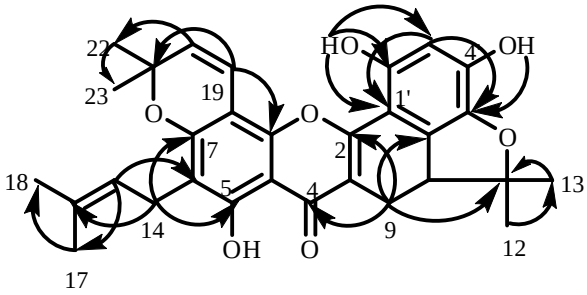
Proton ($\boldsymbol{\delta}_{ppm}$)	⟷	Correlated proton ($\boldsymbol{\delta}_{ppm}$)
H-6 (6.31)		H-8 (6.47)
H_{α}-9 (2.40)		H_{β}-9 (3.21), H-10 (3.39)
H_{β}-9 (3.21)		H_{α}-9 (2.40), H-10 (3.39)
H-10 (3.39)		H_{α}-9 (2.40), H_{β}-9 (3.21)
H-14 (6.69)		H-15 (5.57)

AE8

5a,6-Dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-9-(3-methyl-2-buten-1-yl)-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one



AE8 is a yellow solid, m.p. 249-251 °C. The UV spectrum showed maximum absorptions at 236, 256, 265, 278, 335 and 390 nm. The IR spectrum showed the stretching of hydroxyl group (3371 cm^{-1}) and carbonyl group (1629 cm^{-1}). The ^{1}H NMR spectrum showed a singlet signal of a chelated proton 5-OH at δ 13.42 and two singlet signals of non chelated protons 2′-OH and 4′-OH at δ 7.78 and 9.23, respectively. An aromatic proton at δ 6.38 (*s*) was assigned for H-3′. The spectrum further showed the signals corresponding to furanoxanthonoid moiety (δ 2.40, *t*, *J* = 15.0 Hz, H_{α}-9; 3.23, *dd*, *J* = 15.0, 7.2 Hz, H_{β}-9; 3.41, *dd*, *J* = 15.0, 7.2 Hz, H-10). The prenyl unit commemorated from distinctive signals of two equivalent methylene protons at δ 3.33 (*d*, H-14), olefinic proton at δ 5.24 (*t*, H-15) and two methyl protons at δ 1.68 (*s*, 17-CH_3) and 1.81 (*s*, 18-CH_3). Its location was assigned at C-6 by HMBC correlation of OH-5 and of H-15 to C-6. Moreover, a chromene ring was detected from the characteristic signals at δ 5.57 (*d*, H-20), 6.76 (*d*, H-19) and 1.46 (*s*, 22-CH_3 and 23-CH_3). The correlations of H-19 to C-8a, and of H-20 to C-8, confirmed the orientation of 2,2-dimethylchromene ring at C-7 and C-8 position. The assigned structure of **AE8** was in agreement with **artonin F** (Hano, Y. *et al*. 1990).



Major HMBC of **AE8**

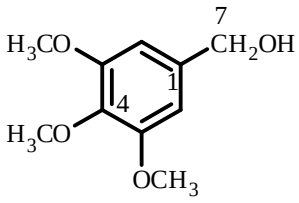
Table 18 ^{13}C, ^{1}H and HMBC spectral data of **AE8**

Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	160.3 (C)	-	-
3	111.5 (C)	-	-
4	180.7 (C=O)	-	-
4a	104.3 (C)	-	-
5	158.7 (C)	-	-
6	112.5 (C)	-	-
7	156.4 (C)	-	-
8	100.5 (CH)	-	-
8a	149.2 (C)	-	-
9	19.9 (CH_2)	3.23 ($1H_\beta$, *dd*, 15.0, 7.2)	C-2, C-3, C-4, C-6′, C-10
		2.40 ($1H_\alpha$, *t*, 15.0)	C-2, C-3, C-4, C-6′, C-10, C-11
10	46.6 (CH)	3.41 (1H, *dd*, 15.0, 7.2)	C-1′, C-5′, C-6′, C-9, C-11, C-12, C-13
11	93.5 (C)	-	-
12	22.7 (CH_2)	1.35 (3H, *s*)	C-10, C-11, C-13
13	28.1 (CH_3)	1.66 (3H, *s*)	C-10, C-12
14	21.3 (CH_2)	3.33 (2H, *d*, 7.2)	C-5, C-6, C-7, C-15, C-16
15	122.1 (CH)	5.24 (1H, *t*, 7.2)	C-6, C-14, C-17, C-18
16	131.3 (C)	-	-
17	17.9 (CH_3)	1.68 (3H, *s*)	C-15, C-16, C-18
18	25.8 (CH_3)	1.81 (3H, *s*)	C-15, C-16, C-17
19	115.3 (CH)	6.76 (1H, *d*, 9.9)	C-7, C-8, C-8a, C-20, C-21
20	127.1 (CH)	5.57 (1H, *d*, 9.9)	C-8, C-21, C-22, C-23
21	77.3 (C)	-	-
22	28.0 (CH_3)	1.46 (3H, *s*)	C-20, C-21, C-23
23	28.0 (CH_3)	1.46 (3H, *s*)	C-20, C-21, C-22
1′	103.4 (C)	-	-
2′	150.1 (C)	-	-
3′	104.6 (C)	6.38 (1H, *s*)	C-1′, C-2, C-2′, C-4′, C-5′
4′	146.4 (C)	-	-
5′	137.2 (C)	-	-
6′	131.8 (C)	-	-
5-OH	-	13.42 (1H, *s*)	C-4, C-4a, C-5, C-6
2′-OH	-	7.78 (1H, *s*)	C-1′, C-2′, C-3′
4′-OH	-	9.23 (1H, *s*)	C-5′

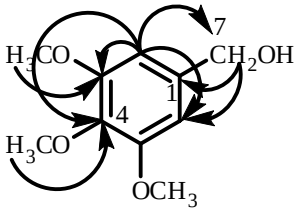
Table 19 ^{1}H-^{1}H COSY spectral data of **AE8**

Proton (δ_{ppm})		Correlated proton (δ_{ppm})
H_{α}-9 (2.40)	⟷	H_{β}-9 (3.23), H-10 (3.41)
H_{β}-9 (3.23)	⟷	H_{α}-9 (2.40), H-10 (3.41)
H-10 (3.41)	⟷	H_{α}-9 (2.40), H_{β}-9 (3.23)
H-14 (3.33)	⟷	H-15 (5.24), H-17 (1.68), H-18 (1.81)
H-15 (5.24)	⟷	H-14 (3.33), H-17 (1.68), H-18 (1.81)
H-17 (1.68)	⟷	H-14 (3.33), H-15 (5.24), H-18 (1.81)
H-18 (1.81)	⟷	H-14 (3.33), H-15 (5.24), H-17 (1.68)
H-19 (6.76)	⟷	H-20 (5.57)

AE9
(3,4,5-Trimethoxyphenyl)methanol



AE9 is a red-brown gum. The ^{1}H NMR spectrum exhibited a singlet resonance of two equivalent meta-aromatic protons at δ 6.61 (H-2 and H-6) indicating a tetrasubstituted benzene ring. The remaining proton resonances were those of a hydroxy methylene protons (δ 4.65, *s*, 2H), a methoxyl group (δ 3.85, *s*, 6H) and two equivalent methoxyl group (δ 3.88, *s*, 6H). These substituent groups were placed at C-1, C-4, C-3 and C-5, respectively. The placement of 1–CH_2OH was confirmed by HMBC correlation of –CH_2 to C-2 and C-3. These assignment indicated that **AE9** was (3,4,5-trimethoxyphenyl)methanol.



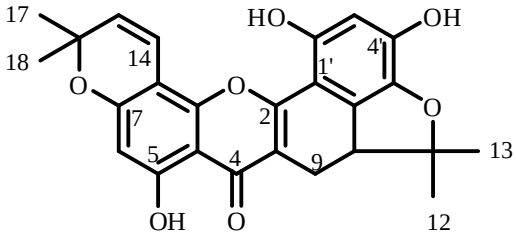
Major HMBC of **AE9**

Table 20 ^{13}C, ^{1}H and HMBC spectral data of **AE9**

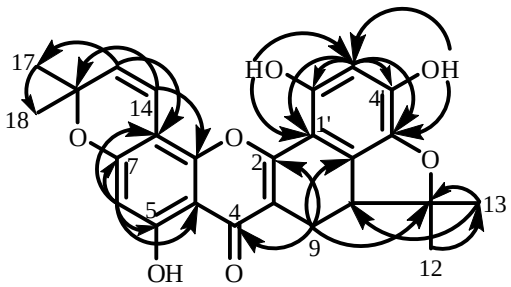
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
1	135.5 (C)	-	-
2	103.9 (CH)	6.61 (1H, *s*)	C-3, C-4, C-5, C-6, C-7
3	153.5 (C)	-	-
4	137.5 (C)	-	-
5	153.5 (C)	-	-
6	103.9 (CH)	6.61 (1H, *s*)	C-2, C-3, C-4, C-5, C-7
7	65.6 (CH_2)	4.65 (2H, *s*)	C-1, C-2, C-6
3-OCH_3	56.1 (OCH_3)	3.88 (3H, *s*)	C-3, C-5
4-OCH_3	60.9 (OCH_3)	3.85 (3H, *s*)	C-4
5-OCH_3	56.1 (OCH_3)	3.88 (3H, *s*)	C-3, C-5

AE10

5a,6-Dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-5*H*,7*H*,11*H*-benzo furo[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one



AE10 is a yellow solid, m.p. 284-285 °C. The UV spectrum showed maximum absorption bands at 228, 257, 272, 312, 330 and 391 nm. The IR spectrum showed the absorption bands of O-H stretching at 3405 cm^{-1}, C=O stretching at 1642 cm^{-1}. The ^{1}H NMR spectrum indicated the presence of a chelated hydroxyl group (δ 13.22, 5-OH), an aromatic proton H-3′ (δ 6.38) and a furanoxanthonoid moiety (δ 3.38, H-10; δ 3.21, H_{β}-9; δ 2.40, H_{α}-9; δ 1.66, 13-CH_3 and δ 1.34, 12-CH_3). The ^{1}H NMR spectrum (**Table 21**) further showed a signal of an aromatic proton (δ 6.23, H-6, *s*) and a characteristic signals of a 2,2-dimethylchromene ring (δ 1.46, 17-CH_3 and 18-CH_3, 5.56, H-15 and δ 6.78, H-14). The HMBC correlations of H-6 to C-5, C-4a, C-7, C-8 and H-3′ to C-1′, C-2′, C-4′, C-5′ confirmed the assignment of H-6 and H-3′. The HMBC correlations of H-14 to C-6, C-8, C-8a and of H-15 to C-8 confirmed the placement of the chromene ring at C-7 and C-8. **AE10** was identified to be **cycloartobiloxanthone** (Sultanbawa, *et al*., 1989).



Major HMBC of **AE10**

Table 21 ^{13}C, ^{1}H and HMBC spectral data of **AE10**

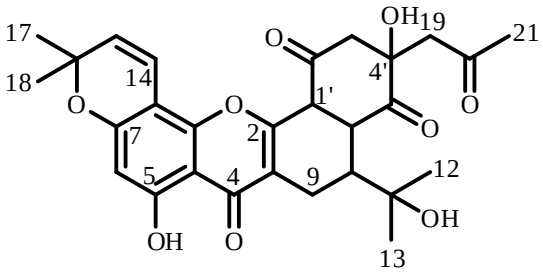
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	160.7 (C)	-	-
3	111.6 (C)	-	-
4	180.6 (C=O)	-	-
4a	104.7 (C)	-	-
5	161.5 (C)	-	-
6	99.9 (CH)	6.23 (1H, *s*)	C-4, C-4a, C-5, C-7, C-8
7	158.7 (C)	-	-
8	101.0 (C)	-	-
8a	150.9 (C)	-	-
9	19.8 (CH_2)	3.21 ($1H_\beta$, *dd*, 15.0, 7.2)	C-2, C-3, C-4, C-6′, C-10
		2.40 ($1H_\alpha$, *t*, 15.0)	C-2, C-3, C-4, C-6′, C-10, C-11
10	46.6 (CH)	3.38 (1H, *dd*, 15.0, 7.2)	C-1′, C-3, C-5′, C-6′, C-9, C-11, C-12, C-13
11	93.5 (C)	-	-
12	22.6 (CH_3)	1.34 (3H, *s*)	C-10, C-11, C-13
13	28.1 (CH_3)	1.66 (3H, *s*)	C-10, C-11, C-12
14	115.0 (CH)	6.78 (1H, *d*, 10.0)	C-6, C-8, C-8a, C-15, C-16
15	127.3 (CH)	5.56 (1H, *d*, 10.0)	C-8, C-16, C-17, C-18
16	77.8 (C)	-	-
17	28.1 (CH_3)	1.46 (3H, *s*)	C-14, C-15, C-16, C-18
18	28.1 (CH_3)	1.46 (3H, *s*)	C-14, C-15, C-16, C-17
1′	103.4 (C)	-	-
2′	150.3 (C)	-	-
3′	104.7 (CH)	6.38 (1H, *s*)	C-1′, C-2′, C-4′, C-5′
4′	146.5 (C)	-	-
5′	137.2 (C)	-	-
6′	131.9 (C)	-	-
5-OH	-	13.22 (1H, *s*)	C-4a, C-4, C-5, C-6
2′-OH	-	8.00 (1H, *s*)	C-1′, C-2′, C-3′
4′-OH	-	9.26 (1H, *s*)	C-3′, C-4′, C-5′

Table 22 ^{1}H-^{1}H COSY spectral data of **AE10**

Proton (δ_{ppm})		Correlated proton (δ_{ppm})
H_{α}-9 (2.40)	⟷	H_{β}-9 (3.21), H-10 (3.38)
H_{β}-9 (3.21)	⟷	H_{α}-9 (2.40), H-10 (3.38)
H-10 (3.38)	⟷	H_{α}-9 (2.40), H_{β}-9 (3.21)
H-14 (6.78)	⟷	H-15 (5.56)

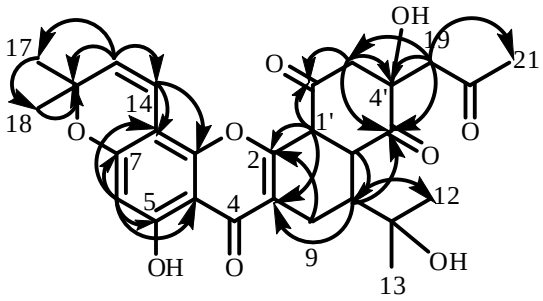
AE11

New quinonobenzoxanthone derivative



AE11 is a yellow solid, m.p. 199-200 °C. The UV spectrum showed the absorption bands at 217, 229, 245, 267, 303 and 354 nm. The IR spectrum indicated the presence of O-H stretching at 3433 cm^{-1} and C=O stretching at 1720, 1647 and 1584 cm^{-1}. The ^{1}H NMR spectral data of **AE11** in $CDCl_3$ (**Table 23**) exhibited the signals of a chelated phenolic hydrogen proton at δ 12.56 (*s*, 5-OH), an isolated aromatic proton at δ 6.27 (*s*, H-6) and a set of 2,2-dimethylchromene ring at δ 6.77 (*d*, H-14); 5.59 (*d*, H-15); 1.48 (*s*, 17-CH_3); 1.46 (*s*, 18-CH_3). The ^{1}H NMR spectra also showed the resonances of two methyl groups at δ 0.90 and 1.20 (*s*, 12-CH_3 and 13-CH_3), methylene protons at δ 2.96 and 2.58 (*dd*, *J* = 16.8, 5.7 Hz, 2H-9), three methine protons at δ 2.62 (*d*, H-1′), 2.92 (*m*, H-10), 3.50 (*t*, H-6′). ^{1}H- ^{1}H COSY correlations of H-10 to H-9, H-6′ and of H-6′ to H-1′ confirmed the assignment of a partial structure (-C_9-C_{10}-$C_{6'}$-$C_{1'}$-). The chemical shift value of C-11 (δ 74.5) indicated that it was oxycarbon. The correlations of 2H-9 and H-1′ to C-2 and C-3 supported the connection at C-3 and C-2. In addition, the resonances of signals of non-equivalent methylene protons at δ 2.67 and 2.63 (*br s*, 2H-3′) showed the HMBC correlation with C-2′, C-4′ and C-5′. A propanoyl side chain was suggested from the proton resonances of methyl protons at δ 2.27 (CH_3-21, *s*) and 2H-19 at δ 3.00 and 2.93 (*br s*, each). The presences of four carbonyl groups were indicated from the ^{13}C NMR spectrum. The resonance at δ 207.6 reveal the carbonyl carbon of a propanoyl side chain whereas the resonance at δ 180.9 was assigned for C-4. The quinonoid structure was implied from the carbonyl carbon resonances at δ 198.8 (C-2′) and 205.5 (C-5′). The HMBC correlations of H-19 to C-3′, C-4′, C-5′, C-20, C-21 together with 4′-OH (δ 4.30) to C-3′, C-4′ and C-5′ indicated that the propanoyl side chain and

a hydroxyl group were attached to a quinonoid structure at C-4′. The ^{3}J correlation of H-10 to C-3, C-5′, C-11 and C-12 suggested the formation of a cyclic between C-3 and a quinonoid structure together with hydroxyl propyl group as the side chain. The chromene moiety was placed at C-7 and C-8 due to HMBC correlations of H-14 to C-7, C-8, C-8a and of H-15 to C-8. Therefore a new quinonoid dihydroxanthone structure was assigned for **AE11**.



Major HMBC of **AE11**

Table 23 ^{13}C, ^{1}H and HMBC spectral data of **AE11**

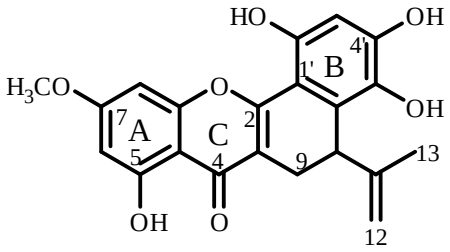
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	156.9 (C)	-	-
3	115.9 (C)	-	-
4	180.9 (C)	-	-
4a	104.9 (C=O)	-	-
5	161.6 (C)	-	-
6	100.3 (CH)	6.27 (1H, *s*)	C-4a, C-5, C-7, C-8
7	159.7 (C)	-	-
8	101.2 (C)	-	-
8a	151.8 (C)	-	-
9	22.6 (CH_2)	2.96 (1H, *dd*, 16.8, 5.7)	C-2, C-3, C-6′, C-10
		2.58 (1H, *dd*, 16.8, 5.7)	C-2, C-3, C-6′, C-10
10	32.8 (CH)	2.92 (1H, *m*)	C-3, C-5′, C-6′, C-11, C-12
11	74.5 (C)	-	-
12	25.3 (CH_3)	0.90 (3H, *s*)	C-10, C-11, C-13
13	31.9 (CH_3)	1.20 (3H, *s*)	C-10, C-11, C-12
14	114.8 (CH)	6.77 (1H, *d*, 10.0)	C-7, C-8, C-8a, C-16
15	127.4 (CH)	5.59 (1H, *d*, 10.0)	C-8, C-16, C-17, C-18
16	78.2 (C)	-	-
17	28.3 (CH_3)	1.48 (3H, *s*)	C-15, C-16, C-18
18	28.2 (CH_3)	1.46 (3H, *s*)	C-15, C-16, C-17
19	46.9 (CH_2)	3.00 (1H, *br s*)	C-3′, C-4′, C-5′, C-20, C-21
		2.93 (1H, *br s*)	C-3′, C-4′, C-5′, C-20, C-21
20	207.6 (C=O)	-	-
21	32.0 (CH)	2.27 (3H, *s*)	C-19, C-20
1′	46.9 (CH)	2.62 (1H, *d*, 2.1)	C-2, C-2′, C-3, C-5′, C-6′
2′	198.8 (C=O)	-	-
3′	43.5 (CH_2)	2.67 (1H, *br s*)	C-2′, C-4′, C-5′
		2.63 (1H, *br s*)	C-2′, C-4′, C-5′
4′	75.6 (C)	-	C-2, C-2′, C-10
5′	205.5 (C=O)	-	-
6′	47.8 (CH)	3.50 (1H, *t*, 2.1)	C-2, C-2′, C-10
5-OH	-	12.56 (1H, *s*)	C-4a, C-5, C-6, C-7
4′-OH	-	4.30 (1H, *s*)	C-3′, C-4′, C-5′
11-OH	-	3.49 (1H, *s*)	-

Table 24 ^{1}H-^{1}H COSY spectral data of **AE11**

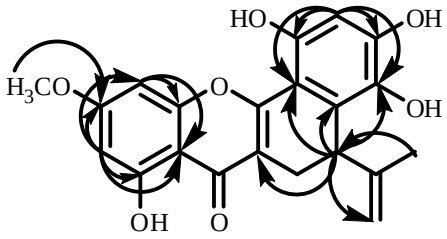
Proton (δ_{ppm})		Correlated proton (δ_{ppm})
H-9 (2.96)	⟷	H-9 (2.58), H-10 (2.92)
H-10 (2.92)	⟷	H-9 (2.96 and 2.58), H-6′ (3.50)
H-14 (6.77)	⟷	H-15 (5.59)
H-19 (3.00)	⟷	H-19 (2.93)
H-1′ (2.62)	⟷	H-6′ (3.50)
H-3′ (2.67)	⟷	H-3′ (2.63)
H-6′ (3.50)	⟷	H-1′ (2.62), H-10 (2.92)

AE12

1,3,4,8-Tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*]xanthen-7-(6*H*)-one



AE12 is a brown-yellow solid, m.p. 242-243 °C. Its molecular formula of $C_{21}H_{18}O_7$ was established on the basis of mass spectrum, EI-MS ($[M]^+$ *m/z* 382.1068). The UV spectrum showed maximum absorption bands at 214, 228, 261, 314 and 380 nm. The IR spectrum showed the stretching of O-H (3180 cm^{-1}), C=O (1653 cm^{-1}). The ^1H NMR spectrum (**Table 25**) exhibited signals of a hydrogen-bonded hydroxyl proton at δ 13.23 (*s*, 5-OH), a pair of meta-coupled aromatic protons at δ 6.30 and 6.65 (J = 2.4 Hz, H-6 and H-8), an aromatic proton at δ 6.52 (H-3′) and a singlet of methoxyl group at δ 3.89 (7-OCH_3). An ABX system signal of non-equivalent methylene protons H_α-9 (δ 2.46, *dd*), H_β-9 (δ 3.41, *dd*) and a methine proton H-10 (δ 4.00, *d*) were shown in the spectrum. The spectrum further showed signals of non-equivalent vinylic protons (δ 4.29, *s*, H_α-12 and δ 4.65, *s*, H_β-12) and methyl protons (δ 1.78, *s*, H-13), corresponding to an isopropenyl group. The HMBC correlations of H-10 to C-3, C-12, C-1′, C-5′ and C-6′ suggested that the cyclic was formed at C-3 and C-6′ position, whereas the isopropenyl group was linked to the cyclic by C-10. These signals corresponded to the characteristic signals of a dihydrobenzoxanthone skeleton (Hakim, *et al.*, 2006). The 2′, 4′, 5′-trioxygenated pattern with H-3′ resonating at δ 6.52 was proposed for B-ring based on the biogenetic pattern of constituents in *Artocarpus* genus (Hakim, *et al.*, 2006). The assigned structure was found to be the methoxy derivative of artonol E, whose methoxyl group was proposed at C-7 according to ^3J correlation of OCH_3, H-6 and H-8 to C-7. Consequently, a new dihydrobenzoxanthone derivative, 1,3,4,8-tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*]xanthen-7(6*H*)-one was assigned for **AE12**.



Major HMBC of **AE12**

Table 25 ^{13}C, ^{1}H and HMBC spectral data of **AE12**

Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	161.0 (C)	-	-
3	110.6 (C)	-	-
4	180.1 (C=O)	-	-
4a	104.7 (C)	-	-
5	161.9 (C)	-	-
6	97.7 (CH)	6.30 (1H, *d*, 2.4)	C-4a, C-5, C-7, C-8
7	165.1 (C)	-	-
8	92.2 (CH)	6.65 (1H, *d*, 2.4)	C-4a, C-6, C-7, C-8a
8a	156.7 (C)	-	-
9	21.4 (CH_2)	3.41 ($1H_\beta$, *dd*, 15.9, 1.8)	C-2, C-3, C-4, C-6′, C-10, C-11
		2.46 ($1H_\alpha$, *dd*, 15.9, 6.3)	C-2, C-3, C-4, C-6′, C-11
10	37.0 (CH)	4.00 (1H, *d*, 6.3)	C-3, C-5′, C-6′, C-9, C-11, C-12
11	144.4 (C)	-	-
12	110.9 (CH_2)	4.65 ($1H_\beta$, *s*)	C-13
		4.29 ($1H_\alpha$, *s*)	C-10, C-11, C-13
13	21.0 (CH_3)	1.78 (3H, *s*)	C-10, C-11, C-12
1′	105.5 (C)	-	-
2′	150.5 (C)	-	-
3′	102.9 (CH)	6.52 (1H, *s*)	C-1′,C-2′, C-4′,C-5′
4′	150.3 (C)	-	-
5′	136.0 (C)	-	-
6′	128.3 (C)	-	-
7-OCH_3	55.4 (CH_3)	3.89 (3H, *s*)	C-7
5-OH	-	13.23 (1H, *s*)	C-4, C-4a, C-5, C-6
*OH	-	8.27 (1H, *s*)	-

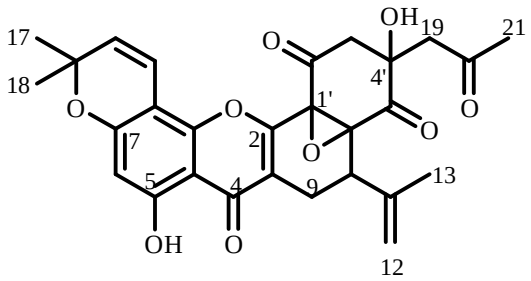
* the position not identified

Table 26 ^{1}H-^{1}H COSY spectral data of **AE12**

Proton ($\boldsymbol{\delta}_{ppm}$)		Correlated proton ($\boldsymbol{\delta}_{ppm}$)
H-6 (6.30)	⟷	H-8 (6.65)
H_α-9 (2.46)	⟷	H_β-9 (3.41), H-10 (4.00)
H_β-9 (3.41)	⟷	H-10 (4.00), H_α-9 (2.46)
H-10 (4.00)	⟷	H_α-9 (2.46), H_β-9 (3.41)

AE13

New quinonobenzoxanthone derivative



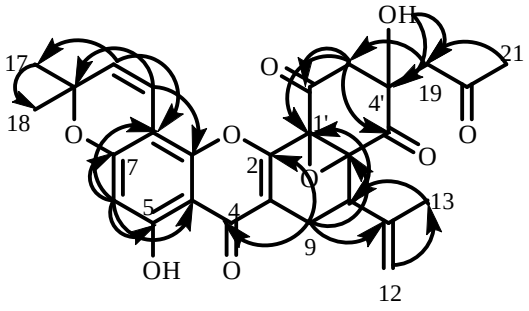
AE13 is a yellow solid, m.p. 202-203 °C. Its EI-MS exhibited a molecular ion peak at *m/z* 506.1572, consistent with a molecular formula of $C_{28}H_{26}O_9$. The UV spectrum showed maximum absorptions at 212, 232, 269, 308, 327 and 361 nm. The IR spectrum showed the stretching of hydroxyl (3426 cm^{-1}) and carbonyl groups (1753, 1722, 1697 and 1657 cm^{-1}). The ^1H NMR spectrum (**Table 27**) showed a singlet resonance of a hydrogen-bonded hydroxyl group 5-OH at δ 12.42, an aromatic proton H-6 at (δ 6.28, *s*), and protons in a 2, 2-dimethylchromene ring at δ 6.78, 5.60 (each *d*, *J* = 10.2 Hz), 1.49, 1.46 (each 3H, *s*), non-equivalent methylene protons H-3′ (δ 3.47 and 3.57, *d*, *J* = 19.4 Hz each) and a propanoyl side chain [δ 2.43 (CH_3-21, *s*), δ 3.03 and 3.25 (2H-19, *d*)]. The spectrum further showed the resonances of an isopropenyl moiety [CH_3-13 (δ 1.67, *s*) and 2H-12 (δ 4.98, *s* and 4.91, *d*, *J* = 0.9 Hz)], a methine proton (δ 3.38, *d*, H-10) and methylene protons (δ 2.89, *d*, H_β-9 and 2.49, *dd*, H_α-9). The quinonoid dihydroxanthone with isopropenyl side chain then was assigned for **AE13**. The oxirane ring was assignable by the oxycarbon resonances at δ 61.9 (C-1′) and 72.0 (C-6′). HMBC correlation of H-3′ at δ 3.57 to the carbon at δ 61.9 (C-1′) and of 2H-9 at δ 2.49 and 2.89 to the carbon at δ 72.0 (C-6′) confirmed the position of the oxirane ring. The proposed structure of **AE13** was in agreement with molecular ion of *m/z* 506.1572 ($C_{28}H_{26}O_9$). The HMBC (**Table 27**) and cosy correlations (**Table 28**) supported the assigned structure.

Table 27 ^{13}C, ^{1}H and HMBC spectral data of **AE13**

Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	155.2 (C)	-	-
3	117.3 (C)	-	-
4	181.4 (C=O)	-	-
4a	106.6 (C)	-	-
5	162.8 (C)	-	-
6	102.0 (CH)	6.28 (1H, *s*)	C-4a, C-5, C-7, C-8
7	161.3 (C)	-	-
8	103.1 (CH)	-	-
8a	153.4 (C)	-	-
9	24.3 (CH_2)	2.49 ($1H_\alpha$, *dd*, 17.1, 7.2)	C-2, C-3, C-4, C-6′, C-10, C-11
		2.89 ($1H_\beta$, *d*, 17.1)	C-2, C-3, C-4, C-6′, C-10, C-11
10	41.1 (CH)	3.38 (1H, *d*, 7.2)	C-1′, C-3, C-6′, C-9, C-11, C-13
11	145.1 (C)	-	-
12	117.8 (CH_2)	4.98 ($1H_\beta$, *s*)	C-10, C-11, C-13
		4.91 ($1H_\alpha$, *d*, 0.9)	C-10, C-13
13	22.5 (CH_3)	1.67 (3H, *s*)	C-10, C-11, C-12
14	116.3 (CH)	6.78 (1H, *d*, 10.2)	C-7, C-8, C-8a, C-16
15	129.1 (CH)	5.60 (1H, *d*, 10.2)	C-8, C-16,C-17, C-18
16	79.9 (C)	-	-
17	29.9 (CH_3)	1.49 (3H, *s*)	C-15, C-16, C-18
18	29.7 (CH_3)	1.46 (3H, *s*)	C-15, C-16, C-17
19	41.7 (CH_2)	3.25 ($1H_\beta$, *d*, 15.8)	C-3′, C-4′, C-5′, C-20
		3.03 ($1H_\alpha$, *d*, 15.8)	C-4′, C-5′, C-20
20	213.3 (C=O)	-	-
21	33.3 (CH_3)	2.43 (3H, *s*)	C-19, C-20
1′	61.9 (C)	-	-
2′	195.6 (C=O)	-	-
3′	50.9 (CH_2)	3.57 (1H, *d*, 19.4)	C-1′, C-2′, C-5′
		3.47 (1H, *d*, 19.4)	C-2′, C-4′, C-5′, C-19
4′	83.6 (C)	-	-
5′	198.7 (C=O)	-	-
6′	72.0 (C)	-	-
5-OH	-	12.42 (1H, *s*)	C-4, C-4a, C-5, C-6
4′-OH	-	5.64 (1H, *s*)	C-4′, C-19

Table 28 ^{1}H-^{1}H COSY spectral data of **AE13**

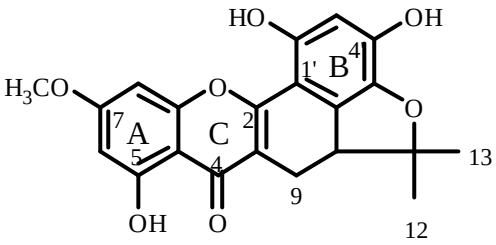
Proton (δ_{ppm})		Correlated proton (δ_{ppm})
H-3′ (3.57)	⟷	H-3′ (3.47)
H_{α}-9 (2.49)	⟷	H_{β}-9 (2.89), H-10 (3.38)
H_{β}-9 (2.89)	⟷	H_{α}-9 (2.49), H-10 (3.38)
H-10 (3.38)	⟷	H_{α}-9 (2.49), H_{β}-9 (2.49)
H_{α}-12 (4.91)	⟷	H_{β}-12 (4.98), H-13 (1.67)
H_{β}-12 (4.98)	⟷	H_{α}-12 (4.91), H-13 (1.67)
H-13 (1.67)	⟷	H_{α}-12 (4.91), H-12$_{\beta}$ (4.98)
H-14 (6.78)	⟷	H-15 (5.60)
H_{α}-19 (3.03)	⟷	H_{β}-19 (3.25)



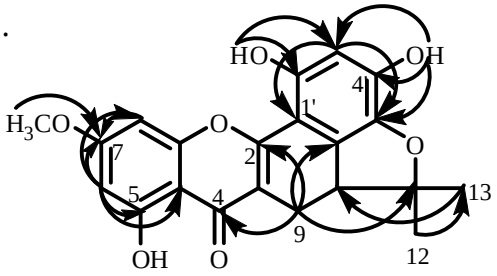
Major HMBC of **AE13**

AE14

5a,6-Dihydro-1,3,8-trihydroxy-10-methoxy-5,5-dimethyl-5*H*,7*H*-benzofuro[3,4-*bc*]xanthen-7-one



AE14 is a yellow solid, m.p. 287-288 °C. The UV spectrum exhibited absorption maxima at 225, 266, 270, 304 and 362 nm. The IR spectrum showed the absorption bands of hydroxyl groups at 3369 cm^{-1} and a carbonyl group at 1629 cm^{-1}. The ^1H NMR spectrum exhibited the signals of a hydrogen bonded hydroxyl group (δ 13.17, *s*, 5-OH), methoxyl protons (δ 3.88, *s*, 7-OCH_3), an isolated aromatic proton (δ 6.39, *s*, H-3′) and two *meta* aromatic protons (δ 6.32, *d*, H-6 and δ 6.56, *d*, H-8). The position of *meta* protons H-6 and H-8 was confirmed by the HMBC correlations of H-6 to C-4a, C-8, and of H-8 to C-4a, C-6. The methoxyl group was assigned at C-7 by HMBC correlation of 7-OCH_3 and H-8 to C-7. The spectrum further showed the signals of two hydroxyl protons at δ 8.38 and δ 9.71 and they were located at C-2′ and C-4′, respectively due to HMBC correlations of 2′-OH to C-1′, C-2′,C-3′ and of 4′-OH to C-3′, C-4′, C-5′. Two singlet signals of two methyl groups (δ 1.35, *s*, 12-CH_3 and δ 1.67, *s*, 13-CH_3) and an ABX system signals of a methine proton (δ 3.38, *dd*, H-10) and methylene protons (δ 3.22, *dd*, H_β-9 and 2.40, *t*, H_β-9) were assigned for the characteristic signals of a furanodihydrobenzo-xanthone skeleton. The HMBC correlations of H-10 to C-3, C-9, C-11, C-12, C-13, C-6′ suggested that the cyclized prenyl moiety was located at C-3 position and was linked to ring B at C-6′ position. The assignment of **AE14** was in agreement with the structure of **artonin K** (Namdaung, *et al*., 2006).



Major HMBC of **AE14**

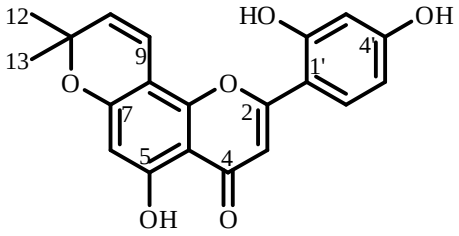
Table 29 ^{13}C, ^{1}H and HMBC spectral data of **AE14**

Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	165.9 (C)	-	-
3	116.4 (C)	-	-
4	185.2 (C=O)	-	-
4a	110.5 (C)	-	-
5	166.5 (C)	-	-
6	102.8 (CH)	6.32 (1H, *d*, 2.1)	C-4a, C-5, C-7, C-8
7	169.6 (C)	-	-
8	97.1 (CH)	6.56 (1H, *d*, 2.1)	C-4a, C-6, C-7, C-8a
8a	161.3 (C)	-	-
9	24.6 (CH_2)	3.22 ($1H_\beta$, *dd*, 15.0, 6.9)	C-2, C-3, C-4, C-6′, C-10
		2.40 ($1H_\alpha$, *t*, 15.0)	C-3, C-6′, C-10, C-11
10	51.4 (CH)	3.38 (1H, *dd*, 15.0, 6.9)	C-6′, C-9, C-11, C-12, C-13
11	97.8 (C)	-	-
12	27.4 (CH_3)	1.35 (3H, *s*)	C-10, C-11, C-13
13	32.9 (CH_3)	1.67 (3H, *s*)	C-10, C-11, C-12
1′	108.2 (C)	-	-
2′	155.3 (C)	-	-
3′	109.6 (CH)	6.39 (1H, *s*)	C-1′, C-2′, C-4′, C-5′
4′	151.5 (C)	-	-
5′	141.9 (C)	-	-
6′	136.6 (C)	-	-
7-OCH_3	60.5 (OCH_3)	3.88 (3H, *s*)	C-7
5-OH	-	13.17 (1H, *s*)	C-3′, C-5, C-6
2′-OH	-	8.38 (1H, *s*)	C-1′, C-2′, C-3′
4′-OH	-	9.71 (1H, *s*)	C-3′, C-4′, C-5′

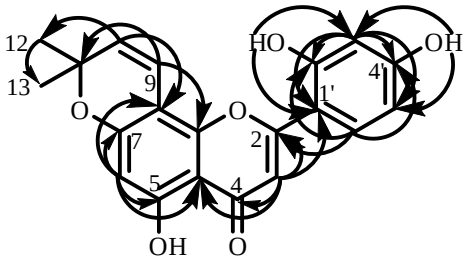
Table 30 ^{1}H-^{1}H COSY spectral data of **AE14**

Proton ($\boldsymbol{\delta}_{ppm}$)		Correlated proton ($\boldsymbol{\delta}_{ppm}$)
H-6 (6.32)	⟷	H-8 (6.56)
H_α-9 (2.40)	⟷	H_β-9 (2.40), H-10 (3.38)
H_β-9 (3.22)	⟷	H_α-9 (2.40), H-10 (3.38)
H-10 (3.38)	⟷	H_α-9 (2.40), H_β-9 (3.22)

AE15
5-Hydroxy-8,8-dimethyl-2-(2,4-dihydroxyphenyl)-4*H*,8*H*-benzo[1,2-*b*′]dipyran-4-one



AE15 is a pale yellow solid, m.p. 189-191 °C. The UV spectrum exhibited the absorption bands at 212, 230, 254, 272, 287, 307 and 357 nm. The IR spectrum showed the O-H stretching at 3379 cm^{-1} and the C=O stretching at 1651 and 1555 cm^{-1}.The ^{1}H NMR spectrum showed the characteristic resonances of a flavone proton at δ 7.15 (*s*, H-3), a hydrogen-bonded hydroxyl proton at δ 13.53 (*s*, 5-OH) and an aromatic proton at δ 6.44 (*s*, H-6). The resonances of two vinylic methine protons H-9 (δ 6.67, *d*, *J* = 10.2 Hz), H-10 (δ 5.74, *d*, *J* = 10.2 Hz), and two methyl groups 12-CH_3 (δ 1.47, *s*), 13-CH_3 (δ 1.47, *s*) revealed the presence of a 2,2-dimethylchromene ring. This moiety was placed at C-7 and C-8 of the parent structure due to HMBC correlations of H-9 to C-7, C-8a and of H-6 to C-5, C-7, C-8. A doublet at δ 6.58 (*J* = 2.1 Hz), a doublet of doublet at δ 6.54 (*J* = 8.7, 2.1 Hz) and a doublet δ 7.83 (*J* = 8.7 Hz) were in agreement with the ABX type of aromatic protons H-3′, H-5′ and H-6′. Thus **AE15** was assigned as 5-hydroxy-8,8-dimethyl-2-(2,4-dihydroxyphenyl)-4*H*,8*H*-benzo[1,2-*b*′]dipyran-4-one, a new flavone derivative.



Major HMBC of **AE15**

Table 31 ^{13}C, ^{1}H and HMBC spectral data of **AE15**

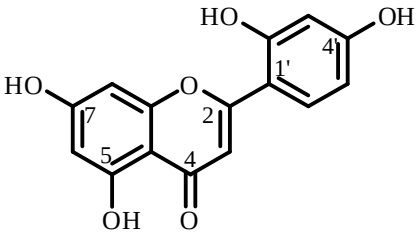
Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	162.3 (C)	-	-
3	107.5 (CH)	7.15 (1H, *s*)	C-1′, C-2, C-4, C-4a
4	182.8 (C=O)	-	-
4a	104.9 (C)	-	-
5	157.1 (C)	-	-
6	94.6 (CH)	6.44 (1H, *s*)	C-4a, C-5, C-7, C-8
7	159.1 (C)	-	-
8	104.9 (C)	-	-
8a	156.3 (C)	-	-
9	115.0 (CH)	6.67 (1H, *d*, 10.2)	C-7, C-8a, C-11
10	128.1 (CH)	5.74 (1H, *d*, 10.2)	C-8, C-11, C-12, C-13
11	78.3 (C)	-	-
12	27.6 (CH_3)	1.47 (3H, *s*)	C-10, C-11, C-13
13	27.6 (CH_3)	1.47 (3H, *s*)	C-10, C-11, C-12
1′	104.9 (C)	-	-
2′	158.8 (C)	-	-
3′	103.5 (CH)	6.58 (1H, *d*, 2.1)	C-2′, C-4′,C-5′
4′	161.9 (C)	-	-
5′	108.2 (CH)	6.54 (1H, *dd*, 8.7, 2.1)	C-2, C-2′, C-4′
6′	129.9 (CH)	7.83 (1H, *d*, 8.7)	C-2, C-2′, C-4′
5-OH	-	13.53 (1H, *s*)	C-4a, C-5

Table 32 ^{1}H-^{1}H COSY spectral data of **AE15**

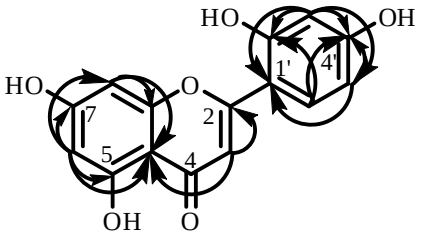
Proton ($\boldsymbol{\delta}_{ppm}$)		Correlated proton ($\boldsymbol{\delta}_{ppm}$)
H-9 (6.67)	⟷	H-10 (5.74)
H-3′ (6.58)	⟷	H-5′ (6.54)
H-5′ (6.54)	⟷	H-3′ (6.58), H-6′ (7.83)
H-6′ (7.83)	⟷	H-5′ (6.54)

AE16

2-(2,4-Dihydroxyphenyl)-5,7-dihydroxy-4*H*-chromen-4-one



AE16 is a pale creamy solid. The ^{1}H NMR spectrum showed the characteristic resonances of a flavone proton at δ 6.96 (s, H-3), a hydrogen-bonded hydroxyl proton at δ 13.00 (*s*, 5-OH), three free hydroxyl protons at δ 9.95, 9.90, 9.42, and meta aromatic protons at δ 6.36 (*d*, *J* = 2.5 Hz) and 6.10 (*d*, *J* = 2.5 Hz). The signals of doublet at δ 6.48 (*J* = 2.5 Hz), a doublet of doublet at δ 6.42 (*J* = 8.5, 2.5 Hz) and a doublet at δ 7.70 (*J* = 8.5 Hz) were in agreement with the ABX type of aromatic protons H-3′, H-5′ and H-6′. Thus **AE16** was assigned as 2-(2,4-dihydroxyphenyl)-5,7-dihydroxy-4*H*-chromen-4-one which was corresponded to norartocarpetin (Amarasinghe, *et al*., 2008).



Major HMBC of **AE16**

Table 33 ^{13}C, ^{1}H and HMBC spectral data of **AE16**

Position	δ_C (C-Type)	δ_H (*mult*, J_{Hz})	HMBC
2	158.5 (C)	-	-
3	108.2 (CH)	6.96 (1H, *s*)	C-2, C-4a
4	182.6 (C=O)	-	-
4°	103.5 (C)	-	-
5	162.0 (C)	-	-
6	93.6 (CH)	6.36 (1H, *d*, 2.5)	C-4a, C-5, C-7, C-8
7	164.0 (C)	-	-
8	98.5 (C)	6.10 (1H, *d*, 2.5)	C-4a, C-6, C-8a
8°	162.4 (C)	-	-
1′	107.6 (C)	-	-
2′	161.8 (C)	-	-
3′	103.4 (CH)	6.48 (1H, *d*, 2.5)	C-1′, C-2′, C-4′,C-5′
4′	158.0 (C)	-	-
5′	107.7 (CH)	6.42 (1H, *dd*, 8.5, 2.5)	C-1′, C-3′, C-4′
6′	129.9 (CH)	7.70 (1H, *d*, 8.5)	C-2′, C-4′
5-OH	-	13.00 (1H, *s*)	C-4a, C-5, C-6
*OH	-	9.42 (*s*)	-
*OH	-	9.90 (*s*)	-
*OH	-	9.95 (*s*)	-

* the position not identified

Table 34 ^{1}H-^{1}H COSY spectral data of **AE 16**

Proton ($\boldsymbol{\delta}_{ppm}$)		Correlated proton ($\boldsymbol{\delta}_{ppm}$)
H-6 (6.36)	⟷	H-8 (6.10)
H-3′ (6.48)	⟷	H-5′ (6.42)
H-5′ (6.42)	⟷	H-3′ (6.48), H-6′ (7.70)
H-6′ (7.70)	⟷	H-5′ (6.42)

3.2 Evaluation of biological activities of the crude extracts

3.2.1 Antimicrobial activity

Dried bark of *A. elasticus* was extracted with dichloromethane and acetone to give dichloromethane extract (AeD) and acetone extract (AeA). Each extract was screened for antibacterial activity against *Staphylococcus aureus* ATCC25923 (SA), methicillin-resistant *Stapphylococcus aureus* (MRSA SK1), *Pseudomonas aeruginosa* ATCC27853 (PA), and *Escherichia coli* ATCC25922, for antiyeast activity on *Candida albicans* NCPF3153 (CA), and *Cryptococcus neoformans* ATCC90113 flucytosine-resistant (CN90113), and for antifungal activity on *Microsporum gypseum* clinical isolate (M. gypseum). It was found that the CH_2Cl_2 extract showed activity with MIC 128 μg/ml for SA and MRSA SK1. The acetone extract exhibited activity with MIC 16 μg/ml. Both extracts showed no activity for PA and EC. Both extracts showed no antiyeast activity and antifungal activity. The results are shown in **Table 35** and **Table 36**

Table 35 Antibacterial activity of crude extracts from the bark of *A. elasticus*

Fractions	Antibacterial activity (MIC, μg/ml)			
	SA	MRSA SK1	PA	EC
AeD	128	128	>200	>200
AeA	16	16	>200	>200
Vancomycin	1	1	-	-
Gentamicin	-	-	1	1

Table 36 Antiyeast and Antifungal activity of crude extracts from the bark of *A. elasticus*

Fractions	Antiyeast activity (MIC, μg/ml)		Antifungal activity (MIC, μg/ml)
	CA	CN90113	*M. gypseum*
AeD	>200	>200	>200
AeA	>200	>200	>200
Amphotericin B	0.125	0.25	-
Miconazole	-	-	1

Some of the pure compounds obtained from CH_2Cl_2 extract were evaluated for their antibacterial activities against S. aureus ATCC25923, and MRSA SK1. The result (**Table 37**) indicated that **AE4**, **AE8**, **AE13** and **AE14** were less active than the crude extract. Whereas **AE1**, **AE10** and **AE12** were more active than the crude extract. Among the active compounds **AE1** showed the strongest inhibitory activity with a MIC value of 4 and 8 μg/ml against *S. aureus* ATCC25923, and MRSA SK1, respectively. However it was less active than vancomycin, the standard antibiotic (MIC 1 μg/ml). **AE2**, **AE3**, **AE5**, **AE6**, **AE7**, **AE9**, **AE11**, **AE15** and **AE16** were not tested due to insufficient quantities.

Table 37 Antibacterial activity of compounds isolated from the bark of *A. elasticus*

Compound	Antibacterial activity (MIC, μg/ml)	
	SA	MRSA SK1
AE1	4	8
AE4	> 200	> 200
AE8	> 200	> 200
AE10	16	16
AE12	32	16
AE13	128	-
AE14	200	200
Vancomycin	1	1

3.2.2 Cytotoxic activity

The dichloromethane extract (AeD) and acetone extract (AeA) were further evaluated for cytotoxicity against C6 (Glial tumor), D17 (Bone cancer), OLO (Colon cancer) and PC3 Prostate cancer**.** According to the MIC value shown in **Table 37**. acetone extract was found to inhibit cancer cell lines with IC_{50} in the range of 300-337.5 μg/ml, whereas dichloromethane extract was found to be inactive for cytotoxic activity.

Table 38 Cytotoxic activity of crude extracts from the bark of *A. elasticus*

Fractions	Cytotoxic activity (IC_{50} μg/ml)			
	C6	D17	OLO 205	PC3
	Glial tumor	Bone cancer	Colon cancer	Prostate cancer
AeD	NA	NA	NA	NA
AeA	337.5	315	~300	NA

NA = no activity

3.3 Review of biological activities of the known compounds obtained from this study

Biological activities of some compounds isolated from this study have been previously investigated. Based on the search from SciFinder Scholar the biological activities of artonin E (**AE1**), artnol B (**AE5**), 7-demethylartonol E (**AE10**), artonin F (**AE8**), cycloartobiloxanthone (**AE10**) and norartocarpetin (**AE16**) are summarized.

Artonin E (**AE1**) is the major component of *A. elasticus*. It showed strong radical scavenging properties (DPPH radical) (Jayasinghe, *et al*., 2008) and cytotoxicity to cell lines such as murine leukemia P388 cell line (IC_{50} 0.06 μg/ml) (Hakim, *et al*., 2006), 1A9 (Ovarian, ED_{50} 1.25 μg/ml), MCF-7 (breast

adenocarcinoma, ED_{50} 2.2 μg/ml), HCT-8 (ileocecal, ED_{50} 3.3 μg/ml) and MDAMB-231 (breast adenocarcinoma, ED_{50} 3.0 μg/ml) (Wang, *et al*., 2004). Furthermore, it also reduced the amount of urinary protein excretion compared to nephritic mice (Fukai, *et al*., 2003).

Artonol B (**AE5**) has been reported to show cytotoxicity against the human small cell lung cancer (NCI-H 187, IC_{50} 1.26 μg/ml) (Namdaung, *et al.*, 2006) and murine leukemia cell (P388, IC_{50} >100 μg/ml) (Hakim, *et al*., 2002).

7-Demethylartonol E **(AE6)** has been tested for antiplasmodial activity against *Plasmodium falciparum* (IC_{50} 7.9 μg/ml) and antimycobacterial activity against *Mycobacterium tuberculosis* (MIC 50 μg/ml). It was also toxic to human small cell lung cancer (NCI-H187, IC_{50} 5.7 μg/ml) (Namdaung, *et al.*, 2006).

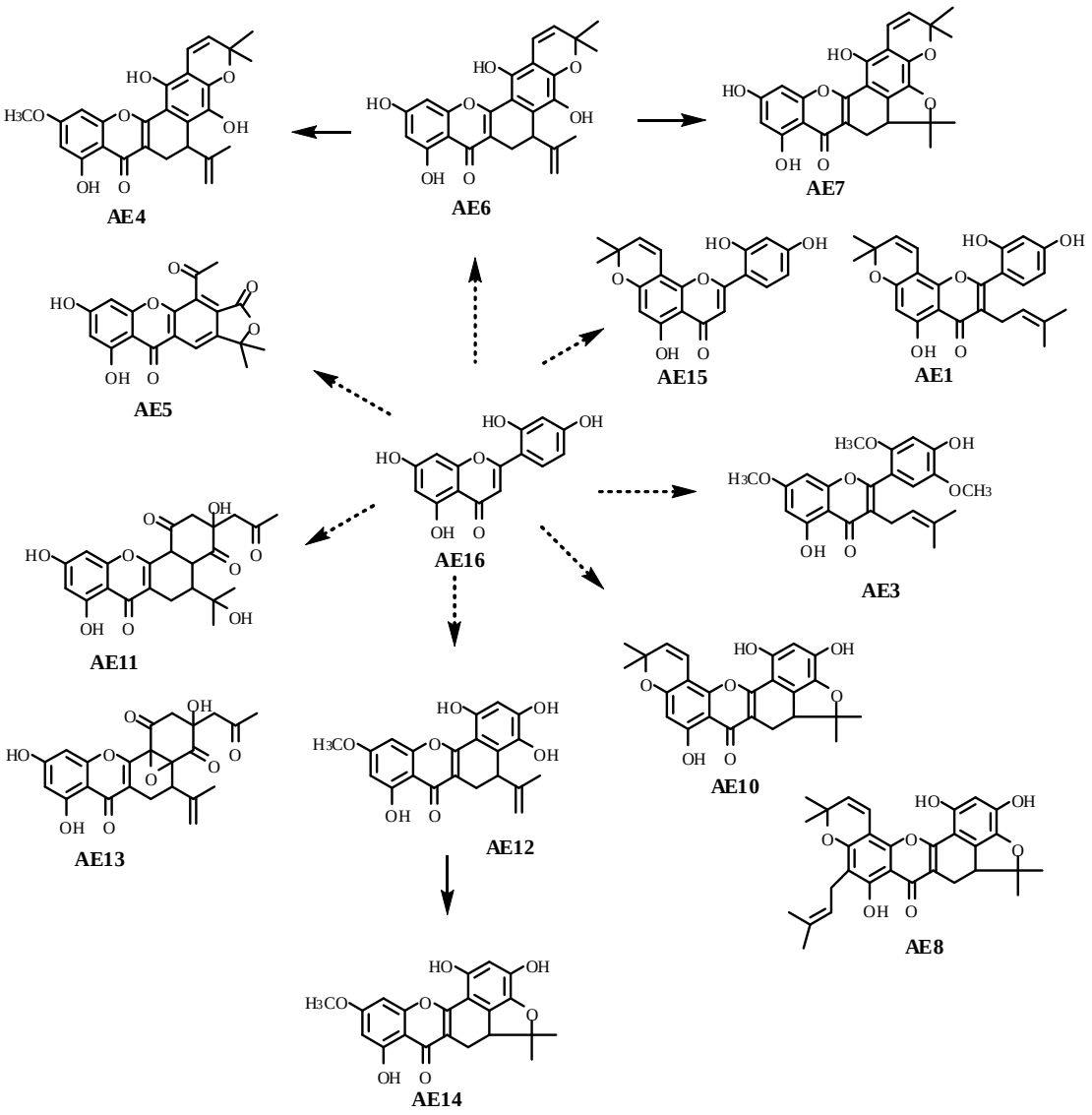
Artonin F (**AE8**) has been tested for antiplasmodial activity against *Plasmodium falciparum* (IC_{50} 2.4 μg/ml) and antimycobacterial activity against *Mycobacterium tuberculosis* (MIC 6.25 μg/ml) (Namdaung, *et al.*, 2006).

Cycloartobiloxanthone (**AE10**) has been tested for antiplasmodial activity against *Plasmodium falciparum* (IC_{50} 3.7 μg/ml) and antimycobacterial activity against *Mycobacterium tuberculosis* (MIC 25 μg/ml) (Namdaung, *et al.*, 2006). The radical scavenging properties (DPPH radical) were studied (Jayasinghe, *et al*., 2008). It also exhibited cytotoxicity against human epidermoid carcinoma of the nasopharynx (KB, IC_{50} 8.56 μg/ml), human breast cancer (BC, IC_{50} 4.23 μg/ml) and human small cell lung cancer (NCI-H187, IC_{50} 11.83 μg/ml).

Norartocarpetin (**AE16**) has been reported to exhibit strong toxicity against *Artemia salina* shrimp, LC_{50} 0.05 μg/ml.

3.4 Biogenesis of flavonoids and related compounds from *Artocarpus elasticus*

Relationships between the various classes of secondary metabolites from *Artocarpus elasticus* is outlined in **Scheme 4**.



Scheme 4 Relationships of prenylated flavonoids from *A. elasticus*

Biosynthetic route for the formation of **AE7** (furanodihydrobenzoxanthone skeleton), a new compound, from simple flavones is proposed in **Scheme 5** (Sultanbawa, *et al*., 1989).

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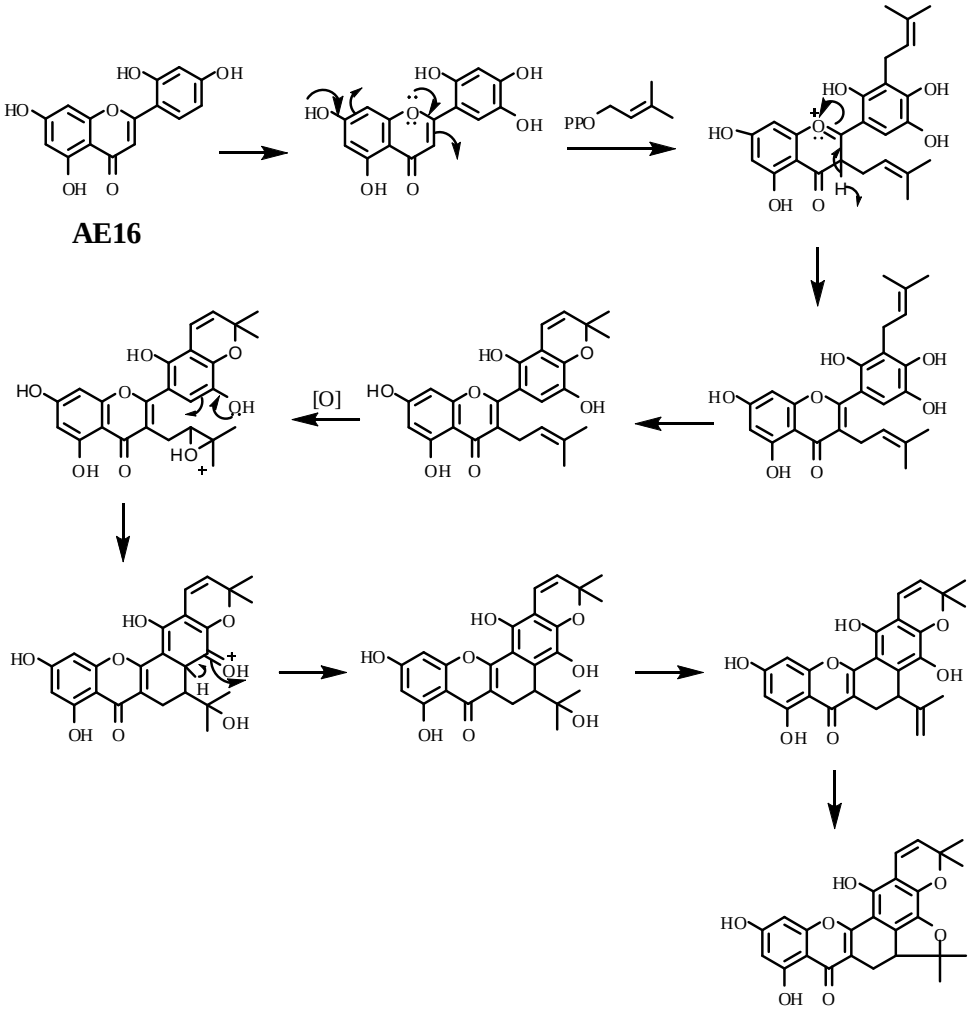
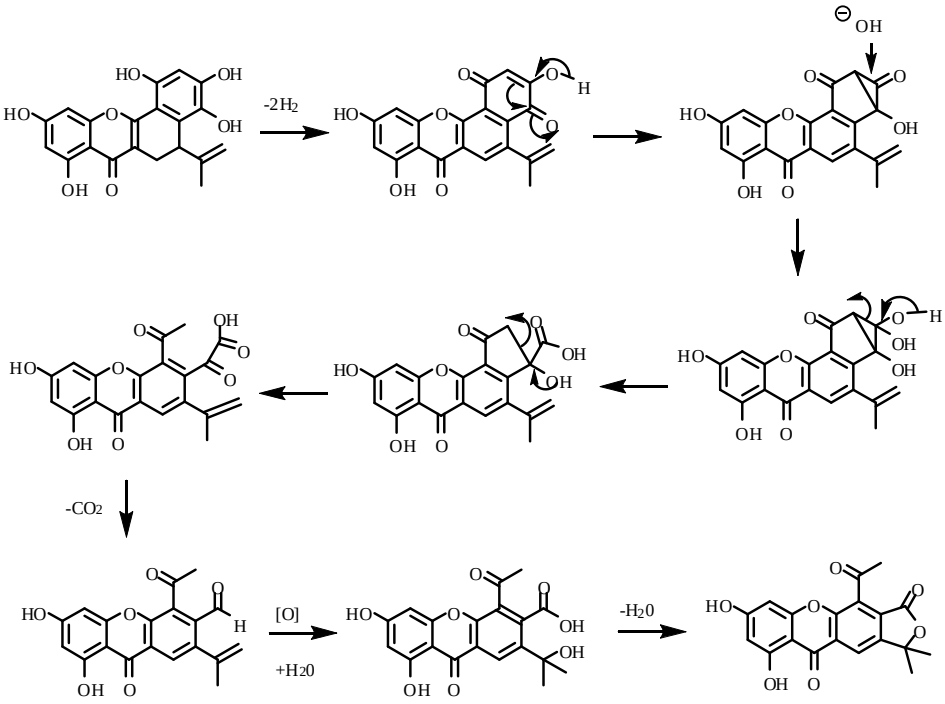


Scheme 5 Proposed biogenetic route of **AE7**

Biogenetic route of artonol B (**AE5**) (xanthonolide skeleton) has been describe by Aida, *et al*., 1997 as shown in **scheme 6**.



Scheme 6 Proposed biogenetic route of the xanthonolide types of compounds

Conclusion

Investigation of the constituents from the bark of *A. elasticus* led to the isolation of sixteen compounds including four flavone derivatives: 5-hydroxy-8,8-dimethyl-3-(3-methyl-2-butenyl)-2-(2,4,5-trihydroxyphenyl)-4*H*,8*H*-benzo[1,2-b:3,4-*b*′]dipyran-4-one (**AE1**), 5-hydroxy-2-(4-hydroxy-2,5-dimethoxyphenyl)-7-methoxy-3-(3-methylbut-2-enyl)-4*H*-chromen-4-one (**AE3**), 5-hydroxy-8,8-dimethyl-2-(2,4-dihydroxyphenyl)-4*H*,8*H*-benzo[1,2-*b*′]dipyran-4-one (**AE15**), and 2-(2,4-dihydroxyphenyl)-5,7-dihydroxy-4*H*-chromen-4-one (**AE16**), three dihydrobenzoxanthone derivatives: 6,7-dihydro-5,9,14-trihydroxy-11-methoxy-3,3-dimethyl-6-(1-methylethyl)-3*H*,8*H*-[1]benzopyrano[7,6-*c*]xanthen-8-one (**AE4**), 6,7-dihydro-5,9,11,14-tetrahydroxy-3,3-dimethyl-6-(1-methylethenyl)-(-)-3*H*,8*H*-pyrano[3′,2′:4,5]benzo[1,2-*c*]xanthen-8-one (**AE6**) and 1,3,4,8-tetrahydroxy-10-methoxy-5-(prop-1-en-2-yl)-5*H*-benzo[*c*]xanthen-7-(6*H*)-one (**AE12**), four furanodihydrobenzoxanthone derivatives: (**AE7**), 5a,6-dihydro-1,3,8-trihydroxyl-5,5,11,11-tetramethyl-9-(3-methyl-2-buten-1-yl)-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (**AE8**), 5a,6-dihydro-1,3,8-trihydroxy-5,5,11,11-tetramethyl-5*H*,7*H*,11*H*-benzofuro[3,4-*bc*]pyrano[3,2-*h*]xanthen-7-one (**AE10**) and 5a,6-dihydro-1,3,8-trihydroxy-10-methoxy-5,5-dimethyl-5*H*,7*H*-benzofuro[3,4-*bc*]xanthen-7-one (**AE14**), two quinonoxanthone derivatives: (**AE11**) and (**AE13**), one xanthonolide: 12-acetyl-6-hydroxy-3,3,9,9-tetramethyl-3*H*,7*H*,furo[3,4-*b*]pyrano[3,2-*h*]xanthene-7,11(9*H*)-dione (**AE5**), one dihydroisocoumarin: 8-hydroxy-3-methyl-isochroman-1-one (**AE2**), and one benzyl alcohol derivative: (3,4,5-trimethoxy phenyl) methanol (**AE9**). **AE3**, **AE7**, **AE11**, **AE12**, **AE13** and **AE15** are new compounds. **AE1**, **AE2**, **AE4**, **AE5**, **AE8**, **AE9**, **AE10**, **AE14** and **AE16** were obtained for the first time from this plant. **AE6** were previously isolated from this plant. **AE1** showed the best activity to inhibit the growth of *S. aureus* ATCC25923 and MRSA SK1 with a MIC value of 4 and 8 μg/ml. Further study on the biological activity of the isolated compound should be performed.

REFERENCES

Achmad, S. A.; Hakim, E. H.; Juliawaty, L. D.; Makmur, L.; Suyatno; Aimi, N.; Ghisalberti, E. L. 1996. "A New Prenylated Flavone from *Artocarpus champeden*", *J. Nat. Prod.*, 59, 878-879.

Aida, M.; Shinomiya, K.; Hano, Y.; Nomura, T. 1993. "Artonin J, K, and L, Three New Isoprenylated Flavones from the Root Bark of *Artocarpus heterophyllus* Lamk.", *Heterocycles*, 36 (3), 575-583.

Aida, M.; Yamaguchi, N.; Hano, Y.; Nomura, T. 1997. "Artonols A, B, C, D, and E, Five New Isoprenylated Phenols from the Bark of *Artocarpus communis* Forst.", *Heterocycles*, 45 (1), 163-175.

Amarasinghe, N. R.; Jayasinghe, L.; Hara, N.; Fujimoto, Y. 2008. "Chemical Constituents of the Fruits of *Artocarpus altilis*", *Biochemical Systematics and Ecology*, 36, 323-325.

Arung, E. T.; Shimizu, K.; Kondo, R. 2006. "Inhibitory Effect of Artocarpanone from *Artocarpus heterophyllus* on Melanin Biosynthesis", *Biol. Pharm. Bull.*, 29 (9), 1966-1969.

Boonlaksiri, C.; Oonanant, W.; Kongsaeree, P.; Kittakoop, P.; Tanticharoen, M.; Thebtaranonth, Y. 2000. "An Antimalarial Stilbene from *Artocarpus integer*", *Phytochemistry*, 54, 415-417.

Cerqueira, F.; Cidade, H.; Ufford, L. V.; Beukelman, C.; Kijjoa, A.; Nascimento, M. S. J. 2008. "The Natural Prenylated Flavone Artelastin is an Inhibitor of ROS and NO production", *International Immunopharmacology*, 8, 597-602.

Cerqueira, F.; Cordeiro-Da-Silva, A.; Araujo, N.; Cidade, H.; Kijjoa, A.; Nascimento. 2003. “Inhibition of Lymphocyte Proliferation by Prenylated Flavones: Artelastin as a Potent Inhibitor”, *Life Sciences*, 73, 2321-2334.

Chan, S.- C.; Ko, H.-H.; Lin, C.- N. 2003. “New Prenylflavonoids from *Artocarpus communis*”, *J. Nat. Prod.*, 66, 427-430.

Chantrapromma, S.; Boonnak, N.; Fun, H.-K.; Karalai, C. 2007. “Artocarpin dichloromethane hemisolvate”, *Acta Cryst*., E63, o1864-o1866.

Chung, M.- I.; Lu, C.- M.; Huang, P.-L.; Lin, C.- N. 1995. “Prenylflavonoids of *Artocarpus heterophyllus*”, *Phytochemistry*, 40 (4), 1279-1282.

Dimitriadis, C.; Gill, M.; Harte, M. F. 1997. “The First Stereospecific Approach to Both Enantiomers of Mullein”, *Tetrahedron*: *Asymmetry*, 8 (13), 2153-2158.

Fukai, T.; Satoh, K.; Nomura, T.; Sakagami, H. 2003. “Antinephritis and Radical Scavenging Activity of Prenylflavonoids”, *Fitoterapia*, 74, 720-724.

Fun, H.-K., Boonnak, N.; Chantrapromma, S. 2007. “A Cocrystal of Friedelan-3β-ol and Friedelin”, *Acta cryst*., E63, o2014-o2016.

Hakim, E. H.; Achmad, S. A.; Juliawaty, L. D.; Makmur, L.; Syah, Y. M.; Aimi, N.; Kitajima, M.; Takayama, H.; Ghisalberti, E. L. 2006. “Prenylated Flavonoids and Related Compounds of the Indonesian *Artocarpus* (Moraceae)”, *J. Nat. Med*., 60, 161-184.

Hakim, E. H.; Asnizar; Yurnawilis; Aimi, N.; Kitajima, M.; Takayama, H. 2002. “Artoindonesianin P, a New Prenylated Flavone with Cytotoxic Activity from *Artocarpus lanceifolius*”, *Fitoterapia*, 73, 668-673.

Hakim, E. H.; Fahriyati. A.; Kau, M. S.; Achmad, S. A.; Makmur, L.; Ghisalberti, E. L.; Nomura, T. 1999. "Artoindonesianins A and B, Two New Prenylated Flavones from the Root of *Artocarpus champeden*", *J. Nat. Prod*., 62, 613-615.

Hakim, H. H.; Juliawaty, L. D.; Syah, Y. M.; Achmad, A. S. 2005. "Molecular Diversity of *Artocarpus champeden* (Moraceae): A species Endemic to Indonesia", *Molecular Diversity*, 9, 149-158.

Hakim, E. H.; Ulinnuha, U. Z.; Syah, Y. M.; Ghisalberti, E. L. 2002. "Artoindonesianins N and O, New Prenylated Stilbene and Prenylated Arylbenzofuran Derivatives from *Artocarpus gomezianus*", *Fitoterapia*, 73, 597-603.

Hano, Y.; Inami, R.; Nomura, T. 1993. "Components of the Bark of *Artocarpus rigida* BL. 2.[*,1] Structures of Four New Isoprenylated Flavone Derivatives Artonins M, N, O, and P", *Heterocycles*, 35 (2), 1341-1350.

Hano, Y.; Yamagami, Y.; Miki, M.; Isohata, R.; Nomura, T. 1990. "Artonins E and F, Two New Prenylflavones from the Bark of *Artocarpus communis* Forst.", *Heterocycles*, 31 (5), 877-882.

Han, A.-R.; Kang, Y.-J.; Windono, T.; Lee, S. K.; Seo, E.-K. 2006. "Prenylated Flavonoids from the Heartwood of *Artocarpus communis* with Inhibitory Activity on Lipopolysaccharide-Induced Nitric Oxide Production", *J. Nat. Prod*. 69, 719-721.

Jayasinghe, L.; Balasooriya, B. A. I. S.; Padmini, W. C.; Hara, N.; Fujimoto, Y. 2004. "Geranyl Chalcone Derivatives with Antifungal and Radical Scavenging Properties from the Leaves of *Artocarpus nobilis*", *Phytochemistry*, 65, 1287-1290.

Jayasinghe, L.; Rupasinghe, G. K.; Hara, N.; Fujimoto, Y. 2006. “Geranylated Phenolic Constituents from the Fruits of *Artocarpus nobilis*”, *Phytochemistry*, 67, 1353-1358.

Jayasinghe, U. L. B.; Samarakoon, T. B.; Kumarihamy, B. M. M.; Hara, N.; Fujjimoto, Y. 2008. “Four New Prenylated Flavonoids and Xanthones from the Root Bark of *Artocarpus nobilis*”, *Fitoterapia*, 79, 37-41.

Kijjoa, A.; Cidade, H. M.; Gonzalez, M. J. T. G.; Afonso, C. M.; Silva, A. M. S.; Herz, W. 1998. “Further Prenylflavonoids from *Artocarpus elasticus*”, *Phytochemistry*, 47 (5), 875-878.

Kijjoa, A.; Cidade, H. M.; Pinto, M. M. M.; Gonzalez, M. J. T. G.; Anantachoke, C.; Gedris, T. E.; Herz, W. 1996. “Prenylflavonoids from *Artocarpus elasticus*”, *Phytochemistry*, 43 (3), 691-694.

Ko, H.- H.; Lu, Y.- H.; Yang, S.- Z.; Won, S.- J.; Lin, C.- N. 2005. “Cytotoxic Prenylflavonoids from *Artocarpus elasticus*”, *J. Nat. Prod*., 68, 1692-1695.

Likhitwitayawuid, K.; Sritularak, B. 2001. “A New Dimeric Stilbene with Tyrosinase Inhibitiory Activity from *Artocarpus gomezianus*”, *J. Nat. Prod*., 64, 1457-1459.

Likhitwitayawuid, K.; Supudompol, B.; Sritularak, B.; Lipipun, V.; Rapp, K.; Schinazi, R. F. 2005. “Phenolics with Anti-HSV and Anti-HIV Activities from *Artocarpus gomezianus*, *Mallotus pallidus*, and *Triphhasia trifolia*”, *Pharmaceutical Biology*, 43 (8), 651-657.

Lin, C.- N.; Lu, C.- M.; Huang, L.- P. 1995. “Flavonoids from *Artocarpus heterophyllus*”, *Phytochemistry*, 39 (6), 1447-1451.

Lin, C.- N.; Chiu, P.- H.; Fang, S.- C.; Shieh, B.- J.; Wu, R.- R. 1996. "Revised Structure of Broussoflavonol G and the 2D NMR Spectra of Some Related Prenylflavonoids", *Phytochemistry*, 41 (4), 1215-1217.

Lin, C.- N.; Shieh, W.- L. 1991. "Prenylflavonoids and Pyranodihyhydrobenzoxanthone from *Artocarpus communis*", *Phytochemistry*, 30 (5), 1669-1671.

Lin, C.- N.; Shieh, W.- L. 1992. "Pyranoflavonoids from *Artocarpus communis*", *Phytochemistry*, 31 (8), 2922-2924.

Lu, C.- M.; Lin, C.- N. 1993. "Two 2′,4′,6′-Trioxygenated Flavanones from *Artocarpus heterophyllus*", *Phytochemistry*, 33 (4), 909-911.

Namduang, U.; Aroonberk, N.; Suksamrarn, S.; Danwiesetkanjana, K.; Saenboonrueng, J.; Arjchomphu, W.; Suksamrarn, A. 2006. "Bioactive Constituents of the Root of *Artocapus rigidus* subsp. *Rigidus*", *Chem. Pharm. Bull.*, 54 (10), 1433-1436.

Parenti, P.; Pizzigoni, A.; Hanozet, G.; Hakim, E.- H.; Makmur, L.; Achmad, S.- A.; Giordana, B. 1998. "A New Prenylated Flavone from *Artocarpus champeden* Inhibits the K^+-Dependent Amino Acid Transport in Bombyx mori Midgut", *Biochemical and Biophysical Research communications*, 244, 445-448.

Patil, A. D.; Freyer, A. J.; Killmer, L.; Offen, P.; Taylor, P. B.; Votta, B. J.; Johnson, R. K. 2002. "A New Dimeric Dihydrochalcone and New Prenylated Flavone from the Bud Covers of *Artocarpus altilis*: Potent Inhibitors of Cathepsin K", *J. Nat. Prod.*, 65, 624-627.

Pedro, M.; Ferreira, M. M.; Cidade, H.; Kijjoa, A.; Bronze-da-Rocha, E.; Nascimento, M. S. J. 2005. "Artelastin is a Cytotoxic Prenylated Flavone that Disturbs Microtubules and Interferes with DNA replication in MCF-7 human breast cancer cells", *Life Sciences*, 77, 293-311.

Puntunchai, A.; Kittakoop, P.; Rajviroongit, S.; Vimuttipong, S.; Likhitwitayawuid, K.; Thebtaranonth, Y. 2004. “Lakoochins A and B, New Antimycobacterial Stilbene Derivatives from *Artocarpus lakoocha*”, *J. Nat. Prod.*, 67, 485-486.

Shieh, W.- L.; Lin, C.- N. 1992. “A Quinonoid Pyranobenzoxanthone and Pyranodihydrobenzoxanthone from *Artocarpus communis*”, *Phytochemistry*, 31(1), 364-367.

Shimizu, K.; Kondo, R.; Sakai, K. 1997. “A Stilbene Derivative from *Artocarpus incisus*”, *Phytochemistry*, 45 (6), 1297-1298.

Shimizu, K.; Kondo, R.; Sakai, K.; Buabarn, S.; Dilokkunanant, U. 2000. “A Geranylated Chalcone with 5α-Reductase Inhibitory Properties from *Artocarpus incisus*”, *Phytochemistry*, 54, 737-739.

Sultanbawa, M. U. S.; Surendrakumar, S. 1989. “Two Pyranodihydrobenzoxanthones from *Artocarpus nobilis*”, *Phytochemistry*, 28 (2), 599-605.

Syah, Y. M.; Achmad, S. A.; Ghisalberti, E. L.; Hakim, E. H.; Makmur, L.; Mujahidin, D. 2001. “Artoindonesianins G-I, Three New Isoprenylated Flavones from *Artocarpus lanceifolius*”, *Fitoterapia*, 72, 765-773.

Syah, Y. M.; Achmad, S. A.; Ghisalberti, E. L.; Hakim, E. H.; Makmur, L.; Mujahidin, D. 2002. “Artoindonesianins Q-T, Four Isoprenylated Flavones from *Artocarpus champeden* Spreng. (Moraceae)”, *Phytochemistry*, 61, 949-953.

Syah, Y. M.; Achmad, S. A.; Ghisalberti, E. L.; Hakim, E. H.; Mujahidin, D. 2002. “Two New Cytotoxic Isoprenylated Flavones, Artoindonesianins U and V, From the Heartwood of *Artocarpus champeden*”, *Fitoterapia*, 75, 134-140.

Syah, Y. M.; Juliawaty, L. D.; Achmad, S. A.; Hakim, E. H.; Ghisalberti, E. L. 2006. "Cytotoxic Prenylated Flavones from *Artocarpus champeden*", *J. Nat. Med.*, 60, 308-312.

Wang, Y.- H.; Hou, A.- J.; Chen, L.; Chen, D.- F.; Sun, H.- D.; Zhao, Q.- S.; Bastow, K. F.; Yuka, N.; Wang, X.- H.; Lee, K.-H. 2004. "New Isoprenylated Flavones, Artochamins A-E, and Cytotoxic Principles from *Artocarpus chama*", *J. Nat. Prod.*, 67, 757-761.

Wang, Y.; Xu, K.; Lin, L.; Pan, Y.; Zheng, X. 2007. "Geranyl Flavonoids from the Leaves of *Artocarpus altilis*", *Phytochemistry*, 68, 1300-1306.

Wei, B. - L.; Weng, J.- R.; Chiu, P. - H.; Hung, C. - F.; Wang, J. - P.; Lin, C. - N. 2005. "Antiinflammatory Flavonoids from *Artocarpus heterophyllus* and *Artocarpus communis*", *J. Agric. Food Chem.*, 53, 3867-3871.

Widyawaruyanti, A.; Subehan; Surya, K. K.; Awale, S.; Nindatu, M.; Zaini, N.- C.; Syafruddin, D.; Asih, P. B. S.; Tezuka, Y.; Kadota, S. 2007. "New Prenylated Flavones from *Artocarpus champeden*, and Their Antimalarial Activity in Vitro", *J. Nat. Med.*, 61, 410-413.

APPENDIX

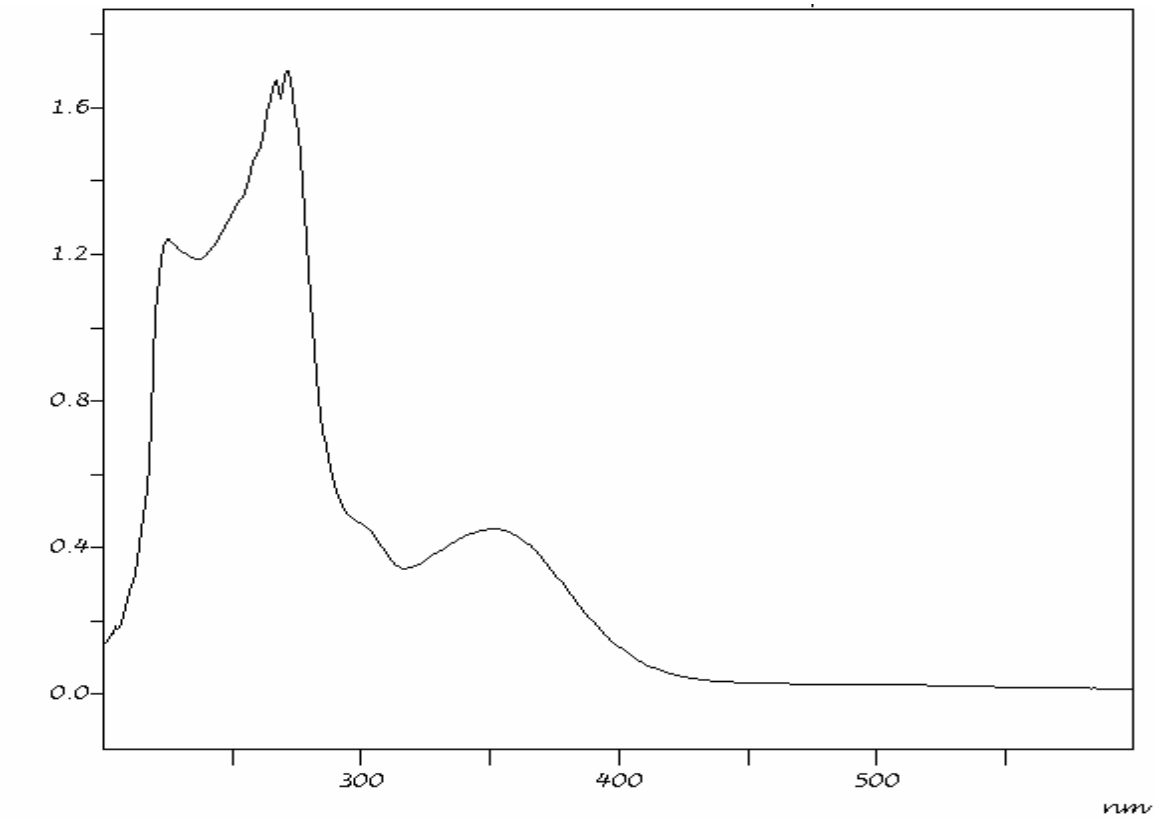


Figure 6 UV (CH_3OH) spectrum of **AE1**

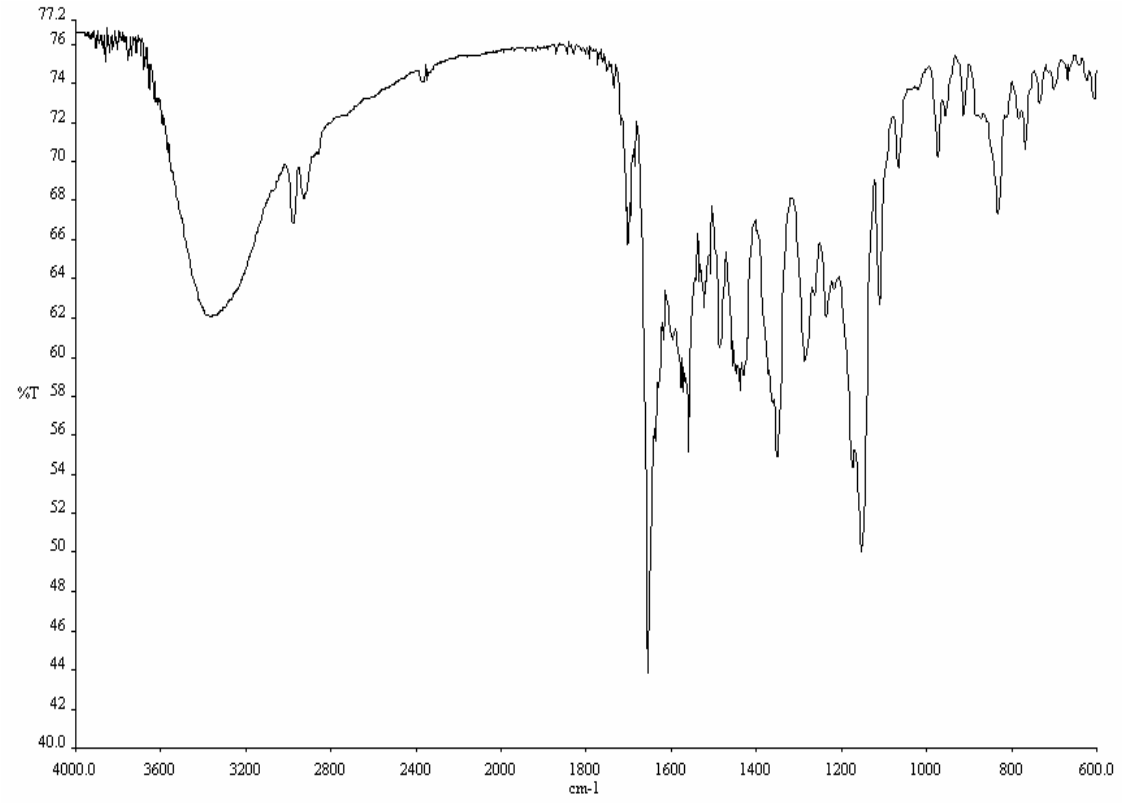


Figure 7 FT-IR (Neat) spectrum of **AE1**

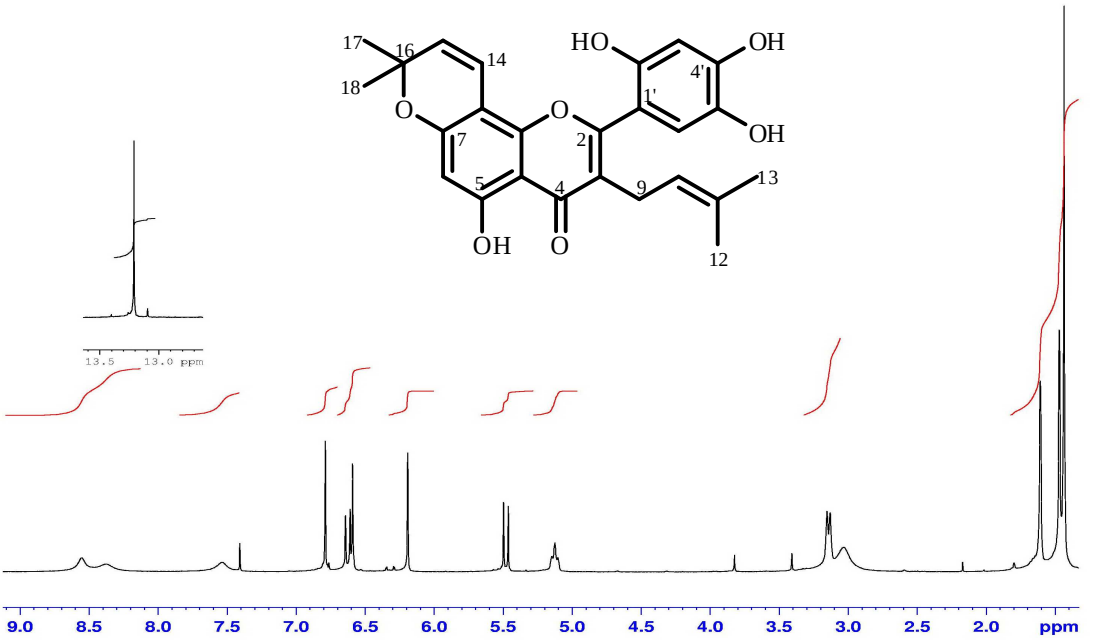


Figure 8 ^{1}H NMR (300 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE1**

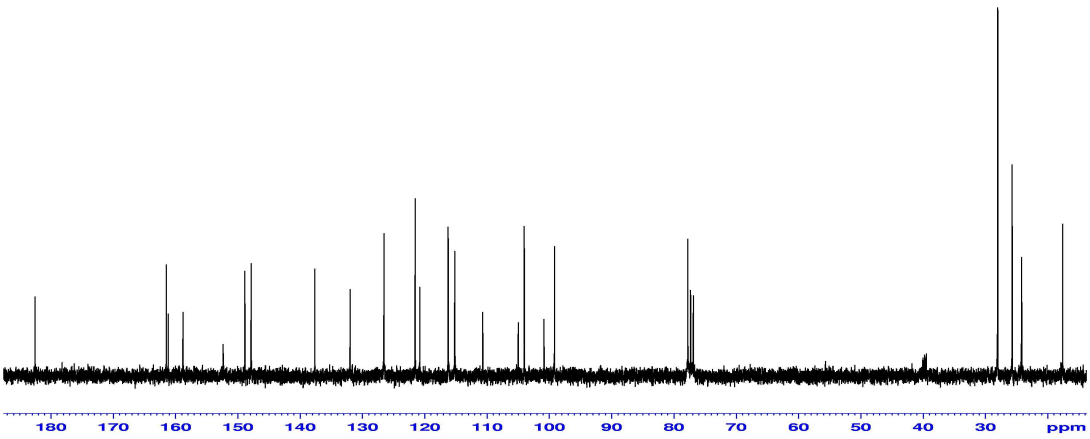


Figure 9 ^{13}C NMR (75 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE1**

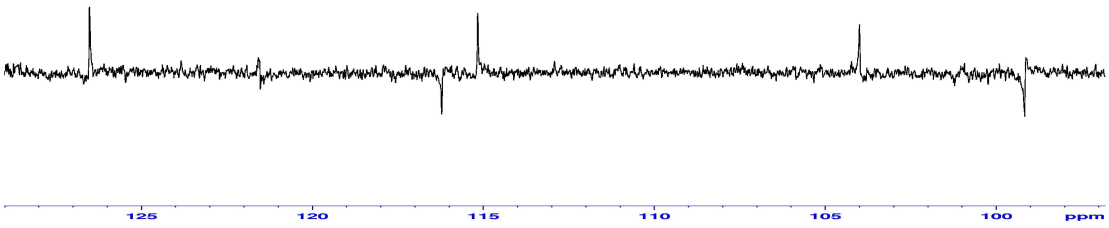


Figure 10 DEPT 135° ($CDCl_3$+DMSO-d_6) spectrum of **AE1**

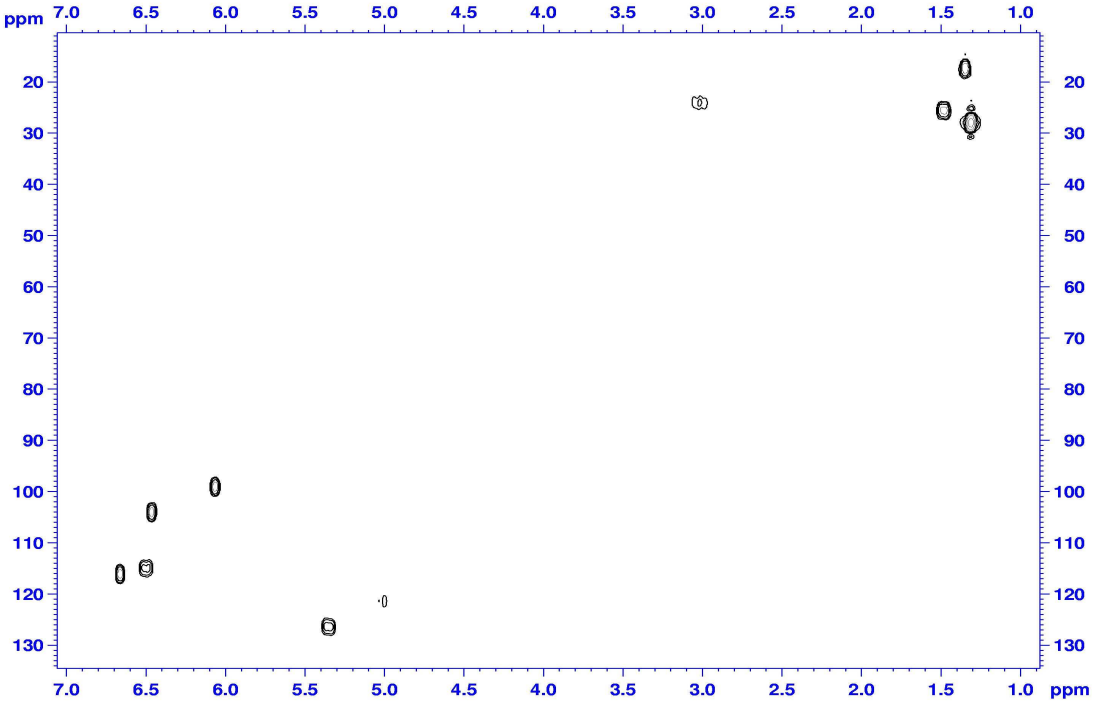


Figure 11 2D HMQC spectrum of **AE1**

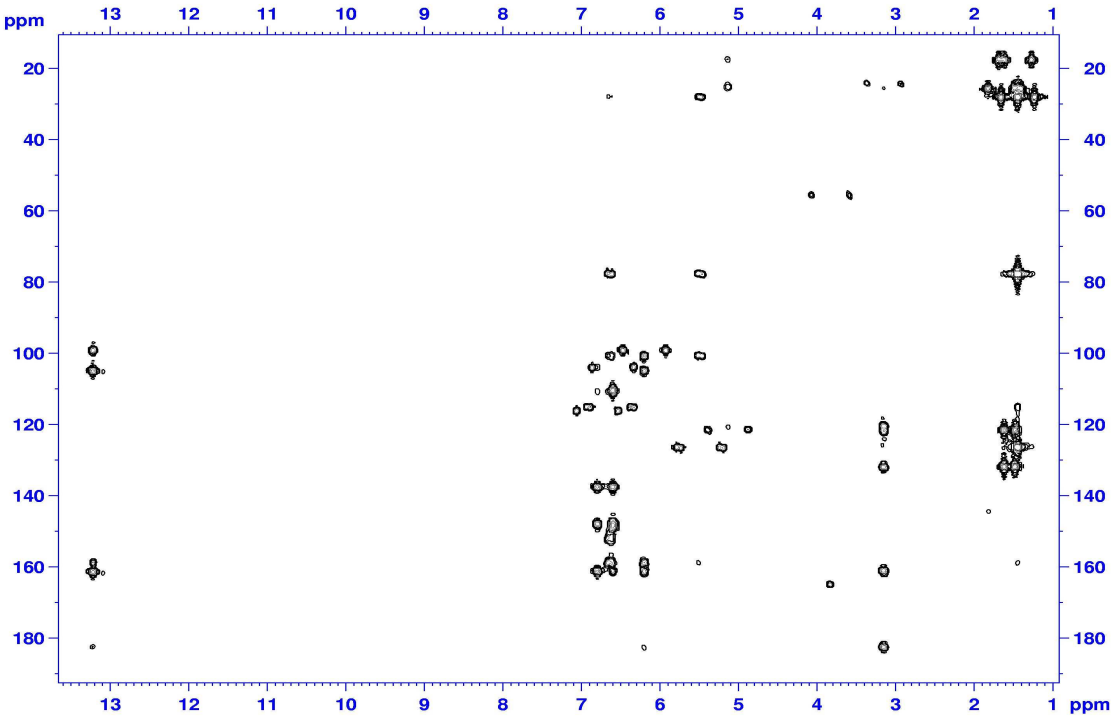


Figure 12 2D HMBC spectrum of **AE1**

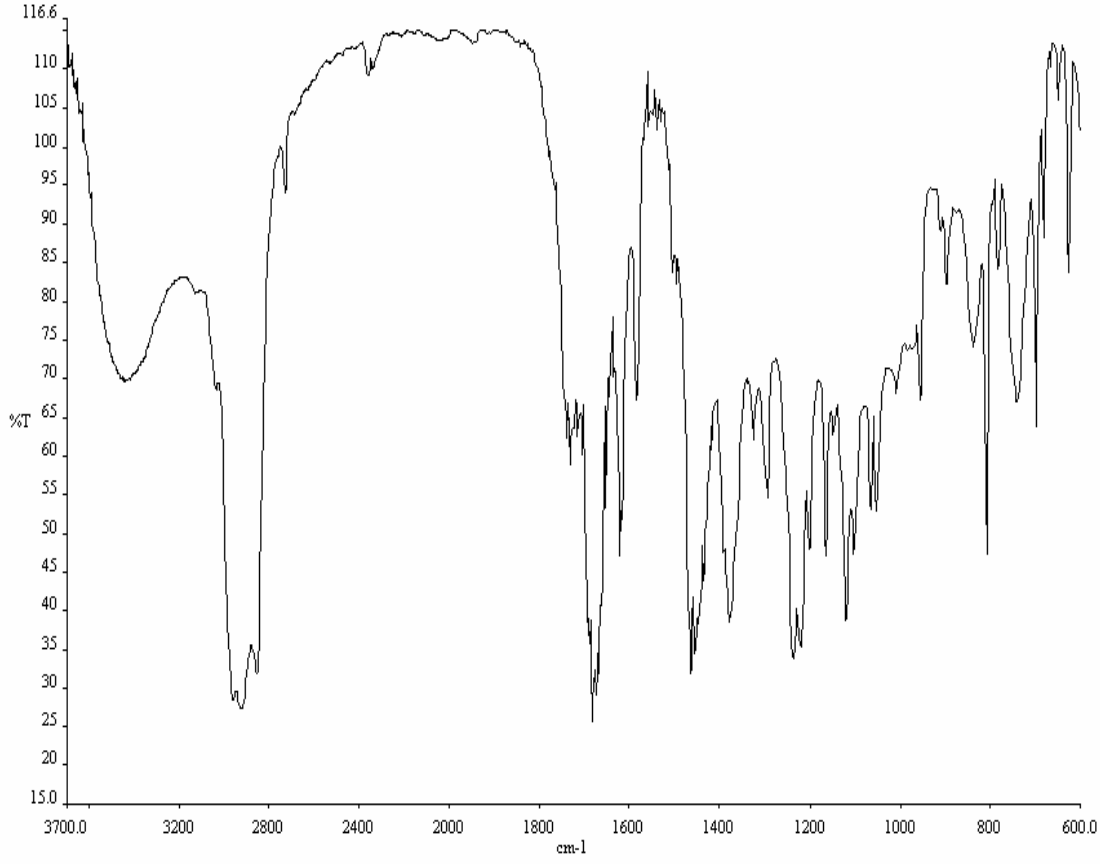


Figure 13 FT-IR (Neat) spectrum of **AE2**

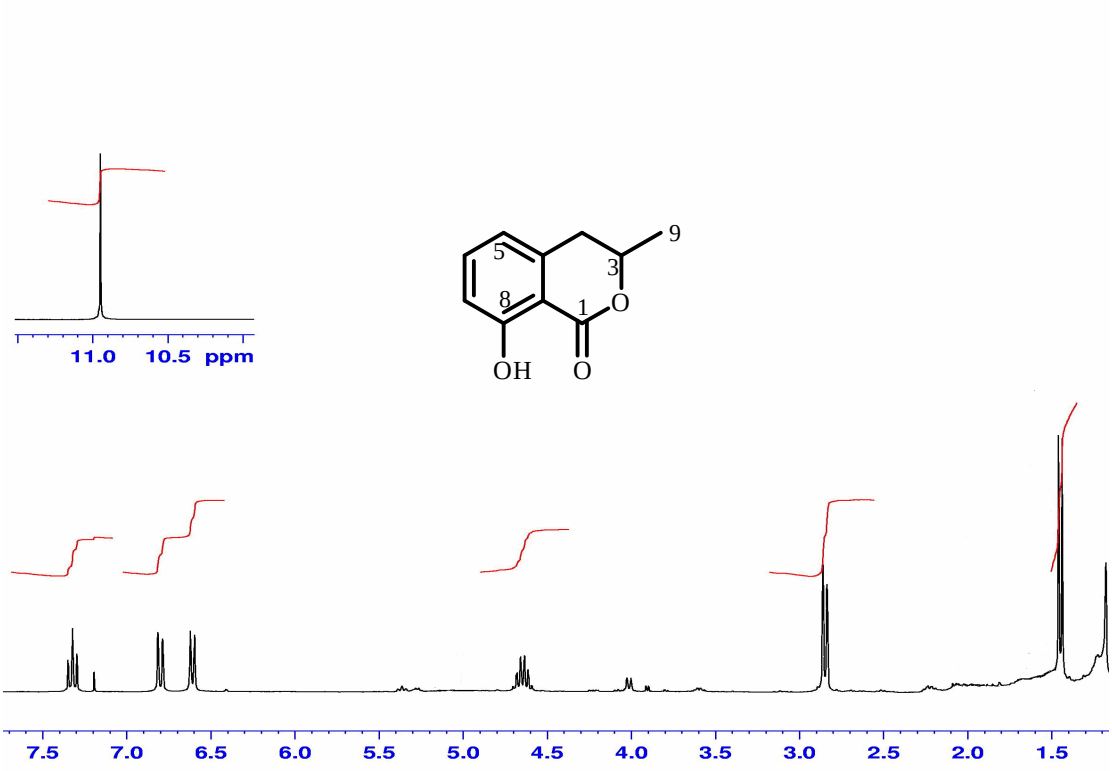


Figure 14 ^{1}H NMR (300 MHz) ($CDCl_3$) spectrum of **AE2**

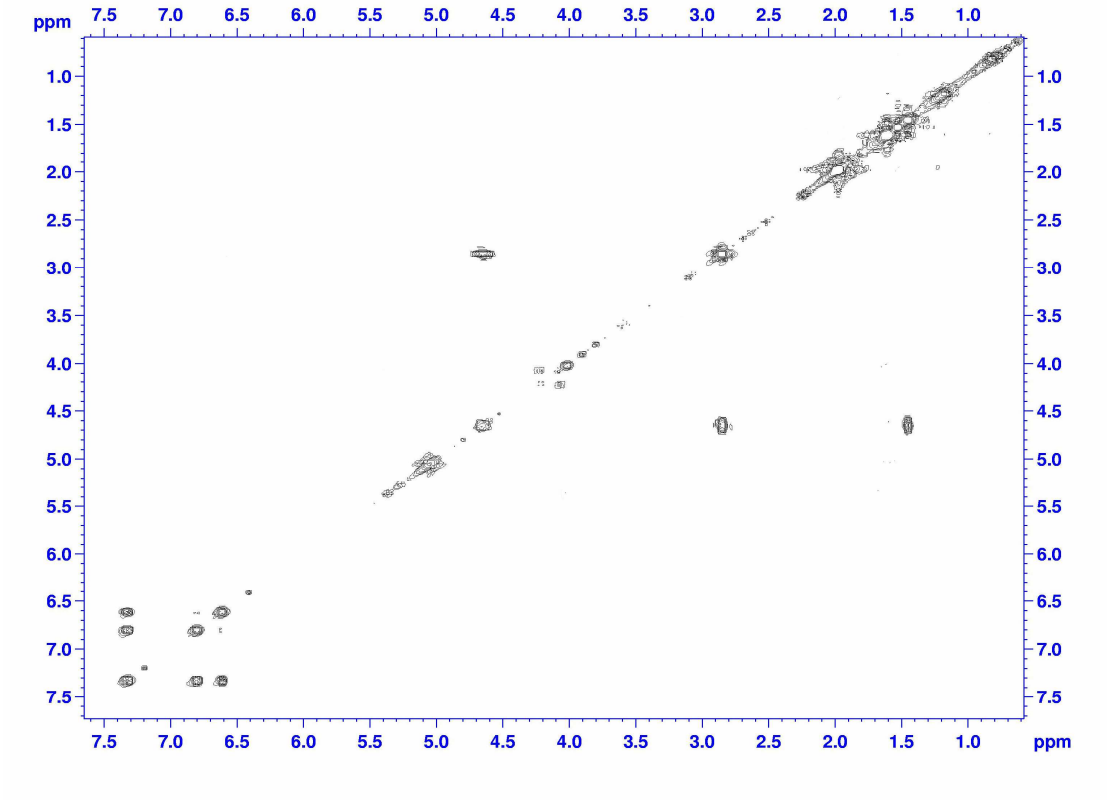


Figure 15 ^{1}H-^{1}H COSY spectrum of **AE2**

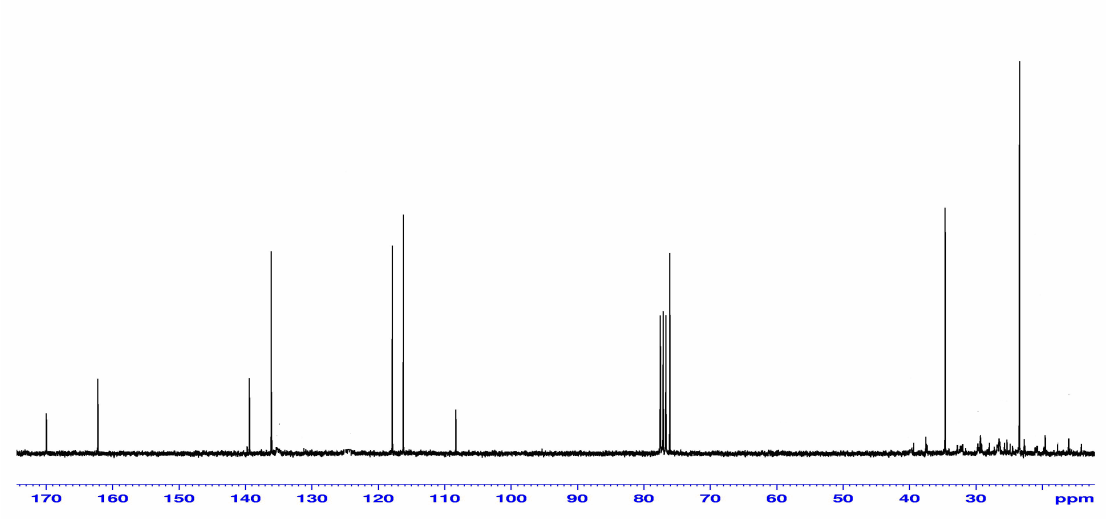


Figure 16 ^{13}C NMR (75 MHz) ($CDCl_3$) spectrum of **AE2**

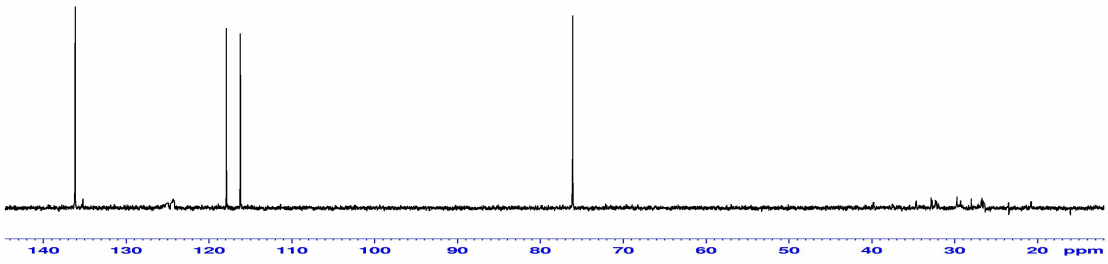


Figure 17 DEPT 135° ($CDCl_3$) spectrum of **AE2**

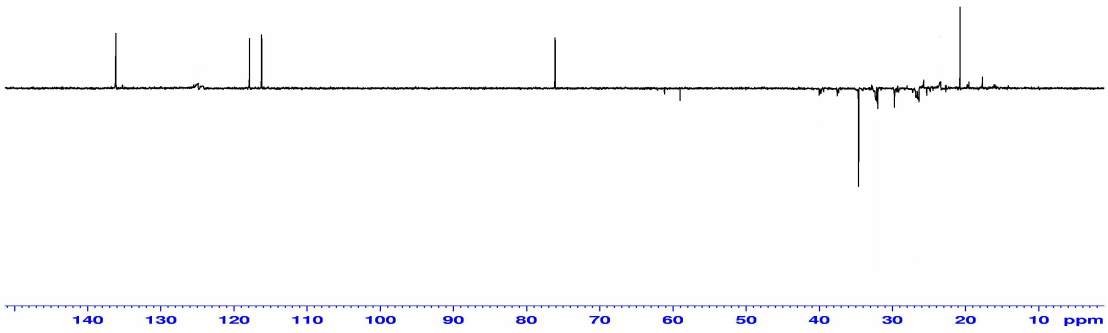


Figure 18 DEPT 90° ($CDCl_3$) spectrum of **AE2**

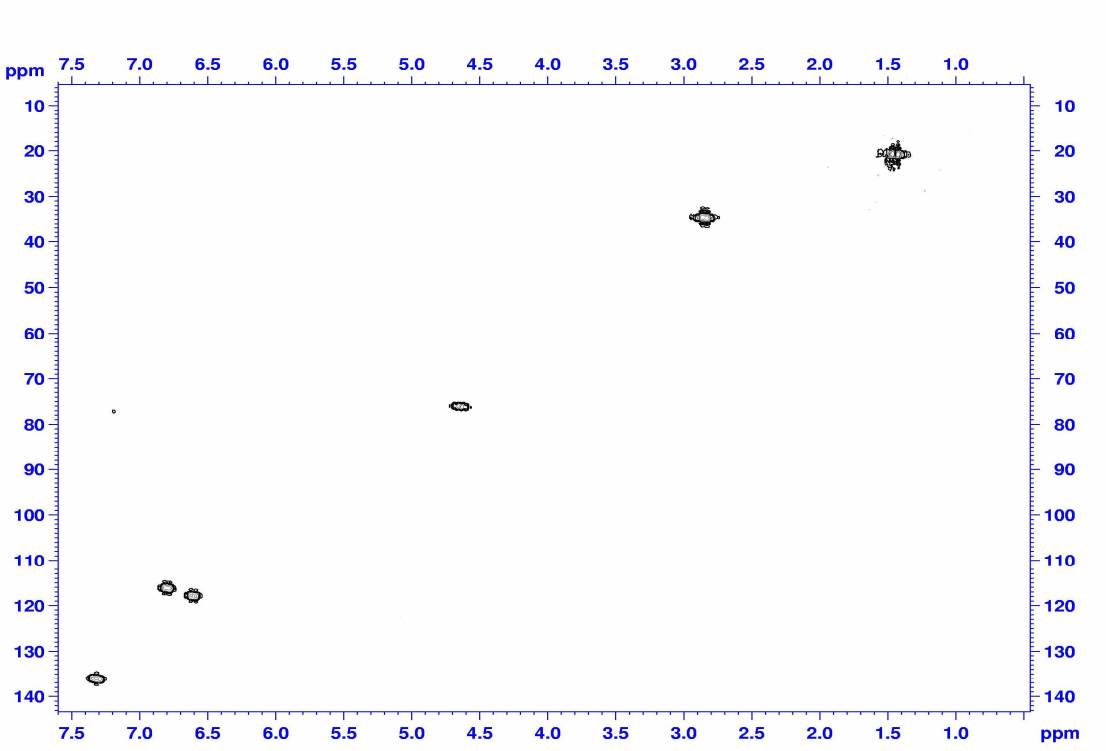


Figure 19 2D HMQC spectrum of **AE2**

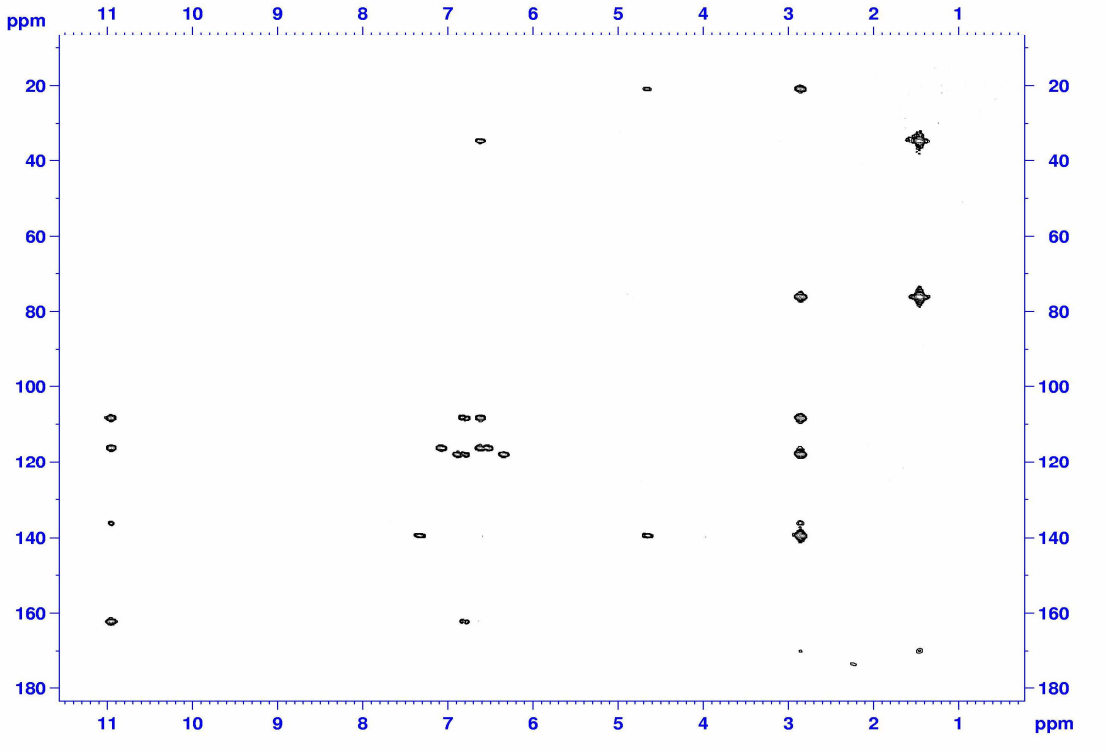


Figure 20 2D HMBC spectrum of **AE2**

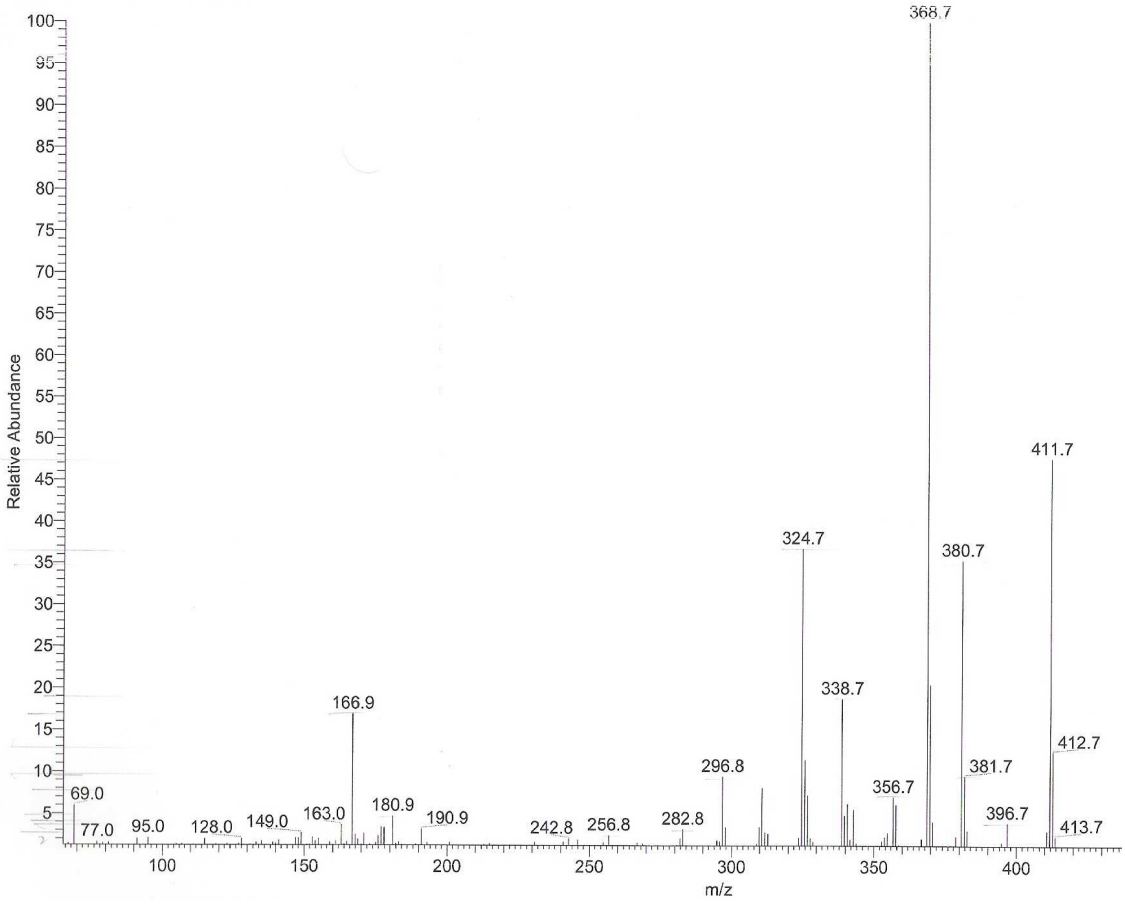


Figure 21 EI-MS spectrum of **AE3**

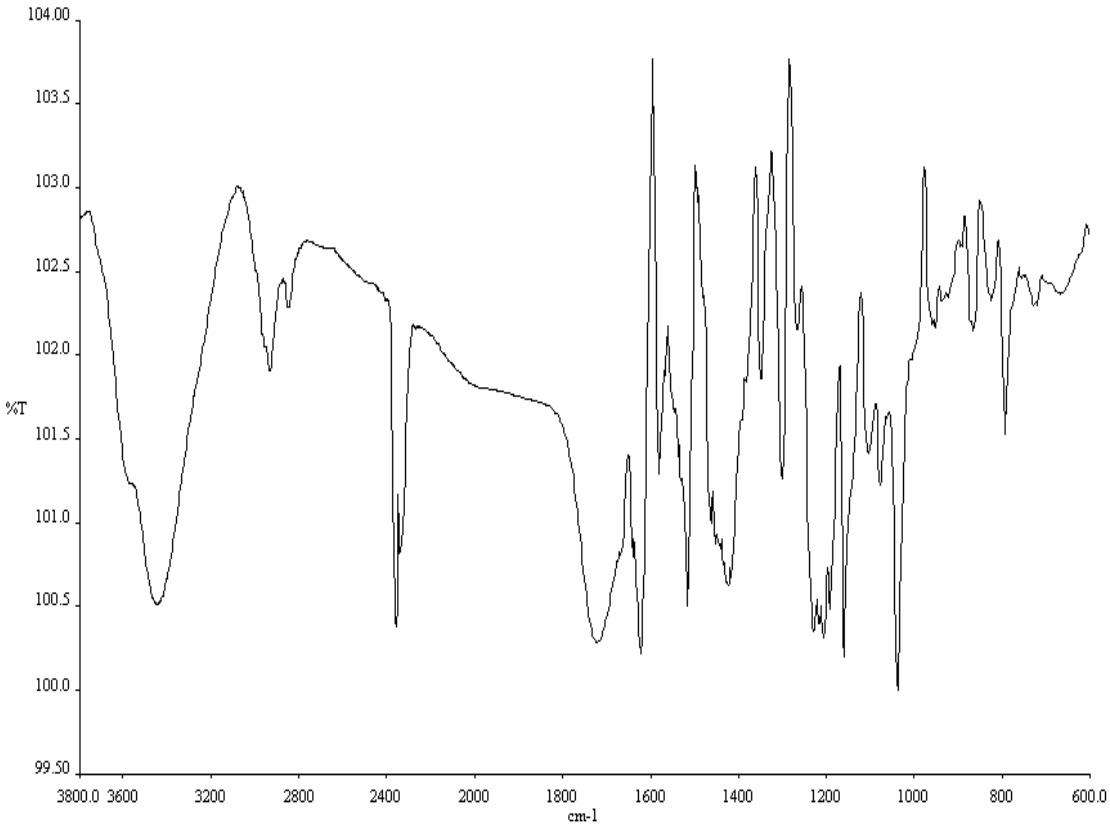


Figure 22 FT-IR (Neat) spectrum of **AE3**

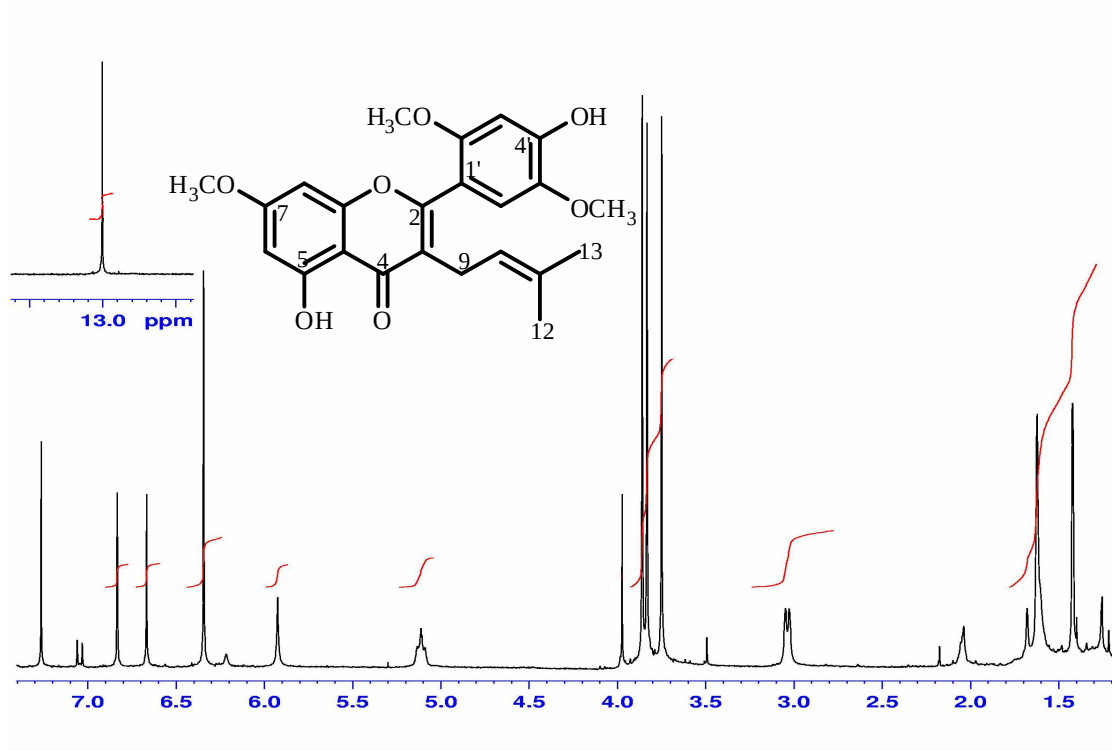


Figure 23 ^{1}H NMR (300 MHz) ($CDCl_3$) spectrum of **AE3**

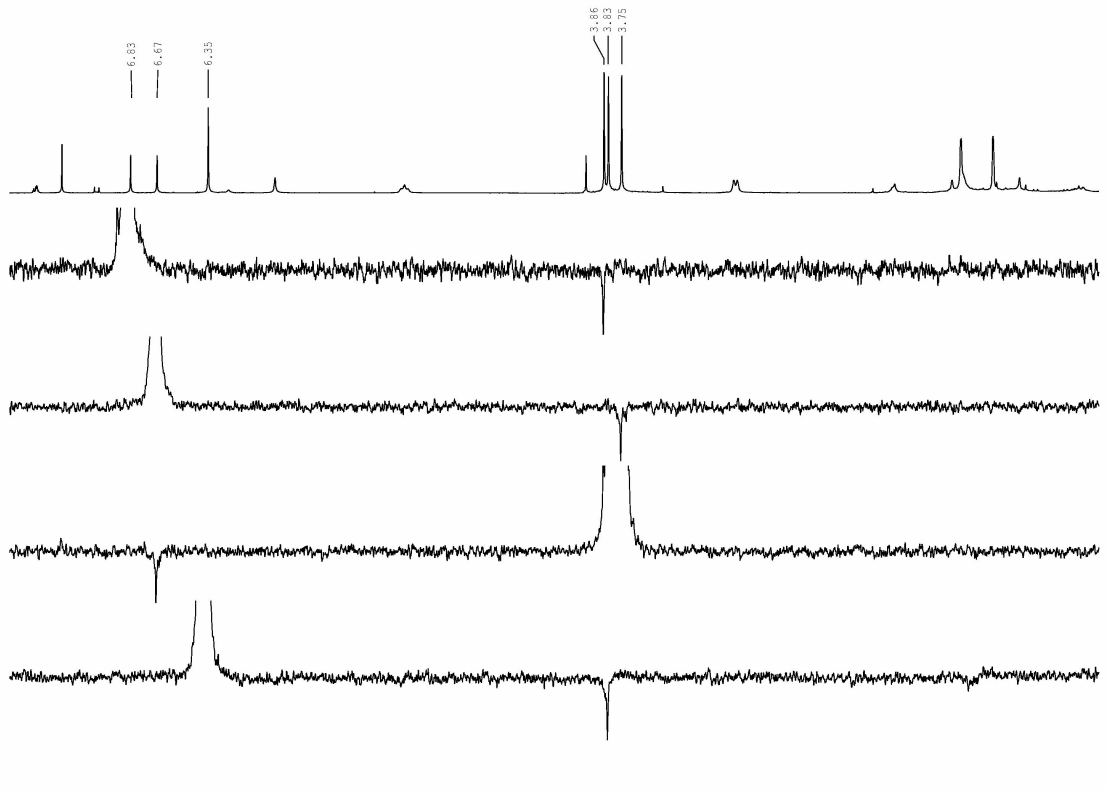


Figure 29 NOEDIFF spectrum of **AE3** after irradiation

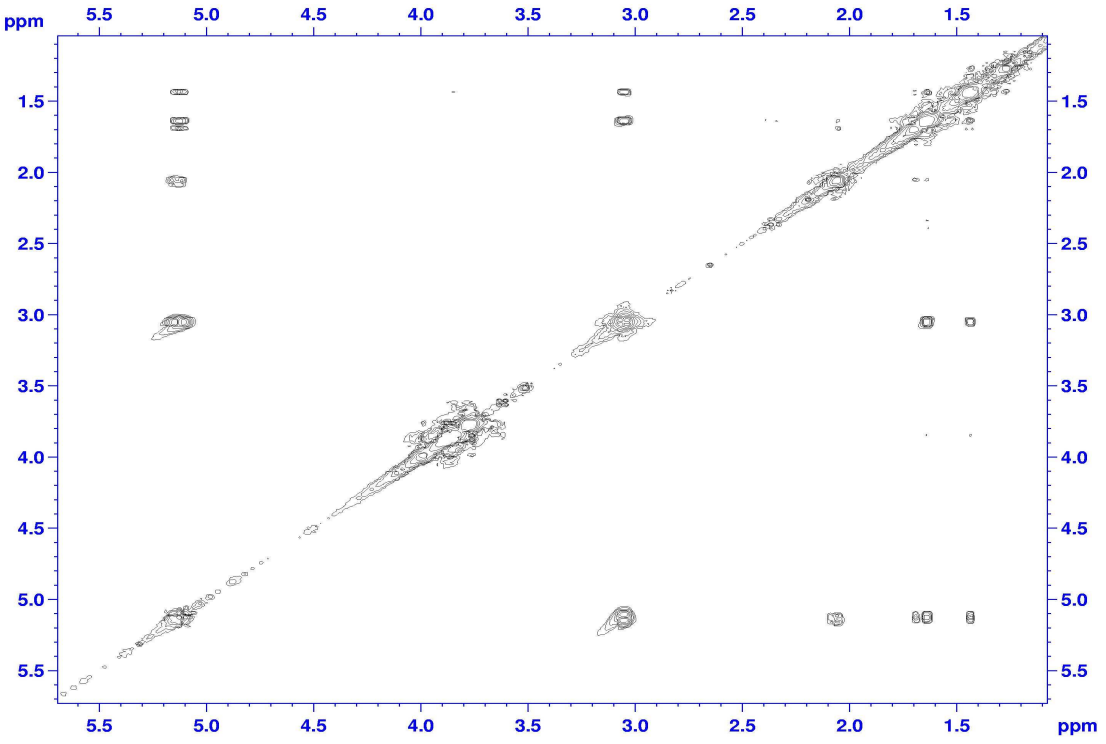


Figure 25 ^{1}H-^{1}H COSY spectrum of **AE3**

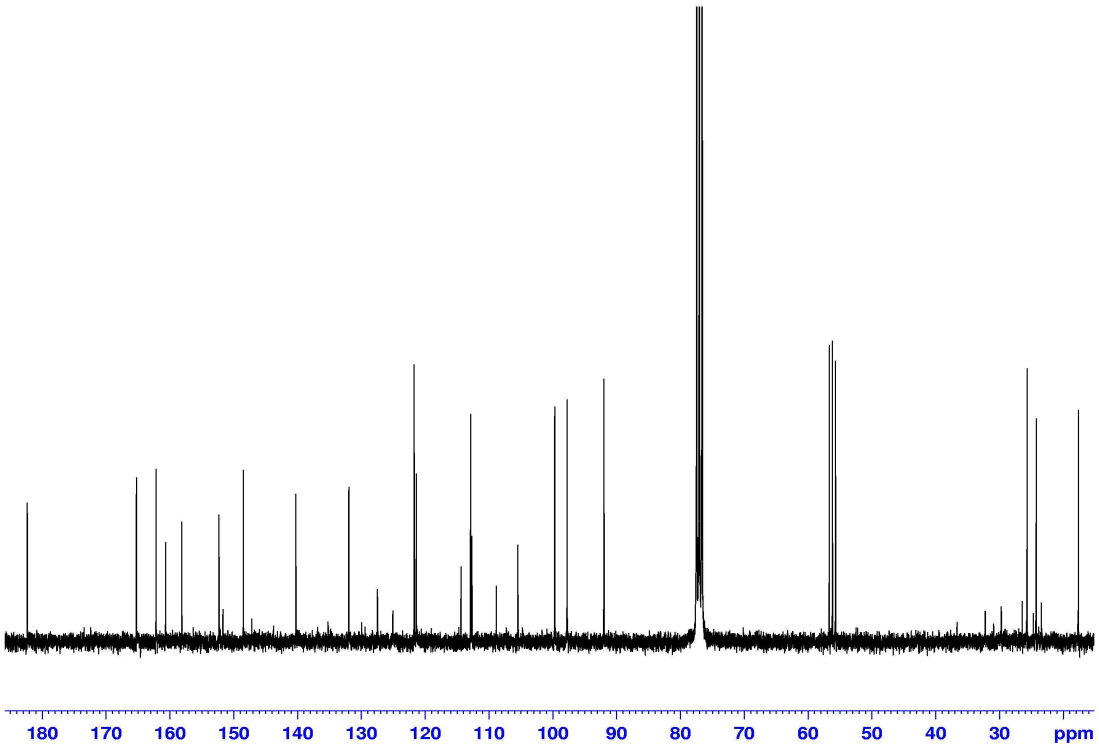


Figure 26 ^{13}C NMR (75 MHz) ($CDCl_3$) spectrum of **AE3**

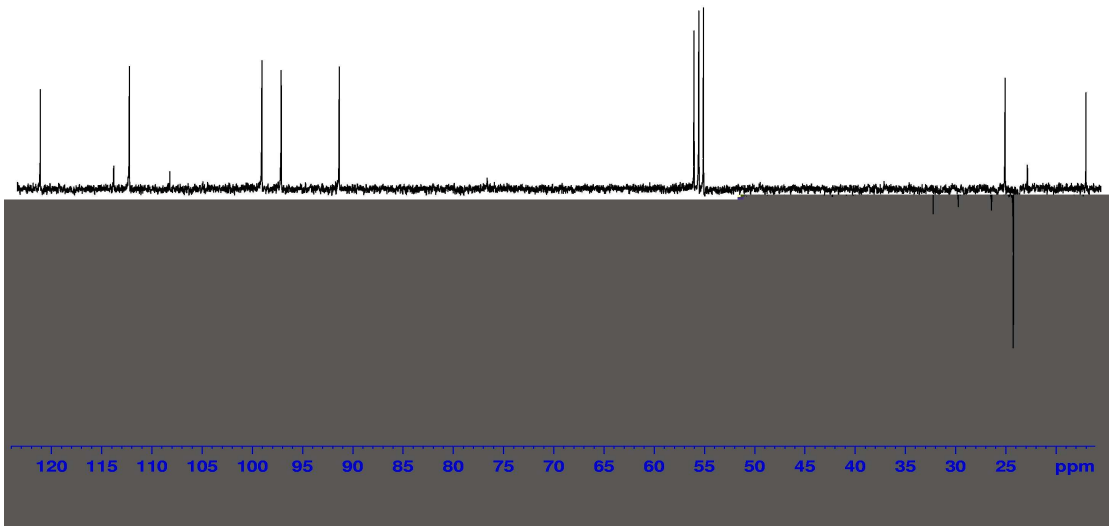


Figure 27 DEPT 135° ($CDCl_3$) spectrum of **AE3**

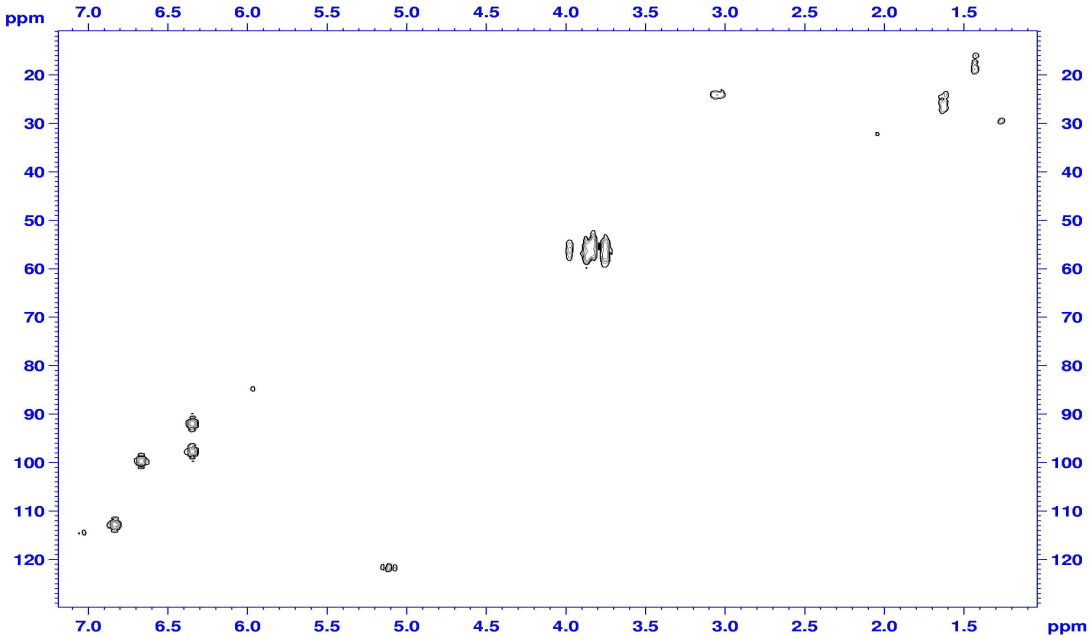


Figure 28 2D HMQC spectrum of **AE3**

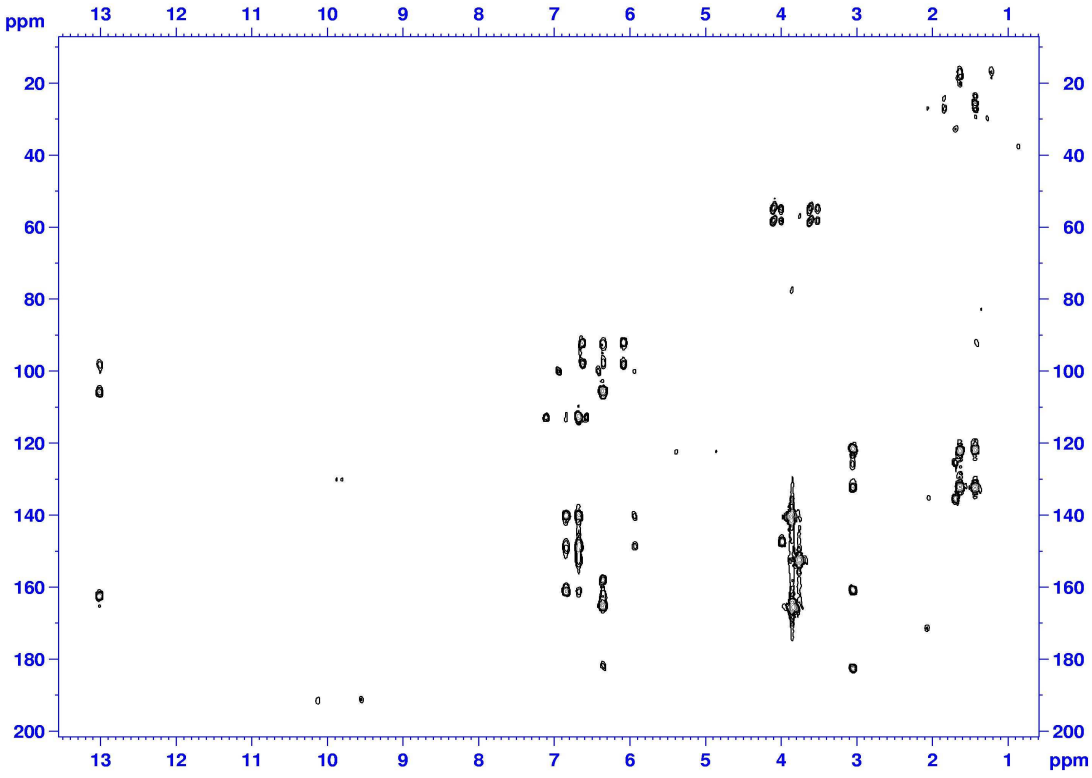


Figure 29 2D HMBC spectrum of **AE3**

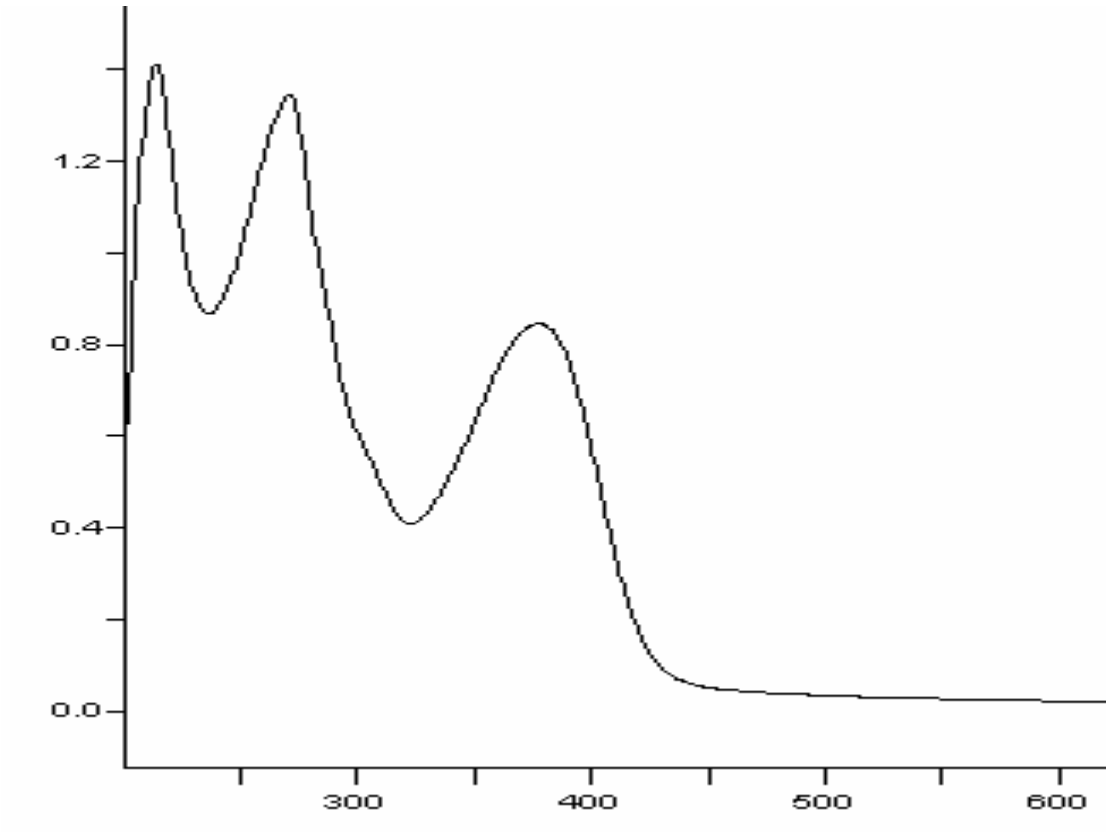


Figure 30 UV (EtOH) spectrum of **AE4**

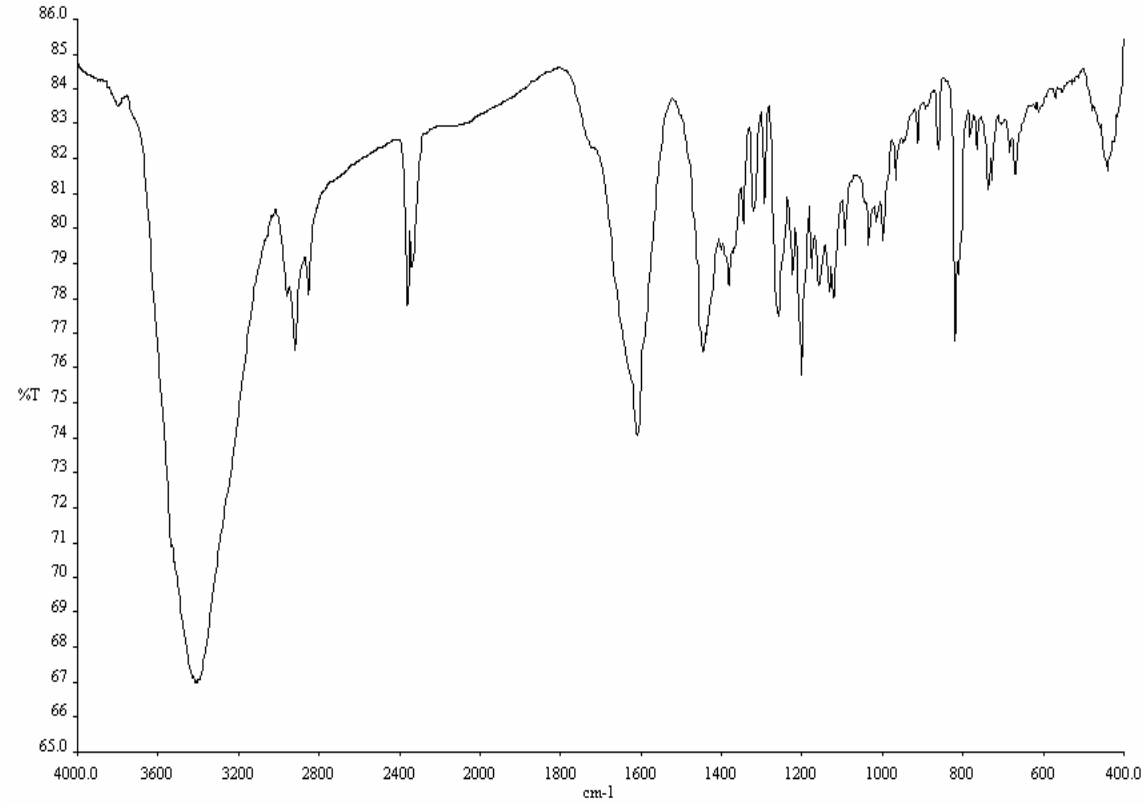


Figure 31 FT-IR (Neat) spectrum of **AE4**

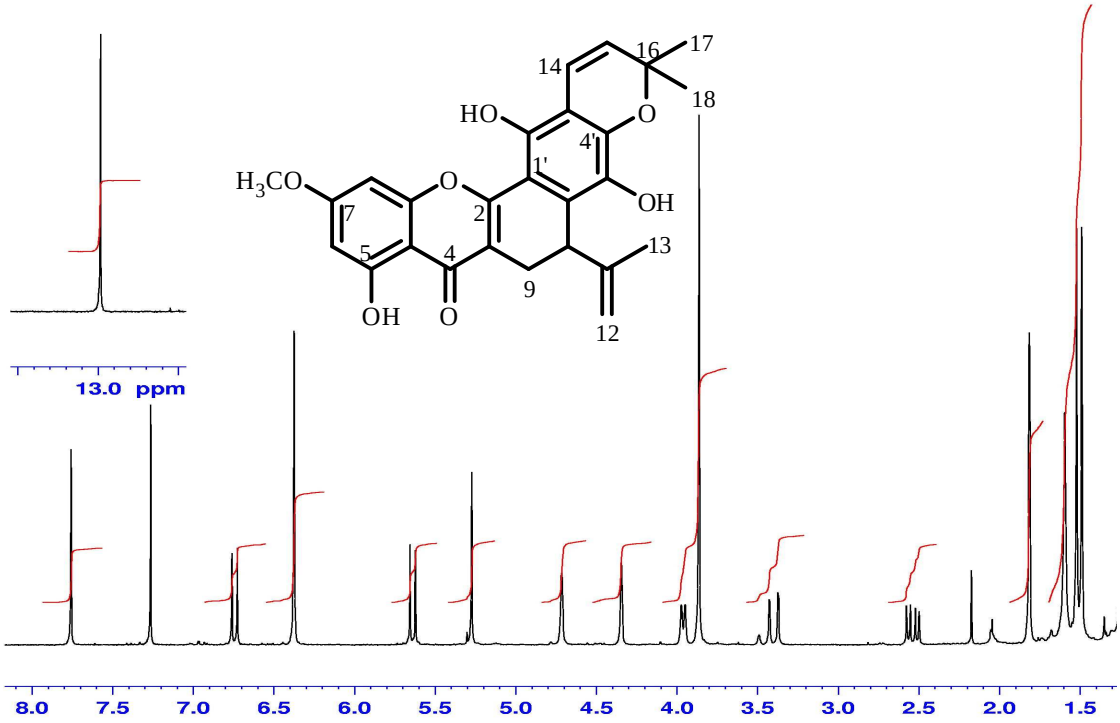


Figure 32 ^{1}H NMR (300 MHz) ($CDCl_3$) spectrum of **AE4**

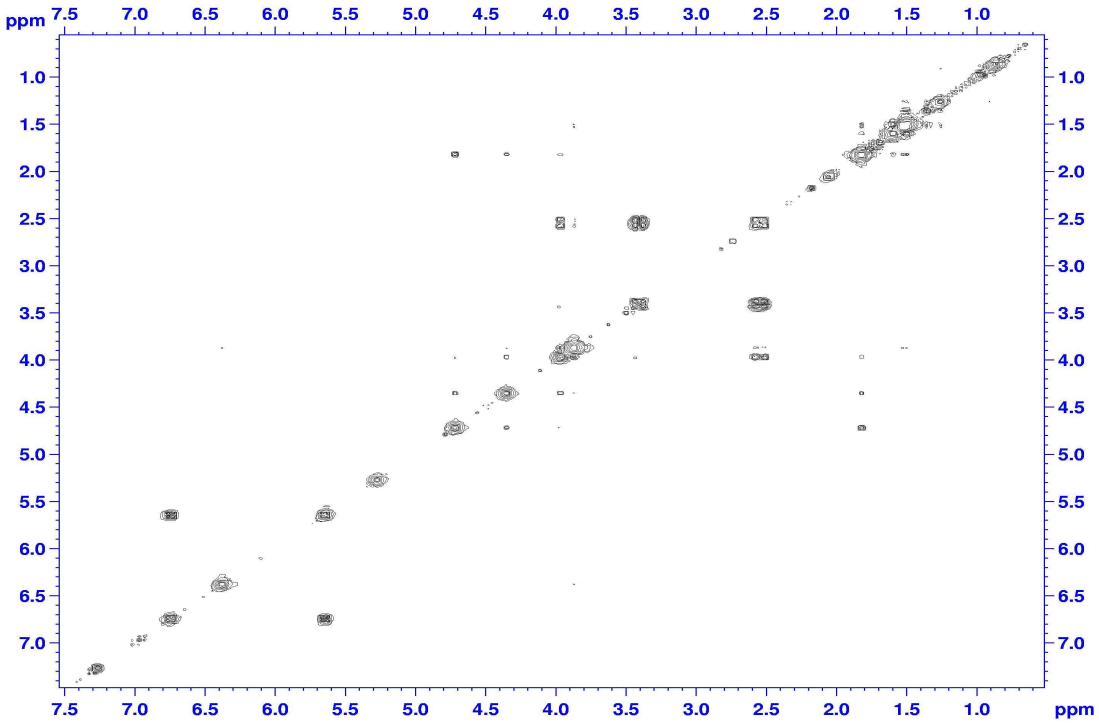


Figure 33 ^{1}H-^{1}H COSY spectrum of **AE4**

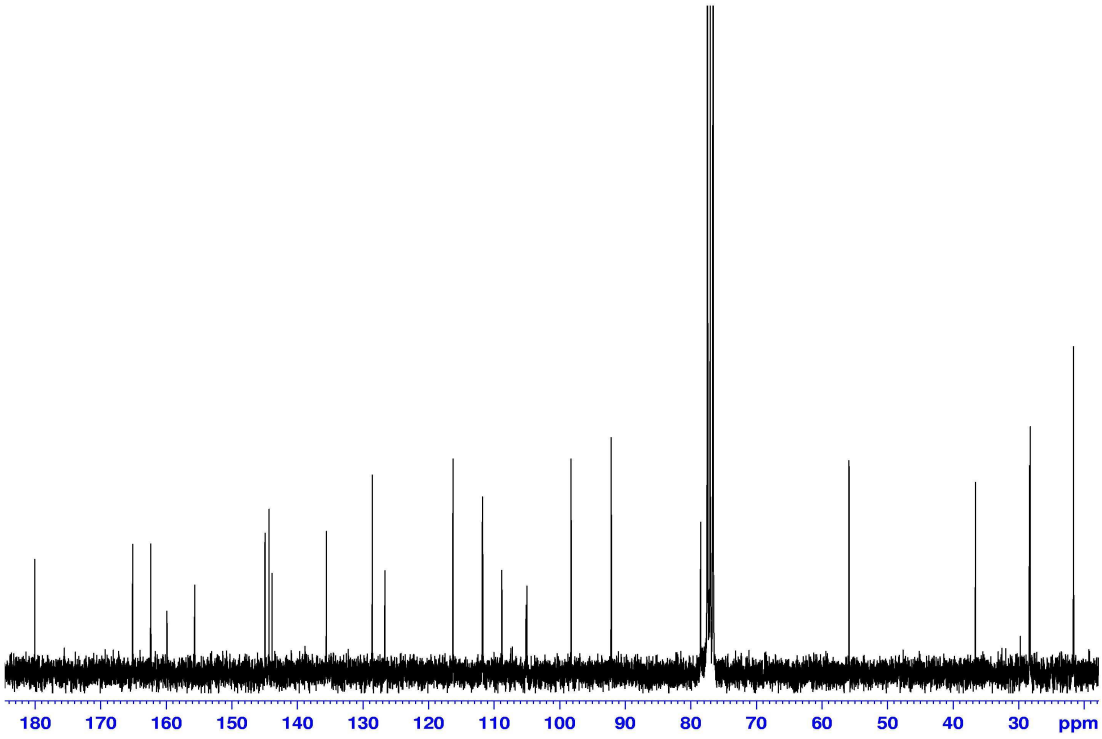


Figure 34 ^{13}C NMR (75 MHz) ($CDCl_3$) spectrum of **AE4**

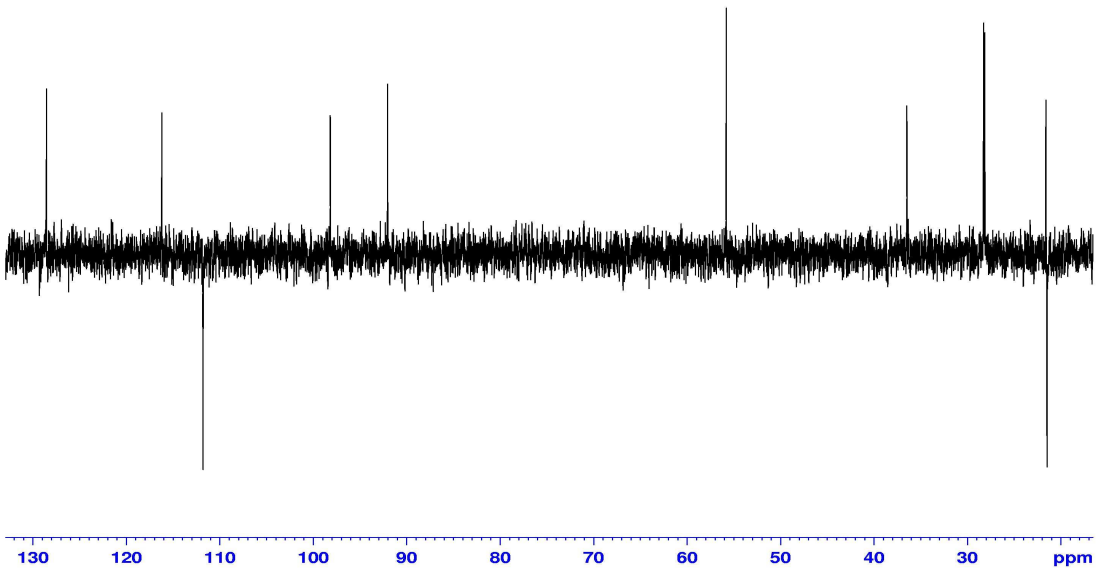


Figure 35 DEPT 135° ($CDCl_3$) spectrum of **AE4**

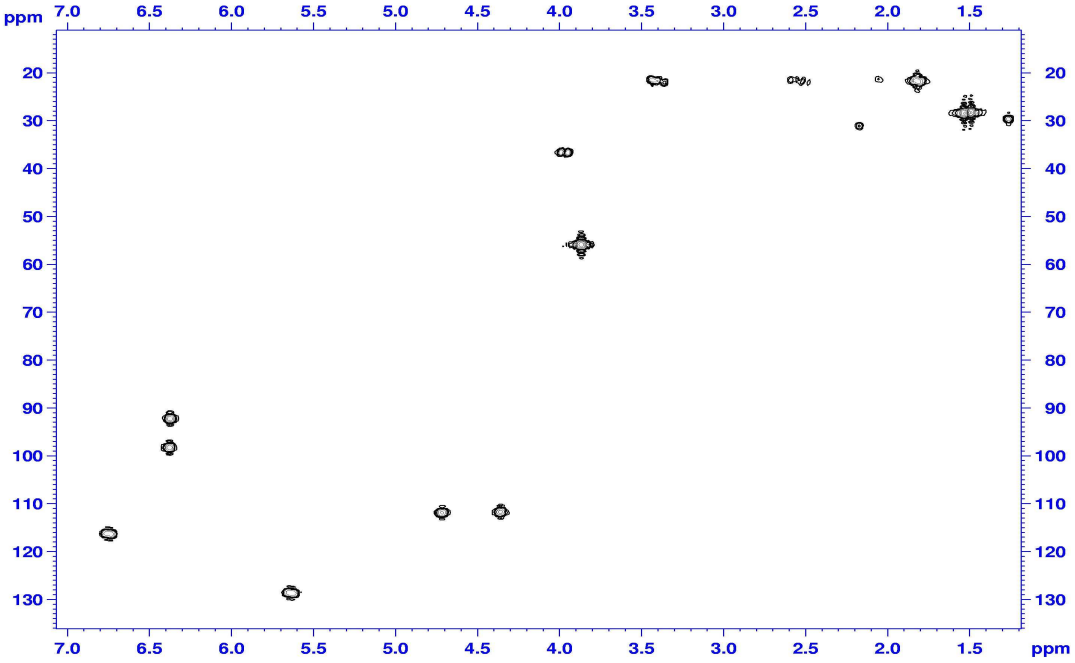


Figure 36 2D HMQC spectrum of **AE4**

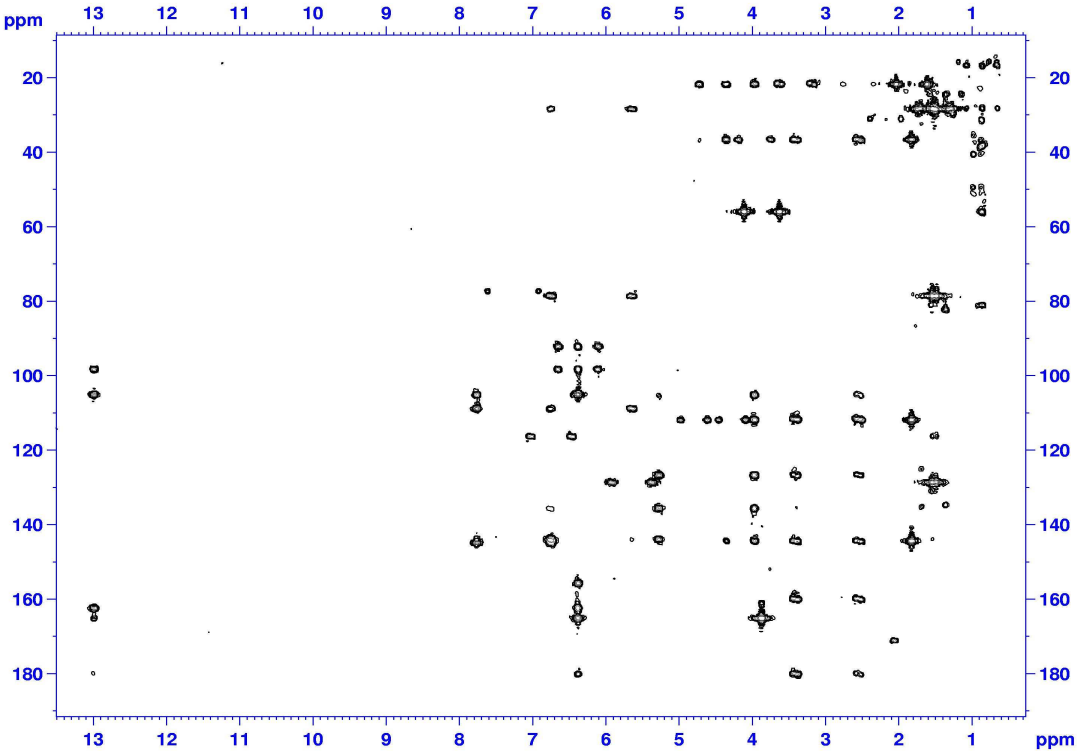


Figure 37 2D HMBC spectrum of **AE4**

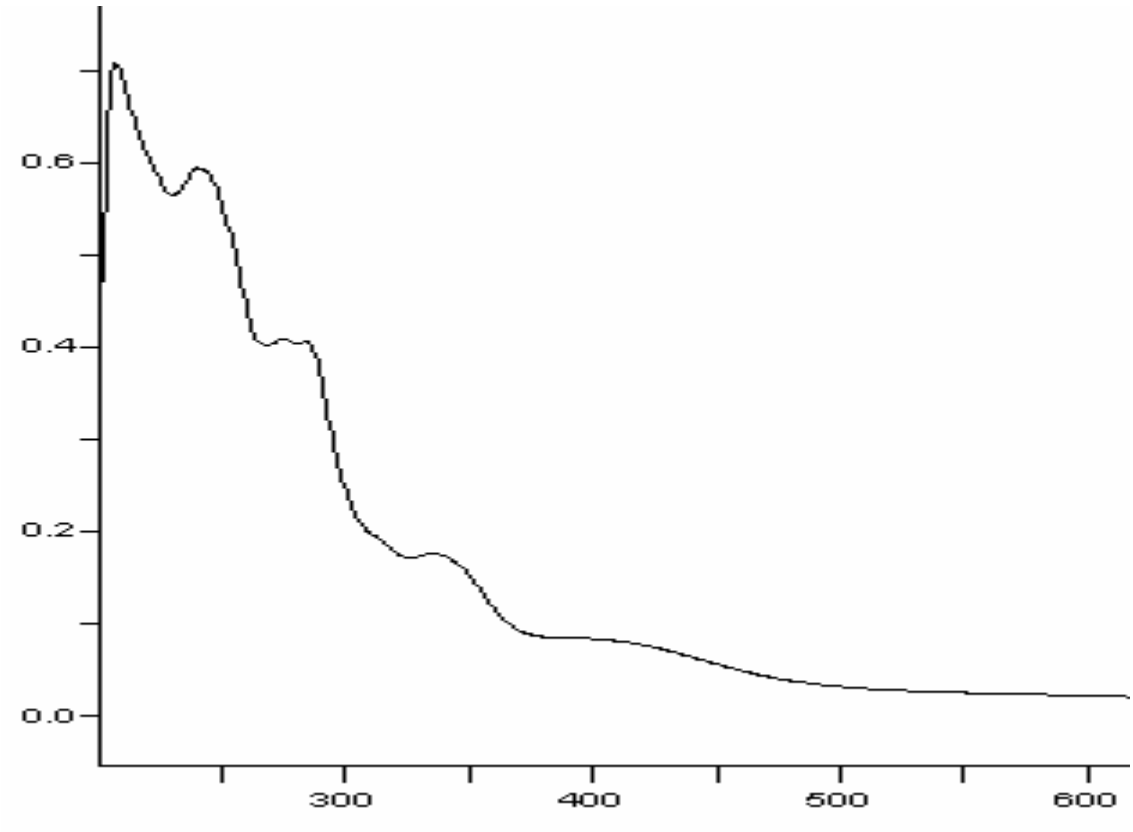


Figure 38 UV (EtOH) spectrum of **AE5**

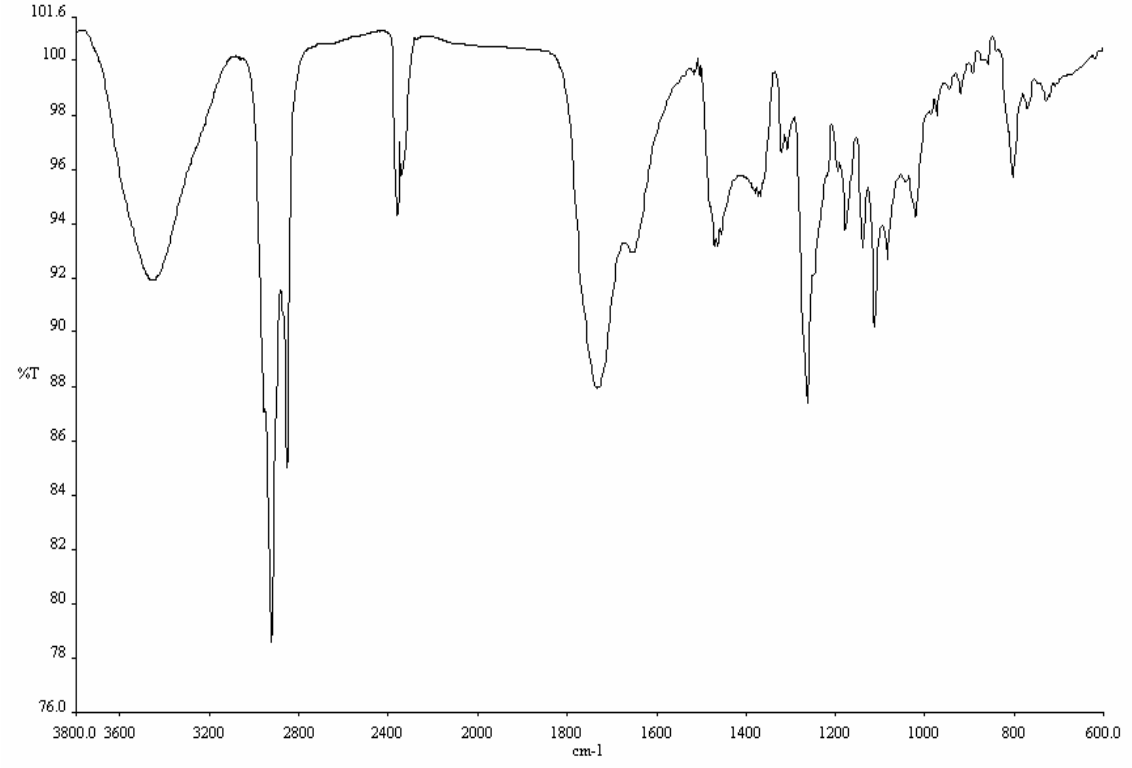


Figure 39 FT-IR (Neat) spectrum of **AE5**

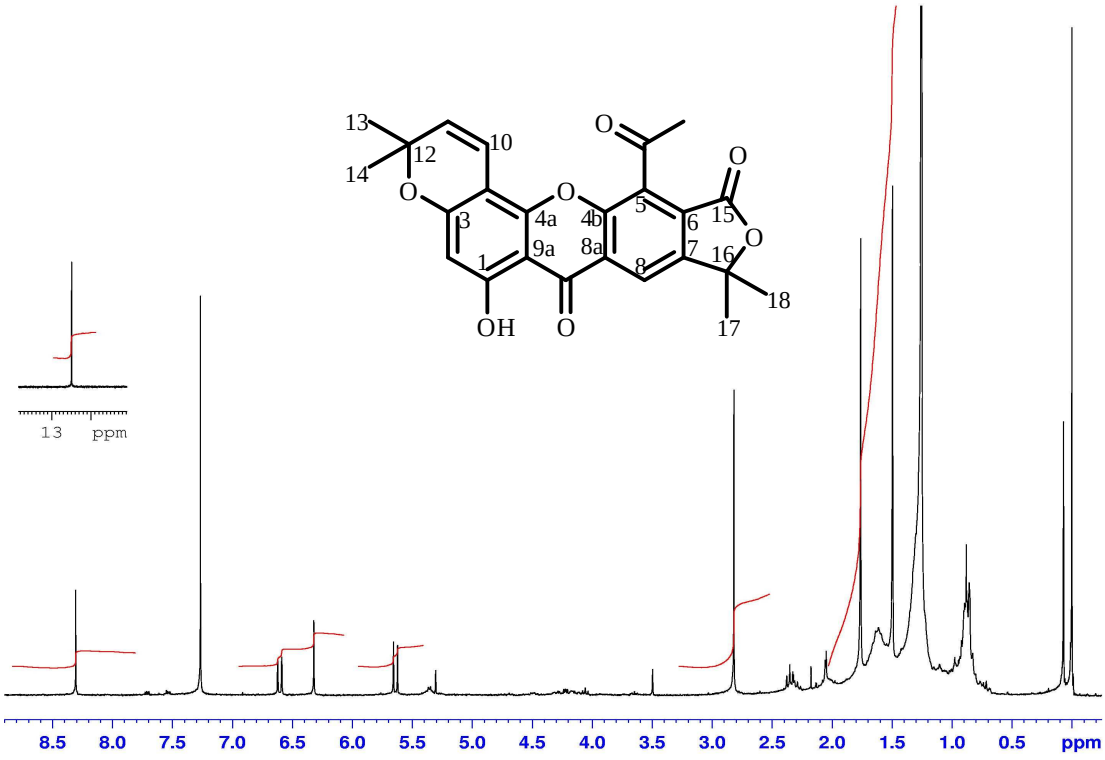


Figure 40 ^{1}H NMR (300 MHz) ($CDCl_3$) spectrum of **AE5**

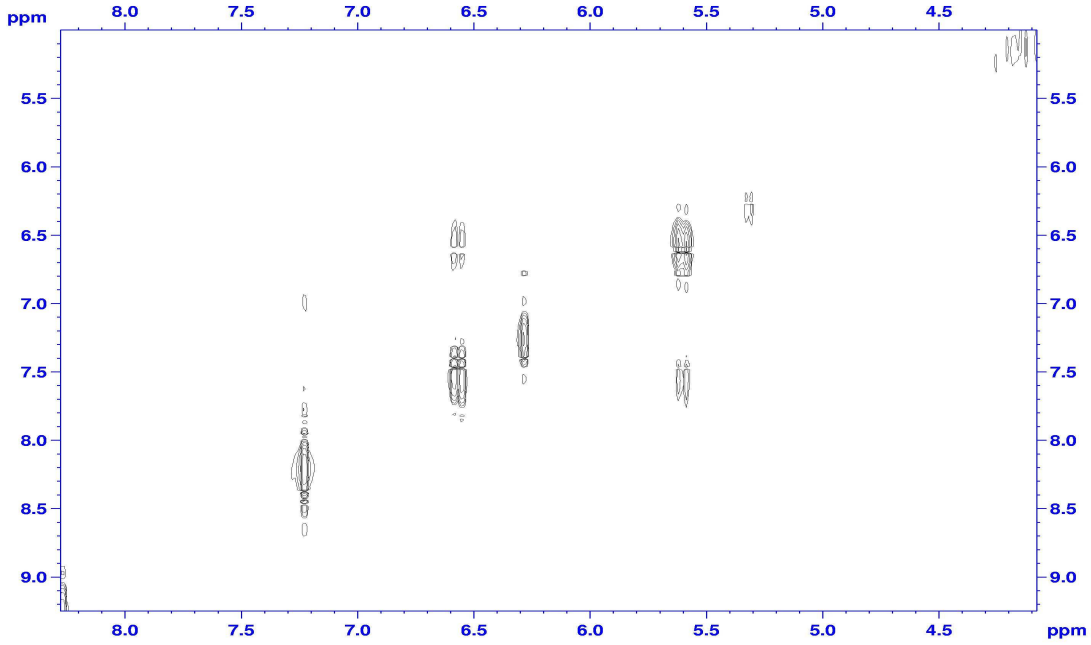


Figure 41 ^{1}H-^{1}H COSY spectrum of **AE5**

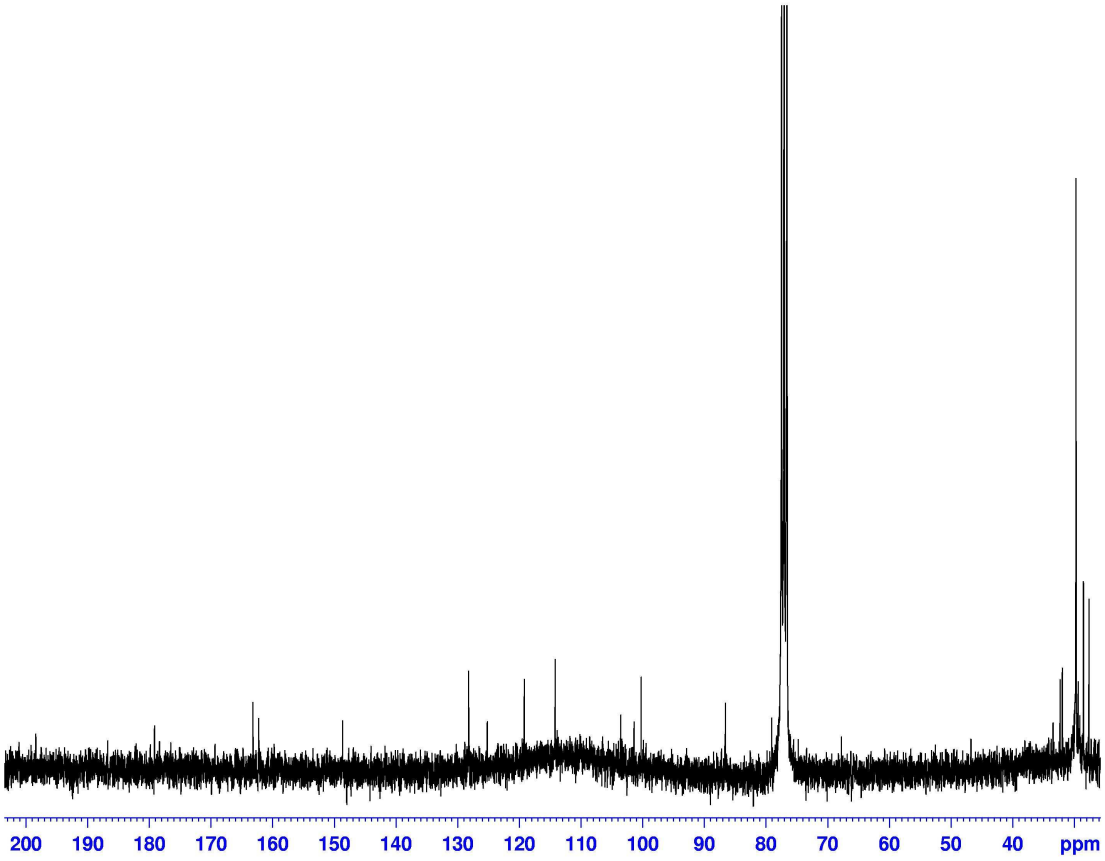


Figure 42 ^{13}C NMR (75 MHz) ($CDCl_3$) spectrum of **AE5**

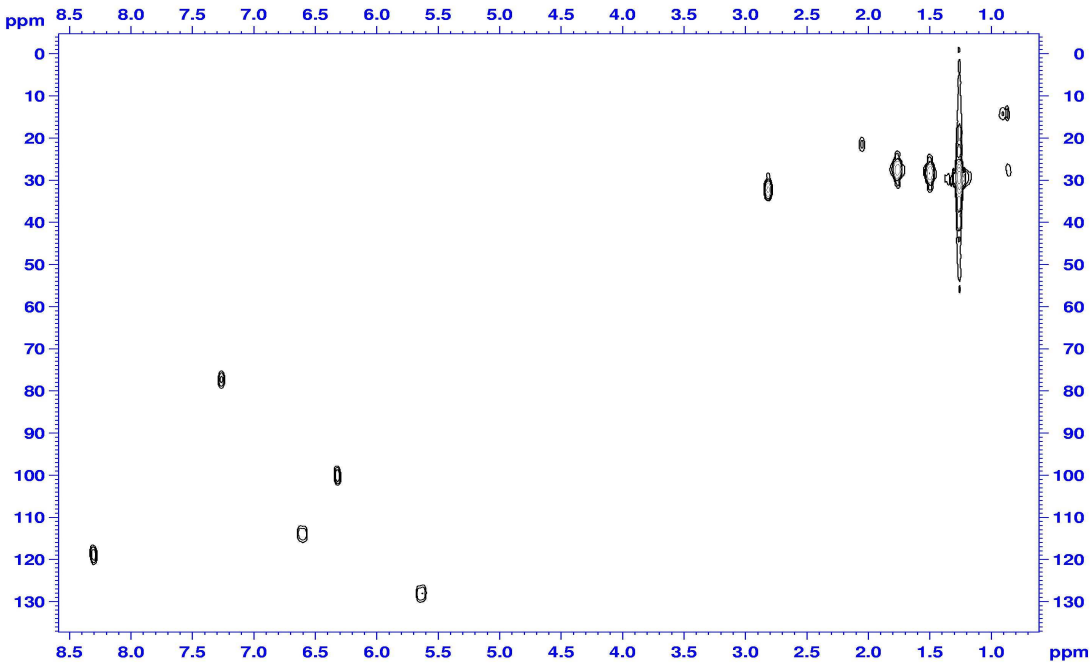


Figure 43 2D HMQC spectrum of **AE5**

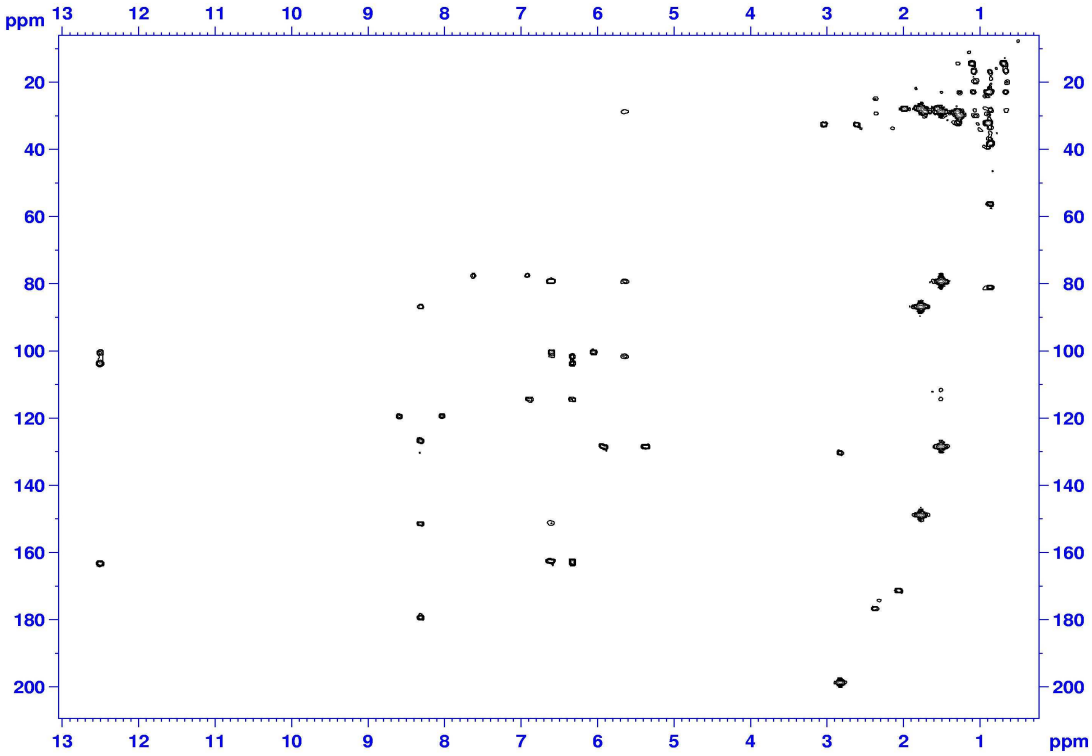


Figure 44 2D HMBC spectrum of **AE5**

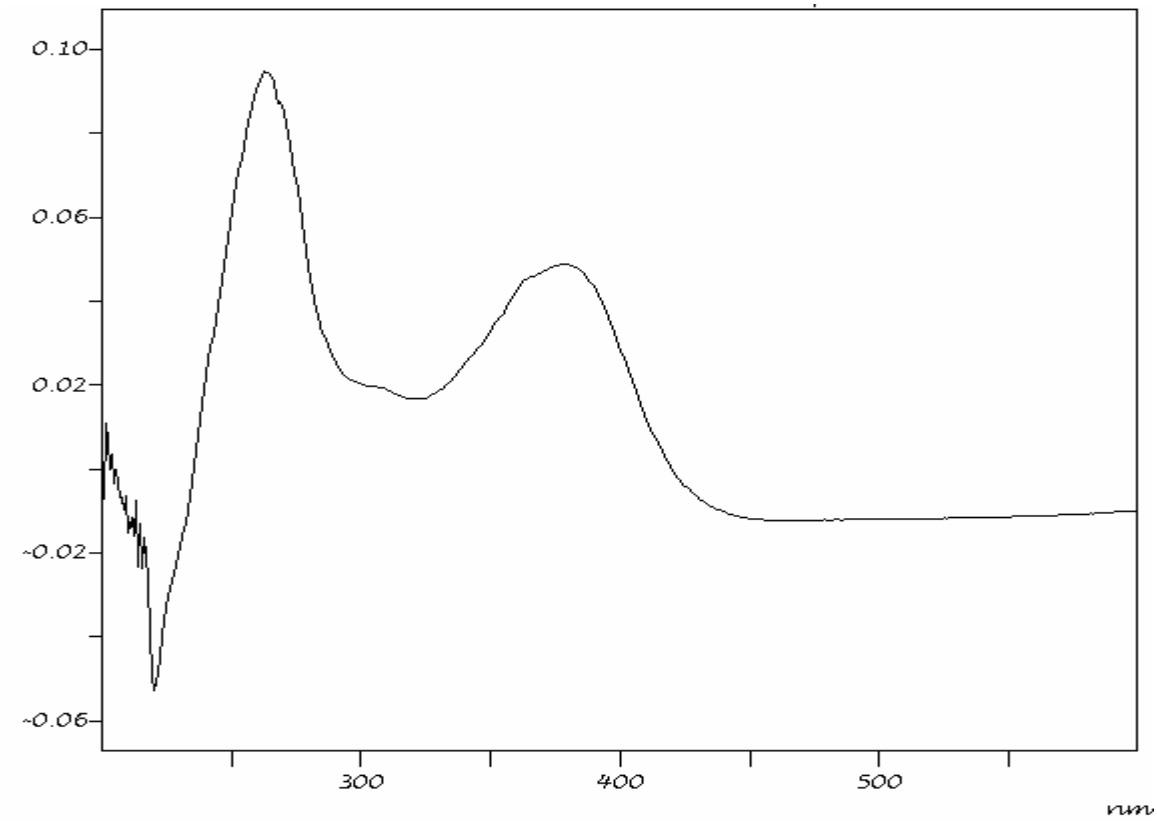


Figure 45 UV (CH_3OH) spectrum of **AE6**

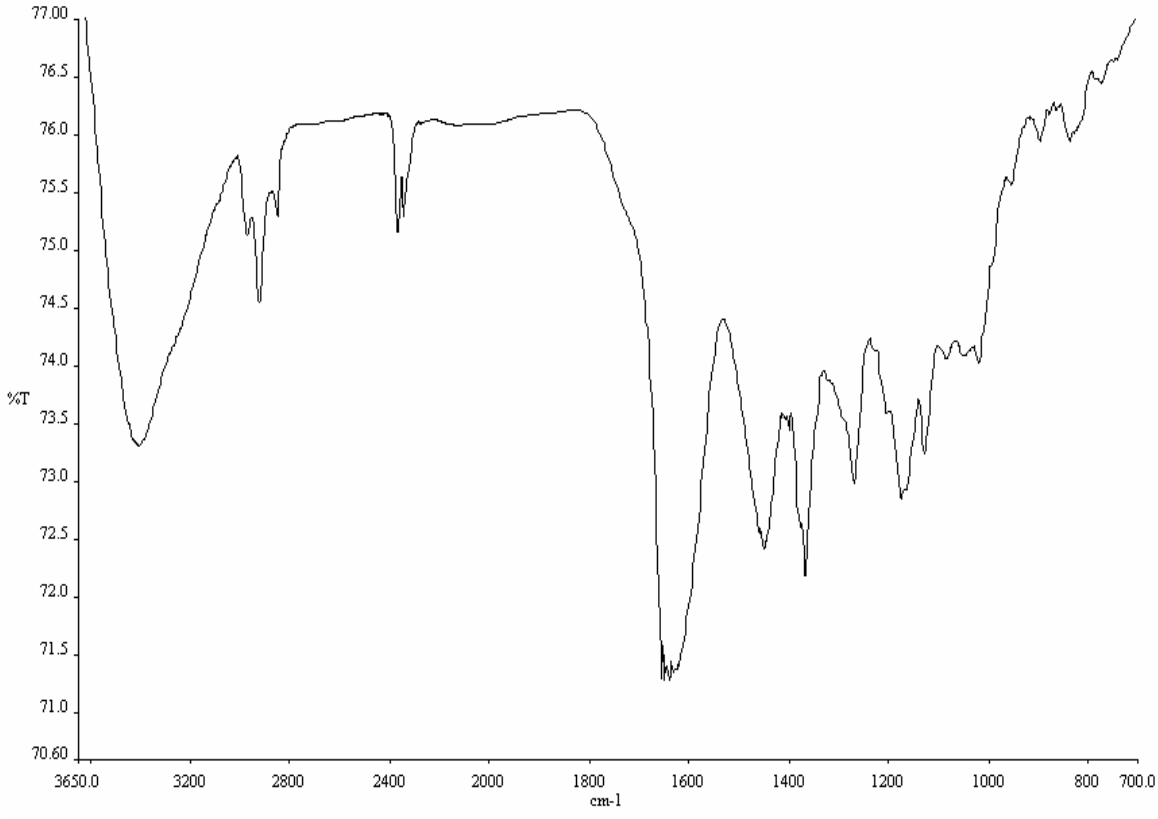


Figure 46 FT-IR (Neat) spectrum of **AE6**

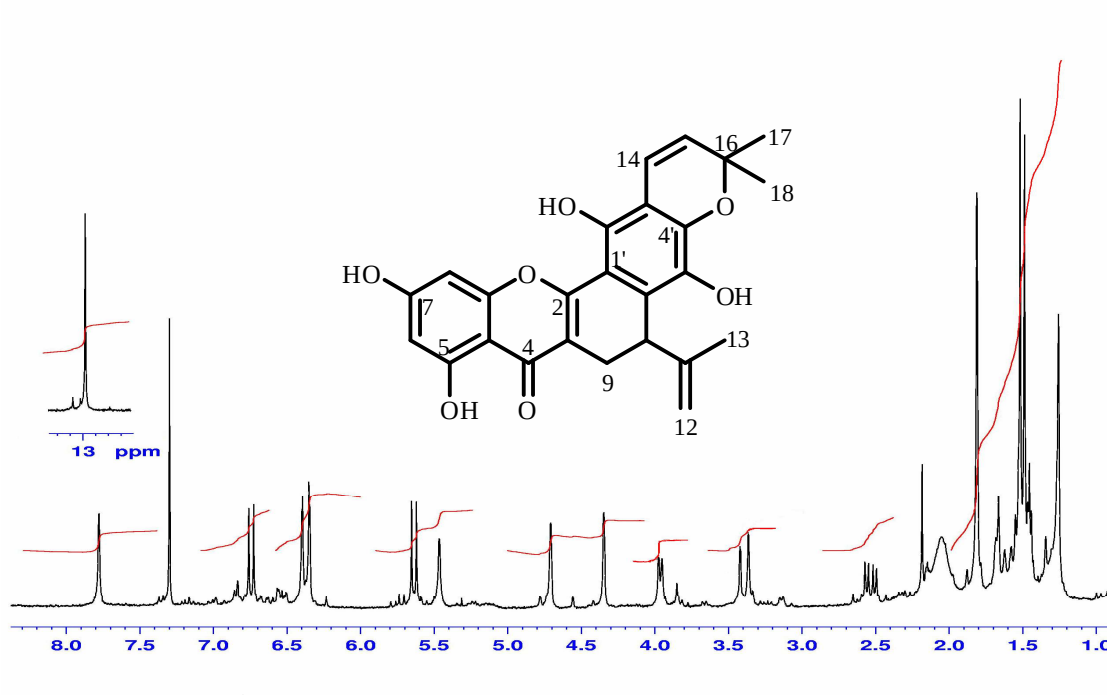


Figure 47 ^{1}H NMR (300 MHz) ($CDCl_3$+Acetone-d_6) spectrum of **AE6**

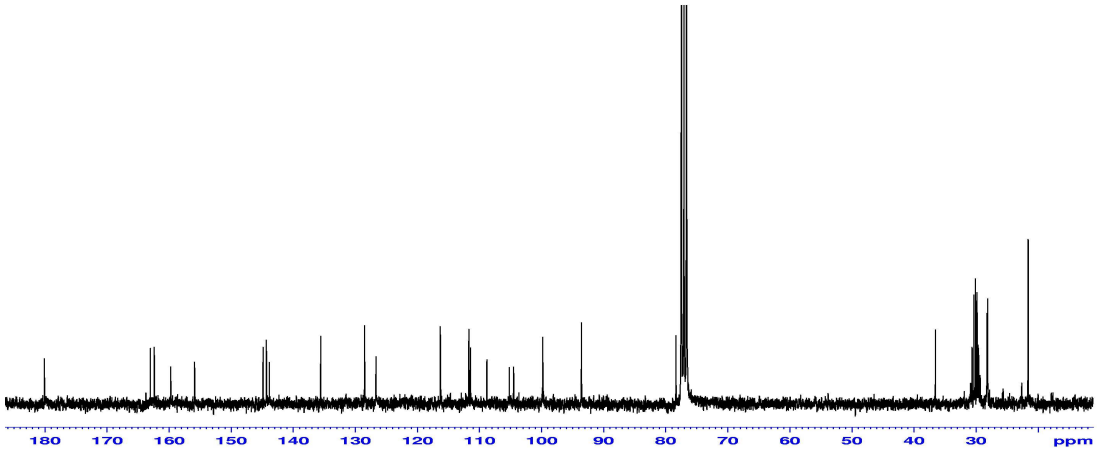


Figure 48 ^{13}C NMR (75 MHz) ($CDCl_3$+Acetone-d_6) spectrum of **AE6**

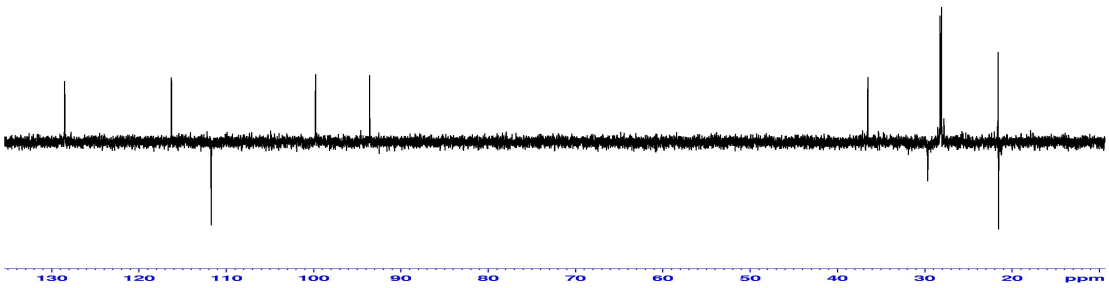


Figure 49 DEPT 135° ($CDCl_3$+Acetone-d_6) spectrum of **AE6**

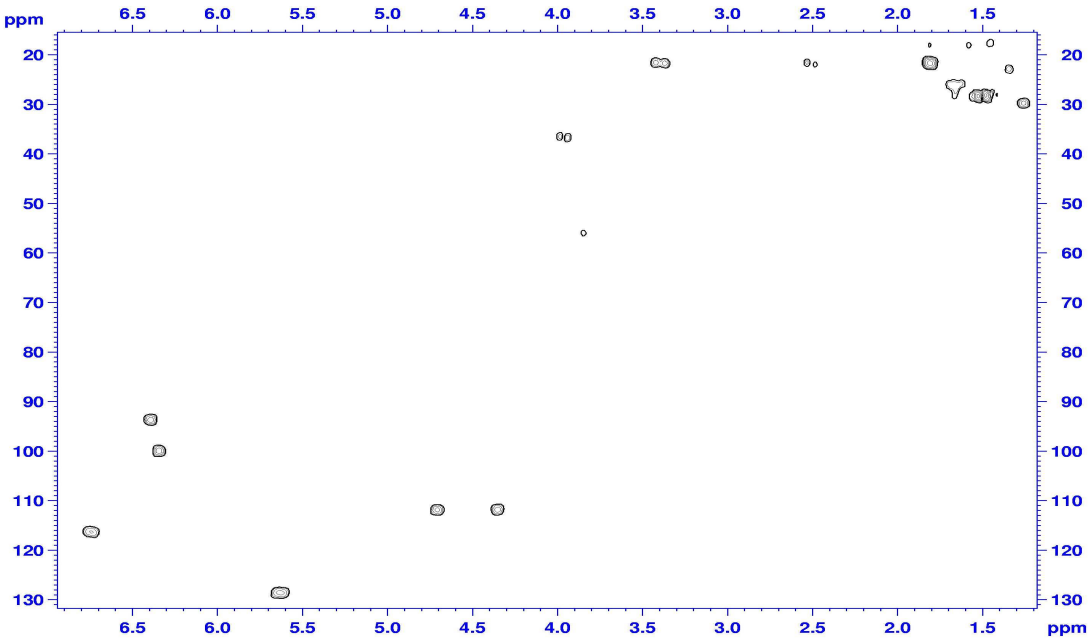


Figure 50 2D HMQC spectrum of **AE6**

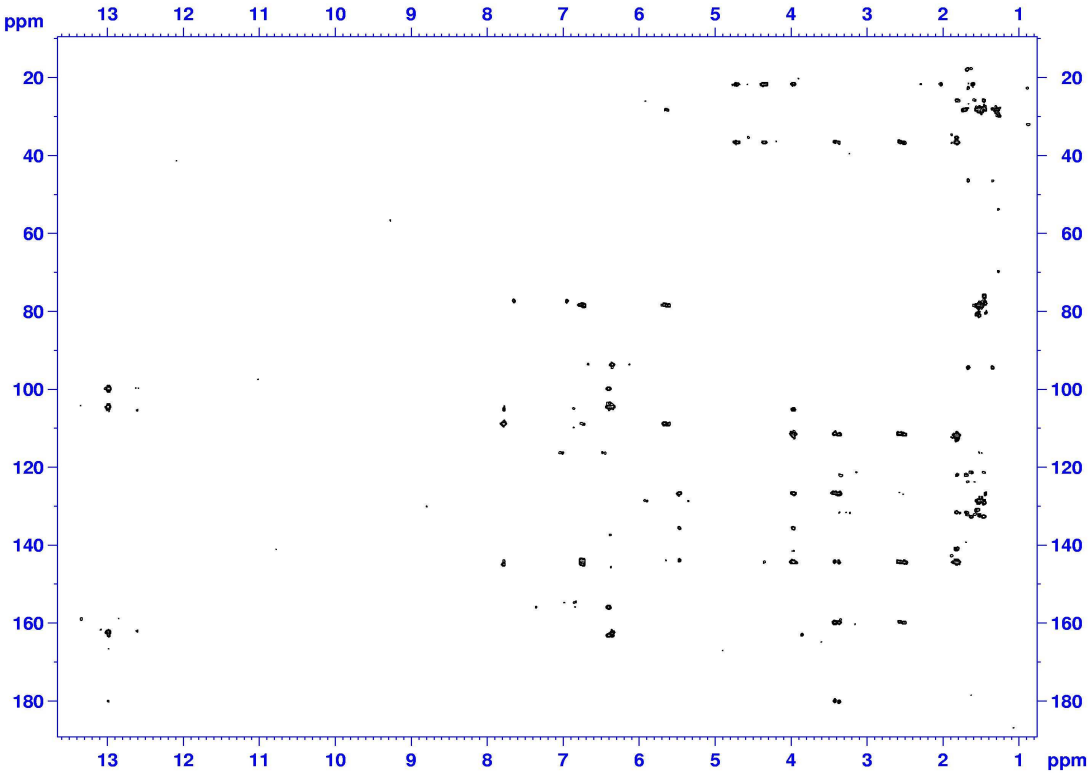


Figure 51 2D HMBC spectrum of **AE6**

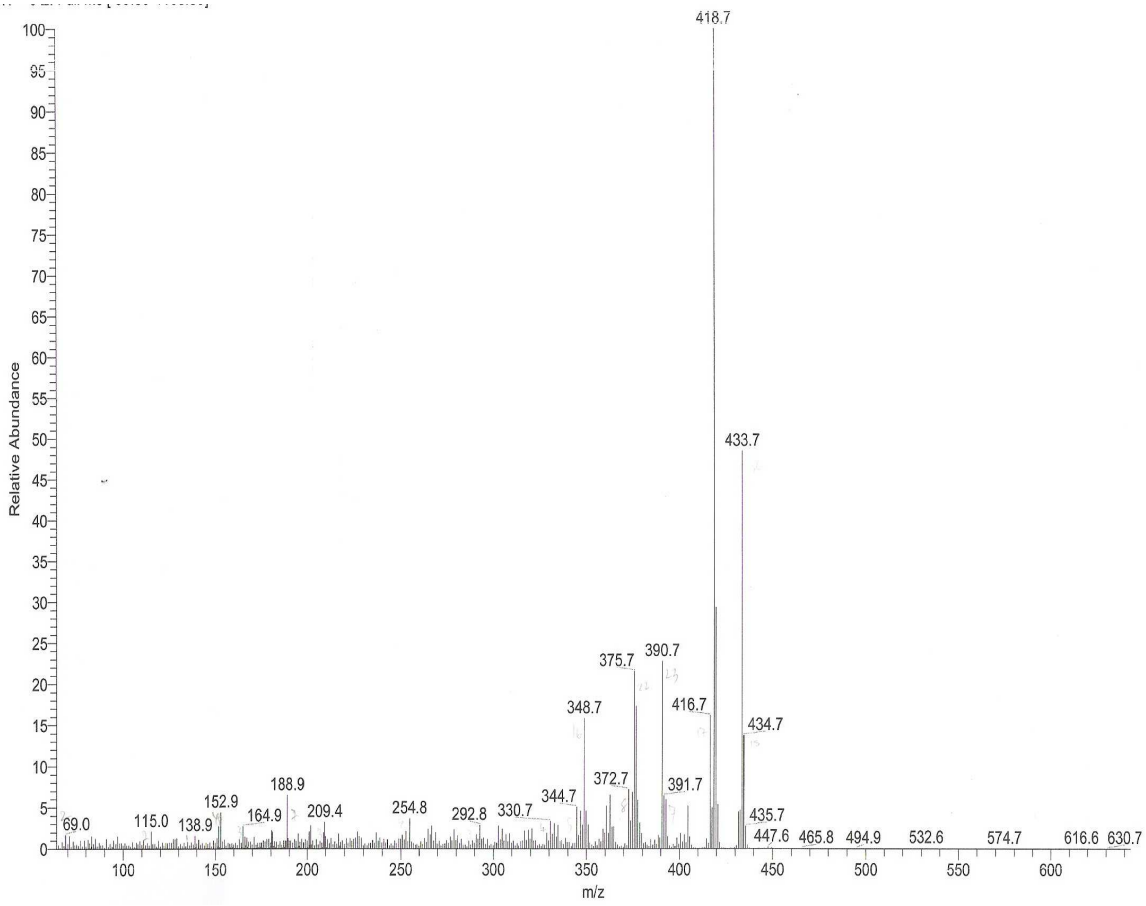


Figure 52 EI-MS spectrum of **AE7**

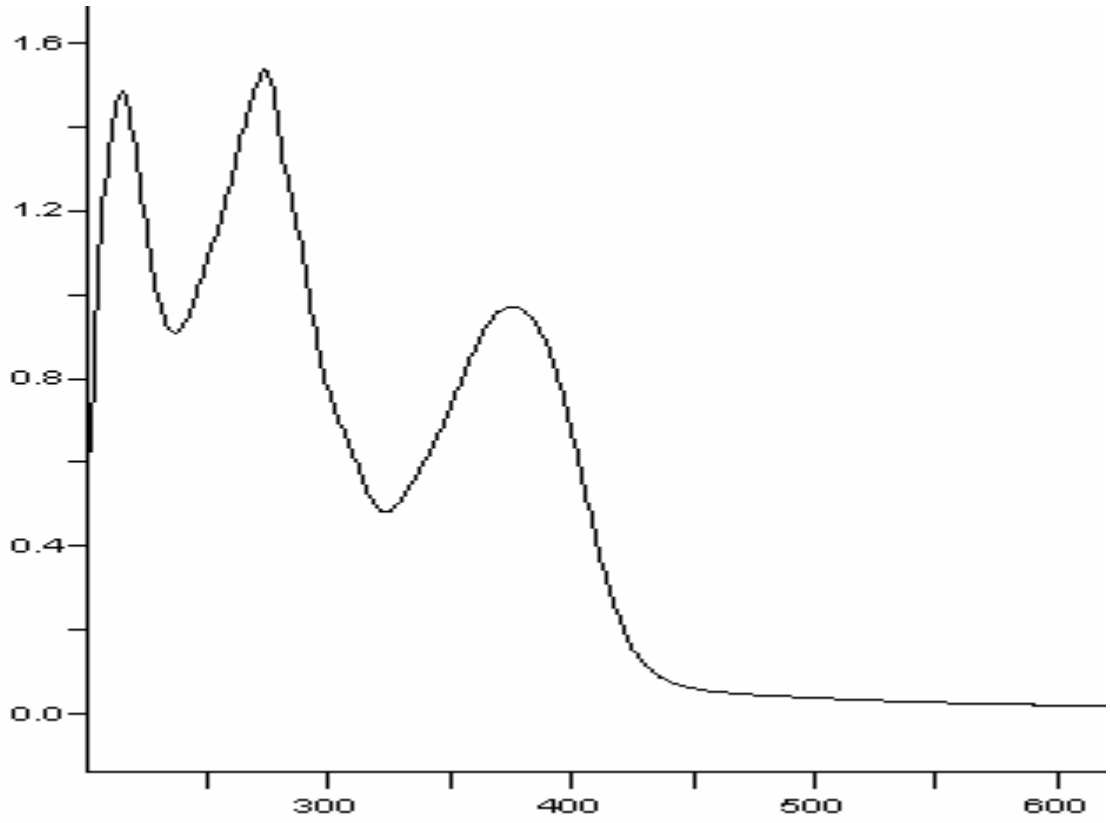


Figure 53 UV (EtOH) spectrum of **AE7**

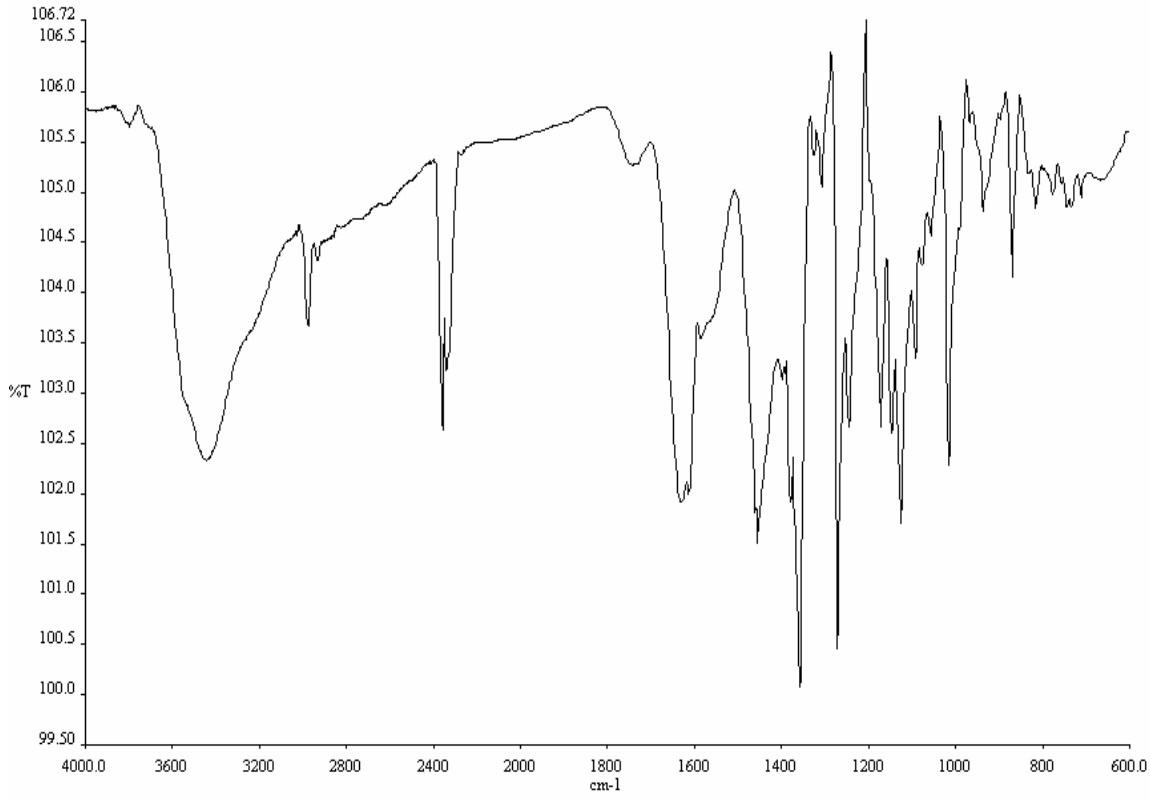


Figure 54 FT-IR (Neat) spectrum of **AE7**

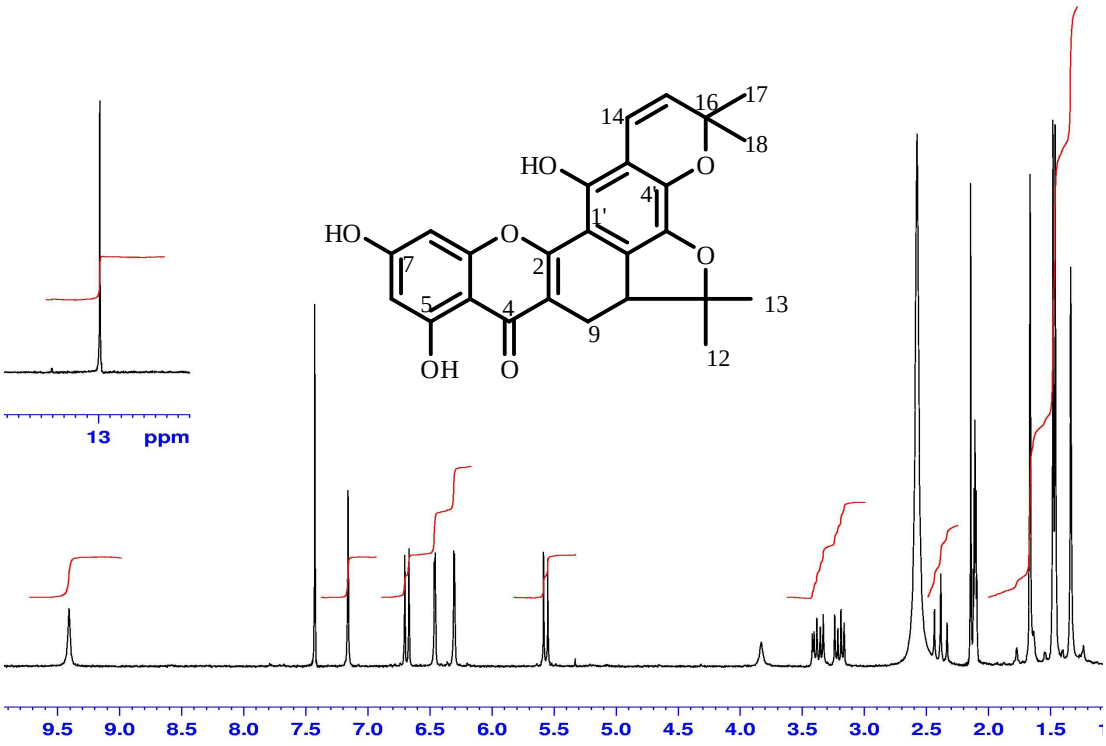


Figure 55 ^{1}H NMR (300 MHz) ($CDCl_3$+Acetone-d_6) spectrum of **AE7**

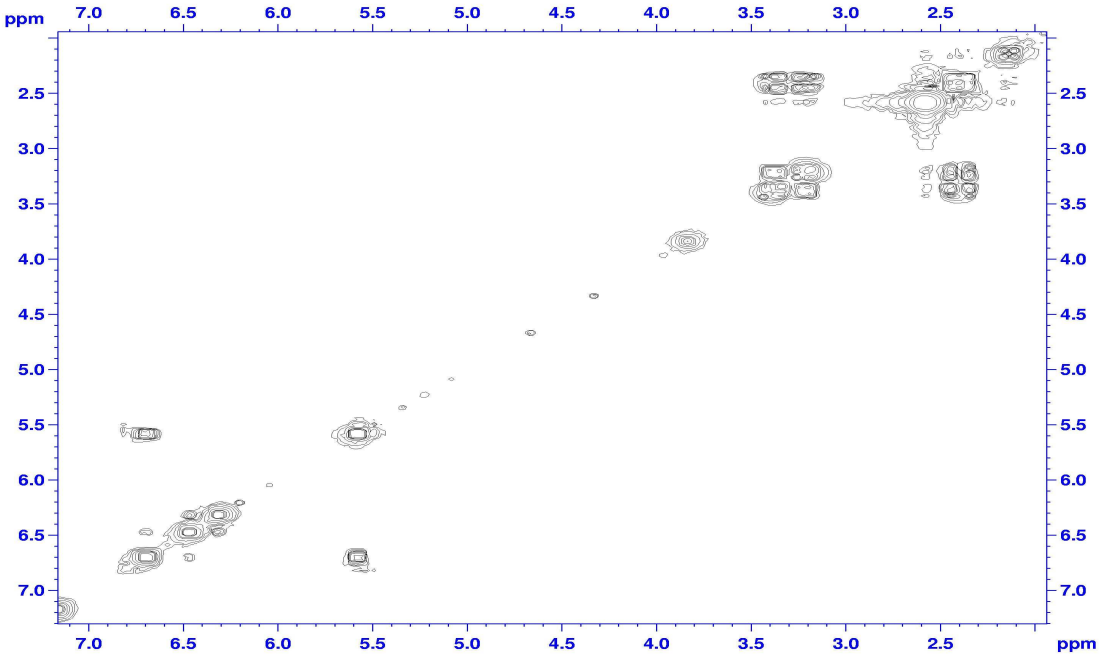


Figure 56 ^{1}H-^{1}H COSY spectrum of **AE7**

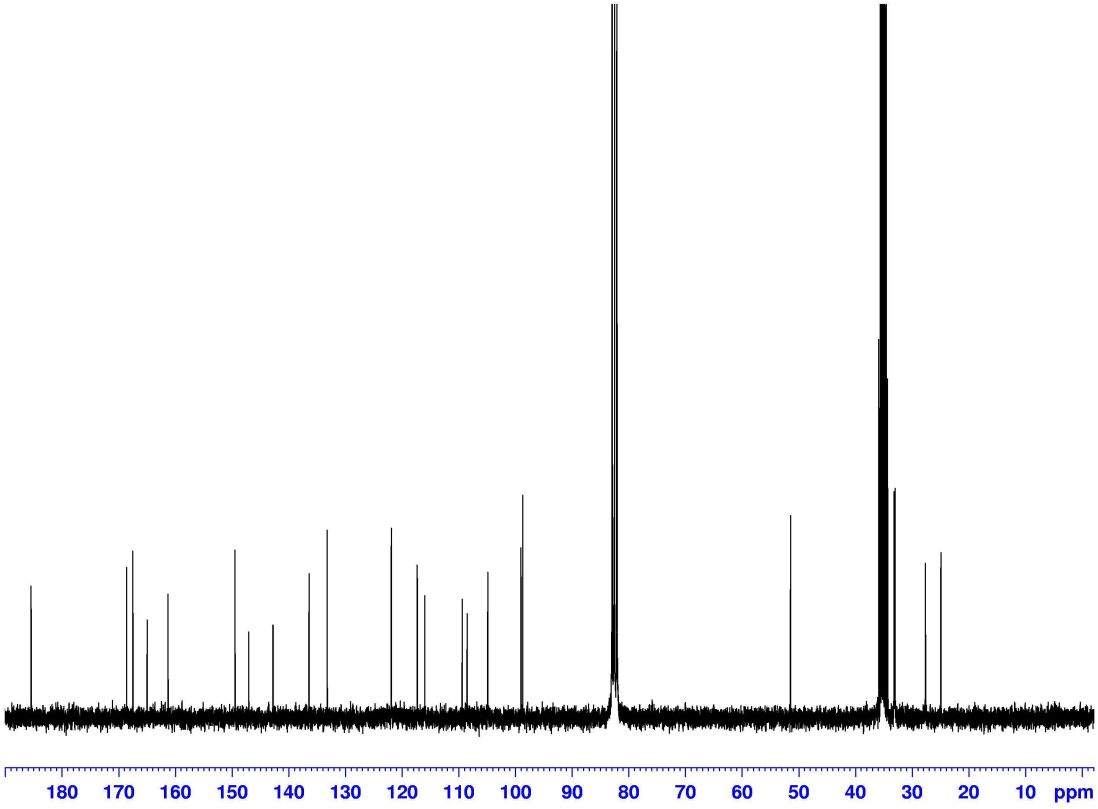


Figure 57 ^{13}C NMR (75 MHz) ($CDCl_3$+Acetone-d_6) spectrum of **AE7**

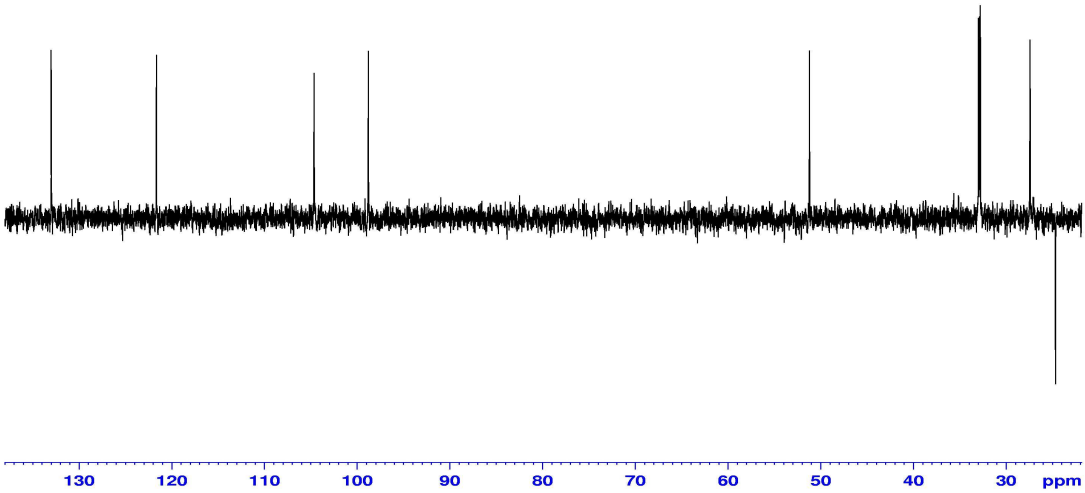


Figure 58 DEPT 135° ($CDCl_3$+Acetone-d_6) spectrum of **AE7**

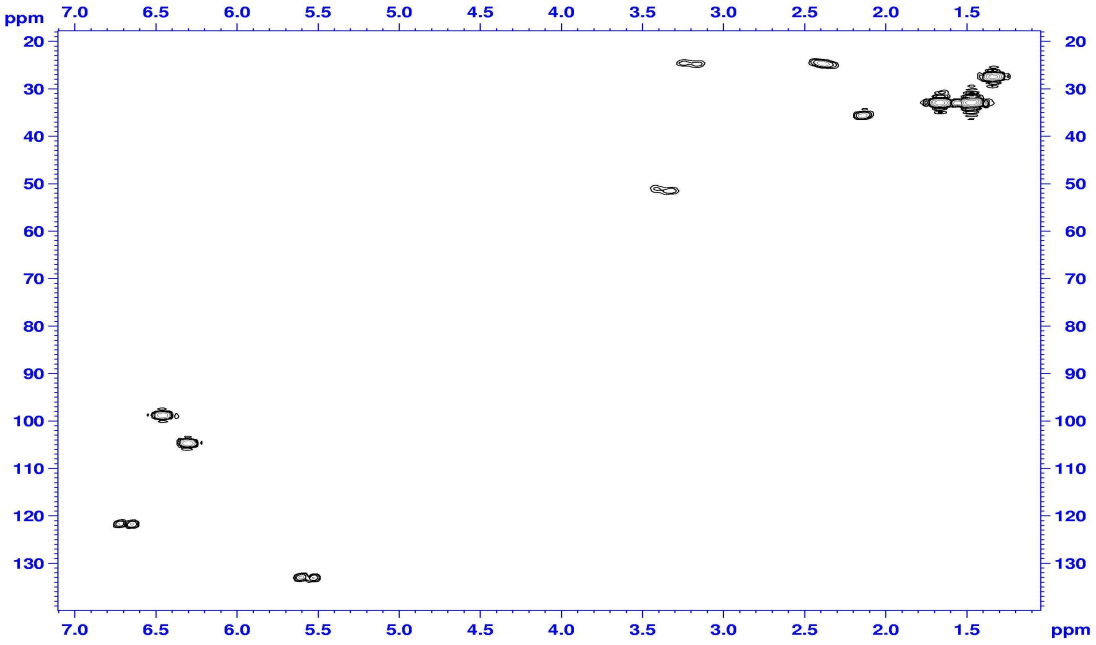


Figure 59 2D HMQC spectrum of **AE7**

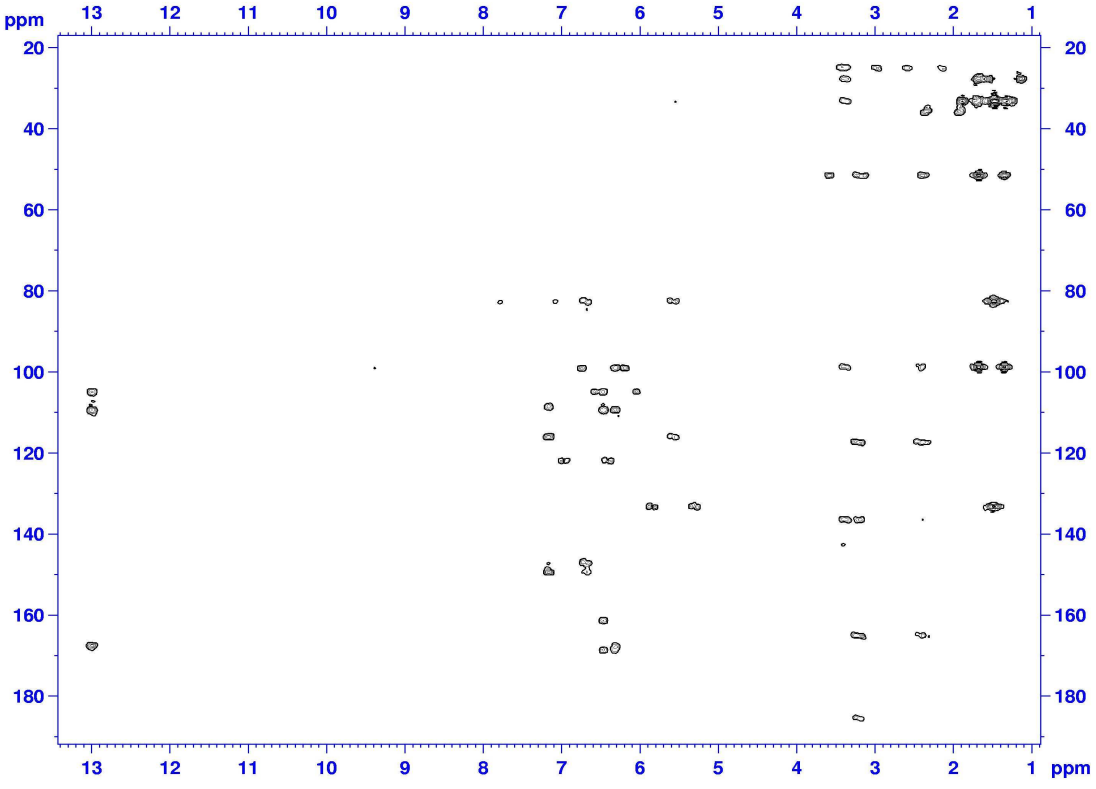


Figure 60 2D HMBC spectrum of **AE7**

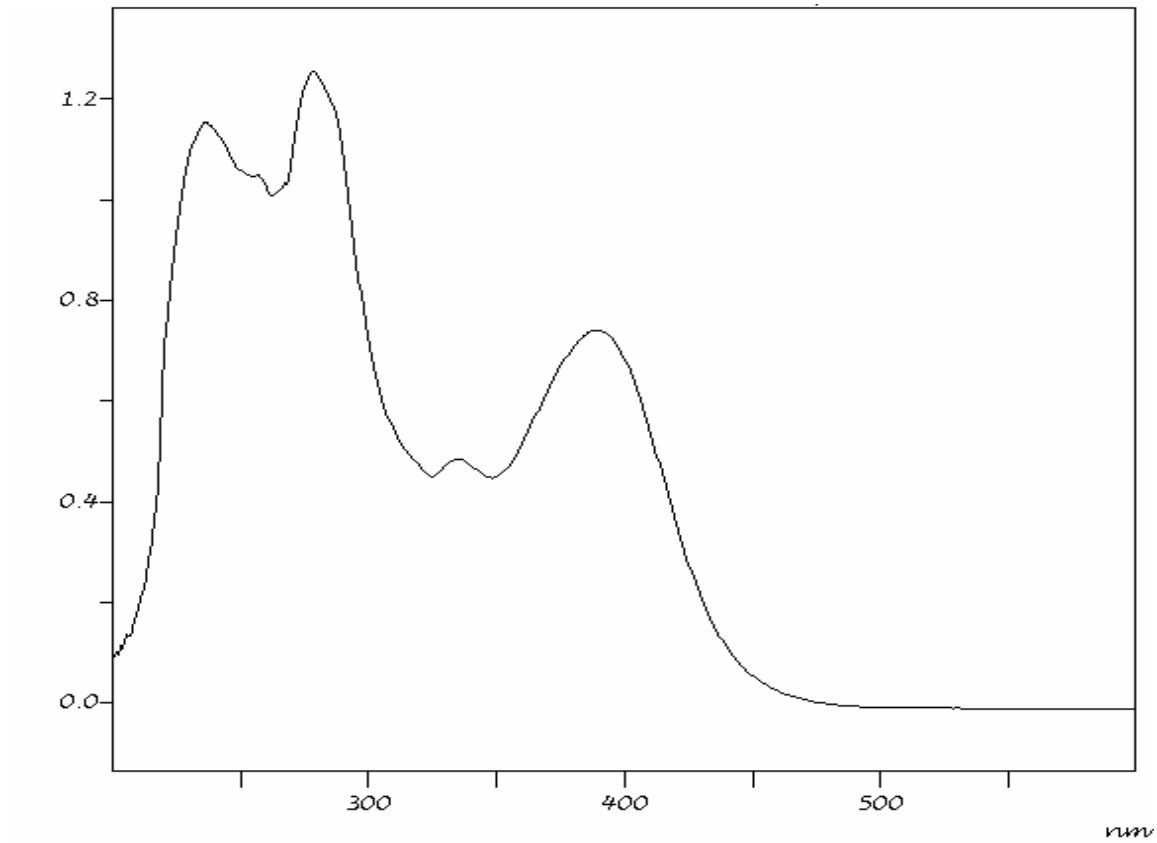


Figure 61 UV (CH_3OH) spectrum of **AE8**

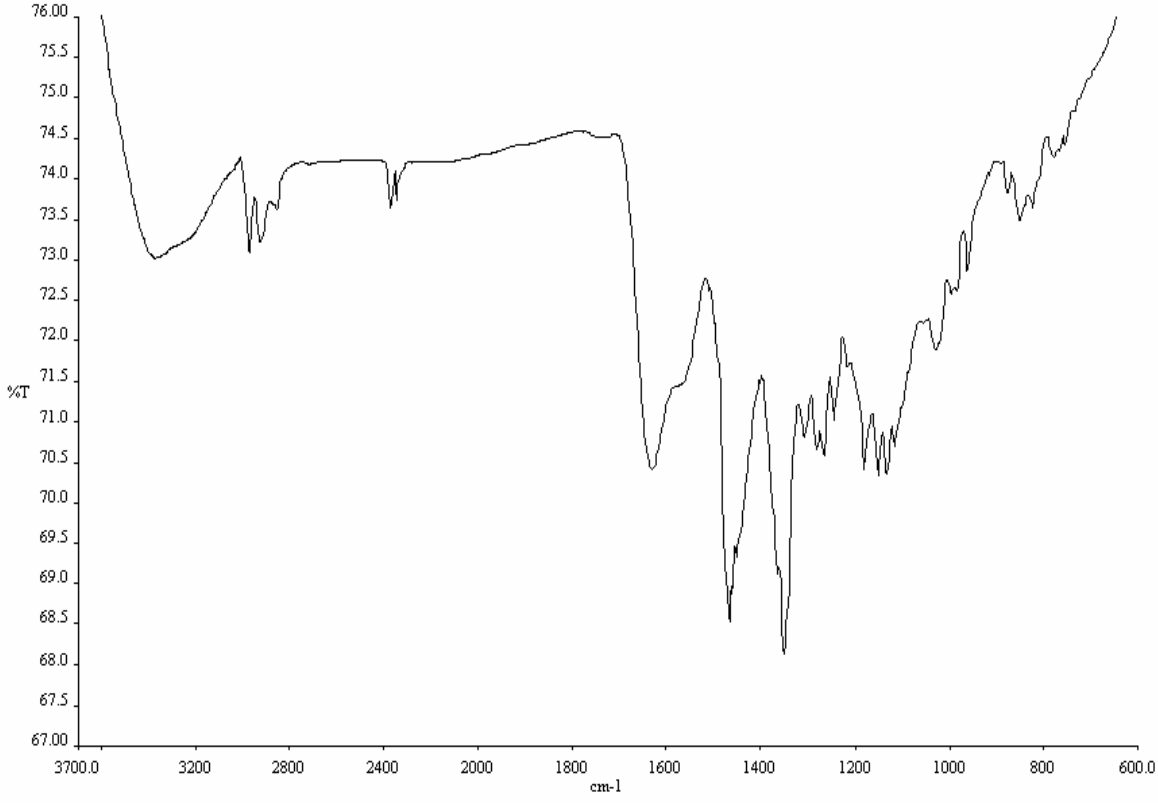


Figure 62 FT-IR (Neat) spectrum of **AE8**

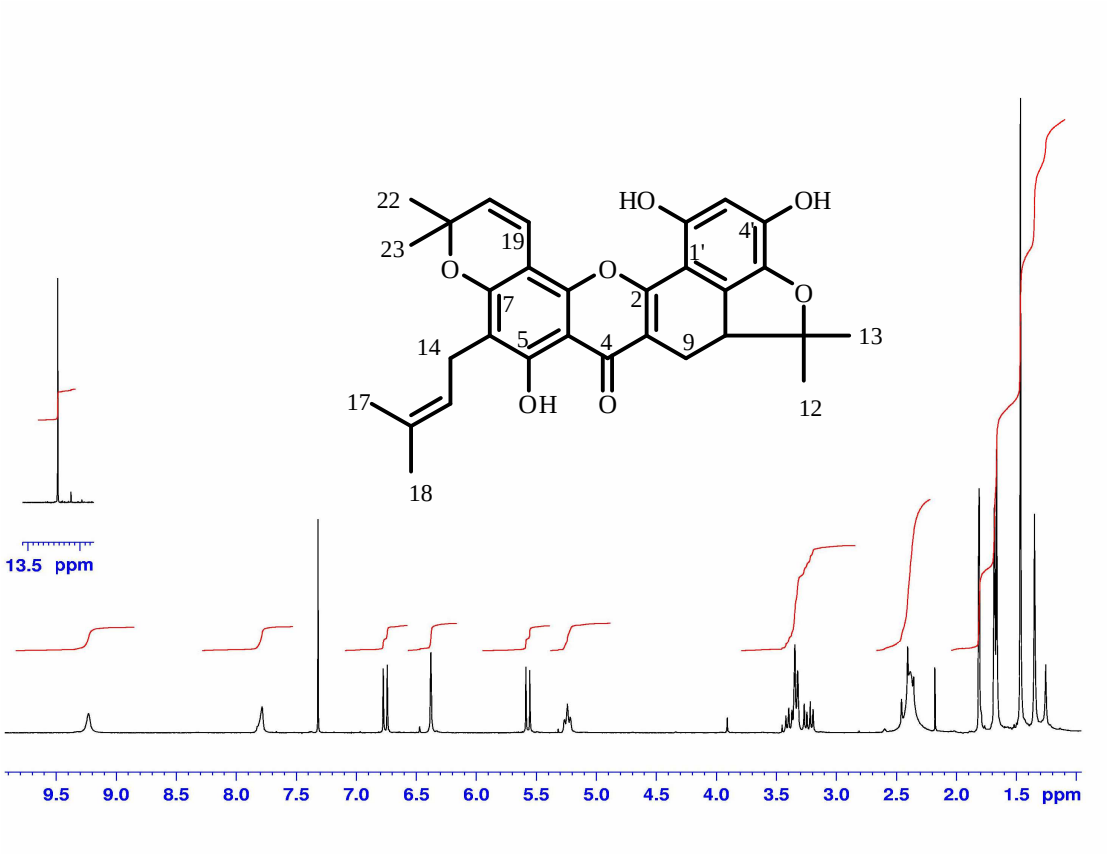


Figure 63 ^{1}H NMR (300 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE8**

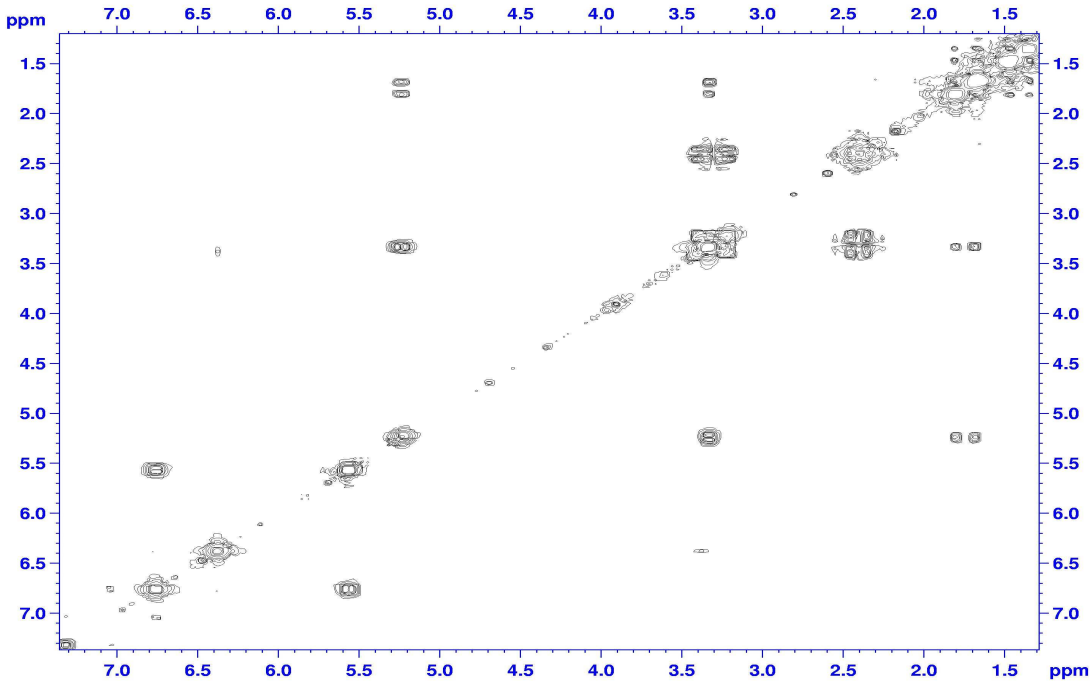


Figure 64 ^{1}H-^{1}H COSY spectrum of **AE8**

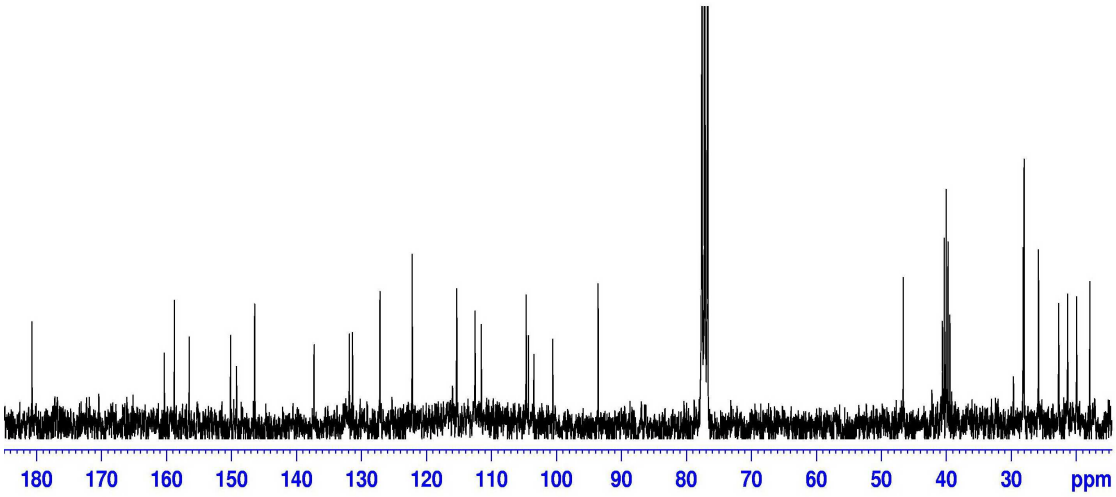


Figure 65 ^{13}C NMR (75 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE8**

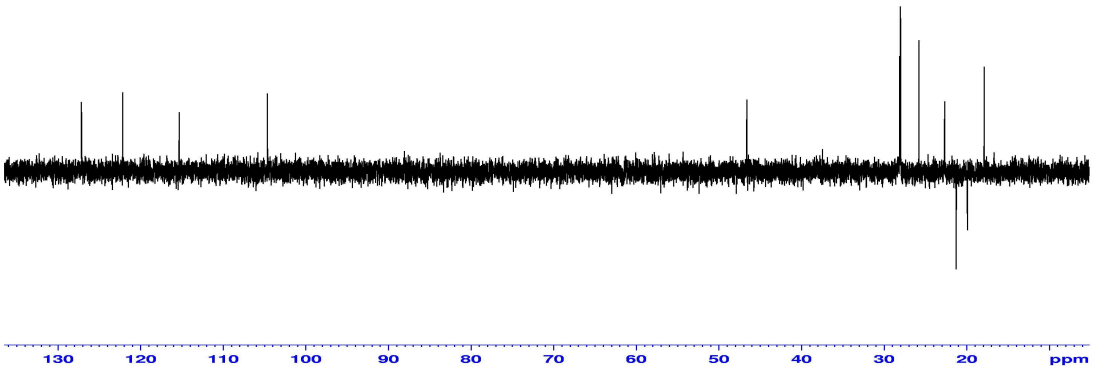


Figure 66 DEPT 135° ($CDCl_3$+DMSO-d_6) spectrum of **AE8**

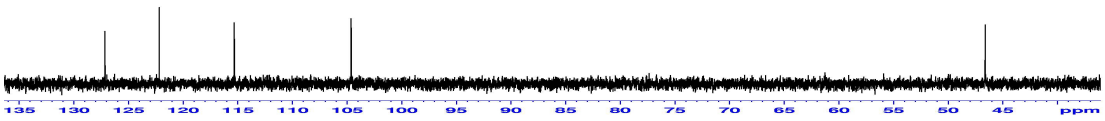


Figure 67 DEPT 90° ($CDCl_3$+DMSO-d_6) spectrum of **AE8**

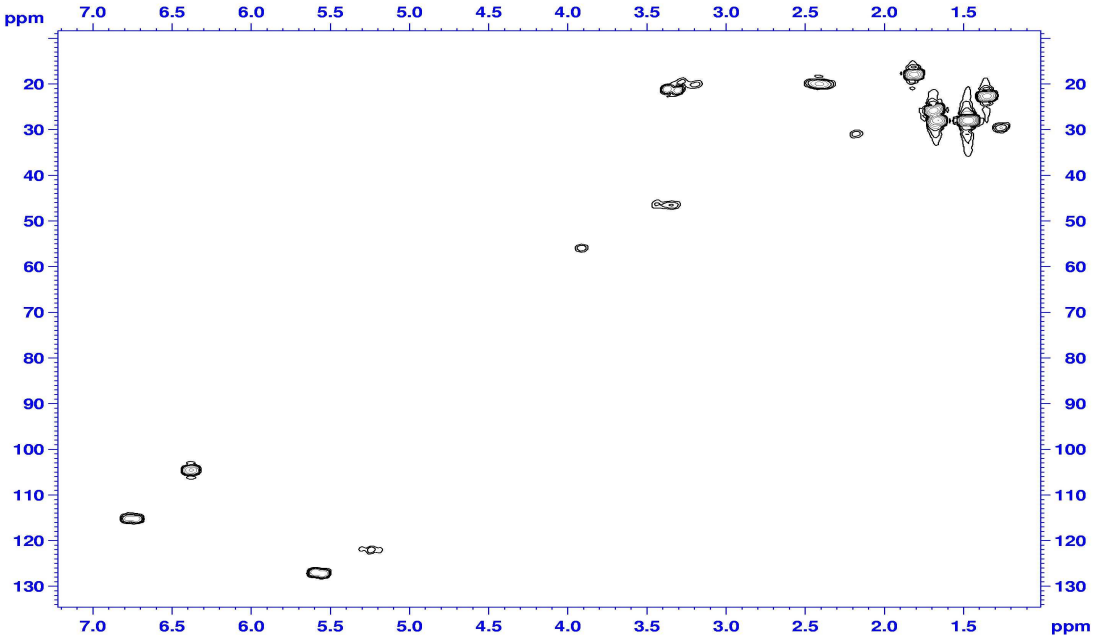


Figure 68 2D HMQC spectrum of **AE8**

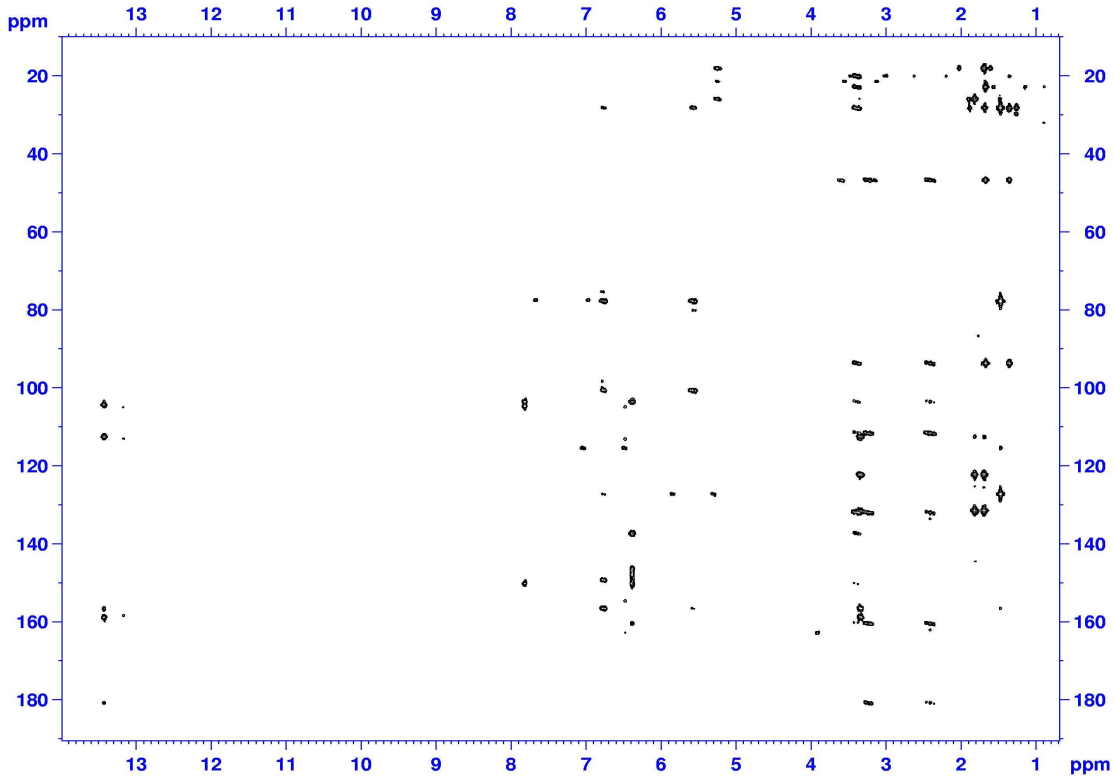


Figure 69 2D HMBC spectrum of **AE8**

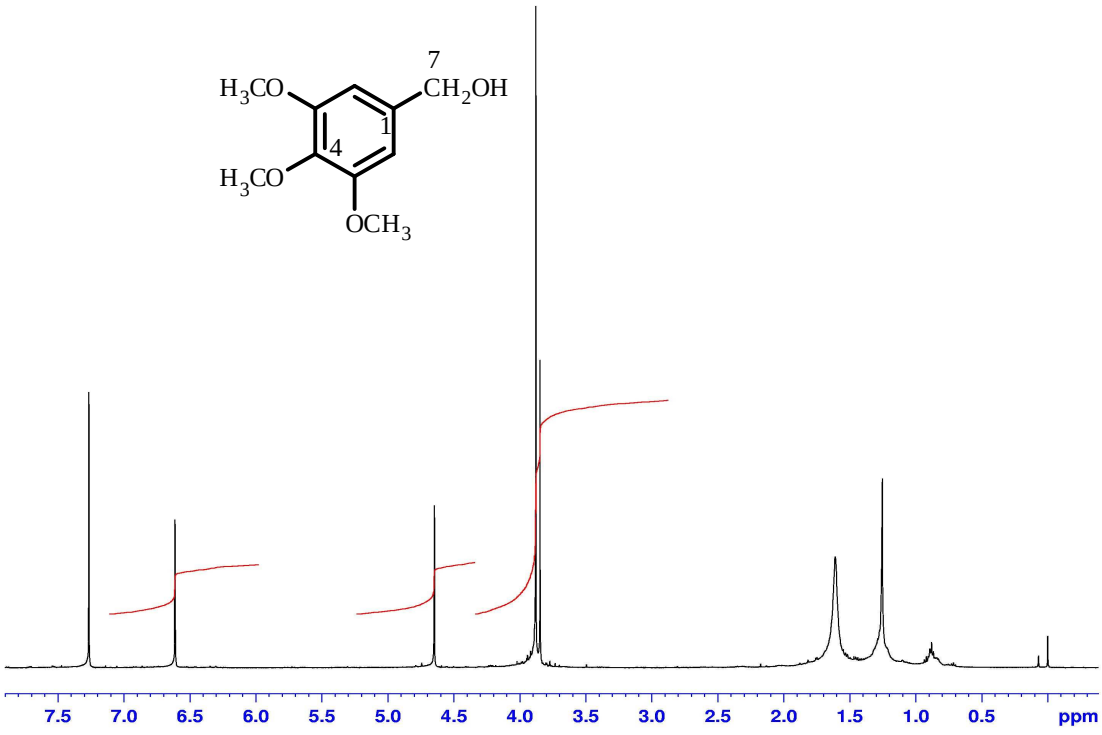


Figure 70 ^{1}H NMR (500 MHz) ($CDCl_3$) spectrum of **AE9**

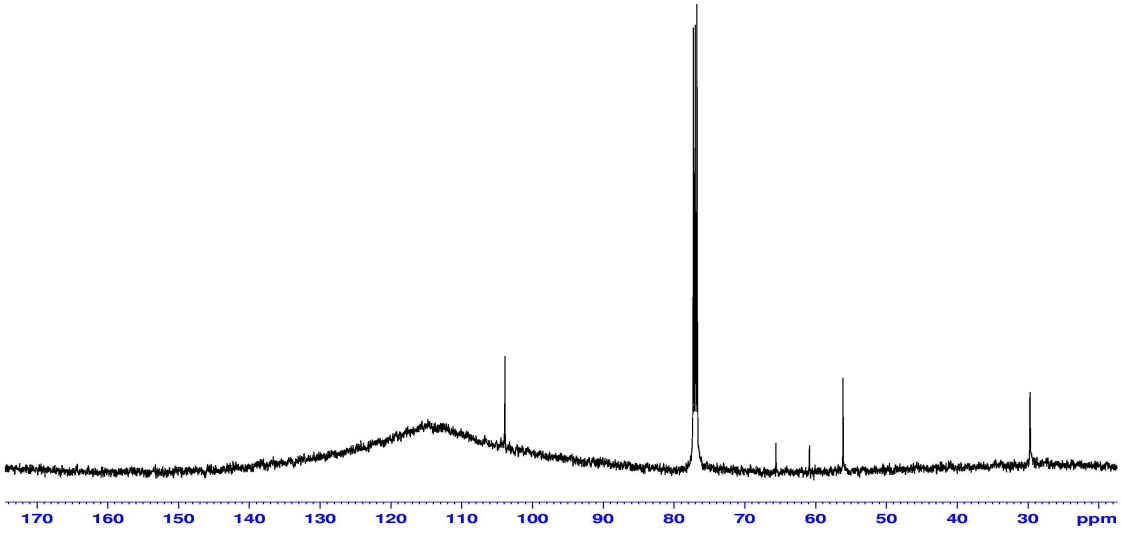


Figure 71 ^{13}C NMR (125 MHz) ($CDCl_3$) spectrum of **AE9**

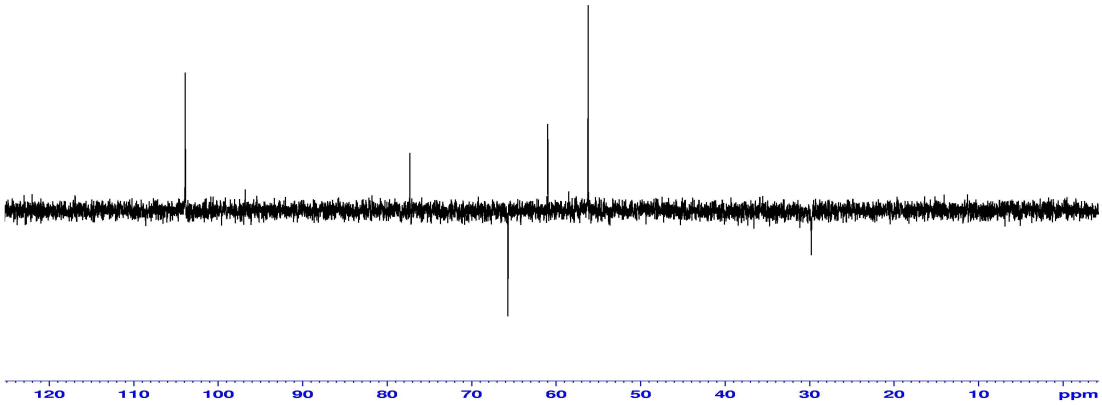


Figure 72 DEPT 135° ($CDCl_3$) spectrum of **AE9**

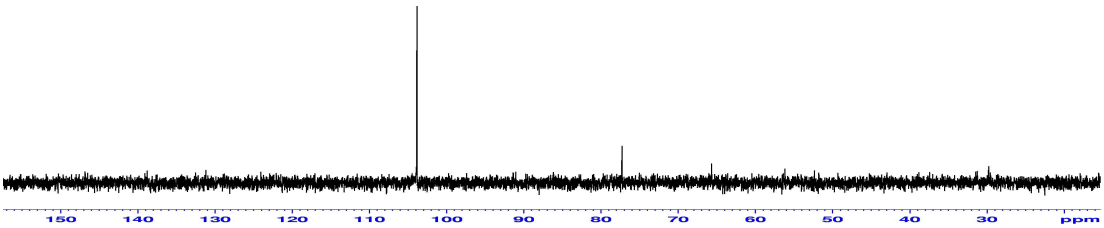


Figure 73 DEPT 90° ($CDCl_3$) spectrum of **AE9**

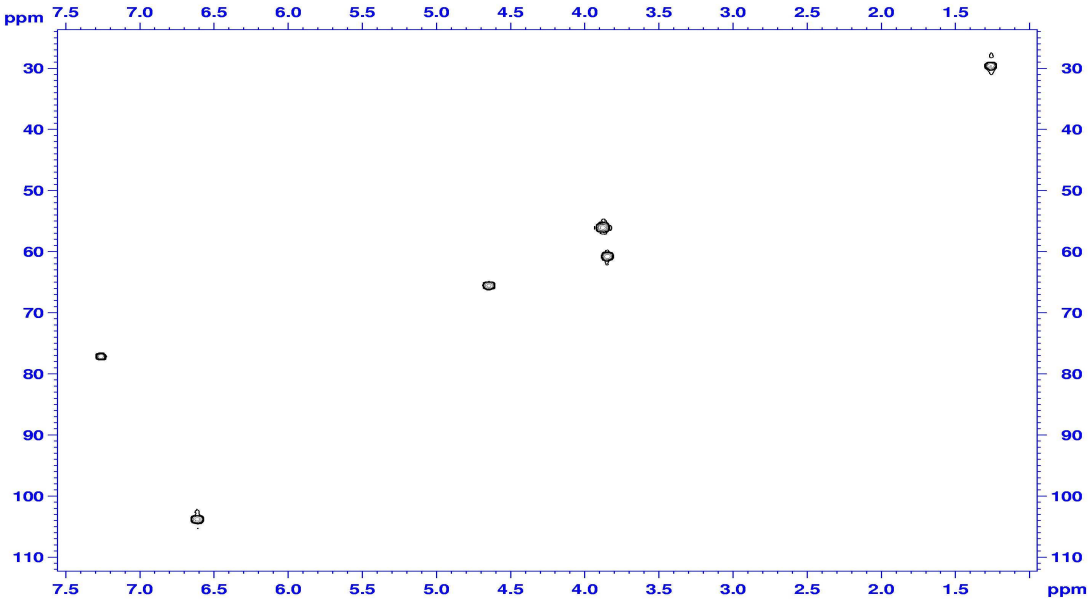


Figure 74 2D HMQC spectrum of **AE9**

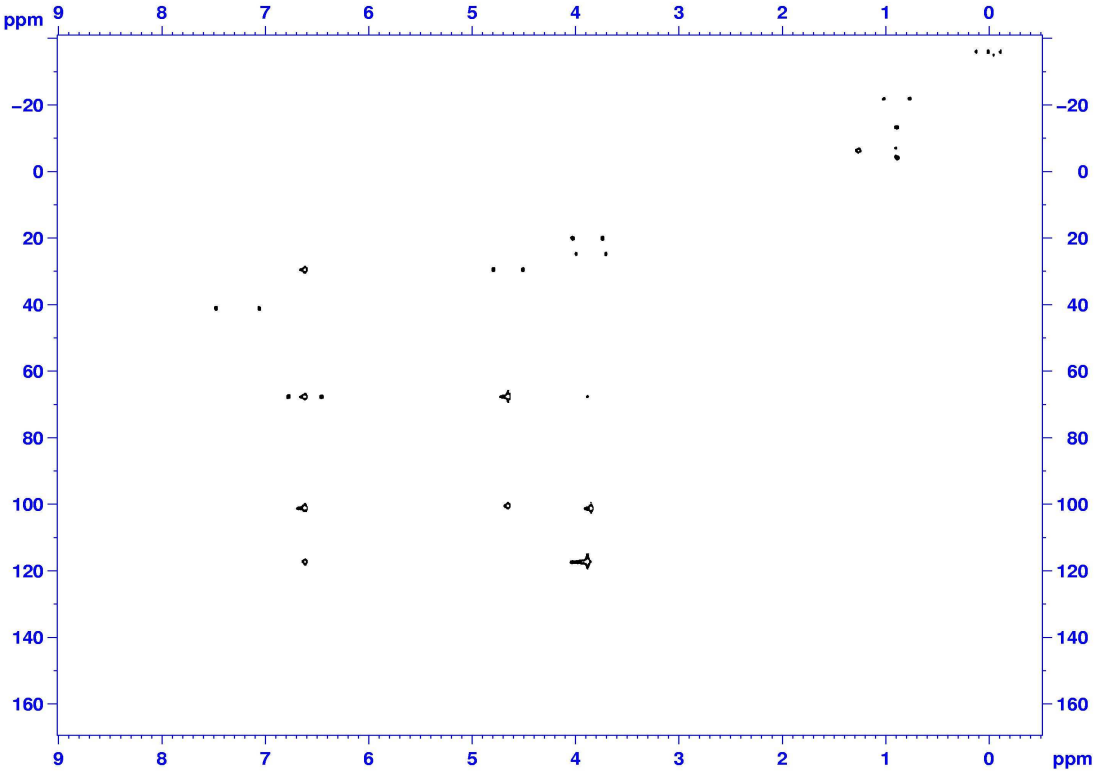


Figure 75 2D HMBC spectrum of **AE9**

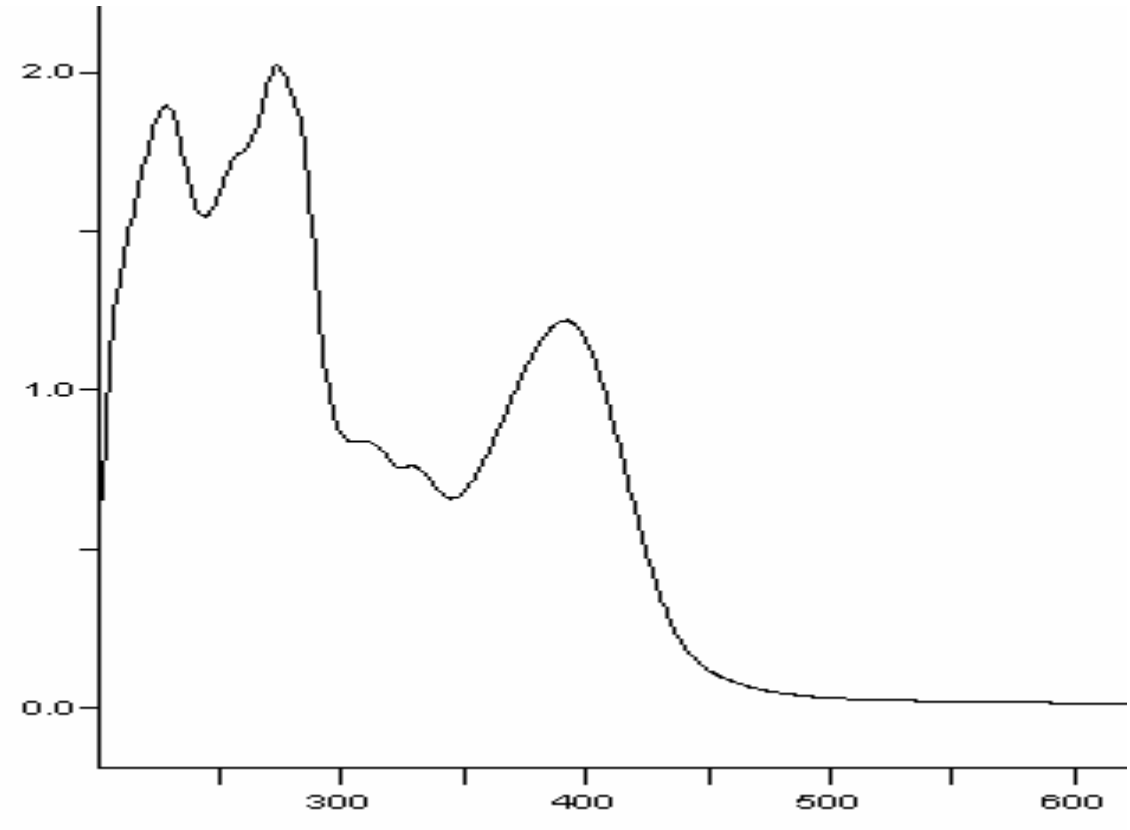


Figure 76 UV (EtOH) spectrum of **AE10**

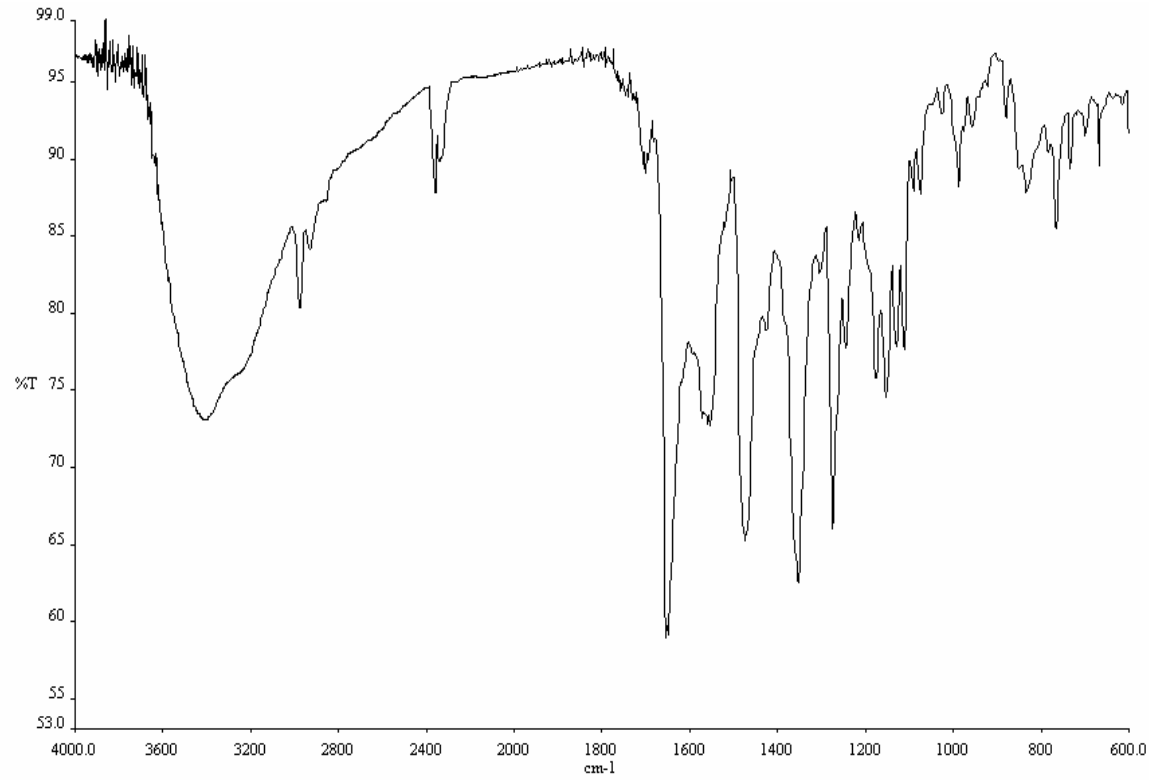


Figure 77 FT-IR (Neat) spectrum of **AE10**

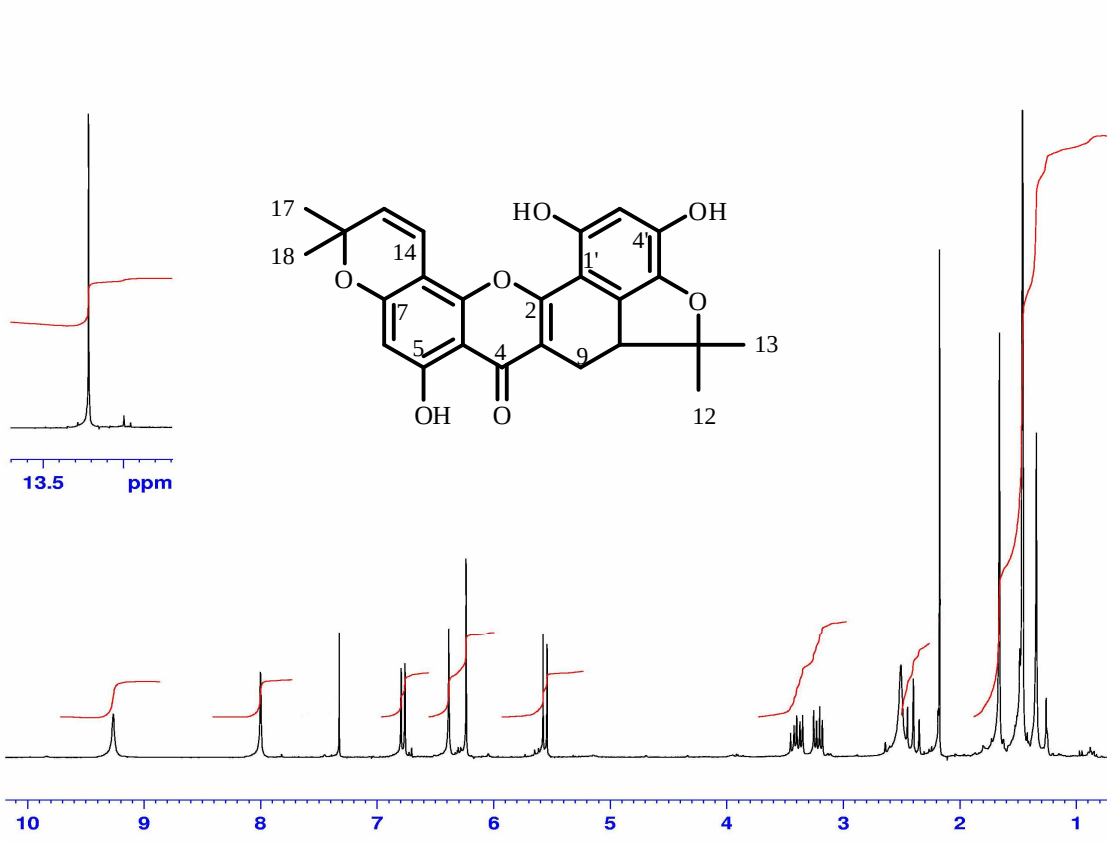


Figure 78 ^{1}H NMR (300 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE10**

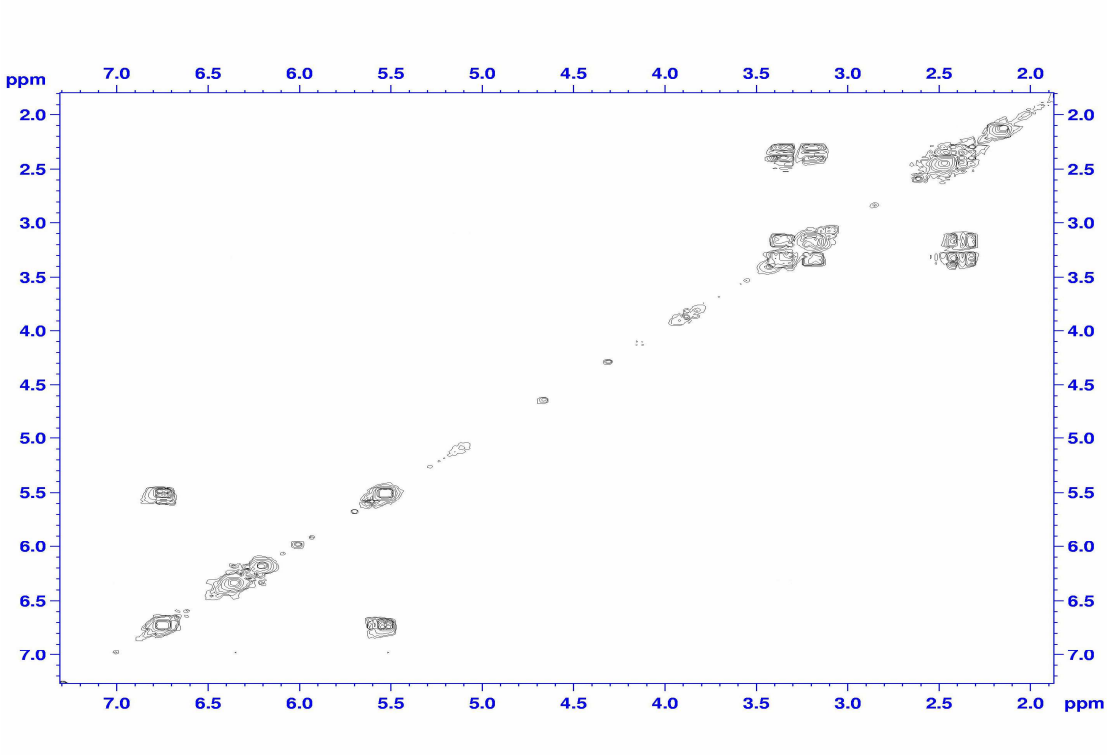


Figure 79 ^{1}H-^{1}H COSY spectrum of **AE10**

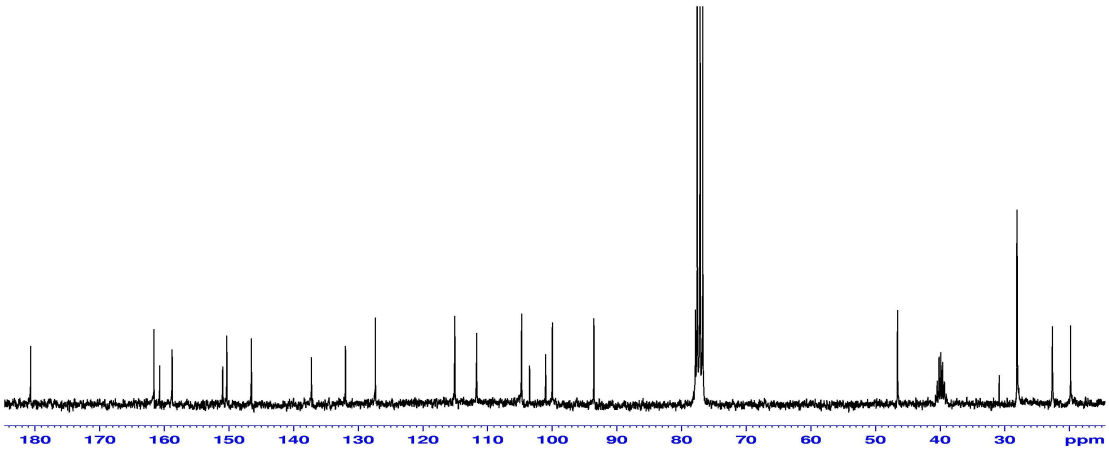


Figure 80 ^{13}C NMR (75 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE10**

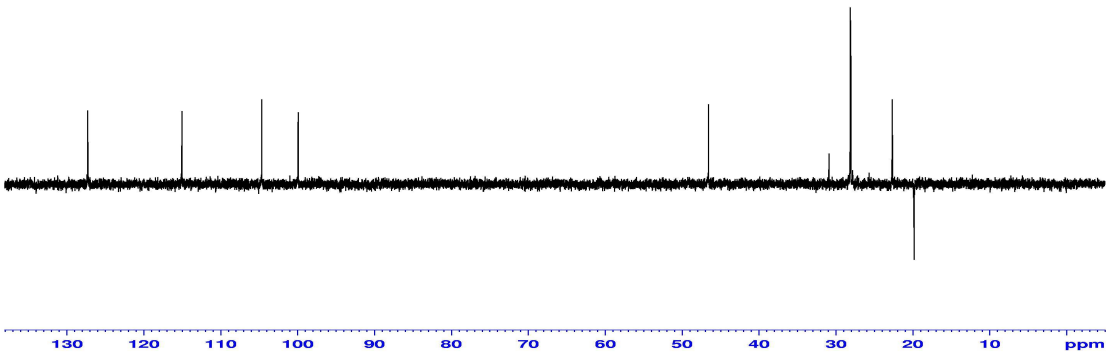


Figure 81 DEPT 135° ($CDCl_3$+DMSO-d_6) spectrum of **AE10**

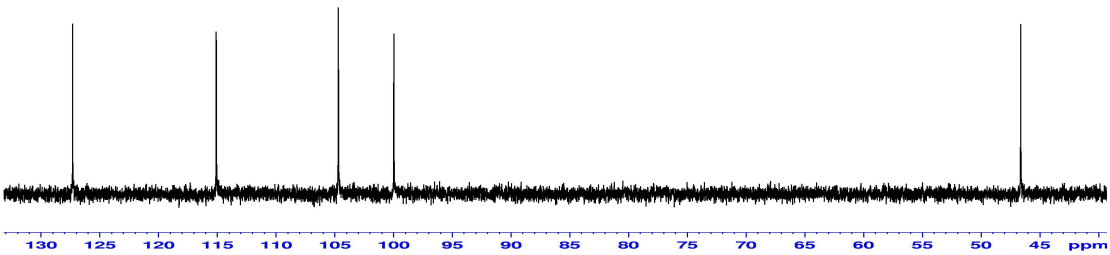


Figure 82 DEPT 90° ($CDCl_3$+DMSO-d_6) spectrum of **AE10**

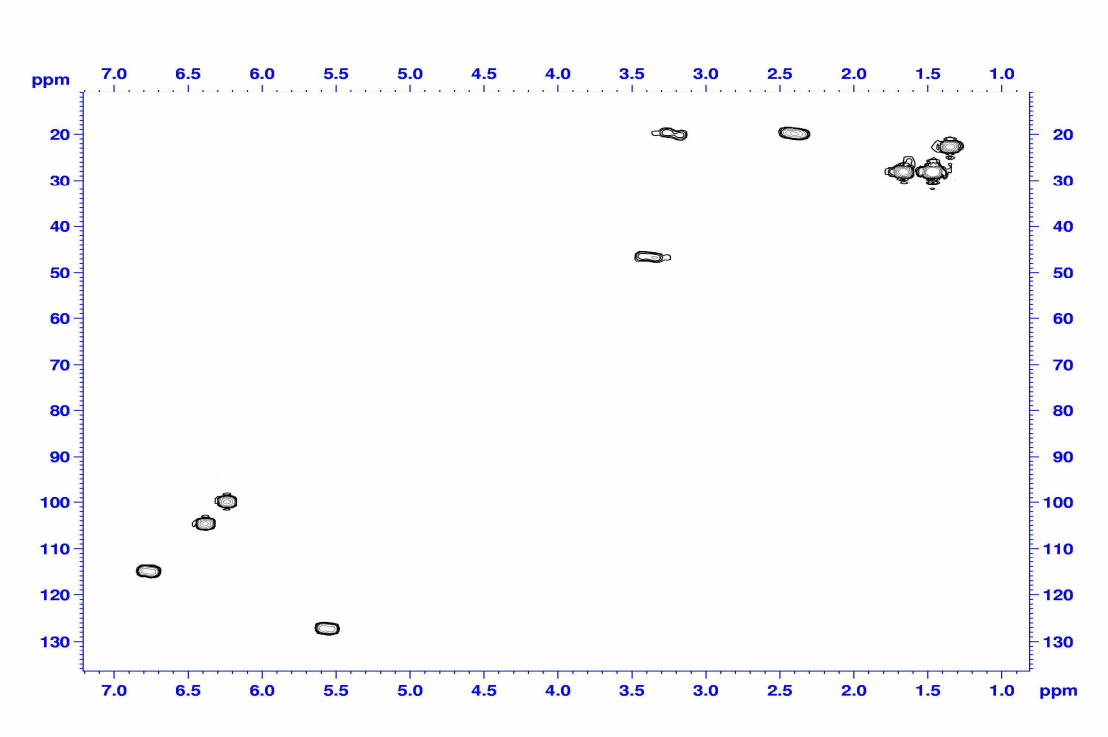


Figure 83 2D HMQC spectrum of **AE10**

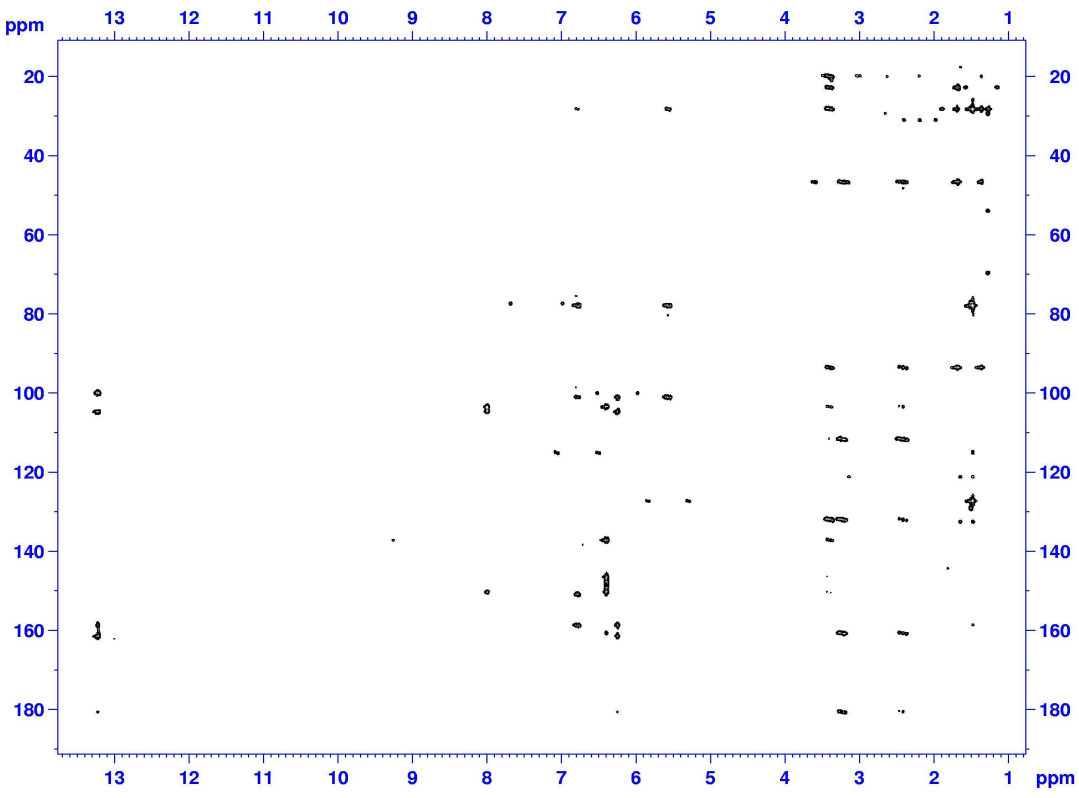


Figure 84 2D HMBC spectrum of **AE10**

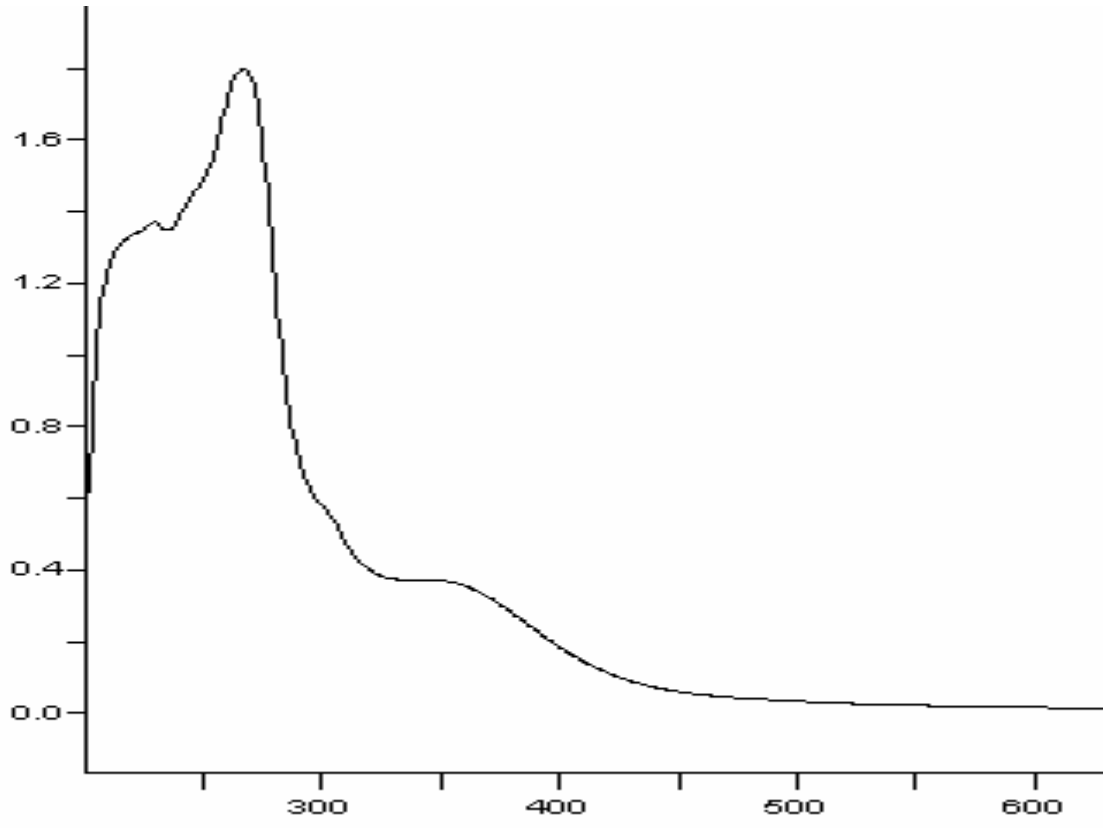


Figure 85 UV (EtOH) spectrum of **AE11**

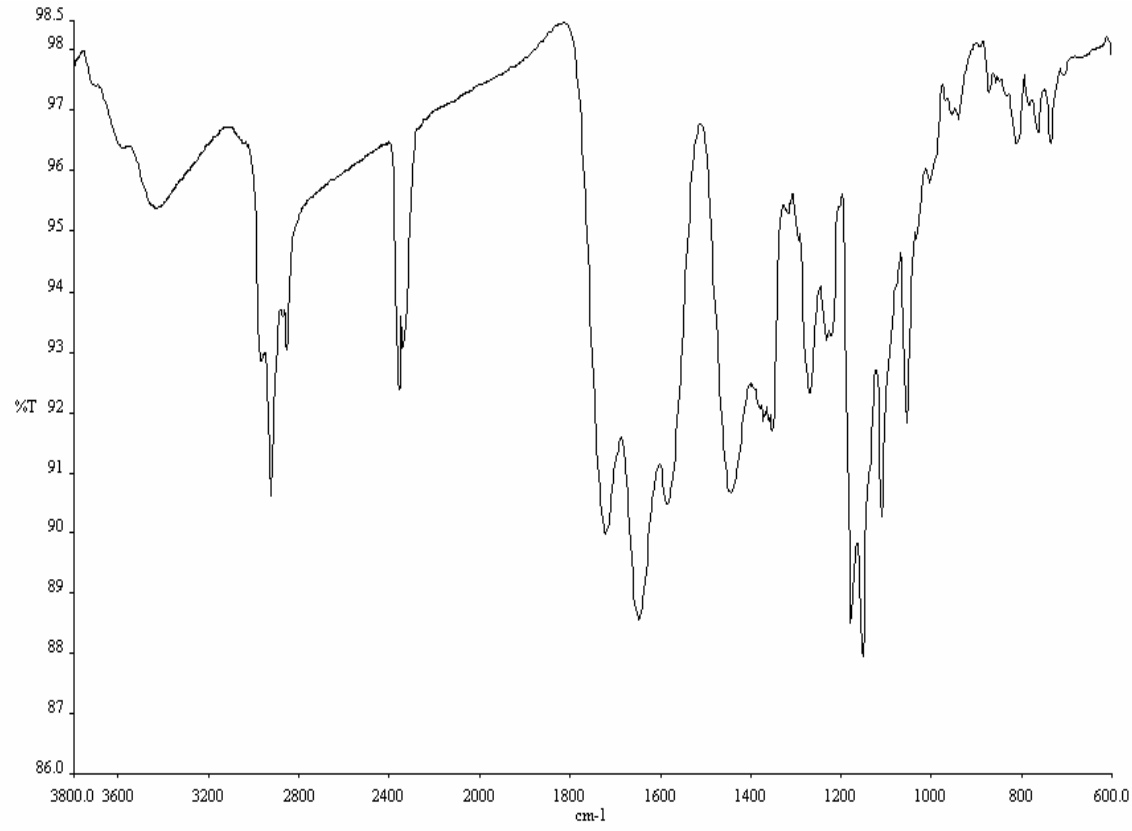


Figure 86 FT-IR (Neat) spectrum of **AE11**

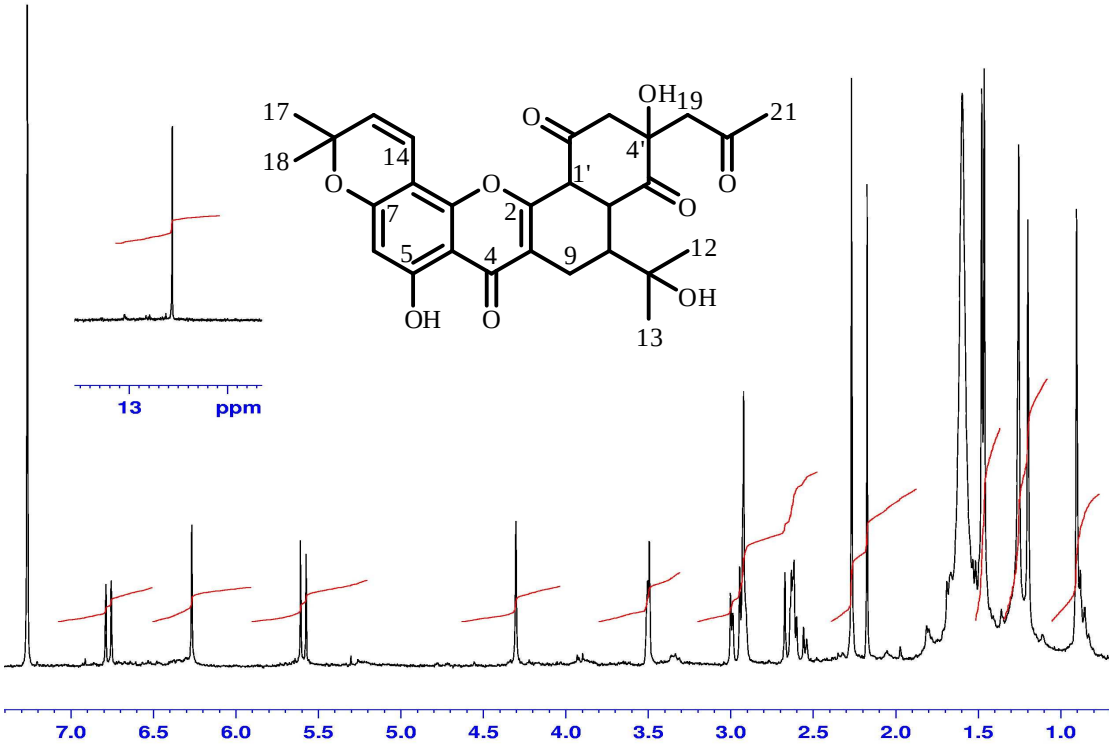


Figure 87 ^{1}H NMR (300 MHz) ($CDCl_3$) spectrum of **AE11**

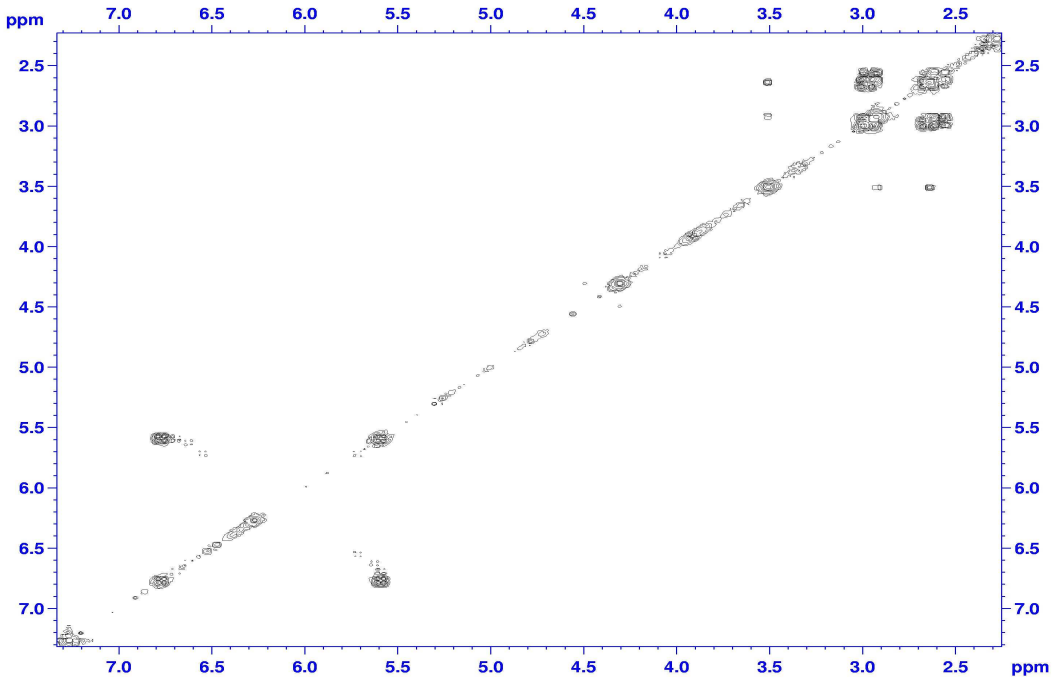


Figure 88 ^{1}H-^{1}H COSY spectrum of **AE11**

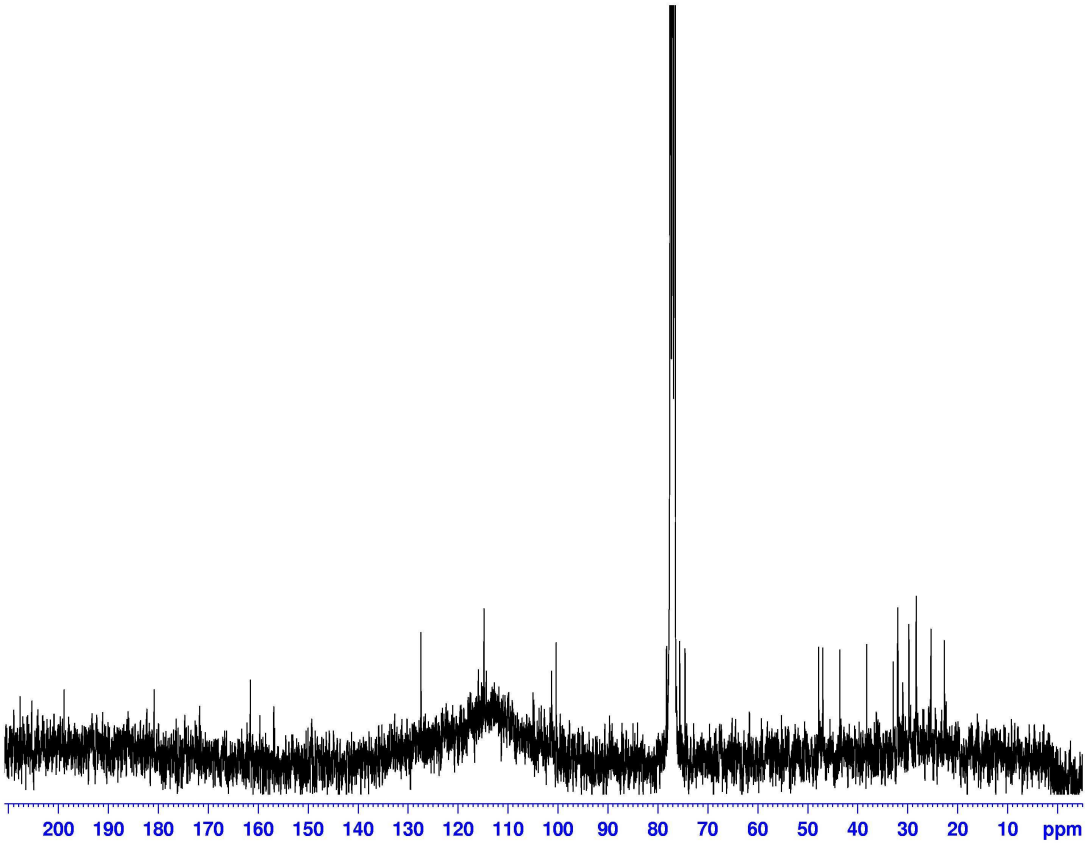


Figure 89 ^{13}C NMR (75 MHz) ($CDCl_3$) spectrum of **AE11**

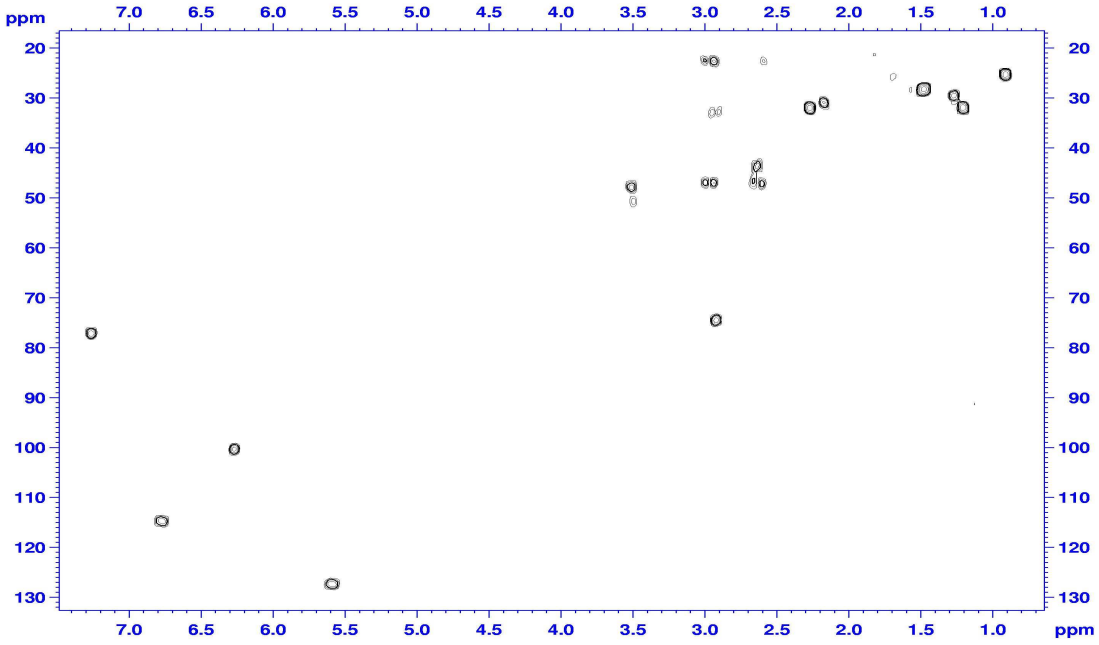


Figure 90 2D HMQC spectrum of **AE11**

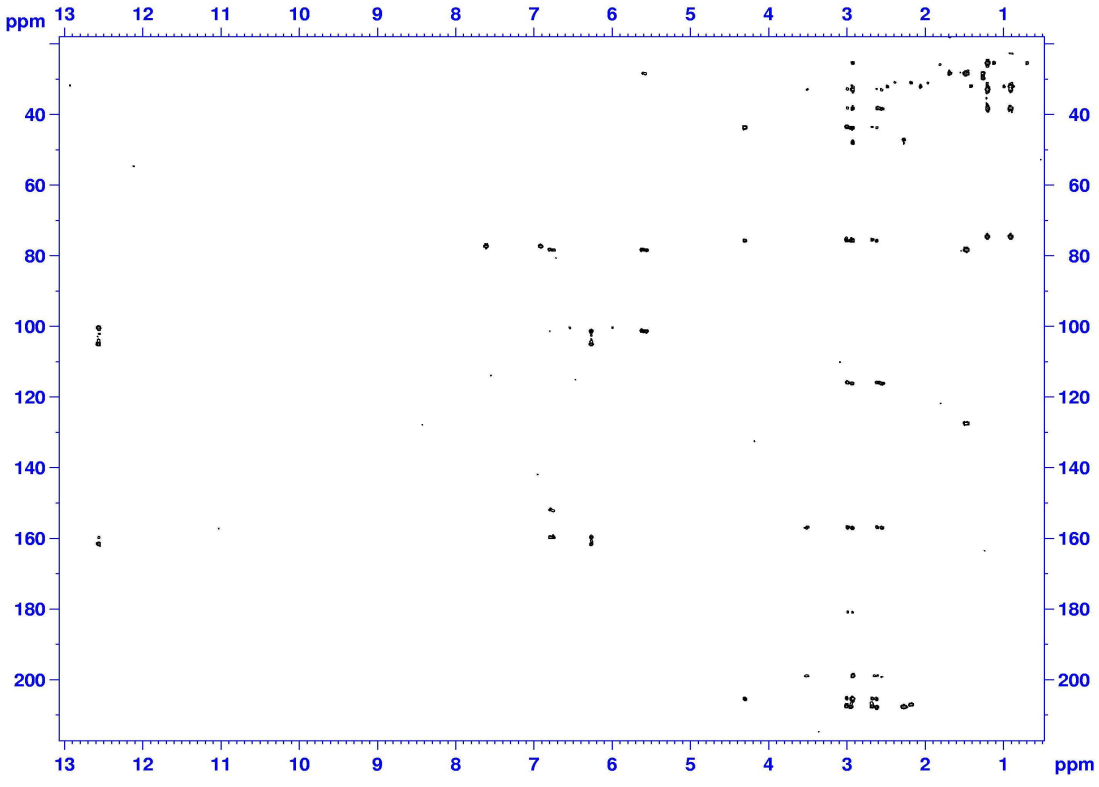


Figure 91 2D HMBC spectrum of **AE11**

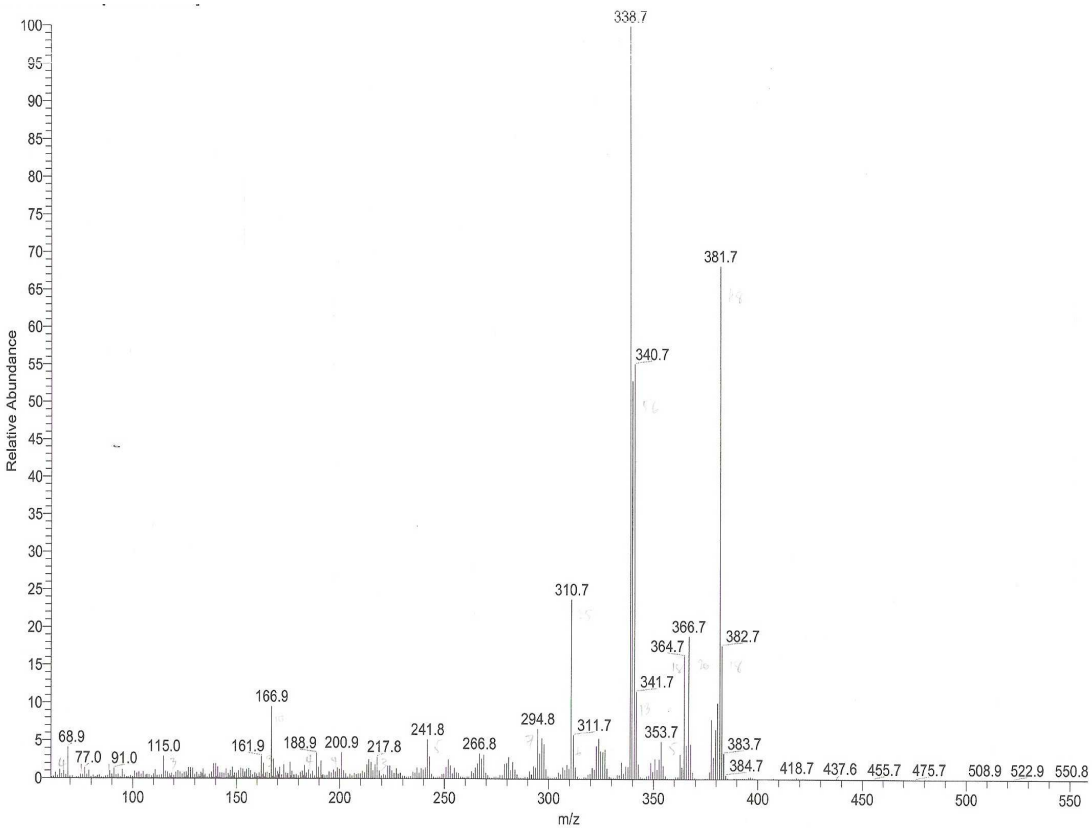


Figure 92 EI-MS spectrum of **AE12**

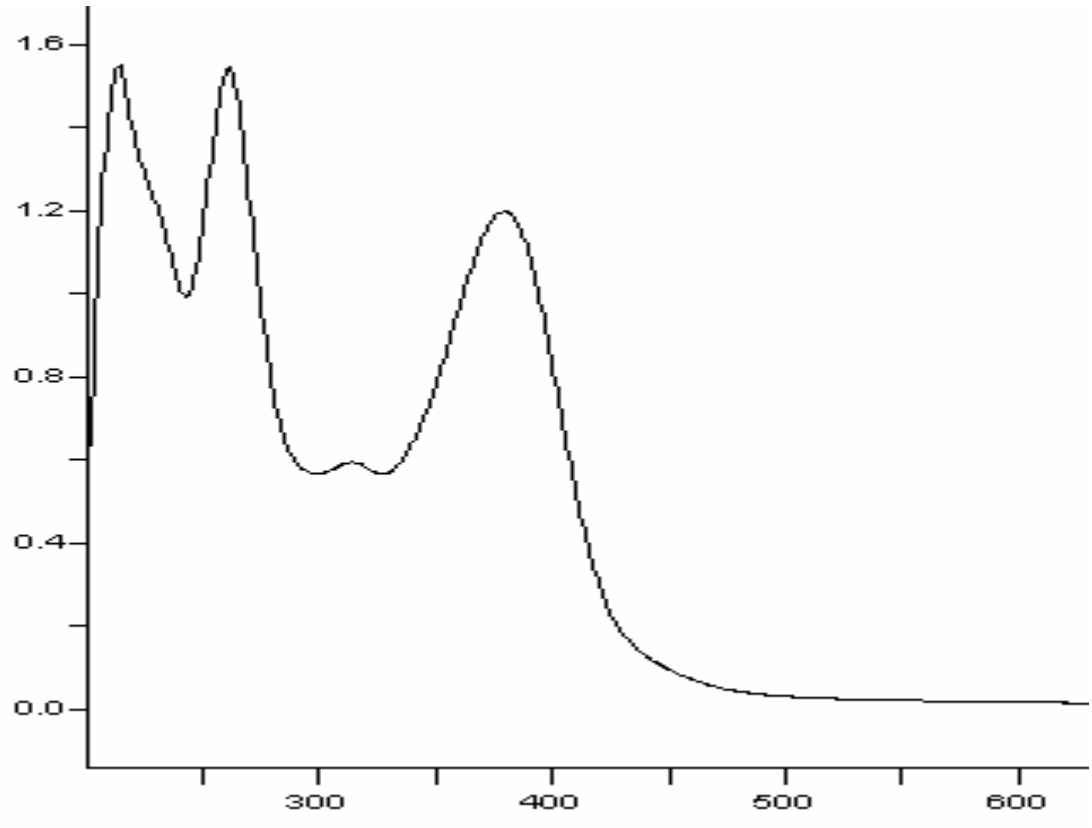


Figure 93 UV (EtOH) spectrum of **AE12**

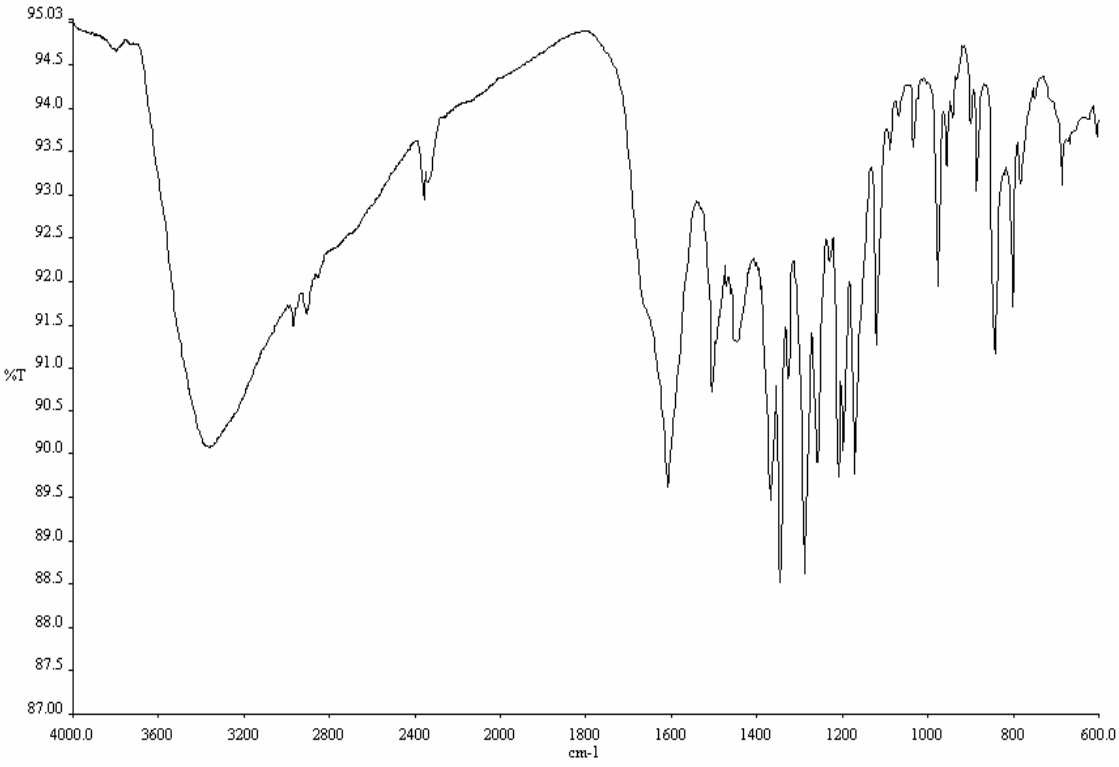


Figure 94 FT-IR (Neat) spectrum of **AE12**

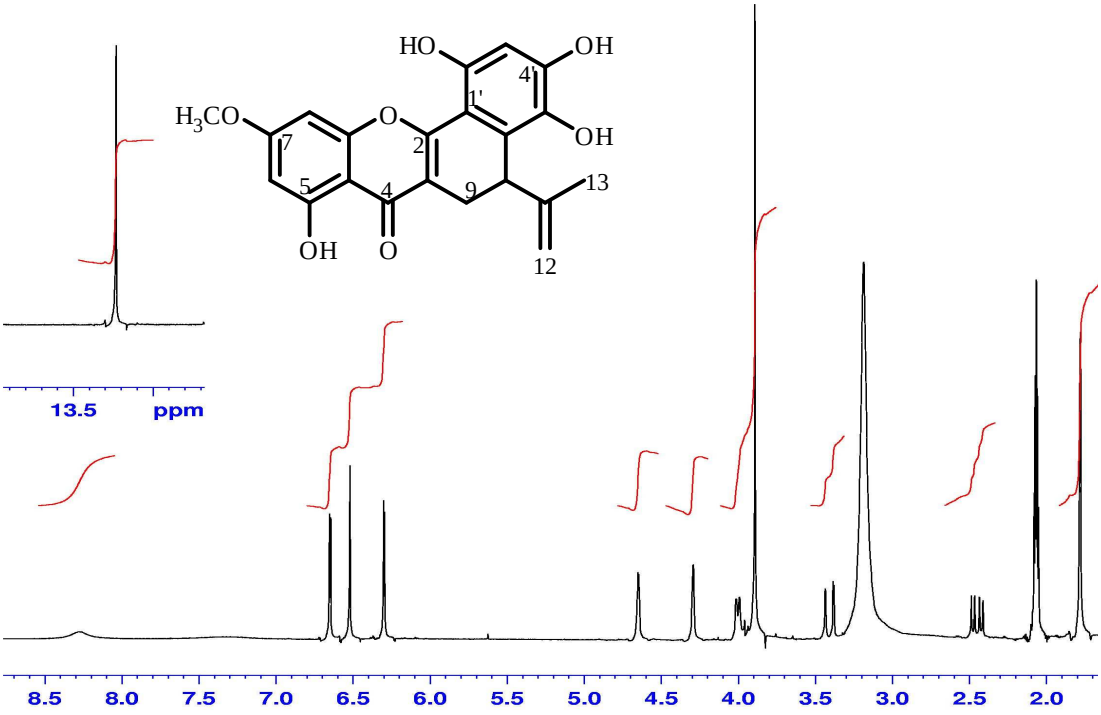


Figure 95 ^{1}H NMR (300 MHz) (Acetone-d_6) spectrum of **AE12**

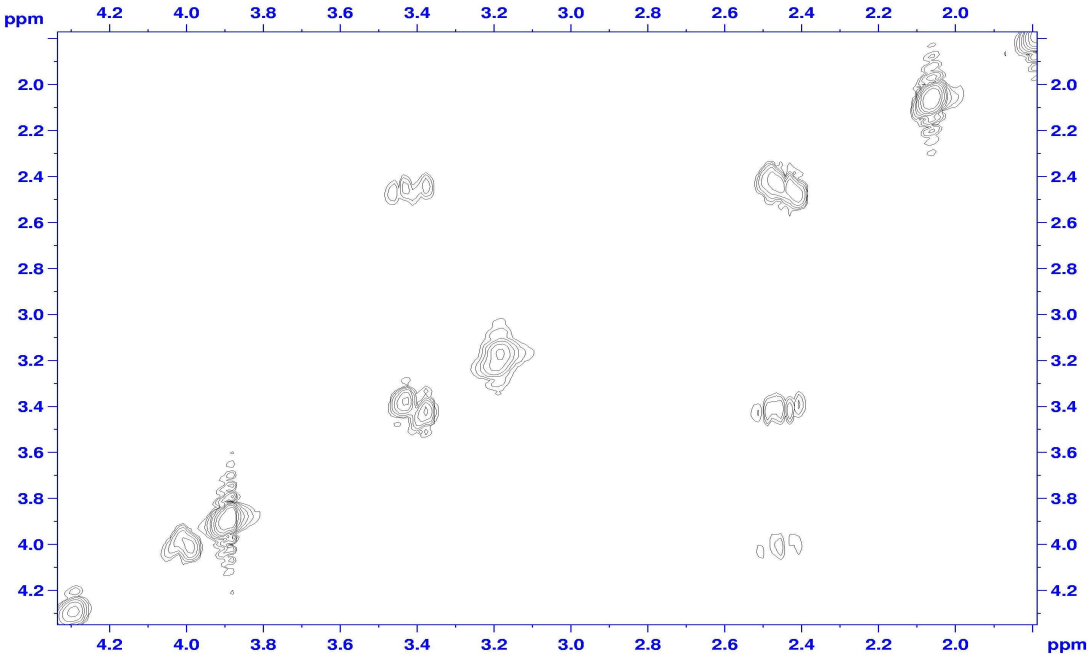


Figure 96 ^{1}H-^{1}H COSY spectrum of **AE12**

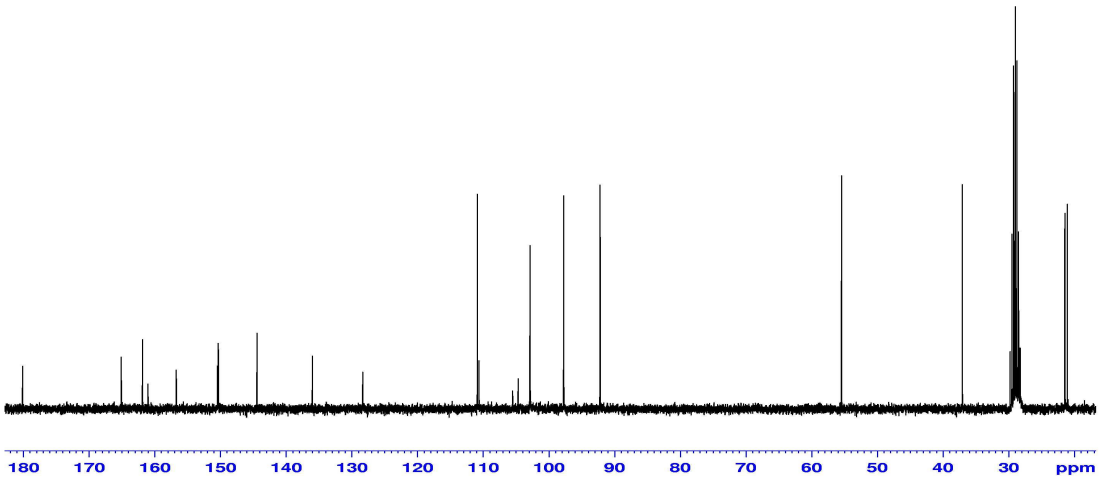


Figure 97 ^{13}C NMR (75 MHz) (Acetone-d_6) spectrum of **AE12**

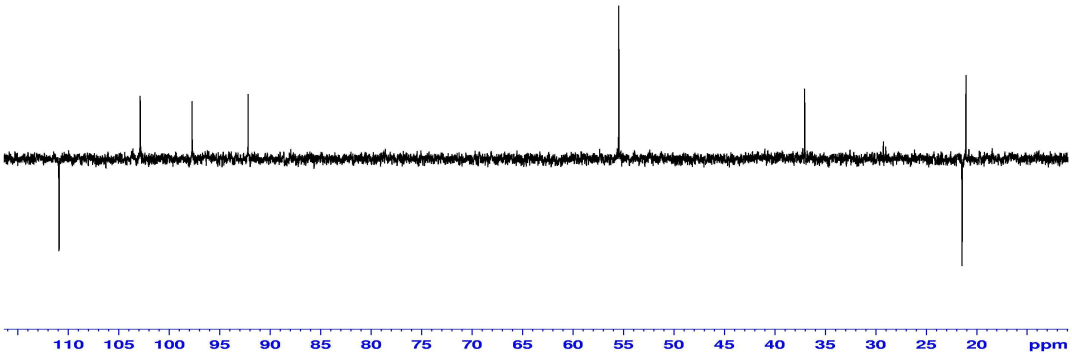


Figure 98 DEPT 135° (Acetone-d_6) spectrum of **AE12**

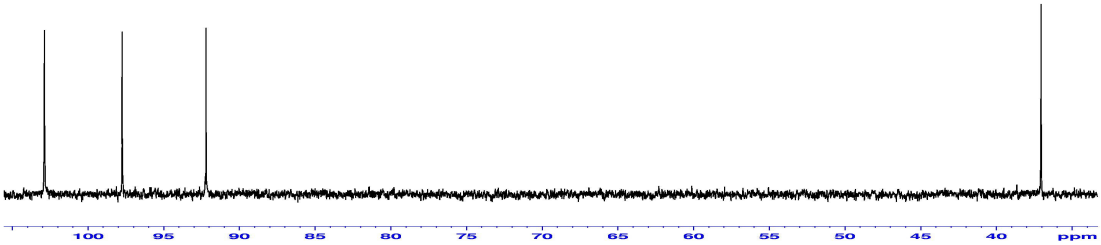


Figure 99 DEPT 90° (Acetone-d_6) spectrum of **AE12**

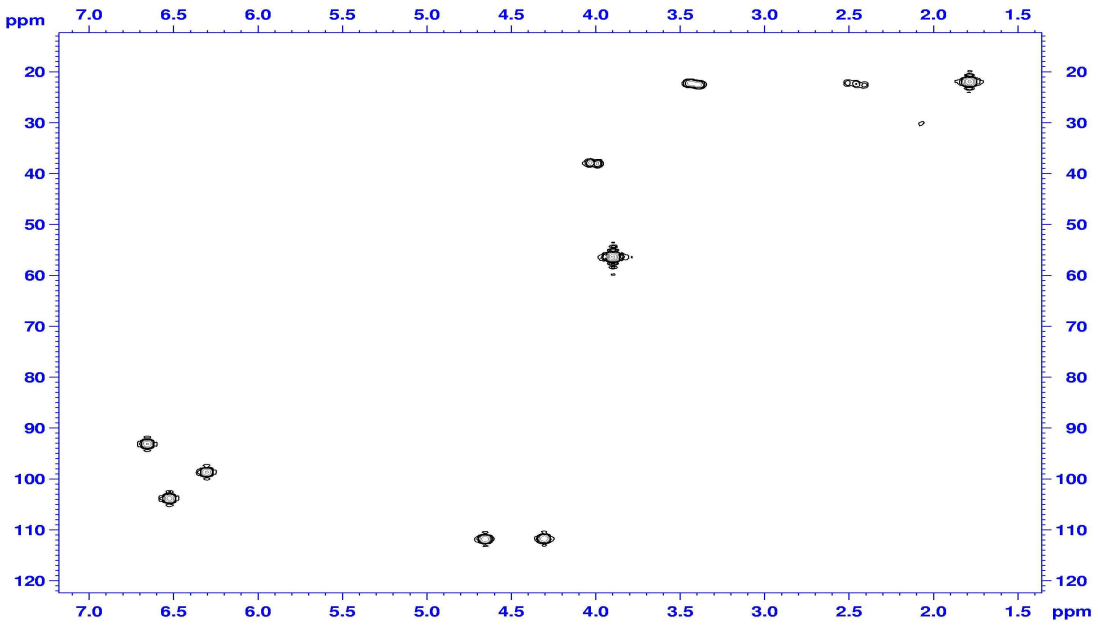


Figure 100 2D HMQC spectrum of **AE12**

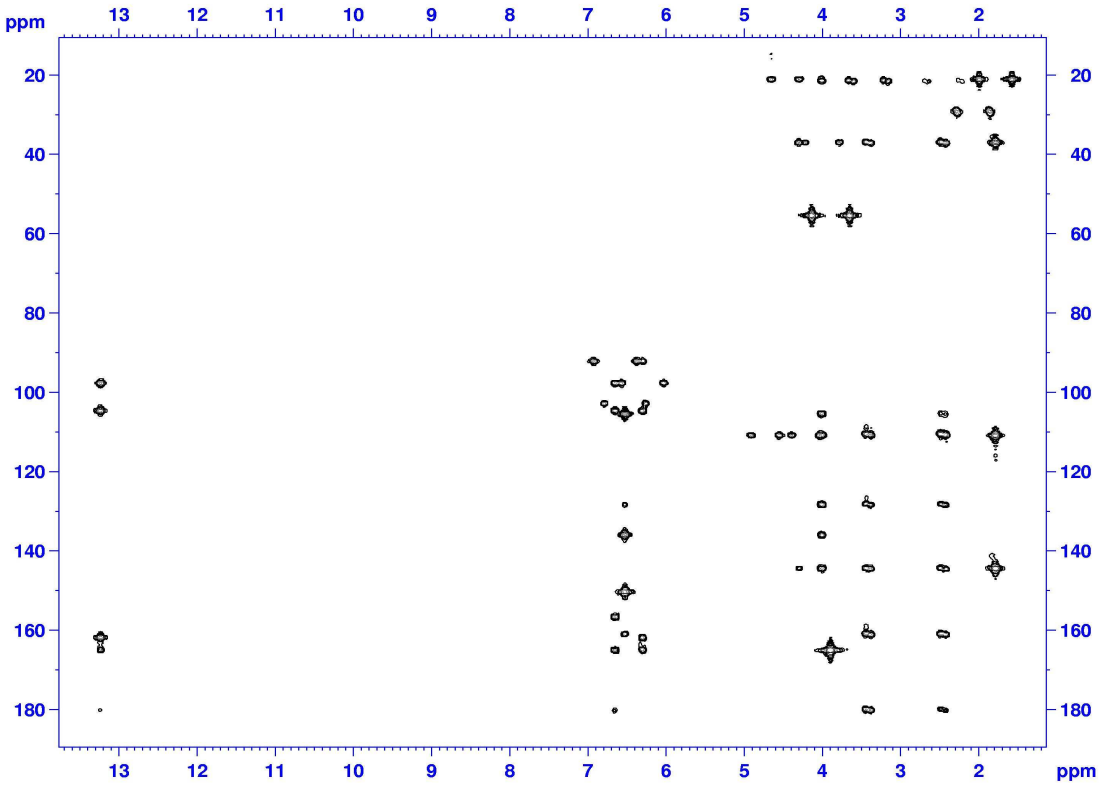


Figure 101 2D HMBC spectrum of **AE12**

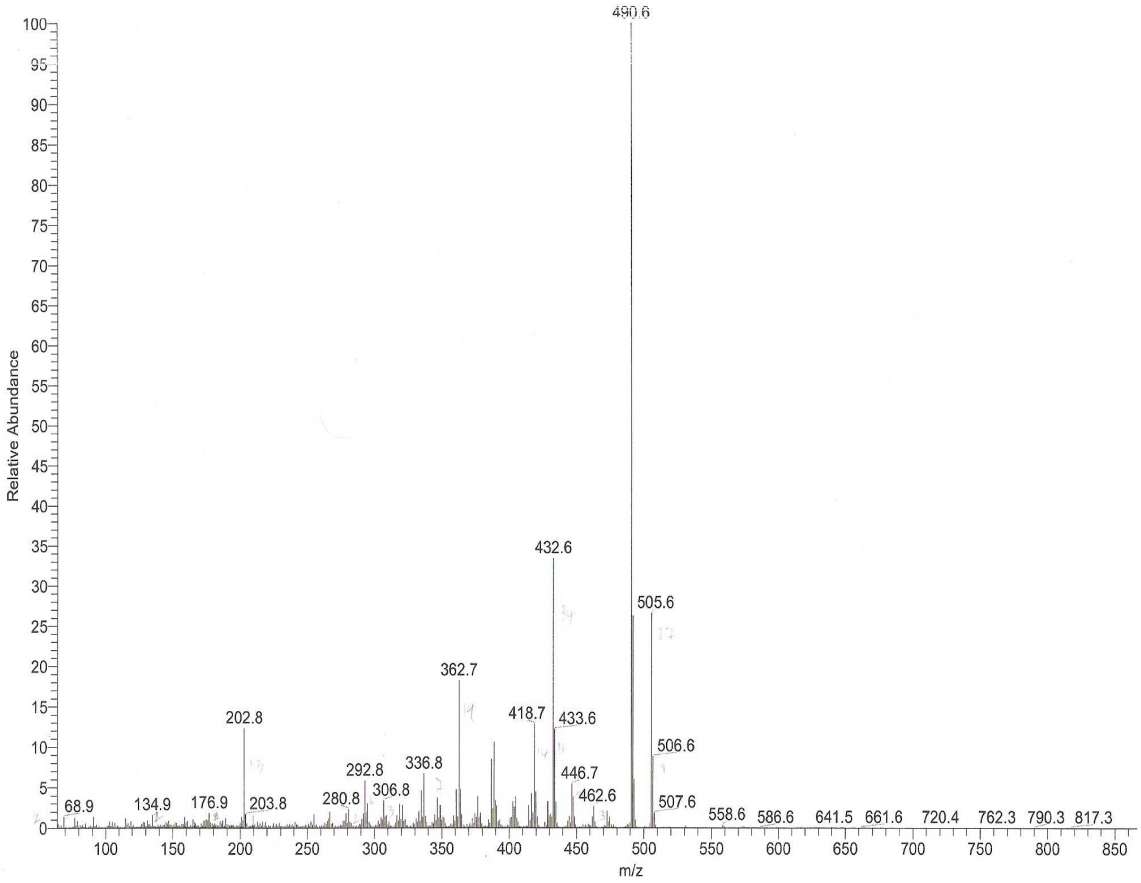


Figure 102 EI-MS spectrum of **AE13**

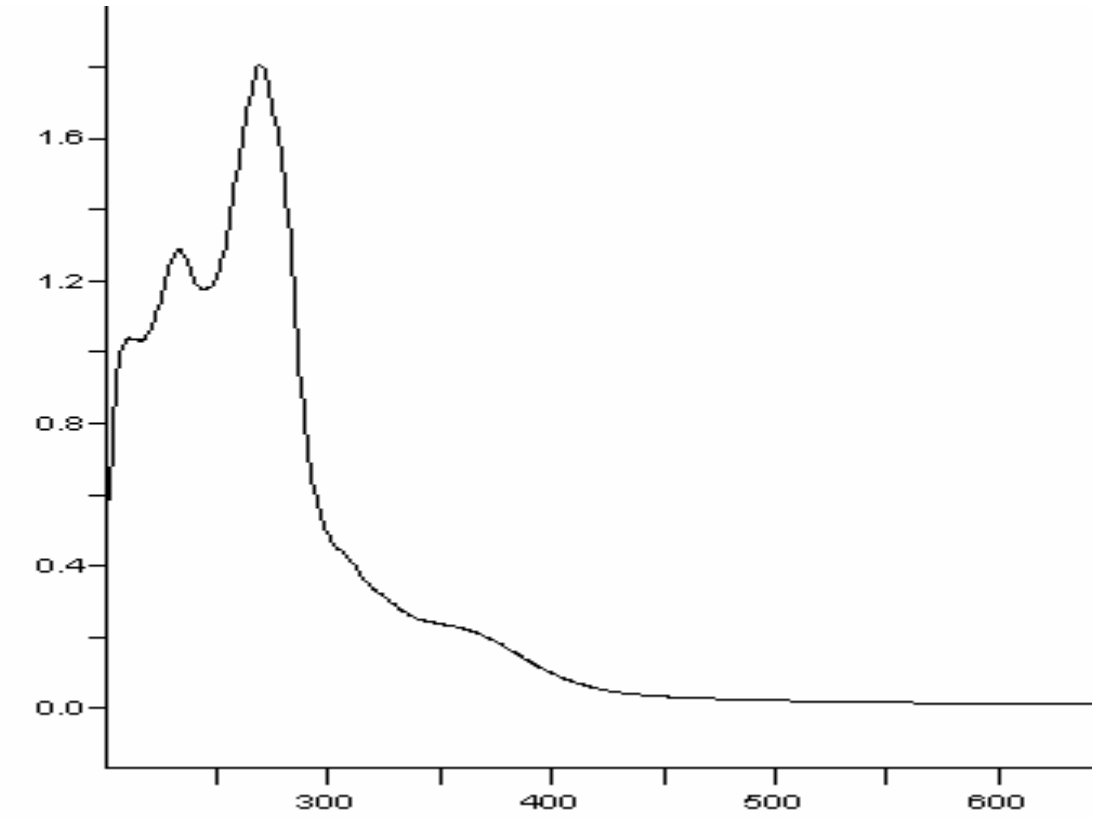


Figure 103 UV (EtOH) spectrum of **AE13**

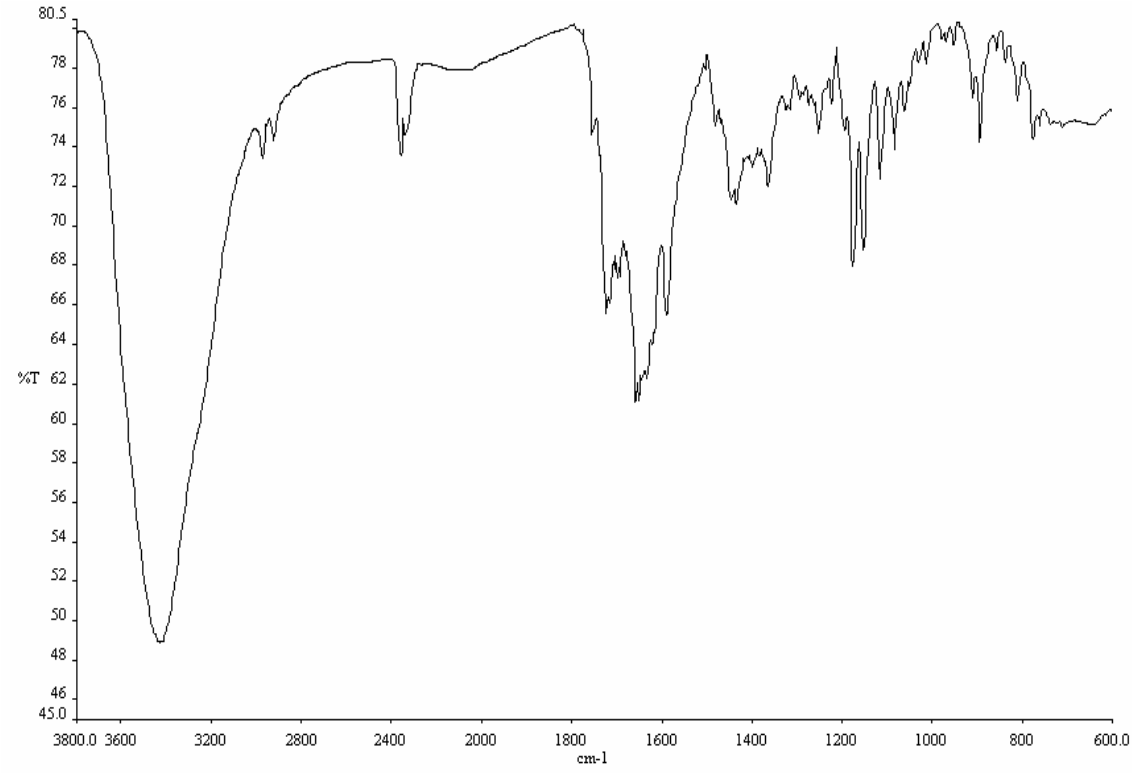


Figure 104 FT-IR (Neat) spectrum of **AE13**

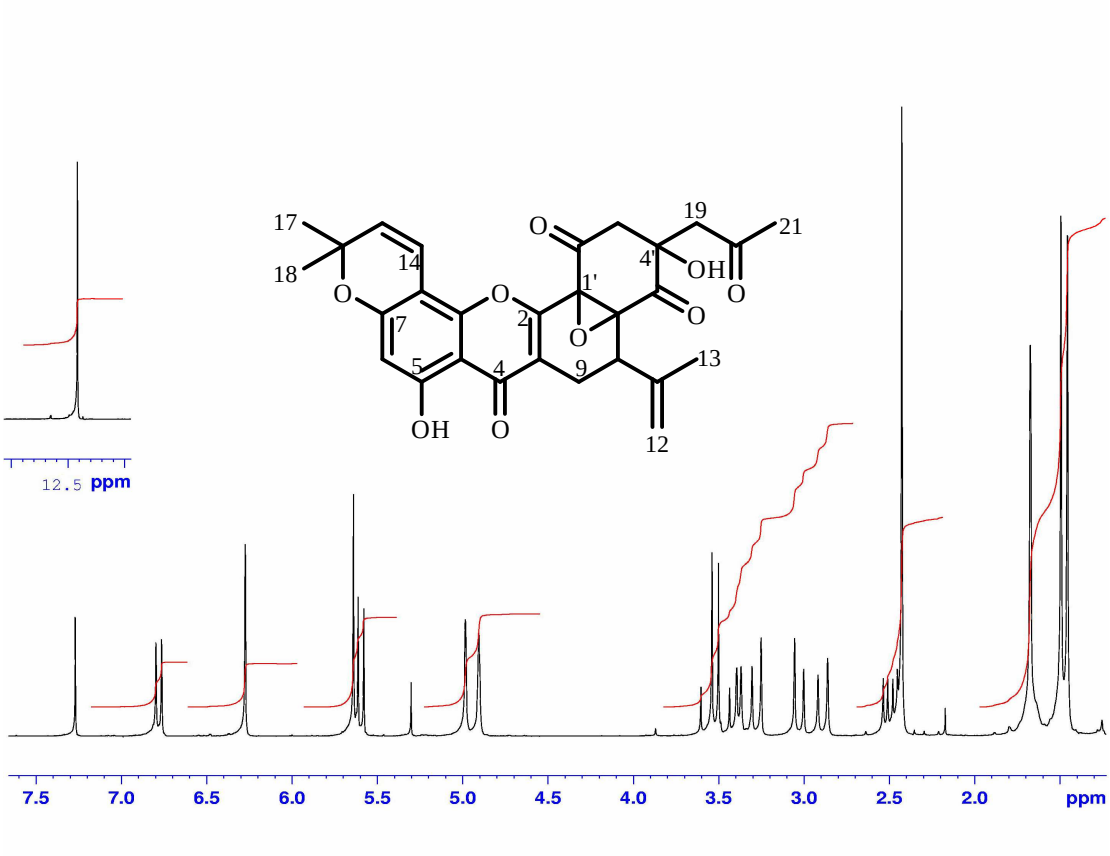


Figure 105 ^{1}H NMR (300 MHz) ($CDCl_3$) spectrum of **AE13**

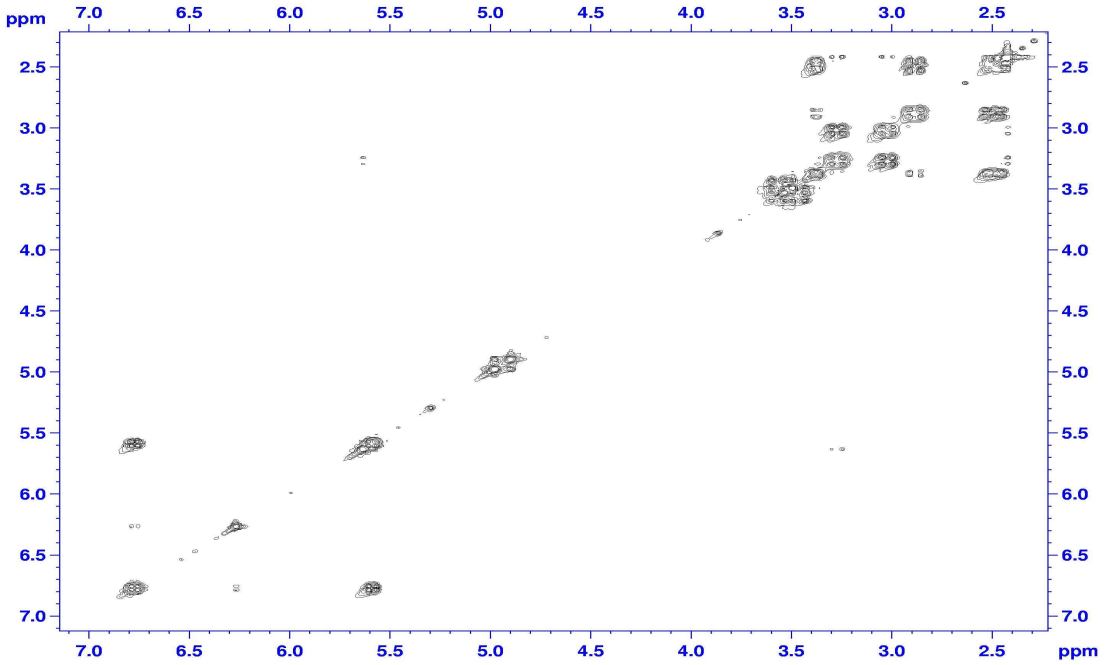


Figure 106 ^{1}H-^{1}H COSY spectrum of **AE13**

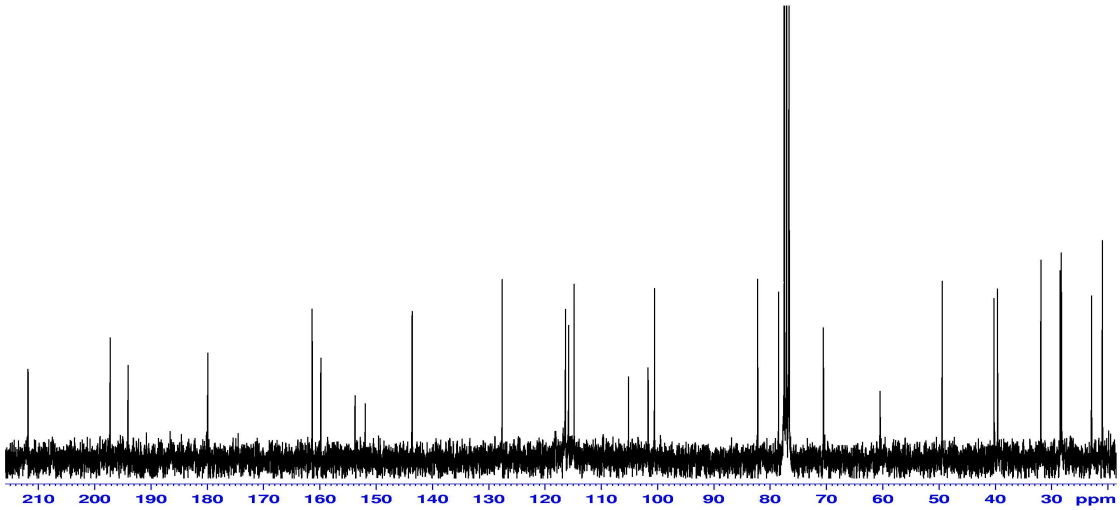


Figure 107 ^{13}C NMR (75 MHz) ($CDCl_3$) spectrum of **AE13**

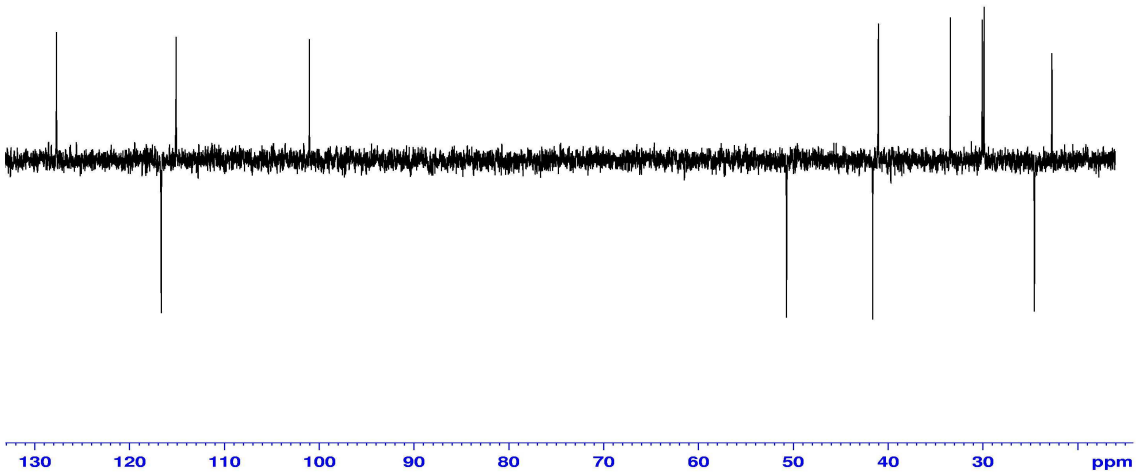


Figure 108 DEPT 135° ($CDCl_3$) spectrum of **AE13**

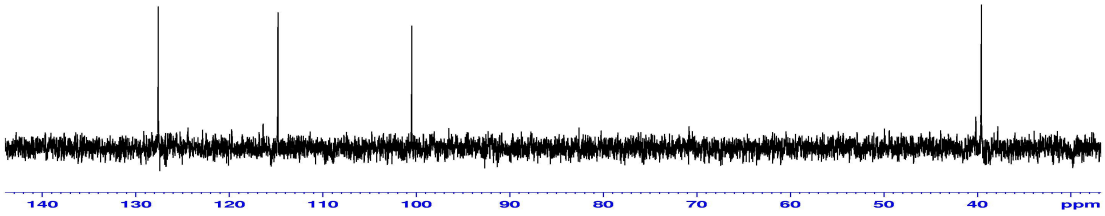


Figure 109 DEPT 90° ($CDCl_3$) spectrum of **AE13**

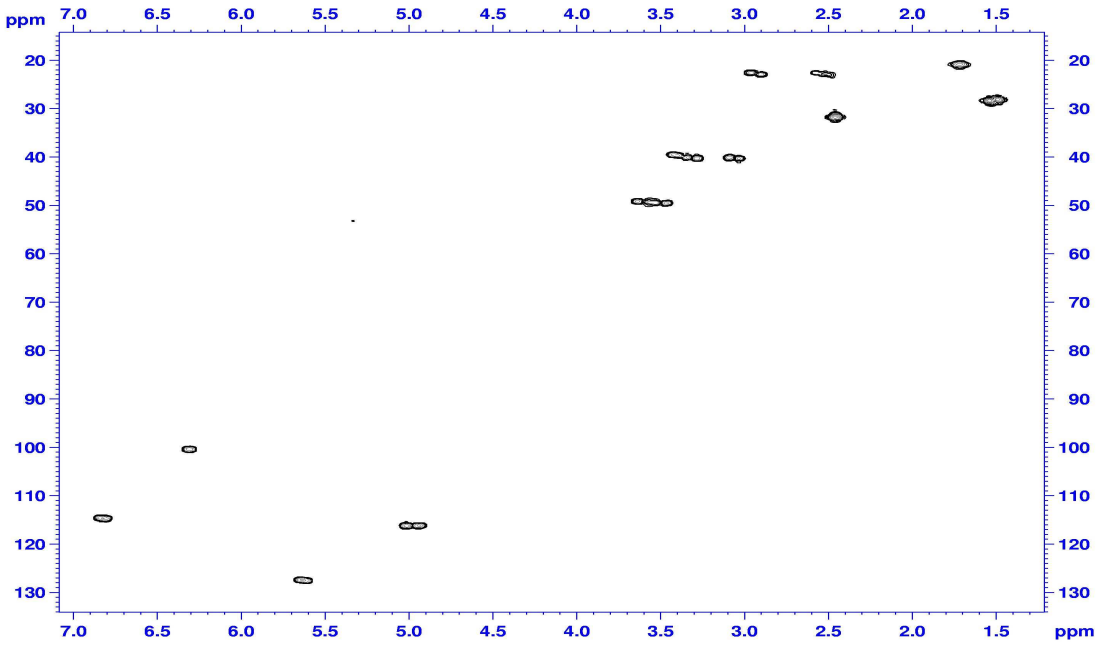


Figure 110 2D HMQC spectrum of **AE13**

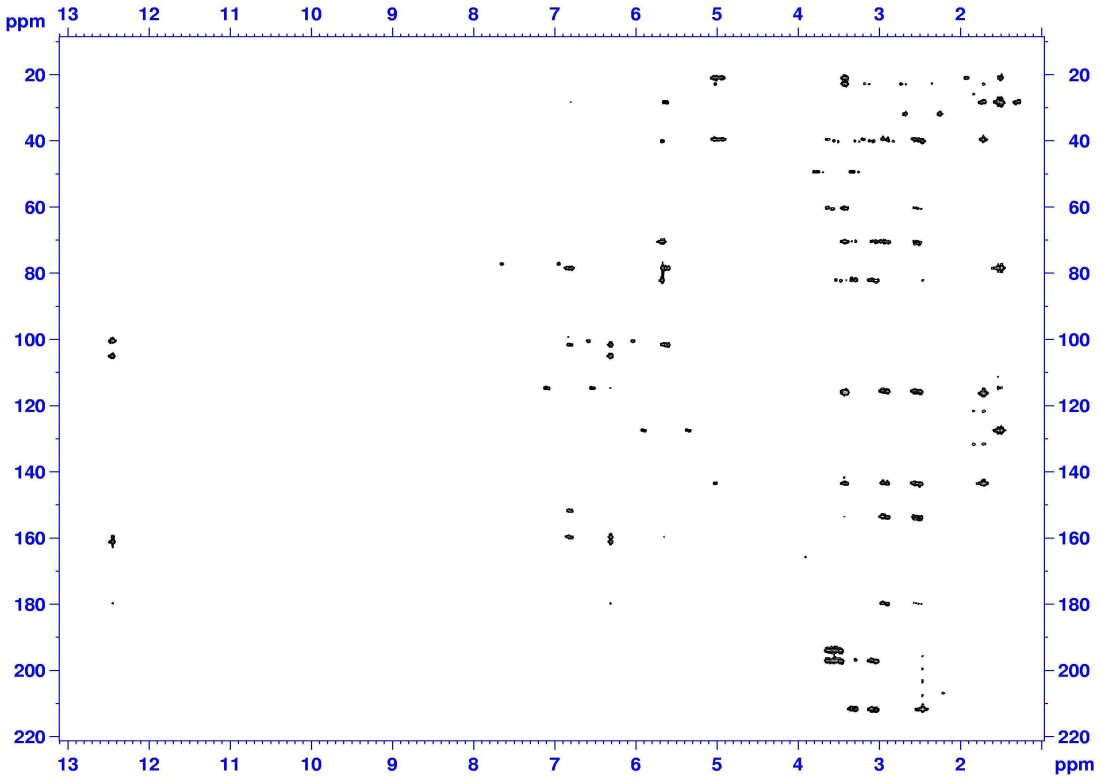


Figure 111 2D HMBC spectrum of **AE13**

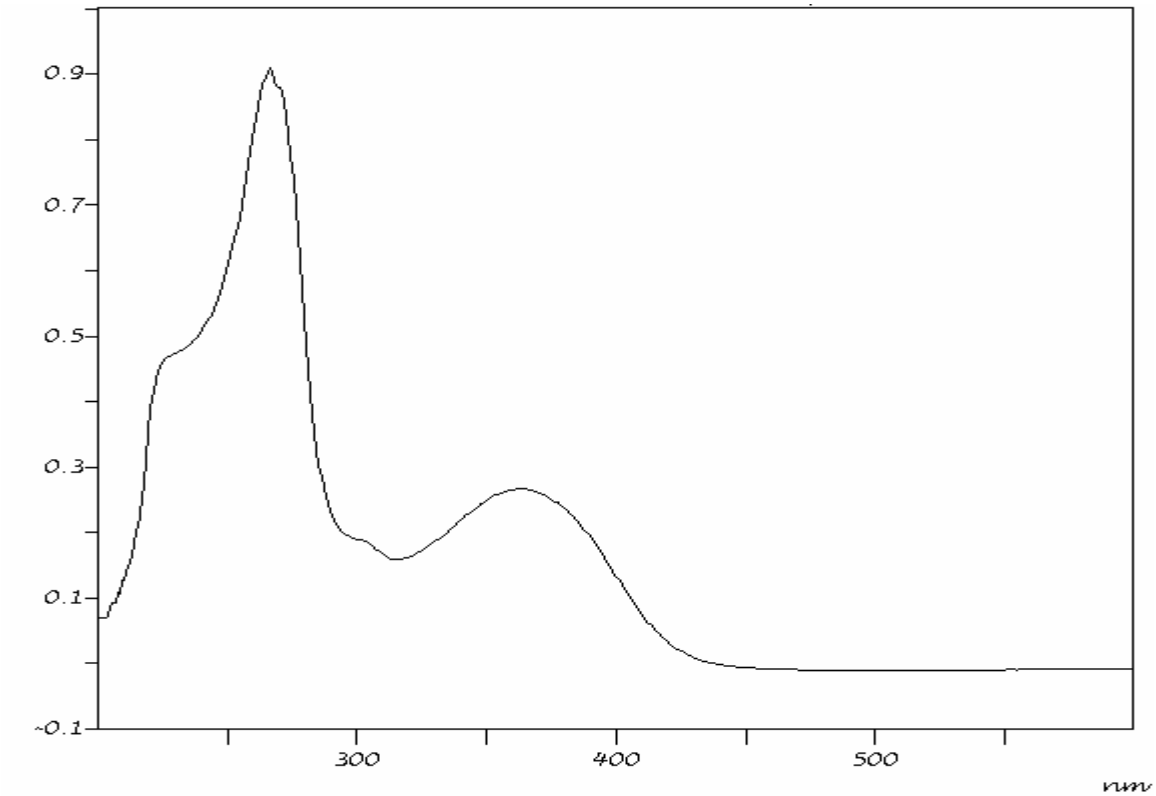


Figure 112 UV (CH_3OH) spectrum of **AE14**

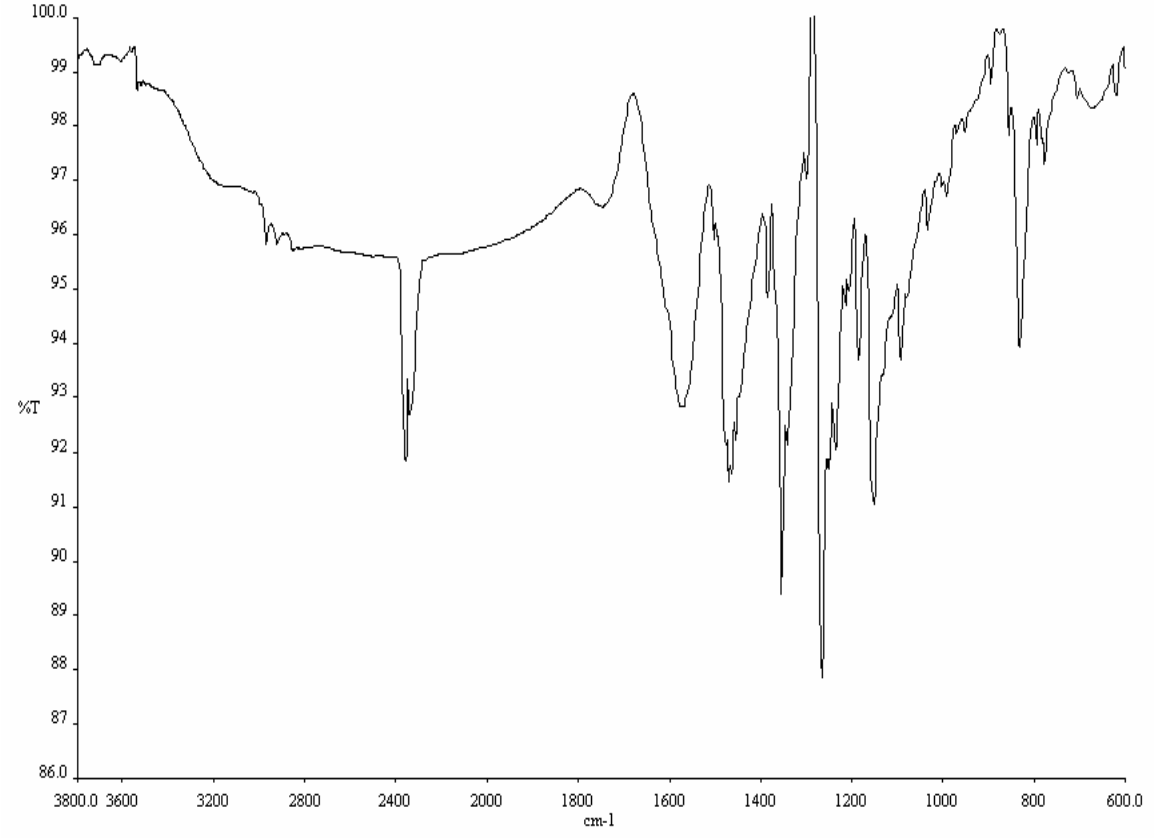


Figure 113 FT-IR (Neat) spectrum of **AE14**

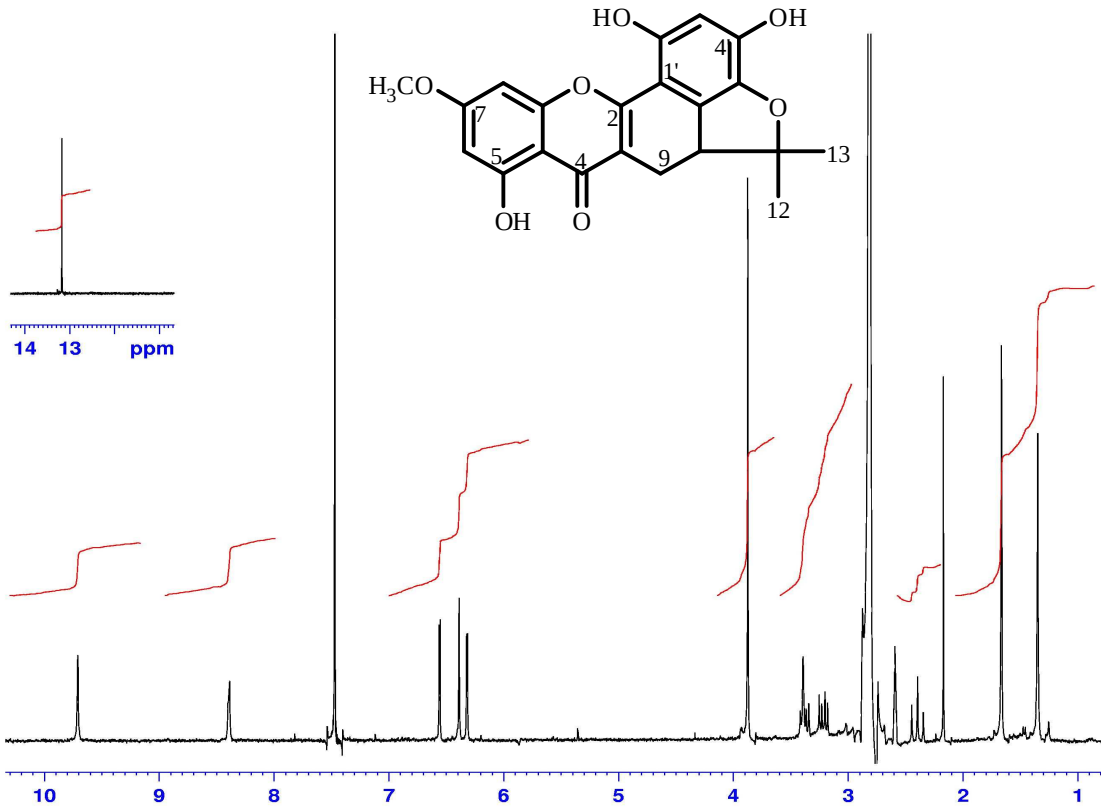


Figure 114 ^{1}H NMR (300 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE14**

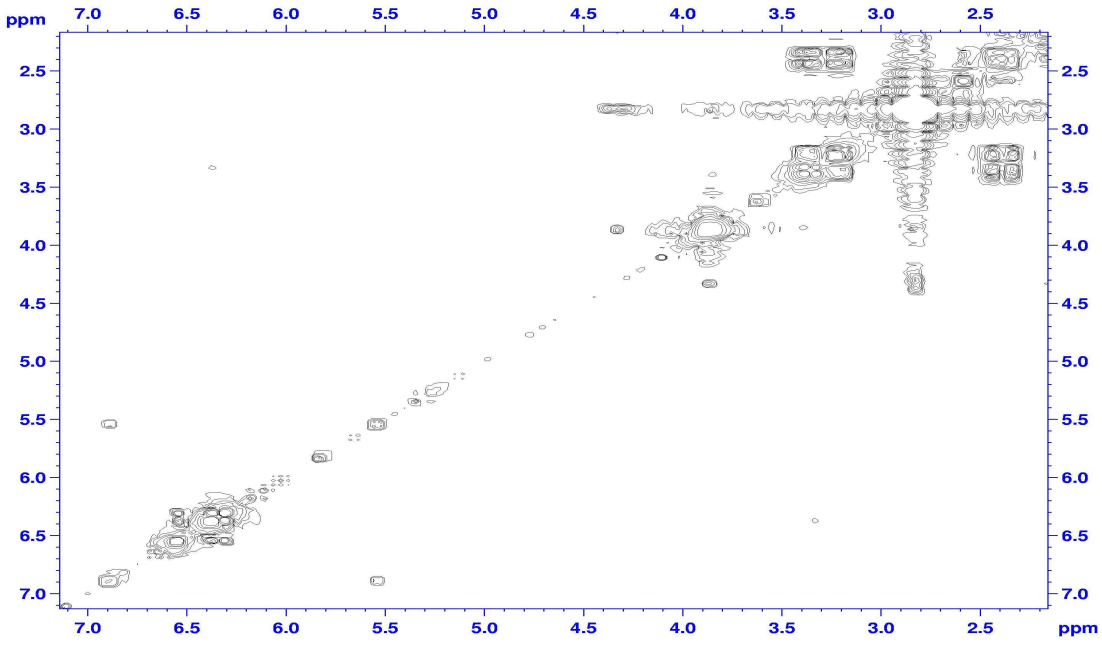


Figure 115 ^{1}H-^{1}H COSY spectrum of **AE14**

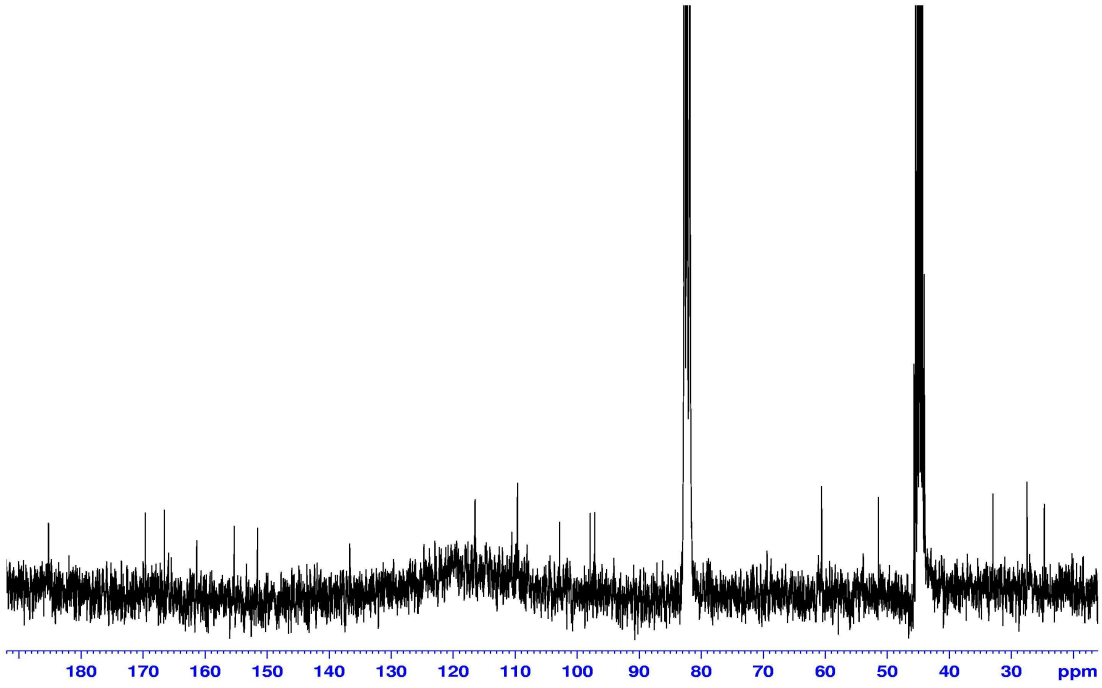


Figure 116 ^{13}C NMR (75 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE14**

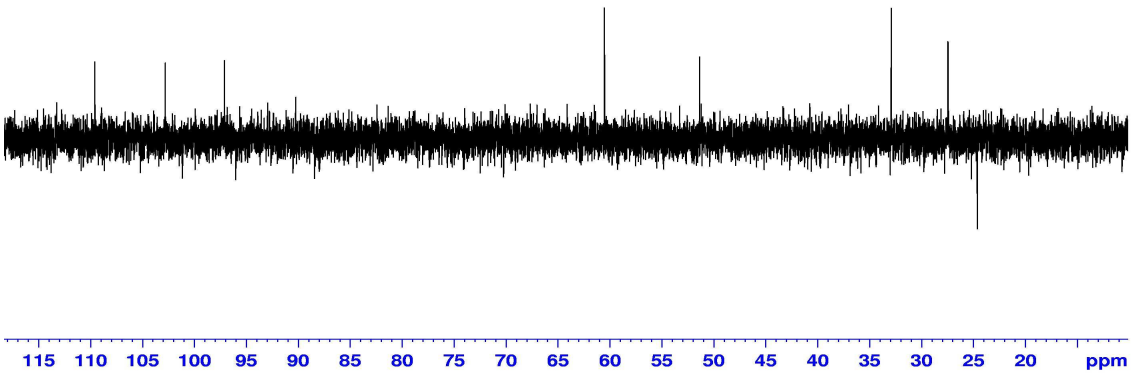


Figure 117 DEPT 135° ($CDCl_3$+DMSO-d_6) spectrum of **AE14**

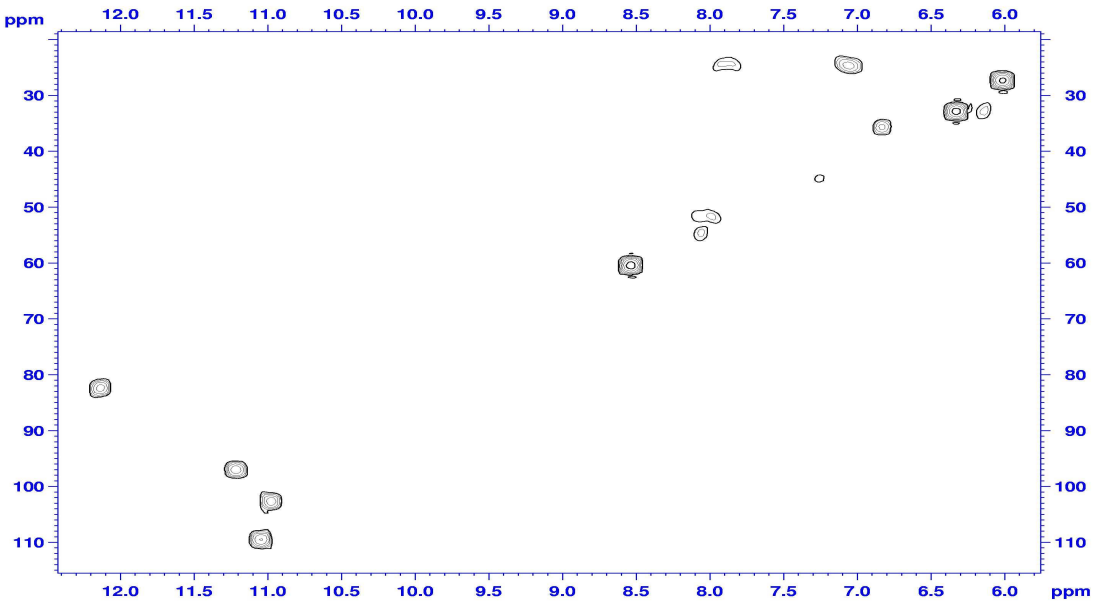


Figure 118 2D HMQC spectrum of **AE14**

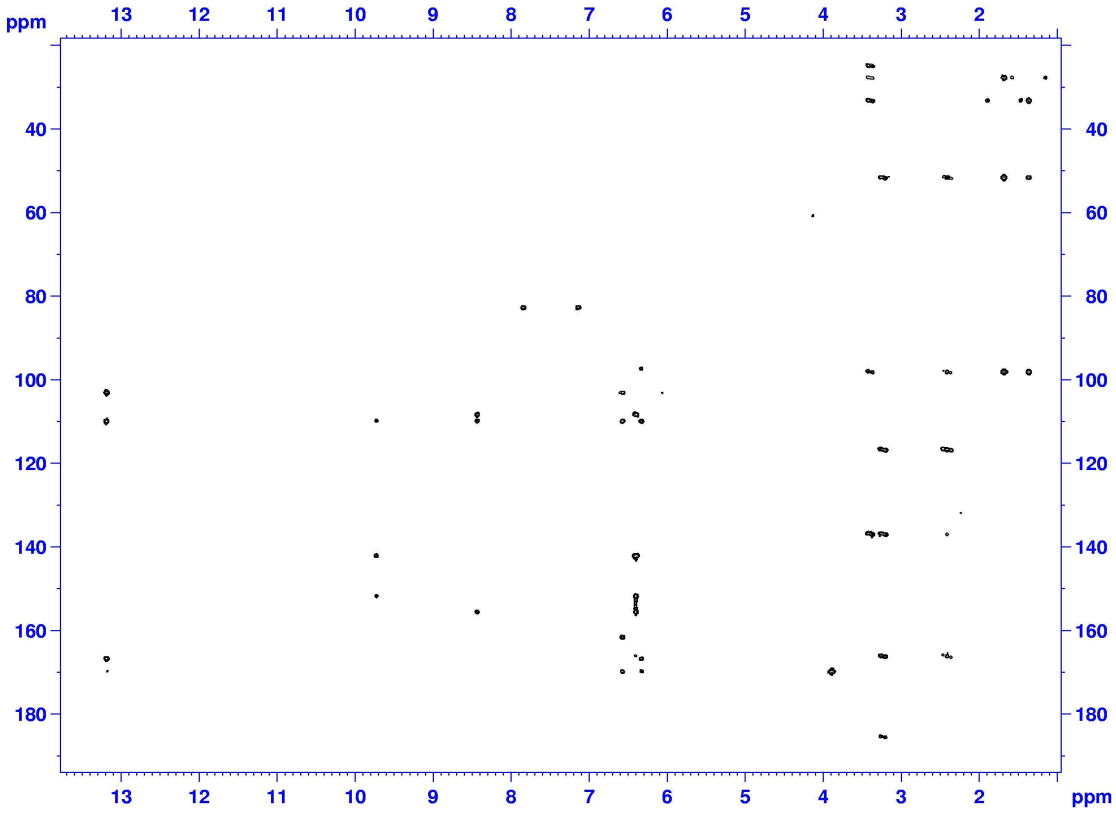


Figure 119 2D HMBC spectrum of **AE14**

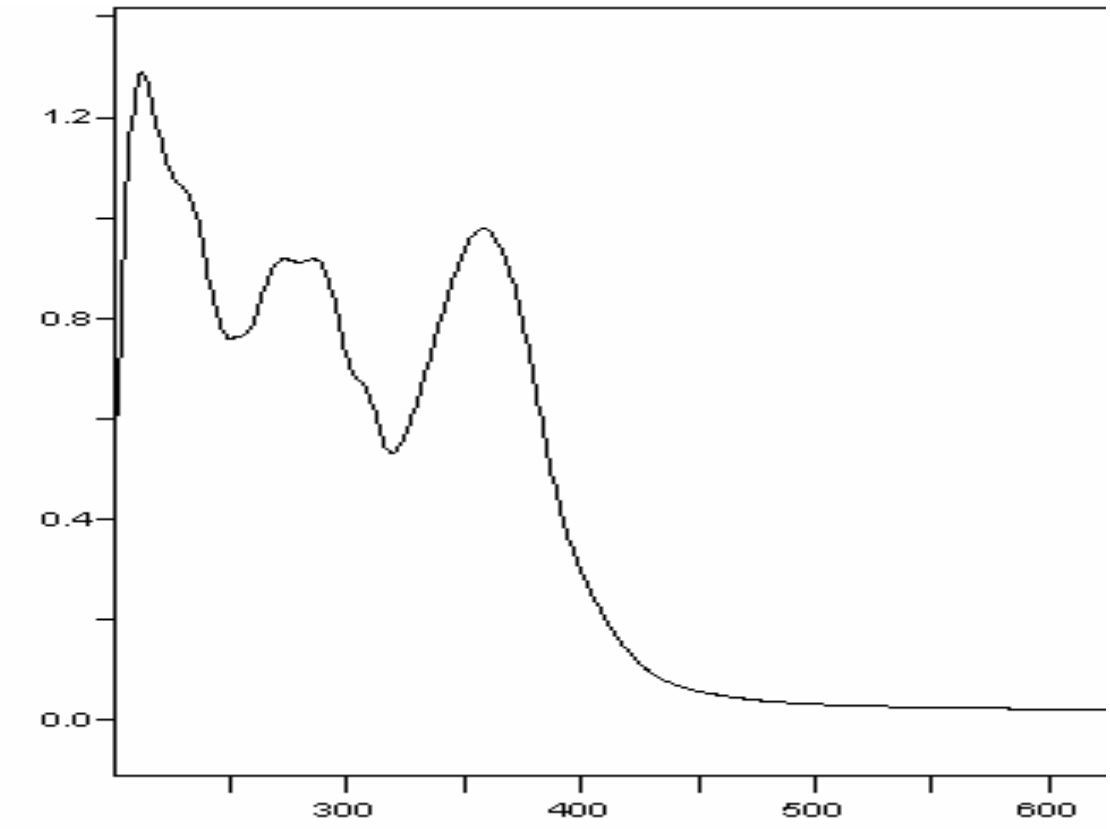


Figure 120 UV (EtOH) spectrum of **AE15**

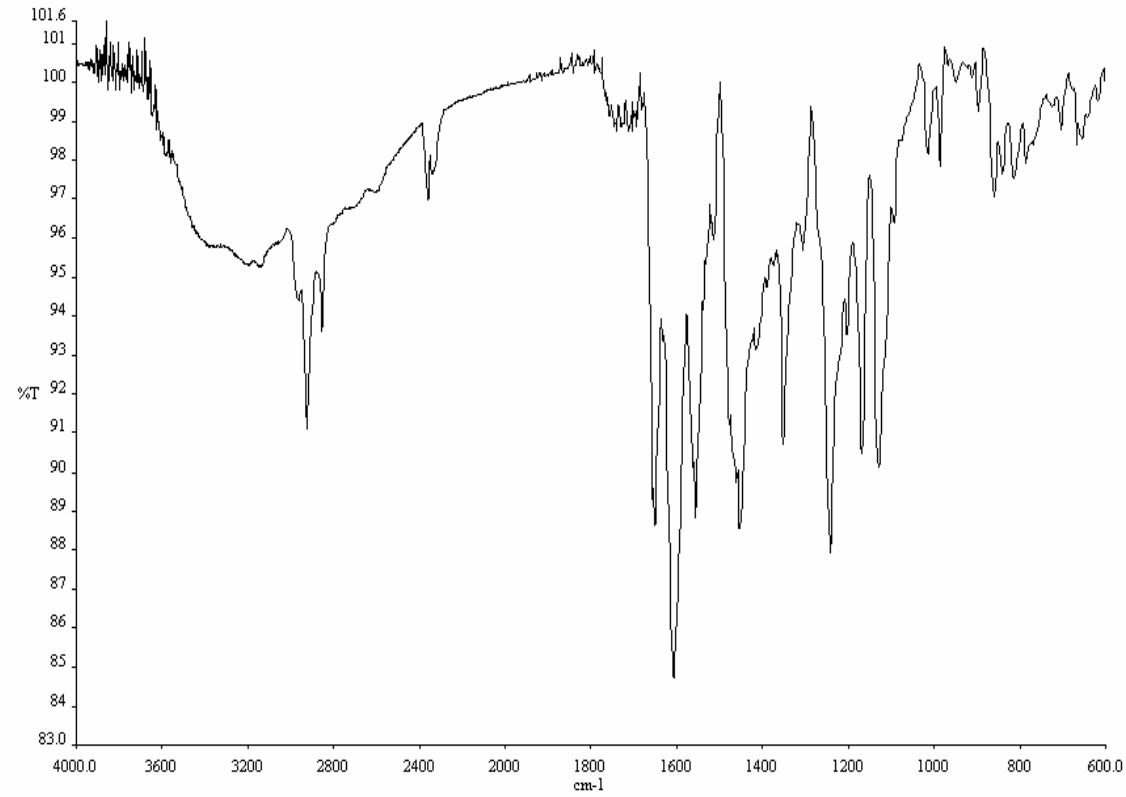


Figure 121 FT-IR (Neat) spectrum of **AE15**

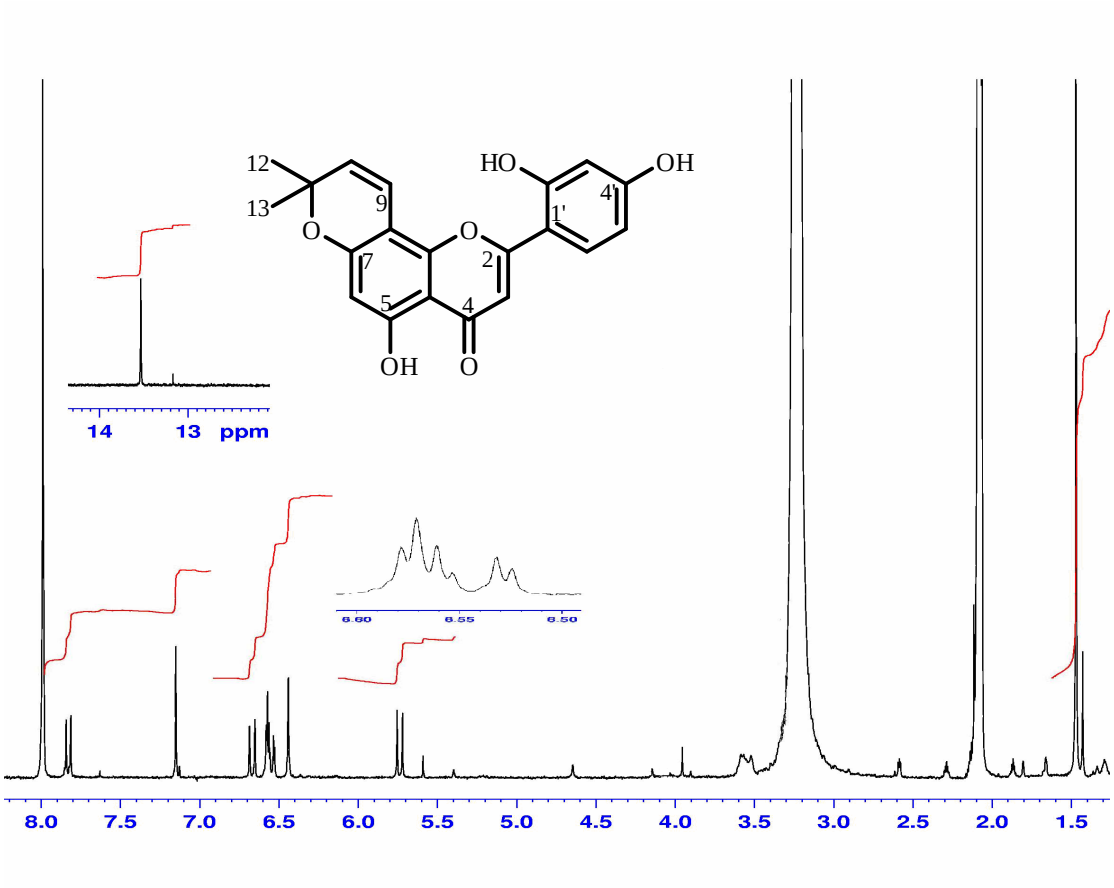


Figure 122 ^{1}H NMR (300 MHz) (Acetone-d_6) spectrum of **AE15**

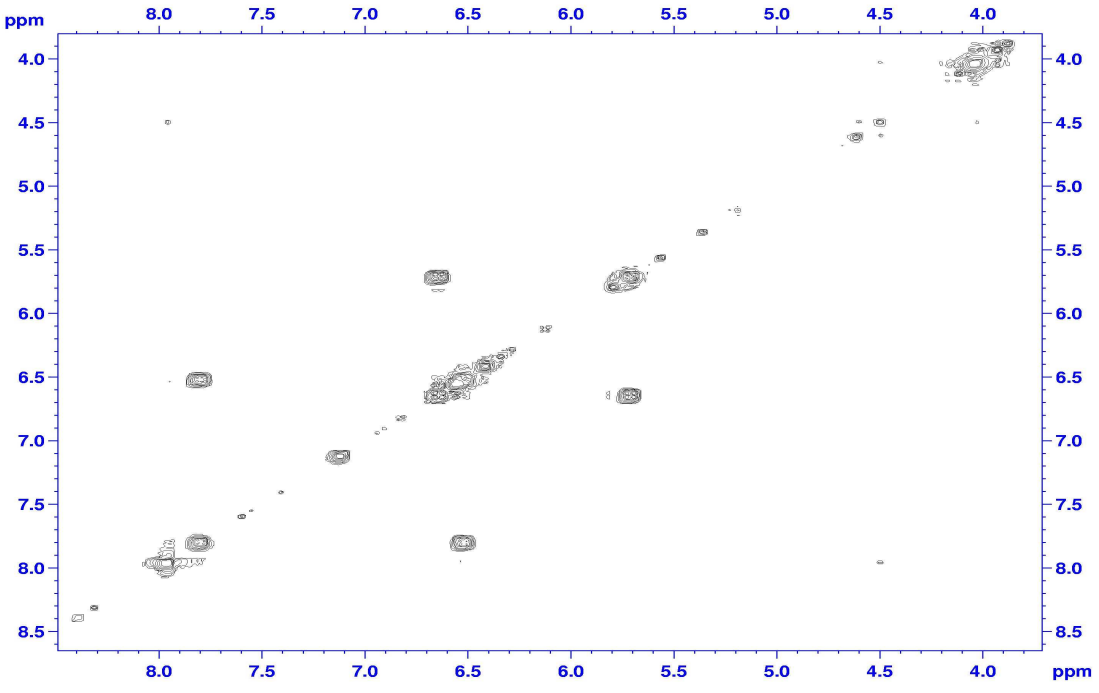


Figure 123 ^{1}H-^{1}H COSY spectrum of **AE15**

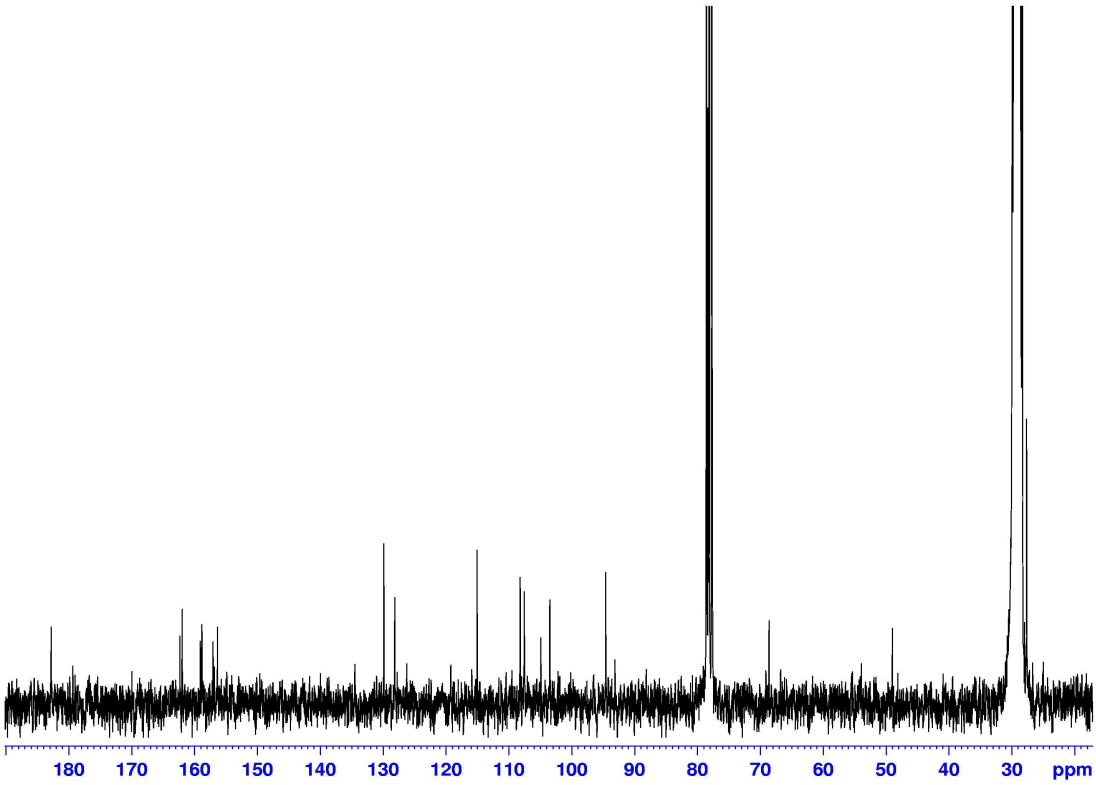


Figure 124 ^{13}C NMR (75 MHz) (Acetone-d_6) spectrum of **AE15**

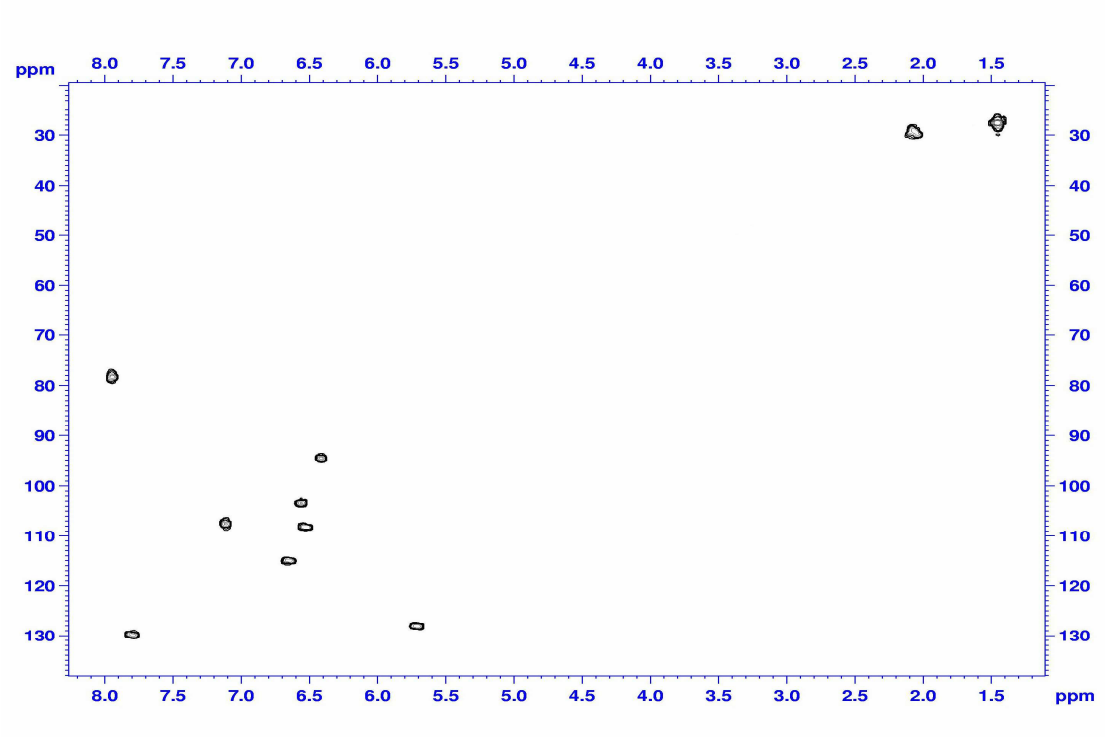


Figure 125 2D HMQC spectrum of **AE15**

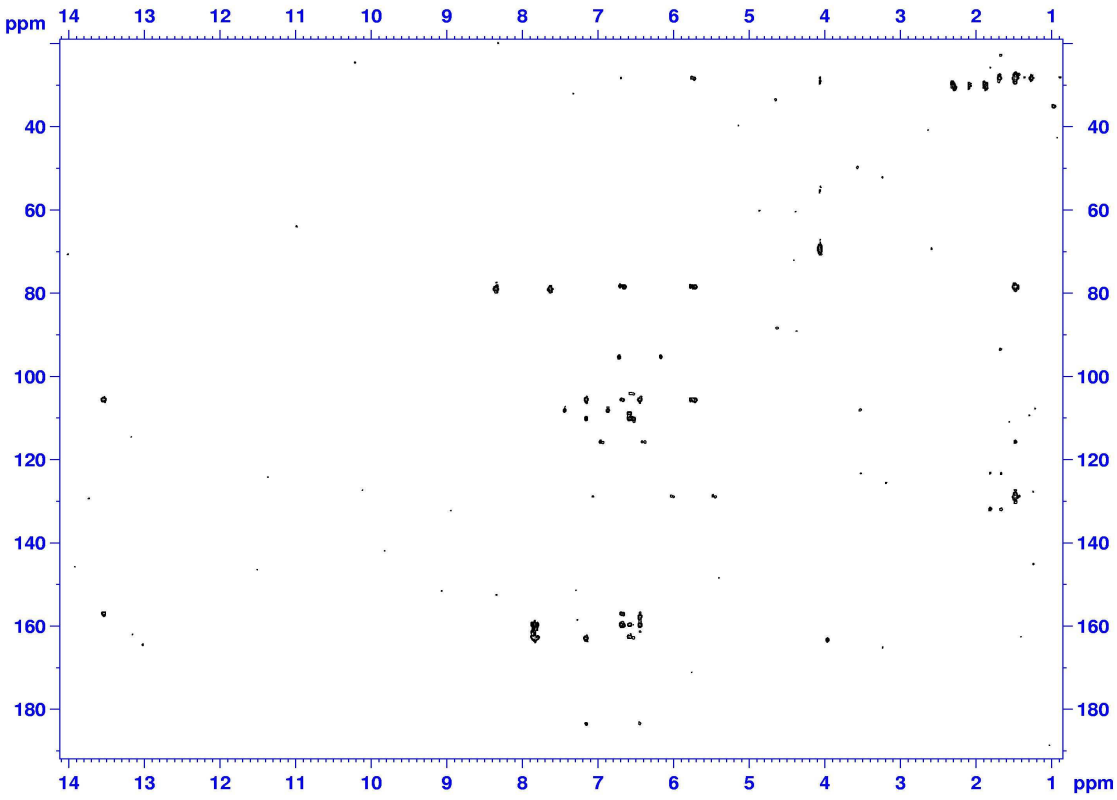


Figure 126 2D HMBC spectrum of **AE15**

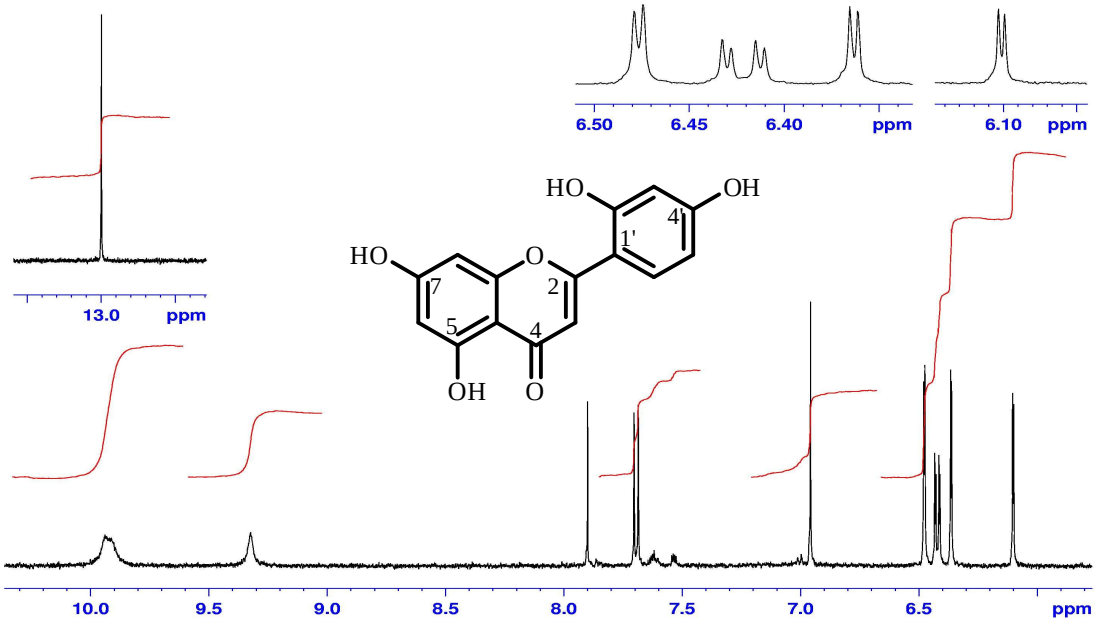


Figure 127 ^{1}H NMR (500 MHz) ($CDCl_3$) spectrum of **AE16**

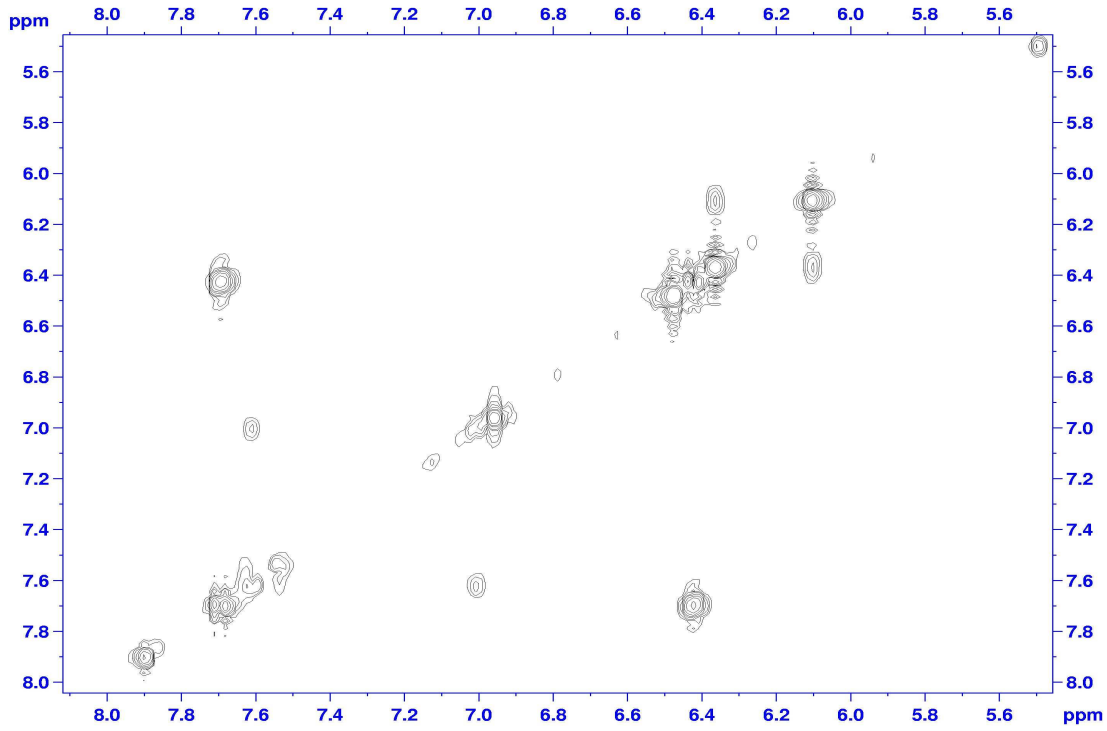


Figure 128 ^{1}H-^{1}H COSY spectrum of **AE16**

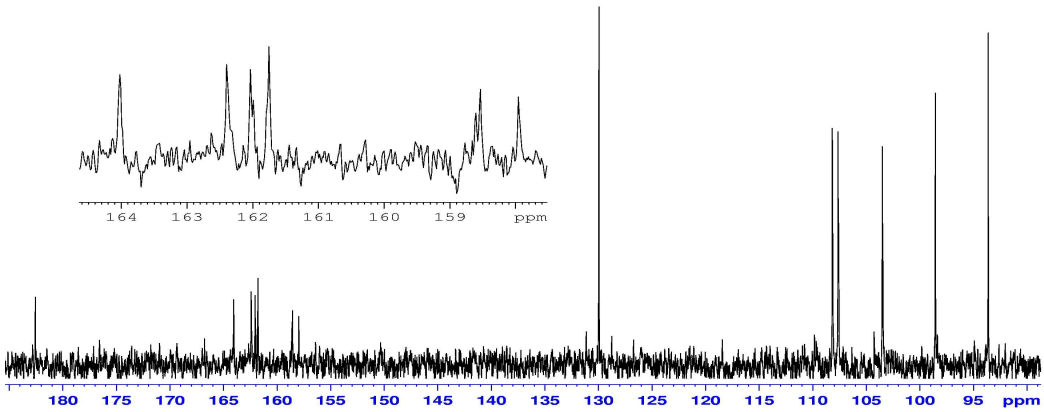


Figure 129 ^{13}C NMR (125 MHz) ($CDCl_3$+DMSO-d_6) spectrum of **AE16**

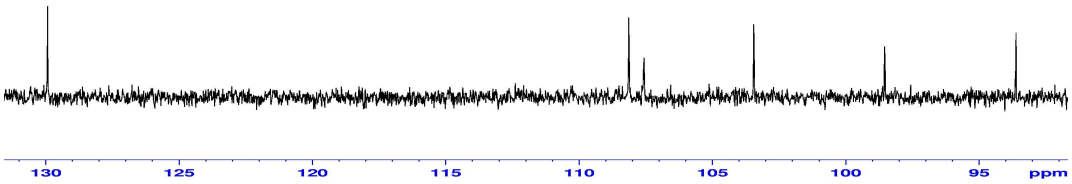


Figure 130 DEPT 135° ($CDCl_3$+DMSO-d_6) spectrum of **AE16**

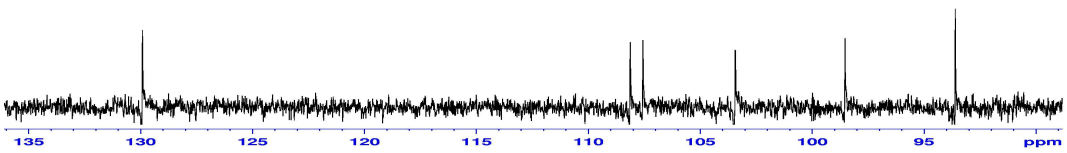


Figure 131 DEPT 90° ($CDCl_3$+DMSO-d_6) spectrum of **AE16**

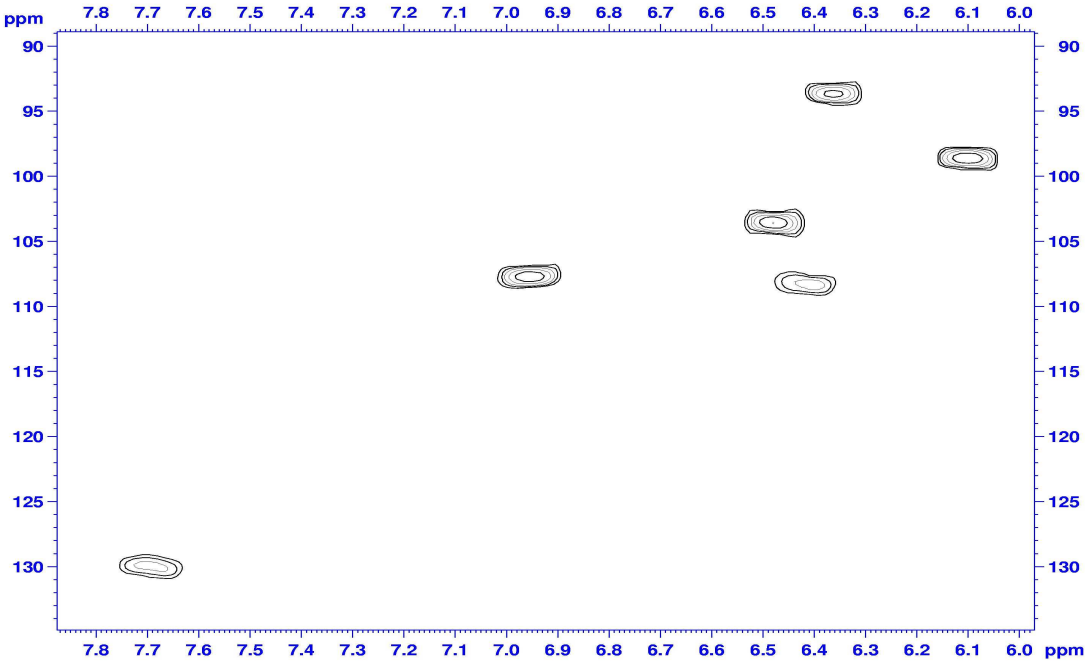


Figure 132 2D HMQC spectrum of **AE16**

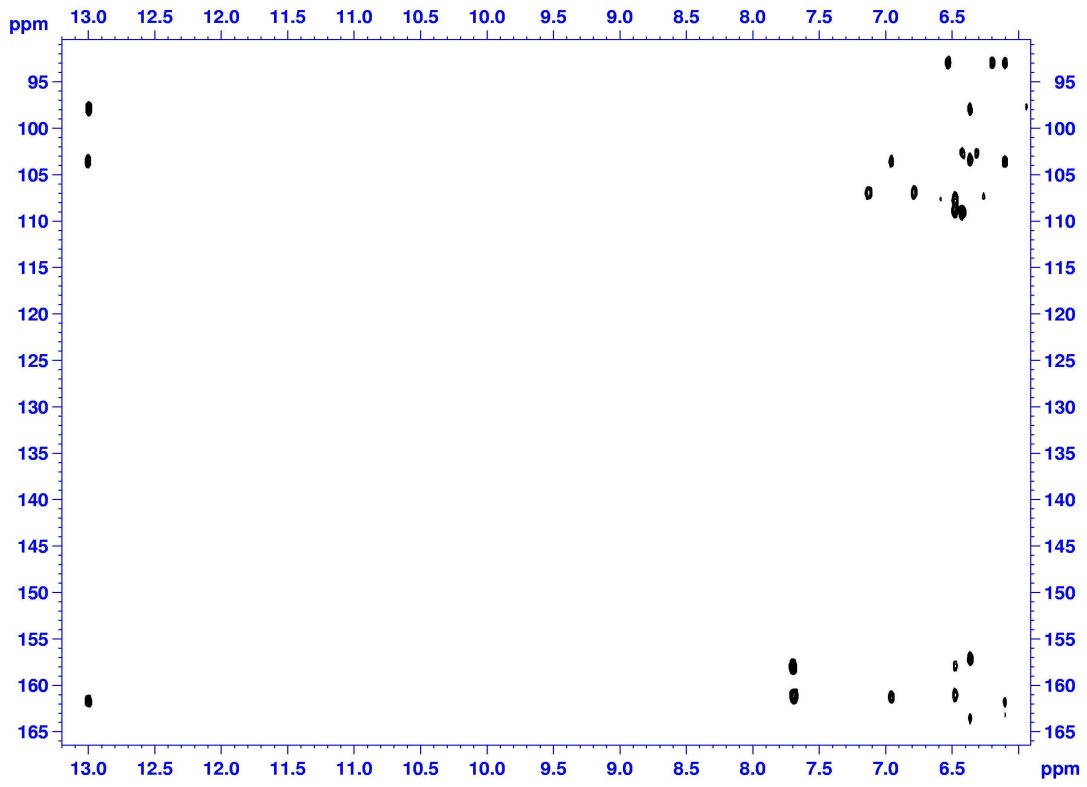


Figure 133 2D HMBC spectrum of **AE16**

VITAE

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B.Sc. (Chemistry)	Prince of Songkla University	2006

Scholarship Awards during Enrolment

Center of Excellence for Innovation in Chemistry (PERCH-CIC), Commission on Higher Education, Ministry of Education

List of Publications and Proceedings

1. A. Yanya and W. Mahabusarakam. "Prenylated Flavonoids from the Bark of *Artocarpus elasticus*". The 6th IMT-GT UNINET CONFERENCE 2008, The Gurney Resort Hotel & Residences Penang, Penang, Malaysia, 28-30 August 2008. (Poster presentation)
2. Aeesoh Yanya and Wilawan Mahabusarakam. "Prenylated Flavones from the Bark of *Artocarpus elasticus*". 4th National Grade Research Conference, Burapha University, Chonburi, Thailand, 13 March 2009. (Poster presentation)