CHAPTER II

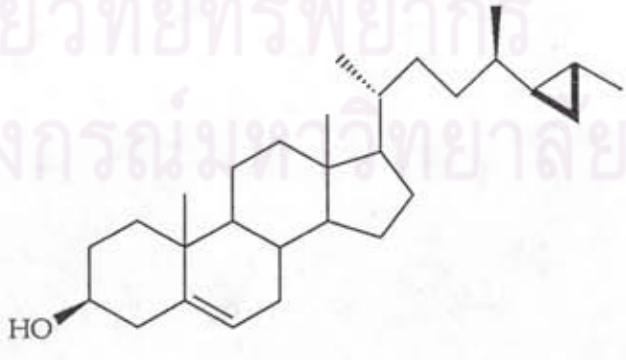
HISTORICAL

1. The Investigation of Chemical Constituents in the *Petrosia*

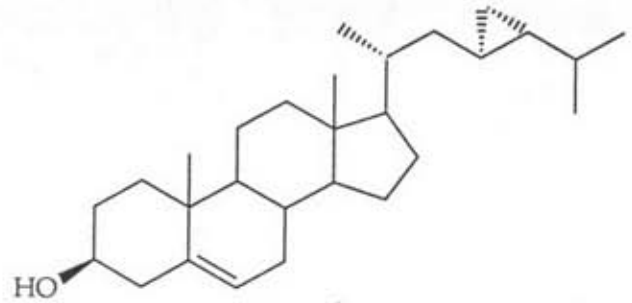
Chemical constituents isolated from the genus *Petrosia* sponges were reported as sterols, fatty acids, aldehydes, alkaloids and acetylenic compounds. The occurrence of these compounds are described as the followings.

1.1 Sterols

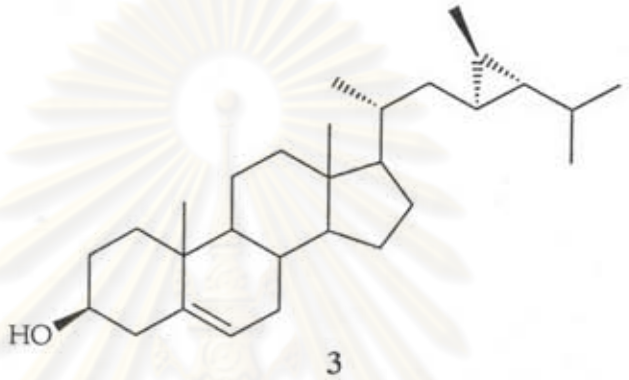
Sponges were the first invertebrates shown to contain sterols other than cholesterol. In light of the rich diversity of sponge sterols, their use in chemotaxonomy has been investigated (Kerr and Baker, 1991). For many years the carbon range of sterols extended from C_{27} to C_{29} (Scheuer, 1973), but discoveries of a norcholesterol and of baikalosterol increased the carbon range of sponge sterols from C_{26} to C_{32} (Kerr and Baker, 1991). For *Petrosia* spp., the carbon range of their sterols varied from C_{26} to C_{30}. The most intriguing feature was the presence of cyclopropanes, such as petrosterol (**1**), initially isolated from *Petrosia ficiformis* (Mattia et al., 1978; Ravi et al., 1978; Sica and Zollo, 1978), 23(*R*), 24(*R*)-methylenecholesterol (**2**) (Proudfoot and Djerassi, 1984), 23,24-dihydrocalysterol (**3**) from *P. ficiformis* (Siedel, Proudfoot and Djerassi, 1986), 5α–petrostanol (**4**), hebesterol (**5**) and 23, 24-dihydro-5α-calystanol (**6**) from *P. hebes* (Cho and Djerassi, 1987).



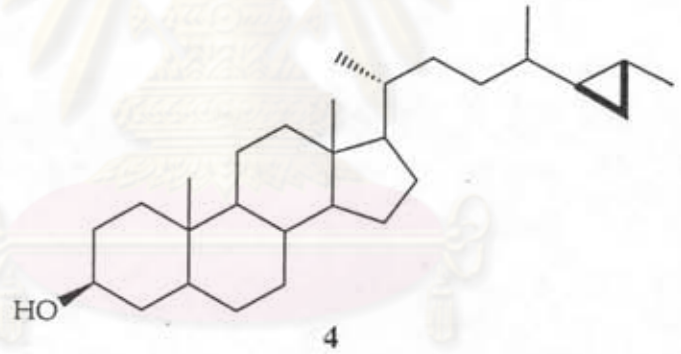
1



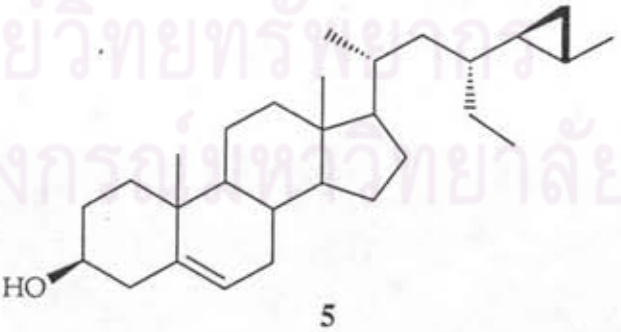
2



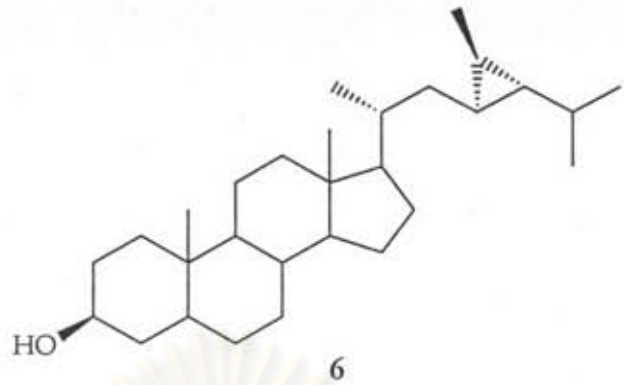
3



4

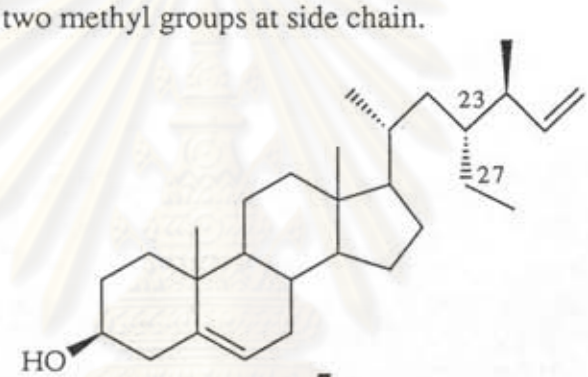


5

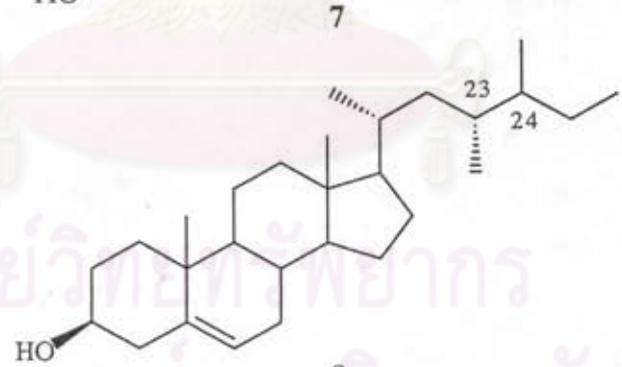


6

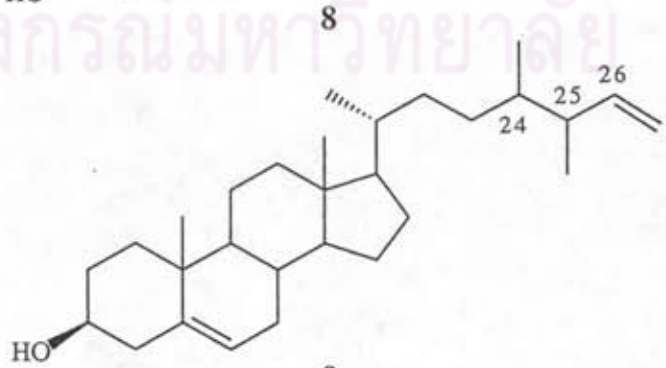
Also, alkylation could occur at all carbons of the cholesterol side chain (C_{22}-C_{27}). For example: ficisterol (**7**) had a 23-ethyl group, norficisterol (**8**) (Khalil et al., 1980) and (24*R*, 25*R*)-24,26-dimethylcholesta-5,26-dien-3β-ol (**9**) (Khalil, Djerassi and Sica, 1980) had two methyl groups at side chain.



7

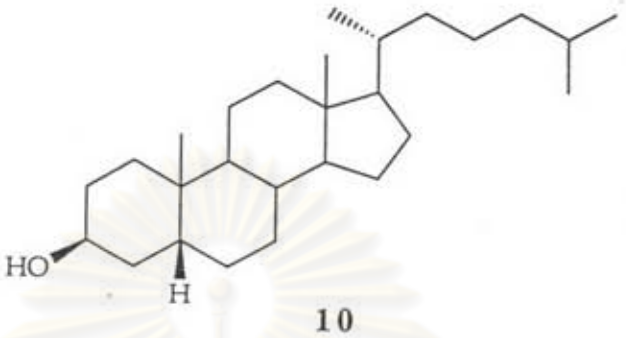


8



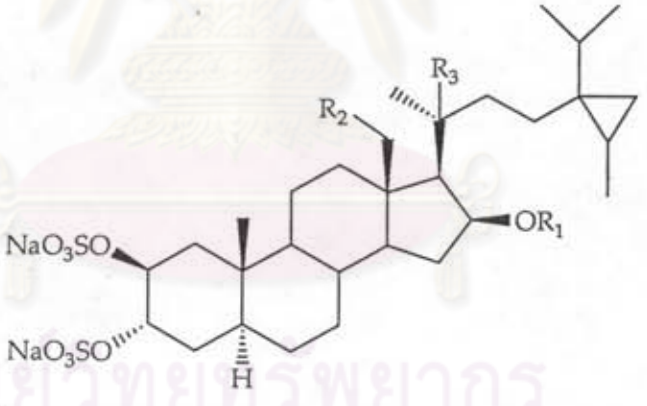
9

Other unconventional sponge sterols included $\Delta^{5,26}$ sterols (**9**) of *P. ficiformis* (Khalil, Djerassi and Sica, 1980) and 5β-stanols such as coprostanol (5β-cholestan-3β-ol) (**10**) of *P. ficiformis* (Seidel, Proudfoot and Djerassi, 1986).

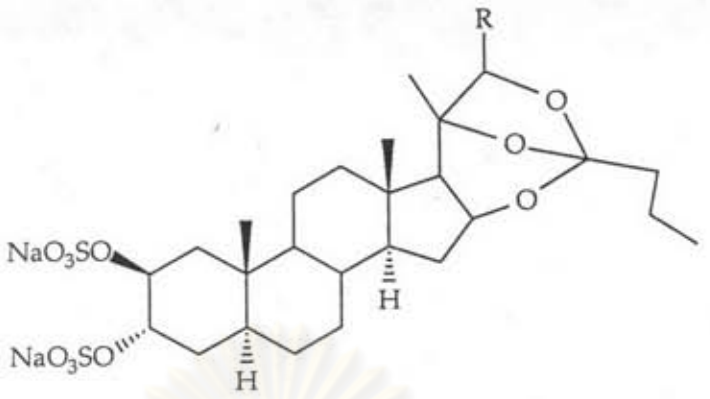


10

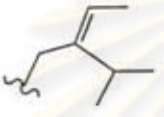
The most interesting sterols from the *Petrosia* spp. were the sulfate esters of polyhydroxylated sterols because of their antiviral activities. These compounds were isolated from *P. weinbergi* : weinbersterol disulfates A (**11**), B (**12**) (Sun et al., 1991), and orthosterol disulfates A (**13**), B (**14**) and C (**15**) (Koehn, Gunasekara and Cross, 1991).



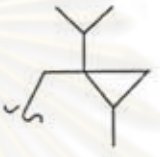
11 $R_1 = R_2 = H$, $R_3 = OH$
12 $R_1 = H$, $R_2 = OH$, $R_3 = H$



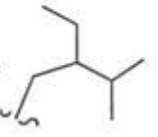
13 R =



14 R =



15 R =



Weinbersterol disulfates A and B were active *in vitro* against feline leukemia virus (FELV) (ED_{50} = 4.0 and 5.2 μg/ml, respectively). Only weinbersterol disulfates A showed activity against the human immunodeficiency virus (HIV) (ED_{50} = 1.0 μg/ml) (Sun et al., 1991). Orthosterol disulfates A, B and C showed activity against FELV, mouse influenza virus (PR8) and mouse corona virus (A59) (Koehn, Gunasekera and Cross, 1991). The reports about the sterols of the *Petrosia* were summarized in Table 1.

Table 1 Sterols from *Petrosia* spp.

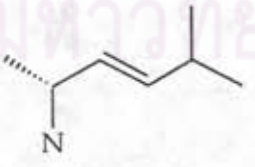
Carbon range	Structural formula	Source	*Ref.
C-26		*P. hebes*	2

Table 1 (continued)

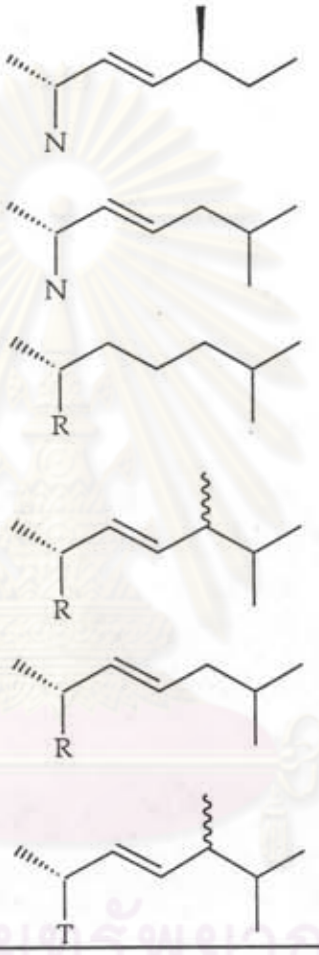
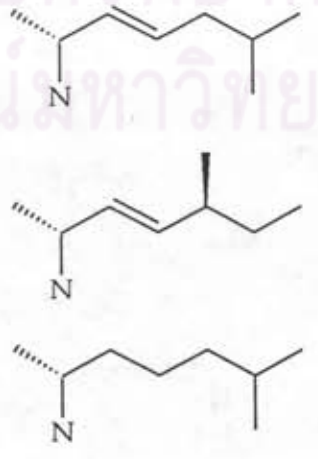
Carbon range	Structural formula	Source	*Ref.
C-27		*P. ficiformis*	3
C-27		*P. hebes*	2

Table 1 (continued)

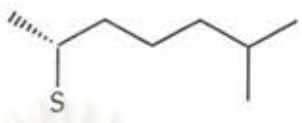
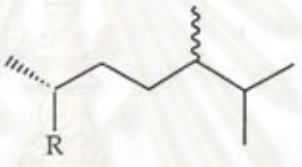
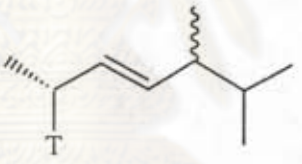
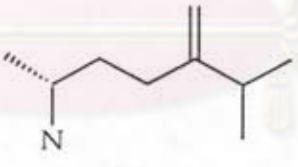
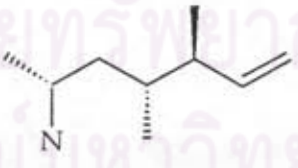
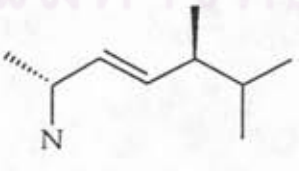
Carbon range	Structural formula	Source	*Ref.
C-27		*P. hebes*	2
C-28	     	*P. ficiformis*	3

Table 1 (continued)

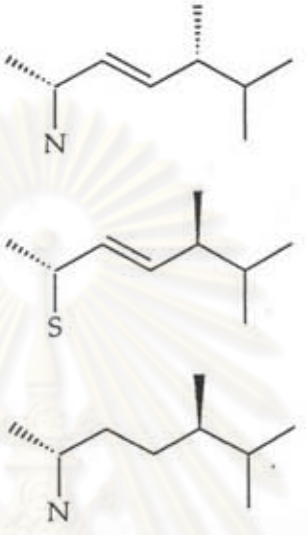
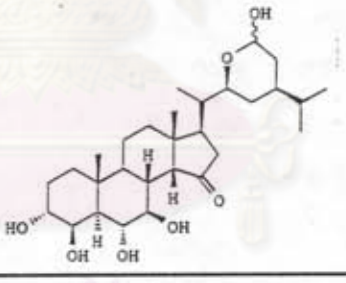
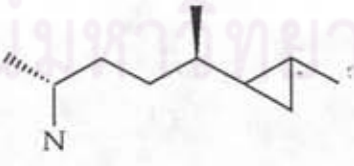
Carbon range	Structural formula	Source	*Ref
C-28		*P. ficiformis*	3
C-29		*P. contignata*	1
C-29		*P. ficiformis* *P. hebes*	2, 3

Table 1 (continued)

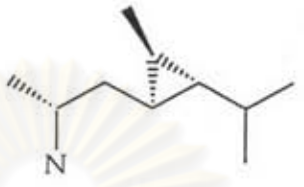
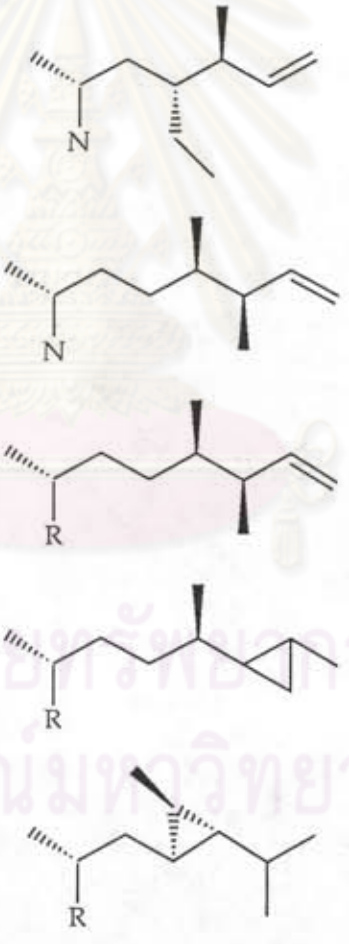
Carbon range	Structural formula	Source	*Ref.
C-29		*P. ficiformis* *P. hebes*	2, 3
C-29		*P. ficiformis*	3

Table 1 (continued)

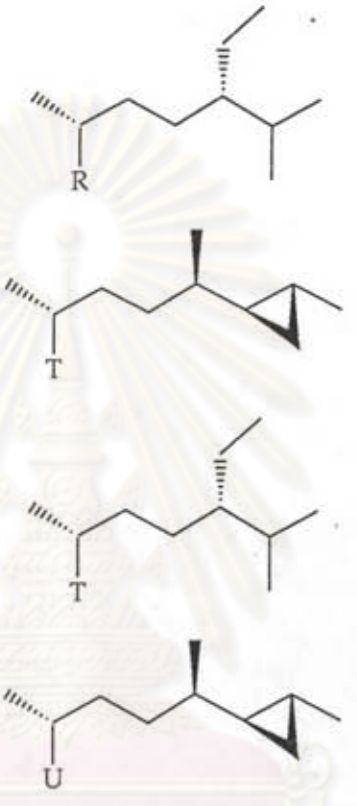
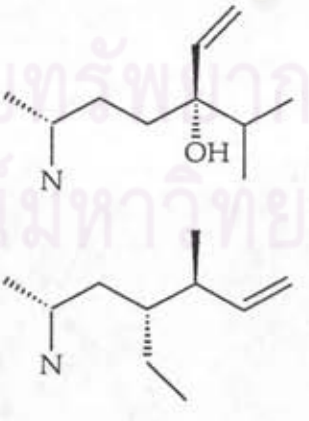
Carbon range	Structural formula	Source	*Ref.
C-29		*P. ficiformis*	3
C-29		*P. hebes*	2

Table 1 (continued)

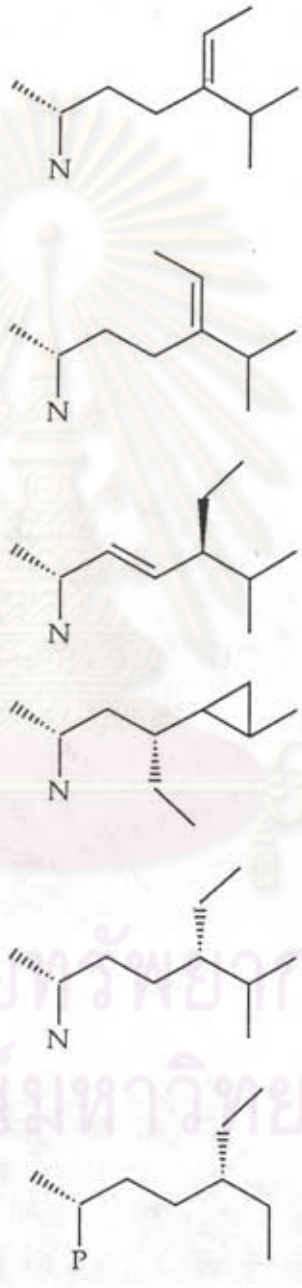
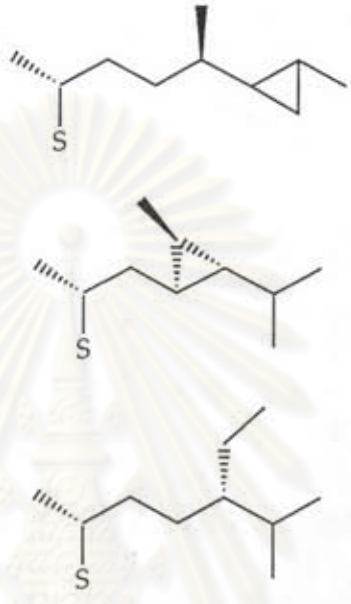
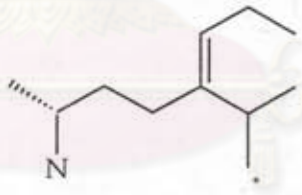
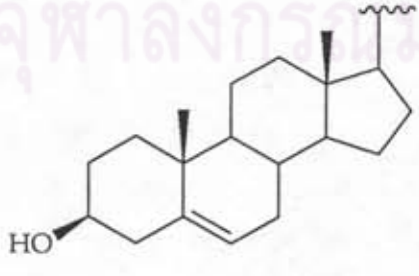
Carbon range	Structural formula	Source	*Ref.
C-29		*P.hebes*	2

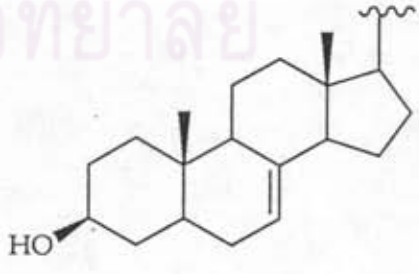
Table 1 (continued)

Carbon range	Structural formula	Source	*Ref.
C-29		*P. hebes*	2
C-30		*P. hebes*	2

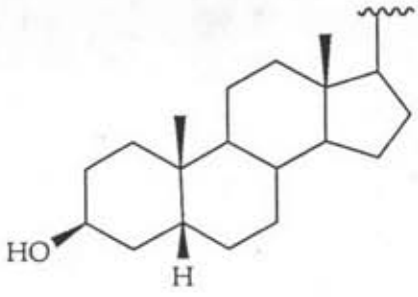
*Ref.: 1 Burgoyne, D.L. and Anderson, R.J., 1992
2 Cho and Djerassi, 1987
3 Seidel, Proudfoot, and Djerassi, 1986



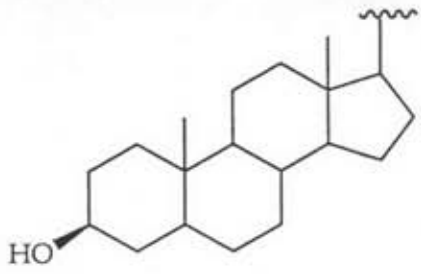
N



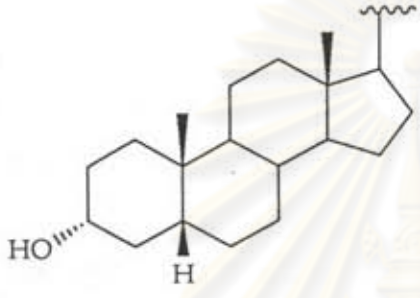
P



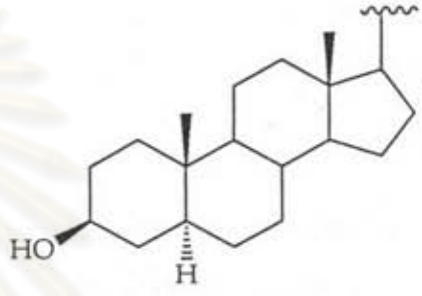
R



S



T



U

1.2 Fatty Acids

Most of fatty acids from the genus *Petrosia* were unbranched acids except some fatty acids from the sponge *Petrosia ficiformis* (Ayanoglu et al., 1982). Typical fatty acids contained straight chains 14 to 22 carbon atoms long, whereas these demospongic acids contained 14-34 carbons . The summary of these compounds were shown in Table 2.

Table 2 Fatty acids in *Petrosia* spp.

Source	Name	**Ref.
Petrosia sp.	12-Methyltridecanoic (*i*-:14:0)	4
P. pellasarca, P. ficiformis, Petrosia sp.	Tetradecanoic (14:0)	1,3,4
P. pellasarca, P. ficiformis, Petrosia sp.	4,8,12-Trimethyltridecanoic (16:0)	1,3,4
P. pellasarca, P. ficiformis, Petrosia sp.	13-Methyltetradecanoic(*i*-15:0)	1,3,4
P. pellasarca, P. ficiformis, Petrosia sp.	12-Methyltetradecanoic(*a*-15:0)	1,3,4
Petrosia sp.	Pentadecanoic (15:0)	4
P. pellasarca, P. ficiformis, Petrosia sp.	14-Methylpentadecanoic (*i*-16:0)	1,3,4
P. pellasarca, P. ficiformis, Petrosia sp.	9-Hexadecenoic(Δ^9-16:1)	1,3,4
Petrosia sp.	11-Hexadecenoic(16:1)	4

Table 2 (continued)

Source	Name	**Ref.
P. pellasarca, P. ficiformis, Petrosia sp.	Hexadecanoic(16:0)	1,3,4
P. ficiformis, Petrosia sp.	15-Methyl-9-hexadecanoic (Δ^9-*i*- -17:1)	1,4
Petrosia sp.	Methylhexadecanoic(17:0)	4
P. ficiformis	10-Methylhexadecanoic	1
P. ficiformis, Petrosia sp.	15-Methylhexadecanoic(*i* -17:0)	1,4
P. ficiformis, Petrosia sp.	14-Methylhexadecanoic(*a* -17:0)	1,4
Petrosia sp.	2-Methoxy-5-hexadecenoic (16:1)	4
Petrosia sp.	9-Heptadecenoic(Δ^9-17:1)	4
Petrosia sp.	11-Heptadecenoic(Δ^{11}-17:1)	4
P. pellasarca, Petrosia sp.	Heptadecanoic(17:0)	3,4
P. pellasarca	9-Octadecenoic(Δ^9-18:1)	3
P. pellasarca, P. ficiformis, Petrosia sp.	11-Octadecenoic(Δ^{11}-18:1)	1,3,4
P. pellasarca, P. ficiformis, Petrosia sp.	Octadecanoic(18:0)	1,3,4
P. pellasarca, Petrosia sp.	Methyloctadecanoic(19:0)	3,4
P. ficiformis	11-Methyloctadecanoic(19:0)	1
Petrosia sp.	17-Methyloctadecanoic(*i* -19:0)	4
Petrosia sp.	11-Nonadecenoic(19:1)	4
Petrosia sp.	Nonadecanoic(19:0)	4
P. pellasarca, Petrosia sp.	5,8,11,14-Eicosatetraenoic(20:4)	3,4
Petrosia sp.	8,11,14,17-Eicosatetraenoic(20:4)	4
Petrosia sp.	Methylnonadecanoic(20:0)	4
P. pellasarca, Petrosia sp.	Eicosanoic(20:0)	3,4
Petrosia sp.	19-Methyleicosanoic(*i* -21:0)	4
Petrosia sp.	18-Methyleicosanoic(*ai* -21:0)	4
Petrosia sp.	13-Heneicosanoic(Δ^{13}-*ai* -21:1)	4
P. ficiformis	7,13,16-Docosatrienoic ($\Delta^{7,13,16}$-22:3)	1
Petrosia sp.	4,7,10,13,16,19-Docosa-hexaenoic(22:6)	4
P. pellasarca, Petrosia sp.	7,10,13,16,19-Docosa-tetraenoic(22:4)	3,4

Table 2 (continued)

Source	Name	**Ref.
P. ficiformis	24-Metyhl-5,9-pentacosadienoic-($\Delta^{5,9}$-*i*-26:2)	1
Petrosia sp.	Docosanoic(22:0)	4
Petrosia sp.	2-Hydroxydocosanoic(22:0)	4
Petrosia sp.	21-Methyldocosanoic(*i* -23:0)	4
Petrosia sp.	Tricosanoic(23:0)	4
Petrosia sp.	16-Tetracosenoic(24:1)	4
Petrosia sp.	17-Tetracosenoic(24:1)	4
Petrosia sp.	19-Tetracosenoic(24:1)	4
P. ficiformis	15-Methyldocosanoic(24:0)	1
Petrosia sp.	Tetracosanoic(24:0)	4
Petrosia sp.	17-Pentacosenoic(25:1)	4
P. ficiformis	15-Methyltricosanoic(25:0)	1
Petrosia sp.	5,9-Hexacosadienoic(26:2)	4
Petrosia sp.	6-Bromo-5,9-hexacosadienoic (26:2)	4
Petrosia sp.	17-Hexacosenoic(26:1)	4
Petrosia sp.	19-Hexacosenoic(26:1)	4
Petrosia sp.	Hexacosanoic(26:0)	4
Petrosia sp.	5,9-Heptacosadienoic(27:2)	4
Petrosia sp.	6-Bromo-5,9-heptacosadienoic (27:2)	4
Petrosia sp.	19-Heptacosenoic(27:1)	4
Petrosia sp.	Heptacosanoic(27:0)	4
P. pellasarca	25-Methylhexacosanoic(*i* -27:0)	3
P. pellasarca	24-Methylhexacosanoic(*ai* -27:0)	3
P. ficiformis	*Z,Z*-25-Methyl-5,9-hexacosa-dienoic ($\Delta^{5,9}$ -*i* -27:2)	1
P. ficiformis	*Z,Z*-24-Methyl-5,9-hexacosa-dienoic ($\Delta^{5,9}$ -*ai* -27:2)	1
Petrosia sp.	5,9-Octacosadienoic(28:2)	4
Petrosia sp.	5,9,23-Tricontatrienoic(30:3)	4

Table 2 (continued)

Source	Name	**Ref.
Petrosia sp.	6-Bromo-5,9-octacosadienoic (28:2)	4
P. hebes, P. ficiformis	(5Z,9Z)-6-Bromo-25-methyl-5,9-hexacosadienoic($\Delta^{5,9}$ -*i* -28:2)	2
P. ficiformis	(5Z,9Z)-6-Bromo-24-methyl-5,9-hexacosadienoic($\Delta^{5,9}$ -*ai* -28:2)	2
P. pellasarca	9-Octacosenoic(28:1)	3
P. pellasarca	Octacosanoic(28:0)	3
P. pellasarca	27-Methyloctacosanoic(*i* -29:0)	3
P. pellasarca	26-Methyloctacosanoic(*ai* -29:0)	3
P. pellasarca	Nonacosanoic(29:0)	3
P. pellasarca	5,9-Triacontadienoic(30:2)	3
P. pellasarca	Triacontanoic(30:0)	3
P. pellasarca	Hentriacontanoic(31:0)	3
P. pellasarca	Dotriacontanoic(32:0)	3
P. pellasarca	19,22,25,28,31-Tetratriaconta-pentaenoic(34:5)	3

** Ref.: 1 Ayanoglu et al., 1982
2 Wijekoon, Ayanoglu, and Djerassi, 1984
3 Carballeira and Reyes, 1990
4 Carbielleira and Shalabi, 1993

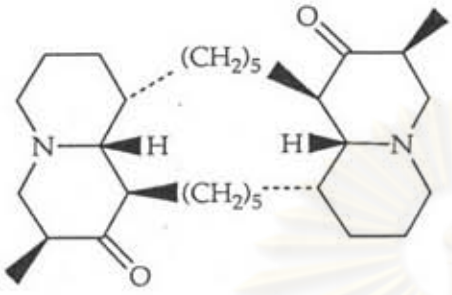
1.3 Aldehydes

Carballeira and Shalabi, 1993 investigated six aldehydes from the caribbean sponge *Petrosia* sp. as the following: Hexadecanal (16:0), Heptadecanal (17:0), Octadecanal (18:0), 17-Tetracosenal (24:1), 17-Pentacosenal (25:1), and 17-Hexa-cosenal (26:1).

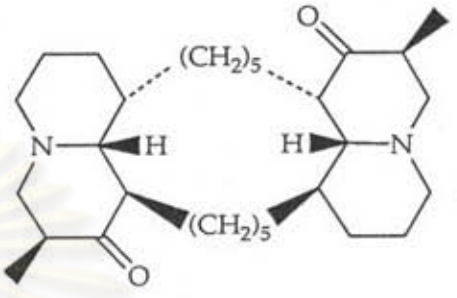
1.4 Alkaloids

There were a few papers about alkaloids from the genus *Petrosia*. The ichthyotoxicity of *Petrosia seriata* was associated with a group of at least eight alkaloids. Two new bis-quinolizidone alkaloids, petrosin-A (**16**) and petrosin-B(**17**), had been shown to be stereoisomers of petrosin (**18**) (Faulkner, 1986). The other alkaloid isolated from the marine sponge *Petrosia* sp. collected at Belize was

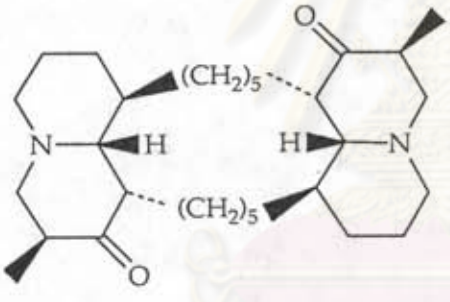
petrosamine (**19**). It was a novel pigment which showed antimicrobial activity against *Staphylococcus aureus* and *Bacillus subtilis*. The colour of the pigment petrosamine was dependent on the polarity of the solvent and varied from blue to purple and green (Molinski et al., 1988).



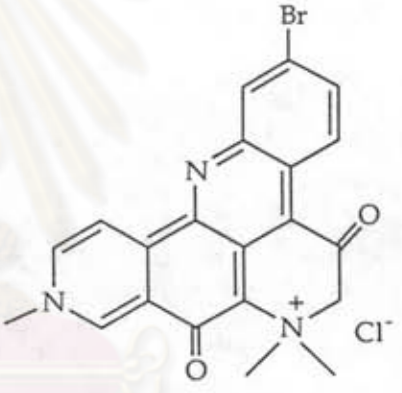
16



17



18



19

1.5 Acetylenic compounds

The acetylenic compounds isolated from sponges of the genus *Petrosia* were summarized in Table 3 including other acetylenic compounds from other marine organisms. So far about 30 acetylenic compounds have been isolated from the genus *Petrosia* .

2. The Distribution of Acetylenic compounds in Marine Organisms

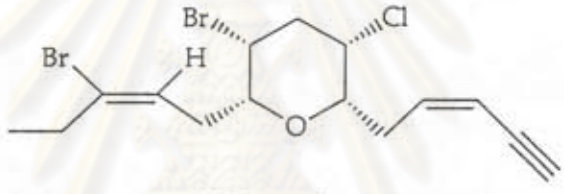
The number of acetylenic compounds found in marine organisms which structures were known todays is about seventy compounds. Some of these compounds had previously shown a variety of biological activities such as antibacterial, cytotoxic, and enzyme inhibitors (Bourguet-Kondracki et al., 1992). Acetylenic compounds are divided to five groups by their structures as the followings:

1. Straight chain acetylenes

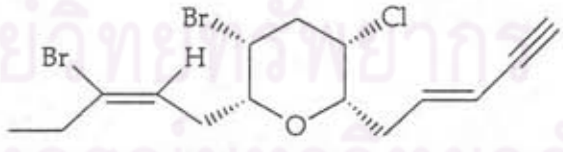
These compounds are composed of carbon ranging from 9 to 55 atoms. Most acetylenic compounds are members of this group. However, some compounds have substituted groups such as halogens (bromine or chlorine), keto or enol groups, acid or their esters. Consequently, the straight chain acetylenes are divided to three groups by their substitution as described in Table 3.

2. Acetylenes with one or more tetrahydropyran rings.

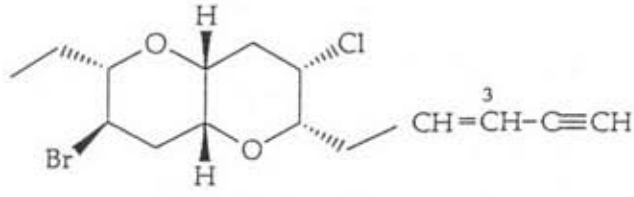
There were only a few reports of this group. Four compounds (**20-22**) were isolated from Sea Hare *Aplysia dactylomela* (Mc Donald et al., 1975; Vanderah and Schmitz, 1976, Gopichand, Schmitz, and Shelly, 1981). The others (**23-26**) were isolated from Red alga *Laurencia majuscula* (Wright et al., 1993). Their names and structures are described as below.



20 Dactylene



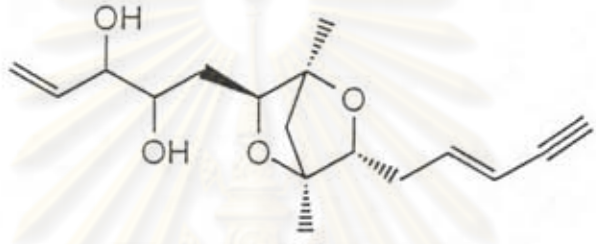
21 Isodactylene



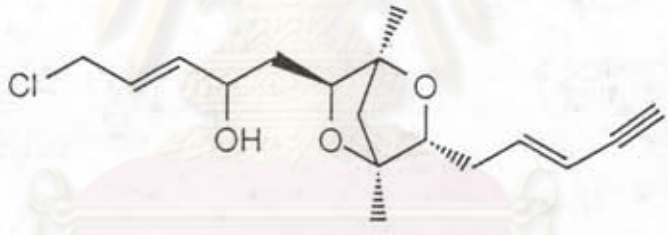
Dactomelyne

22.1 3*E*

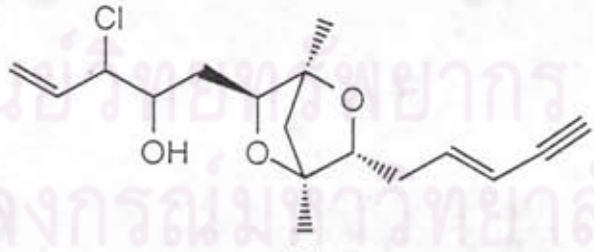
22.2 3*Z*



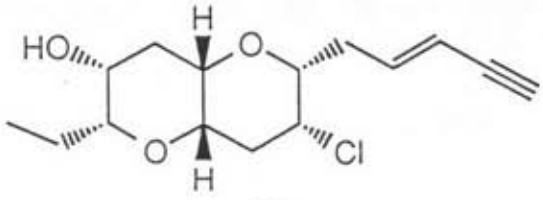
23



24



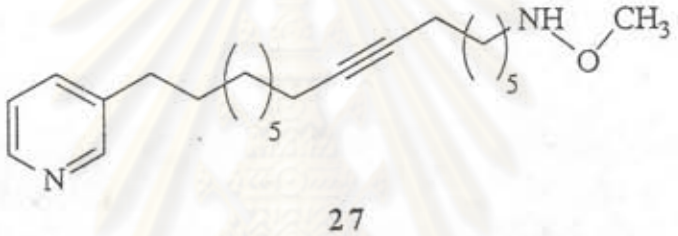
25



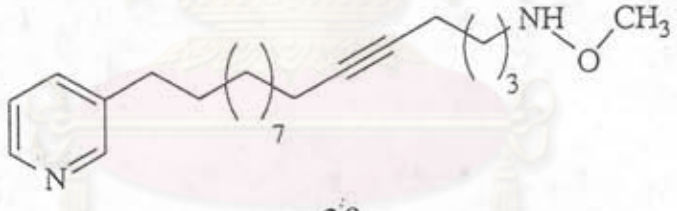
26

3. Acetylenes with pyridine ring.

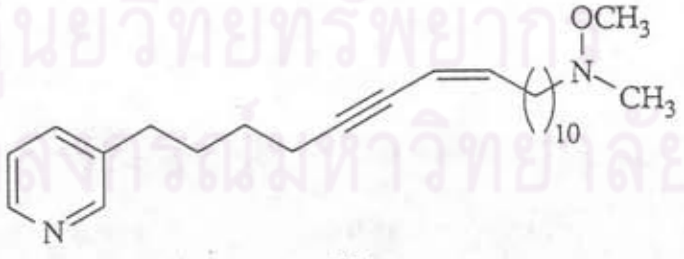
There were three compounds: Niphatyne A (**27**) , Niphatyne B (**28**) isolated from the sponge *Niphates* sp.(Quinoa and Crews, 1987) and Xestamines A (**29**) isolated from *Xestospongia weidenmayeri* (Sakemi, Totton and Sun, 1990). Their structures are shown below.



27



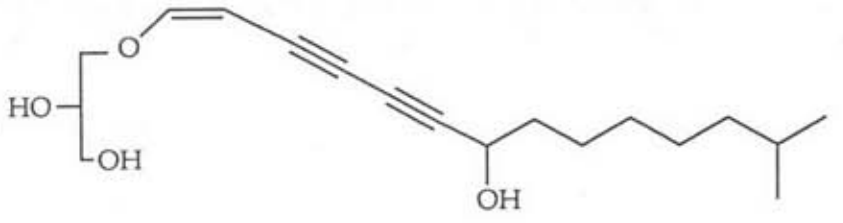
28



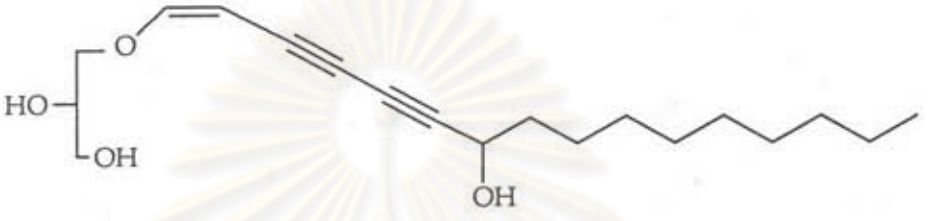
29

4. Acetylenic glyceryl ethers

Two diyne enol ethers: 3-{[1Z)-7-hydroxy-13-methyltetradeca-1-ene-3,5-diynyl]oxy}-1,2-propanediol (**30**) and 3-{[1Z)-7-hydroxy-hexadeca-1-ene-3,5-diynyl] oxy}-1,2-propanediol (**31**) were isolated from sponge *Petrosia hebes*. Both of them were not significantly cytotoxic (P-388, ID_{50}'s >6 and >11 μg/ml, respectively) (Perry et al., 1990).



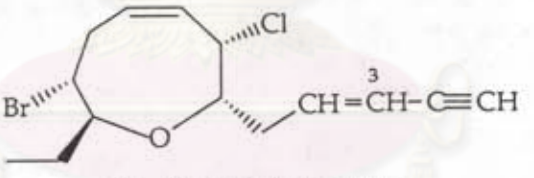
30



31

5. Miscellaneous acetylene

There is only one compound, 12-epiobtusenyne (**31**) from Sea Hare *Aplysia dactylomela* (Gopichand, Schmitz, and Shelly, 1981) that differs from other acetylenes. The structure is shown as below.



32 12-Epiobtusenyne

3. Biological Activities of Acetylenic Compounds from Marine Organisms

The acetylenic compounds from marine organisms were reported to have a variety of biological activities. The most interesting compounds were polyacetylenic acids from the sponge *Xestospongia muta* because they showed activity as HIV-1 protease inhibition at IC_{50} = 6-12 μM (Patil et al., 1992). Most activities of these acetylenic compounds were antimicrobial and cytotoxic. Other activities of them were antifungal, ichythyotoxic, and enzyme inhibitor. The total biological activities were summarized in Table 4.

Table 3 Summary of straight chain acetylenes

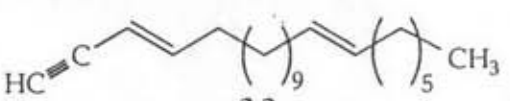
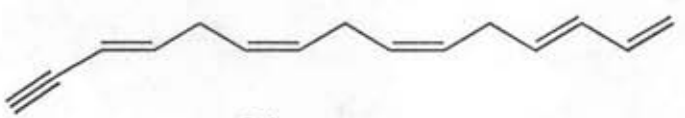
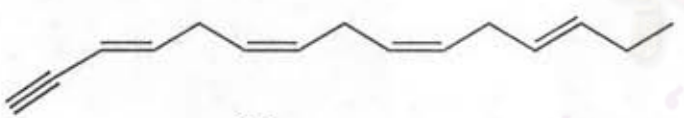
Name and/or Structural formula	Source	Reference
1. Ordinary acetylenes		
 **33**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 **34**	Red alga: Laurencia majuscula	Wright et al., 1993
 **35**	Red alga: Laurencia majuscula	Wright et al., 1993

Table 3 (continued)

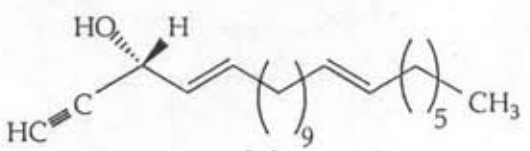
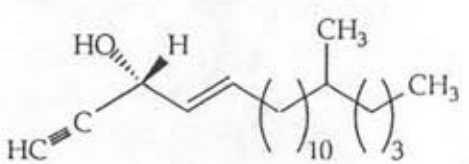
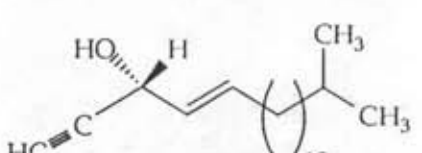
Name and/or Structural formula	Source	Reference
2. Oxygenated acetylenes		
 **36**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 **37**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 **38**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992

Table 3 (continued)

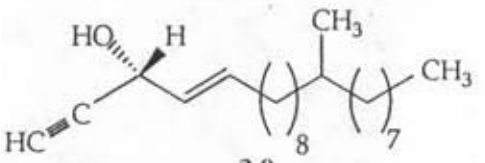
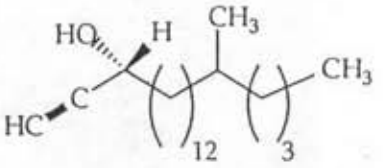
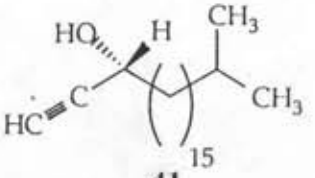
Name and/or Structural formula	Source	Reference
 **39**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 **40**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 **41**	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992

Table 3 (continued)

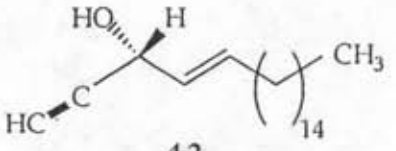
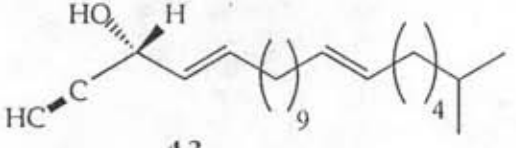
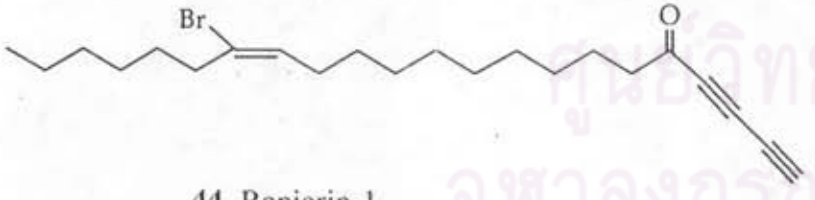
Name and/or Structural formula	Source	Reference
 42	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 43	Sponge: *Cribrochalina vasculum*	Aiello, Fattorusso and Menna, 1992
 44 Renierin-1	Sponge: *Reniera fulva*	Cimino and Stefano, 1977

Table 3 (continued)

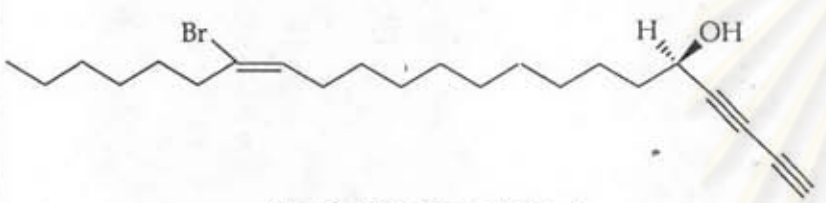
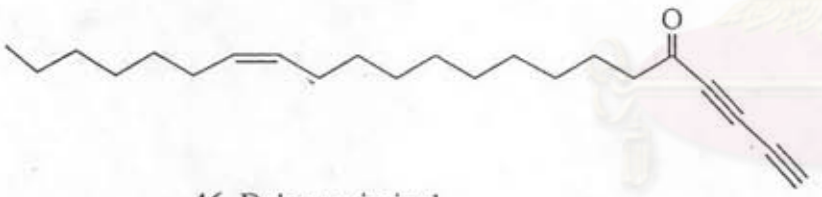
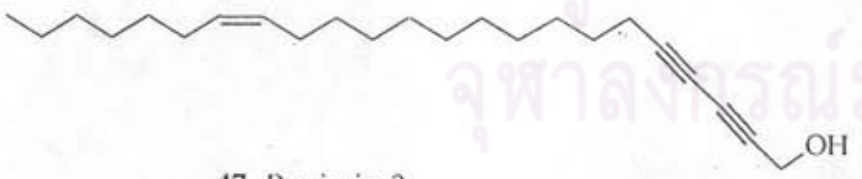
Names and Structural formulae	Sources	References
 **45** 18-Dihydrorenierin-1	Sponge: *Reniera fulva*	Cimino and De Stefano, 1977
 **46** Debrorenierin-1	Sponge: *Reniera fulva*	Cimino and De Stefano, 1977
 **47** Renierin-2	Sponge: *Reniera fulva*	Cimino and De Stefano, 1977

Table 3 (continued)

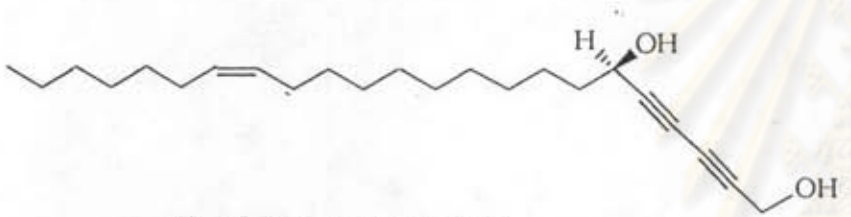
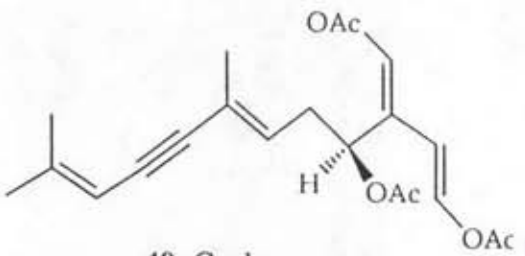
Name and/or Structural formula	Source	Reference
 **48** 18-Hydroxyrenierin-2	Sponge: *Reniera fulva*	Cimino and De Stefano, 1977
 **49** Caulerpenyne	Green alga: *Caulerpa prolifera*	Amico et al., 1978

Table 3 (continued)

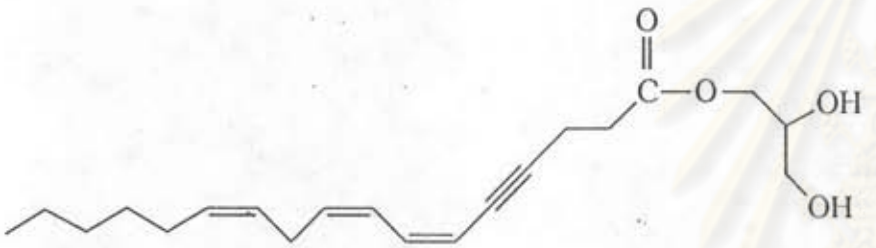
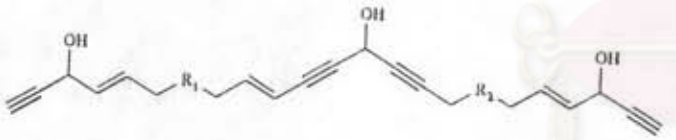
Name and/or Structural formula	Source	Reference
 **50**	Red alga: *Liagora farinosa*	Paul and Fenical, 1980
 $R_1+R_2 = C_nH_{2n-6}$ **51** n = 25 **52** n = 28 $R_1+R_2 = C_nH_{2n-4}$ **53** n = 28 **54** n = 31 **55** n = 34	Nudibranch: *Peldotoris atromaculata* and Sponge:*Petrosia ficiformis*	Castiello et al., 1980

Table 3 (continued)

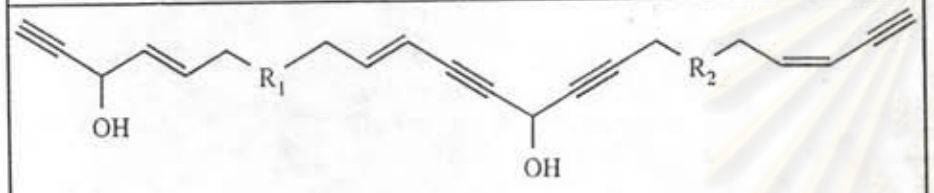
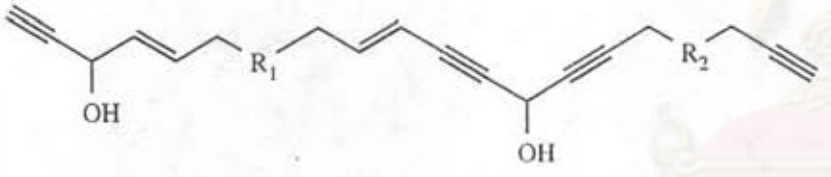
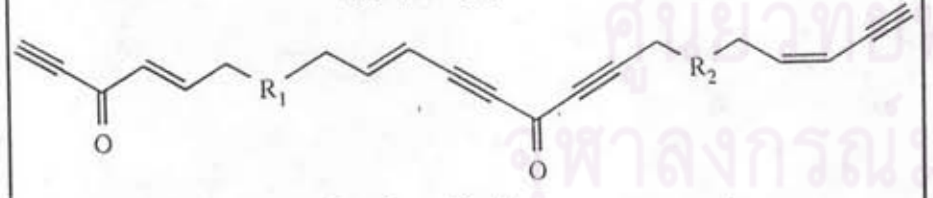
Name and/or Structural formula	Source	Reference
 $R_1+R_2 = C_nH_{2n-4}$ **56** n = 26 **57** n = 29	Sponge: *Petrosia ficiformis*	Cimino et al., 1981
 $R_1+R_2 = C_nH_{2n-4}$ **58** n = 28 **59** n = 31 **60** n = 34	Sponge: *Petrosia ficiformis*	Cimino et al., 1981
 $R_1+R_2 = C_nH_{2n-4}$ **61** n = 26 **62** n = 29	Sponge: *Petrosia ficiformis*	Cimino et al., 1981

Table 3 (continued)

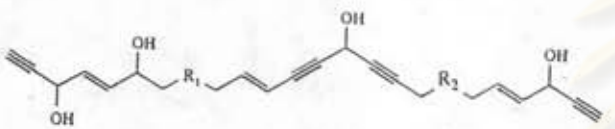
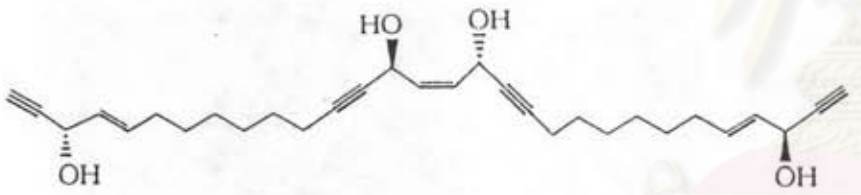
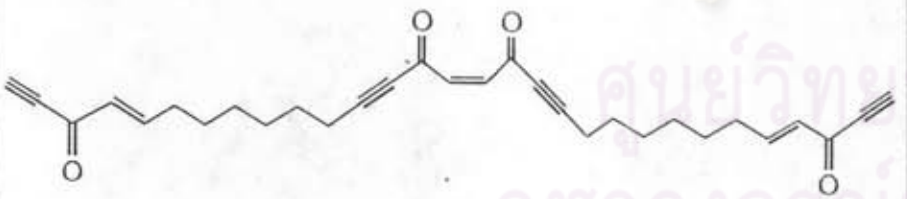
Name and Structural formula	Source	Reference
 **63** $R_1+R_2 = C_{24}H_{44}$	Sponge: *Petrosia ficiformis*	Cimino et al., 1985
 **64** Petrosynol	Sponge: *Petrosia* sp.	Fusetani et al., 1987
 **65** Petrosynone	Sponge: *Petrosia* sp.	Fusetani et al., 1987

Table 3 (continued)

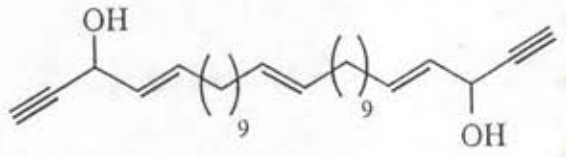
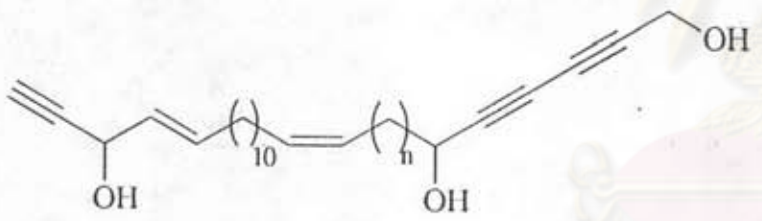
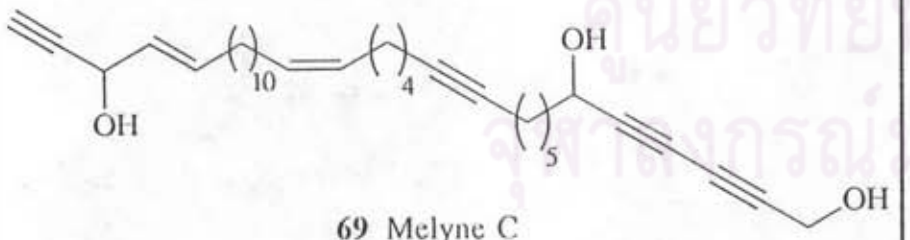
Name and/or Structural formula	Source	Reference
 **66** Duryne	Sponge: *Cribochalina dura*	Wright et al., 1987
 **67** Melyne A : n = 10 **68** Melyne B : n = 9	Sponge: *Xestospongia* sp.	Quiñoa and Crews, 1988
 **69** Melyne C	Sponge: *Xestospongia* sp.	Quinoa and Crews, 1988

Table 3 (continued)

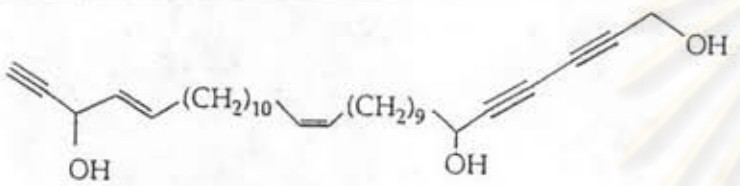
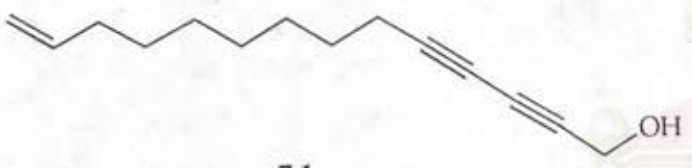
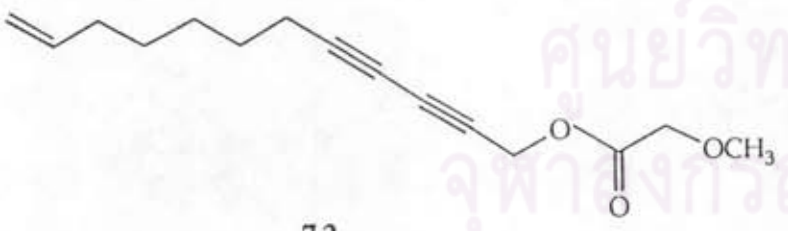
Name and/or Structural formula	Source	Reference
 **70**	Sponge: *Xestospongia* sp.	Quiñoa and Crews, 1988
 **71**	Hard coral: *Pectinia lactuca* and *Montipora mollis*	Higa et al., 1990
 **72**	Hard coral: *Pectinia lactuca* and *Montipora mollis*	Higa et al., 1990

Table 3 (continued)

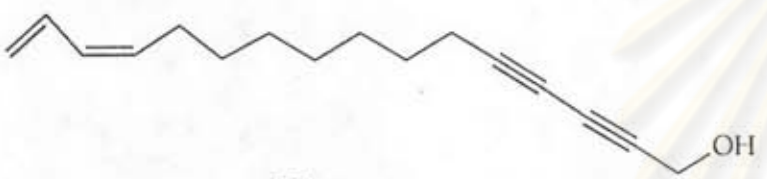
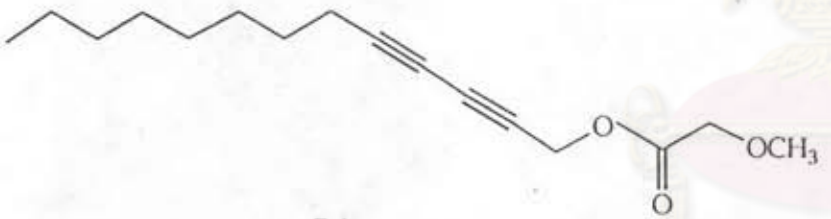
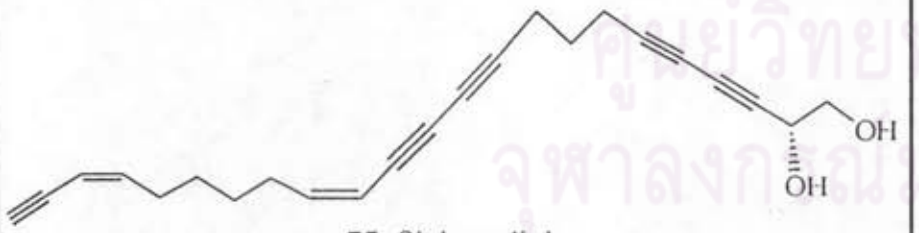
Name and/or Structural formula	Source	Reference
 **73**	Hard coral: *Pectinia lactuca*	Higa et al., 1990
 **74**	Hard coral: *Montipora mollis*	Higa et al., 1990
 **75** Siphonodiol	Sponge: *Siphonochalina truncata*	Fusetani et al., 1987

Table 3 (continued)

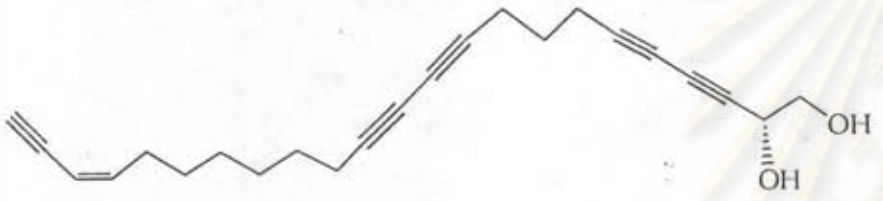
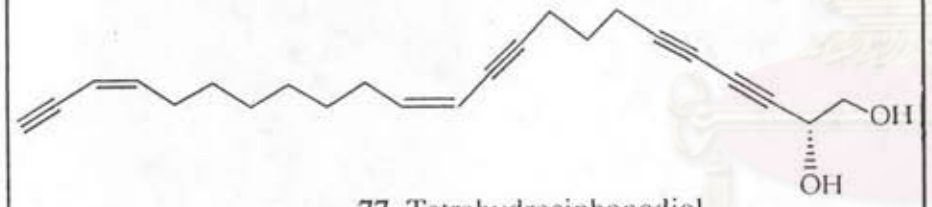
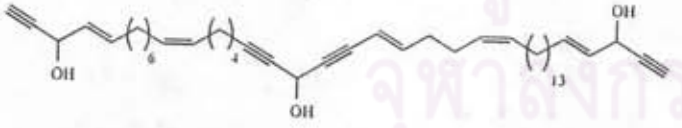
Name and/or Structural formula	Source	Reference
 **76** Dihydrosiphonodiol	Sponge: *Siphonochalina truncata*	Fusetani et al., 1987
 **77** Tetrahydrosiphonodiol	Sponge: *Siphonochalina truncata*	Fusetani et al., 1987
 **78** Petroformyne-1	Sponge: *Petrosia ficiformis*	Cimino et al., 1989

Table 3 (continued)

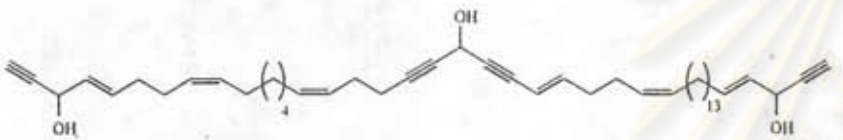
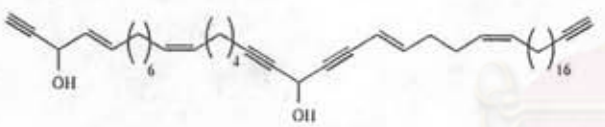
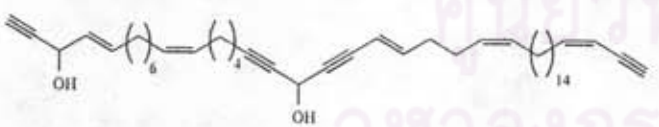
Name and/or Structural formula	Source	Reference
 **79** Petroformyne-2	Sponge: *Petrosia ficiformis*	Cimino et al., 1989
 **80** Petroformyne-3	Sponge: *Petrosia ficiformis*	Cimino et al., 1989
 **81** Petroformyne-4	Sponge: *Petrosia ficiformis*	Cimino et al., 1989

Table 3 (continued)

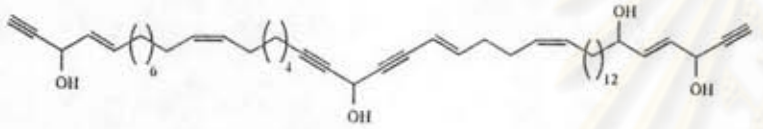
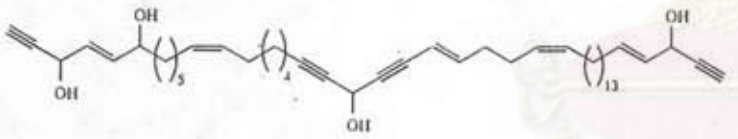
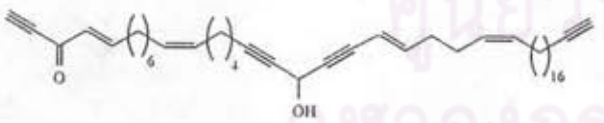
Name and/or Structural formula	Source	Reference
 **82** Petroformyne-5a	Sponge: *Petrosia ficiformis*	Cimino et al., 1990
 **83** Petroformyne-5b	Sponge: *Petrosia ficiformis*	Cimino et al., 1990
 **84** Petroformyne-6	Sponge: *Petrosia ficiformis*	Cimino et al., 1990

Table 3 (continued)

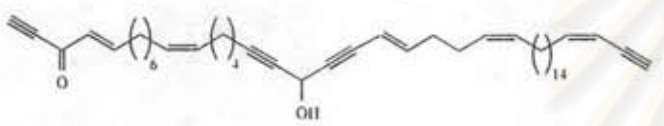
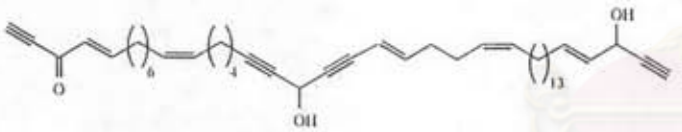
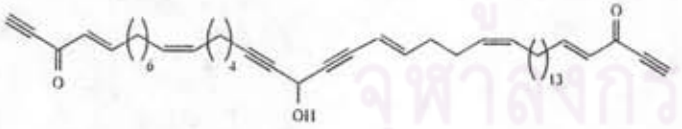
Name and/or Structural formula	Source	Reference
 **85** Petroformyne-7	Sponge: *Petrosia ficiformis*	Cimino et al., 1990
 **86** Petroformyne-8a	Sponge: *Petrosia ficiformis*	Cimino et al., 1990
 **87** Petroformyne-8b	Sponge: *Petrosia ficiformis*	Cimino et al., 1990

Table 3 (continued)

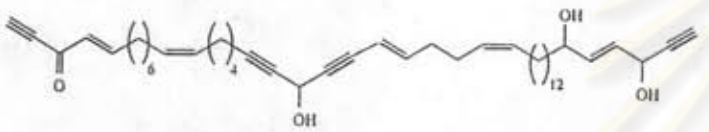
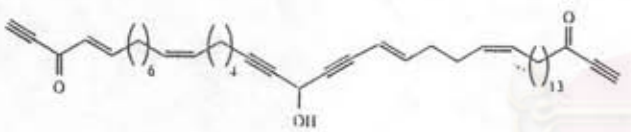
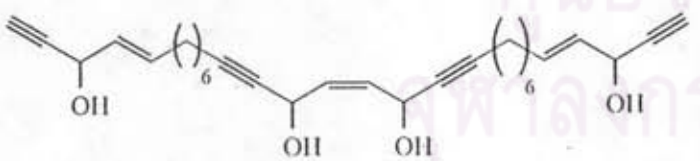
Name and/or Structural formula	Source	Reference
 **88** Petroformyne-9a	Sponge: *Petrosia ficiformis*	Cimino et al., 1990
 **89** Petroformyne-9b	Sponge: *Petrosia ficiformis*	Cimino et al., 1990
 **90**	Sponge: *Petrosia* sp.	Fusetani et al., 1983

Table 3 (continued)

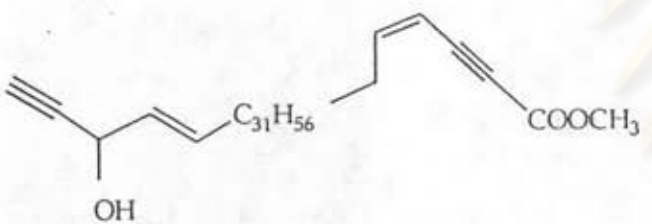
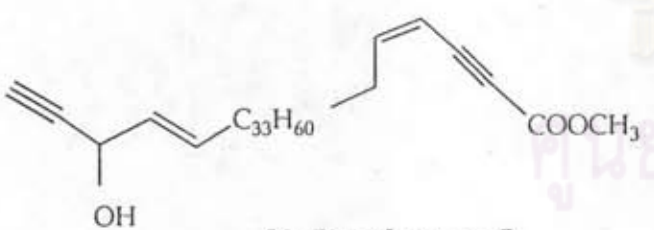
Name and/or Structural formula	Source	Reference
3. Acetylenic acids or esters		
3.1 2-yne system		
 **91** Petroformyne A	Sponge:*Petrosia ficiformis*	Cimino et al., 1990
 **92** Petroformyne B	Sponge:*Petrosia ficiformis*	Cimino et al., 1990

Table 3 (continued)

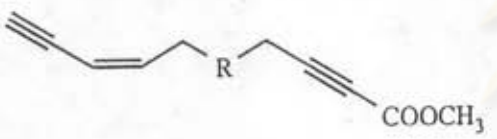
Name and/or Structural formula	Source	Reference
 $R_1+R_2 = C_nH_{2n-2}$ **93** n = 16 **94** n = 18	Sponge: *Petrosia ficiformis*	Cimino et al., 1981
 **95** $R_1+R_2 = C_{25}H_{48}$	Sponge: *Petrosia ficiformis*	Cimino et al., 1985

Table 3 (continued)

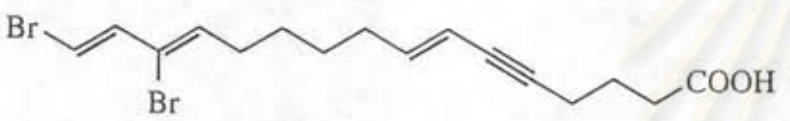
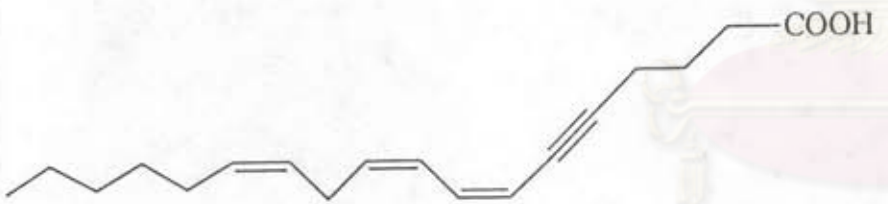
Name and/or Structural formula	Source	Reference
3.2 5-yne system	Sponge:*Xestospongia muta*	Schmitz and Gopichand, 1978
 **96**		
	Red alga: *Liagora farinosa*	Paul and Fenical, 1980
 **97**		

Table 3 (continued)

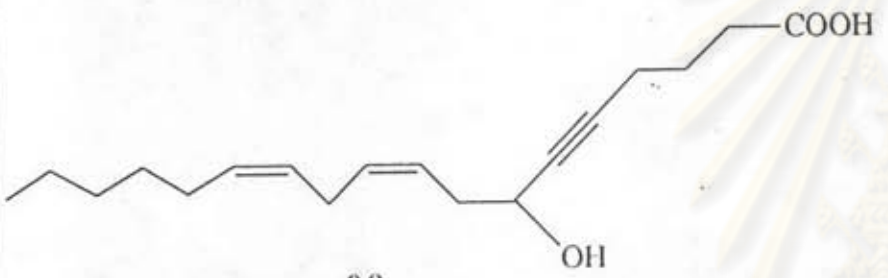
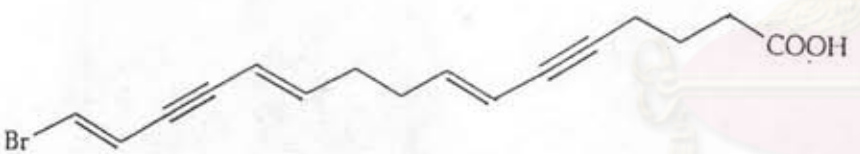
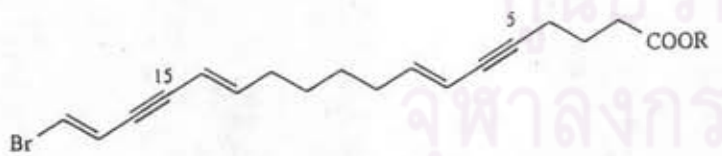
Name and/or Structural formula	Source	Reference
 **98**	Red alga: *Liagora farinosa*	Paul and Fenical, 1980
 **99**	Sponge: *Xestospongia* sp. and *Xestospongia muta*	Hirsh, Carmely, and Kashman, 1987; Patil et al., 1992
 **100** R = H **101** R = CH_3	Sponge: *Xestospongia muta*	Patil et al., 1992

Table 3 (continued)

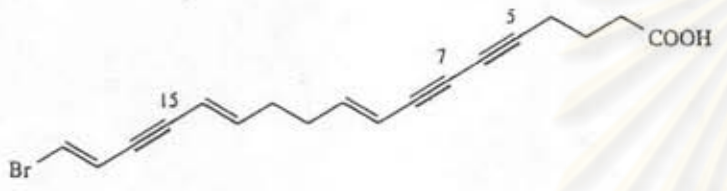
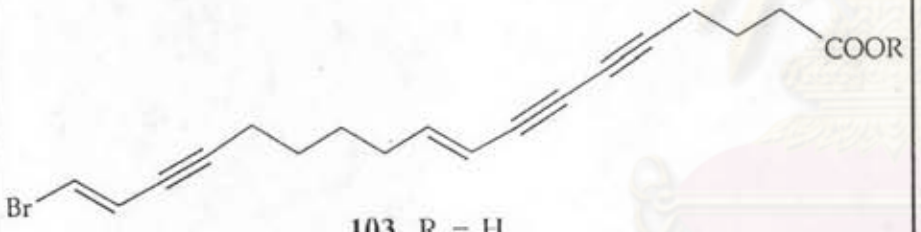
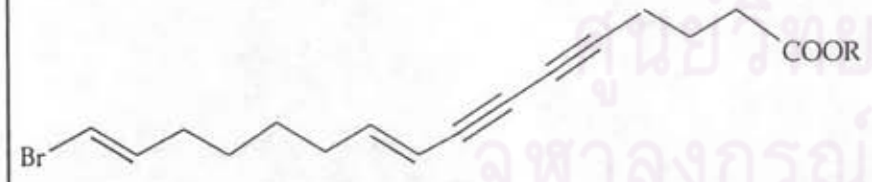
Name and/or Structural formula	Source	Reference
 **102**	Sponge: *Xestospongia muta*	Patil et al., 1992
 **103** R = H **104** R = CH_3	Sponge: *Xestospongia muta*	Patil et al., 1992
 **105** R = H **106** R = CH_3	Sponge: *Xestospongia muta*	Patil et al., 1992

Table 3 (continued)

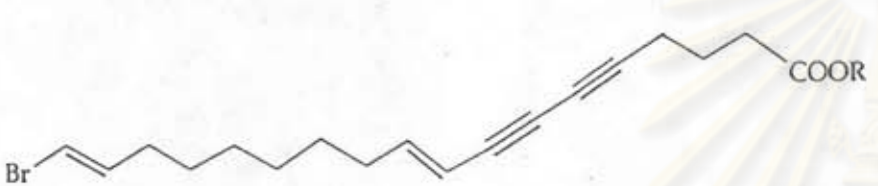
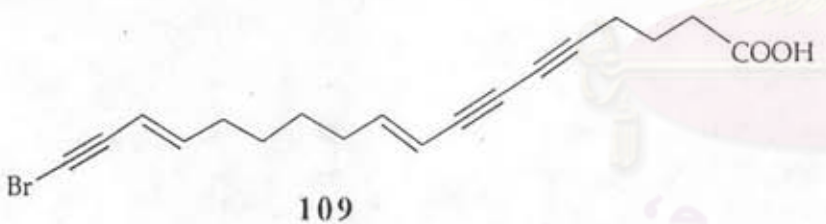
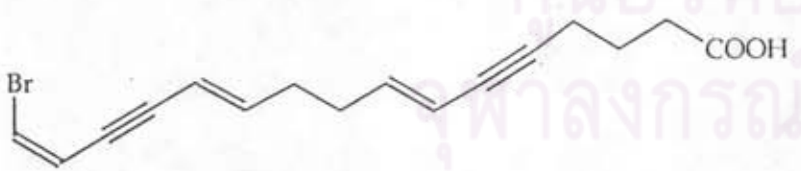
Name and/or Structural formula	Source	Reference
 **107** R = H **108** R = CH_3	Sponge: *Xestospongia muta*	Patil et al., 1992
 **109**	Sponge: *Xestospongia muta*	Patil et al., 1992
 **110**	Sponge:*Xestospongia* sp.	Hirsh, Carmely, and Kashman, 1987

Table 3 (continued)

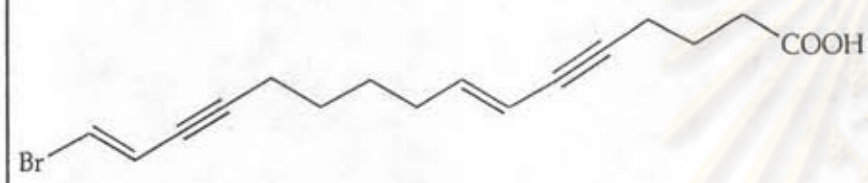
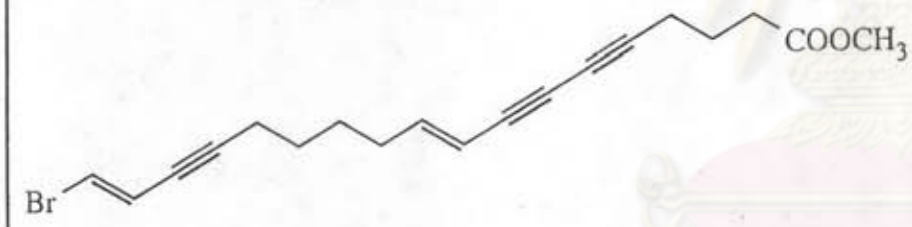
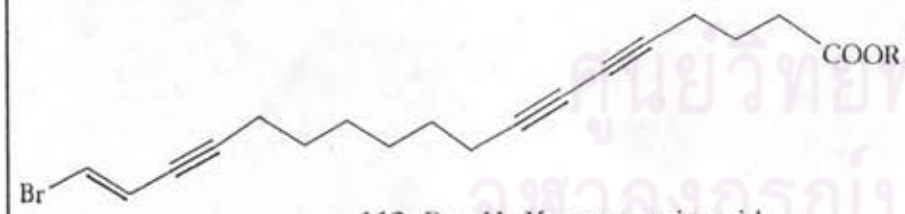
Name and/or Structural formula	Source	Reference
 **111**	Sponge:*Xestospongia* sp.	Hirsh, Carmely, and Kashman, 1987
 **112**	Sponge: *Xestospongia testudinaria*	Quinn and Tucker, 1991
 **113** R = H; Xestospongic acid **114** R = CH_2CH_3	Sponge: *Xestospongia testudinaria*	Bourguet-Kondracki et al. , 1992

Table 3 (continued)

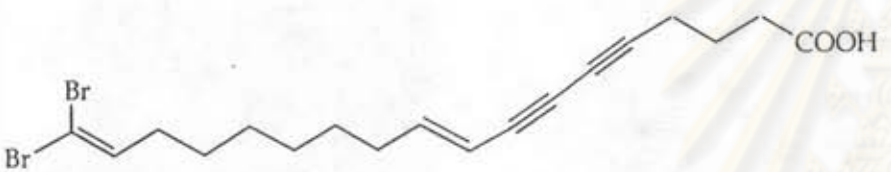
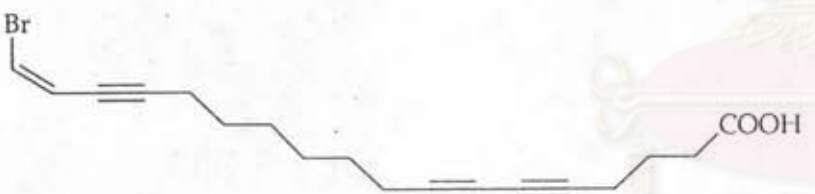
Name and/or Structural formula	Source	Reference
 **115**	Sponge:*Xestospongia* sp.	Hirsh, Carmely, and Kashman, 1987
 **116**	Sponge: *Petrosia volcano*	Fusetani et al.,1993

Table 3 (continued)

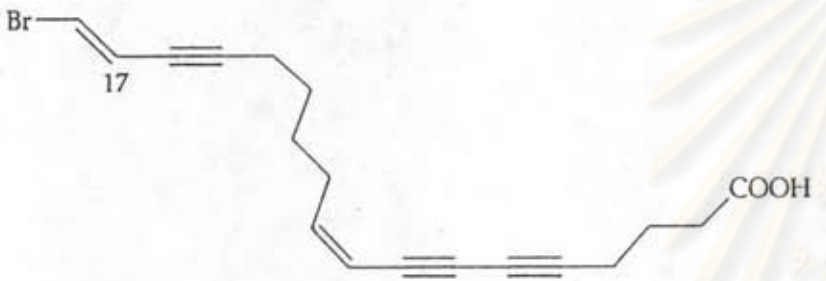
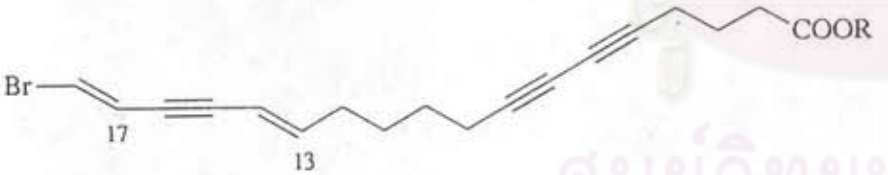
Name and/or Structural formula	Source	Reference
 **117** 17Z **118** 17*E*	Sponge: *Petrosia volcano*	Fusetani et al., 1993
 **119** R = H **120** R = H; 13Z **121** R = H; 17Z	Sponge: *Petrosia volcano*	Fusetani et al.,1993

Table 3 (continued)

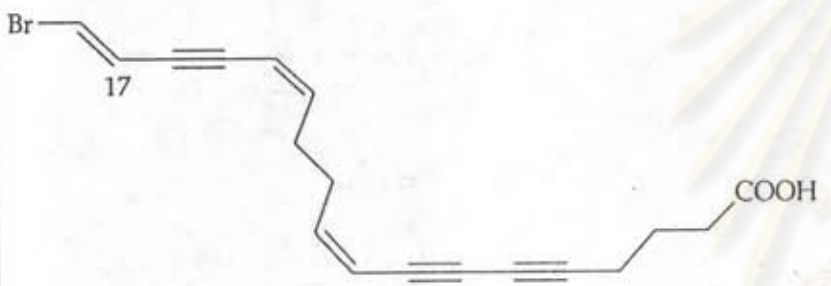
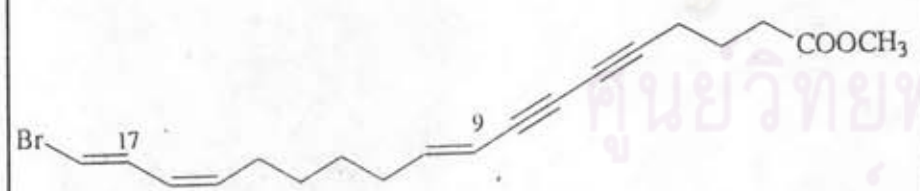
Name and/or Structural formula	Source	Reference
 **122**	Sponge: *Petrosia volcano*	Fusetani et al.,1993
 **123** 9*E* **124** 9*Z*	Sponge: *Petrosia volcano*	Fusetani et al.,1993

Table 3 (continued)

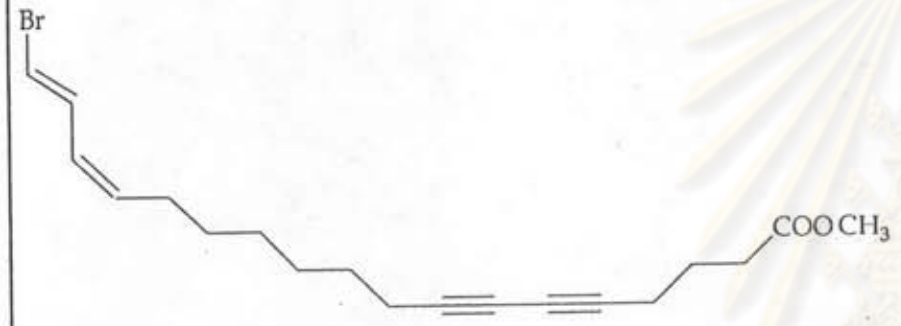
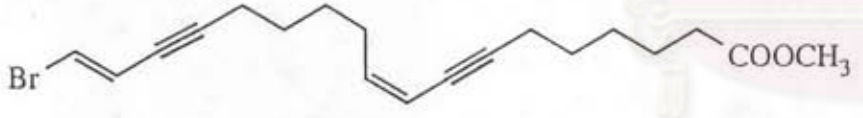
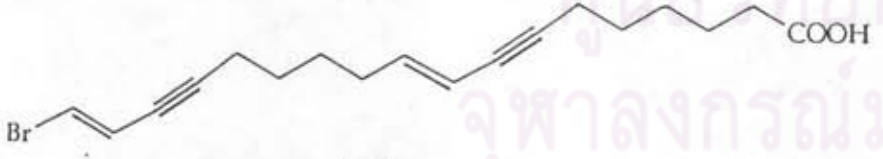
Name and/or Structural formula	Source	Reference
 **125**	Sponge: *Petrosia volcano*	Fusetani et al.,1993
3.3 7-yne system  **126**	Sponge: *Xestospongia testudinaria*	Quinn and Tucker, 1991
 **127**	Sponge: *Xestospongia testudinaria*; *Xestospongia* sp.	Quinn and Tucker, 1985; Hirsh, Carmely, and Kashman, 1987

Table 4 Summary of biological activities of acetylenic compounds from marine organisms.

Compound	Biological activity	Reference
96	Cytotoxic to PS *in vivo*	Schmitz and Gopichand, 1978
66	Cytotoxic to P-388 murine leukemia and human tumor cell lines	Wright et al., 1987
27-28	Cytotoxic to P-388	Quiñoa and Crews, 1987
90	Inhibit cell division of fertilized sea urchin egg	Fusetani et al., 1983
64	Inhibit cell division of starfish egg; Antifungal against *Mortierella ramannianus*	Fusetani et al., 1987
78-85	Inhibit cell division of starfish egg; Active in brine shrimp assay	Cimino et al., 1989; Cimino et al., 1990
91-92	Active in brine shrimp assay	Cimino et al., 1990
97	Toxic toward the reef-dwelling fish	Paul and Fenical, 1980
65	Antimicrobial against *Bacillus subtilis*	Fusetani et al., 1987
67	Active against *Giardia* (an intestinal protozoan)	Quinoa and Crews, 1988

Table 4 (continued)

Compound	Biological activity	Reference
72, 74	Antimicrobial against *Bacillus subtilis, Staphylococcus aureus, Aspergillus* sp., and *Cladosporiium* sp.	Higa et al., 1990
113	Antimicrobial against *Staphylococcus aureus;* Na^+/K^+ ATPase inhibitor; Antifungal against *Mortierella ramannianus*	Bourguet-Kondracki et al., 1992, Fusetani et al., 1993
75-77	H,K-ATPase inhibitor	Fusetani et al., 1987
100, 102 103, 105, 107-109	HIV-1 protease inhibitors	Patil et al., 1992