

# Secondary metabolites from mangrove-associated fungi: source, chemistry and bioactivities

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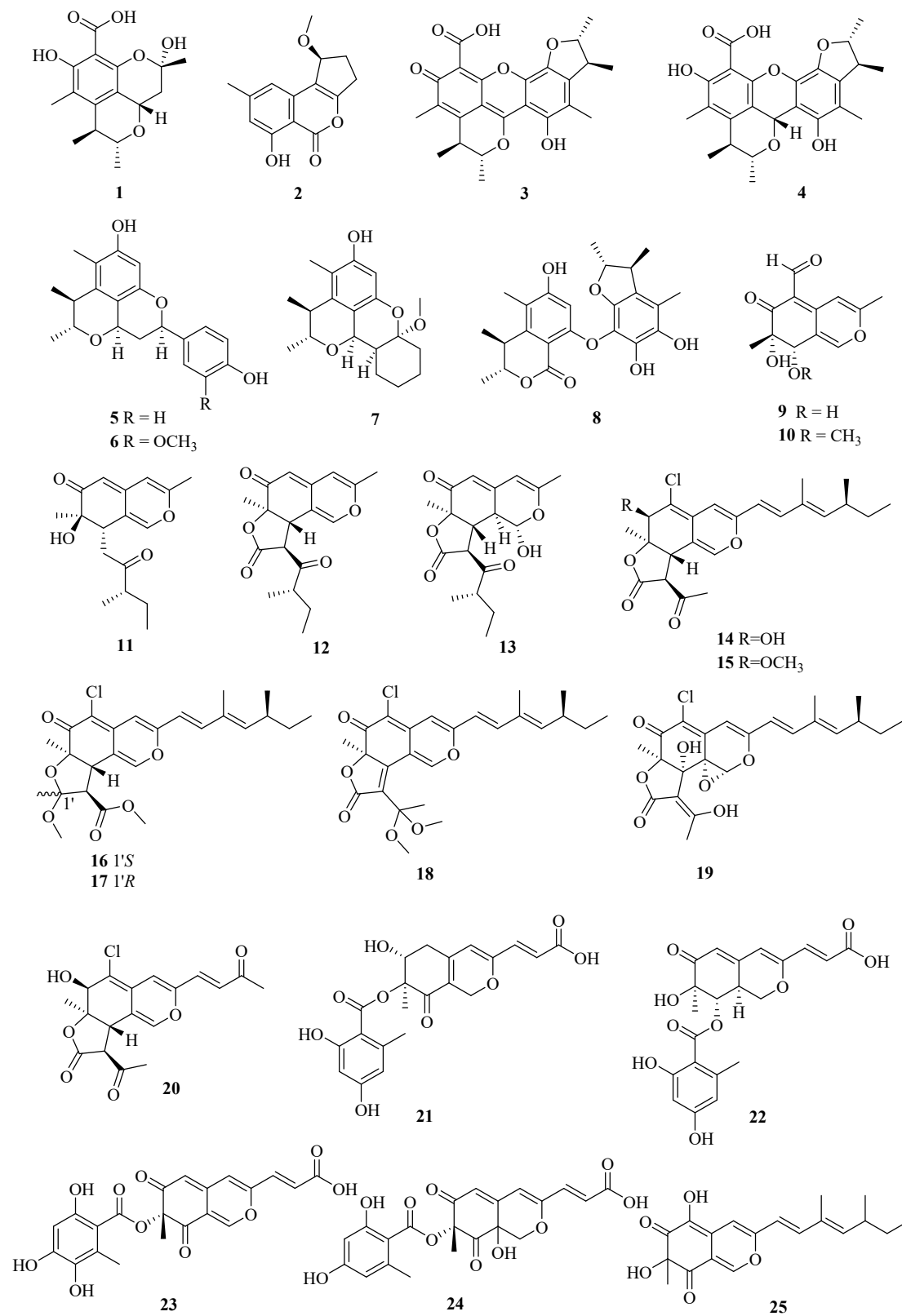
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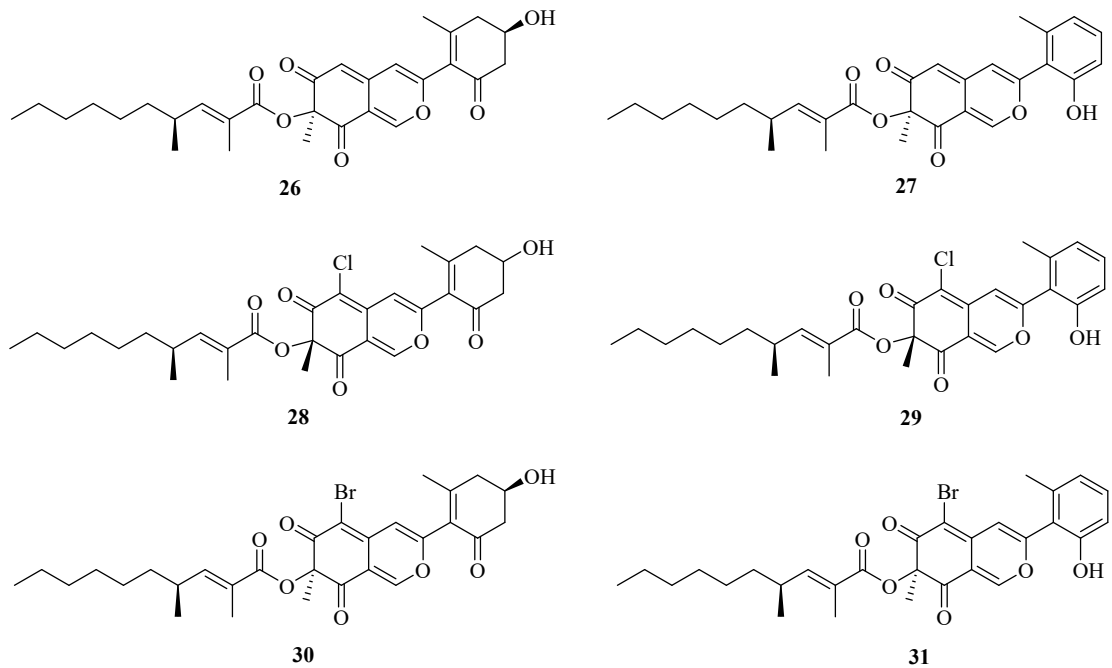
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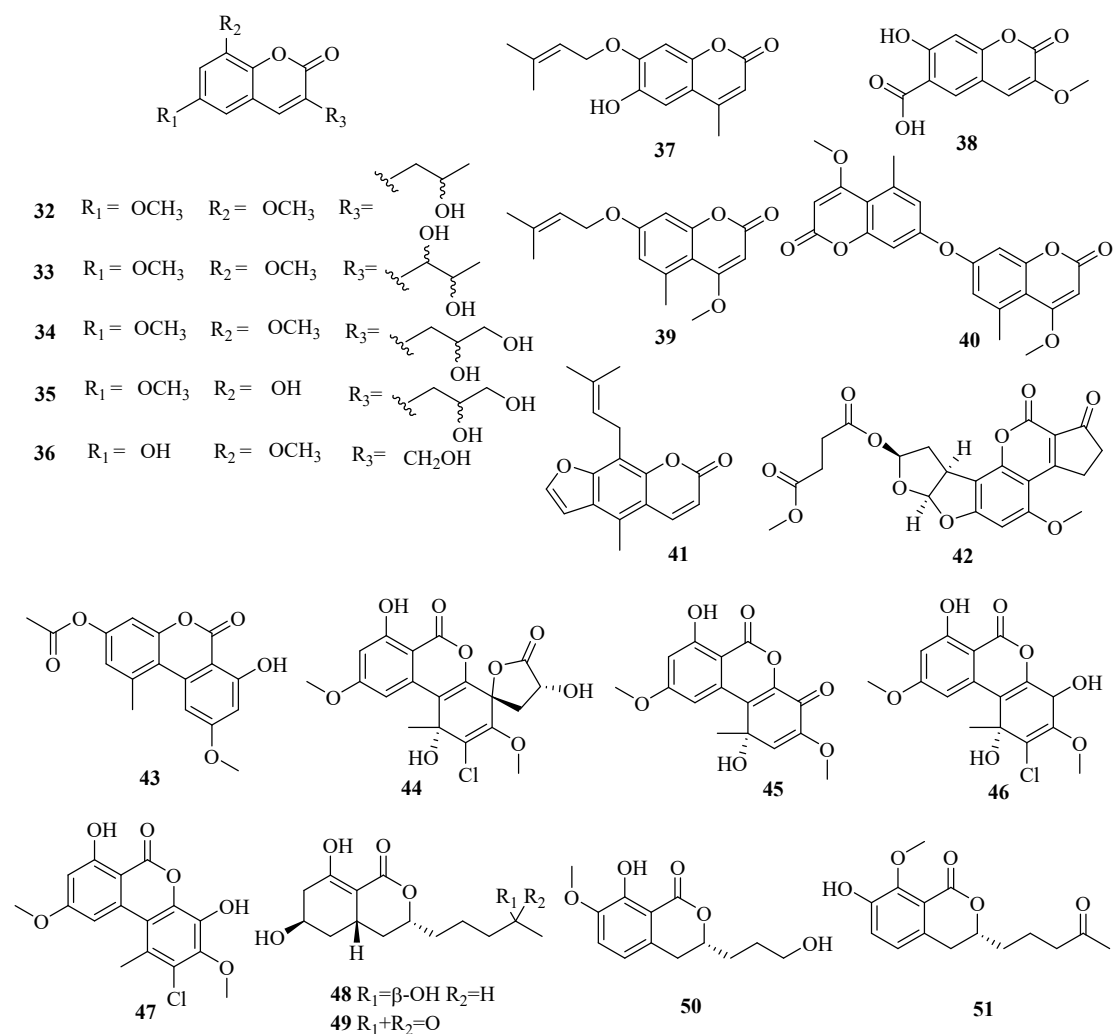
## 3.1 Polyketides (1–874, 874)

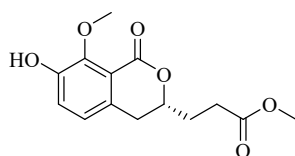
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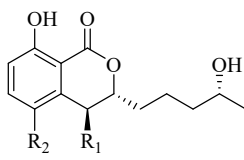


### 3.1.2 Coumarins and Isocoumarins (32–145, 114)

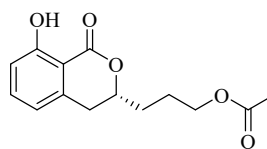




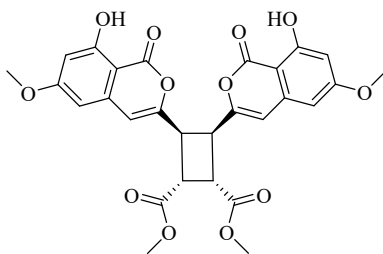
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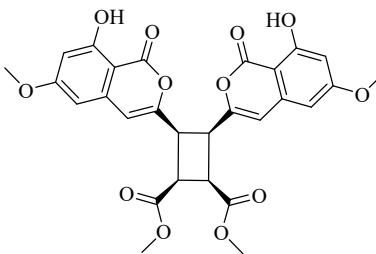
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55 R<sub>1</sub>=OH R<sub>2</sub>=H



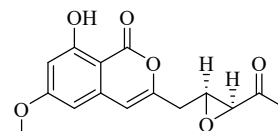
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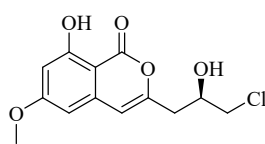
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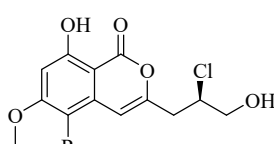
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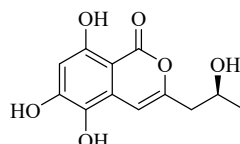
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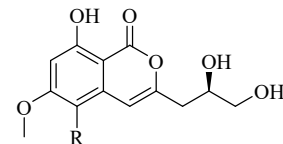
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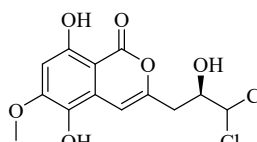
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61 R = OH



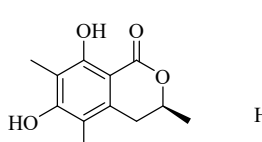
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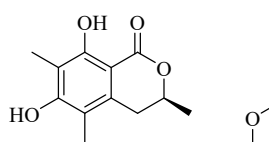
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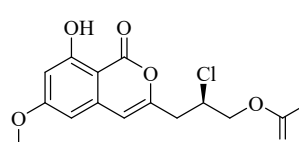
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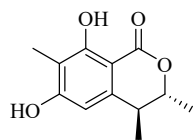
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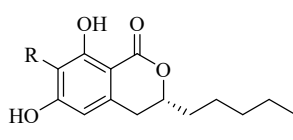
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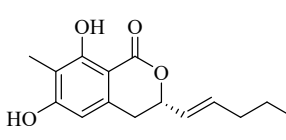
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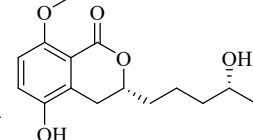
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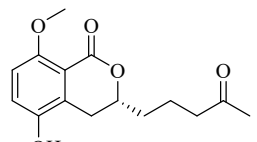
70 R = CH<sub>3</sub>  
71 R = H



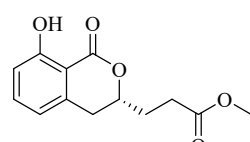
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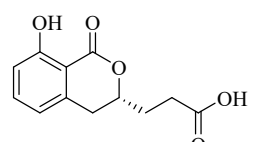
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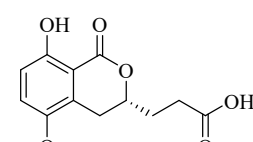
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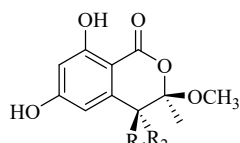
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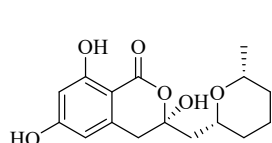
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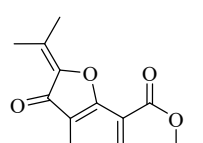
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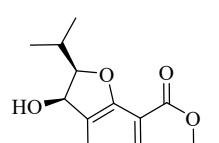
78 R<sub>1</sub>=OH, R<sub>2</sub>=H  
79 R<sub>1</sub>=H, R<sub>2</sub>=OH



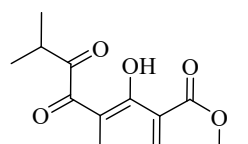
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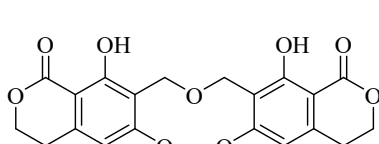
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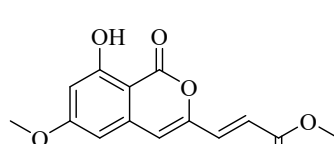
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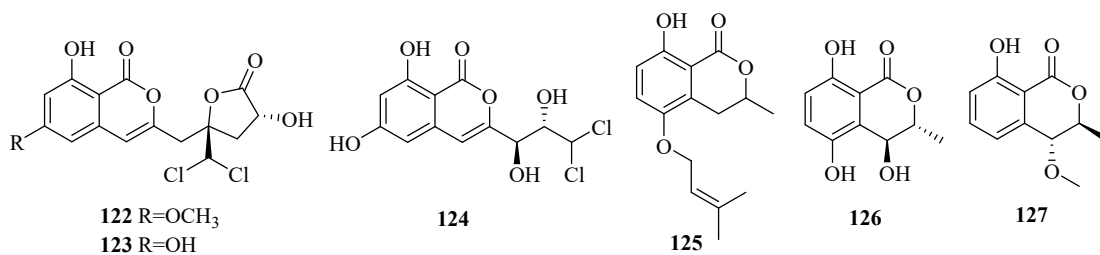
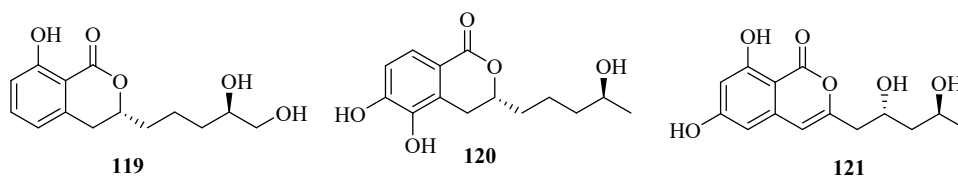
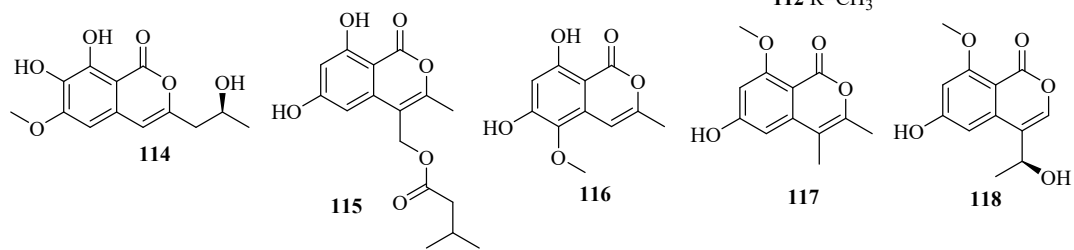
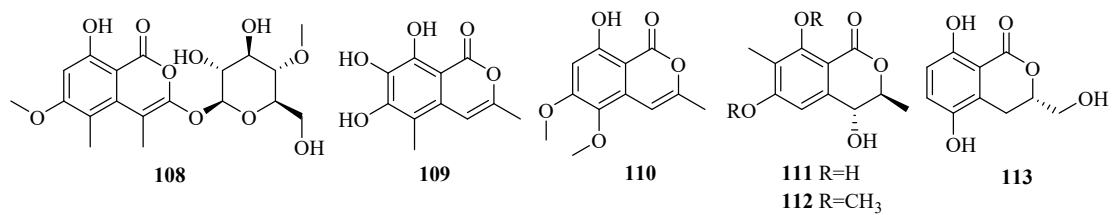
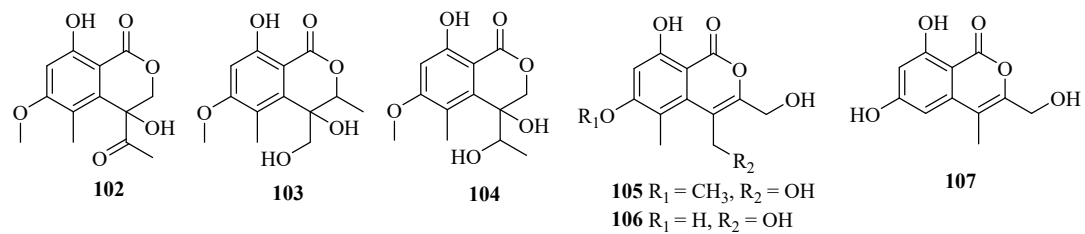
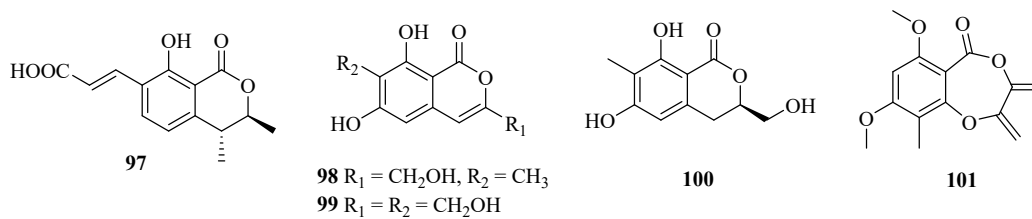
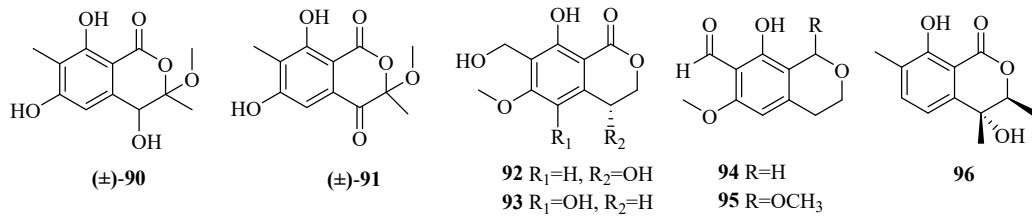
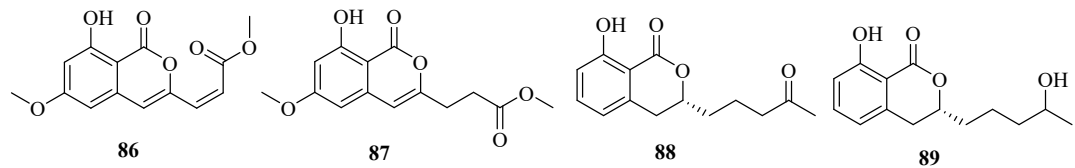
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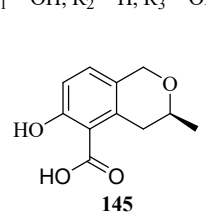
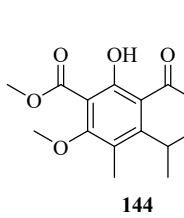
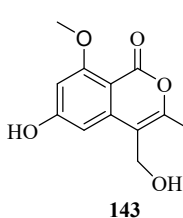
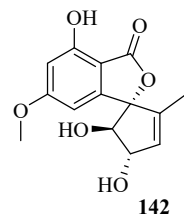
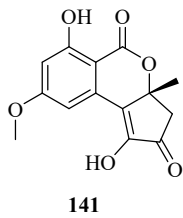
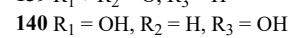
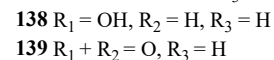
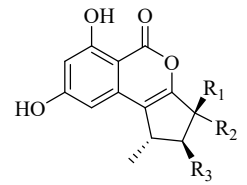
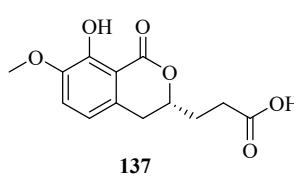
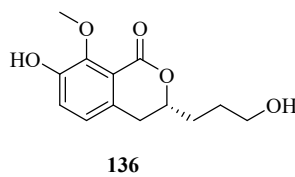
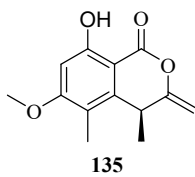
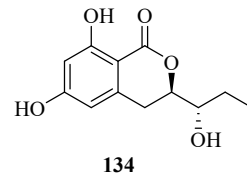
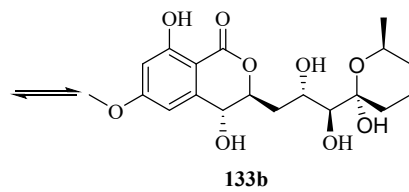
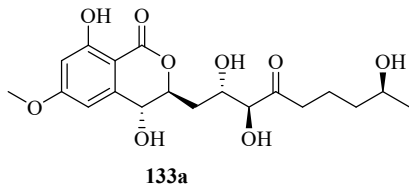
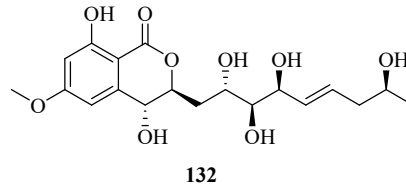
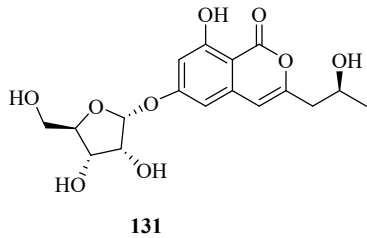
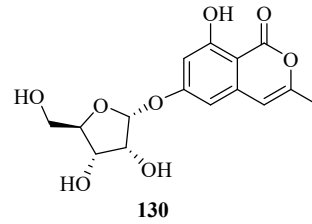
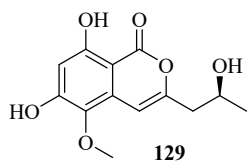
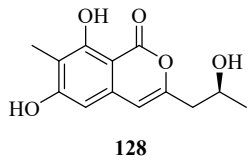


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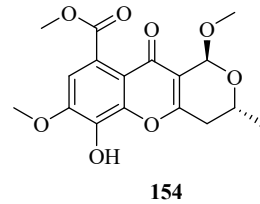
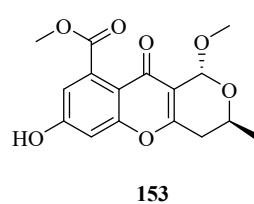
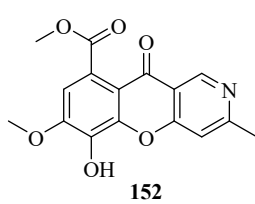
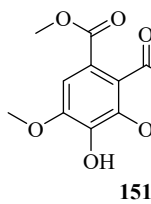
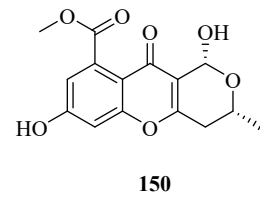
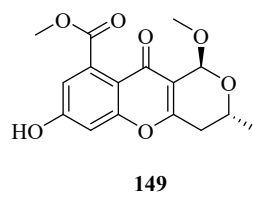
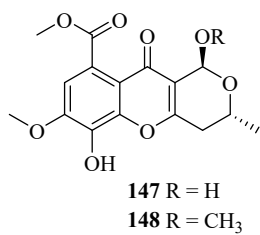
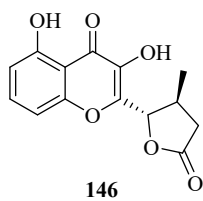


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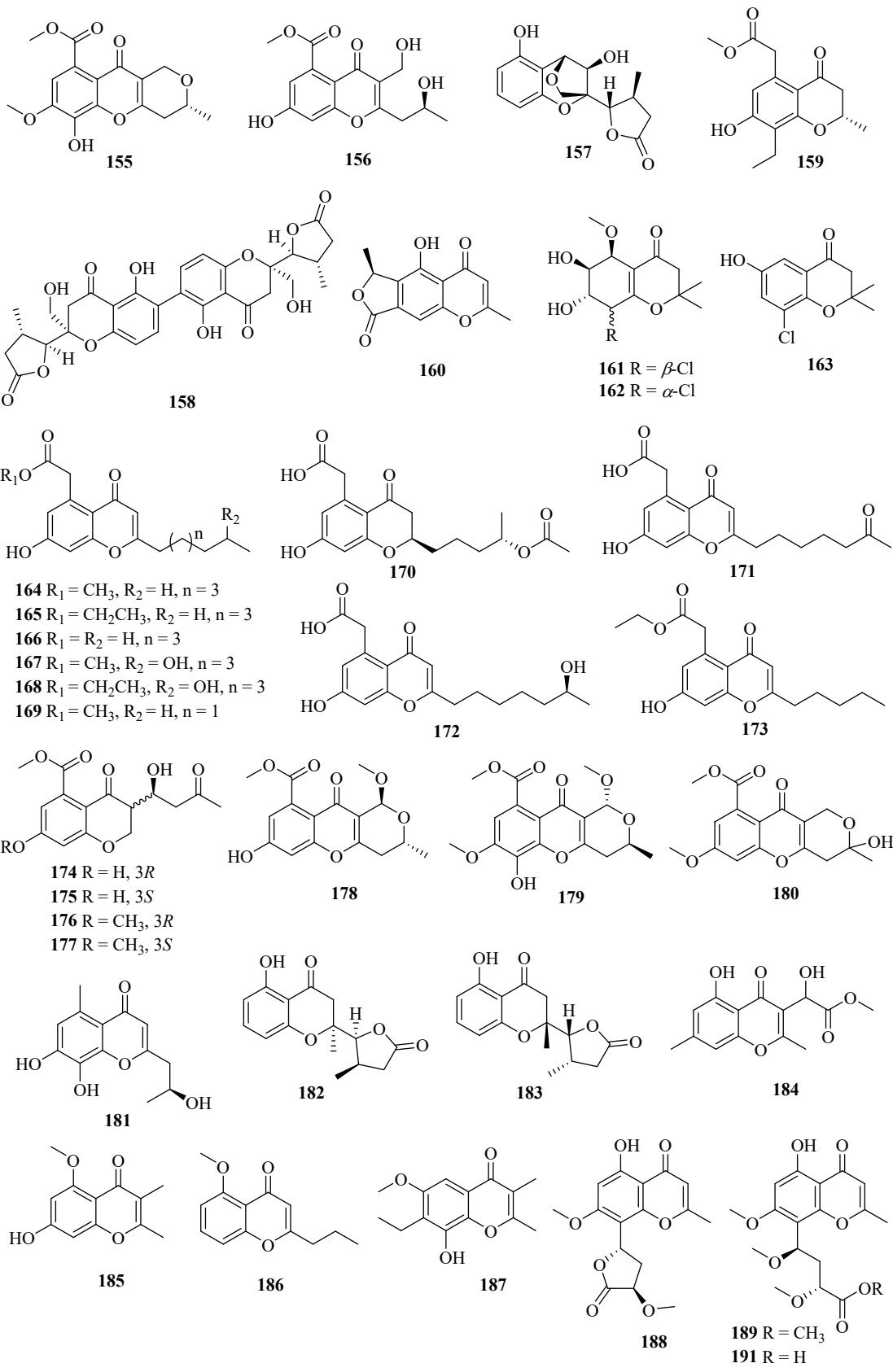


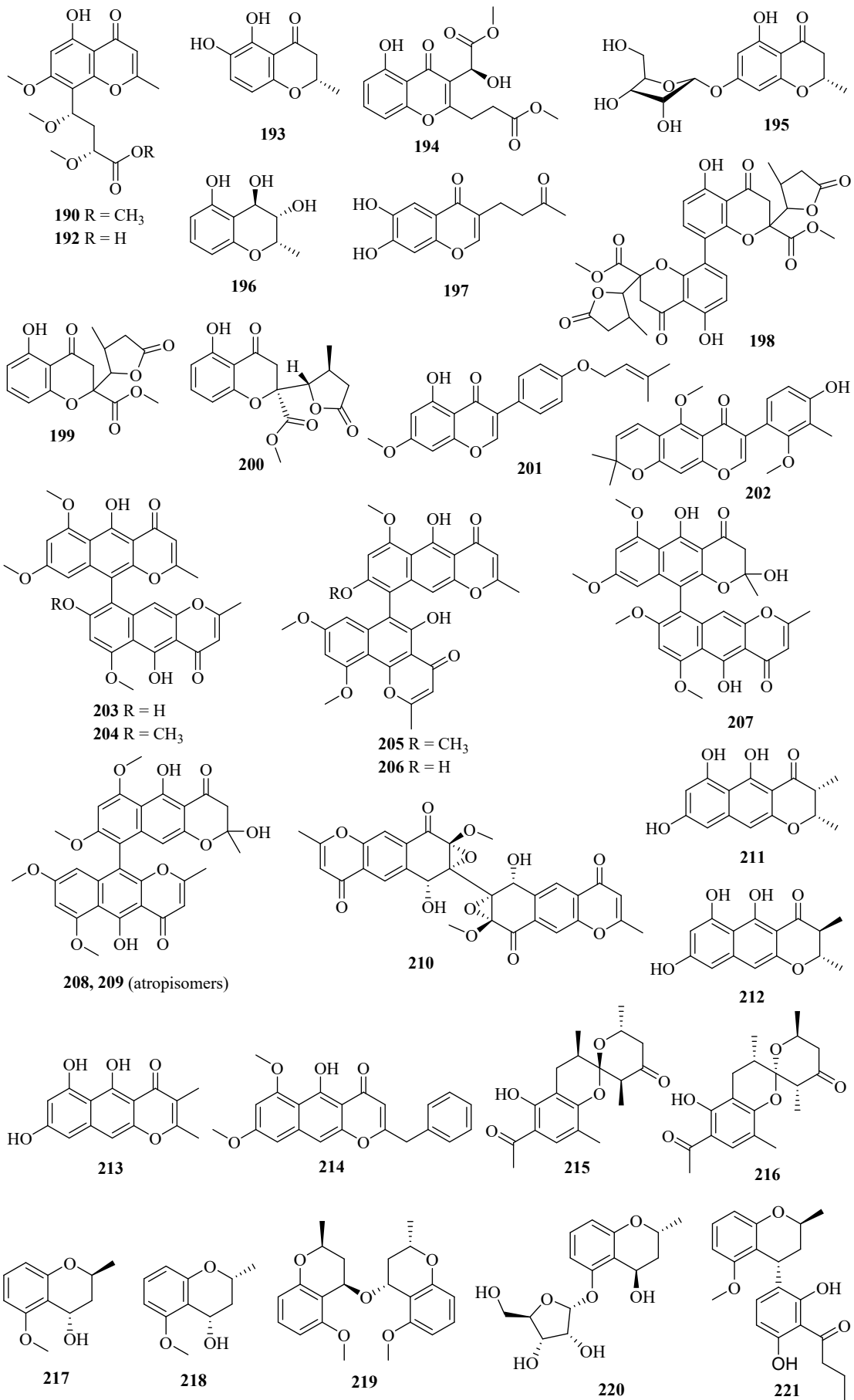


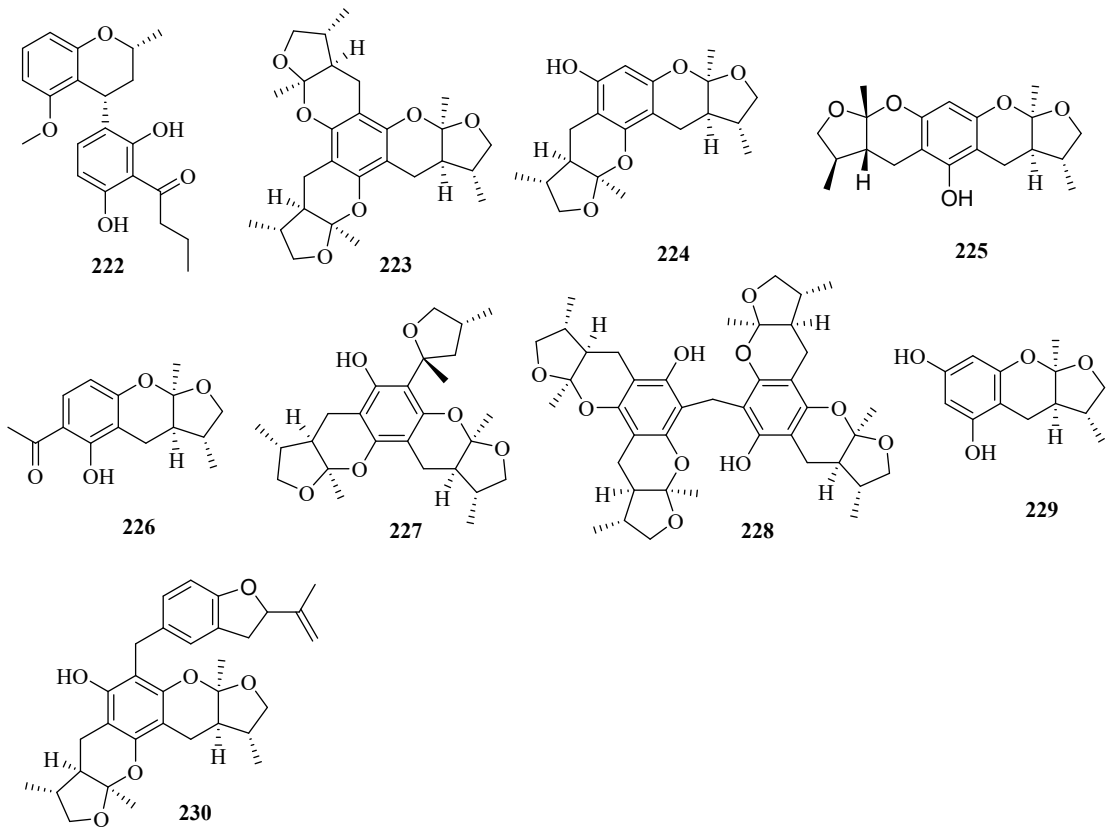
### 3.1.3 Chromones (146–230, 25)



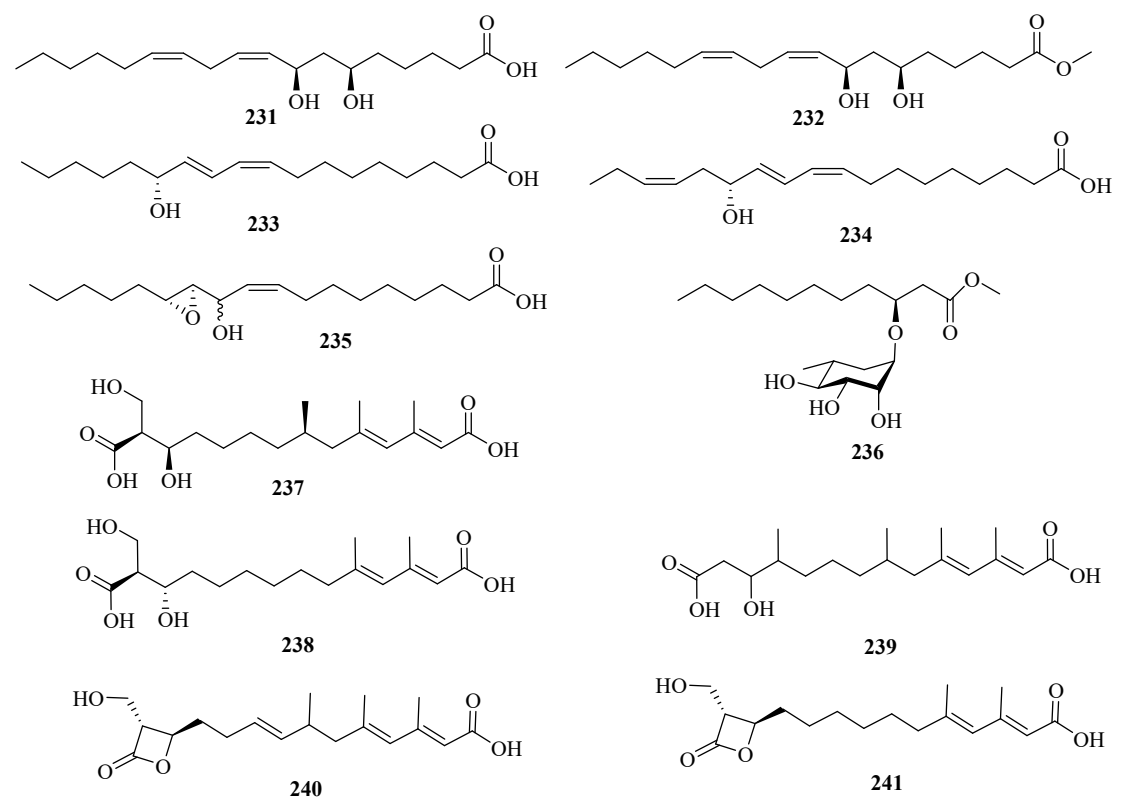


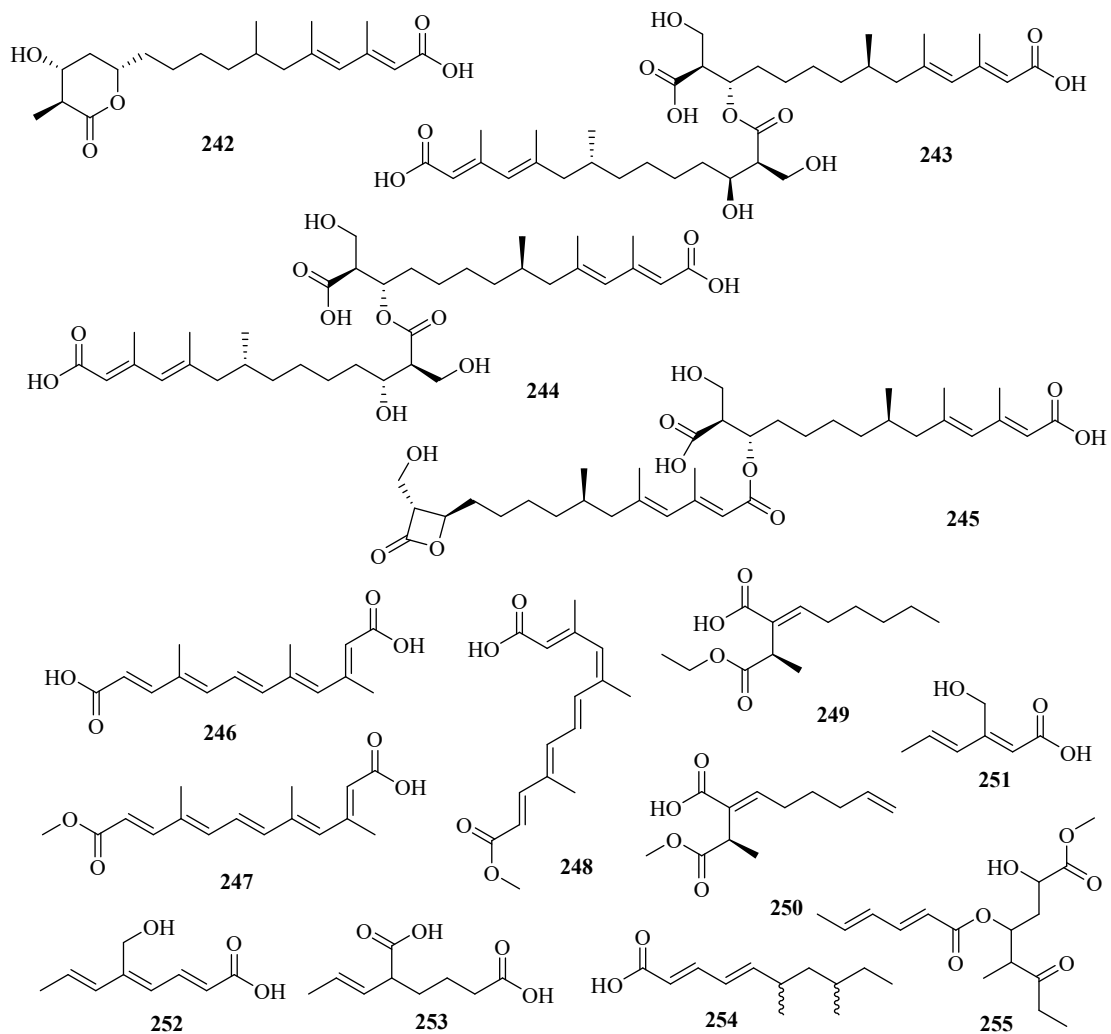




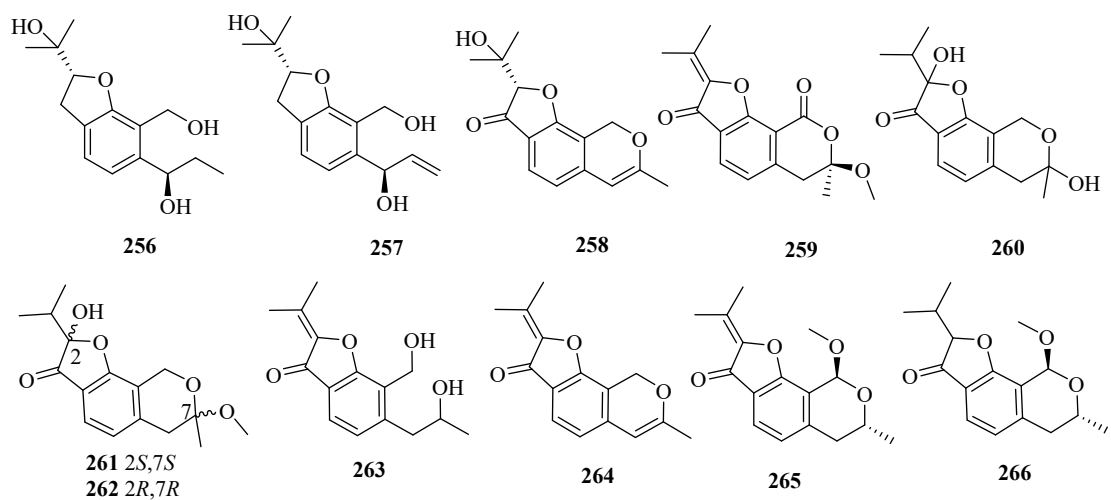


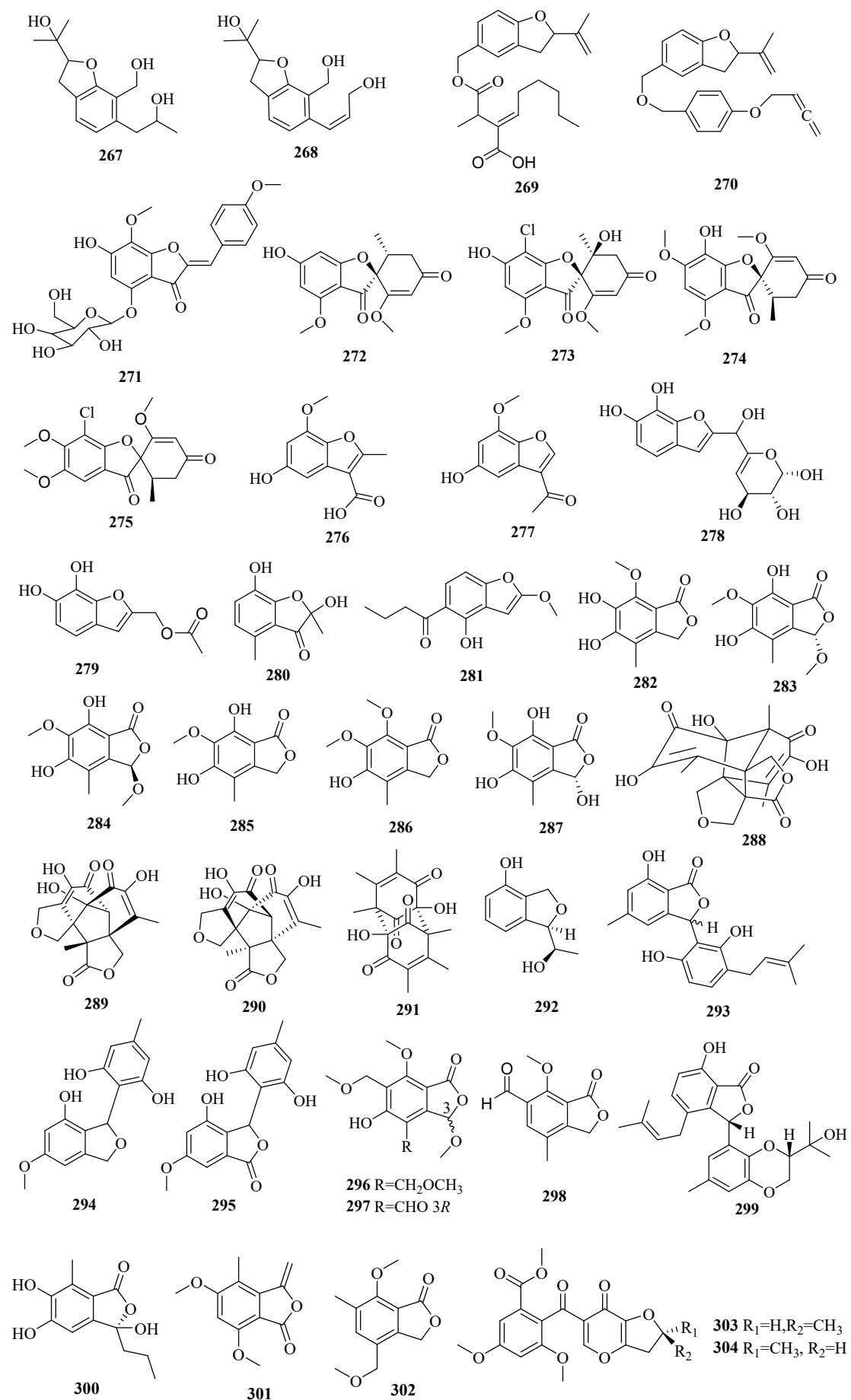
**3.1.4 Fatty acids and their esters (231–255, 25)**

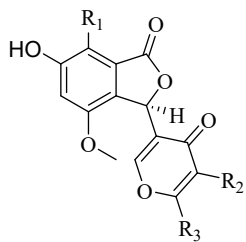




### 3.1.5 Funans (256–335, 80)



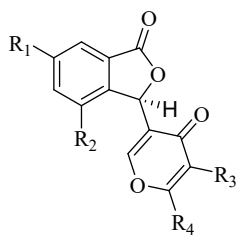




305  $R_1=R_2=H, R_3=nPr$

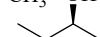
306  $R_1=H, R_2=OCH_3, R_3=nPr$

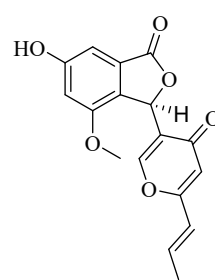
307  $R_1=OCH_3, R_2=H, R_3=propenyl$



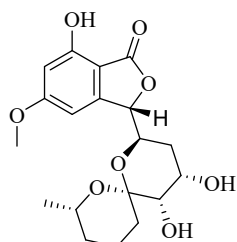
308  $R_1=OH, R_2=OCH_3, R_3=H, R_4=CH_3$

309  $R_1=R_2=OCH_3, R_3=OH, R_4=CH_3$

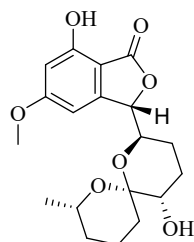
310  $R_1=R_2=OCH_3, R_3=H, R_4=$  



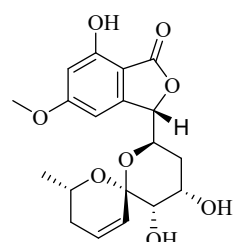
311



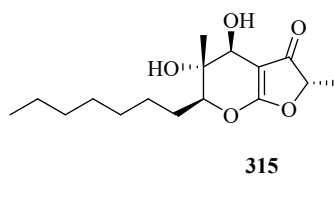
312



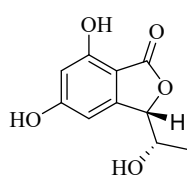
313



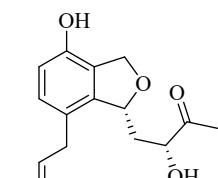
314



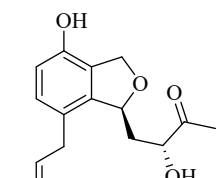
315



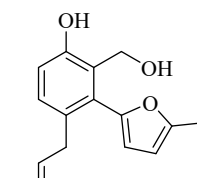
316



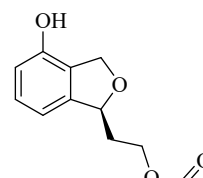
317



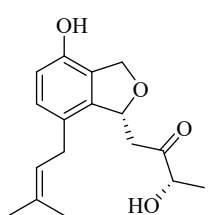
318



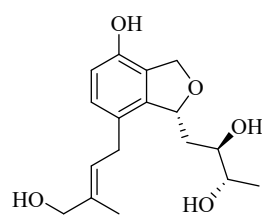
319



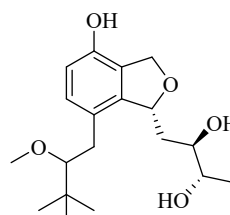
320



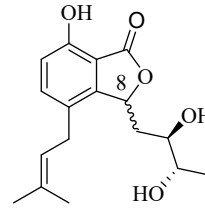
321



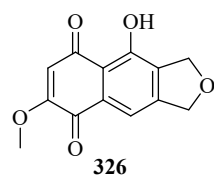
322



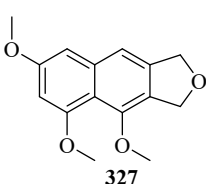
323



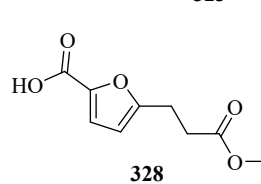
324 8S  
325 8R



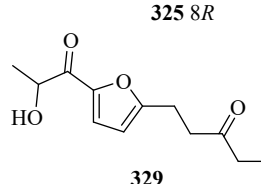
326



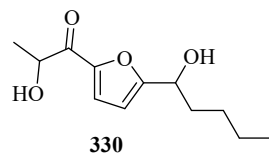
327



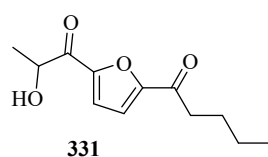
328



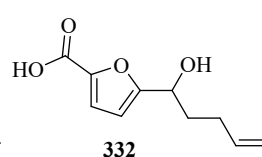
329



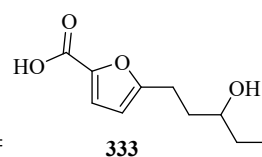
330



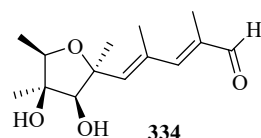
331



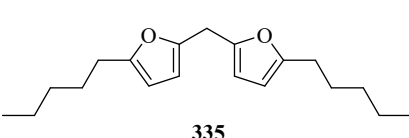
332



333

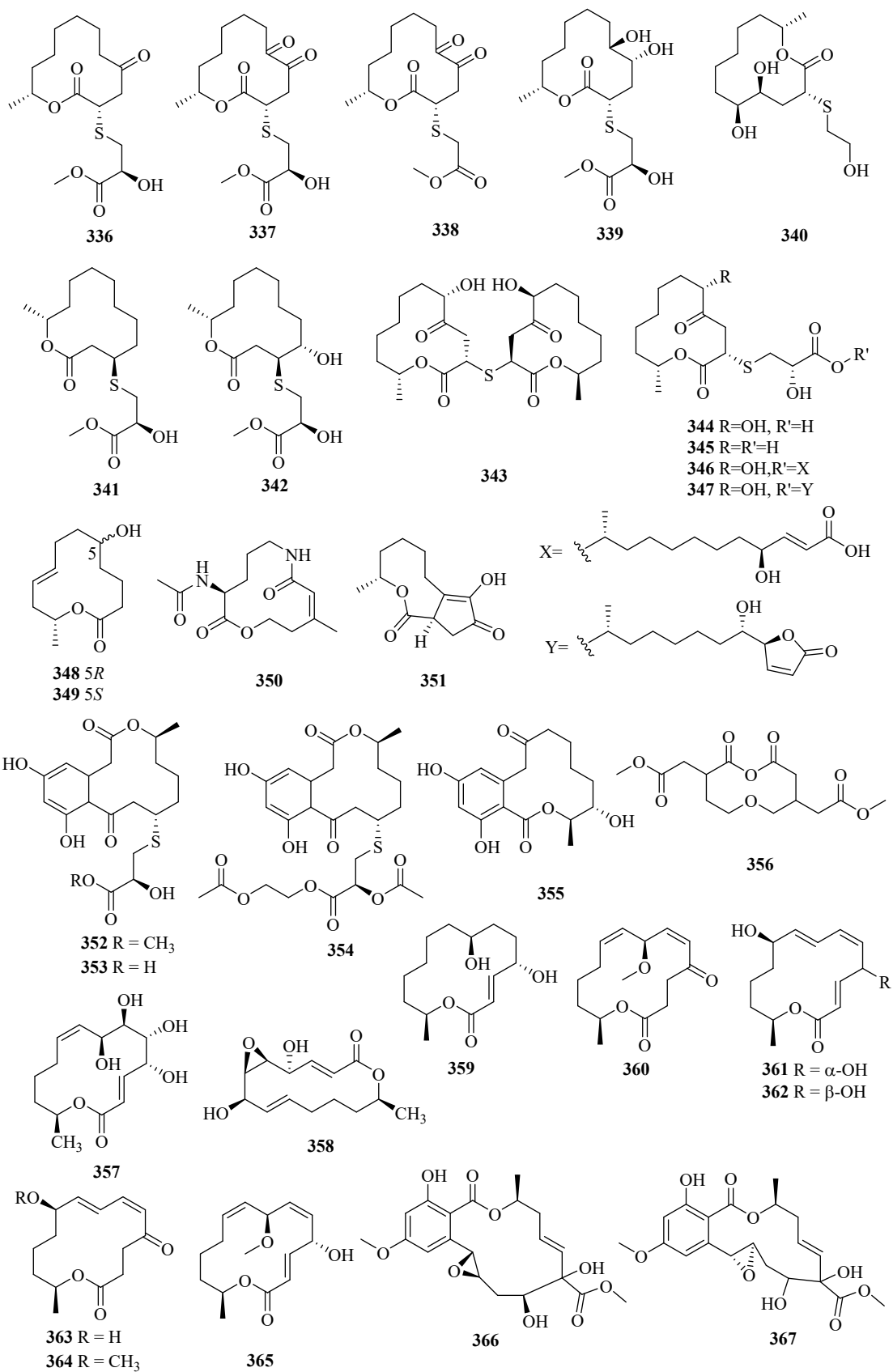


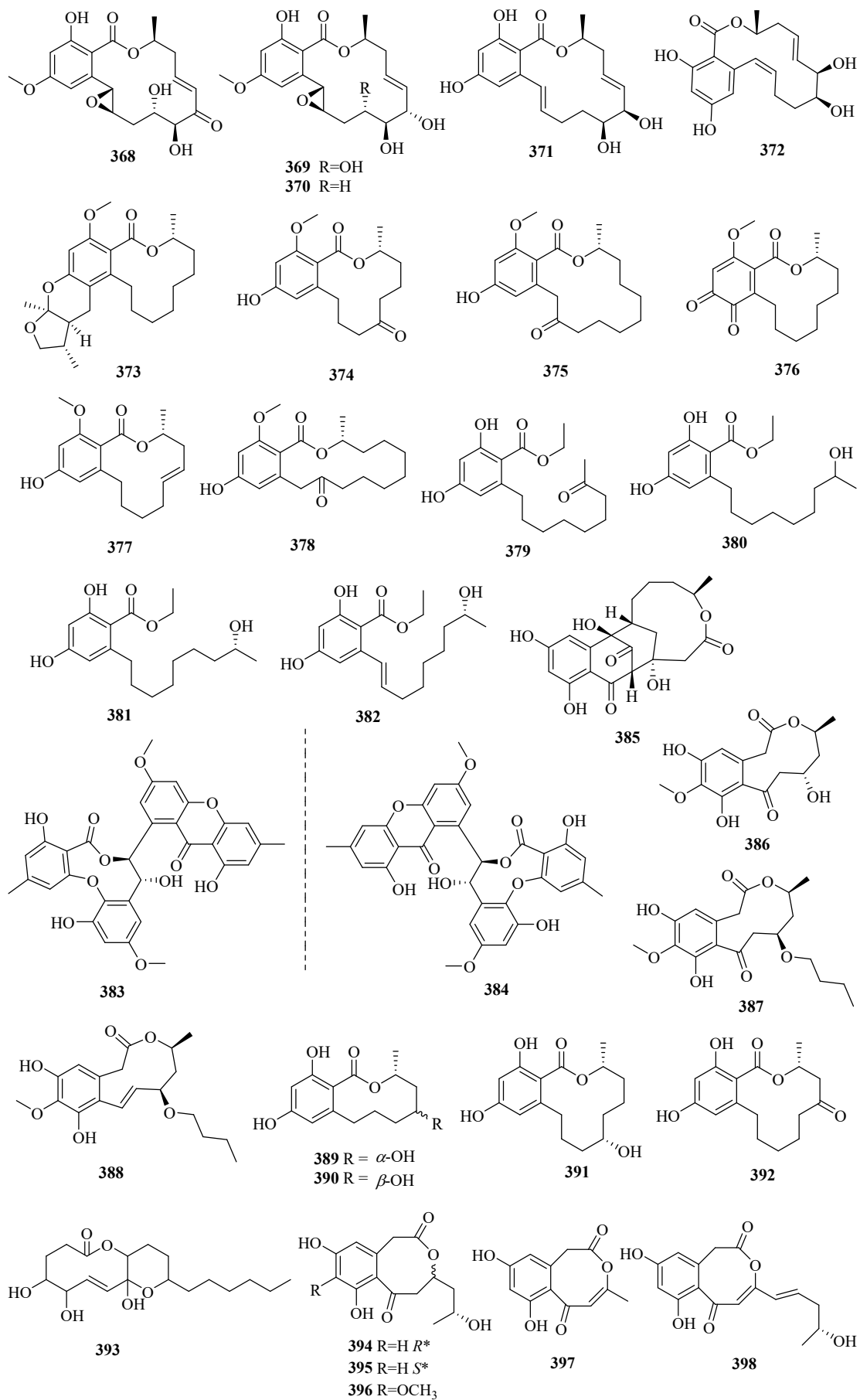
334



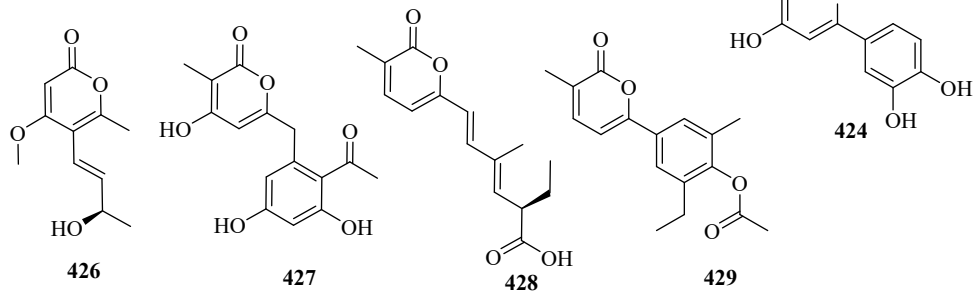
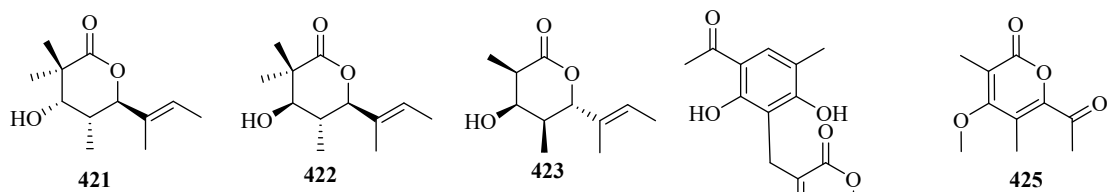
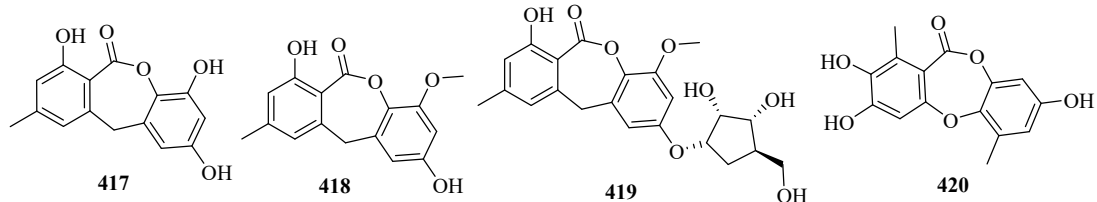
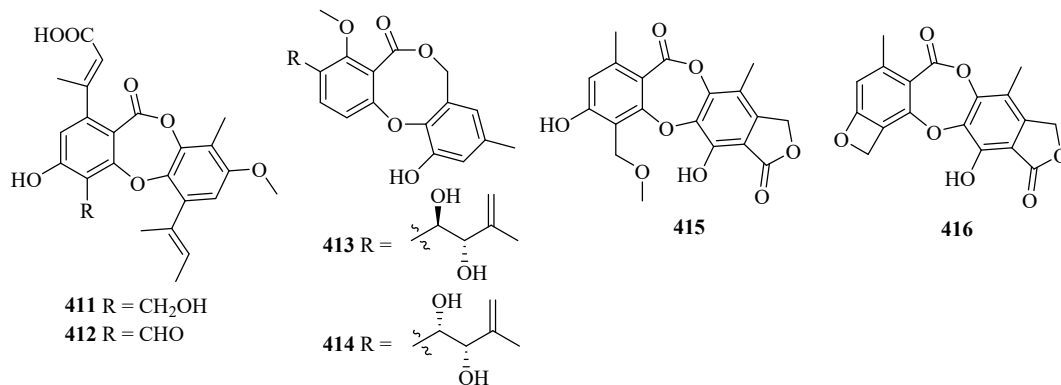
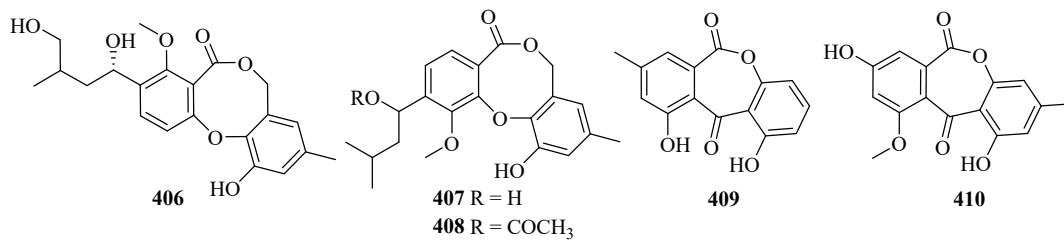
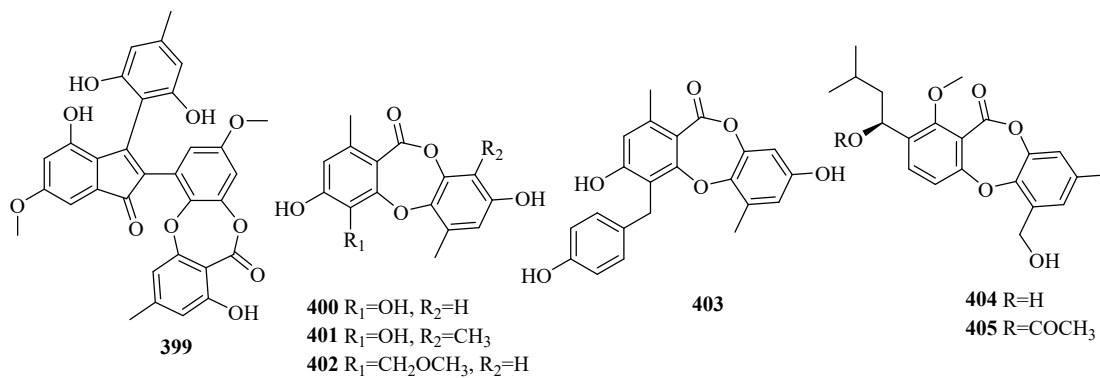
335

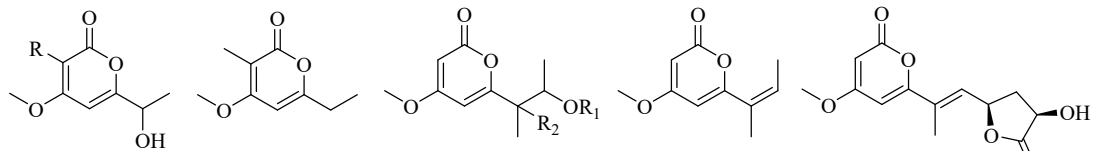
3.1.6 Lactones (336–496, 161)











430 R = H

431 R = CH<sub>3</sub>

432

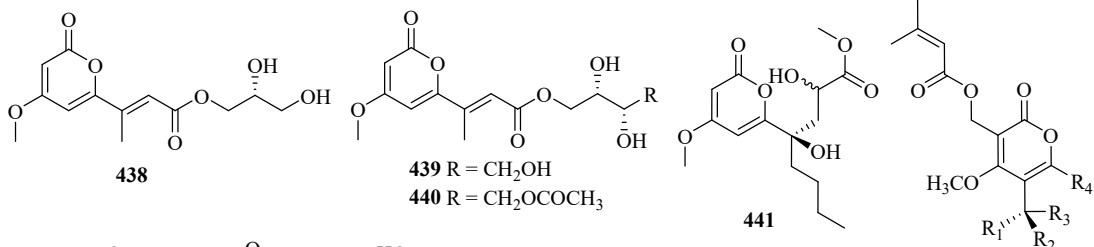
433 R<sub>1</sub> = H, R<sub>2</sub> = OH

434 R<sub>1</sub> = R<sub>2</sub> = H

435 R<sub>1</sub> = COCH<sub>3</sub>, R<sub>2</sub> = H

436

437



438

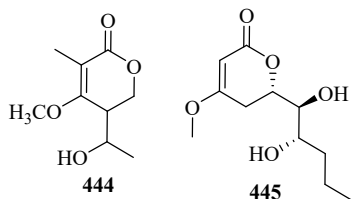
439 R = CH<sub>2</sub>OH

440 R = CH<sub>2</sub>OCOCH<sub>3</sub>

441

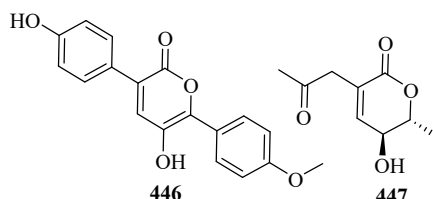
442 R<sub>1</sub> = OH, R<sub>2</sub> = R<sub>4</sub> = H, R<sub>3</sub> = CH<sub>3</sub>

443 R<sub>1</sub> = R<sub>2</sub> = H, R<sub>3</sub> = OH, R<sub>4</sub> = CH<sub>3</sub>



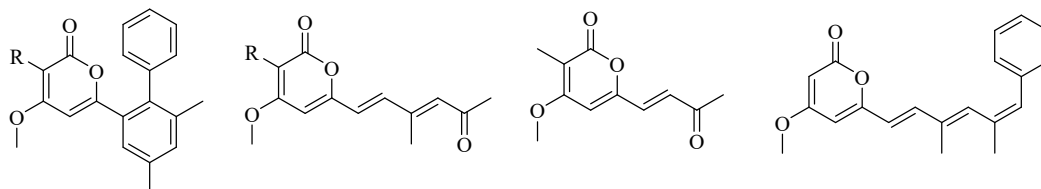
444

445



446

447



448 R = H

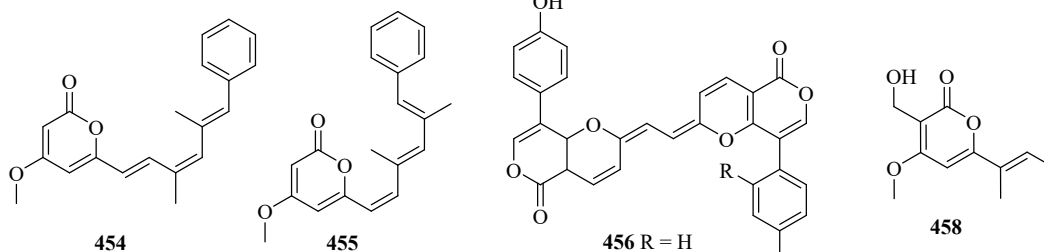
449 R = CH<sub>3</sub>

450 R = H

451 R = CH<sub>3</sub>

452

453



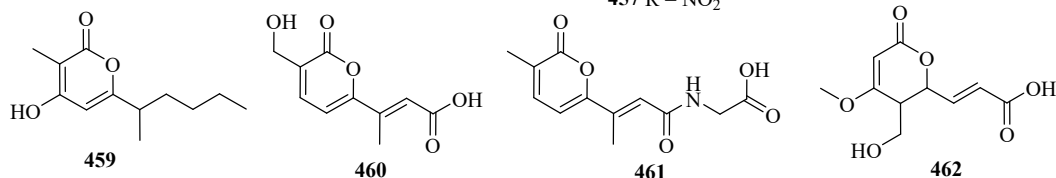
454

455

456 R = H

457 R = NO<sub>2</sub>

458

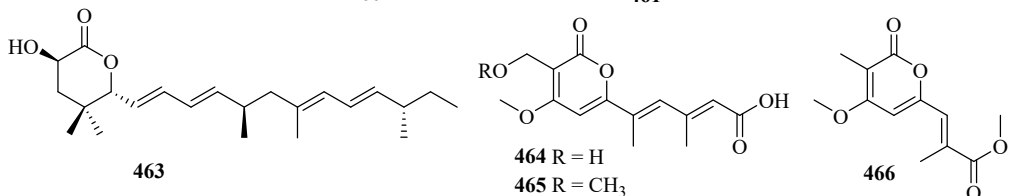


459

460

461

462

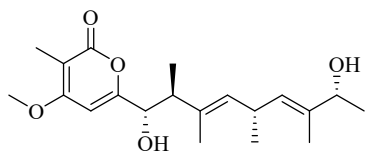


463

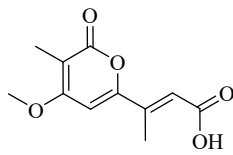
464 R = H

465 R = CH<sub>3</sub>

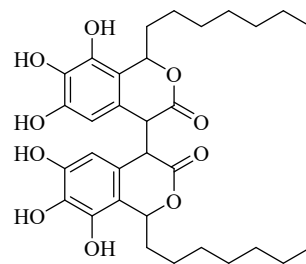
466



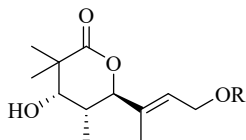
467



468

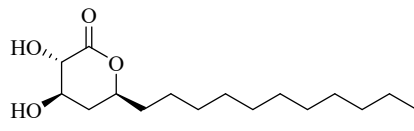


469

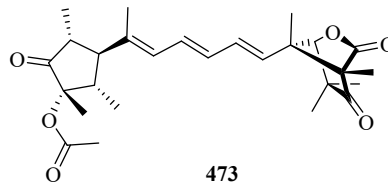


470 R=H

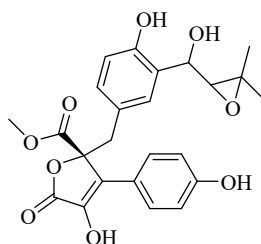
471 R=COCH<sub>3</sub>



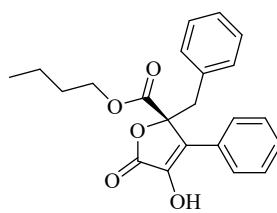
472



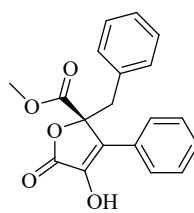
473



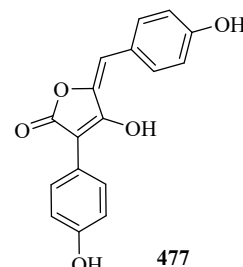
474



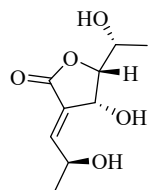
475



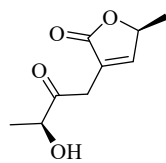
476



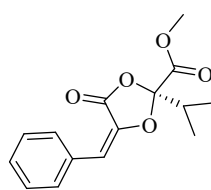
477



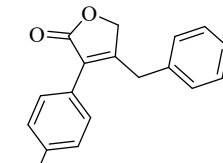
478



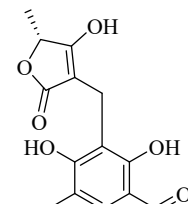
479



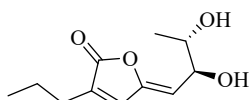
480



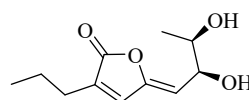
481



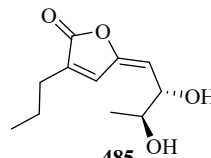
482



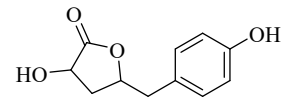
483



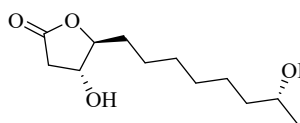
484



485

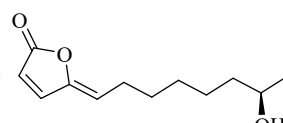


486

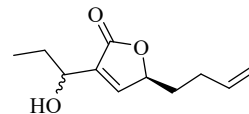


487 R=H

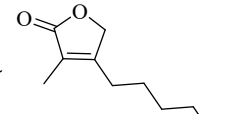
488 R=COCH<sub>3</sub>



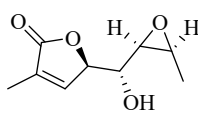
489



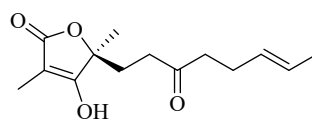
490



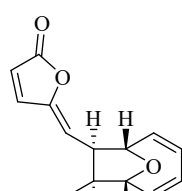
491



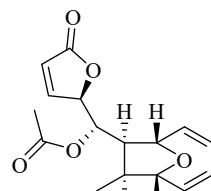
492



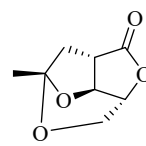
493



494

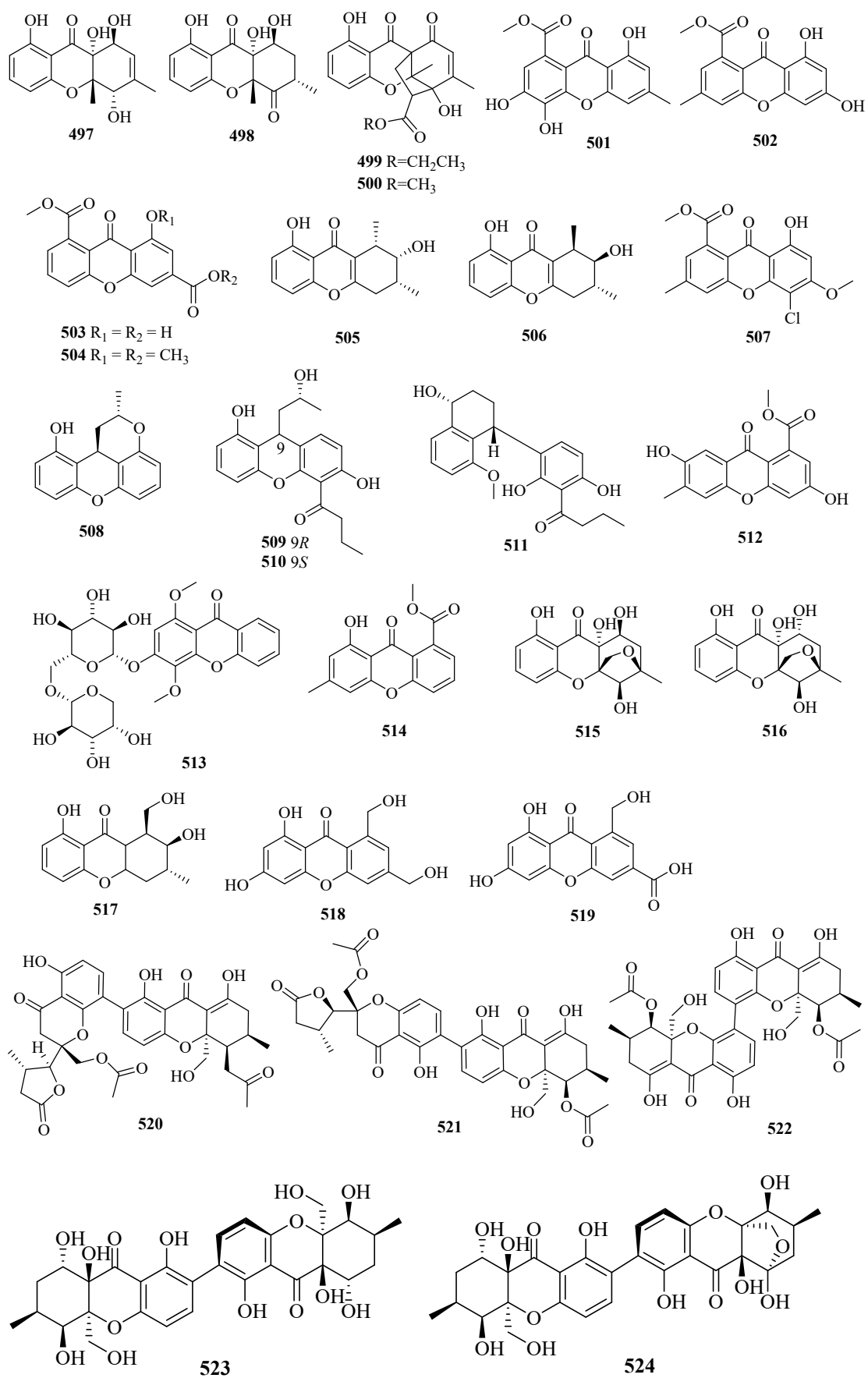


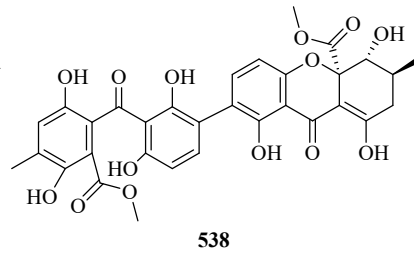
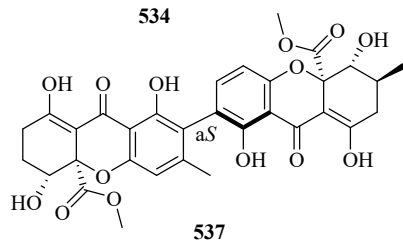
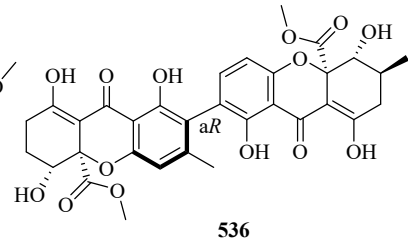
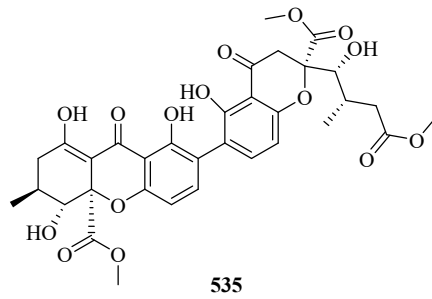
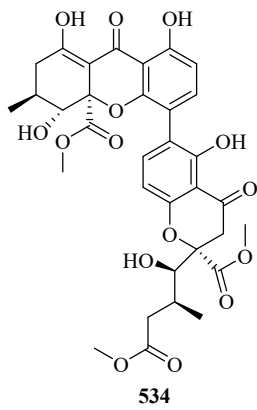
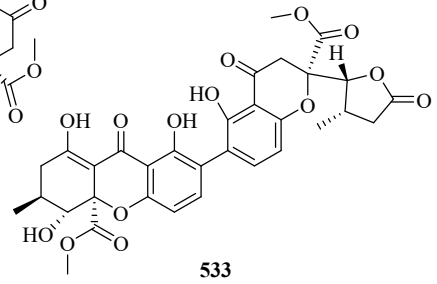
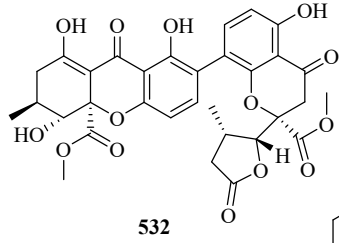
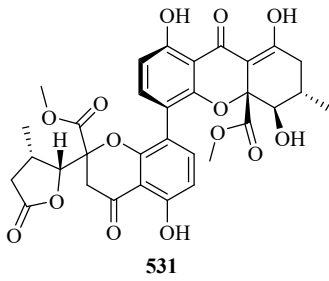
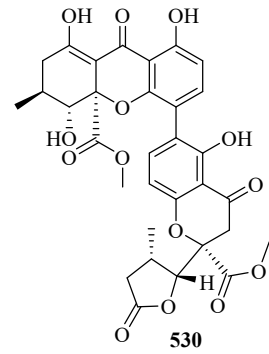
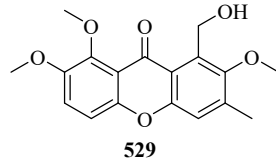
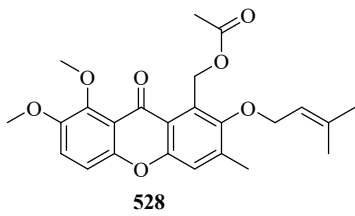
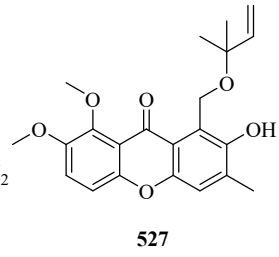
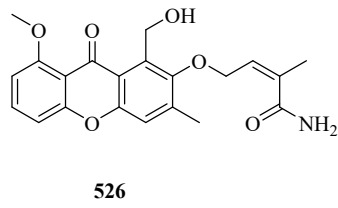
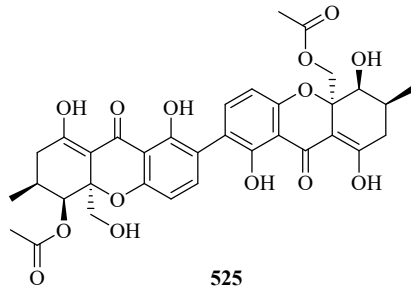
495

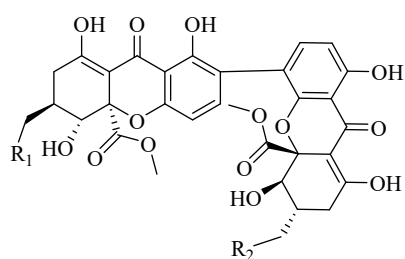


496

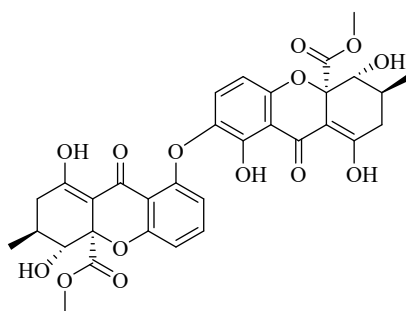
### 3.1.7 Xanthone and benzophenones (497–587, 91)



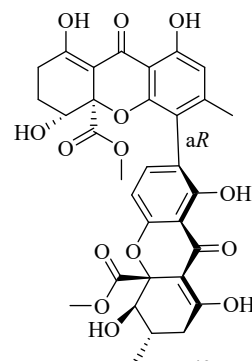




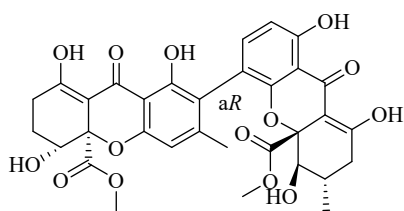
539  $R_1=OH$   $R_2=H$   
540  $R_1=H$ ,  $R_2=OH$



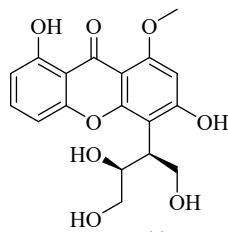
541



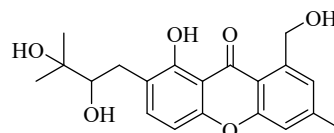
542



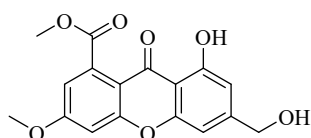
543



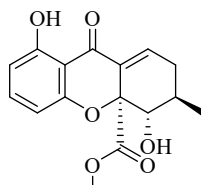
544



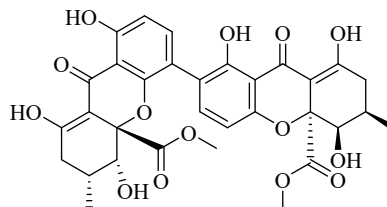
545



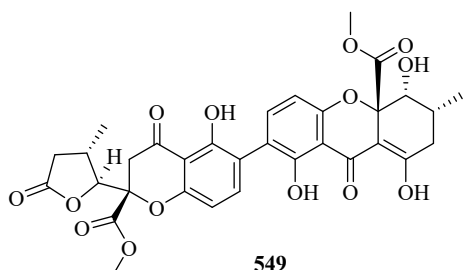
546



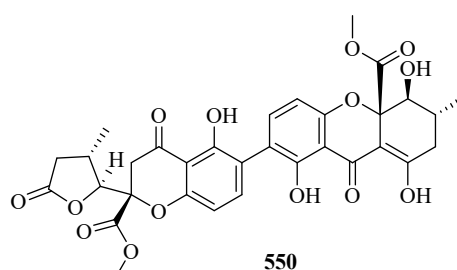
547



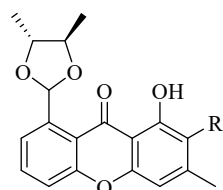
548



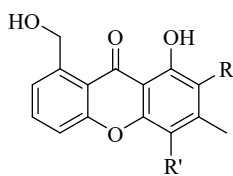
549



550



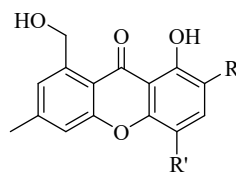
551  $R = X$



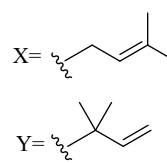
552  $R=X$ ,  $R'=Y$

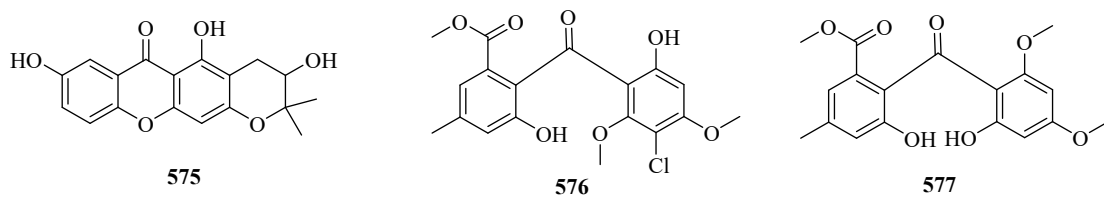
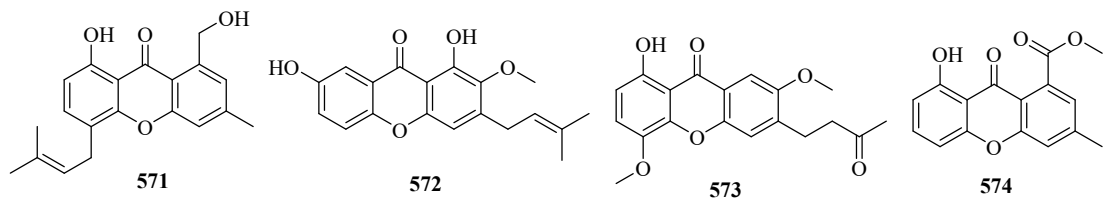
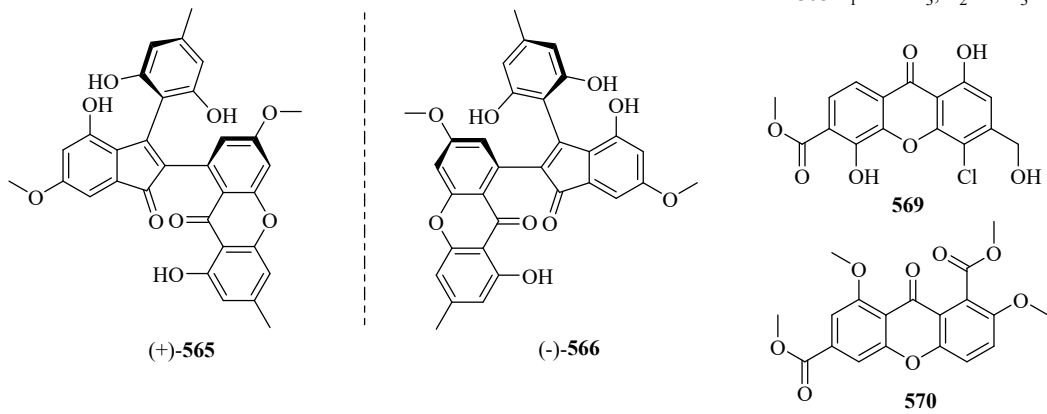
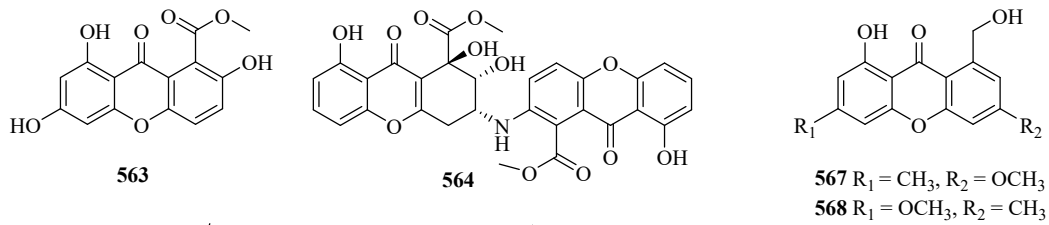
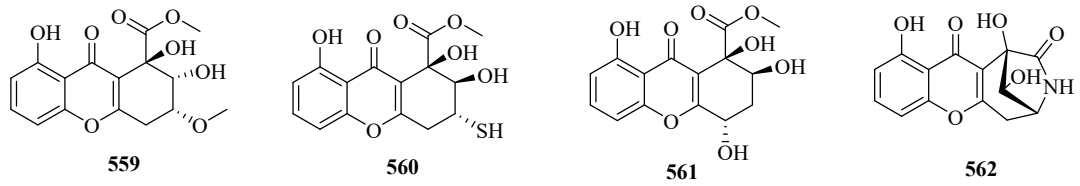
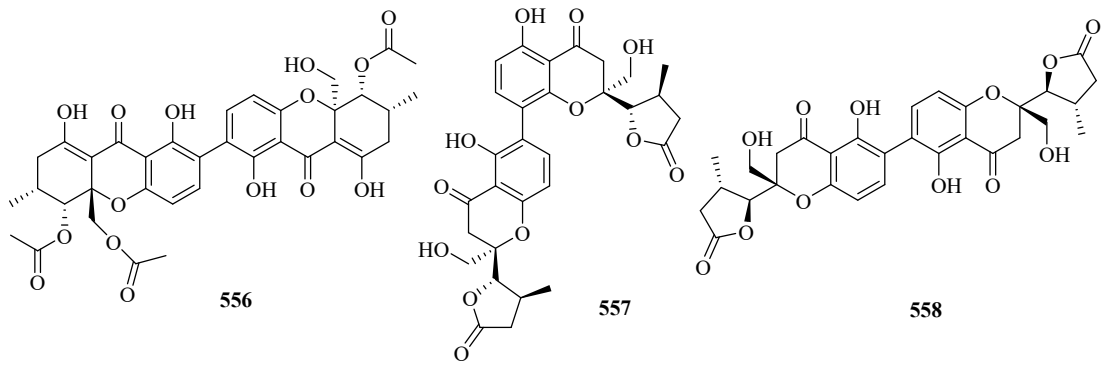
553  $R=R'=X$

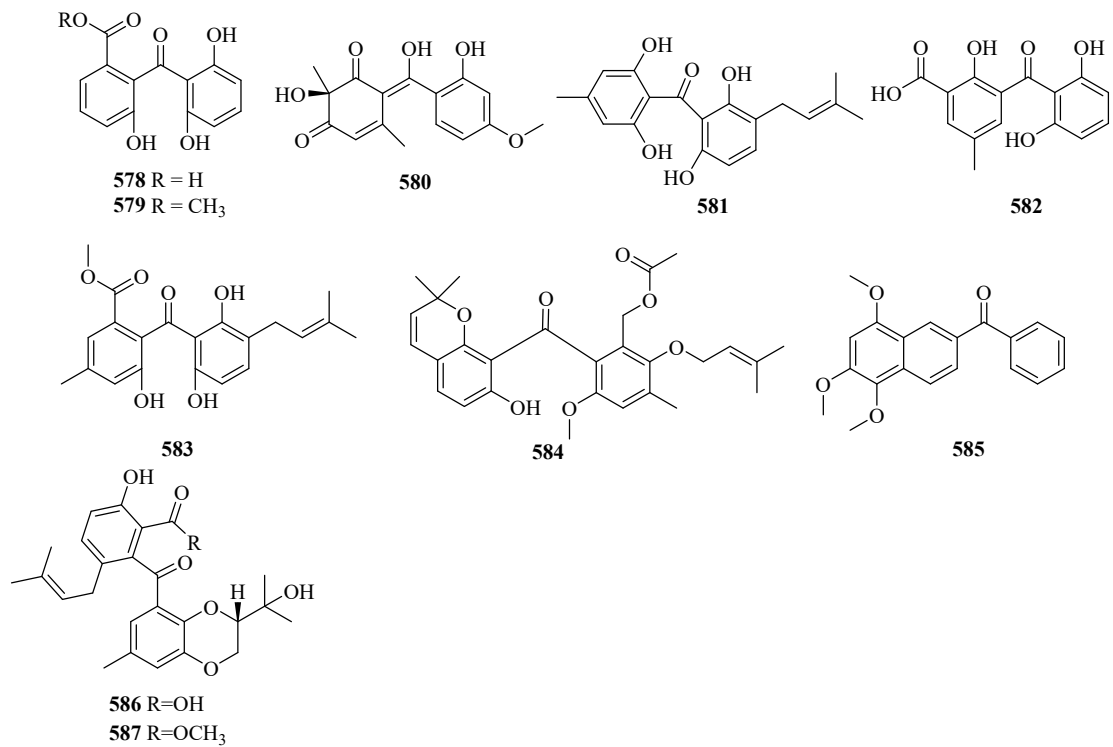
554  $R=Y$ ,  $R'=X$



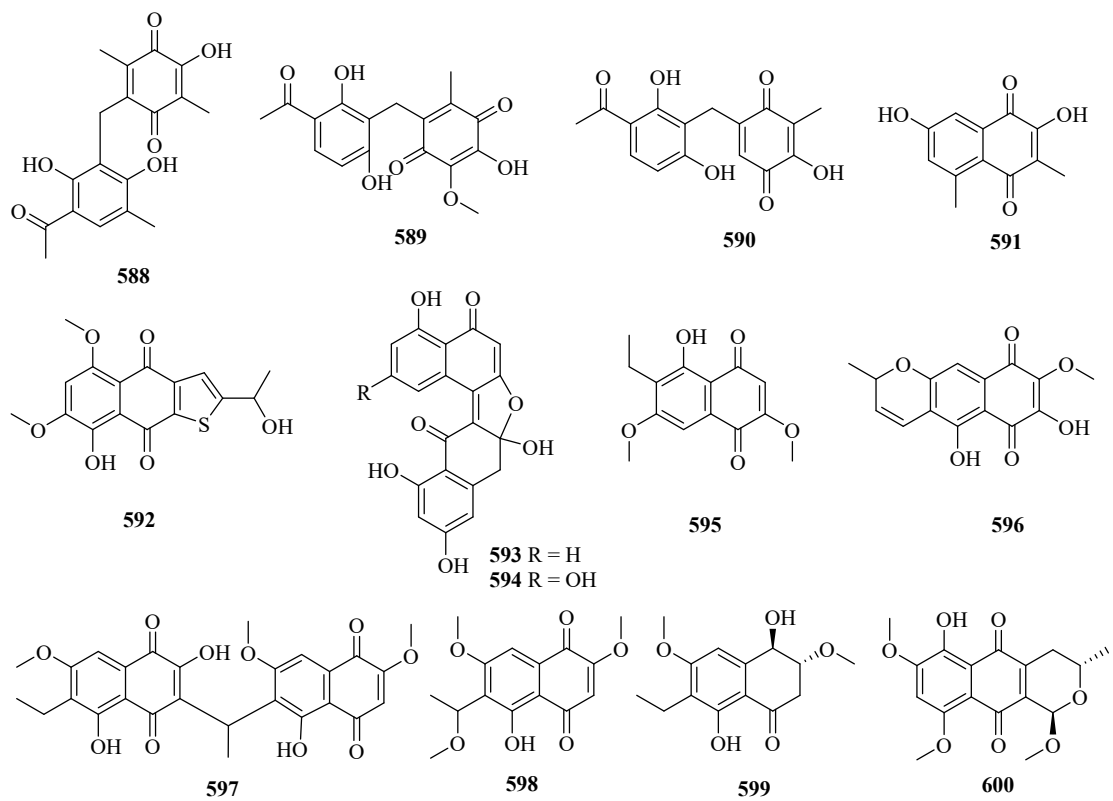
555  $R=X$ ,  $R'=Y$



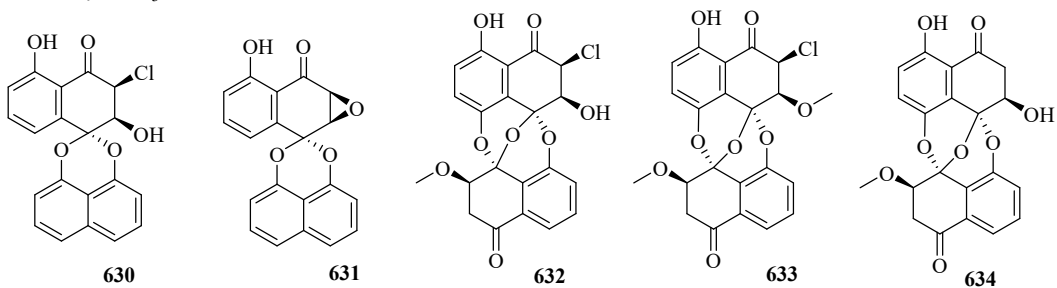
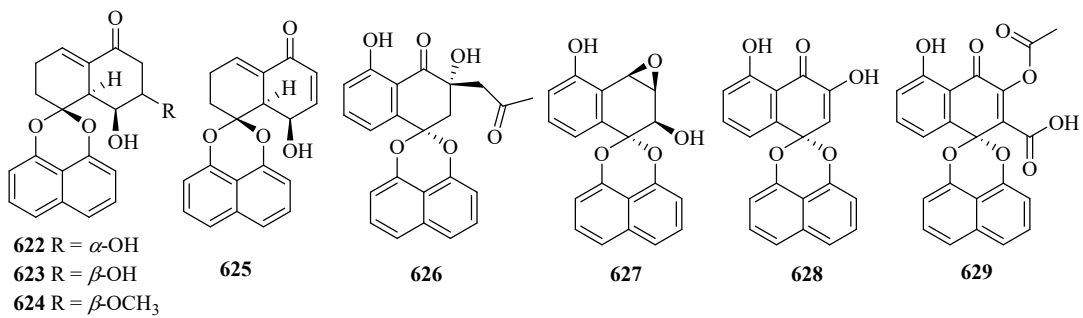
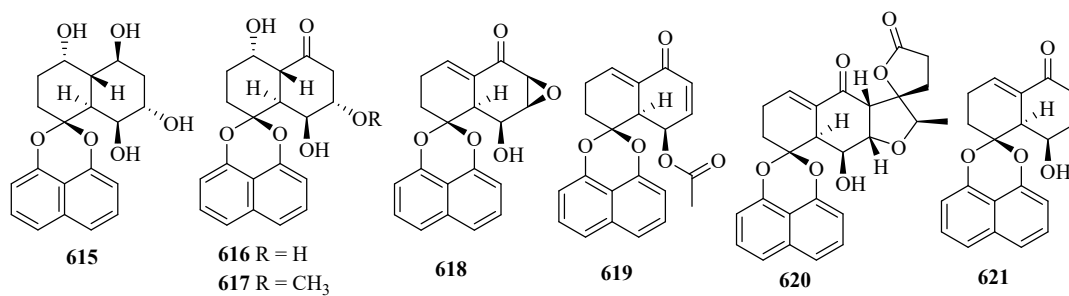
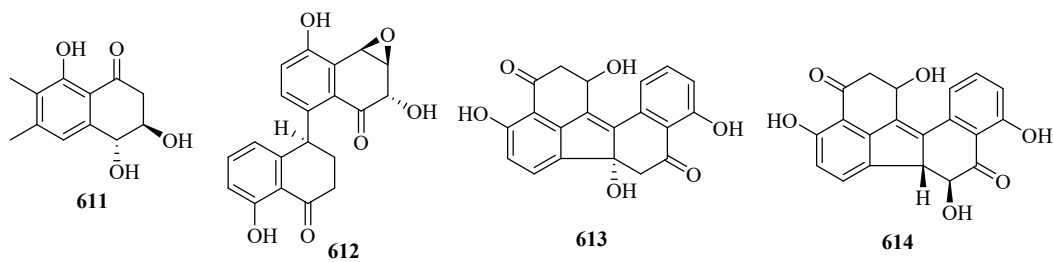
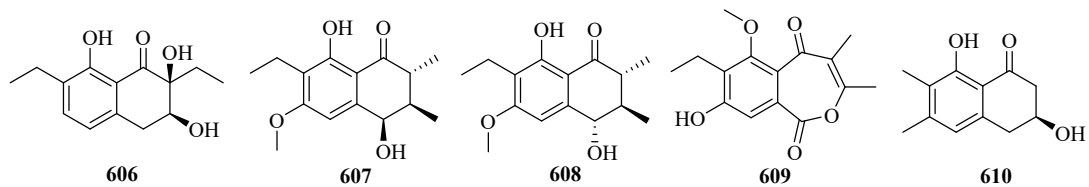
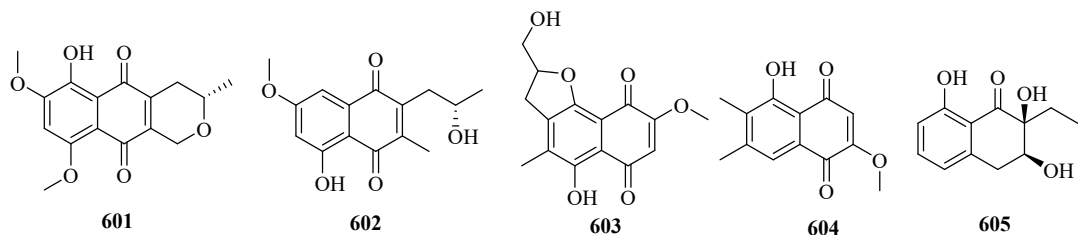


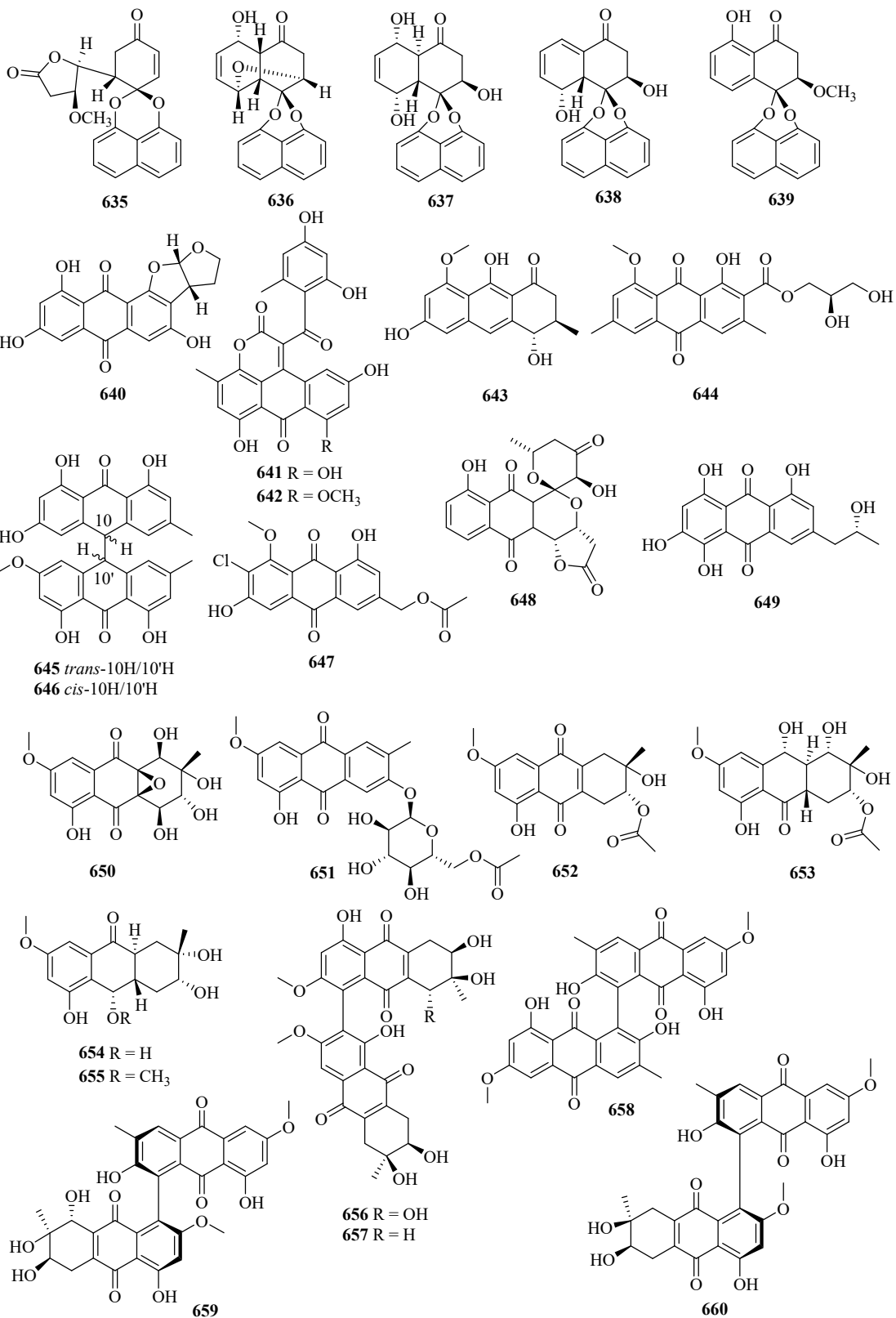


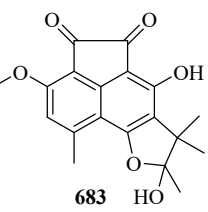
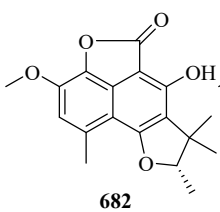
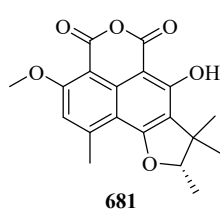
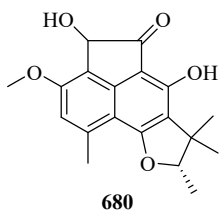
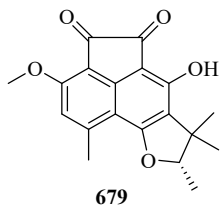
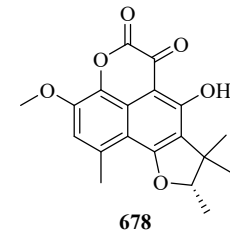
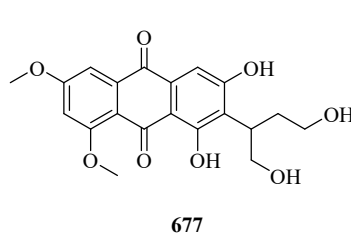
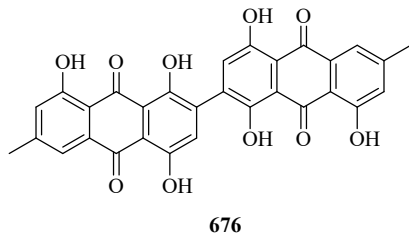
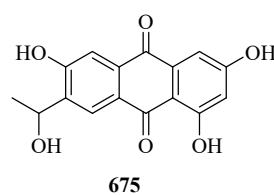
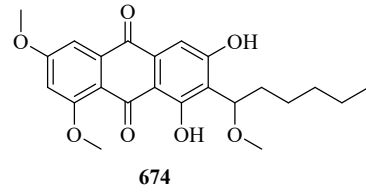
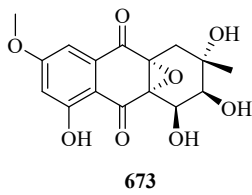
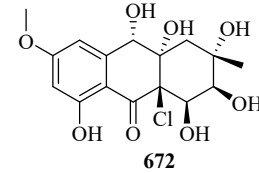
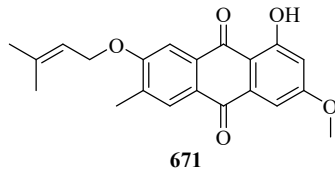
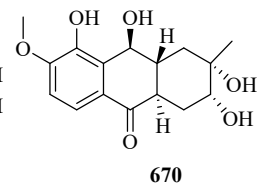
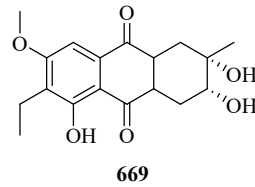
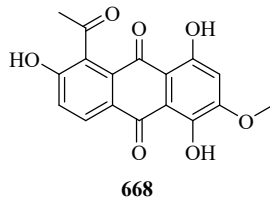
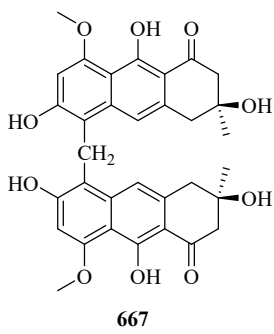
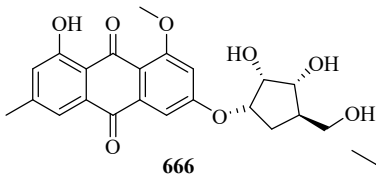
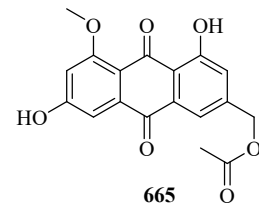
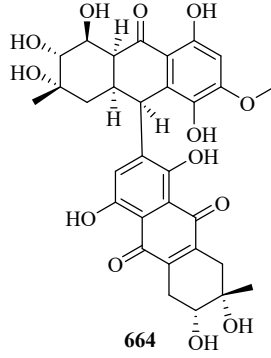
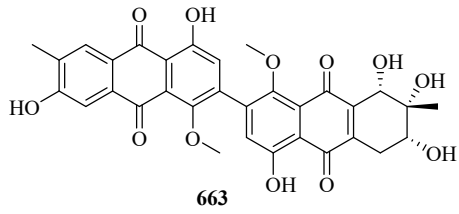
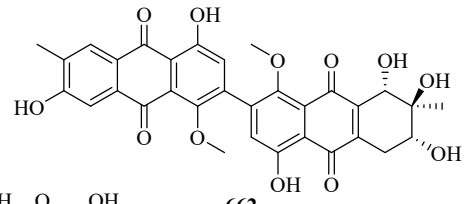
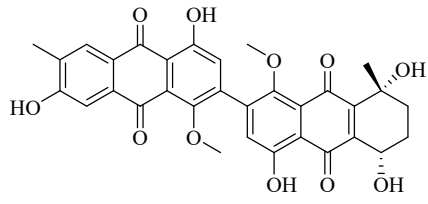
### 3.1.8 Quinones (588–700, 113)

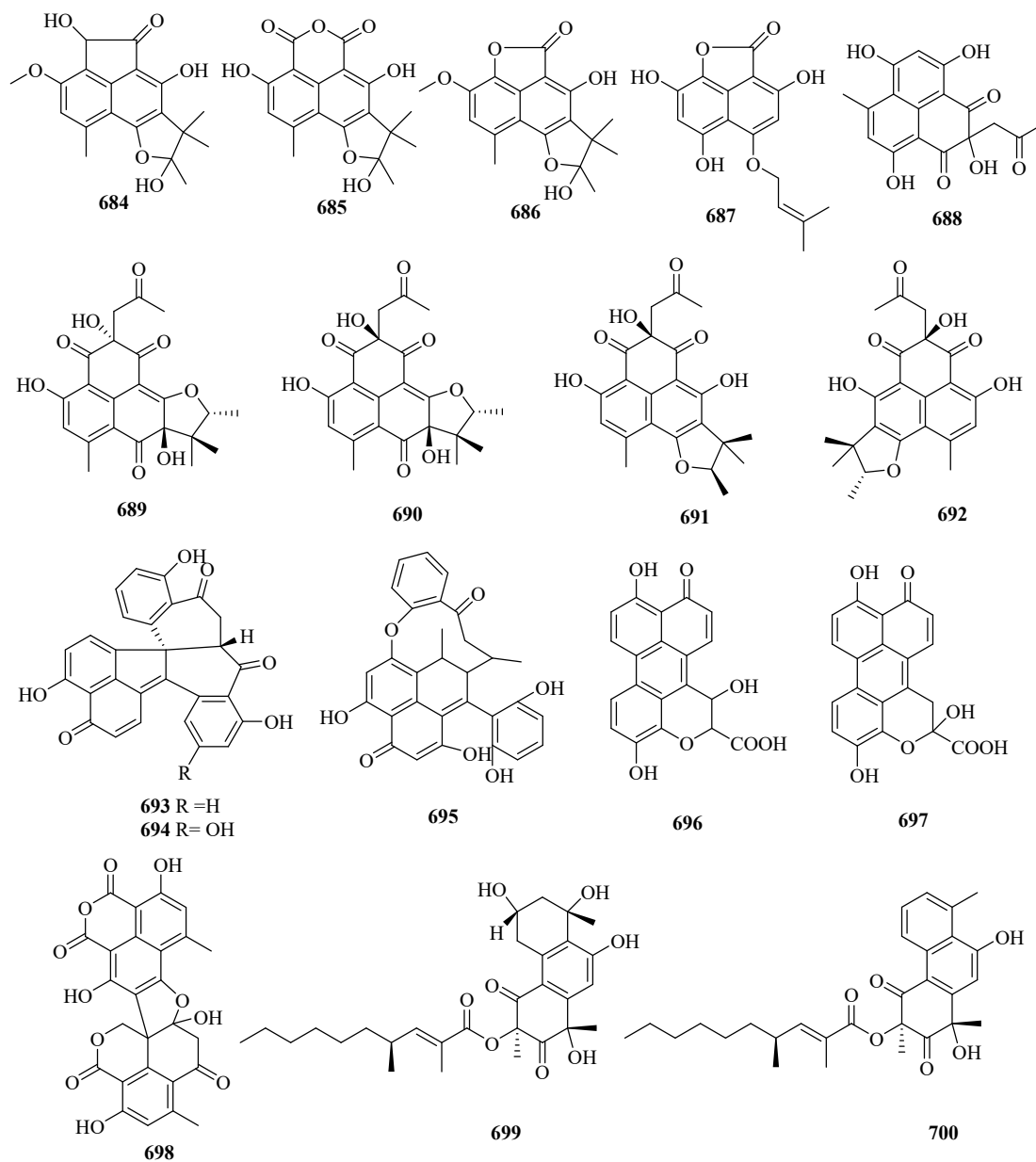




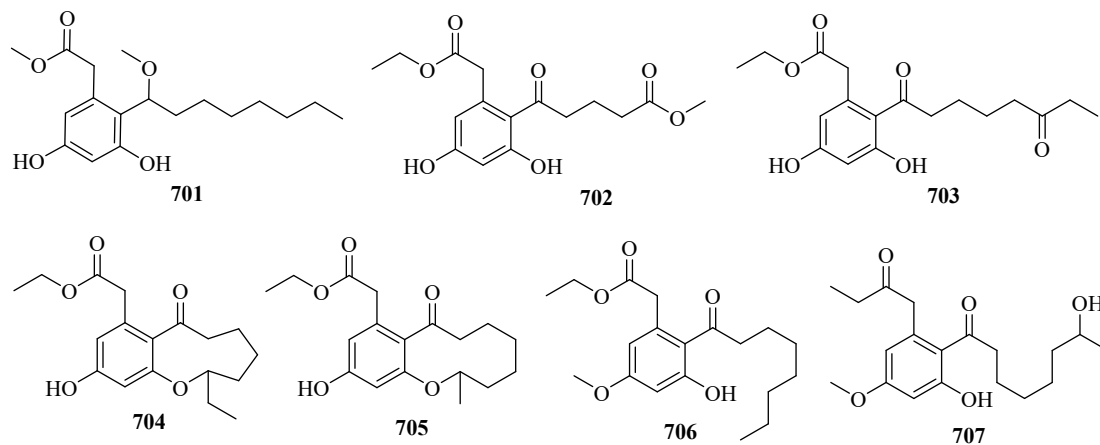


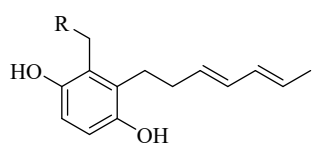




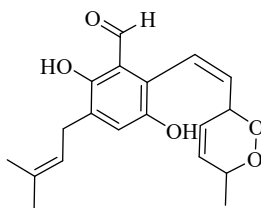


### 3.1.9 Phenol, phenolic acid and their ethers (701–830, 130)

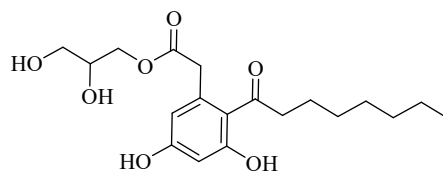




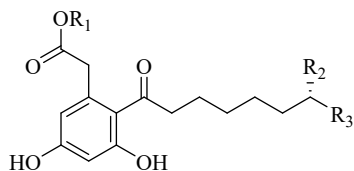
708 R = OH  
709 R = OCH<sub>3</sub>



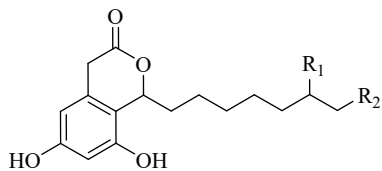
710



711



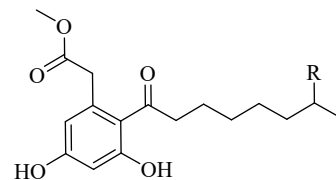
712 R<sub>1</sub> = CH<sub>3</sub>, R<sub>2</sub> = H, R<sub>3</sub> = CH<sub>2</sub>OCOCH<sub>3</sub>  
713 R<sub>1</sub> = CH<sub>2</sub>CH<sub>3</sub>, R<sub>2</sub> = OCOCH<sub>3</sub>, R<sub>3</sub> = CH<sub>3</sub>



714 R<sub>1</sub> = OH, R<sub>2</sub> = H

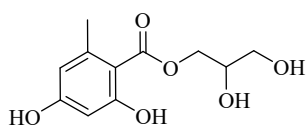
715 R<sub>1</sub> = OCOCH<sub>3</sub>, R<sub>2</sub> = H

716 R<sub>1</sub> = H, R<sub>2</sub> = OCOCH<sub>3</sub>

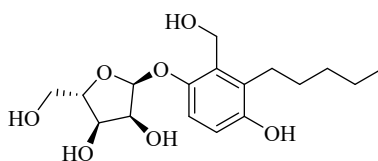


717 R = OH

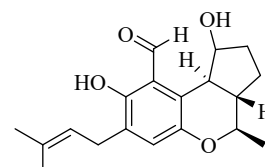
718 R = H



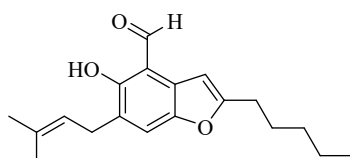
719



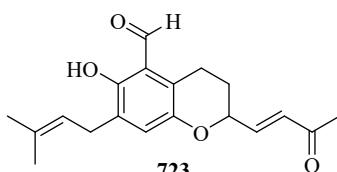
720



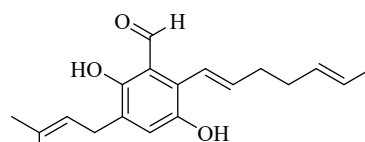
721



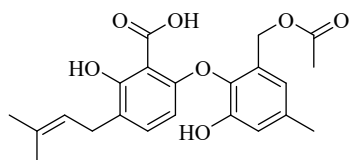
722



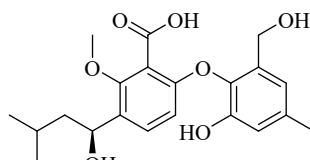
723



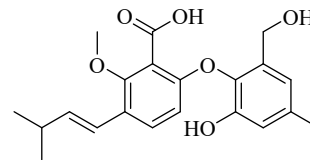
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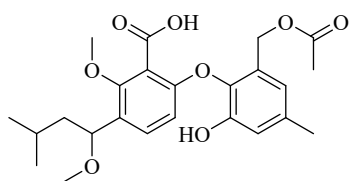
725



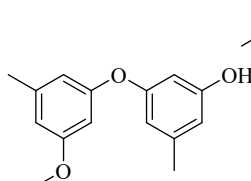
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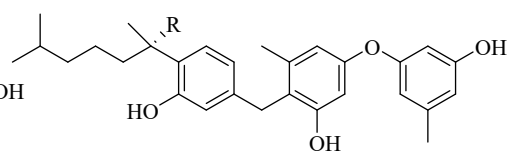
727



728

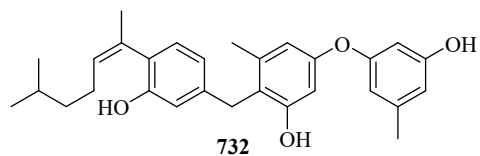


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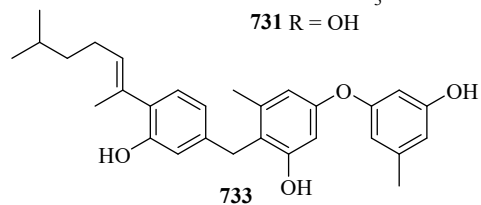


730 R = OCH<sub>3</sub>

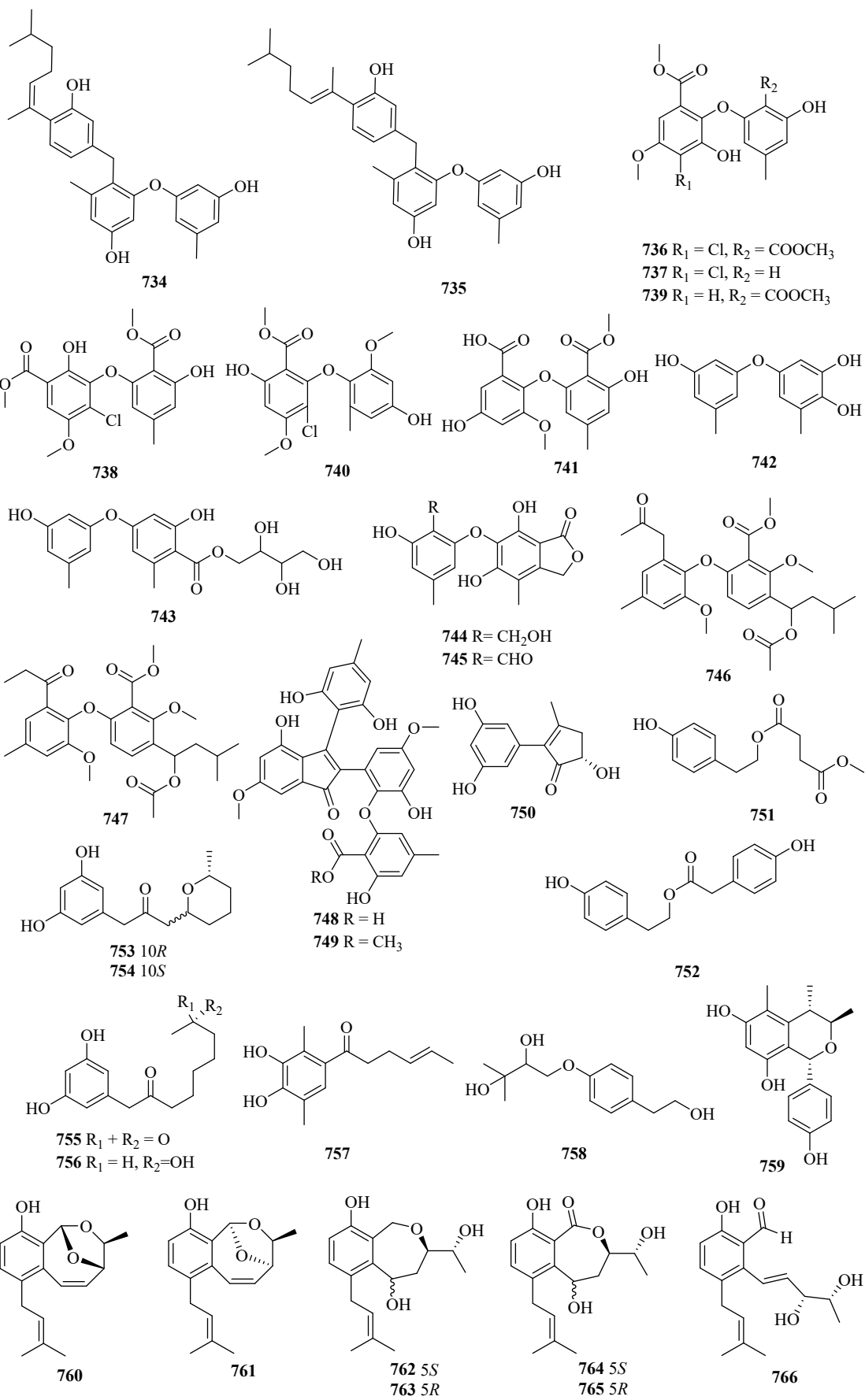
731 R = OH

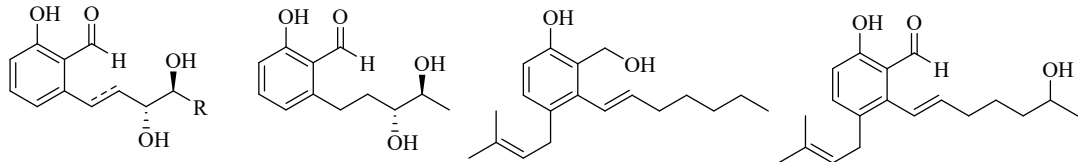


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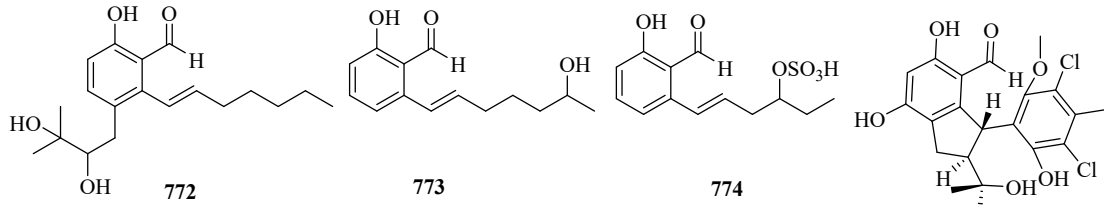
767 R = CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> Δ<sup>8</sup>

769

770

771

768 R = CH<sub>3</sub>

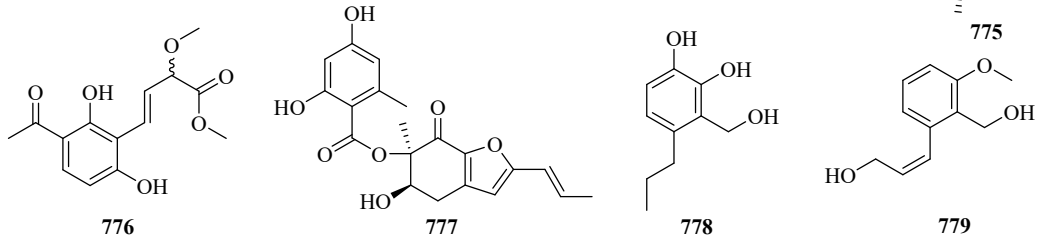


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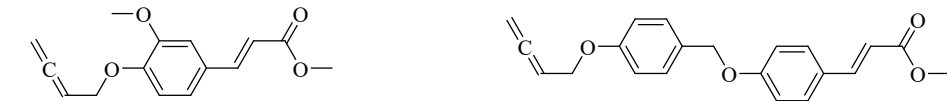


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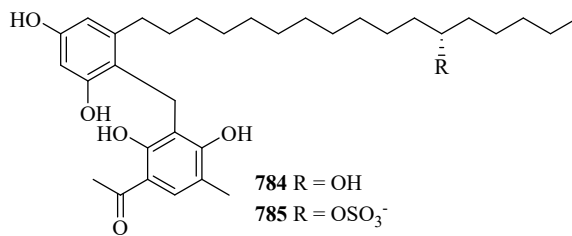
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781



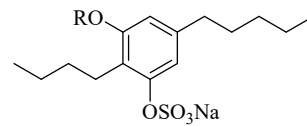
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783



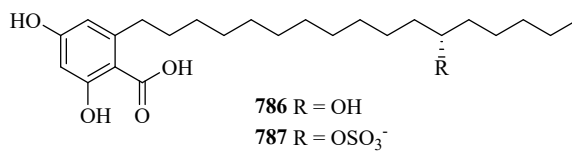
784 R = OH

785 R = OSO<sub>3</sub><sup>-</sup>



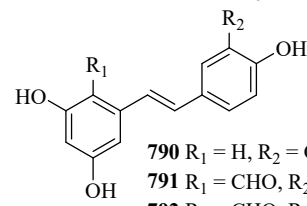
788 R = H

789 R = COCH<sub>3</sub>



786 R = OH

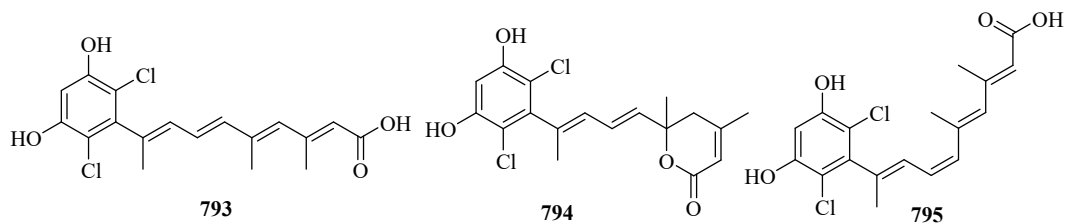
787 R = OSO<sub>3</sub><sup>-</sup>



790 R<sub>1</sub> = H, R<sub>2</sub> = CHO

791 R<sub>1</sub> = CHO, R<sub>2</sub> = CHO

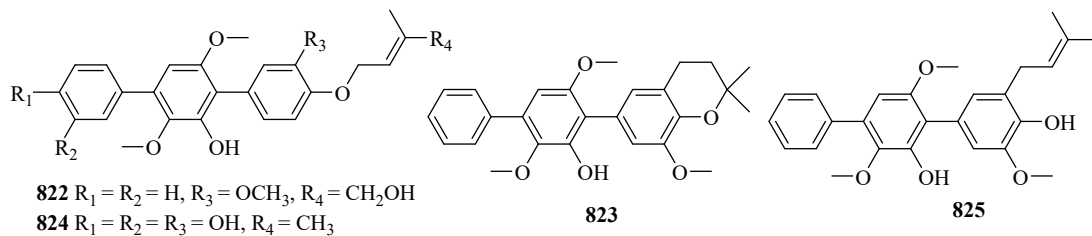
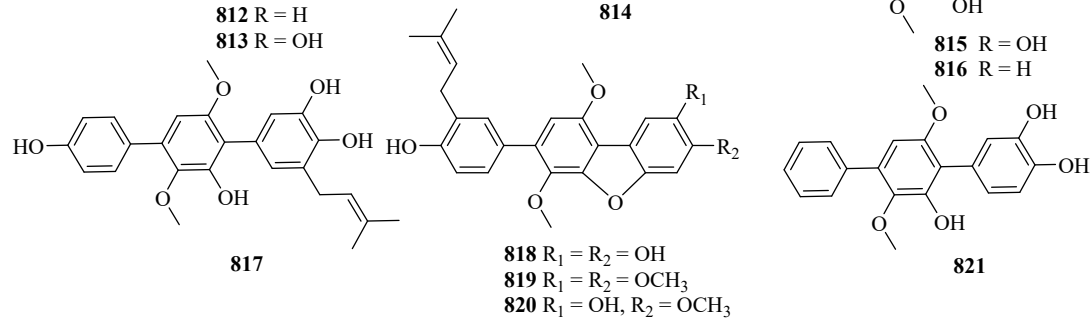
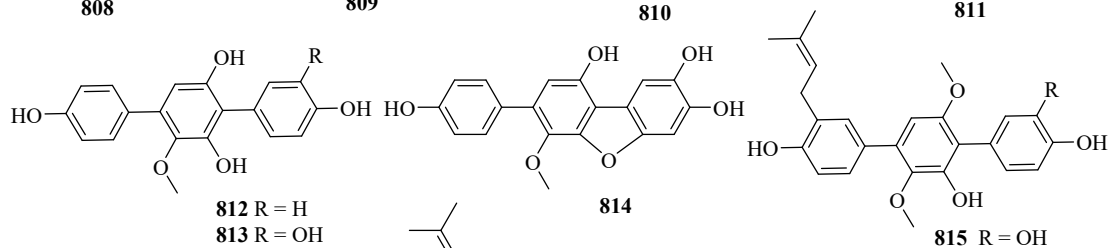
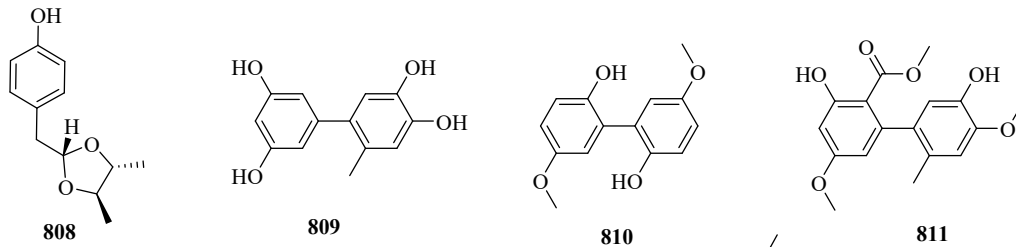
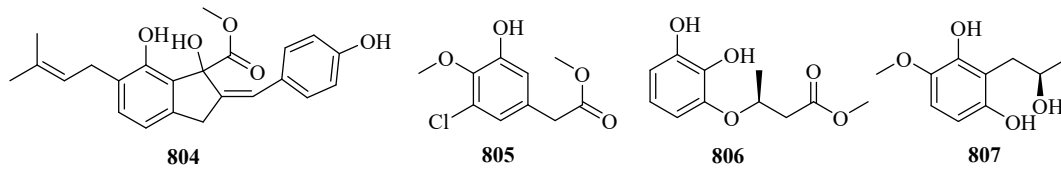
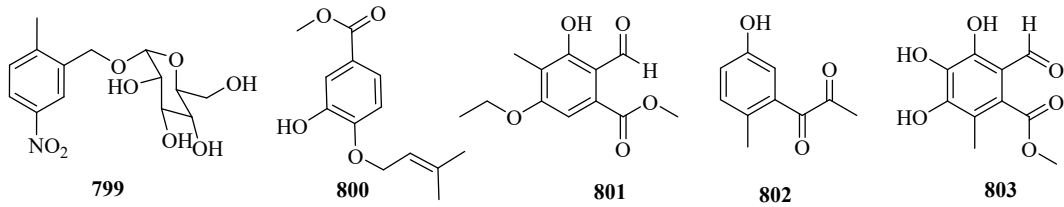
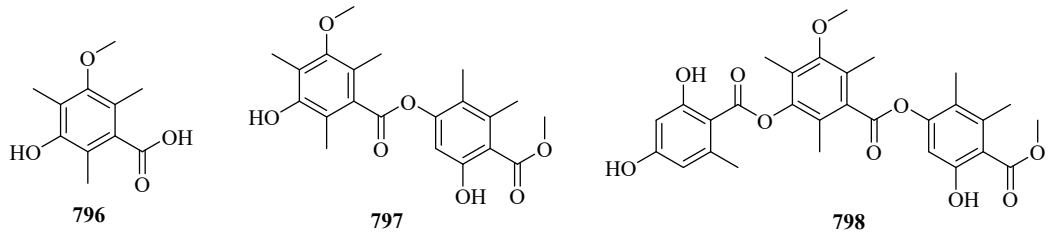
792 R<sub>1</sub> = CHO, R<sub>2</sub> = H



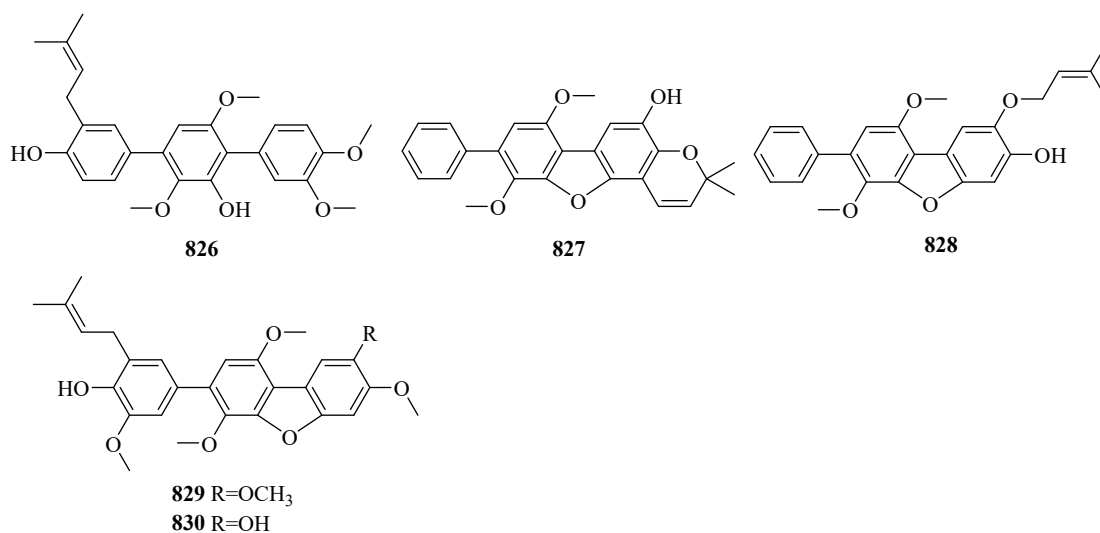
793

794

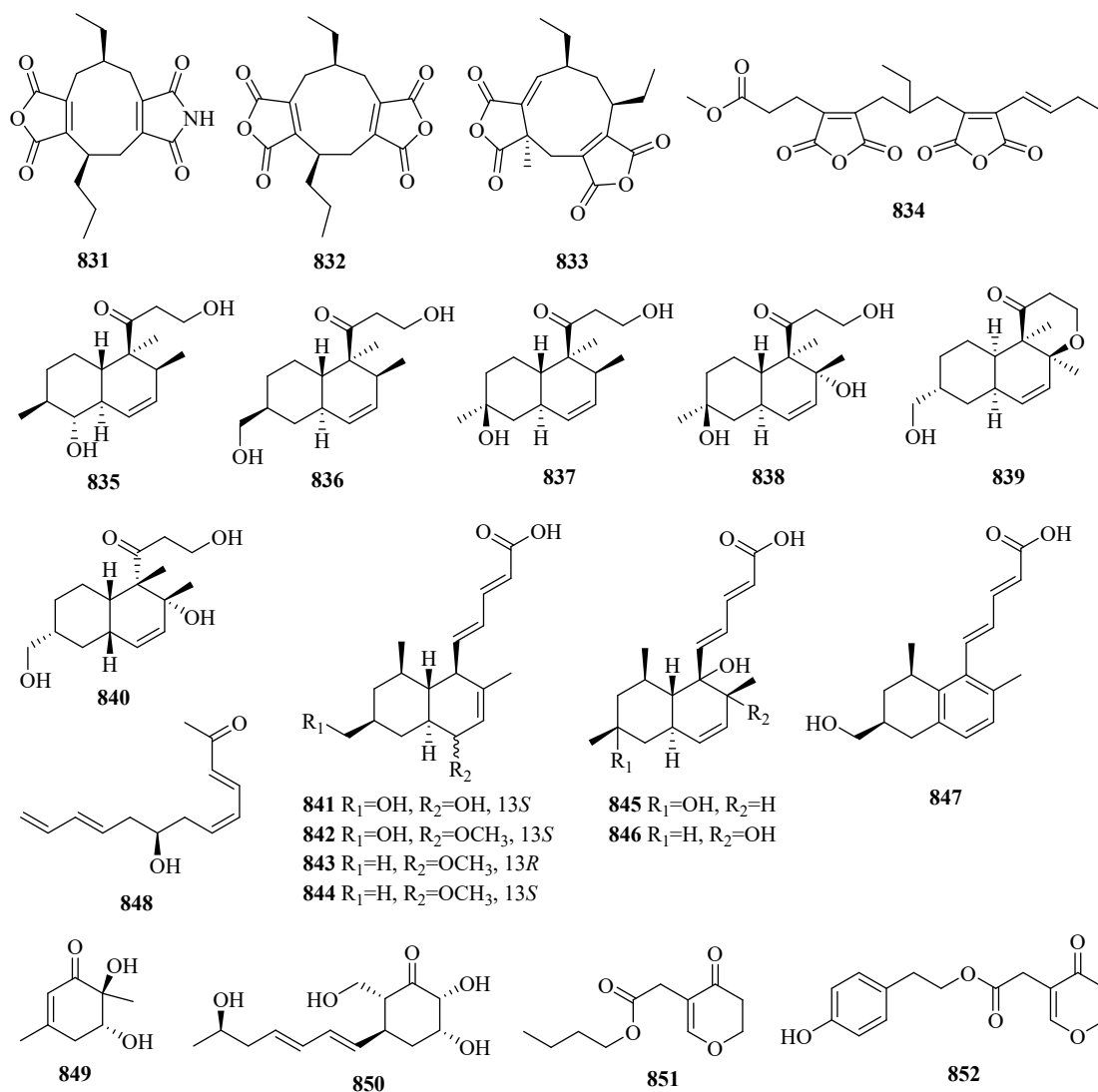
795

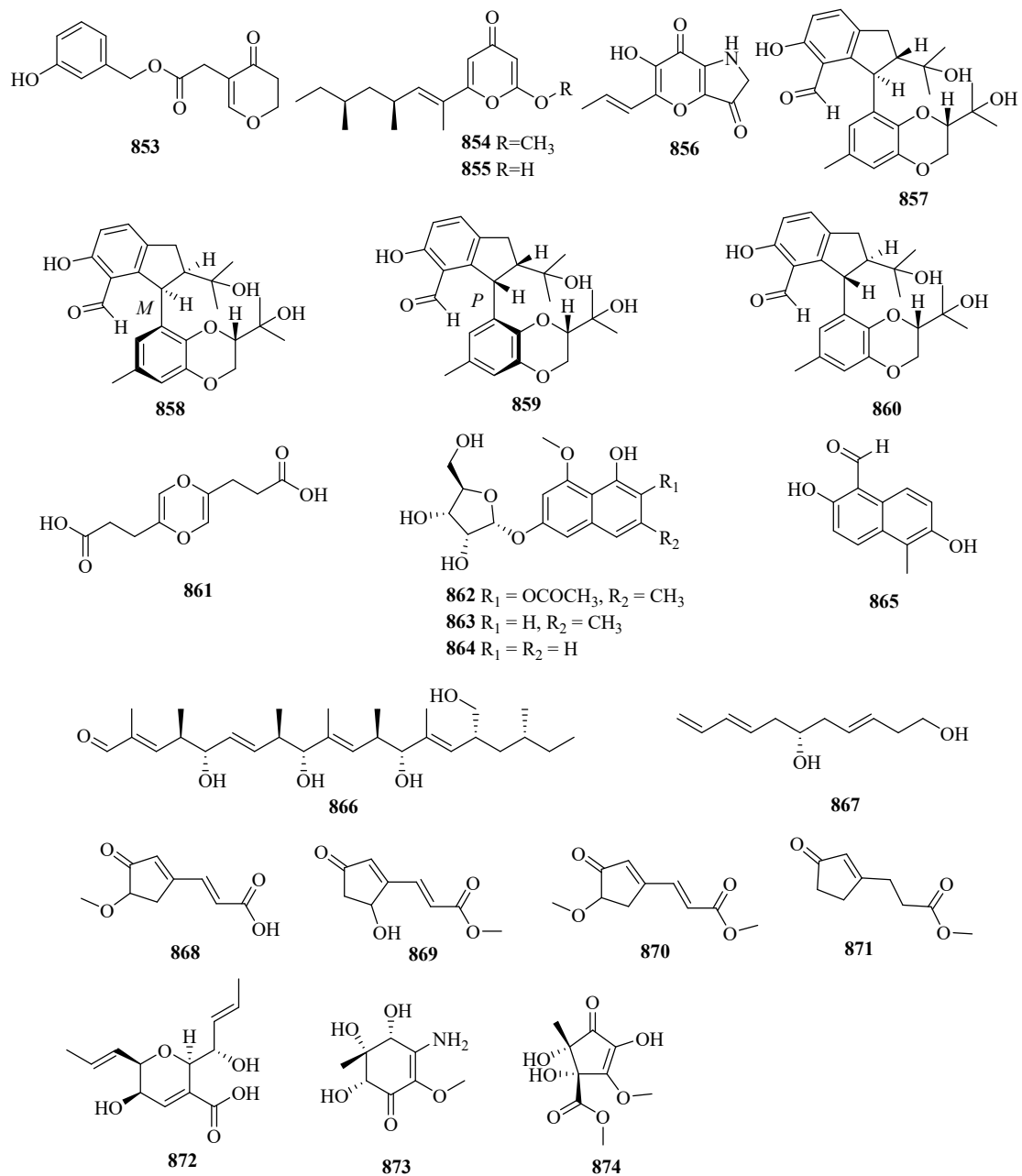






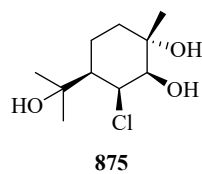
3.1.10 Others (831–874, 44)



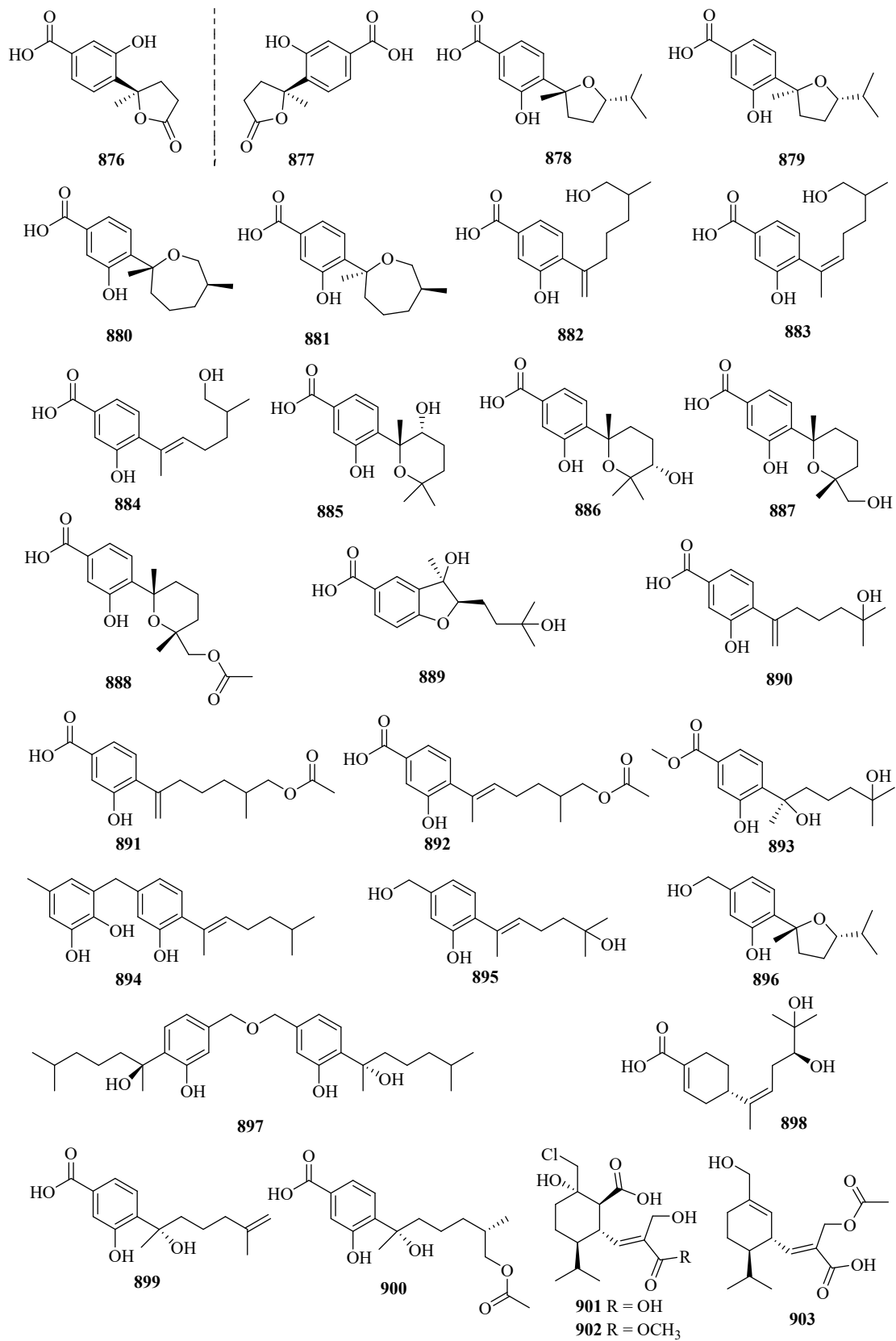


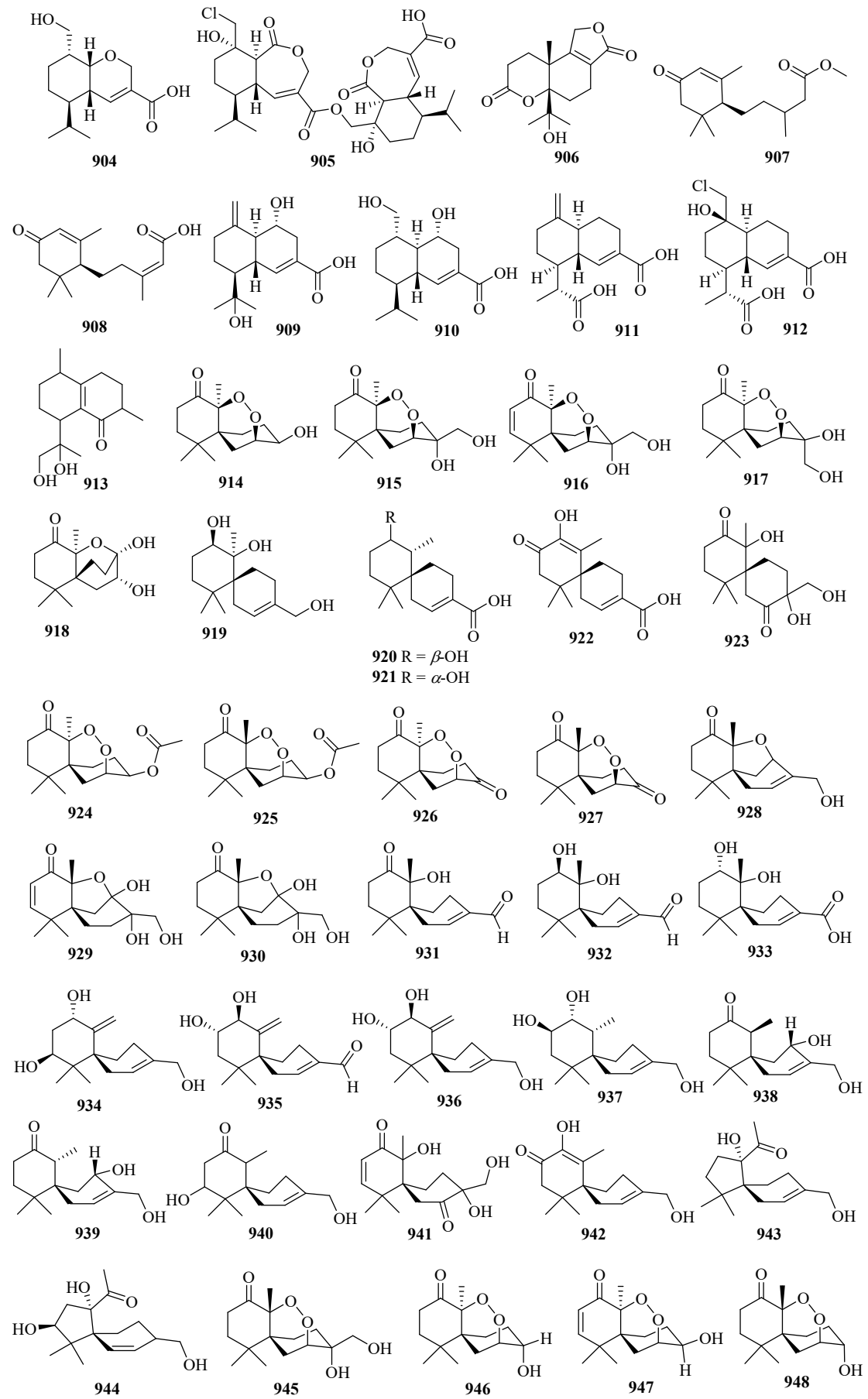
## 3.2 Terpenoids (875–1145, 271)

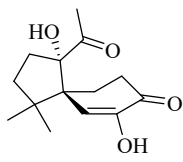
### 3.2.1 Monoterpenes (875, 1)



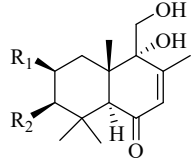
### 3.2.2 Sesquiterpenes (876–1011, 136)



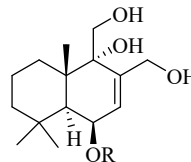




949

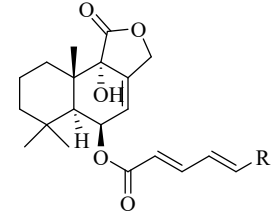


950  $R_1 = H, R_2 = OH$   
951  $R_1 = OH, R_2 = H$



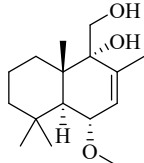
952  $R = CH_3$

953  $R =$

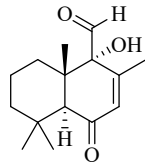


954  $R =$

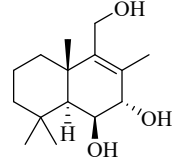
955  $R =$



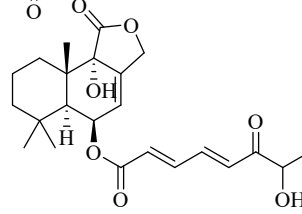
958



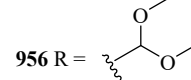
959



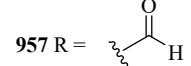
960



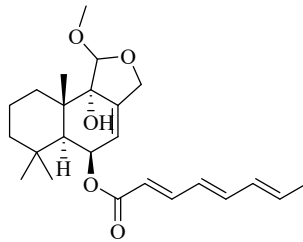
961



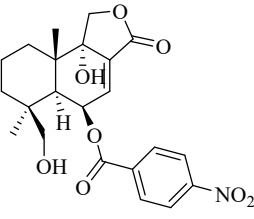
956  $R =$



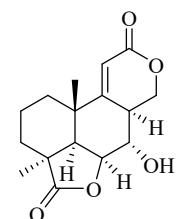
957  $R =$



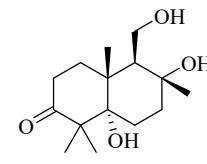
962



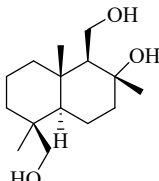
963



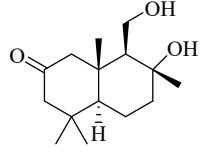
964



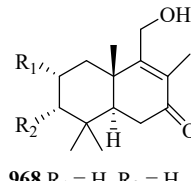
965



966



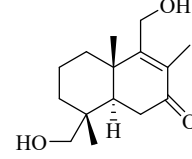
967



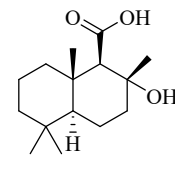
968  $R_1 = H, R_2 = H$

969  $R_1 = OH, R_2 = H$

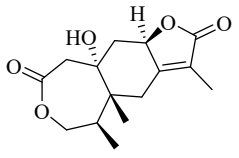
970  $R_1 = H, R_2 = H$



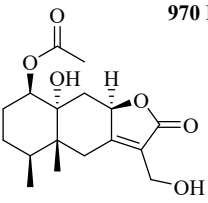
971



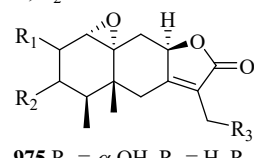
972



973



974

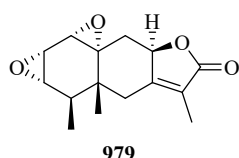


975  $R_1 = \alpha-OH, R_2 = H, R_3 = OH$

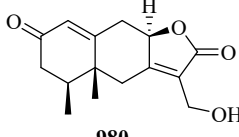
976  $R_1 = \beta-OH, R_2 = H, R_3 = OH$

977  $R_1 = H, R_2 = \alpha-OH, R_3 = OH$

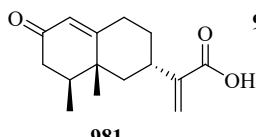
978  $R_1 = H, R_2 = \beta-OH, R_3 = OH$



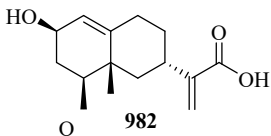
979



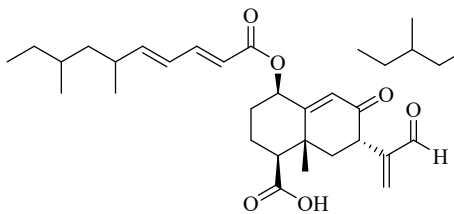
980



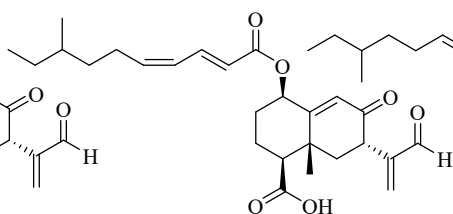
981



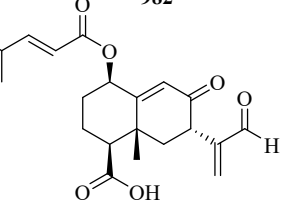
982



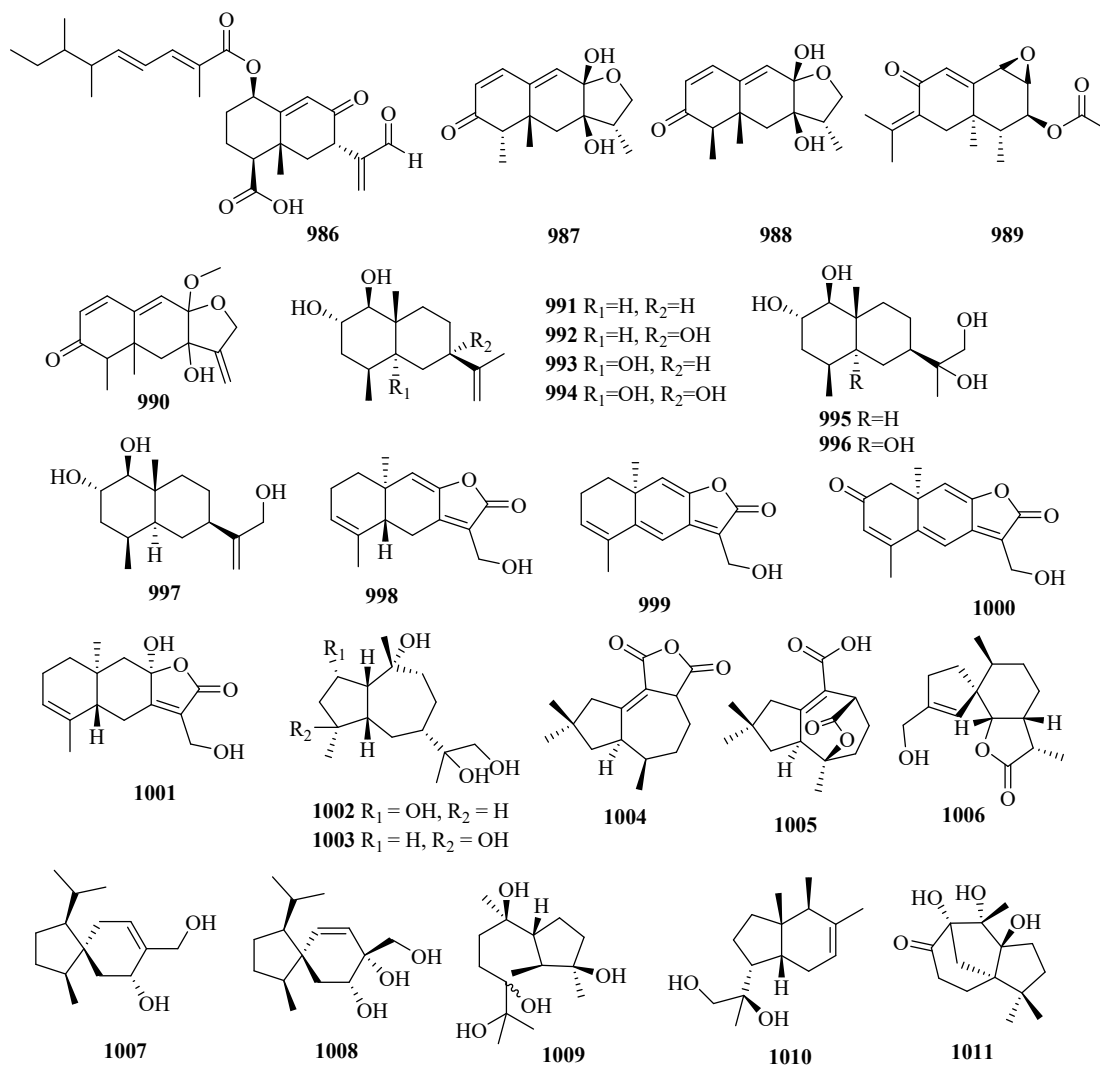
983



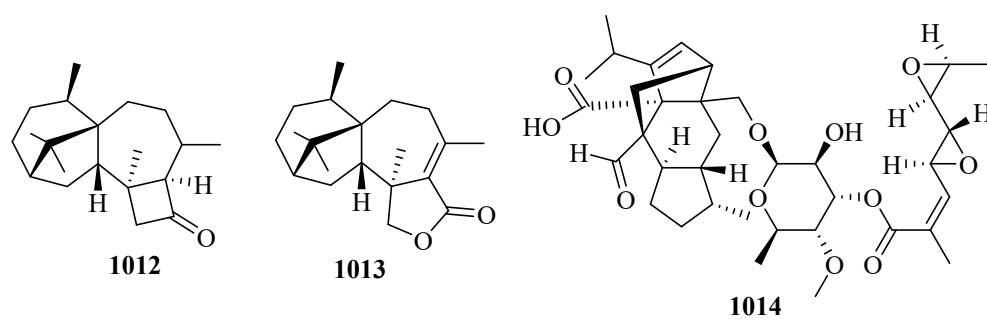
984



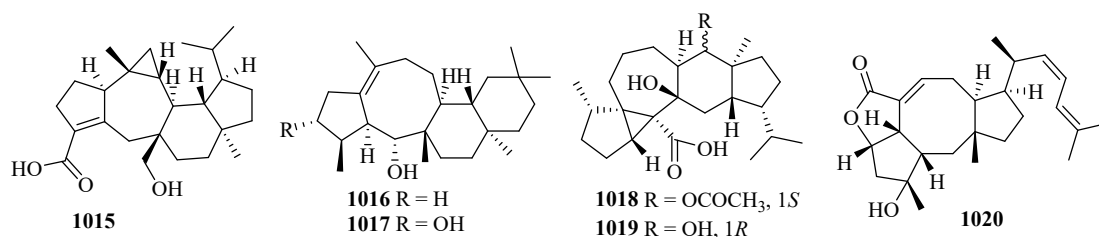
985

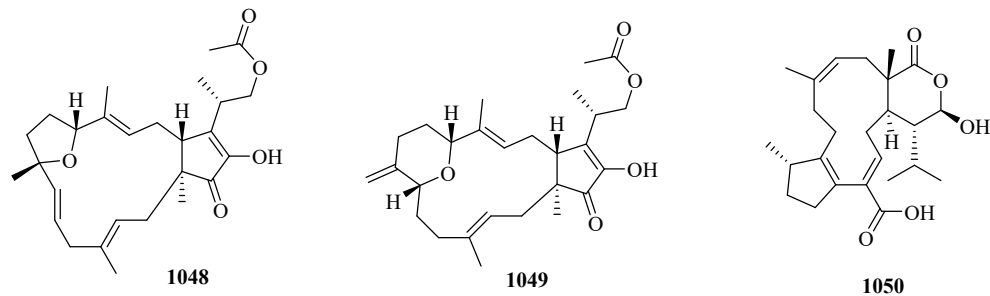
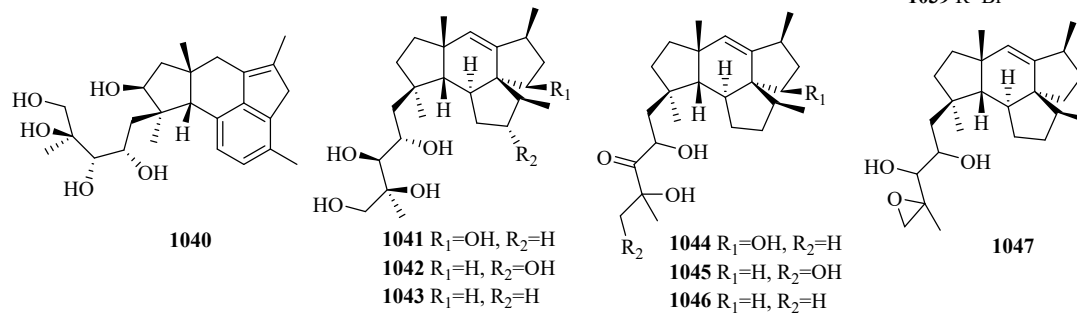
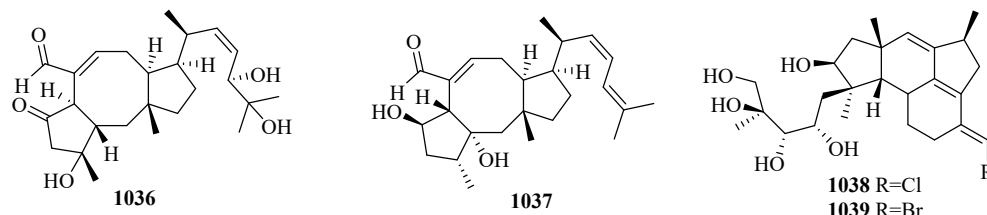
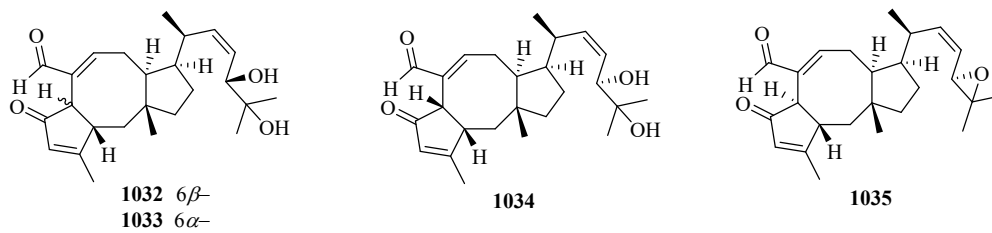
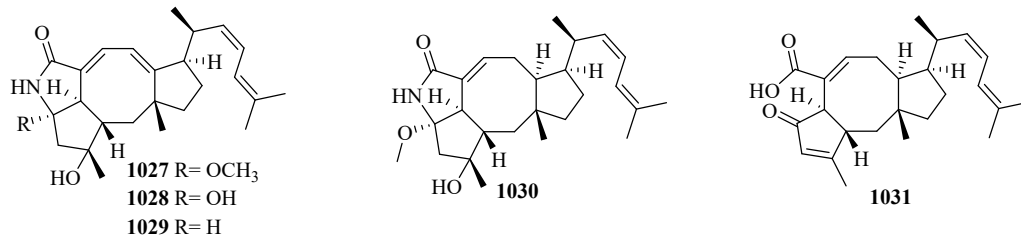
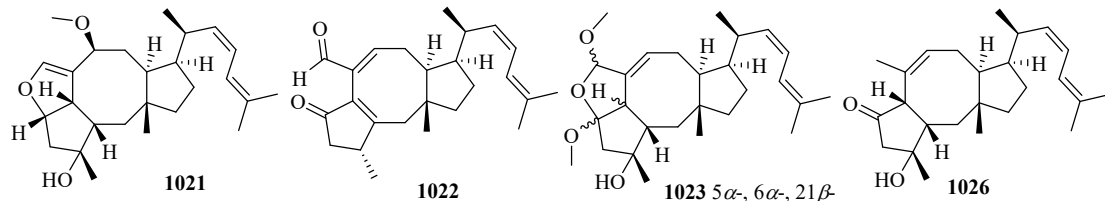


### 3.2.3 Diterpenes (1012–1014, 3)

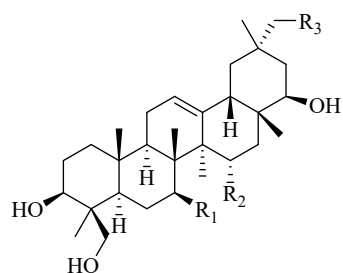


### 3.2.4 Sesterterpenes (1015–1050, 36)

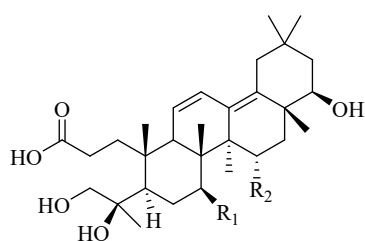




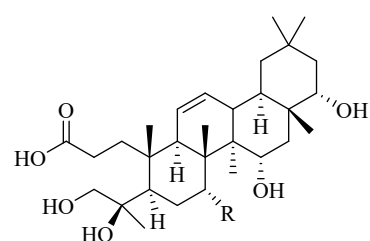
### 3.2.5 Triterpenes (1051–1058, 8)



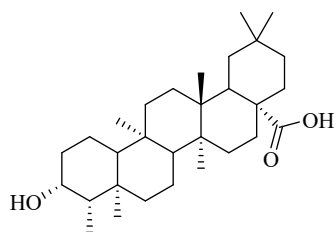
- 1051**  $R_1 = R_3 = H, R_2 = OH$   
**1052**  $R_1 = R_2 = OH, R_3 = H$   
**1053**  $R_1 = R_3 = OH, R_2 = H$



- 1054**  $R_1 = H, R_2 = OH$   
**1055**  $R_1 = OH, R_2 = H$

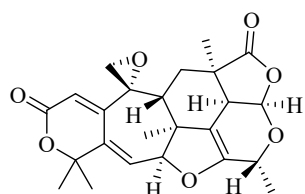


- 1056**  $R = OH$   
**1057**  $R = H$

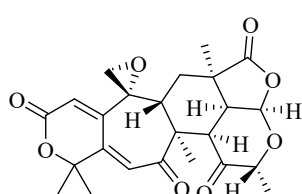


**1058**

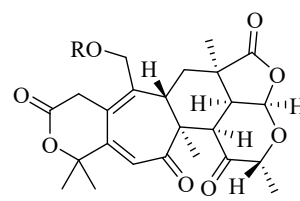
### 3.2.6 Meroterpenes (1059–1131, 73)



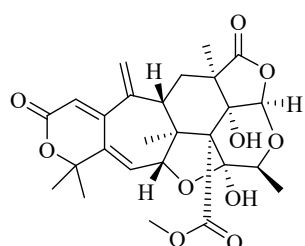
**1059**



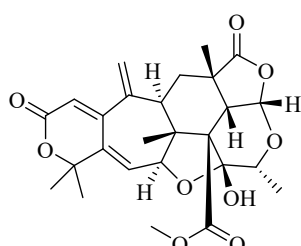
**1060**



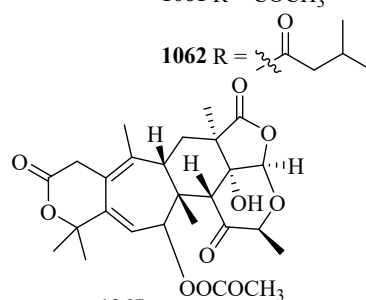
- 1061**  $R = COCH_3$

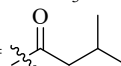


**1063**

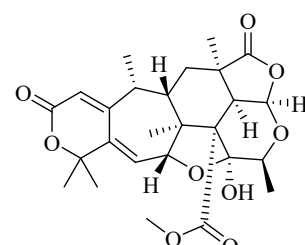


**1064**

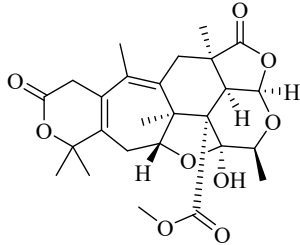


- 1062**  $R =$  

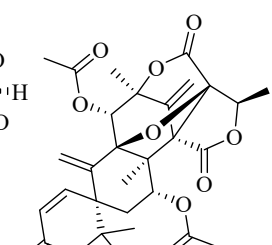
**1065**



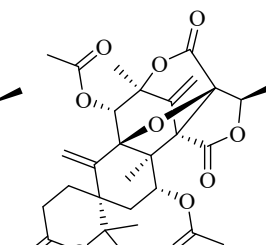
**1066**



**1067**

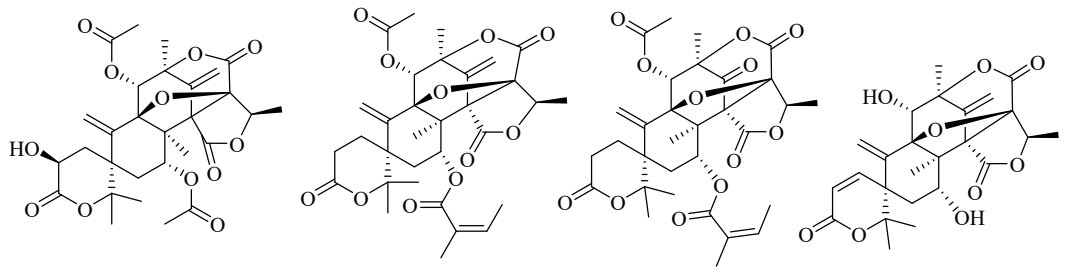


**1068**

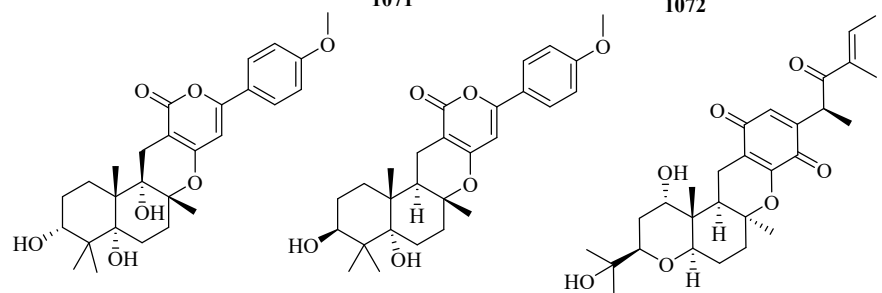


**1069**

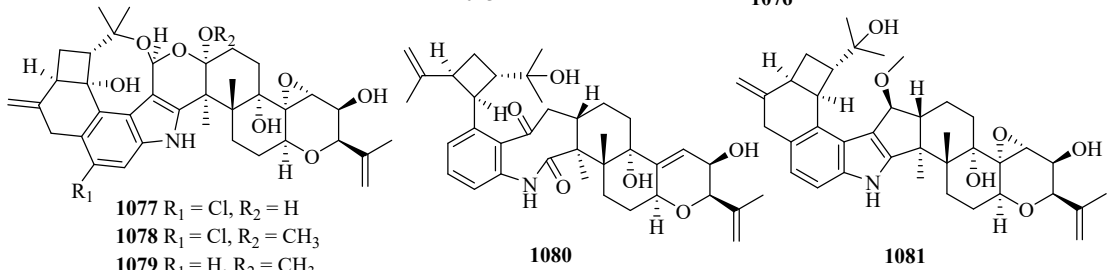




1070 1071 1072 1073

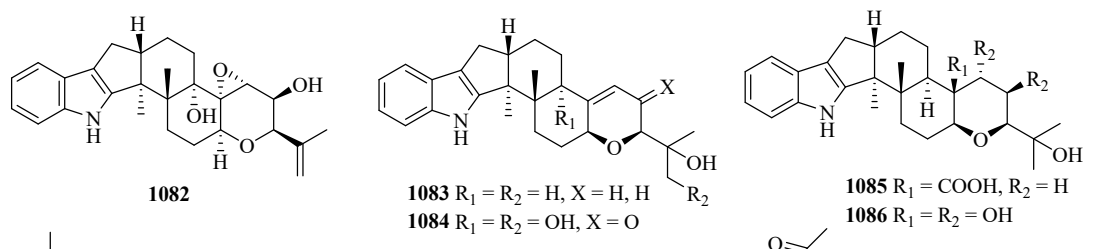


1074 1075 1076

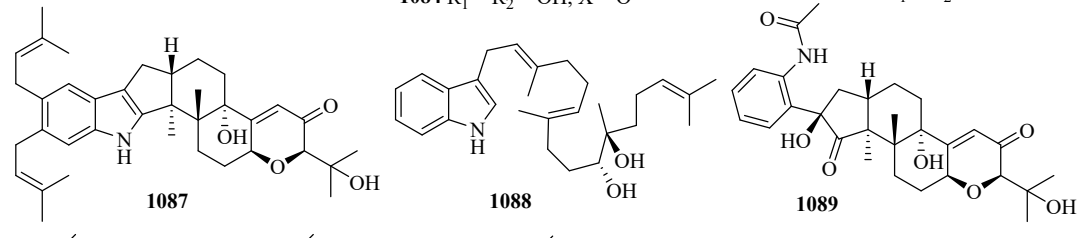


1077  $R_1 = Cl, R_2 = H$   
 1078  $R_1 = Cl, R_2 = CH_3$   
 1079  $R_1 = H, R_2 = CH_3$

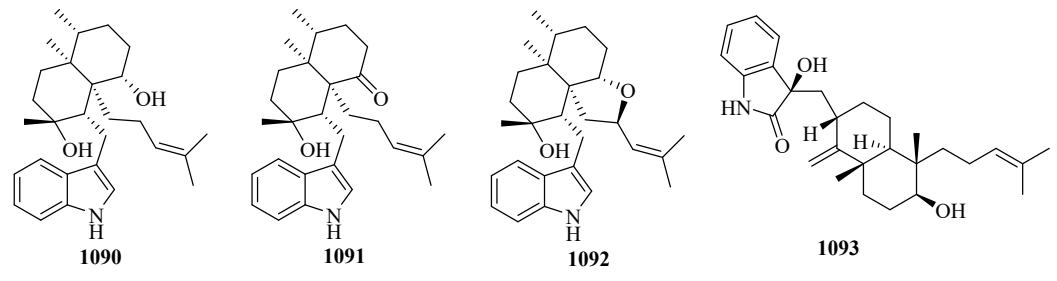
1080 1081



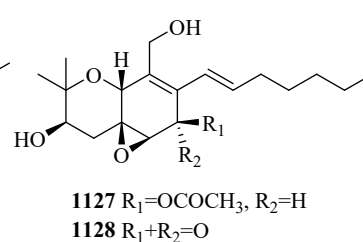
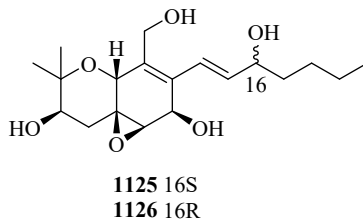
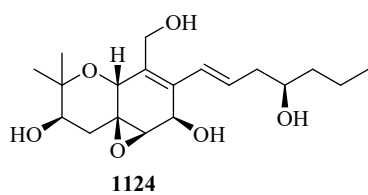
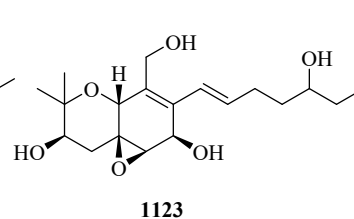
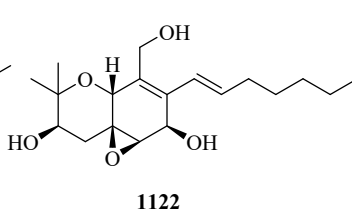
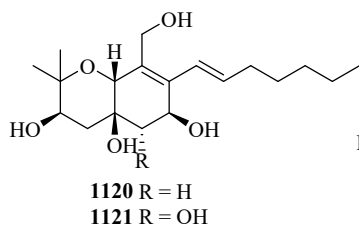
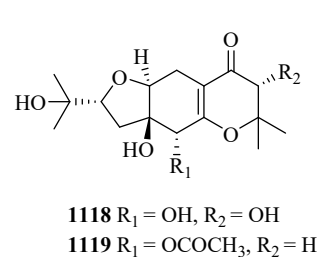
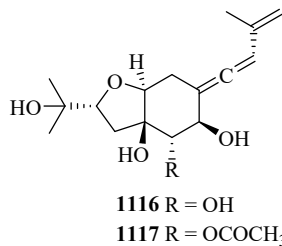
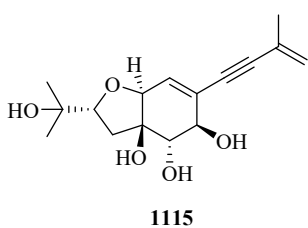
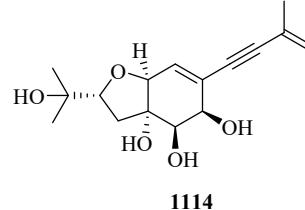
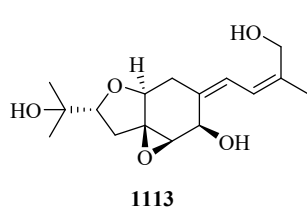
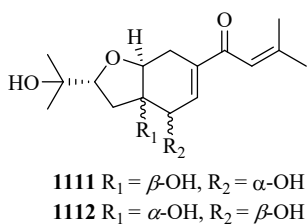
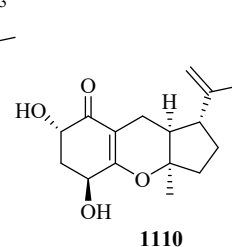
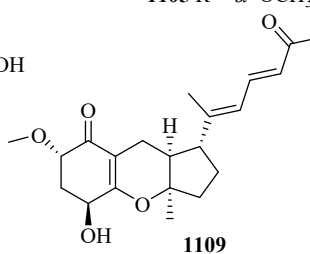
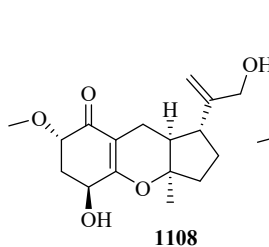
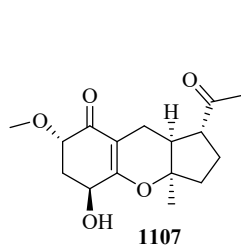
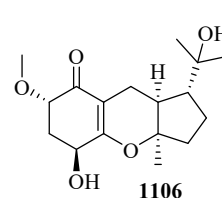
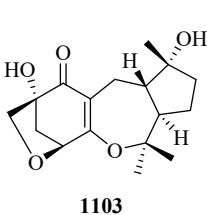
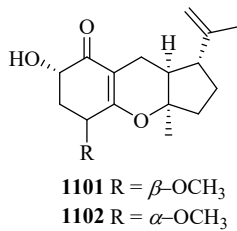
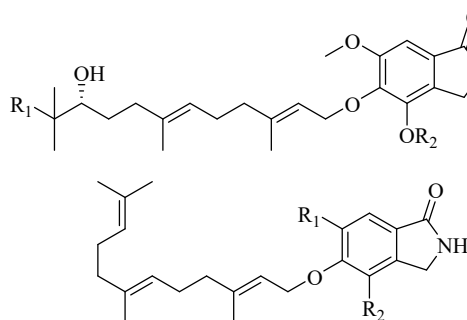
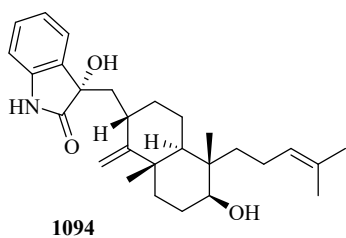
1082 1083  $R_1 = R_2 = H, X = H, H$   
 1084  $R_1 = R_2 = OH, X = O$   
 1085  $R_1 = COOH, R_2 = H$   
 1086  $R_1 = R_2 = OH$

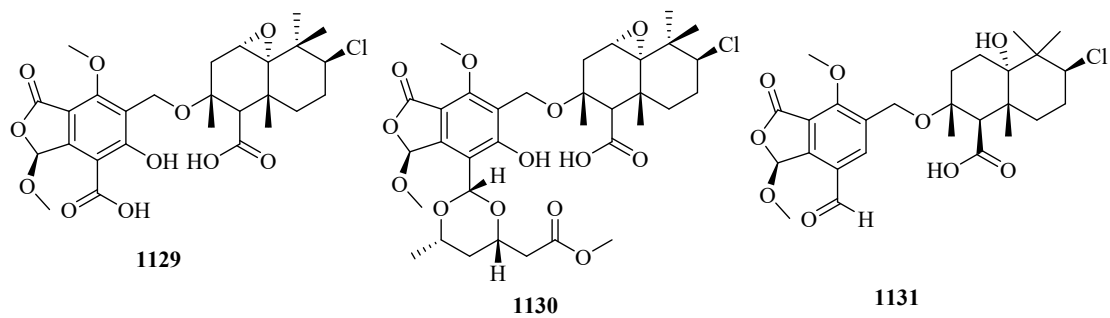


1087 1088 1089

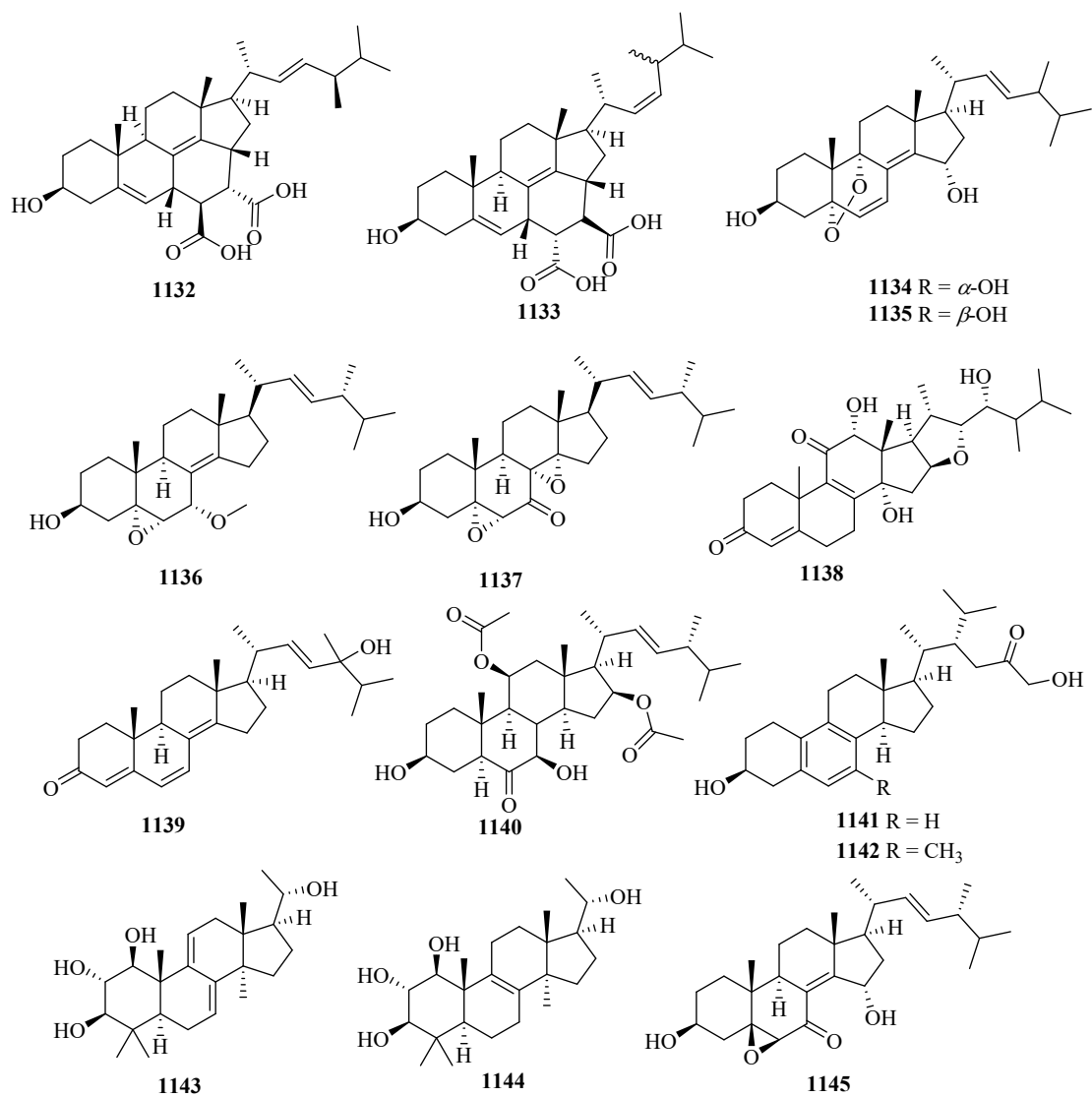


1090 1091 1092 1093





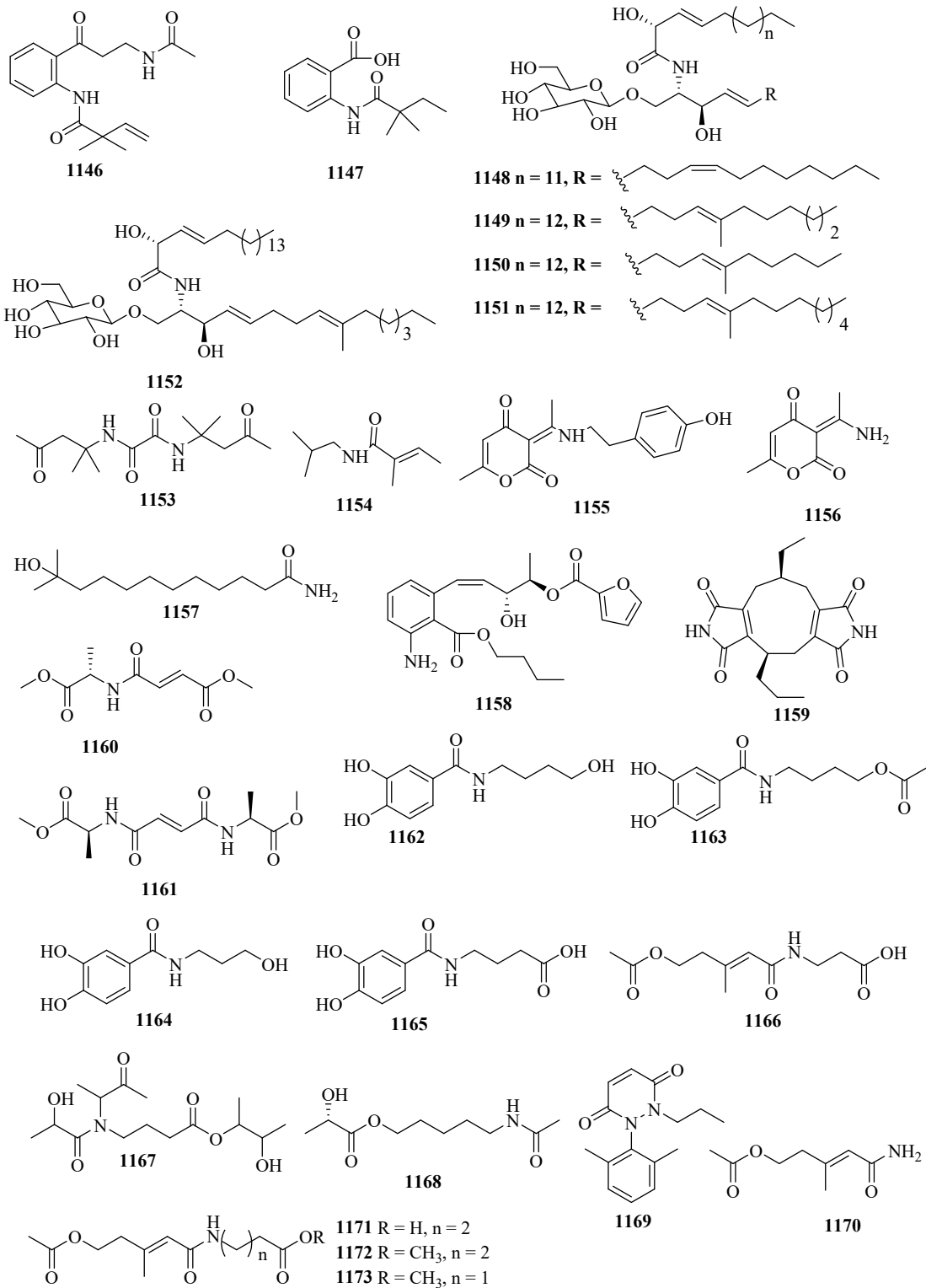
### 3.2.7 Steroids (1132–1145, 14)



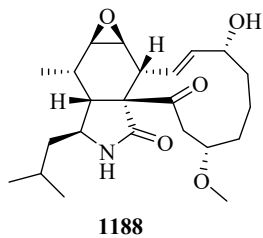
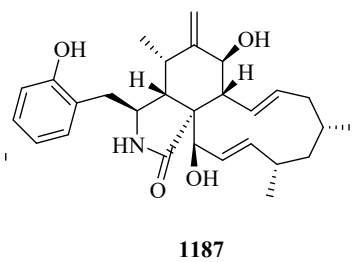
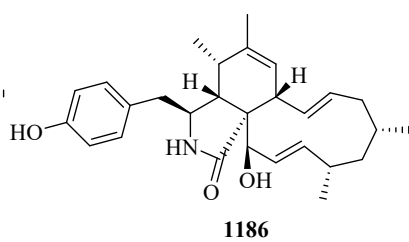
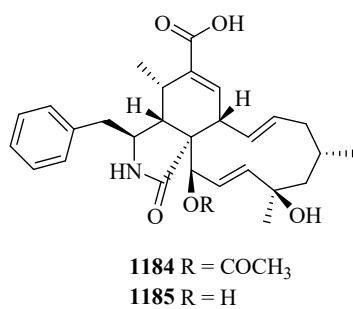
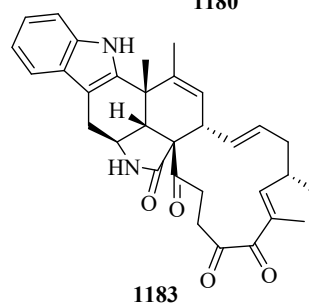
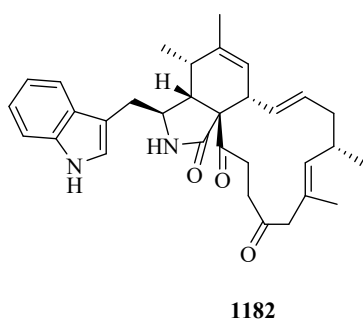
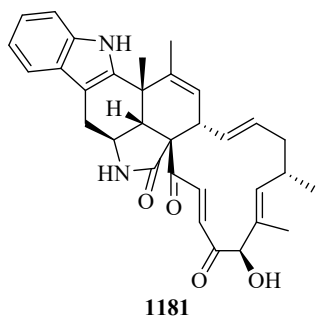
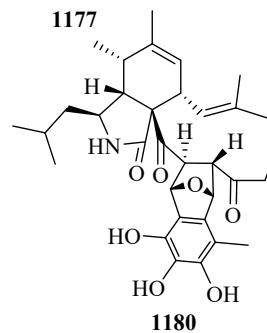
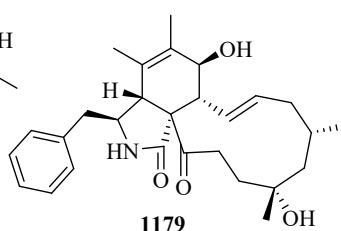
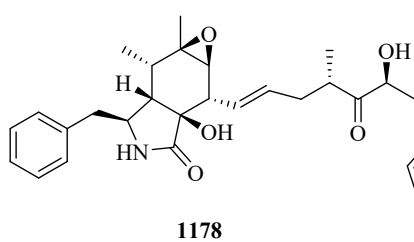
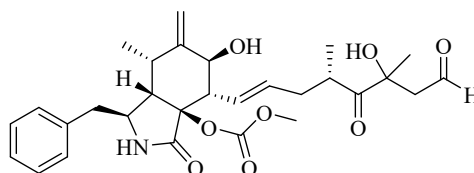
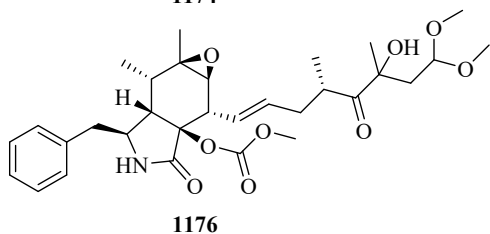
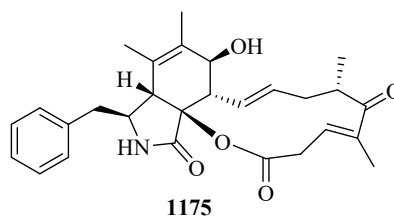
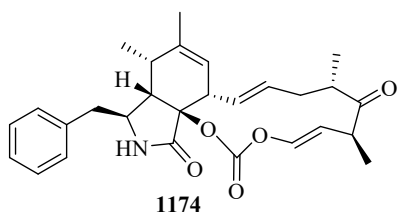
### 3.3 Alkaloids and other nitrogen-containing metabolites

#### (1146–1308, 163)

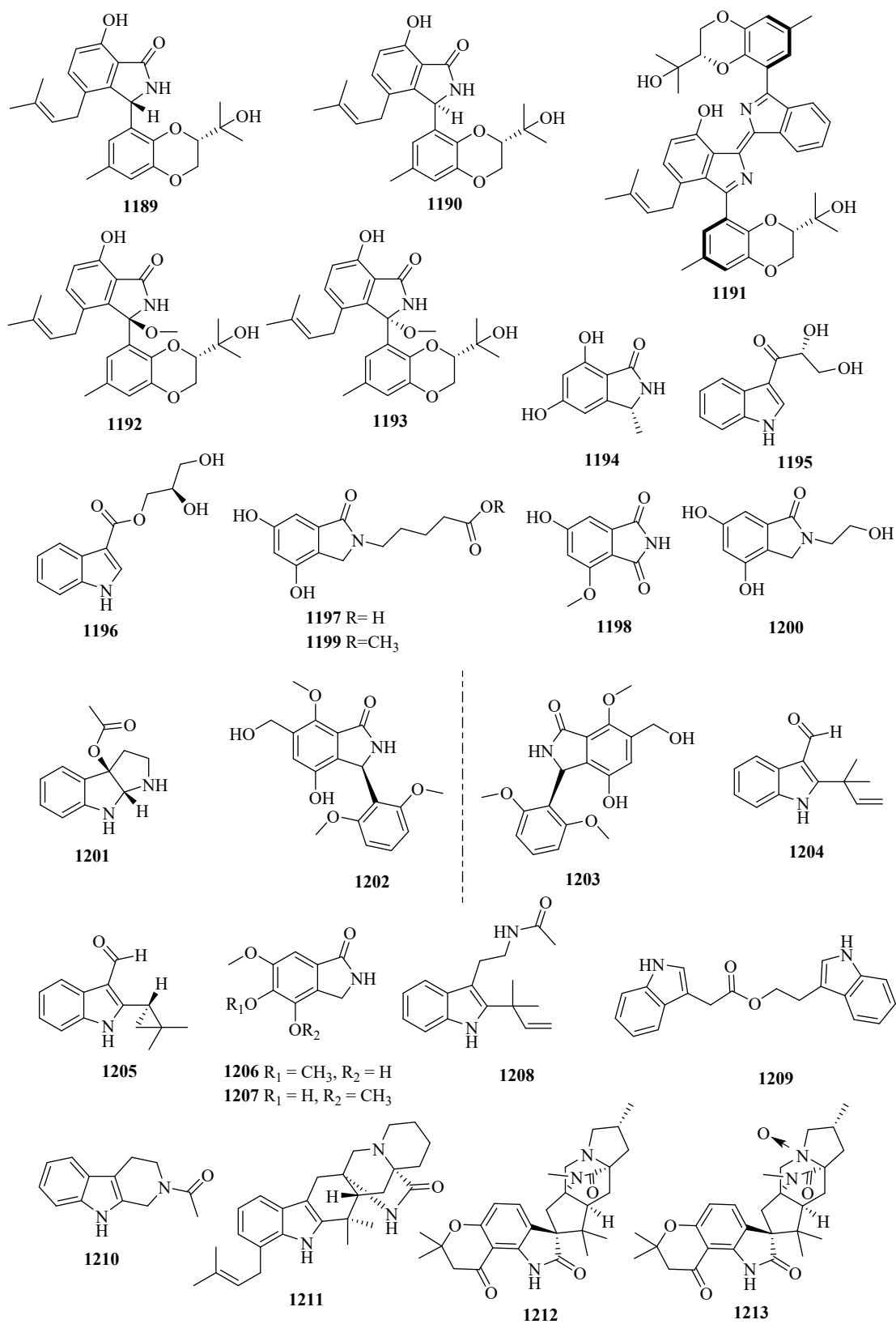
##### 3.3.1 Amines and amides (1146–1173, 28)

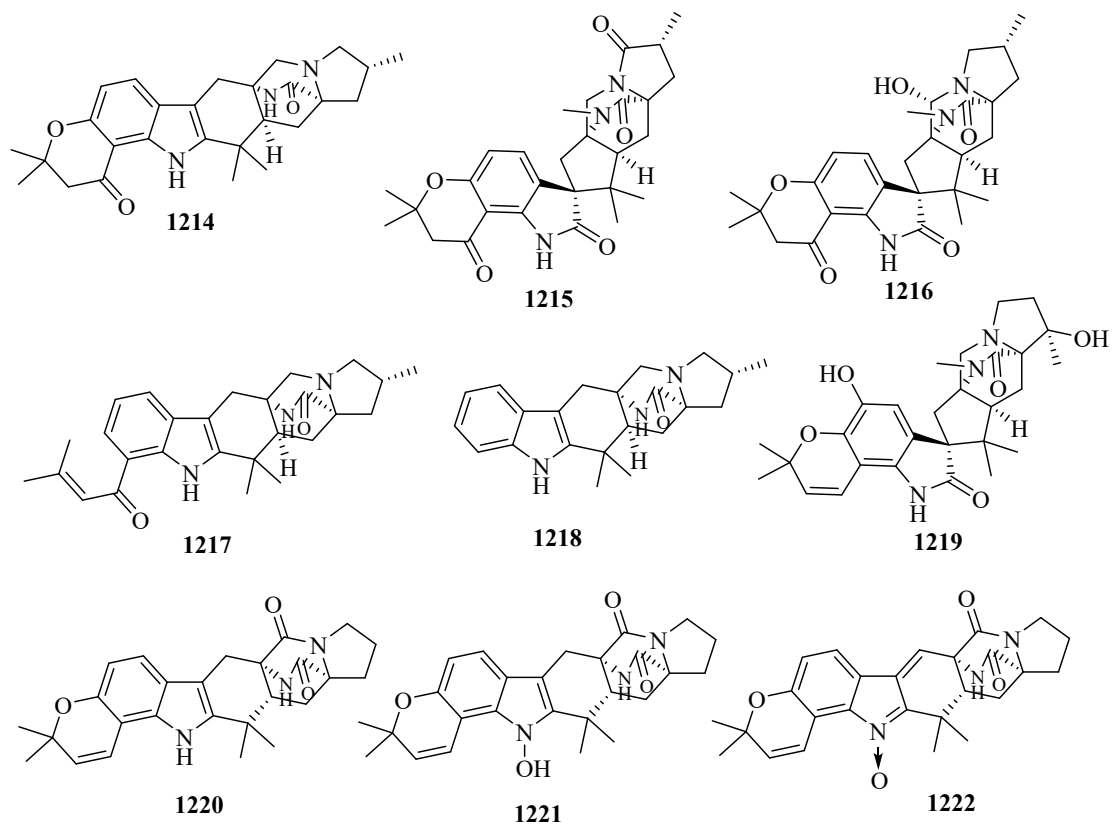


3.3.2 Cytochalasins (1174–1188, 15)

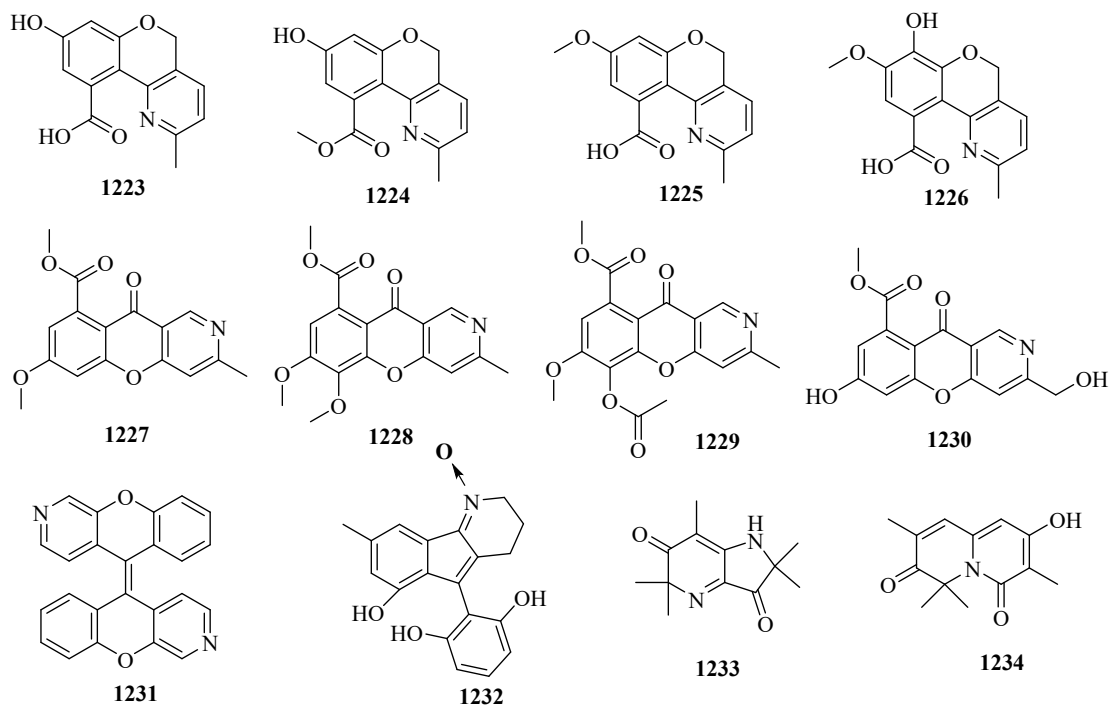


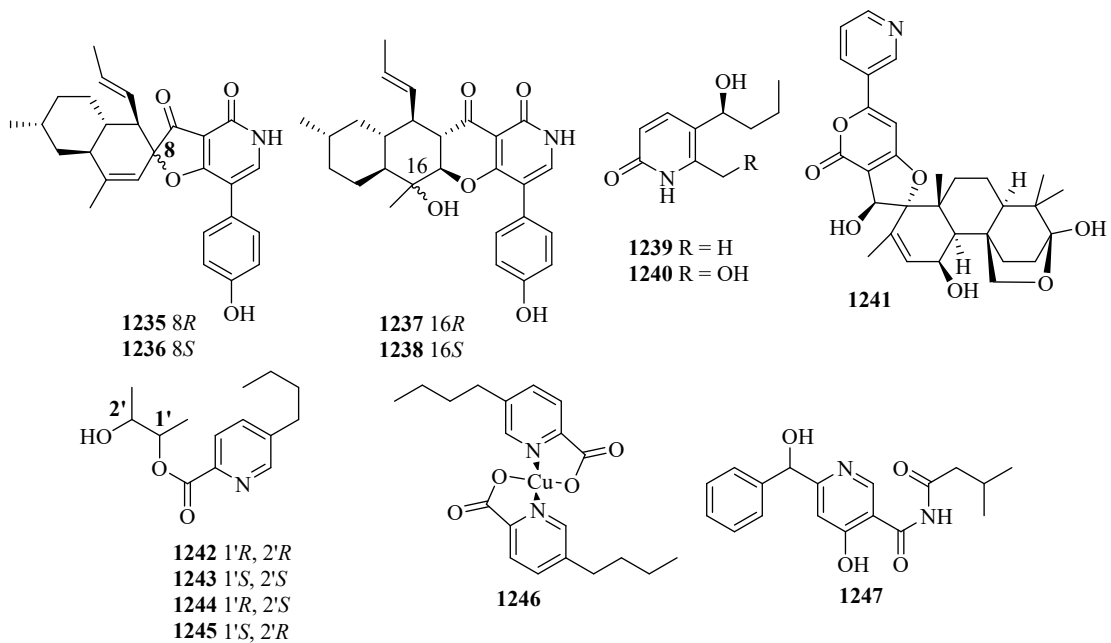
### 3.3.3 Indoles and isoindoles (1189–1222, 34)



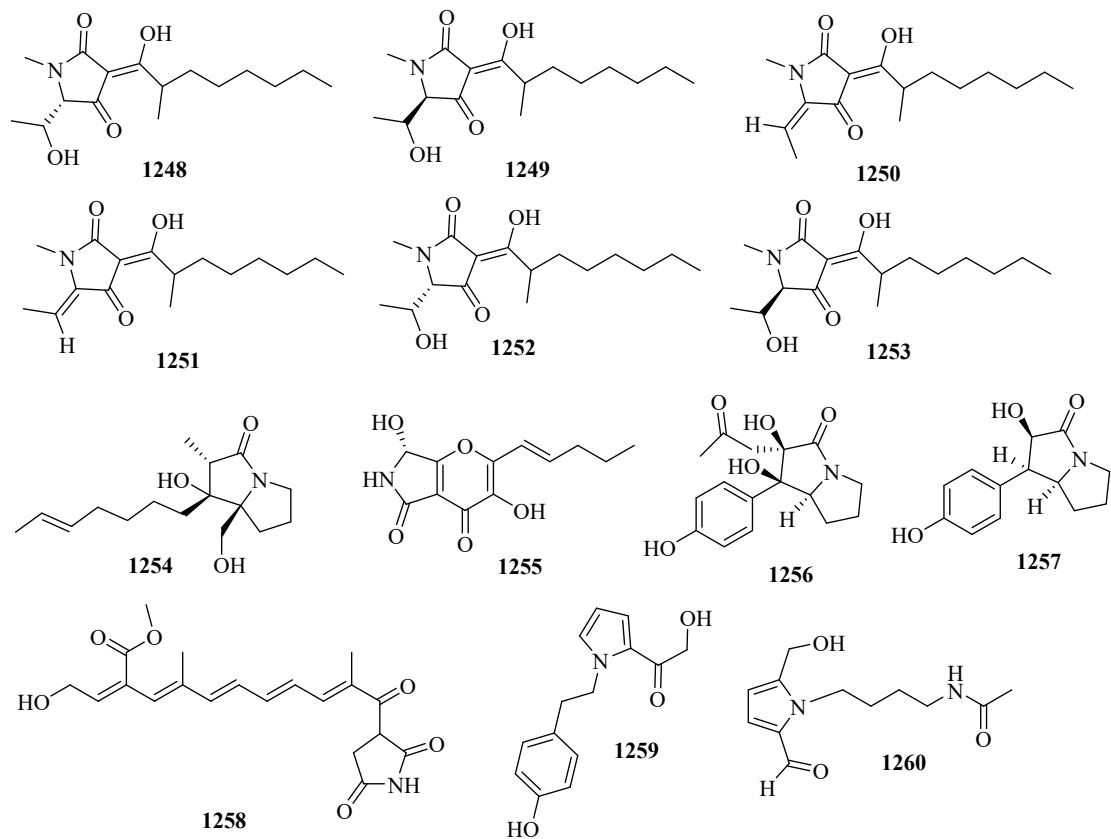


### 3.3.4 Pyridines (1223–1247, 25)

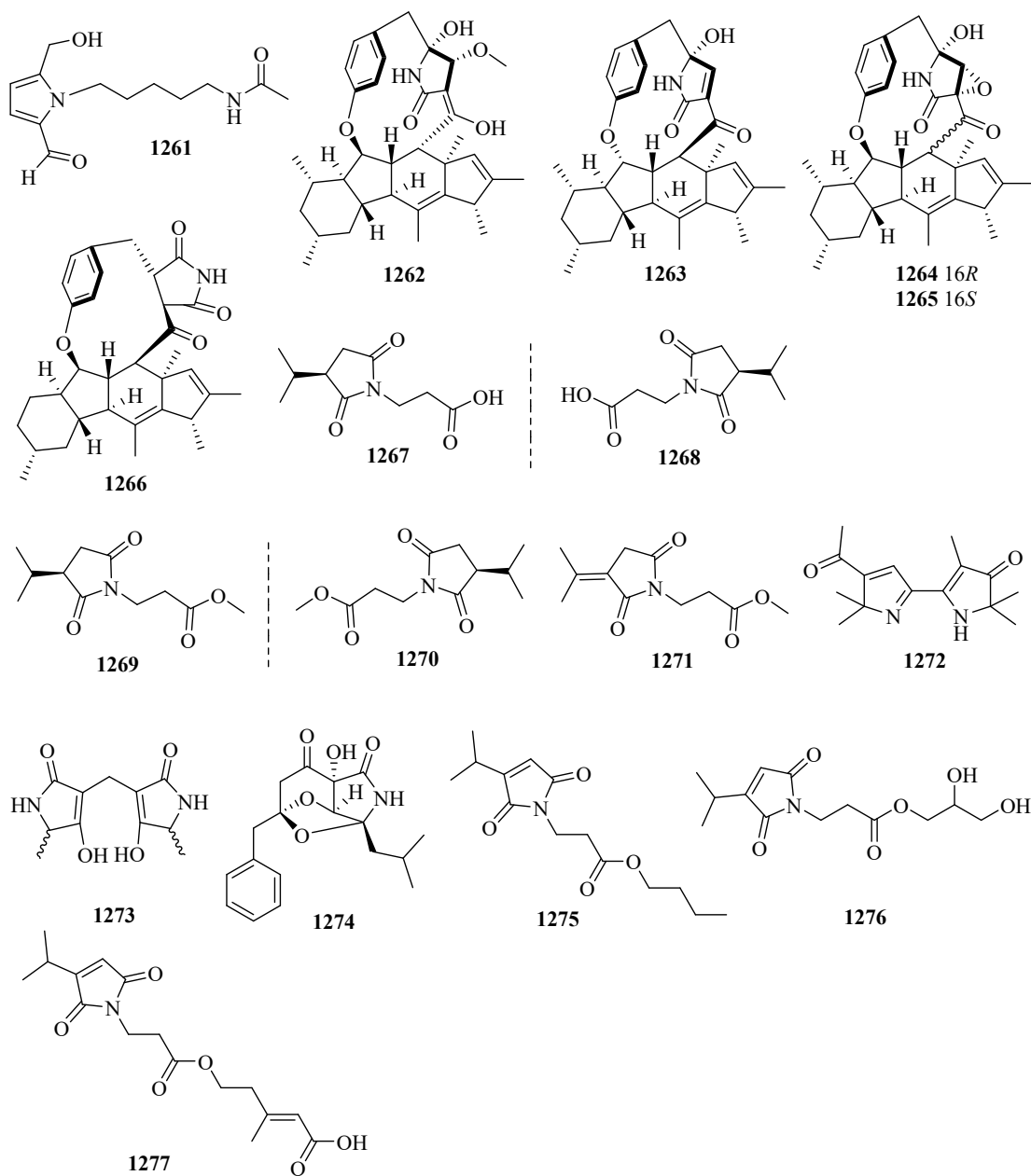




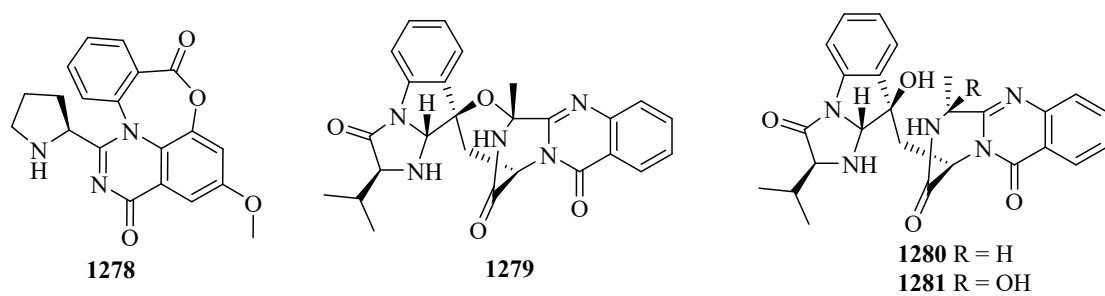
### 3.3.5 Pyrroles and pyrrolidines (1248–1277, 30)

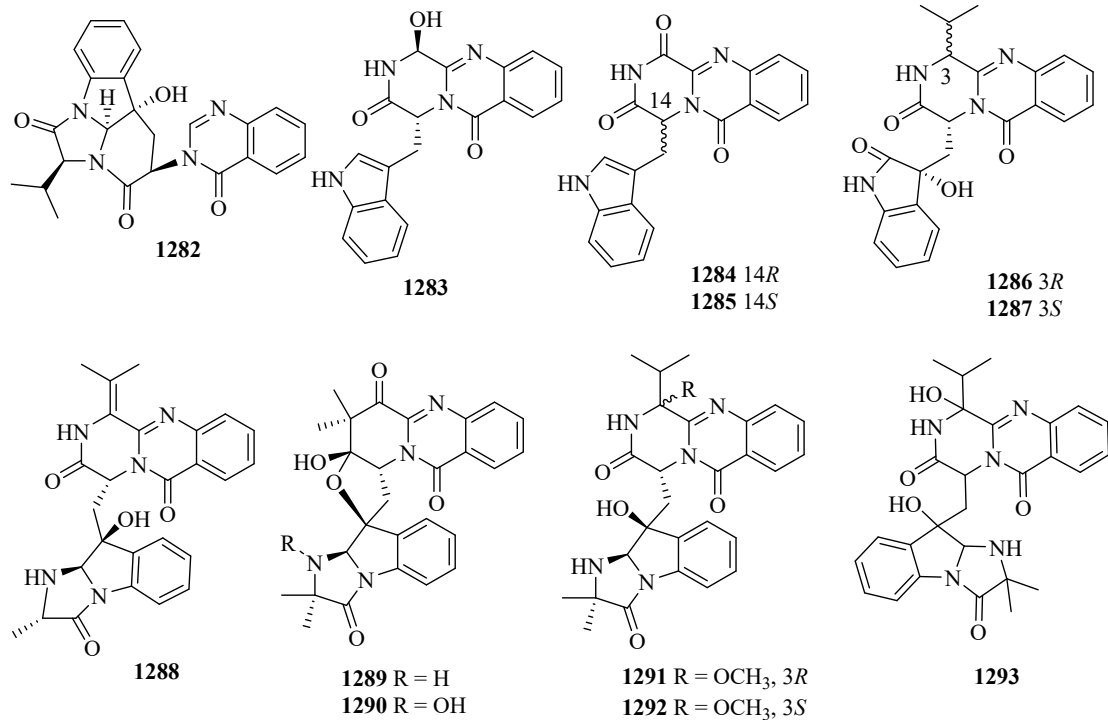




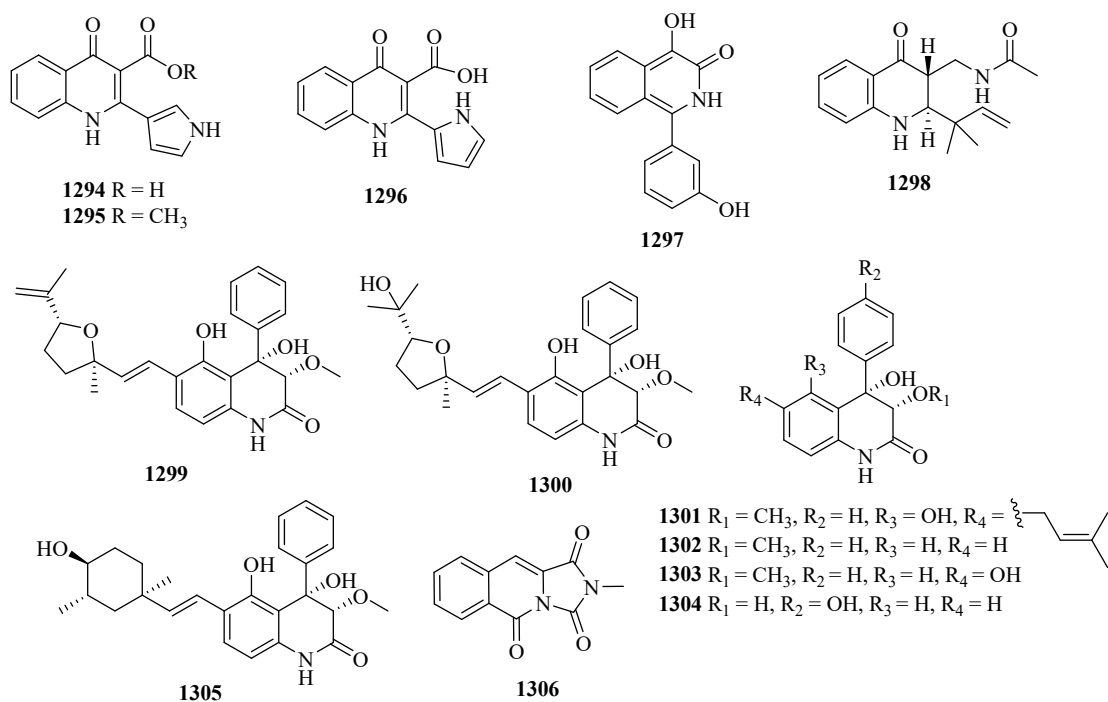


### 3.3.6 Quinazolines (1278–1293, 16)

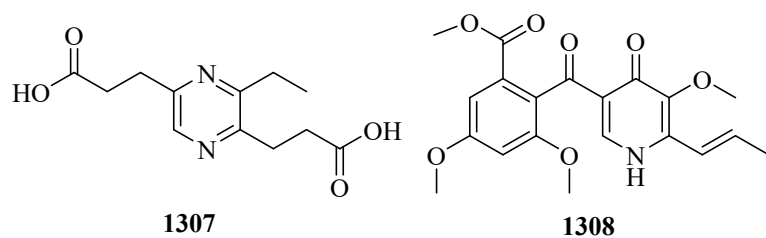




### 3.3.7 Quinolines and Isoquinolines (1294–1306, 13)

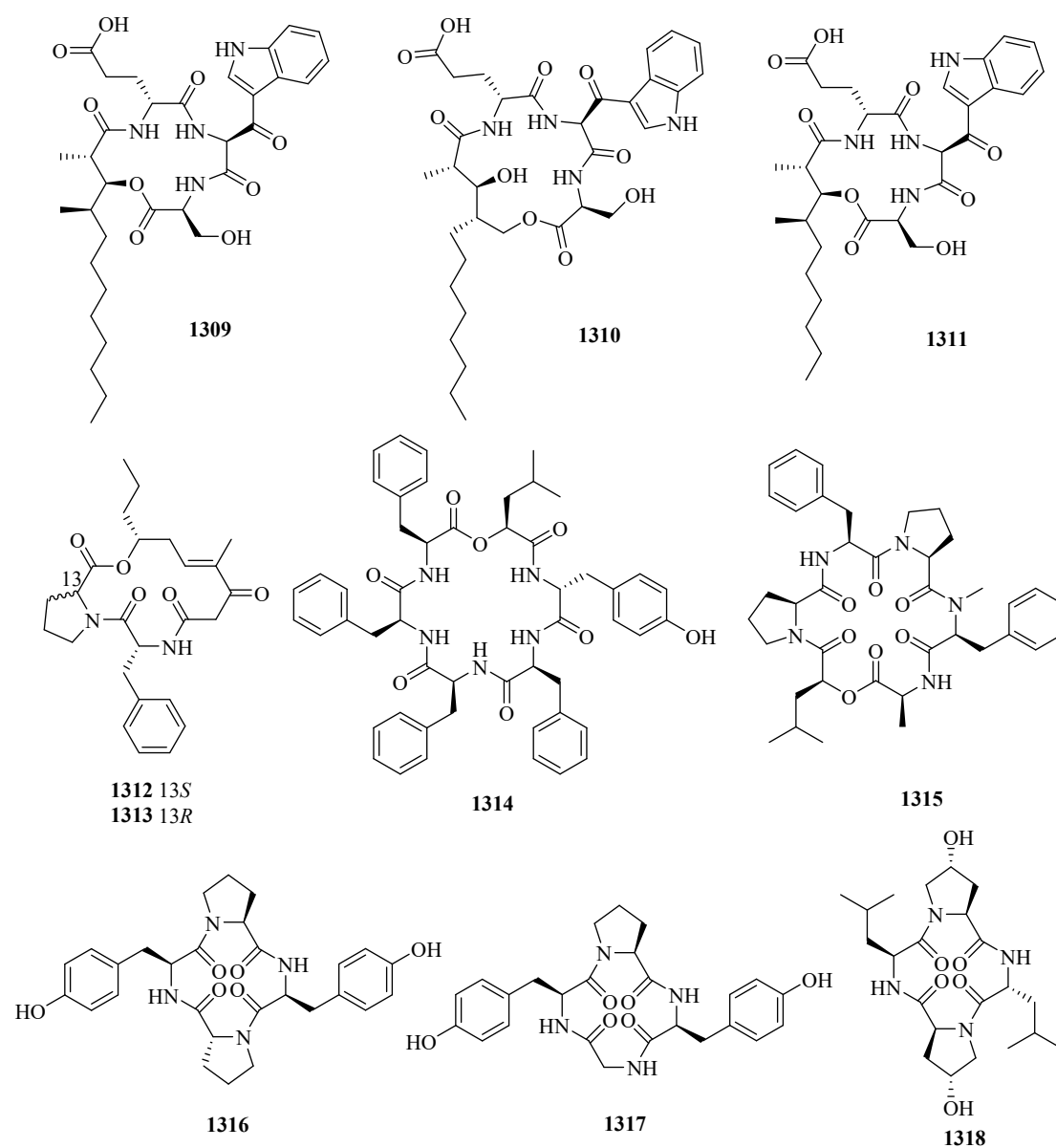


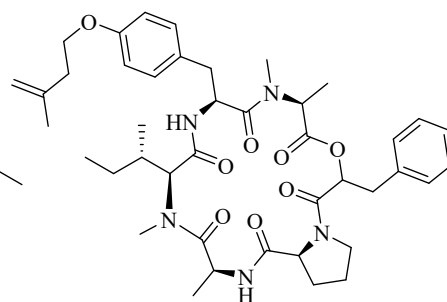
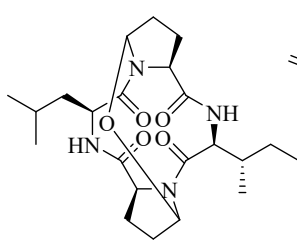
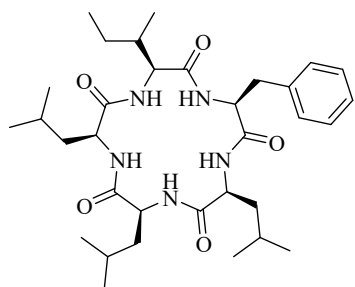
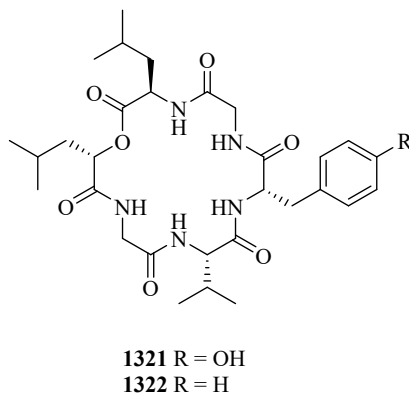
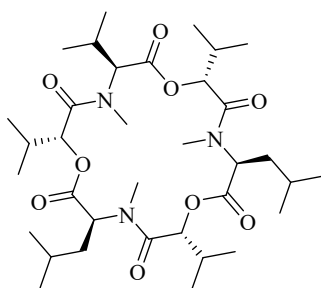
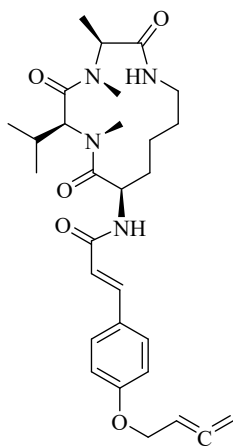
### 3.3.8 other (1307, 1308, 2)



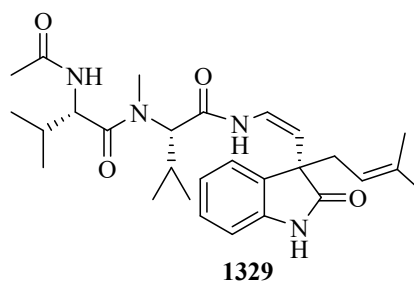
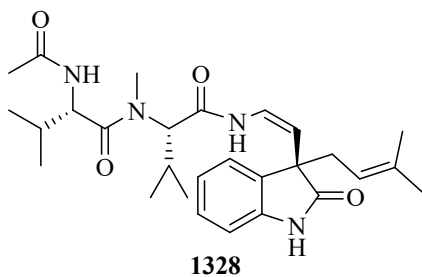
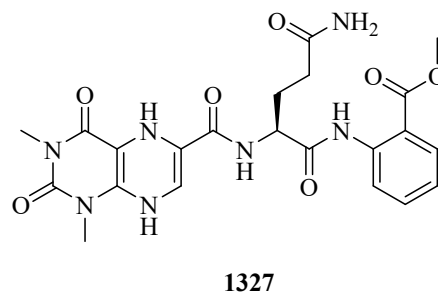
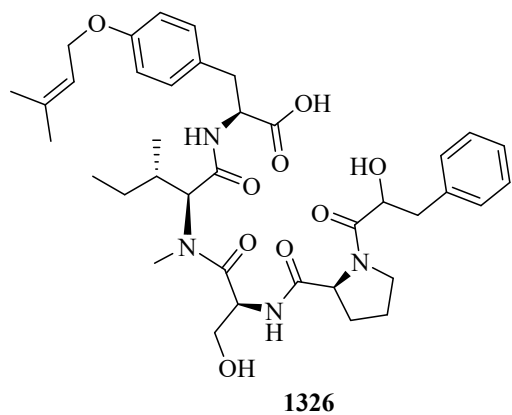
## 3.4 Peptides including diketopiperazines (1309–1387, 79)

### 3.4.1 Cyclic Peptides (1309–1325, 17)

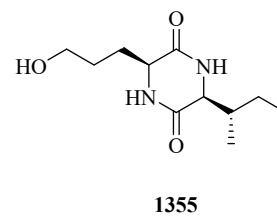
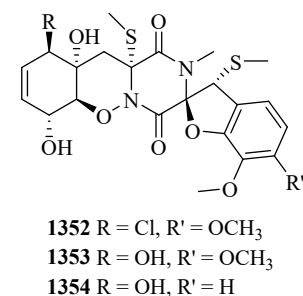
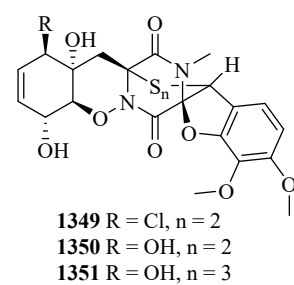
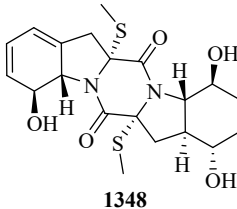
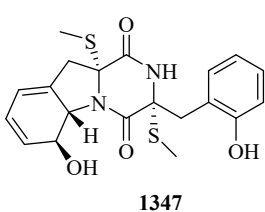
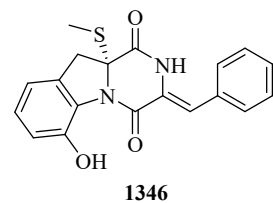
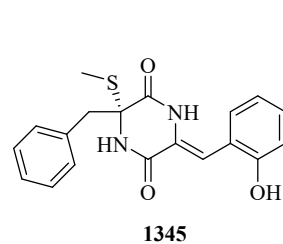
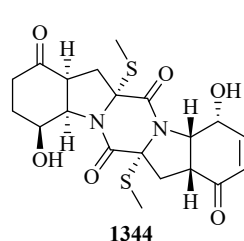
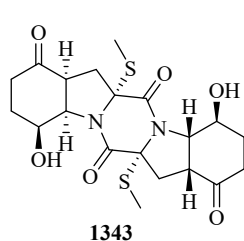
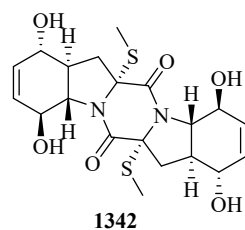
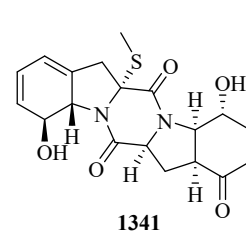
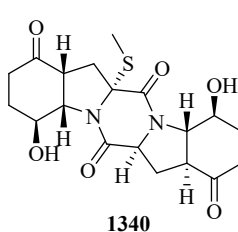
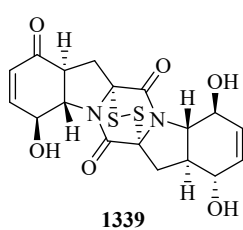
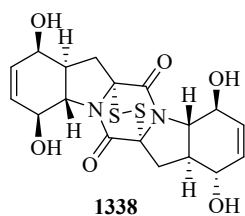
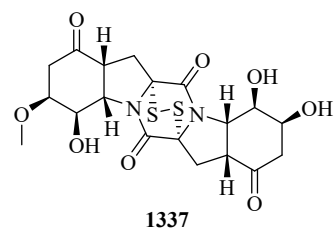
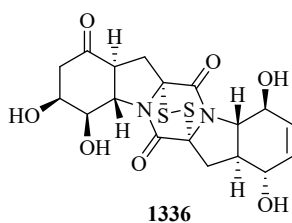
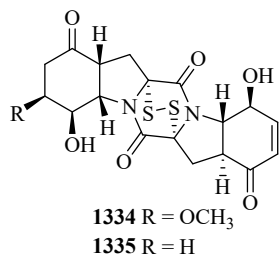
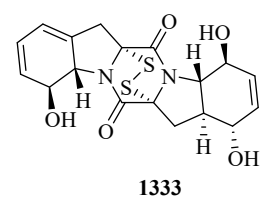
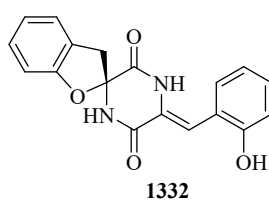
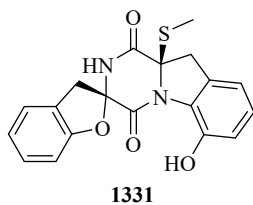
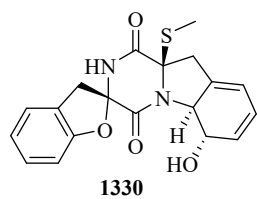


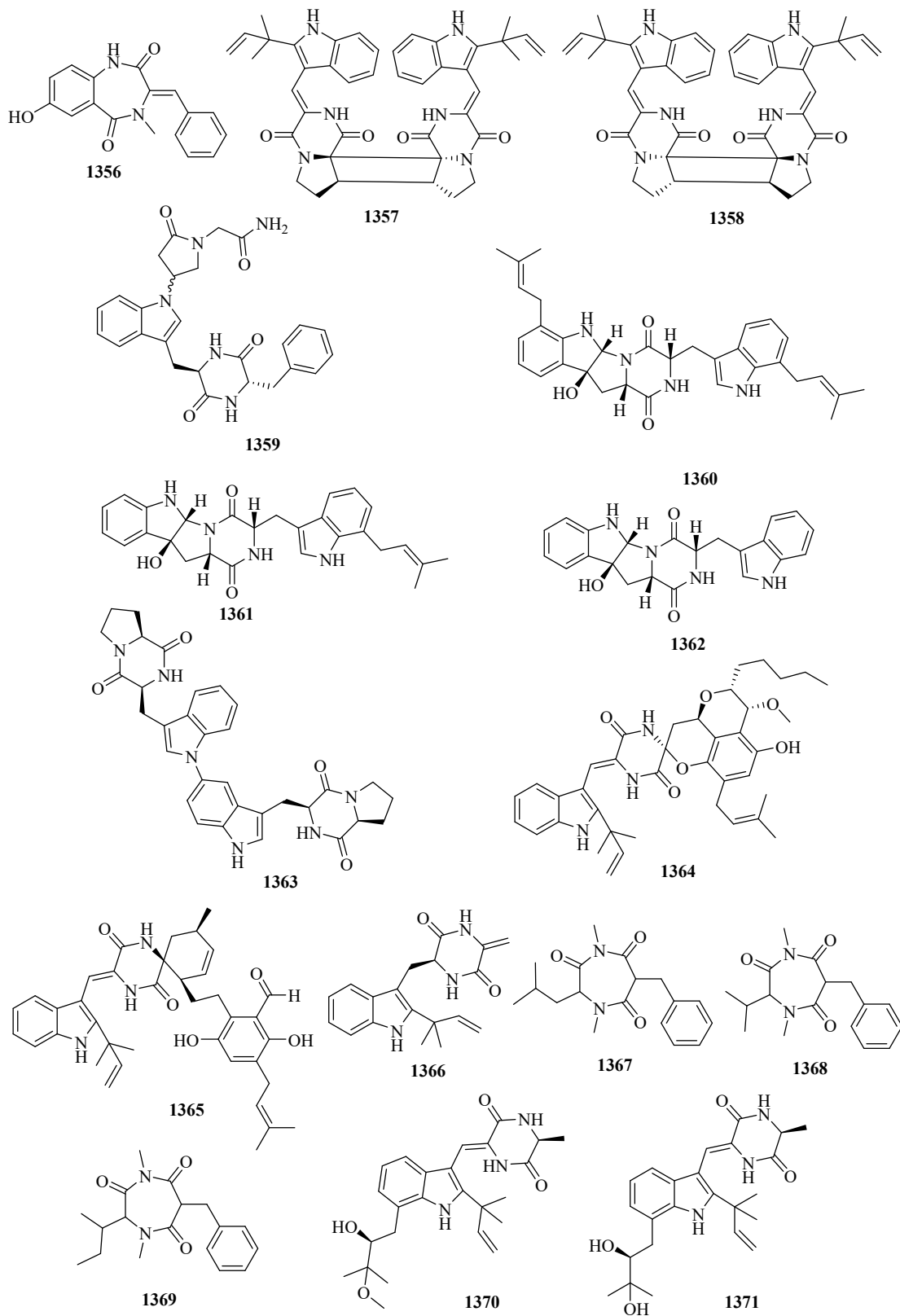


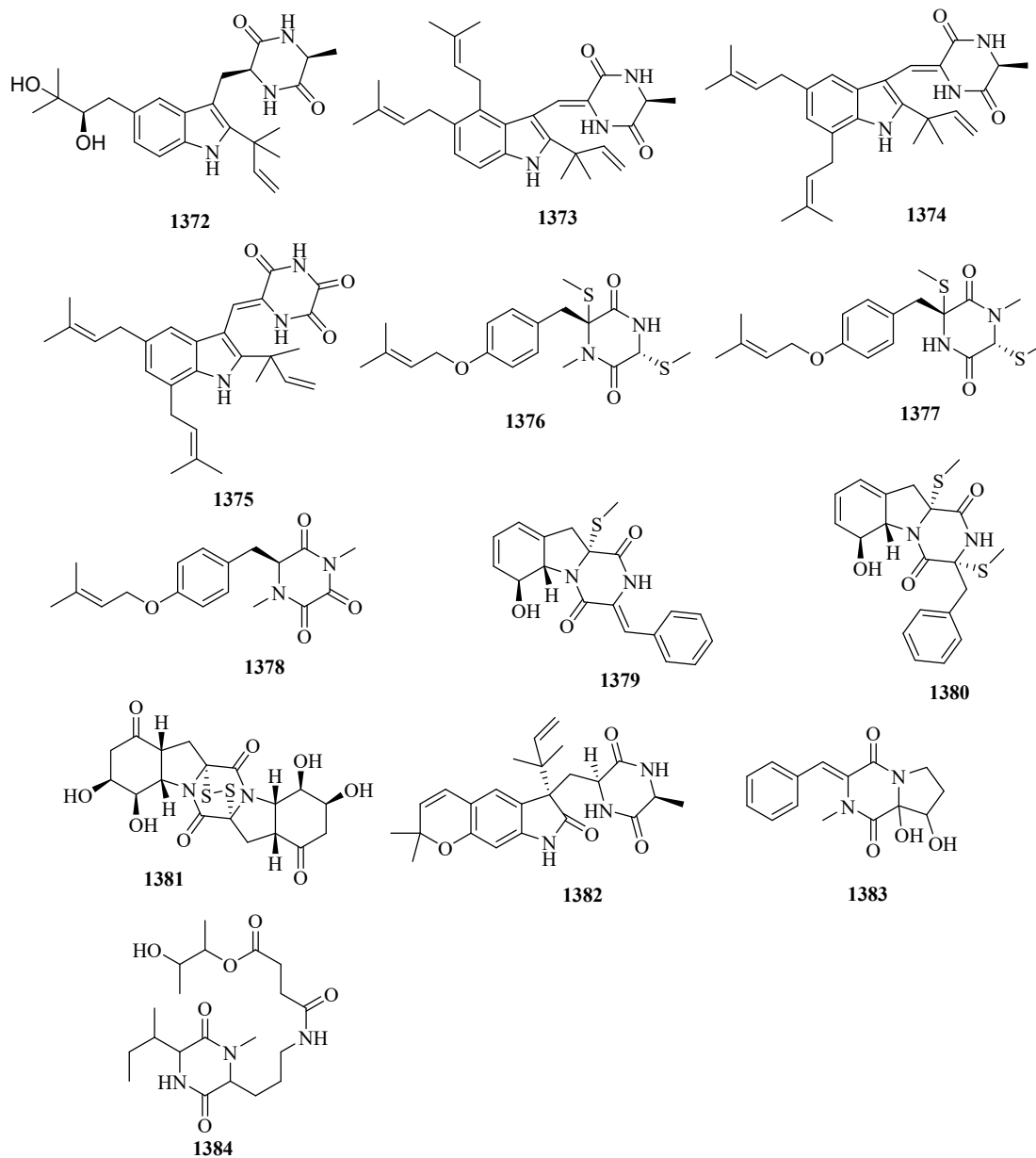
### 3.4.2 Linear peptides (1326–1329, 4)



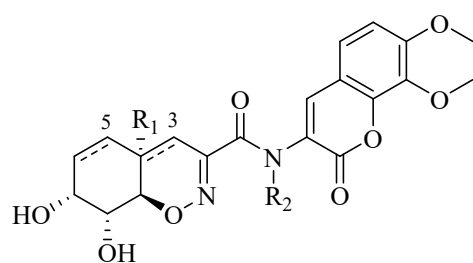
### 3.4.3 Diketopiperazines (1330–1384, 55)







#### 3.4.4 Other peptides (1385–1387, 3)



1385 R<sub>1</sub> = OH, R<sub>2</sub> = H, Δ<sup>5,6</sup>

1386 R<sub>1</sub> = OH, R<sub>2</sub> = H

1387 R<sub>1</sub> = CH<sub>3</sub>, Δ<sup>3,4</sup>, Δ<sup>5,6</sup>