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ADVANCES IN TRITERPENOID RESEARCH, 1990–1994

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Key Word Index—triterpenoids; new skeleta; structure elucidation; total synthesis; biosynthesis; natural distribution; biological activity.

Abstract—Triterpenoids isolated and characterized from various sources are reviewed. The newer spectroscopic techniques used in their structure elucidation, the new skeleta characterized, their total chemical synthesis, and their biosynthesis are discussed. A compilation of the triterpenoids isolated during the period 1990–1994 along with their occurrence, physical data, spectroscopy and X-ray analysis used for their characterization, is included. The biological activities of the triterpenoids are also discussed. Copyright © 1997 Elsevier Science Ltd

INTRODUCTION

Triterpenoids have been attractive constituents for research, not so much, perhaps, for their commercial or therapeutic importance, but for the relative ease with which they are available and amenable to purification. However, the widespread reports in recent years on their useful biological activities and indeed some practical applications, have made these metabolites more relevant and interesting. The occurrence of triterpenoids even in non-photosynthetic bacteria and significant discoveries on geohopanoids [1] and biohopanoids [2], have created much interest from both evolutionary and functional aspects.

This review presents an overview in relation to their newer carbon skeleta, the methodology employed for their structure elucidation, their modification and synthesis, as well as the biological activities reported during the period 1990–1994. Our previous reviews on triterpenoids [3, 4] covered the literature for the period 1977–1989. The literature up to 1976 was covered by earlier comprehensive reviews [5–9].

TRITERPENOIDS WITH NEW SKELETA

A large number of new triterpenoids have been isolated since the earlier review [4] was written. Most of these compounds are variants of known skeletal types. Some of the new structures, however, possess novel carbon skeleta and represent unique biosynthetic end products. The majority of triterpenes possess the conventional skeleta arising from the cyclization of squalene-2,3-epoxide to fused polycyclic products. More unusual are the incompletely cyclized compounds, or ones exhibiting cyclization within the chain, or two consecutive cyclizations rather than with cyclization beginning at one end. While triterpenes with rearranged carbocyclic skeleta have been isolated quite frequently, there are some whose skeleta are formed through extensive oxidation accompanied by various bond cleavages.

Monocyclic triterpene

Achilleol A (**1**), possessing a new monocyclic triterpene skeleton, was isolated from *Achillea odorata* (Compositae) [10]. This is the first example of a triterpene with a monocyclic skeleton in which the biosynthesis is arrested in the first step of cyclization of squalene-2,3-epoxide.

Tricyclic triterpene

Achilleol B (**2**) with a new tricyclic triterpene skeleton was also isolated from *Achillea odorata* (Compositae) [11], and formation from the monocyclic achilleol A (**1**) has been proposed. Its bicyclic system may arise in an analogous way to that of the D and E rings in some pentacyclic triterpenes. The anomalous *trans* ring fusion in (**2**), indicates a deviation in the last steps of the biosynthetic pathway. Instead of 1,2-hydrogen migration, as postulated in oleanane type triterpenes,

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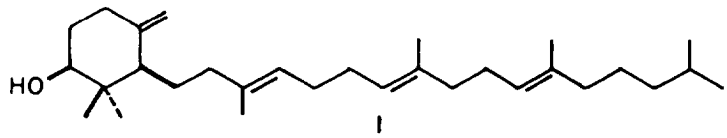
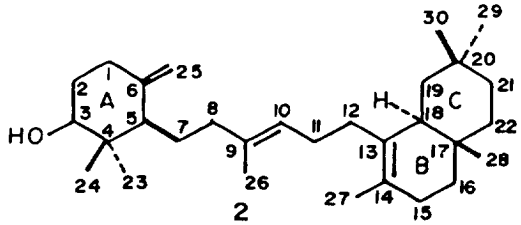


1
Achilleol A



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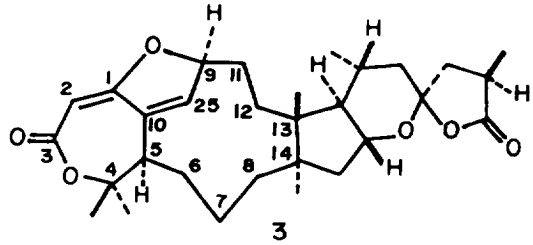
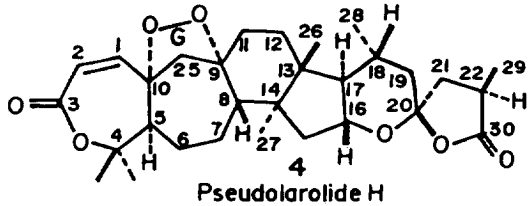
Achilleol B



3
Pseudolarolide E



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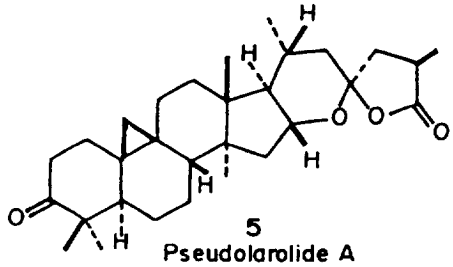
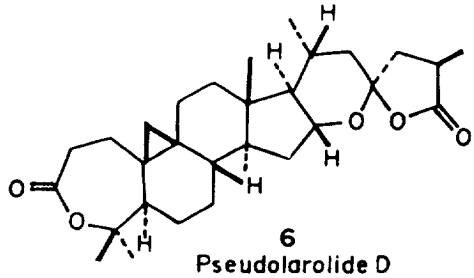
Pseudolarolide H



5
Pseudolarolide A



6
Pseudolarolide D

a 1,3-hydride shift leading to a subsequent proton elimination should produce **2**.

Pseudolarolides

Pseudolarolides E (**3**) and H (**4**), two triterpene dilactones possessing, respectively, 11- and 7-membered B-rings, were isolated from the seeds of *Pseudolarix kaempferi* (Pinaceae) [12, 13]. Pseudolarolides A (**5**) and D (**6**), the probable biogenetic precursors, were also isolated from this plant [13]. While triterpene (**6**) may be assumed to have been formed by enzymic Baeyer–Villiger oxidation of the ketone (**5**), the triterpene (**4**) might be derived from (**6**) by peroxidation accompanied by C_9–C_{10} bond cleavage. Triterpene (**3**) could be formed from (**6**) through extensive oxidation, accompanied by C_8–C_9 and C_9–C_{10} bond cleavages.

Raspacionin

A new squalene derived triterpenoid, raspacionin (**7**) was isolated from the Mediterranean sponge *Raspaciona aculeata* [14]. The structure (**7**), characterized by two *trans* perhydrobenzoxepine moieties linked by an ethylene bridge, is related to those of sipholenol A (**8**) [15, 16], possessing a *trans*-decahydrobenzoxepine part linked by an ethylene bridge to a *cis*-octahydroazulene moiety or to siphonellinol (**9**) [17], with a *trans*-decahydrobenzoxepine part linked by an ethylene bridge to a substituted cycloxhexene group, both isolated from the Red Sea sponge *Siphonochalina siphonella*. The pathway suggested [14] for the formation of raspacionin (**7**) is of special interest. In contrast to the single cyclization process, the suggested route leading to raspacionin, involves two consecutive cyclizations of a tetra-epoxysqualene precursor.

Friedomadeiranes

Triterpenes possessing the madeirane (**10**) skeleton have not yet been isolated. However, triterpenes (**11**), (**12**) and (**13**), (**14**) with the D-friedomadier-14-ene and D:C-friedomadier-7-ene skeleta have been isolated from extracts of *Euphorbia mellifera* (Euphorbiaceae) and their structures elucidated by X-ray analysis [18]. The significant difference between the madeirane skeleton and that of representatives of lupane or hopane class, lies in the unusual arrangement of the substituents in the cyclopentane ring E, the Me group being C19, the isopropyl group in an angular position on C17 and the *cis* D/E ring junction. The synthesis of the madeirane skeleton has been rationalized [18] as follows: typical cyclization of 2,3-oxidosqualene to the dammarenol C20-cation followed by H-migration from C17 to C20 leading to the dammerenol C17-cation, which on unusual cyclization by the addition of C17-cation on C24 from the re-side of the double bond, generates a new spirodammaranol C25-cation. This occurs by an antiperiplanar H-shift from C24 to C25 forming the spirodammaranol C24-cation, which is able to undergo a shift of the C16–C17 bond to give C16–C24, which involves the enlargement of ring D with the formation of the cation, the fundamental skeleton of madeirane. This cation, on usual consecutive antiperiplanar 1,2-migrations of H-C13, Me-C14, and Me-C8, may lead to the formation of the cations of D-friedo- and D:C-friedomadeiranol, respectively.

Naurel A and B

Two stereoisomeric triterpene alcohols (**15**, **16**) with a novel, partially cyclized skeleton centred about a linear conjugated tetraene moiety and having only two carbocyclic rings, were isolated from a Pacific sponge by Guzman and Schmitz [19]. Limatulone (**17**) possessing a similar, partially cyclized squalene skeleton was reported from a limpet, *Collisella limatula* in 1985 [20].

Perovskone

Perovskone (**18**), a triterpene with a novel carbon framework, was isolated from the whole plant of *Perovskia abrotanoides* (Labiatae) [21]. The skeleton of this triterpene, which is not squalene derived, is extremely interesting for biosynthetic studies. Its biogenesis has been suggested to proceed through the addition of geranylpyrophosphate to an icetoxone precursor (**19**) with the formation of carbon–carbon bonds between C-21 and C-8, C-24 and C-9, C-26, C-11 and carbon oxygen bonds.

Squalene-type triterpenes

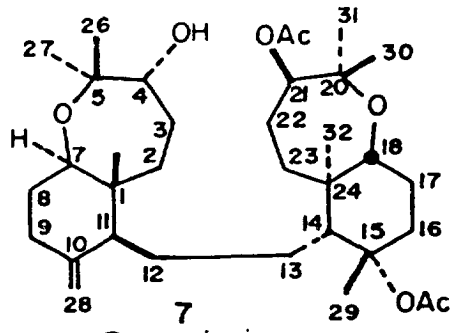
A unique squalene-type triterpene, eurylene (**20**), possessing two tetrahydrofuran rings, was isolated from the wood of *Eurycoma longifolia* (Simaroubaceae) [22]. Longilene peroxide (**21**), another squalene-type triterpene with eight asymmetric carbons and three tetrahydrofuran rings has also been isolated from the same plant [23]. Teurilene (**22**) whose structure is similar to that of longilene peroxide, but possessing different stereochemistry, was isolated by Suzuki *et al.* [24].

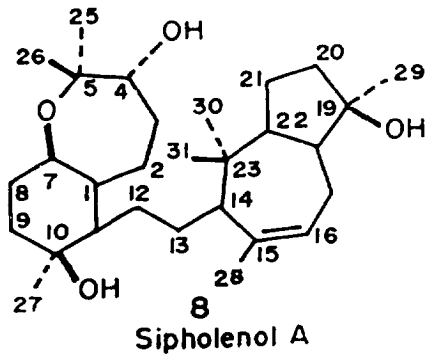
Isomalabaricane triterpenes

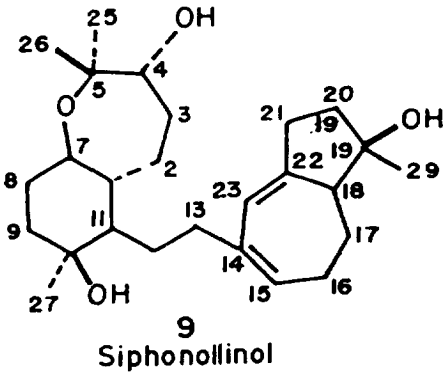
Six new isomalabaricane-type triterpenes, stelliferins A–F (**23**–**28**), possessing antineoplastic activity were isolated from the Okinawan marine sponge *Jaspis stellifera* [25]. These are the second examples of isomalabaricane triterpenes, the first being isolated in 1982 [26].

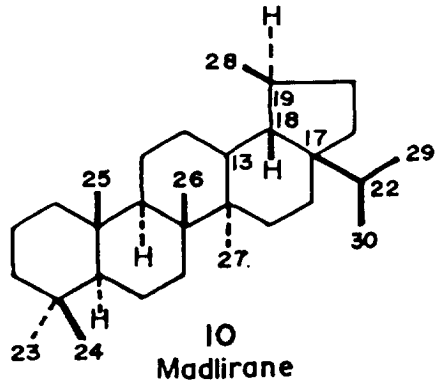
Migrated dammarane and malabaricane triterpenes

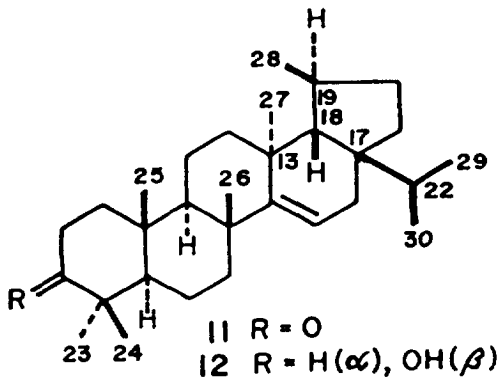
Three new triterpene hydrocarbons, aonena-3,21-diene (**29**), podioda-7,17,21-triene (**30**) and podioda-











8,17,21-triene (**31**) were isolated from fresh rhizomes of *Polypodiodes niponica* (Polypodiaceae). While compound **29** is the first example of a final migrated product of dammarane series, compounds **30** and **31** constitute a new migrated malabaricane series [27].

A-Ring contracted ursane triterpene

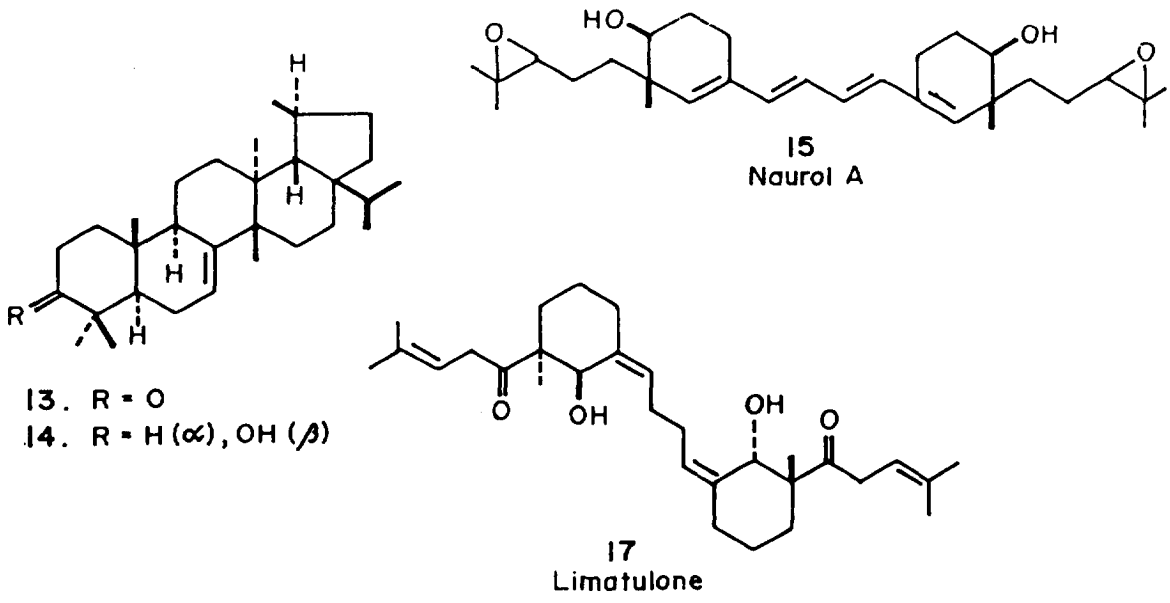
A novel triterpene, hyptadienic acid (**32**) whose structure has been elucidated as A(1)-1,19-dihydroxy-urs-2(3),12-dien-28-oic acid, has been isolated from *Hyptis suaveolenes* (Labiatae) [28]. This is the first report of a naturally occurring A-ring contracted triterpene, outside the lupane series. Coleonolic acid isolated from *Coleus forskohlii* (Labiatae) [29] is identical with hyptadienic acid. The biogenetic formation of hyptadienic acid was suggested from tormentic acid (2α,3β,19α-trihydroxyolean-12-en-28-oic acid), via oxidative cleavage of the C2–C3 bond, to form an intermediate dialdehyde, aldol type condensation, dehydration and reduction.

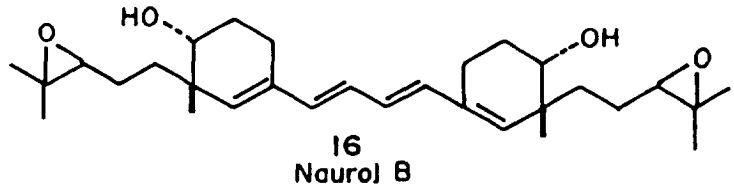
Degraded triterpenoids

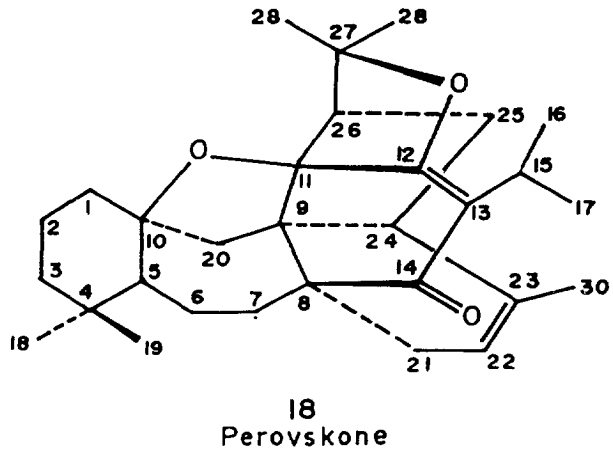
Two degraded triterpenoids, buxapentalactone (**33**) and buxaheptalactone (**34**) have been isolated from the roots of *Buxus papillosa* (Buxaceae) and their structures finally determined using single crystal X-ray diffraction and spectroscopic techniques [30].

Mimusopane (5,10-*friedooleanane*) *triterpenes*

Two new pentacyclic triterpene acids, mimusopic acid (**35**) and mimusopsic acid (**36**) possessing the novel mimusopane (5,10-friedooleanane) skeleton, were isolated from the seeds of *Mimusops elengi*







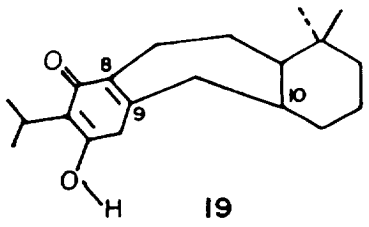
(Sapotaceae) [31]. The formation of these two triterpene acids was rationalized from protobassic acid (2β, 3β, 6β, 23-tetrahydroxyolean-12-en-28-oic acid).

Rearranged hopane and migrated gammacerane triterpenes

Chiratenol (**37**), a novel rearranged hopane (chiratone) triterpenoid [32], and kairatenol (**38**), a new migrated gammacerane (kairatane) triterpenoid [33] were isolated from *Swertia chirata* (Gentianaceae).

Pachanol A

Pachanol A (**39**), a new triterpene possessing a novel skeleton, was isolated from the hydrolysate of the MeOH extract of *Trichocereus pachanoi* (Cactaceae). The unique feature of the skeleton is that it possesses



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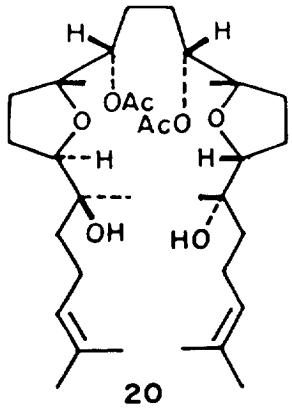
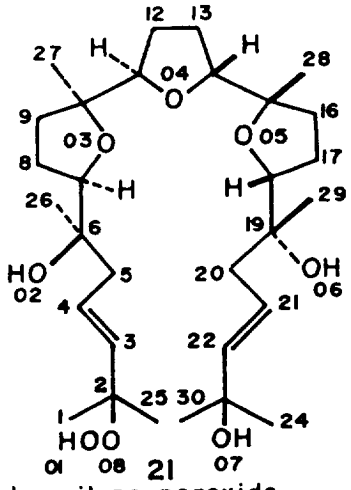
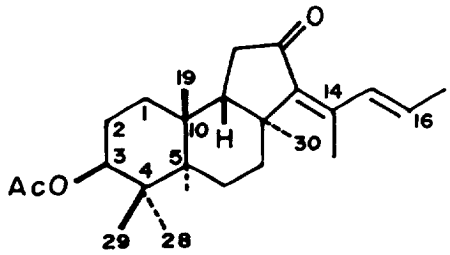


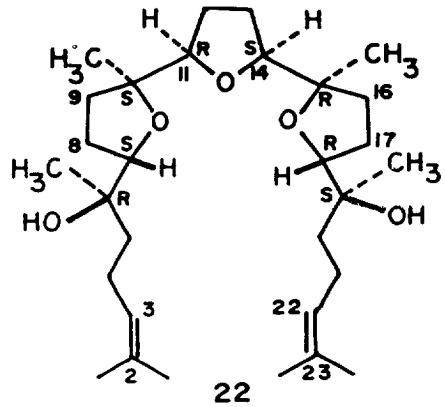
20
Eurylene



Longilene peroxide



23 Stelliferin A R=H
27 Stelliferin E R=Ac

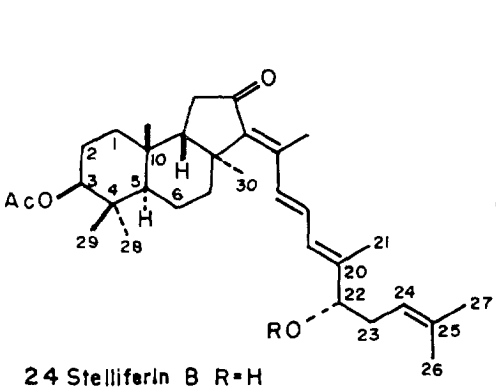


22
Teurilene

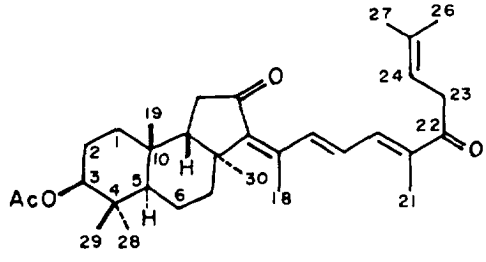
a C-15 methyl group. The structure was determined by single crystal X-ray crystallography, and the ^{1}H and ^{13}C signals were assigned by DEPT, ^{1}H–^{1}H, ^{1}H–^{13}C COSY and ^{1}H–^{13}C long range COSY [34].

Spirocaracolitone

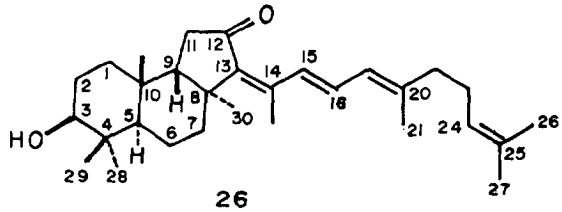
The novel spiro-triterpenoid, spirocaracolitone (**40**), was isolated from a newly described genus and species, *Ruptiliocarpon caracolitone* (Lepidobotryaceae). It is a tree growing in the humid lowland tropical rainforest in Costa Rica. The structure of the triterpene was elucidated by X-ray diffraction and possesses a unique, previously unreported CD spiro friedelin skeleton [35]. The structure (**40**) is most interesting from a biosynthetic point of view. Several of the structural features of the compound are rare and have not been described previously in pentacyclic triterpenoids. The occurrence of a C-12 methyl group or a spiro CD ring system is an unprecedented phenomenon.



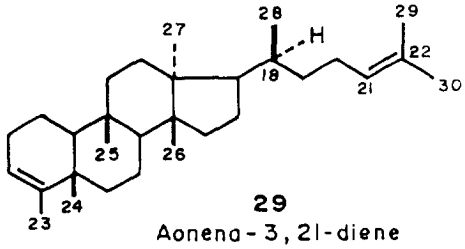
24 Stelliferin B R=H
28 Stelliferin F R=Ac



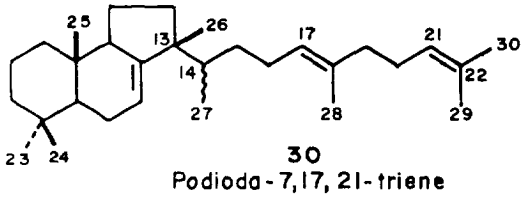
25
Stelliferin C



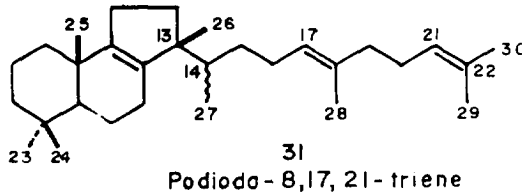
26
Stellifiren D



29
Aoneno-3,21-diene



30
Podioda-7,17,21-triene



31
Podioda-8,17,21-triene

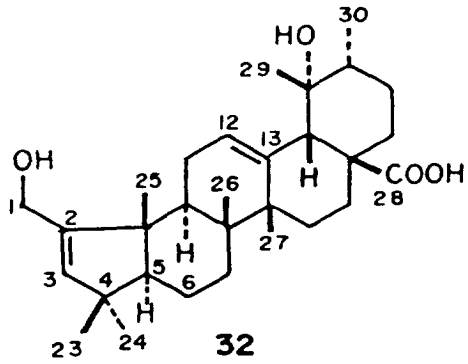
Sodwanones

Six triterpenoids, sodwanones A–F (**41–46**) having three different skeleta, were isolated from the Indo-Pacific sponge *Axinella weltneri* [36, 37]. The structures were determined by 1D and 2D NMR spectroscopy. These triterpenoids comprise two separate cyclic systems presumably obtained from di- or trioxidosqualenes in two separate acid-catalysed cyclizations [38–40]. Each cyclization is suggested to be initiated by a carbonium ion obtained from the protonation of either an epoxide or one of the squalene double bonds. The compounds (**41–46**) possess at least one perhydrobenzoxepine system derived from one half of the squalene precursor and the variety of other systems obtained from the second half of the squalene moiety.

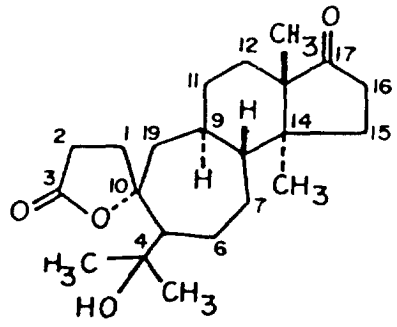
STRUCTURE ELUCIDATION

NMR spectroscopy

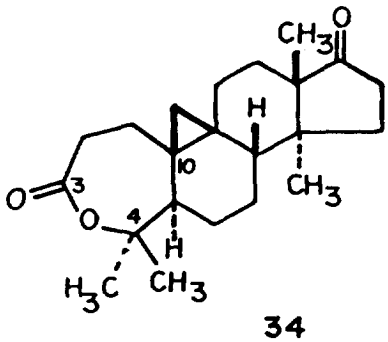
The high level of development in spectroscopic methods has tremendously enhanced the structure elucidation of natural products which previously required considerable intellectual power and chemical insight. Although the developments in each spectroscopic method are remarkable, the structural information now available to the natural product chemist, through NMR spectroscopy, is probably greater and more easily obtained than by any other single technique. NMR spectroscopy is now almost invariably used either for confirmation of a proposed structure by the assignment of a ^{13}C or ^{1}H spectrum, usually supported by NMR data from related model compounds, or for structural proof of complete unknowns, which may require a whole battery of the newer techniques. The structures of stelliferin A (**23**) and five other isomalabaricane triterpenes, stelliferins B–F (**24–28**) were established by spectroscopic analyses, especially 1D and 2D NMR techniques [25]. A combination of the ^{1}H–^{1}H COSY [41] and Homonuclear, Hartman–Hahn (HOHAHA) [42] experiments enabled the definition of the partial structure of the side chain of the product (**23**). In the ^{1}H–^{1}H COSY spectrum the protons H-15 and H-17 showed couplings to the proton H-16. In the HOHAHA spectrum the protons H-15 and H-17 showed correlations to the methyl protons at H-18 and H-21, respectively. Moreover, in the COSY spectrum the carbinyl proton H-22 was coupled to the methylene protons H_2-23, which were coupled to the proton H-24. The proton



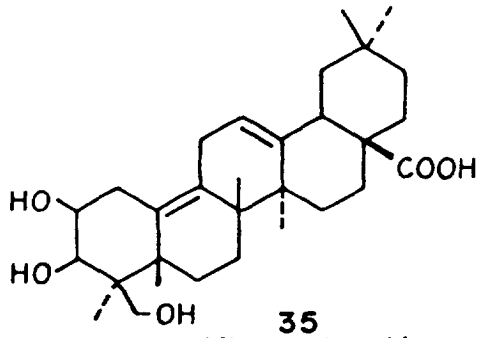
32
Hyptadienic acid



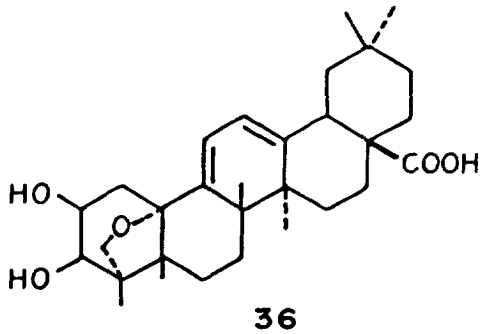
33
Buxapentalactone



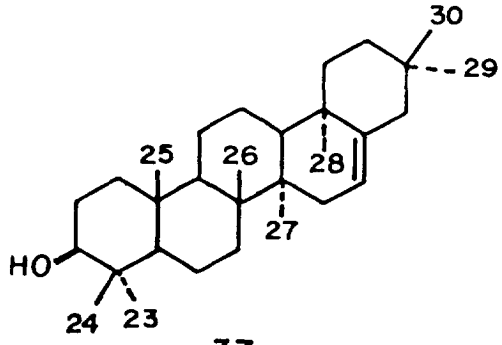
34
Buxaheptalactone



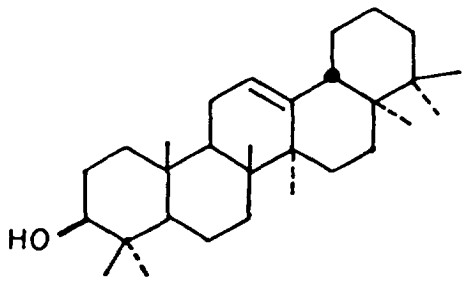
35
Mimusopic acid



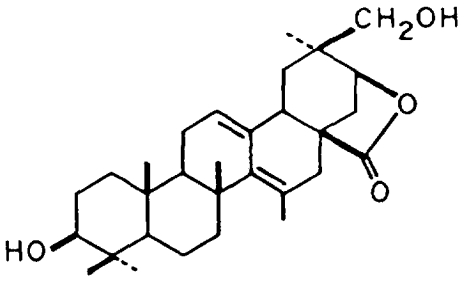
36
Mimusopsic acid



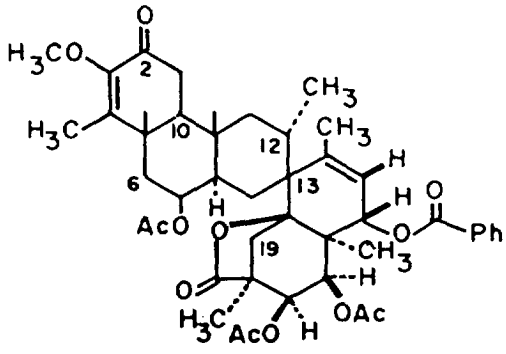
37
Chiratenol



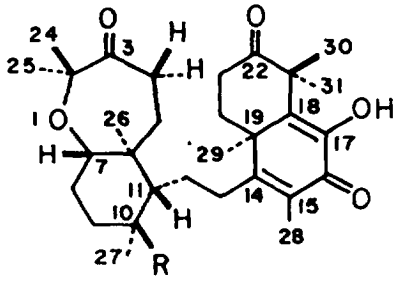
38
Kairatenol



39
Pachanol

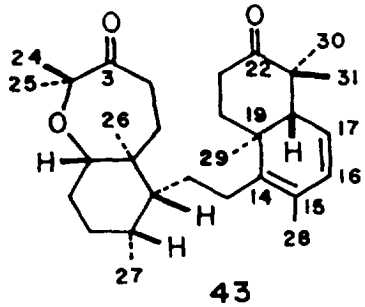


40
Spirocaracolitone

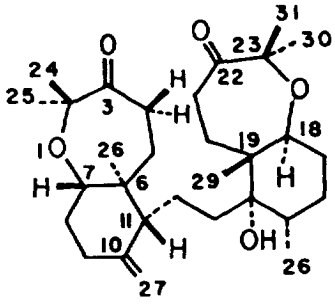


41 Sodwanone A. R = OH

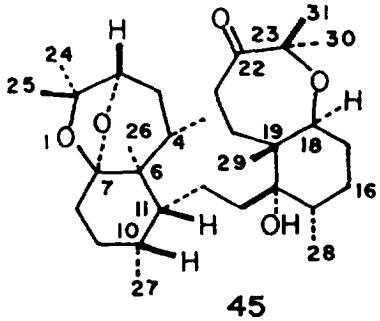
42 Sodwanone B. R = H



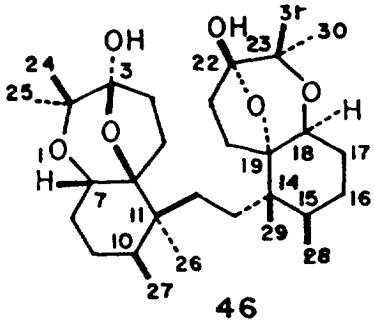
43
Sodwanone C



44
Sodwanone D



45
Sodwanone E



46
Sodwanone F

H-24 was connected to the two methyl protons H-26 and H-27, respectively. The connectivity between H-21 and H-22 was clarified by nuclear Overhauser effect spectroscopy (NOESY). The ^{13}C NMR data, including distortionless enhancement by polarization transfer (DEPT) experiments, revealed the presence of the number of methyls, methylenes, sp^3 methenes including the carbinyl ones, sp^2 methenes and sp^3 and sp^2 quaternary carbons. The protonated carbons were all assigned by heteronuclear multiple quantum coherence (HMQC) [43], and the ^1H-detected heteronuclear multiple-bond correlation (HMBC) technique [44] disclosed connectivity from the acetate methyl proton signal to the ester carbonyl, which was shown to be coupled to the oxymethene proton H-3. Both methyl protons H_3-28 and H_3-29 were coupled to C-34, C-4 and C-5. The methyl protons H_3-19 were coupled to C-1, C-5, C-9 and C-10, respectively. The methyl protons H_3-30 showed connectivities to C-7, C-8, C-9 and C-13. Moreover, in the HMBC spectrum, the methyl protons H_3-18 coupled to C-13. The other carbon–carbon bonds were clarified by detailed analyses of the ^1H–^1H COSY and HMBC spectra of **23**.

The structure elucidation of the bicyclic moiety in achilleol B(**2**) [11] was established by 2D NMR experiments including homonuclear long range COSY (LRCOSY) [41], double quantum filtered COSY (DQFCOSY) [45] and HOHAHA and heteronuclear, normal, long range and reverse long range [43] C-H correlations. The DQFCOSY sequence was selected in order to avoid methyl group crowding on the diagonal. A ^1H–^1H homonuclear correlation using the HOHAHA experiment was very useful for structure elucidation of the acyclic moiety of the molecule, allowing unambiguous assignment of H-8 through H-12 signals.

Mass spectrometry

Mass spectrometry has been in use as an important tool for the structure elucidation of triterpenoids for three decades. Dierassi *et al.* [46] reported in 1963 the mass fragmentation patterns of pentacyclic triterpenoids belonging to the oleanane and ursane classes, as well as some rearranged oleananes and ursanes. Shiojima *et al.* [47] very recently reported the mass spectra of more than 100 saturated and unsaturated pentacyclic triterpenoids belonging to the hopane (**47**) and its rearranged skeleta, the neohopane (**48**), pteronane (**49**), fernane (**50**), adianane (**51**) and filicane (**52**), gammacerane (**53**) and rearranged skeleta, the neogammacerane (**54**) and swertane (**55**), lupane (**56**) and rearranged skeleta, neolupane (**57**) and lactucane (**58**), oleanane (**59**) and rearranged skeleta, the taraxarane (**60**), multiflorane (**61**), glutinane (**62**) and friedelane (**63**), and taraxastane (**64**) and rearranged skeleta, ursane (**65**) and bauerane (**66**). The generation of various characteristic fragments from different carbon skeleta with nuclear double bond(s) has been rationalized.

CHEMICAL MODIFICATION AND SYNTHESIS

With the advent of various spectroscopic techniques, the structure elucidation of a natural product has very often become almost a routine matter. However, the structure elucidation is no longer or only rarely an end in itself. While much of our basic knowledge was derived in the past from degradative studies, its extension today rests primarily on the synthesis of natural products and their analogues and their chemical modifications for a variety of purposes.

Partial synthesis

Manwuweizic acid (**67**) is a potential anticancer triterpene isolated from *Schisandra propinqua* (Schisandraceae). This complex molecule has been synthesized from lanosterol (**68**), a commercial product from the wool industry. Stereoselective introduction of the (Z) α,β-unsaturated carboxylic terminal of the side chain was achieved through oxidative cleavage of the double bond of the side chain of **68**, after protection of the C-3 hydroxy, to an aldehyde followed by a stereoselective Witting reaction and successive MnO_2 and sodium chlorite oxidation. The cleavage of ring A was accomplished by employing a series of transformations followed by an abnormal Beckmann rearrangement [48].

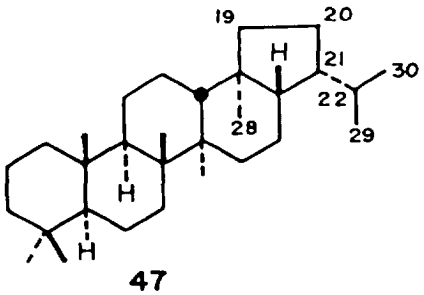
In course of their studies on geochemical biomarkers, Wahhab *et al.* [49] synthesized some lupane standards. During the synthesis of lupane (**56**) in three steps from betulin (**69**), in an overall yield of 47.2% 17β(H)-28-norlupane (**70**) was obtained in 90% purity employing Barton's method for the decarboxylation of 3-oxo-lupane-28-oic acid (**71**). 24,28-Bisnorlupane (**72**) and 24-norlupane (**73**) were prepared by a series of reactions involving formation of the oxime, the seconitrile, the epoxy nitrile, ring closure and finally Wolff–Kishner reduction of the C-3 carbonyl to a methylene moiety.

Approach to total synthesis

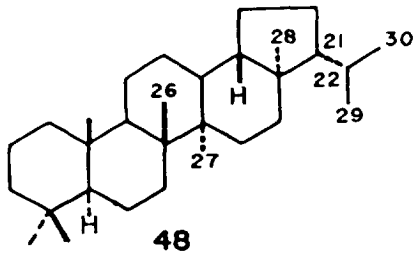
Arseniyadis *et al.* [50] reported the synthesis of triterpenoid precursors for their use as intermediates in the synthesis of isoborneol (**74**) and analogues. Diels-Alder condensation of the bicyclic diene (**75**) with 2,6-dimethyl benzoquinone under thermal and Lewis acid-catalysed conditions, led to the formation of the diastereoisomers (**76**), (**77**), (**78**) and (**79**).

Total synthesis

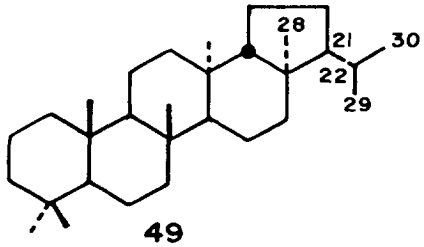
Triterpenoids, specially the pentacyclic triterpenoids which possess five fused rings and eight chiral centres have attracted the attention of synthetic chemists for several decades. Barton *et al.* [51] reported the first total synthesis of β-amyrin demonstrating that 18α-olean-12-ene (**80**) could be converted to β-amyrin in 19 steps (yield 0.001%). Van Tamelin and co-workers [52] reported a synthesis of δ-amyrin (**81**) which had earlier been converted to (**72**). Kametani *et al.* [53] reported on the total synthesis of friedelin. Johnson and co-workers [54] very



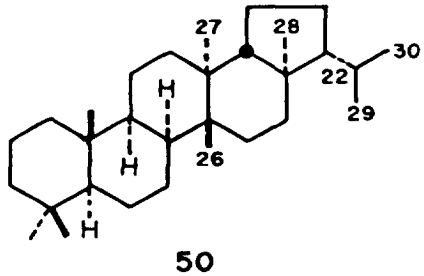
47
Hopane



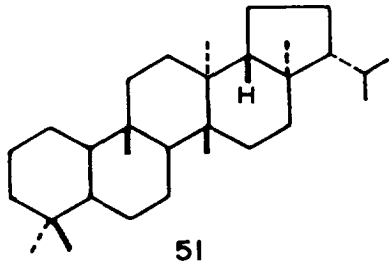
48
Neohopane



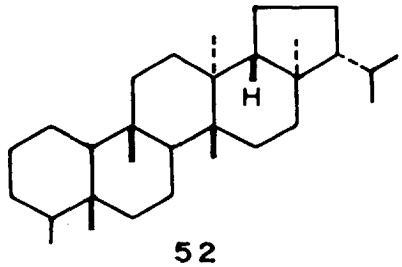
49
Pteronane



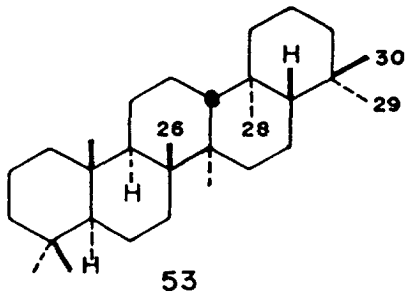
50
Fernane



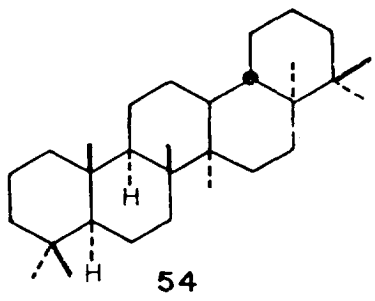
51
Adianane



52
Filicane



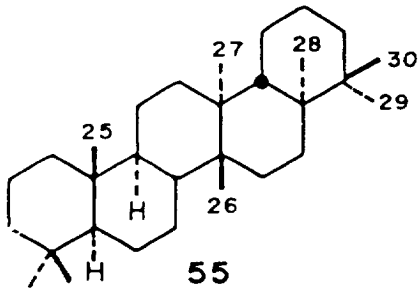
53
Gammacerane



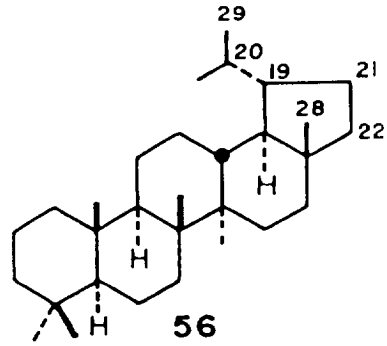
54
Neogammacerane

recently reported the total synthesis of D,L-β-amyrin, utilizing as the key step, a cyclization of a polyolefin having a fluorine atom as a cation-stabilizing (C-S) auxilliary. The polyene substrate (**82**) upon acid-catalysed cyclization yielded the fluoropentacycle (**83**), a compound having five fused rings and bearing six of the eight chiral centres of β-amyrin. Conversion of (**83**) to D,L-β-amyrin entailed oxidative removal of the C-22 allene group, regioselective elimination of the C-13 fluorine atom to produce a C-12 alkene, enlargement and functionalization of ring A and establishment of a *trans* A/B ring fusion. Other pentacyclic triterpenes which have been synthesized in racemic form include (±)-lupeol [55] and (±)-germanicol [56].

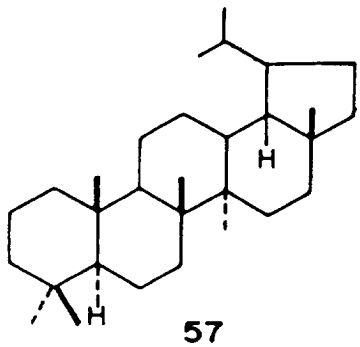
Corey and Lee [57] had reported the first enantioselective total synthesis of oleanolic acid, erythrodiol, β-amyrin and other pentacyclic triterpenes via the key intermediate aegiceradienone (**84**), which is also a natural product. The total synthesis of the β-amyrin series, using 7-methoxy-1-tetralone (**85**) as the starting material, is remarkably short and flexible with regard to providing access to a number of important



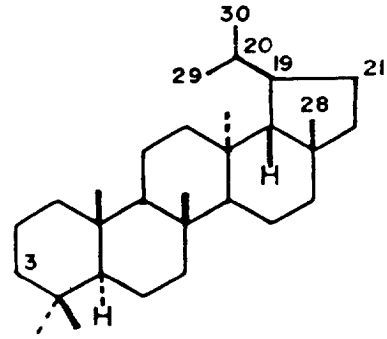
55
Swertane



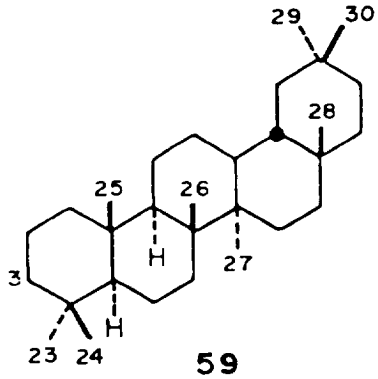
56
Lupane



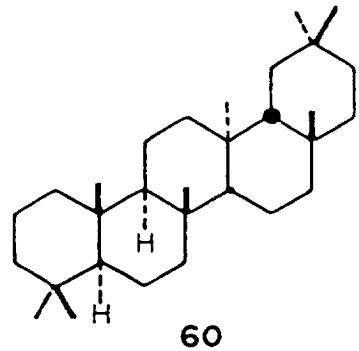
57
Neolupane



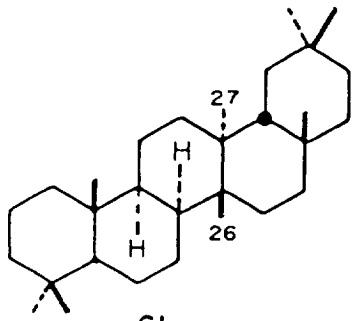
58
Lactucane



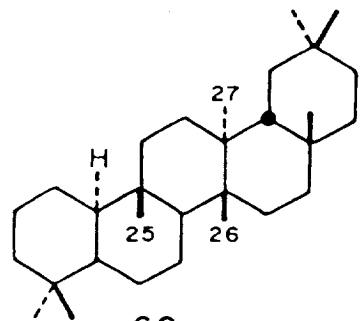
59
Oleanane



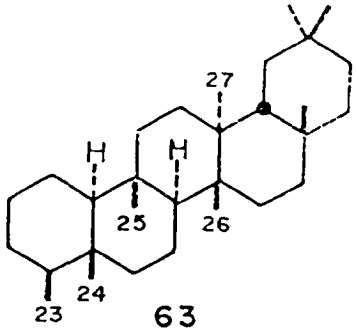
60
Taraxarane



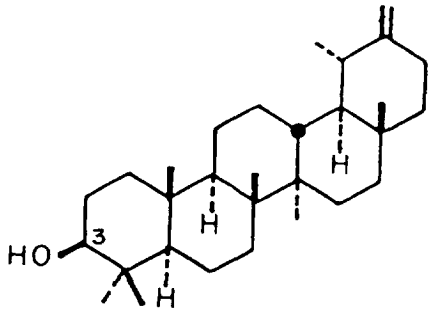
61
Multiflorane



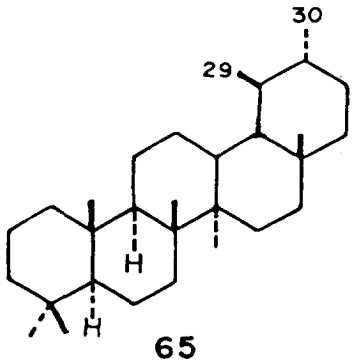
62
Glutinane



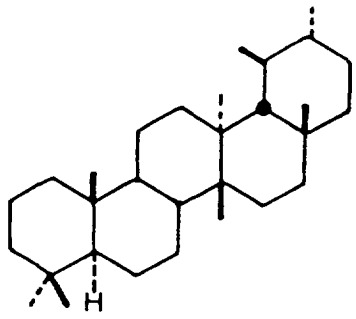
63
Friedelane



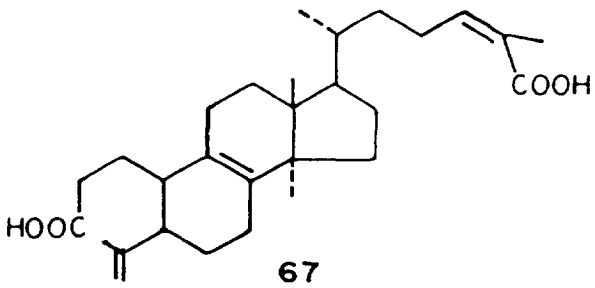
64
Taraxastane



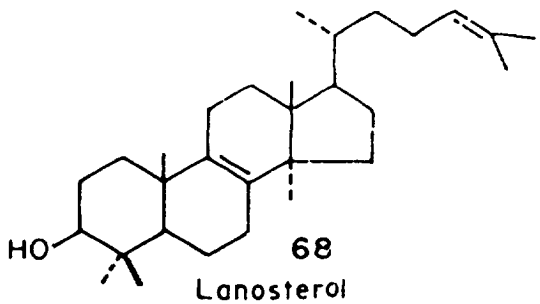
65
Ursane



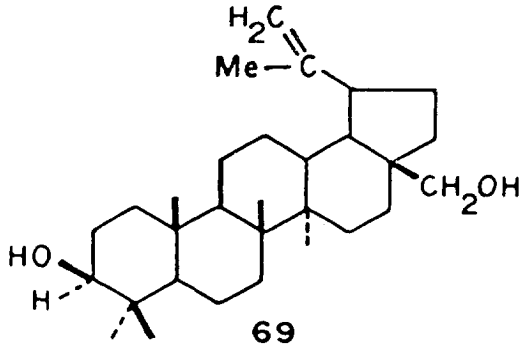
66
Bauerane



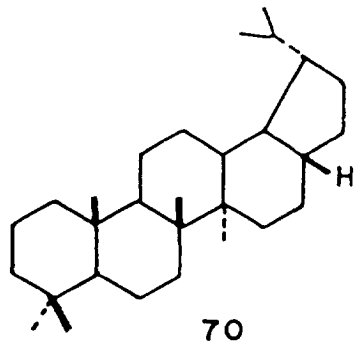
67
Manwuweizic acid



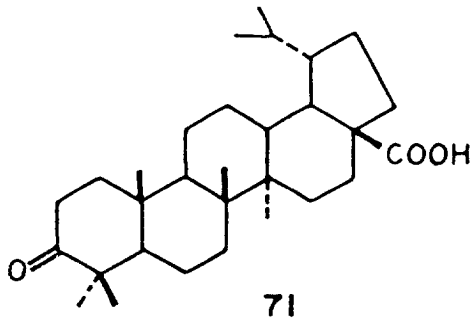
68
Lanosterol



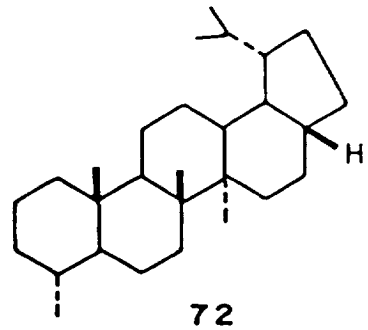
69
Betulin



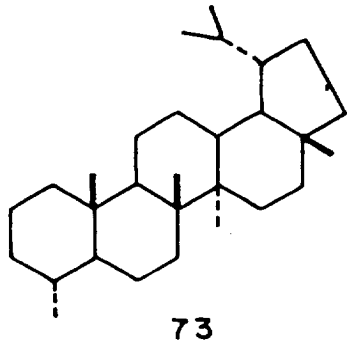
70
17β(H) 28-norlupane



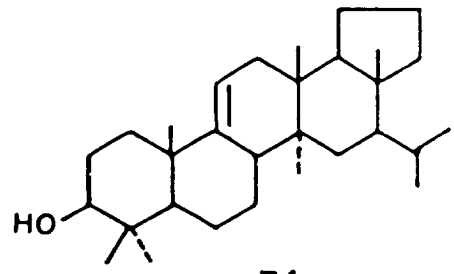
71
3-oxo-lupan-28-oic acid



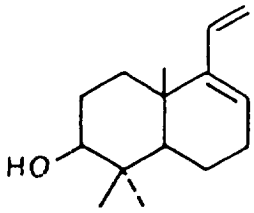
72
24,28-Bisnorlupane



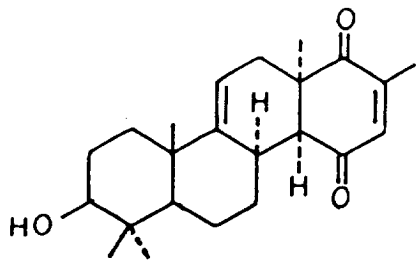
73
24-Norlupane



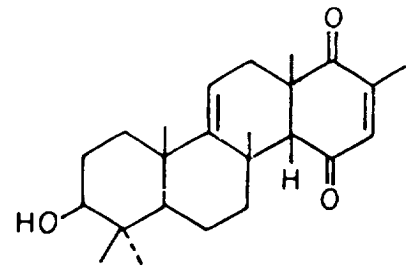
74
Isoarborneol



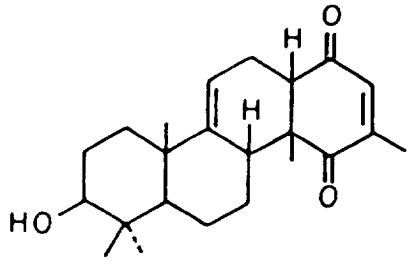
Bicyclic diene
75



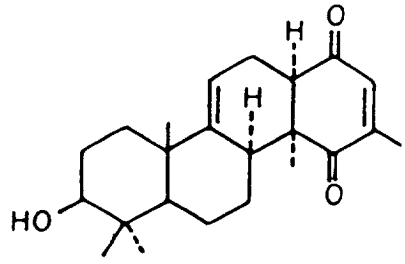
76



77

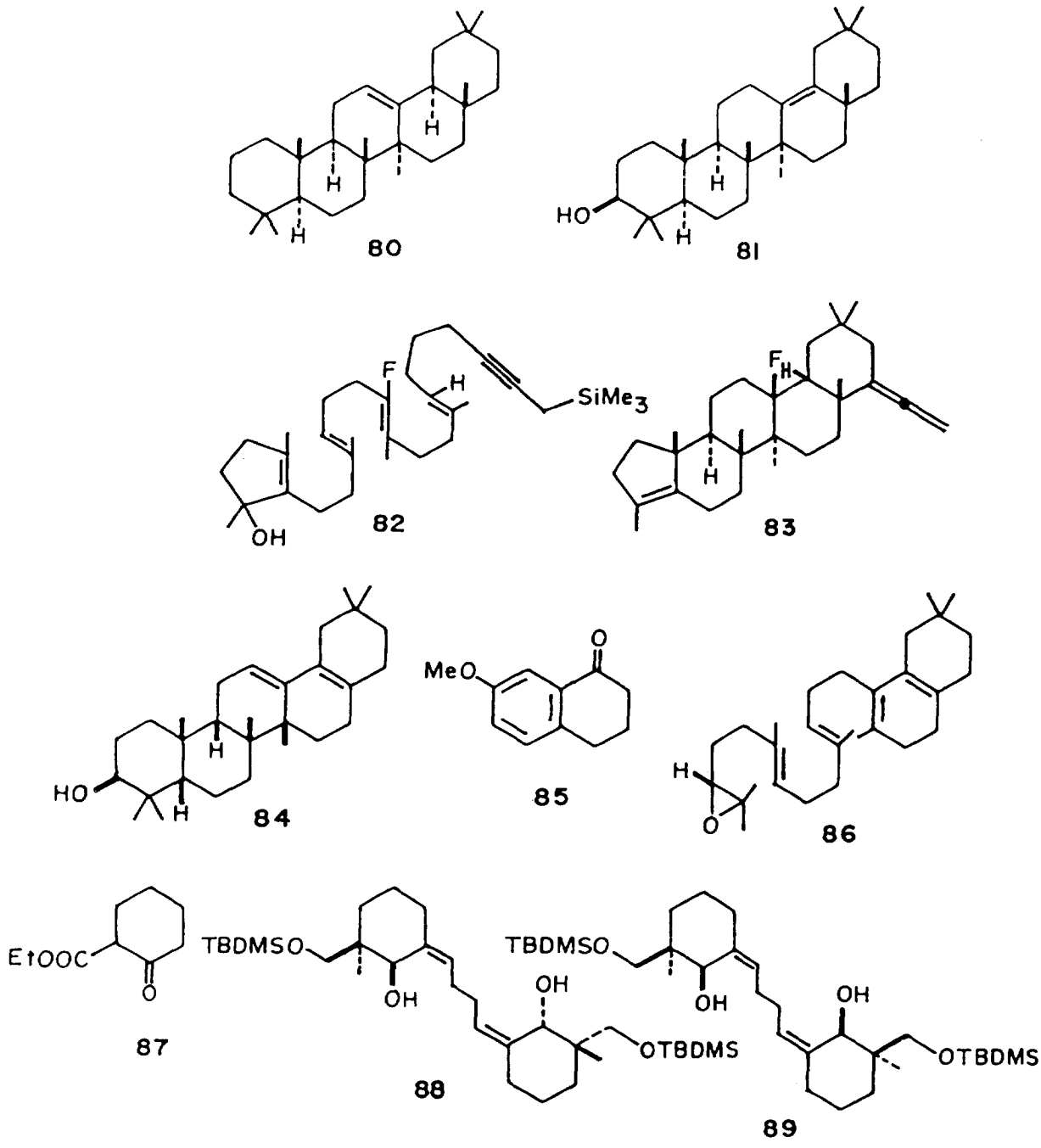


78



79

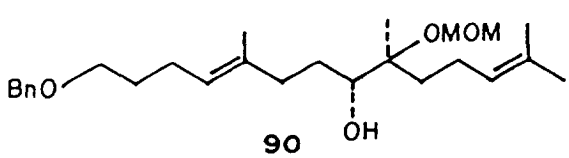
natural products. A single stereocentre in (**86**) was used to control the development of the remaining seven stereocentres of β-amyrin, erythrodiol and oleanolic acid, in a manner reminiscent of the biosynthesis of these compounds from (*S*)-2,3-oxidosqualene. Moreover, the synthesis included some reactions, e.g. a new use of CF_3SO_2O group for the deactivation of olefins toward electrophilic attack, the effectiveness of the chiral oxazaborolidine-catalysed reduction of ketones in a complex enantioselective synthesis, the selective free radical induced cleavage of cyclopropyl ring and a new method for the hydroxyl-



directed, stereocontrolled 1,4-reduction of a 1,3-diene, which should prove to be of considerable utility.

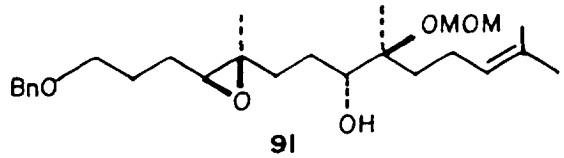
A total synthesis of both *meso*- and (±)-limatulone (**17**), a defensive triterpene metabolite of *Collesella limatula* was achieved by Mori *et al.* [58], starting from ethyl 2-oxo-cyclohexane-1-carboxylate (**87**). The key feature of this synthesis involves the separation of the *meso*-diol (**88**) and the (±)-diol (**89**).

Hashimoto *et al.* [59] reported the first total synthesis of teurilene (**22**), which they accomplished using two vanadium (V) catalysed oxidation–cyclization reactions with different stereoselectivities. The synthesis involved stereoselective and stepwise construction of 2,5-*cis* and 2,5-*trans*-tetrahydrofuran rings, vanadium (V)-catalysed oxidation of the 4-substituted 4-en-1-ol (**90**) and subsequent cyclization of the resulting *anti*-epoxy alcohol (**91**) and a similar oxidation–cyclization of the 5-substituted 4-en-1-ol (**92**), by way of the *syn*-epoxy alcohol (**93**). This was followed by construction of a third tetrahydrofuran ring, by more conventional means. An improved synthesis of (**22**), involving direct formation of bis(tetrahydrofuran) (**94**) from the squalene derivative (**95**), by simultaneous double oxidation–cyclization was also accomplished.



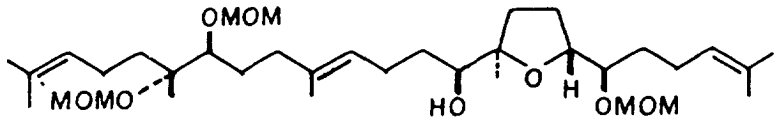
90

MOM = Methoxymethylether



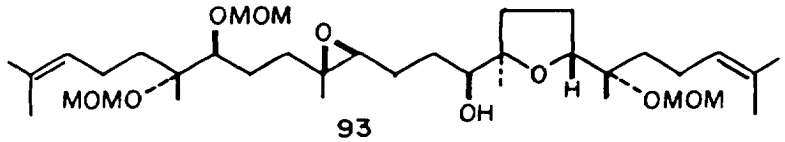
91

MOM = Methoxymethylether



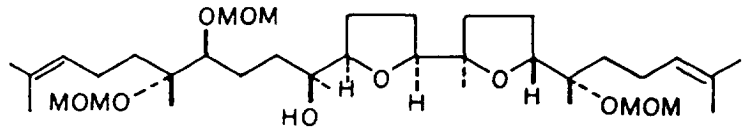
92

MOM = Methoxymethylether



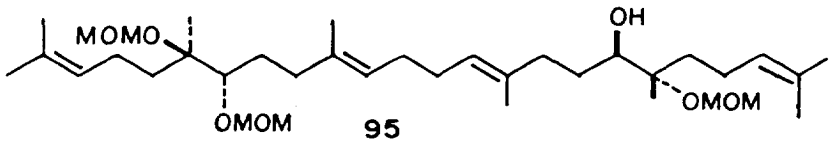
93

Syn epoxy alcohol MOM = Methoxy methyl ether



94

bis(tetrahydrofuran) MOM = Methoxy methyl ether



95

Squalene derivative MOM = Methoxy methyl ether

Glycinoeclepin A (**96**), a natural hatching stimulus for the soybean cyst nematode, has been isolated from the aqueous extract of the roots of *Phaseolus vulgaris* (Leguminosae) and its novel structure was elucidated by spectroscopic and X-ray crystallographic analyses [60]. Three groups of workers have reported its synthesis [61–64]. The synthesis by Corey and Houpis [63] has been claimed to be shorter and simpler, having the potential to provide adequate amounts of the compounds for further research. The significant steps in the synthesis include the enantioselective Michael reaction of **97** and **98** and conversions (**99**) → (**100**), (**100**) → (**101**), and (**102**) → (**103**). Moreover, it has been pointed out that the coupling reaction (**104**) + (**105**) → (**106**), which did not occur with Stille's conditions [Pd(O) reagent] is unusual, and probably occurs by replacement of Bu_3Sn in (**104**) by XPd and a subsequent Heck-type reaction.

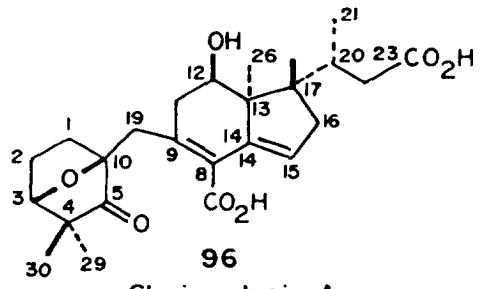
The synthesis of glycenoeclepin A (**96**) by Watanabe and Mori [64], consists of three key steps:

(i) Assymmetric reduction of the prochiral 1,3-diketones (**107**) and (**108**) with Baker's yeast to give the (*S*)-hydroxy ketones (**109**) and (**110**).
(ii) Stereoselective aldol condensation to introduce the C-12 and C-13 asymmetry (**111**), (**112**) → (**113**).
(iii) Reductive lactone cleavage and subsequent aldol condensation to construct the C,D ring system, (**114**) → (**96**).

The first total synthesis (±)-ambrein (**115**) has been accomplished by Mori and Tamura [65] in 0.38% overall yield from geranylacetone (**116**) through 22 steps or in 1.1% yield from (*S*)-3-hydroxy-2,2-dimethyl cyclohexanone (**109**) in 21 steps.

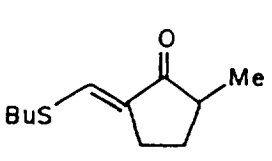
BIOSYNTHESIS

A comprehensive coverage of the biosynthesis of triterpenoids is beyond the scope of this presentation. An excellent review on the enzymic cyclization of squalene and oxidosqualene to sterols and triterpenes, has been published by Abe *et al.* [66], which covers the

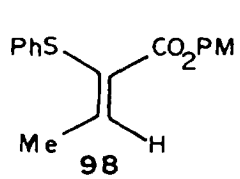


96

Glycinoedepin A

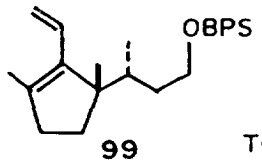


97



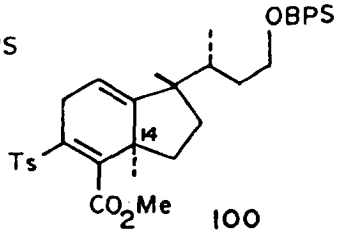
98

PM = Phenyl-menthol



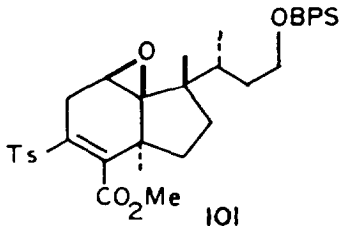
99

BPS = t-butyldiphenylsilyl chloride



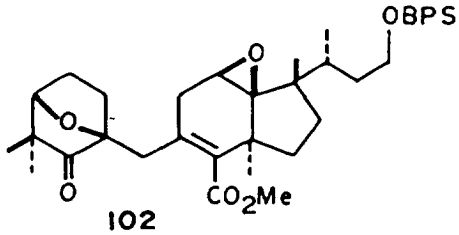
100

BPS = t-butyldiphenylsilyl chloride



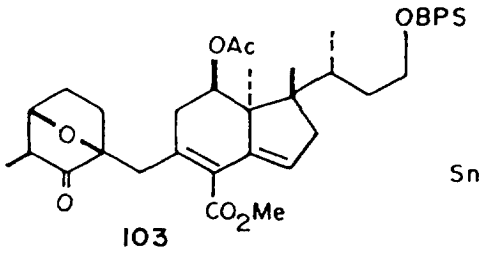
101

BPS = t-butyldiphenylsilyl chloride



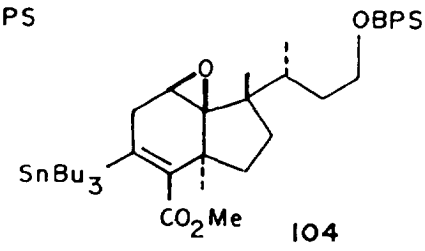
102

BPS = t-butyldiphenylsilyl chloride



103

BPS = t-butyldiphenylsilyl chloride



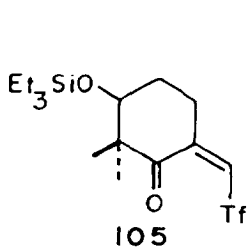
104

BPS = t-butyldiphenylsilyl chloride

literature concerning recent developments, especially those in the past five years in this area. However, some salient points regarding the formation of triterpenes are mentioned here.

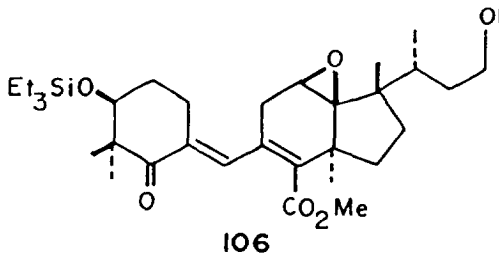
It is now accepted that lanosterol in animals and fungi and cycloartenol in plants are formed by the cyclization of (3*S*)-oxidosqualene, and that the cyclization is initiated by an acid catalyzed oxirane ring opening, with participation by a neighbouring π-bond. While the formation of either lanosterol or cycloartenol proceeds through a chair–boat–chair conformation of (3*S*)-oxidosqualene, cyclization to the pentacyclic triterpenes proceeds via a chair-chair-chair conformation of the substrate. Thus the cyclization first produces the tetracyclic dammarenyl C-20 cation, followed by a rearrangement leading to the pentacyclic β-amyrin or α-amyrin systems, via the baccharenyl, lupenyl and oleanyl cationic species (Scheme 1) [67]. Tetracyclic and pentacyclic triterpenoids generated from these cationic species are also formed in nature. The mechanism of formation of β-amyrin and α-amyrin were confirmed by the incorporation of [2-$^{13}C^2H_3$]- and [5-$^{13}C^2H_3$]-mevalonolactone into oleanolic and ursolic acids using cell suspension cultures of *Rabdistia japonica* and the β-deuterium isotope effect [68, 69].

Remarkable advances have been made in recent years in the study of squalene cyclase and oxidosqualene enzymes. However, Barton and his co-workers [70] reported in 1975 that eukaryotic oxidosqualene cyclases only accepted the (3*S*)- and not the (3*R*)-enantiomer of



105

Tf = Vinyl triflate



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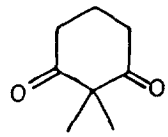
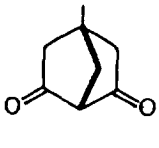
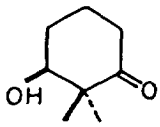


107

BPS = t-butyldiphenylsilyl chloride



108



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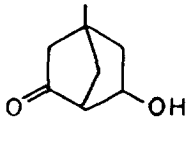

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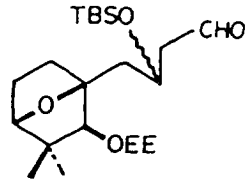
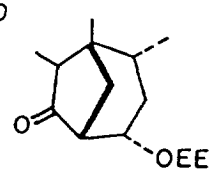


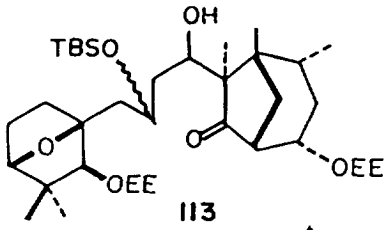
EE = CH(OEt)Me

111



EE = CH(OEt)Me

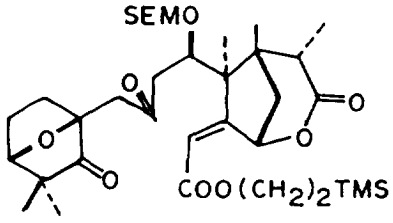
112



113

TBS = $SiMe_2Bu^t$

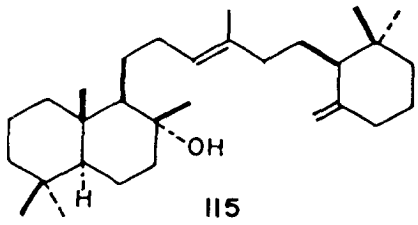
EE = CH(OEt)Me



114

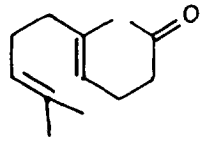
TMS = $SiMe_3$

SEM = $CH_2OCH_2CH_2SiMe_3$



115

Ambrein

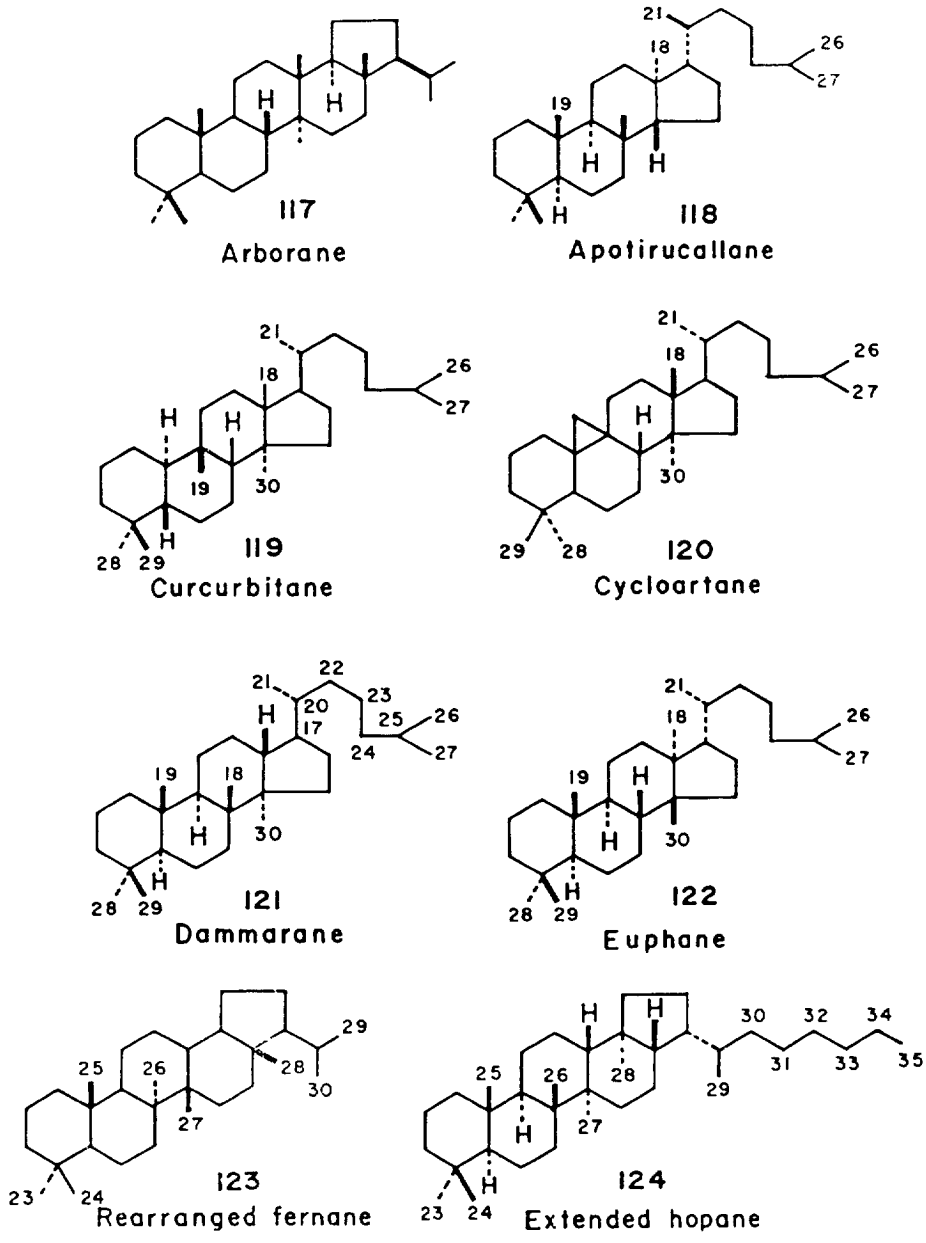


116

Geranylacetone

oxidosqualene as a substrate. Subsequent studies on the bacterial squalene cyclases have revealed that these enzymes display a very low substrate specificity [2, 71, 72]. They can cyclize the natural substrate squalene, as well as both enantiomers (3*S*- and 3*R*-), of oxidosqualene [73–75]. It has been proposed that the prokaryotic squalene cyclases already existed in the anaerobic period of evolution, and that cyclization of squalene via oxidosqualene is a relatively late evolutionary development, which could occur after the evolution of photosynthetic organisms [66, 76]. In protozoans or bacteria, the cyclization of squalene into tetrahymanol or diploptene/diplopterol proceeds without a carbon skeletal rearrangement. The cyclization into tetrahymanol is initiated by a proton attack on a terminal double bond and followed by the addition of H_2O at the resulting gammaceranyl C-21 cationic centre. In the case of hopanoid formation, the hopanyl C-22 carbocation with a five membered E-ring is formed, and then followed by either H-29 proton elimination or the addition of H_2O at the cationic centre yielding diploptene or diplopterol (Scheme 2) (76).

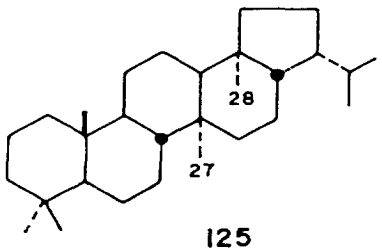
According to the biogenetic isoprene rule of Ruzicka,



the cyclization of all-*trans* squalene proceeds via a well-defined sequence of prechair and preboat conformations. It was proposed that the transformation takes place according to the rules of antiperiplanar cationic 1,2-addition, 1,2-rearrangement and 1,2-elimination, the entire process being a concerted one [77, 78]. According to the proposition of van Tamelen [79], a single transition state for a complex polycyclization is less likely, and the cyclization proceeds through a series of discrete conformationally rigid, partially cyclized carbocationic intermediates. Several monocyclic and bicyclic triterpenes, which are thought to be partially cyclized intermediates, have been isolated from nature [10, 80, 81]. The isolation of these triterpenoids supports the above postulate of van Tamelen.

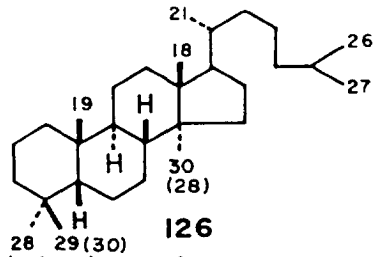
BIOLOGICAL ACTIVITY

Triterpenes of diverse structural types are widely distributed in prokaryotes, as well as eukaryotes. Some plants contain large quantities of triterpenes in their latex and resins and the physiological function of these compounds is generally believed to be a chemical defence against pathogens and herbivores. It is expected, therefore, that triterpenes should act against certain pathogens causing human and animal diseases. However, application of triterpenes as successful therapeutic agents is limited thus far. Perhaps this may primarily be ascribed to the hydrophobic nature of most of the compounds. The recent development in the techniques of solubilization of drugs are likely to overcome this problem and the widespread reports



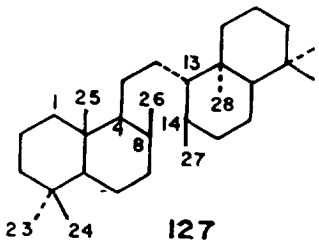
125

C(14a)-Homo-26nor-17α-hopane



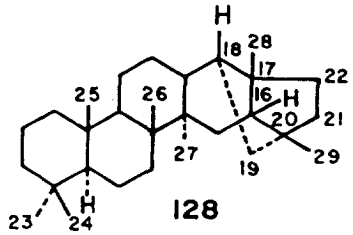
126

Lanostane



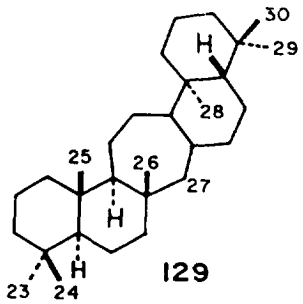
127

Onocerane



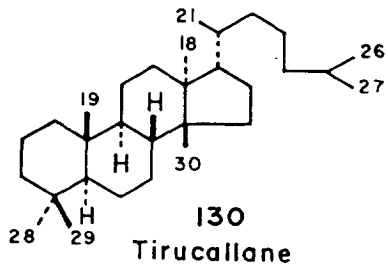
128

Pfaffane



129

Serratane



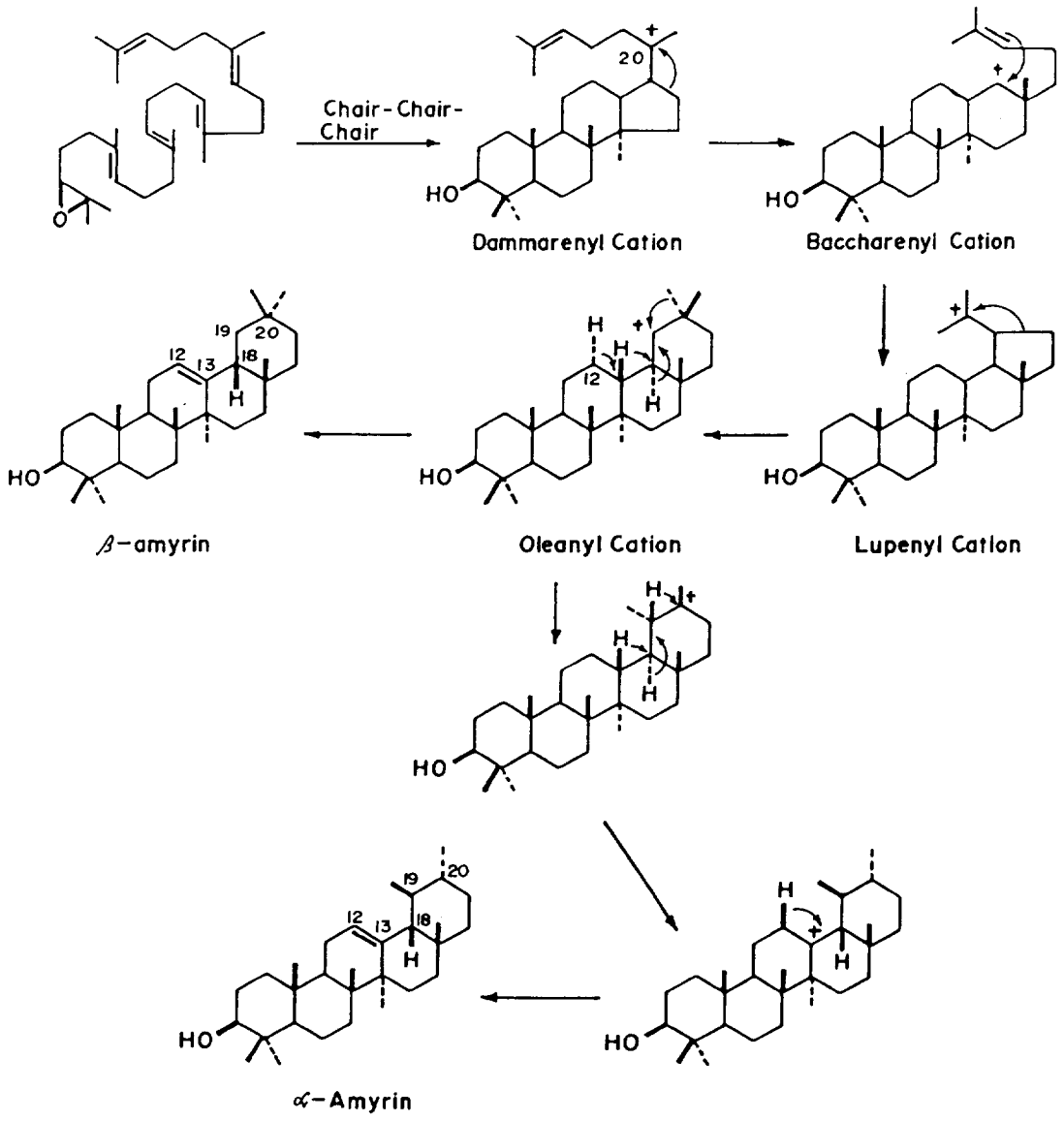
130

Tirucallane

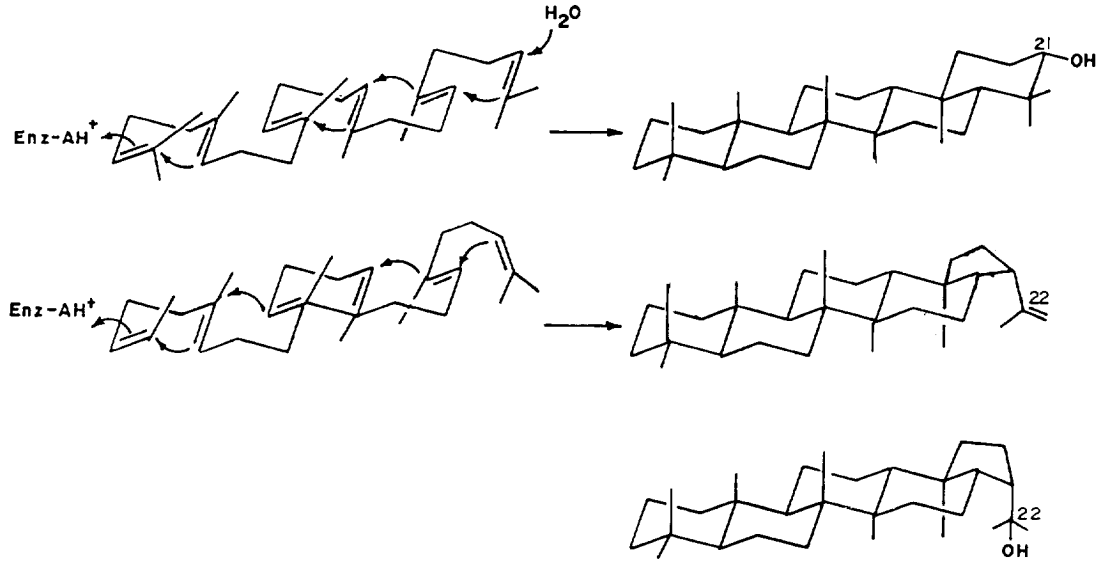
in recent years on useful biological activities of triterpenes, indicate their varied potential.

Antitumour and anticancer activity

The well-known pentacyclic triterpenoid, ursolic acid was previously reported to be cytotoxic against A-549, L-1210 and KB tumour cells [82]. In a recent report it was found to inhibit tumour promotion in mouse skin [83]. 23-Hydroxy-3-oxo-urs-12-en-28-oic acid was found to exhibit antiulcer properties [84]. 3-Oxofriedelan-29-oic acid, 3-oxofriedelan-28-oic acid and 28,29-dihydroxyfriedelan-3-one exhibited cytotoxicity against A-549 lung carcinoma cells with ED_{50} values of 0.21, 1.18 and 0.64 μg/ml, respectively. 3-Oxo-friedelan-28-oic acid was also cytotoxic against both L-1210 (ED_{50} = 2.95 μg/ml) and KB (ED_{50} = 3.7 μg/ml) tumour cells [85]. A patent has been issued [86] on the triterpene acid, 3β-methyl-lanosta-8,24(25)-dien-30-oic acid as an antitumour agent isolated from homogenized penares. Carcinogenesis promoter inhibitors containing Me-3α-methoxy-23-oxo-9β-lanost-7-en-27-oate, 25,26,27-trisnor-23*R*-hydroxy-3α-methoxy-9β-lanost-7-en-24-oic acid, 3,23-dioxo-9β-lanost-7-en-27-oic acid, olean-12-ene-3β, 15α-diol and (3*S*,7*S*)-dihydroxy-7(8 → 9)abeo-9*S*-D:C friedo-B:A neogammaceran-8-one as active ingredients were claimed in a patent [87]. A novel ring A seco triterpene, koetjapic acid and katonic acid isolated from *Sandoricum koetjape* demonstrated significant cyctotoxic activity against cultured P-388 cells (ED_{50}, 0.61 and 0.11 μg/ml, respectively) [88]. Four tetracyclic triterpene acids, applanoxidic acid A–D, isolated from the fungus *Ganoderma applanatum* (Polyporaceae) were reported to have antitumour activity [89]. Manwuweizic acid from *Schisandra propinqua* (Schisandraceae) showed significant inhibitory activity against Lewis lung cancer, brain tumour-22 and solid hepatoma in mice, but no cytotoxic action *in vitro* [48]. Betulinic acid (5 μmol) markedly inhibited the promoting effect of 2.50 μg TPA initiated with 50 μg 7,12-dimethylbenz[*a*]anthracene [90]. The cycloartanoid triterpene 3-oxo-24-cycloartin-21-oic acid isolated from leaves of *Lansium domesticum* (Meliaceae) and some of its derivatives, showed significant inhibitory activity of skin-tumour promotion on the basis of Epstein–Barr virus associated early antigen (EBV-



Scheme 1.



Scheme 2.

EA) examination [91]. A new dammarane triterpene elabunin (see table), showed moderate cytotoxic activity (ED_{50} 1 μg/ml) against L-1210 leukaemic cells [92]. Six isomalabaricane type stilleferins A–F were found to exhibit potent antineoplastic activities against murine leukaemia L-1210 cells (IC_{50} 0.57 ~ 2.1μg/ml) and human epidermoid carcinoma KB cells (IC_{50} 1.4 ~ 6.0 μg/ml) *in vitro* [25]. Abiesenonic acid methyl ester, a triterpenoid compound prepared from abieslactone, suppressed tumour promoter-induced phenomena *in vitro* and *in vivo*. The methyl ester inhibited TPA stimulated ^{32}Pi-incorporation into phospholipids of cultured cells and the promoting action of TPA on skin tumour formation in mice initiated with 7,12-dimethylbenz[*a*]anthracene [93].

Antiinflammatory activity

A new pentacyclic triterpene 2α,3β,23-trihydroxyolean-12-ene was tested orally for possible antiinflammatory and analgesic activity. It was found to have a 28% inhibition at 100 mg/kg of phlogistic response in rat. At the same dose, this compound caused a 37% inhibition of the writhing response in the rat (aspirin, the reference compound shows 85% inhibition at 100 mg/kg) [94]. the $CHCl_3$ extract of the defatted seeds of *Vitex negundo* (Verbenaceae) containing 3β-acetoxyolean-12-en-27-oic acid, 2α,3α-dihydroxyolean-5,12-dien-28-oic acid, 2β,3α-diacetoxyolean-5,12-dien-28-oic acid and 2α,3β-diacetoxy-18-hydroxy-olean-5,12-dien-28-oic acid exhibited antiinflammatory activity [95]. Antiinflammatory activity was found to be exhibited by taraxasterol acetate [96]. Moretenol acetate, moretenol and neulupanol were reported to exhibit antiinflammatory activity [97].

Antiviral/antibacterial activity

Salaspermic acid isolated from *Triterygium wilfordii* (Celastraceae) has been reported [98] to have an inhibitory effect against HIV-1 recombinant reverse transcriptase-associated reverse transcriptase activity. This compound also exhibited an inhibitory effect against HIV-1 reverse transcriptase-associated DNA polymerase activity. On the other hand, salaspermic acid showed no inhibitory effect on the HIV-reverse transcriptase-associated RNAase H-activity, when tested at a concentration of 100 μg/ml with poly(dT).[3H]poly(rA) as substrate. The behaviour of the salaspermic acid was also tested against HIV-2 recombinant reverse-transcriptase-associated reverse transcriptase activity, but the degree of inhibition appeared to be lower (EC_{50} = 100 μg/ml with poly (rC).oligo(dC) as a template-primer). Structure activity correlations indicated that the acetal linkage in ring A and carboxyl group in ring E may be required for the anti-HIV activity [98]. Suberosol, a new C_{31} lanostane type triterpene isolated from *Pollyalthia subarosa* (Annonaceae), inhibited HIV replication in H9 lymphocyte cells with an ED_{50} value of 3 μg/ml, while it inhibited uninfected H9 cell growth with an IC_{50} value of 20 μg/ml [99]. Epilupeol and epilupeol acetate exhibited pronounced antiviral activity against Ranikhet disease virus in chick embryos [100]. Viruses in blood products for transfusion were inactivated by glyclyrrhizic triterpenes and a synergistic amount of compounds such as AZT, dextran, BHT, fatty acids, glycerols or EDTA [101]. Glycyrrhizic triterpenoids in combination with albumin, are used in the treatment of blood products to inactivate or destroy infective viruses found in animal fluids and tissues such as cytomegalovirus. The effectiveness of triterpenoids in killing or inactivating virus was verified in fetal bovine serum, where additions of glycyrrhetinic acid at concentrations of 0.05–0.7%, followed by adjustment to pH 6.5 and 7.4, respectively, for various trials, established a 100% killing of the relatively resistant vesicular stomatitis virus [102].

Miscellaneous

An anticholesteremic triterpene 12(*R*)-acetoxy-3-oxo-24(*Z*)-lanosta-9(11), 24-dien-26-oic acid was isolated from stems of *Kadsura heteroclita* (Leguminoseae). This compound at a concentration of 25 μg/ml, showed 29% inhibition of cholesterol synthesis from ^{14}C mevalonic acid in a mice liver homogenate [103]. (24*Z*)-3-oxo-14(13 → 12) abeo-lanosta-8(9),13(17),24-trien-27-oic acid, showed 12% inhibition of cholesterol synthesis in an *in vitro* study using rat liver homogenate at a concentration of 25 μg/ml [104]. Boehmeryl acetate extracted from *Ipomoea batatas* (Convolvulaceae) appeared to act as an ovipositional stimulant for the sweet potato weevil, *Cylas formicarius elegantulus* [105]. Eighteen compounds within the diterpene and triterpene families were isolated from the metabolites produced by plant cell culture line of the Chinese herbal plant *Tripterygium wilfordii* (Celastraceae). The interest for these compounds was in the treatment of rheumatoid arthritis, skin allergies and for male contraception [106]. Differentiation inducing activity of over 180 extracts of crude drugs and plants was tested using a mouse myeloid leukaemia cell line (MI). The methanolic extract of clove showed remarkable induction of differentiation of MI cells into macrophage-like cells. From the extracts, oleanolic acid and crategolic acid were isolated as the active compounds. Other triterpenes, such as oleananes, ursanes and dammaranes were also tested to investigate the structure activity relationships. Some triterpene aglycones showed differentiation inducing activity, but triterpene glycosides showed little activity. Furthermore, the differentiation inducing activity of these triterpene compounds was also tested against human acute promyelocytic leukaemia cell line (HL-60) [107].

A compilation of the triterpenoids isolated during the period 1990–1994 along with their occurrence, available physical data, spectroscopy and X-ray analysis used for their characterization, is given in the table. The triterpenoids have been arranged by skeleton and the sources from which these have been isolated are listed alphabetically.

Table 1. Composition of triterpenoids isolated during 1990–1994

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Structure No.	References
	Triterpenoids with novel skeleta		
Achillea odorata (Compositae)	Achilleol A, −10.9°, IR, ^1H, ^{13}C, MS, 426 $[M]^+$	**1**	[10]
Achillea odorata (Compositae)	Achilleol B, −8.1°, IR, ^1H, ^{13}C, MS, 526.3870 $[M]^+$	**2**	[11]
Axinella weltneri (Indo Pacific sponge)	Sodwanone A, 253°, −9°, IR, ^1H, ^{13}C, EIMS, X-ray, 500 $[M]^+$	**41**	[36, 37]
	Sodwanone B, −6°, IR, ^1H, ^{13}C, 2D, EIMS, 484 $[M]^+$	**42**	[36, 37]
	Sodwanone C, −35°, IR, ^1H, ^{13}C, 2D, EIMS, 454 $[M]^+$	**43**	[36, 37]
	Sodwanone D, +19°, IR, ^{13}C, EIMS, 2D, 488 $[M]^+$	**44**	[36, 37]
	Sodwanone E, +3°, ^1H, ^{13}C, HREIMS, 2D, 490 $[M]^+$	**45**	[36, 37]
	Sodwanone F, −4°, ^1H, ^{13}C, CIMS, 2D, 506 $[M]^+$	**46**	[36, 37]
Buxus papillosa (Buxaceae)	Buxapentalactone, IR, ^1H, ^{13}C, 2D, HREIMS, X-ray, 362 $[M]^+$	**33**	[30]
	Buxaheptalactone, UV, IR, ^1H, ^{13}C, HREIMS, 344 $[M]^+$	**34**	[30]
Coleus forskohlii (Labiatae)	Coleanolic acid, 245°, ^1H, ^{13}C, 2D, MS, 470 $[M]^+$	**32**	[29]
Euphorbia mellifera (Euphorbiaceae)	D-Friedomadeir-14-en-3-one, 177–179°, +27.5°, IR, ^1H, ^{13}C, X-ray, 424 $[M]^+$	**11**	[18]
	D-Friedomadier-14-en-3β-ol, 250–250.5°, +27.2°, ^1H, ^{13}C, MS, X-ray, 426 $[M]^+$	**12**	[18]
	D:C-Friedo-7-en-3-one, 201.5–202°, −19.8°, IR, ^1H, ^{13}C, X-ray, 424 $[M]^+$	**13**	[18]
	D:C-Friedo-7-en-3β-ol, 228–229°, −32.7°, IR, ^1H, ^{13}C, MS, X-ray, 426 $[M]^+$	**14**	[18]
Eurycoma longifolia (Simaroubaceae)	Eurylene, 146–148°, +4.32°, ^1H, ^{13}C, X-ray, 594 $[M]^+$	**20**	[22]
	Longilene peroxide, 142–143°, −23.0°, ^1H, ^{13}C, MS, X-ray, 488 $[M]^+$	**21**	[23]
Hyptis suaveolenes (Labiatae)	Hyptadienoic acid, 208–210°, 17.0°, IR, ^1H, ^{13}C, MS, 470 $[M]^-$	**32**	[28]
Jaspis stellifera (Okinowan marine sponge)	Stilliferin A, −126.6°, UV, IR, ^1H, ^{13}C, 2D, EIMS, 496 $[M]^-$	**23**	[25]
	Stilliferin B, −166.0°, UV, ^1H, ^{13}C, 496 $[M]^+$	**24**	[25]
	Stilliferin C, −15.2°, IR ^1H, ^{13}C, HREIMS, 494 $[M]^+$	**25**	[25]
	Stilliferin D, +201°, ^1H, ^{13}C, HREIMS, 438 $[M]^+$	**26**	[25]
	Stilliferin E, −409°, IR, ^1H, ^{13}C, 554 $[M]^+$	**27**	[25]
	Stilliferin F, −377°, IR, ^1H, ^{13}C, 554 $[M]^+$	**28**	[25]
Laurencea obtus (Companulaceae)	Teurilene, 84–85°, 0°, IR, ^1H, ^{13}C, X-ray, 492 $[M]^+$	**22**	[24]
Mimusops elengi (Sapotaceae)	Mimusopic acid, 292–294°, +48.57°, IR, ^1H, ^{13}C, EIMS, 486 $[M]^+$	**35**	[31]
	Mimusopsic acid, 234–236°, +20.0°, UV, ^1H, methyl ester, ^{13}C, FABMS, 484 $[M]^+$	**36**	[31]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Structure no. or groups	References
Pacific sponge	Naural A, 97°, +6.21°, UV, IR, ^1H, ^{13}C, FABMS, LRMS, 314.1 $[M]^+$	**15**	[19]
	Naural B, +12.63°, UV, IR, ^1H, ^{13}C, FABMS, 314 $[M]^+$	**16**	[19]
Peroskia abrotanoide (Labiatae)	Pervskone, 192°, +94.0°, UV, IR, ^1H, ^{13}C, MS, X-ray, 450 $[M]^+$	**18**	[21]
Polypodiodes formosana (Polypodiaceae)	+2.5°, IR, ^1H, ^{13}C, EIMS, 428 $[M]^+$	6α-OH,Δ^{21} Achilleol A	[108]
Polypodiodes niponica (Polypodiaceae)	Aonena-3,21-diene, 89–91°, +8.9°, IR, ^1H, EIMS, 410 $[M]^+$	**29**	[27]
	Podioda-7,17,21-triene, −11.5°, ^1H, EIMS, 410 $[M]^+$	**30**	[27]
	Podioda-8,17,21-triene, +11.7°, ^1H, EIMS, 410 $[M]^+$	**31**	[27]
Pseudolarix kaempferi (Pinaceae)	Pseudolarolide A, 466, $[M]^+$	**5**	[12, 13]
	Pseudolarolide D, 482, $[M]^-$	**6**	[12, 13]
	Pseudolarolide E, 209–211°, +2.5°, IR, UV, ^1H, ^{13}C, X-ray, 498 $[M]^+$	**3**	[12]
	Pseudobrolide H, 221.0°, UV, ^1H, ^{13}C, X-ray, 514 $[M]^-$	**4**	[13]
Raspaciona aculeata (Mediterranean sponge)	Raspacionin, 188–189°, 31.4°, IR, ^1H, ^{13}C, 2D, MS, 458 $[M]^+$	**7**	[14]
	−49.1°, IR, ^1H, ^{13}C, HREIMS, CD, 474.3698 $[M]^+$	21-deacetyl, Raspacionin	[376]
	−27.7°, IR, ^1H, ^{13}C, EIMS, CD, 474.3709 $[M]^+$	10-OAc, 21-deacetyl, 28-OH, Raspacionin	[376]
	−38.5°, ^1H, ^{13}C, EIMS, HREIMS, CD, 514.3658 $[M]^-$	10-OAc, 21-deacetyl, 4-oxo, 28-OH, Raspacionin	[376]
	−9.5°, IR, ^1H, ^{13}C, 2D, EIMS, CD, 472.3552 $[M]^+$	10-OAc, 12,15-dideacetyl, 4-oxo, 28-OH, Raspacionin	[376]
	−5.9°, ^1H, ^{13}C, EIMS, HREIMS, CD, 488.3501 $[M]^+$	10-OH, 4,21-dioxo, 28-OH, Raspacionin	[376]
	−18.2°, ^1H, ^{13}C, EIMS, HREIMS, CD, 532.3764 $[M]^+$	10-OAc, 15-deacetyl, 4-oxo, 28-OH, Raspacionin	[376]
	−35.1°, IR, ^1H, ^{13}C, EIMS, CD, 516.3814 $[M]^+$	4,10-di-OAc, 15-deacetyl, 28-OH, Raspacionin	[376]
	−36.1°, ^1H, ^{13}C, EIMS, CD, 488.3501 $[M]^+$	10-OAc, 15-deacetyl, 4,21-di-oxo, 28-OH, Raspacionin	[376]
Ruptiliocarpon caracolitone (Lepidobotryaceae)	Spirocaracolitone, 215–218°, +39.34°, IR, ^1H, ^{13}C, FABMS, X-ray, 774.4 $[M]^+$	**40**	[35]
Swertia chirata (Gentianaceae)	Chiratenol, 237–238°, +68.7°, ^1H, ^{13}C, 2D, MS, 426 $[M]^+$	**37**	[32]
	Kairatenol, 247–248°, +8.1°, ^1H, ^{13}C, MS, 426.3866 $[M]^+$	**38**	[38]
Trichocereus pachanoi (Cactaceae)	Pachanol, >300°, +80.0°, IR, UV, ^1H, ^{13}C, 2D, EIMS, X-ray, 468.3241 $[M]^+$	**39**	[34]
	Triterpenoids with known skeleta		
	Arborane (**117**)		
Rubia cordifolia R. oncotricha (Rubiaceae)	Rubiarbonal A, ^1H, ^{13}C, 2D, 484 $[M]^+$	3β,7β,19α,28-tetra-OH	[109]
	Rubiarbonal B, ^1H, ^{13}C, 2D, 468 $[M]^+$	3β,7β,19α-tri-OH, $\Delta^{9(11)}$	[109]
	Rubiarbonol C, ^1H, ^{13}C, 2D, 526 $[M]^+$	2α-OAc, 3β,7β,19α-tri-OH, $\Delta^{9(11)}$	[109]
	Rubiarbonol D, ^1H, ^{13}C, 2D, 526 $[M]^+$	2α,7β,19α-tri-OH, 3β-OAc, $\Delta^{9(11)}$	[109]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Rubiarbonol E, ^1H, ^{13}C, 2D, 484 $[M]^+$	2α,3β,7β,19α-tetra-OH, $\Delta^{9(11)}$	[109]
	Rubiarbonol F, ^1H, ^{13}C, 2D, 500 $[M]^+$	2α,3β,7β,19α,28-penta-OH, $\Delta^{9(11)}$	[109]
Rubia yunnanensis (Rubiaceae)	Rubiarbornol C, 526 $[M]^+$	3β,7β,28-tri-OH, 19α-OAc, $\Delta^{9(11)}$	[110]
	Rubiarborane A, 524 $[M]^+$	3-oxo, 7β,28-di-OH, 19α-OAc, $\Delta^{9(11)}$	[110]
	Apotirucallane (**118**)		
Dysoxylum roseum (Meliaceae)	Dysorone A, −59.0°, IR, UV, ^1H HREIMS, 468 $[M]^+$	3,7-di-oxo, 29-OH, 21,23-epoxy, $\Delta^{14,24}$	[111]
	Dysorone B, −53.0°, IR, ^1H, ^{13}C, HREIMS, 470 $[M]^-$	3-oxo, 21,23-epoxy, $\Delta^{21,23}$	[111]
	Dysorone C, 149–151°, −44.0°, IR, UV, ^1H, ^{13}C, HREIMS, 470 $[M]^+$	3,7-di-oxo, 21,23-epoxy, $\Delta^{1,14,24}$	[111]
	Dysorone D, −34.0°, IR, ^1H, ^{13}C, EIMS, 452 $[M]^+$	3-oxo, 7α-OH, 21,23-epoxy, $\Delta^{1,14,24}$	[111]
	Dysorone E, 98–100°, −58.5°, UV, IR, ^{13}C, HREIMS, 466 $[M]^+$	3,7-di-oxo, 29-OH, 21,23-epoxy, $\Delta^{1,14,24}$	[111]
	Cucurbitane (**119**)		
Cowania mexicana (Cowaniaceae)	^1H, ^{13}C, 2D, 426 $[M]^+$	15-oxo, 23,24-di-OH	[112]
Momordica charantia (Cucurbitaceae)	+58.0°, IR, ^1H, ^{13}C, 2D, EIMS, 472.3519 $[M]^+$	3β,7β,25-tri-OH, 19-CHO, $\Delta^{5,23}$	[113]
	+48.9°, IR ^1H, ^{13}C, EIMS, 486.3615 $[M]^+$	3β,7β,25-tri-OH, 19-CO_2Me, $\Delta^{5,23}$	[113]
Russulia rosacea (Scrophulariaceae)	458 $[M]^-$	3α,29-di-OH, 27-CO_2H, $\Delta^{5,24}$	[114]
Trichosanthus kirilowii (Cucurbitaceae)	158–160°, UV, IR, ^1H, ^{13}C, MS, 440 $[M]^+$	3β-OH, 7-oxo, $\Delta^{5,24}$	[115]
Wilbrandia ebracteata (Cucurbitaceae)	156–157°, IR, ^1H, ^{13}C, MS, 486 $[M]^+$	2β,3β,20β-tri-OH, 11-oxo, 16α,23α-epoxy, $\Delta^{5,24}$	[116]
	145–146°, IR, ^1H, ^{13}C, MS, 486 $[M]^+$	2β,3β,20β-tri-OH, 11-oxo, 16α,23α-epoxy, $\Delta^{5,24}$	[116]
	168–171°, IR, ^1H, ^{13}C, FABMS, 527 $[M]^+$	2β,3β,6α,20,25-penta-OH, 11-oxo, $\Delta^{5,23}$	[116]
	Cycloartane (**120**)		
Abies marocana (Pinaceae)	165–167°, +27.2°, IR, UV, MS, 456 $[M]^+$	3α-OH,26 → 23 lactone,	[117]
	179–180°, +27.78°, IR, UV, MS, 454 $[M]^+$	3α-OH,26 → 23 lactone Δ^{24}	[117]
Amberboa ramosa (Compositae)	180–181°, +20.6°, IR, ^1H, ^{13}C, HREIMS, 442.3824 $[M]^+$	3β,22-di-OH, 22*R*, Δ^{25}	[118]
	169–170°, −18.0°, IR, MS, 442.3866 $[M]^+$	3β,25-di-OH, Δ^{20}	[118]
Artemesia argyi (Compositae)	472 $[M]^+$	3β-OMe, 25,26-di-OH, $\Delta^{19,23}$	[119]
Artocarpus heterophyllus (Moraceae)	142–144°, +17.0°, ^1H, ^{13}C, 458 $[M]^-$	3-oxo, 24,25-di-OH, (24*R*)	[120]
	142–144°, +17.0°, ^1H, ^{13}C, 458 $[M]^+$	3-oxo, 24,25-di-OH, (24*S*)	[120]
Artocarpus integrifolia (Moraceae)	IR, ^1H, ^{13}C, EIMS, 444 $[M]^+$	23β,25-di-OH, Δ^{23}	[121]
	IR, ^1H, ^{13}C, EIMS, 444 $[M]^-$	3β,24-di-OH, Δ^{25}	[121]
Arundia bambusifolia (Arundinaceae)	Arundinol, 245°, +3.52°, IR ^1H, ^{13}C, MS, 580 $[M]^+$	3β-(*p*-hydroxy-*trans*-cinnamoyloxy), Δ^{24}	[122]
Astragalus adsurgens (Leguminosae)	458 $[M]^+$	(20*R*), (24*S*), 6α,25-di-OH, 3,16-di-oxo, 20,24-epoxy	[123]
	460 $[M]^-$	(20*R*), (24*S*), 3,16-di-oxo, 6α,25-di-OH, 20,24-epoxy	[123]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Astragalus orbiculatus (Leguminosae)	474 $[M]^+$	3β,6α,7β,25-tetra-OH, 16β,23:16α, 24-di-epoxy	[124]
Buxus papillosa (Buxaceae)	Buxatenone, −11.0°, ^1H, ^{13}C, 2D, MS, 326.2245 $[M]^+$	3,17-di-oxo, Δ^1	[125]
	11α-Hydroxy buxatinone, −18.0°, UV, IR, ^1H, ^{13}C, HREIMS, 342.2199 $[M]^+$	11α-OH, 4,4,14-tri-OMe, 3,17-di-oxo, 5α, Δ^1	[126]
	Buxahejrine, +15.0°, UV, IR, ^1H, ^{13}C, EIMS, 374 $[M]^+$	4-OH, 4,14-di-OMe, 17-oxo, 9 (10 → 19) abeo, 3,4-seco, 3-oate, 5α, $\Delta^{1(10),9(11)}$	[126]
Cimicifugae heracleifolise (Ranuncerlaceae)	24-*Epi*-7,8-didehydrocimigenol, 222–223°, +6.36°, IR, ^1H, ^{13}C, 2D, EIMS, 486 $[M]^+$	3β,15α,25-tri-OH, 16β, 23:16α,24-di-epoxy, Δ^7, (23*R*), (24*R*)	[127]
	7,8-Didehydro-cimigenol, IR, ^1H, ^{13}C, MS, 486 $[M]^+$	3β,15α,25-tri-OH, 16β, 23:16α,24-di-epoxy, Δ^7, (23*R*), (24*S*)	[127]
	25-*O*-Acetyl-7,8-didehydrocimigenol, ^1H, ^{13}C, MS, 528 $[M]^+$	3β-OAc, 15α,25-di-OH, 16β,23:16α,24-di-epoxy, Δ^7, (23*R*), (24*S*)	[127]
	3-Keto-24-*epi*-7,8-didehydrocimigenol, 225–226°, −12.4°, IR, ^1H, ^{13}C, MS, 484.67 $[M]^+$	3-oxo, 15α,25-di-OH, 16β,23:16α,24-di-epoxy, Δ^7, (23*R*), (24*R*)	[127]
	24-*Epi*-acerinol, 230–231°, +59.23°, IR, ^1H, ^{13}C, MS, 486 $[M]^+$	15α,25-di-OH, 3,10:16β, 23:16α,24-tri-epoxy, 9,10-seco, Δ^8, (23*R*), (24*R*)	[127]
	Heracleifolinol, 238–239°, IR, ^1H, ^{13}C, MS, 546 $[M]^-$	15α,16α,25-tri-OH, 3,10:16,23-di-epoxy, 9,10-seco, Δ^8	[127]
Curculigo orchioides (Hypoxidaceae)	2D, MS, 474 $[M]^+$	3β,11α,16β-tri-OH, 24-oxo	[128]
	Curculigenin A 140–111°, +18.8°, 2D, MS, 474.37 $[M]^+$	3β,11α,16β-tri-OH, 24-oxo	[129]
	Curculigenin C 108–111°, +78.3°, ^1H, ^{13}C, 2D, EIMS, 458 $[M]^-$	3β,11α,16β-tri-OH, Δ^{24}	[130]
	Curculigenin B, 119–122°, +145.0°, ^1H, ^{13}C, 2D, MS, 476 $[M]^+$	3β,11α,16β,24α-tetra-OH	[130]
Desmos cochinchinensis (Annonaceae)	Desmosinol, 440 $[M]^+$	3β,21-dia-OH, $\Delta^{22,24}$	[131]
Euphorbia caducifolia (Euphorbiaceae)	96–98°, UV, IR ,^1H, ^{13}C, ORD, 440.6942 $[M]^+$	3β-OH, 24-Et, 31-nor, Δ^{20}	[132]
Euphorbia soongarica (Euphorbiaceae)	86–87°, 484 $[M]^-$	3β-OH, 26-Me_2, 25-ene	[133]
Euphorbia clarkeana (Euphorbiaceae)	190–192°, +37.8°, IR, ^1H, ^{13}C, 2D, HEMS, 458.3753 $[M]^+$	3β,20,25-tri-OH, Δ^{22}	[134]
Gardenia storckii, *G. gordonii*, *G. hillii* (Rubiaceae)	^1H HRMS, 438 $[M]^-$	3,23-di-oxo, Δ^{24}	[135]
	^1H, HRMS, 424 $[M]^-$	3,23-di-oxi, 4-nor, Δ^{24}	[135]
	175–177°, ^1H, 440 $[M]^+$	3,24,di-oxo	[135]
Guarea guidona (Meliaceae)	424 $[M]^+$	3-oxo, Δ^{24}	[136]
Guarea trichilioides (Meliaceae)	133–135°, +20.5°, IR, ^1H, ^{13}C, MS, 438 $[M]^+$	3,23-di-oxo, Δ^{24}	[137]
	154–156°, +27.0°, IR, ^1H, ^{13}C, MS, 440 $[M]^+$	3-oxo, 23-OH, Δ^{24}	[137]
	134–136°, +52.7°, IR, ^1H, ^{13}C, 440 $[M]^+$	3-oxo, 23-OH, Δ^{24} [epimer]	[137]
	116–118°, +15.3°, IR, ^1H, ^{13}C, 440 $[M]^-$	3β-OH, 23-oxo, Δ^{24}	[137]
	IR, ^1H, ^{13}C, MS, 440 $[M]^+$	3β,21-di-OH, $\Delta^{24(31),25}$	[137]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Juncus effusus (Juncaceae)	+45.0°, IR, ^1H, ^{13}C, 2D, MS, 442 $[M]^+$	3β,25-di-OH, Δ^{23}	[138]
Kuadsura longipedunculata, *K. coccinea* (Leguminosae)	472 $[M]^+$	3β,21,22,23-tetra-OH, $\Delta^{23,24(31)}$	[139]
	474 $[M]^+$	3-oxo,27 → 22-lactone, Δ^{24}	[140]
	508 $[M]^+$	3 → 4-lactone, 27 → 22-lactone	[140]
Lansium domesticum (Meliaceae)	185–186°, +8.7°, IR, ^1H, ^{13}C, X-ray, EIMS, 454.7 $[M]^-$	3-oxo, 21-COOH, Δ^{24}	[91]
Mangifera indica (Anacardiaceae)	196–198°, +34.9°, IR, ^1H, ^{13}C, 444 $[M]^+$	3β,30-dia-OH	[141]
	180–182°, +27.4°, IR, ^1H, ^{13}C, MS, 428 $[M]^-$	30-OH	[141]
	29-Hydroxymangiferonic acid, 182–183°, +42°, IR, UV, ^1H, ^{13}C, MS, 470 $[M]^+$	3-oxo, 29-OH, 26-CO_2H, Δ^{24}	[142]
Monocyclanthus vignai (Annonaceae)	137–138°, +6.0°, UV, IR, ^1H, ^{13}C, EIMS, CD, 438.3498 $[M]^+$	3,23-di-oxo, Δ^{24}	[143]
	130°, +18.0°, UV, IR ^1H, ^{13}C, EIMS, 440.3654 $[M]^+$	3β-OH, 23-oxo, Δ^{24}	[143]
	111–113°, +15.0°, UV, IR, ^1H, ^{13}C, EIMS, 440.3655 $[M]^+$	3α-OH, 23-oxo, Δ^{24}	[143]
	80–82°, +20°, IR, ^1H, ^{13}C, EIMS, CD, 438.3498 $[M]^+$	3-oxo, 21-CHO, Δ^{24}	[143]
	79–81°, +47.0°, IR, ^1H, ^{13}C, EIMS, 440.3651 $[M]^-$	3β-OH, 21-CHO, Δ^{24}	[143]
	130°, +41.0°, IR, ^1H, ^{13}C, EIMS, 442.3812 $[M]^+$	3β,21-di-OH, Δ^{24}	[143]
	181.0°, +23.0°, IR, ^1H, ^{13}C, EIMS, 456.360 $[M]^-$	3β-OH, 21-CO_2H, Δ^{24}	[143]
	IR, ^1H, ^{13}C, EIMS 356.3605 $[M]^+$	3β,21-di-OH, 21,23-epoxy, Δ^{24}	[143]
	204–205°, +38.0°, IR, ^1H, ^{13}C, EIMS, 458.3762 $[M]^+$	3β,21,23-tri-OH, Δ^{24}	[143]
	CD, IR, ^1H EIMS 438.3498 $[M]^+$	3-oxo, 21,23-epoxy, Δ^{24}	[143]
	IR, ^1H, ^{13}C, EIMS 440 $[M]^-$	3β-OH, 21,23-epoxy, Δ^{24}	[143]
	166–168°, +5.0°, IR, ^1H, ^{13}C, EIMS 440.3659 $[M]^+$	3α-OH, 21,23-epoxy, Δ^{24}	[143]
	177–178°, +30.0°, IR, ^1H, ^{13}C, EIMS 458.3761 $[M]^+$	3β,21,25-tri-OH, 21,24-cyclo	[143]
	203–204°, +18.0°, IR, ^1H, ^{13}C, EIMS, CD, 456.3601 $[M]^+$	3-oxo, 21,25-di-OH, 21,24-cyclo	[143]
Mussanda pubesecus (Rubiaceae)	Heinsiagenin A 452 $[M]^+$	3β-OH, 27-amido, $\Delta^{22,24}$	[144]
Neolitsea serica (Lauraceae)	MS, 438 $[M]^-$	3β-OH, 24-methylene, 25-Me	[145]
	Sericeol, IR, ^1H, ^{13}C, MS, 442.3812 $[M]^+$	3β,20β-di-OH, $\Delta^{24(31)}$	[146]
Notholaena rigida (Pteridaceae)	470 $[M]^+$	3β-OH, 24*R*, 25-isopropylidenoxy	[147]
Notholaena schaffneri (Pteridaceae)	490 $[M]^+$	2α,24α,25-tri-OH, 30-CO_2H	[148]
Papaver sauniferum (Papaveraceae)	97–99°, +62.7°, IR, MS, ^1H, ^{13}C, 400 $[M]^+$	3β-OH, 26,27-bis-nor	[149]
Parthenium argentatum (Compositae)	Argentatin D, 224–227°, −222°, IR, ^1H EIMS, X-ray, 458 $[M]^+$	3β,25-di-OH, 16β,24-epoxy	[150]
Pentatropis spiralis (Asclepiadaceae)	188.0°, +38.5°, IR, ^1H, ^{13}C, FDMS, HRMS, 442.3870 $[M]^+$	3α,25-di-OH, Δ^{22}	[151]
Pistacia integerrima (Anacardiaceae)	484 $[M]^-$	3,11,23-tri-oxo, 26-CO_2H, $\Delta^{1,7(8),16(17),24}$	[152]
Pseudotsuga japonica (Pinaceae)	168–169.5°, +33.2°, IR, ^1H, ^{13}C, EIMS, HREIMS, 472.3917 $[M]^+$	3β-OMe, 27-CO_2H	[153]
Rapanea sp. (Myrsinaceae)	+10.6°, IR, ^1H, ^{13}C, 440 $[M]^+$	3α-OH, 26-CHO, Δ^{24}	[154]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Wrightia tinctoria (Apocynaceae)	99.0°, +18.3°, IR, UV, ^1H, ^{13}C, MS, 400 $[M]^+$	3β-OH, 24-oxo, 25,26,27-tris-nor	[155]
	Dammarane (**121**)		
Betula mandschurica (Betulaceae)	442 $[M]^+$	3-oxo, 20*S*,24*S*-di-OH, Δ^{25}	[156]
Betula glandulosa (Betulaceae)	+48.0°, UV, IR, ^1H, ^{13}C, FABMS, LREIMS, HREIMS, 500 $[M]^+$	3-oxo, 12β-OAc, 20*S*-OH, Δ^{24}	[157]
Betula pendula and B. ermanii (Betulaceae)	278–280°, IR, ^1H, ^{13}C, 492 $[M]^-$	3α,12β,17α,25-tetra-OH, 20,24-epoxy	[158]
Chisocheton macrophyllus (Meliaceae)	154–155°, +82.6, IR, ^1H, ^{13}C, MS, 440.366 $[M]^+$	3-oxo, 24-OH, $\Delta^{20,25}$	[159]
Cleome africana (Capparidaceae)	IR, ^1H, ^{13}C, MS, 470 $[M]^+$	3,25-di-OH, 17,24:20, 24:3,10-tri-epoxy	[160]
	IR, ^1H, ^{13}C, MS, 446 $[M]^+$	3,25-di-OH	[160]
Cleome brachycarpa (Capparidaceae)	Cleocarpone +39°, 210–212°, UV, IR, ^1H, ^{13}C, EIMS, FABMS, CD, 439.3215 $[M]^+$	3-oxo, 25-OH, 17,24:20,24-di-epoxy	[161]
Dysoxylum richii (Meliaceae)	166–167°, +23.0° IR, ^1H, ^{13}C, EIMS, 474 $[M]^+$	3,4-seco, 3-CO_2H, 4-OH, 20*S*,24*S*-epoxy, Δ^{25}	[162]
	140–141°, +57.0°,. IR, ^1H, ^{13}C, EIMS, 440.3661 $[M]^+$	3-oxo, 20*S*,24*S*-epoxy, Δ^{25}	[163]
	146–147°, IR, ^1H, ^{13}C, EIMS, 442 $[M]^-$	3-OH, 20*S*,24*S*-epoxy, Δ^{25}	[163]
	159–161°, 0°, IR, ^1H, ^{13}C, HRMS, 456 $[M]^+$	3,4-seco, 3-CO_2H, 20*S*,24*S*-epoxy, $\Delta^{4(28),25}$	[163]
	IR, ^1H, ^{13}C, EIMS, HRMS, 470 $[M]^+$	3,4-seco, 3-CO_2Me, 20*S*,24*S*-epoxy, $\Delta^{4(28),25}$	[163]
Elacodendron bauchananii (Celastraceae)	Elabunin, ^1H, ^{13}C, CD, X-ray, HRMS 440.3652 $[M]^+$	3-oxo, 16α-OH, $\Delta^{21,24}$	[92]
Gynostemma pentaphyllum (Cucurbitaceae)	^{13}C, X-ray 456.7 $[M]^+$	3β,25β-di-OH, 21-oxo, 21,24-cyclopentane, Δ^{23}	[164]
Juliana adstrigens	500 $[M]^+$	3α,15α-di-OH, 27-OAc, $\Delta^{12,24}$	[165]
Mangifera indica (Anacardiaceae)	143–144°, +34°, IR, ^1H, ^{13}C, MS, 474 $[M]^+$	3-oxo, 20*S*,24*R*-epoxy, 25,26-di-OH	[166]
Neoalsomitra integrifoliola (Cucurbitaceae)	Neoalsomilin A 492 $[M]^-$	3β,12β,23β,25-tetra-OH, 20*S*,24*S*-epoxy	[167]
Notholaema greggi (Pteridaceae)	147°, −24.5°, ^1H, ^{13}C, 2D, EIMS, X-ray, 474 $[M]^+$	3β,12β,25-tri-OH, 20*S*,24*S*-epoxy	[168]
	173°, +22.0°, ^1H, ^{13}C, 2D, EIMS, X-ray, 474 $[M]^+$	3-oxo, 12β,25-di-OH, 20*S*,24*S*-epoxy	[168]
Notholaema rigida (Pteridaceae)	532 $[M]^+$	3β.12β,25-tri-OH, 12-OAc, 20,24-epoxy	[169]
Panax ginseng (Araliaceae)	494 $[M]^+$	3β,6α,12β,20*R*,25-penta-OH	[170]
Pilocarpus spicatus (Rutaceae)	271–272°, IR ^1H, ^{13}C, EIMS, X-ray, 528 $[M]^+$	3β-OAc, 24-Me, 25-Et, 20,24-epoxy	[171]
	211–214°, IR, ^1H, ^{13}C, EIMS, X-ray, 484 $[M]^+$	3-oxo, 24-Me, 25-Et, 20,24-epoxy	[171]
Polanisia dedecandra (Capparidaceae)	Polacandrin, 234–238°, −86.5°, IR, ^1H, ^{13}C, 2D, FABMS, X-ray, 492.3900 $[M]^+$	1β,3α,12β,25-tetra-OH, 20*S*,24*S*-epoxy	[172]
Polypodium vulgare, P. fauriei, P. virginianum (Polypodiaceae)	53–55°, +25°, ^1H, ^{13}C, 410 $[M]^+$	$\Delta^{17,21}$	[173]
Rapanea sp. (Myrsinaceae)	+19.1°, IR, ^1H, ^{13}C, 454 $[M]^+$	3-oxo, 26-CHO, 24*E*, $\Delta^{20,24}$	[154]
Salvia hierosolymitana (Labiatae)	Salvilymitone, 168–171°, +61.0°, IR, ^1H, ^{13}C, EIMS, 474 $[M]^+$	3-oxo, 7β,25-di-OH, 20*S*,24*R*-epoxy	[174]
	Salvilymitol, 90–100°, +2.0°, IR, ^1H, ^{13}C, EIMS, 475 $[M]^-$	3β,7α,25-tri-OH, 20*S*,24*R*-epoxy	[174]
Sativa salicifolia (Compositae)	56–58°, +32.0°, IR, ^1H, ^{13}C, EIMS, 468 $[M]^+$	3β-OAc, $\Delta^{13(17),24}$, 20*S*	[175]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Euphane (**122**)		
Garuga pinnata (Burseraceae)	88–90°, UV, IR, ^1H, ^{13}C, 2D 442 $[M]^+$	1β,3β-di-OH, $\Delta^{7,24}$	[176]
Raeissantia indica (Celastraceae)	129–130°, +34.8°, ^1H, ^{13}C, MS, 458 $[M]^+$	3β,25-di-OH, 24-oxo, 19(10 → 9)abeo, Δ^5	[177]
	UV, IR, ^1H, ^{13}C, 458 $[M]^+$	3-oxo, 24β,25-di-OH, 19(10 → 9)abeo, Δ^5	[177]
	+35.4°, IR, ^1H, ^{13}C, MS, 460 $[M]^+$	3β,24β,25-tri-OH, 19(10 → 9)abeo, Δ^5	[177]
	Fernane (**50**)		
Adiantum edgeworthii (Adiantaceae)	289–291°, −19.9°, IR, ^1H, ester, ^{13}C, 440 $[M]^+$	25-CO_2H, $\Delta^{9(11)}$	[178]
Adianatum venustum (Adiantaceae)	280–282°, IR, ^1H, MS, methyl ester, ^{13}C, 440 $[M]^+$	25-CO_2H, $\Delta^{9(11)}$	[179]
Euphorbia supina (Euphorbiaceae)	Supinenolone E acetate, 268–270°, −48.3°, IR, UV, ^1H, ^{13}C, 2D, HRMS, 482.3753 $[M]^+$	3β-OH, 7-oxo, Δ^8	[180]
	Supinenolone C, 209–210°, −3.0°, ^1H, ^{13}C, HRMS, EIMS, 454.3445 $[M]^+$	3β-OH, 7,11-di-oxo, Δ^8	[181]
	Supinenolone A, 309–310°, −4.3°, UV, IR, ^1H, ^{13}C, CD, EIMS, HRMS, 456.3596 $[M]^+$	3β,7α-di-OH, 11-oxo, Δ^8	[181]
	Supinenolone B, 284–287°, +4.6°, IR, CD, ^1H, ^{13}C, EIMS, HRMS, 456 $[M]^+$	3β,11β-di-OH, 7-oxo, Δ^8	[181]
	Supinenolone D, 209–211°, −21.3°, IR, UV, ^1H, ^{13}C, HRMS, 470 $[M]^+$	3,7,11-tri-oxo, Δ^8	[182]
Microsorium brachylepis var. *normale* (Polypodiaceae)	Methyl ester, 162–163°, +1.1°, MS, ^1H, ^{13}C, 454.3763 $[M]^+$	28-CO_2H, Δ^7	[183]
	Methyl ester, 188–189°, +43.9°, MS, ^1H, ^{13}C, 454.3780 $[M]^+$	28-CO_2H, Δ^8	[183]
	Methyl ester, 155–157°, +9.3°, ^1H, ^{13}C, MS, 454.3794 $[M]^+$	28-CO_2H, $\Delta^{9(11)}$	[183]
Pseudocyphellaria aurata (Compositae)	498 $[M]^+$	3β-OAc, 12β-OH, $\Delta^{9(11)}$	[184]
	496 $[M]^+$	3β,OAc, 12-oxo, $\Delta^{9(11)}$	[184]
	456 $[M]^+$	3β,12β-di-OH, $\Delta^{9(11)}$	[184]
	498 $[M]^-$	3β-OAc, 19β-OH, $\Delta^{9(11)}$	[184]
Seriocostoma pauciflora (Boraginaceae)	Sericotinyl acetate, 268–270°, −12.3°, IR, UV, ^1H, ^{13}C, 2D 466.3799 $[M]^+$	20-OAc, $\Delta^{7,9(11)}$	[185]
	Rearranged Fernane (**123**)		
Ipomea batatas (Convolvulaceae)	238–239.5°, IR, MS, 468 $[M]^-$	3β-OH, $\Delta^{13(18)}$	[105]
	214–215.5°, IR, MS, 510 $[M]^+$	3β-OAc, $\Delta^{13(18)}$	[105]
Euphorbia supina (Euphorbiaceae)	Neospirosupinanetrione, 290–292.5°, +4.8°, IR, ^1H, ^{13}C, EIMS, HRMS, 454 $[M]^+$	7(8 → 9)abeo-9R, D:C-friedo-B′:A′ neogammacerane, 3,7,8-tri-oxo	[182]
	Filicane (**52**)		
Adiantum monochlamys (Polypodiaceae)	Felicenol A, 222–225°, +52.0°, IR, ^1H, ^{13}C, CD, 426.3850 $[M]^-$	6β-OH, Δ^3	[186]
	Felicenol B, 218–221°, +57.0°, IR, ^1H, ^{13}C, 426.3870 $[M]^+$	25-OH, Δ^3	[186]
Cyathea spinulosa (Cyatheaceae)	212–214°, −22.2°, IR, ^1H, ^{13}C, 426 $[M]^+$	3α-OH, $\Delta^{4(23)}$	[187]
	222–224°, +43.0°, IR, ^1H, ^{13}C, 424 $[M]^+$	2-oxo, Δ^3	[187]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Friedelane (**63**)		
Acanthothamnus aphyllus (Celastraceae)	217–219°, +13.8°, IR, ^1H, ^{13}C, MS, 424 $[M]^+$	21-oxo, 22β-OH, $\Delta^{2,4(23)}$	[188]
	294°, IR, ^1H, ^{13}C, 438 $[M]^+$	29-CO_2H, $\Delta^{2,4(23)}$	[188]
Austroplenkia populnea (Celastraceae)	X-ray, 470 $[M]^+$	3-oxo, 30-CO_2Me	[189]
	X-ray, 484.73 $[M]^+$	2-oxo, 3-OH, 30-CO_2Me, $\Delta^{3(4)}$	[190]
	313–315°, IR, MS, X-ray, 472 $[M]^+$	2-oxo, 3β-OH, 20α-CO_2H	[191]
Coloncoba glauca (Flacourtiacea)	Coloncobalactone, 316–317°, +21.0°, IR, ^1H, ^{13}C, EIMS, 438.3114 $[M]^-$	3,27-dioxo, 30-nor, 17 → 15α-lactone, $\Delta^{20(29)}$	[192]
	21β-Hydroxy-coloncobalactone, 305–306°, +29.0°, IR, ^1H, ^{13}C, EIMS 454.3080 $[M]^+$	3,27-di-oxo, 21β-OH, 17 → 15α-lactone, 30-nor, $\Delta^{20(29)}$	[192]
	Kokoonal, 252–253°, −2.0°, IR, ^1H, ^{13}C, EIMS, 440.3648 $[M]^-$	3-oxo, 27-CHO	[193]
	218–219°, +17°, IR, ^1H, ^{13}C, 458.3384 $[M]^+$	3β,21β-di-OH, 30-nor, 27-CO_2H	[193]
Dimocarpus longan (Dimocarpaceae)	Longantriterpene A, X-ray, 428 $[M]^-$	3β-OH	[194]
Euphorbia tirucalli (Euphorbiaceae)	Euphorcinol, ^1H, ^{13}C, 2D, 428 $[M]^-$	1α-OH	[195]
Euphorbia tortiles (Euphorbiaceae)	299–301°, +30.0°, IR, ^1H, ^{13}C, MS, 528 $[M]^+$	3α,21α-di-OAc	[196]
	276–278°, +17.0°, IR, ^1H, ^{13}C, MS, 486 $[M]^+$	3β-OH, 21α-OAc	[196]
Lophanthera lactescens (Malpighiaceae)	256–260°, IR, ^1H, ^{13}C, MS, 728 $[M]^+$	6α,7α,15β,16β,24-penta-OAc, 22α-CO_2Me, 21β,22β-epoxy, 18β-OH, 27,30-nor, 3,4-seco, 3 → 4R lactone, $\Delta^{1,20(29)}$	[197]
Leptosphaeria maculans (Pleosporaceae)	Maculaniol, 218–220°, +19.0°, ^1H, ^{13}C, 2D, 428.4012 $[M]^+$	1α-OH	[198]
Maytenus diversifolia (Celastraceae)	Maytensifolin C, 227–230°, +99.0°, IR, ^1H, ^{13}C, X-ray, 470.3309 $[M]^+$	6β-OH, 3,16,21-tri-oxo	[199]
Maytenus ilicifolia (Celastraceae)	Cangoronine, decomp. at 270°, +46.7°, IR, ^1H, ^{13}C, 484 $[M]^+$	2-oxo, 3β-OH, 24-CHO, 29-CO_2H, $\Delta^{3(4)}$	[200]
	Illicifoline, 270–272°, UV, IR, ^1H, ^{13}C, EIMS, CD, 440 $[M]^+$	3-oxo, 29-OH, Δ^{11}	[200]
Pentropis spiralis (Asclepiadaceae)	Pentatrinol, 428 $[M]^-$	7α-OH	[201]
Peritassa compta (Celastraceae)	269–271°, −6.0°, IR, ^1H, ^{13}C, EIMS, 440.3637 $[M]^+$	3,15-di-oxo	[202]
	275–276°, −32.1°, IR, ^1H, ^{13}C, EIMS, 428 $[M]^+$	15α-OH	[202]
	245–248°, −19.8°, IR, ^1H, ^{13}C, EIMS, 456 $[M]^+$	15α-OH, 1,3-di-oxo	[202]
Phyllanthus flexerosus (Euphorbiaceae)	282.5–285°, −2.6°, UV, IR, ^1H, ^{13}C, HREIMS, X-ray, 440 $[M]^+$	3-oxo, 11β-OH, Δ^1	[203]
Phyllanthus watsonii (Euphorbiaceae)	172–174°, −135°, IR, ^1H, ^{13}C, EIMS, 410.3553 $[M]^+$	3-oxo, 26-nor, Δ^{14}	[204]
Phyllobotryon spathulatum (Flacourtiaceae)	332–333°, +5.0°, IR, ^1H, ^{13}C, EIMS, ester, X-ray, 448 $[M]^+$	3β-OH, 27,29-di-CO_2H	[205]
	+15.0°, IR, ^1H, ^{13}C, EIMS, FABMS, 486 $[M]^-$	19β,21β-di-OH, 30-nor, 27-CO_2Me, $\Delta^{20(29)}$	[205]
Populus yunnanensis (Salicaceae)	484 $[M]^+$	3-oxo, 21α-OAc	[206]
Pristimera grahamii (Hippocrateaceae)	Pristimeronol, 260–262°, IR, ^1H, ^{13}C, 455 $[M]^+$	27-OH, 3,12-di-oxo	[207]
	Pristriol triacetate, 228–231°, IR, MS, 586 $[M]^+$	2α,3α,28-tri-OH	[208]
Salacia reticulata var. (Celastraceae)	280–282°, −40.0°, IR, UV, ^1H, 458 $[M]^+$	3-oxo, 21α,30-di-OH	[209]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Schaefferia cuncifolia (Celastraceae)	^1H, ^{13}C, EIMS, HRMS, 454.3436 $[M]^+$	2-oxo, 29-CO_2H, Δ^3	[210]
	452 $[M]^-$	3-oxo, 25(9 → 8)abeo, 24 → 1 lactone, $\Delta^{4(23)}$	[211]
	438 $[M]^+$	3-oxo, 25(9 → 8)abeo, 24-CHO, $\Delta^{4(23)}$	[211]
Tripterygium wilfordii (Celastraceae)	Salaspermic acid, 320°, ^1H, ^{13}C, HRMS, X-ray, 472 $[M]^+$	3β-OH, 3,24β-epoxy,29-CO_2H	[98]
	Gammacerane (**53**)		
Adiantum monochlayms (Polypodiaceae)	Hankonanediol, 270–272°, +21.0°, IR, ^1H, ^{13}C, 414 $[M]^+$	21α,22β-di-OH, 30-nor	[186]
	*Epi*hankonanediol, 299–301°, +5.0°, IR, ^1H, ^{13}C, 414 $[M]^+$	21β,22β-di-OH, 30-nor	[186]
Picris hieracioides (Compositae)	254–256°, +36.6°, ^1H, ^{13}C, X-ray 410 $[M]^+$	3β-OH, Δ^{16}	[212]
	287–288°, +36.0°, IR, ^1H, ^{13}C, MS, X-ray, 468.3948 $[M]^-$	3β-OAc, Δ^{16}	[212]
	269–270°, +9.9°, IR, MS, X-ray, 426.3881 $[M]^+$	3α-OH, Δ^{16}	[212]
Swertia chirata (Gentianaceae)	247–248°, +8.1°, ^1H, ^{13}C, 426.3866 $[M]^+$	3β-OH, Δ^{16}	[213]
	Extended hopane (**124**)		
Acetobacter aceti	Diacetate, 159–160°, ^1H, MS, 468 $[M]^+$	32β,33-di-OH, $\Delta^{6,12}$	[214]
	144–145°, ^1H, MS, 470 $[M]^+$	32β,33-di-OH, Δ^6	[214]
	Diacetate, 139–140°, ^1H, MS, 482 $[M]^+$	3β-Me, 32β,33-di-OH, $\Delta^{6,11}$	[214]
	137–138°, ^1H, MS, 484 $[M]^-$	3β-Me,32β,33-di-OH, Δ^6	[214]
	^1H, MS, 484 $[M]^+$	3β-Me,32β,33-di-OH, Δ^{11}	[214]
Lepetadenia pyrotechnica (Asclepiadaceae)	Leptadenol, ^1H, ^{13}C, HRMS, EIMS, 426 $[M]^+$	3β-OH, 21α-H, $\Delta^{30(31)}$	[215]
	Hopane (**47**)		
Adiantum caudatum (Polypodiaceae)	242–245°, +3.0°, IR, ^1H, MS, 414 $[M]^+$	29-nor, 22-OH	[216]
Adiantum monochlamys (Polypodiaceae)	213.5–215°, IR, ^1H, ^{13}C, 444 $[M]^+$	(22*S*),22-OH, 30-nor, 21α-H	[186]
Conocephalum japonicum (Hepaticeae)	224–226°, +56°, 444 $[M]^+$	6α,22-di-OH	[217]
	250–259°, IR, ^1H, ^{13}C, EIMS, 428 $[M]^-$	22α-OH	[217]
Cheiripleuria biscuspis (Cheiropleuriaceae)	296–297°, +49.7°, IR, MS, HRMS, 462 $[M]^+$	1α,11α,30-tri-OH	[218]
Chionochloa cheesemanii (Gramineae)	238–241°, ^1H, ^{13}C, EIMS, 440.4018 $[M]^-$	3β-OMe, $\Delta^{22(29)}$	[219]
Cyathea spinulosa (Cyathaceae)	270–275°, +67.1°, IR, ^1H, ^{13}C, 440 $[M]^+$	29 → 17α-lactone	[187]
	286–287, +42.6°, IR, ^1H, ^{13}C, 426 $[M]^+$	17α,29-epoxy	[187]
Davillia meriesii (Davalliaceae)	MS, ^1H, ^{13}C, 410.3883 $[M]^+$	Δ^{16}	[220]
	MS, ^1H, ^{13}C, 410.3912 $[M]^-$	21α-H, $\Delta^{22(29)}$	[220]
Euphorbia supina (Euphorbiaceae)	271–273°, IR, ^1H, ^{13}C, MS, 458.4119 $[M]^+$	17β,21β-epoxy, 3β-OH	[221]
Ficus insipida (Moraceae)	Moretenolactone, 172–174°, IR, ^1H, ^{13}C, MS, 454 $[M]^+$	3β-OH, 24-CO_2H, 21α-H, $\Delta^{22(29)}$	[222]
Ficus thunbergii (Moraceae)	>300°, +40°, ^1H, ^{13}C, EIMS, 454 $[M]^+$	3α-OH, 24-CO_2H, $\Delta^{22(29)}$, (isohopane)	[223]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Fossombronia alaskana, *F. pusilla* (Metzgeriales)	212.0°, +43.1°, ^1H, ^{13}C, MS, 456 $[M]^+$	22-OH, 29-CO_2H	[224]
	215.0°, +37.7°, ^1H, ^{13}C, MS, 426 $[M]^+$	20-OH, $\Delta^{22(29)}$	[224]
	230.0°, +28.9°, ^1H, ^{13}C, MS, 440 $[M]^+$	29-CO_2H, $\Delta^{22(30)}$	[224]
Lophosoria quadripinnata (Lophosoriaceae)	Dryocrassol, 228–232°, +5.0°, ^1H, ^{13}C, EIMS, 428 $[M]^+$	28,30-di-OH	[225]
Mullugo hirta (Molluginaceae)	Mollugogenol G, 242.0°, diacetate, ^1H, ^{13}C, MS, 458 $[M]^+$	3β,16β,24-tri-OH, Δ^5	[226]
Nephrolepsis tuberosa (Pteridophyte)	Tuberosic acid, 266–268°, IR, ^1H, ^{13}C, MS, 454 $[M]^+$	30-CO_2H, $\Delta^{22(29)}$	[227]
Physica aipolia (Physciaceae)	426 $[M]^-$	6-oxo, 22-OH	[228]
	470 $[M]^-$	6α-OAc, 22-OH	[228]
	498 $[M]^-$	6α,22-di-OH, 25-CO_2Me	[228]
Polypodium polypodioides (Polypodiaceae)	Orton acetal, 197–201°, +4.6°, IR, ^1H, ^{13}C, MS, 456 $[M]^+$	30-OMe, 17α,30-epoxy	[229]
Polypodium vulgare, *P. fauriel*, *P. virginianum* (Polypodiaceae)	232–233°, IR, ^1H, EIMS, 412 $[M]^+$	21α-H, 22-OH	[173]
Sericostoma pauciflorum (Boraginaceae)	264–266°, IR, ^1H, ^{13}C, MS, 484.39 $[M]^+$	3β,25-epoxy, 20β-OAc	[230]
	Pauciflorinyl acetate, 240–242°, +47.6°, IR, ^1H, ^{13}C, MS 486 $[M]^-$	23-OH, 20β-OAc	[231]
Swertia chirata (Gentianaceae)	Chiratenol, 236–237°, +24.1°, ^1H, ^{13}C, 426 $[M]^+$	3β-OH, 21α-H, $\Delta^{22(29)}$	[213]
Tripterygium regelii (Celastraceae)	Zeorin, 223–225°, IR, ^1H, ^{13}C, 428 $[M]^-$	6α,22-di-OH	[232]
	C(14a)-Homo-26-Nor-17α-Hopane (**125**)		
Biodegraded Petroleum	^1H, ^{13}C, 398 $[M]^+$	—	[233]
	2D, GCMS, ^1H, 412 $[M]^+$	29-nor	[233]
	Lanostane (**126**)		
Abies alba (Pinaceae)	470 $[M]^+$	3,4-seco, 23-oxo, 26-CO_2Me, $\Delta^{4(30),7}$	[234]
Abies firma (Pinaceae)	216–218, +27.0°, IR, HRMS, X-ray, CD, 468.3243 $[M]^+$	3-oxo, 27-OH, 26 → 23*R* lactone, 9β, $\Delta^{7,24}$	[235]
	239–241°, −58.9°, IR, ^{13}C, EIMS, CD, 454.3449 $[M]^+$	3β-OH, 26 → 23*R* lactone, 9β, $\Delta^{7,24}$	[235]
Abies veitchii (Pinaceae)	245–248°, +27.0°, IR, ^{13}C, EIMS, 452.3290 $[M]^+$	3-oxo, 26 → 23*R* lactone, 9β, $\Delta^{7,24}$	[236]
	Spiroveitchionolide, IR, ^1H, ^{13}C, X-ray 494 $[M]^+$	3-OMe, 7-OH, 8-oxo, 7(8 → 9)abeo, 24-ene, 26 → 23 lactone	[237]
	Veitchiolide, 228–230°, +22.1°, IR, ^{13}C, EIMS, 484.3558 $[M]^+$	3β-OMe,7β-OH, 26 → 23*R* lactone, $\Delta^{9(11),24}$	[238]
Abies species (Pinaceae)	502 $[M]^+$	3α-OH, 23-CO_2Me, $\Delta^{7,14}$	[239]
Ganoderma sp. (Polyporaceae)	185–187°, −4.1°, IR, ^1H, ^{13}C, MS 570 $[M]^+$	3α-malonyloxy, 23-oxo, 26-CO_2H, $\Delta^{24(31)}$	[240]
	161–162°, −1.5°, IR, ^1H, ^{13}C, MS, 586 $[M]^+$	3α-malonyloxy, 23-oxo, 26-CO_2H, 31-OH	[240]
Bridelia tommentosa (Euphorbiaceae)	150–151°, +63.7°, UV, IR, ^1H, ^{13}C, 456 $[M]^+$	3-oxo, 24-Me, $\Delta^{9(11),25}$	[241]
Desmos longiflorus (Annonaceae)	156–158°, UV, IR, ^{13}C, EIMS, 452 $[M]^+$	3-oxo,15α-OH, 24-methylene, $\Delta^{7,9(11)}$	[242]
Ganoderma applanatum (Polyporaceae)	Applanoxidic acid E, 138–139°, +145.0°, UV, IR, ^1H, ^{13}C, HRMS, 512.2740 $[M]^-$	3,12,23-tri-oxo, 15β-OH, 7α,8α-epoxy, 26-CO_2H, $\Delta^{9(11),20}$	[243]
	Applanoxidic acid F, 145–146°, IR, UV, ^1H, ^{13}C, HRMS, 510.2606 $[M]^+$	3,12,15,23-tetra-oxo, 7α,8α-epoxy, $\Delta^{9(11),20}$	[243]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Applanoxidic acid G, 129–130°, +126.0°, UV, IR, ^1H, ^{13}C, HRMS, 513.2513 $[M]^+$	3,12,23-tri-oxo, 15β,20-di-OH, 7α,8α-epoxy, 26-CO_2H, $\Delta^{9(11),16}$	[243]
	Applanoxidic acid H, 161–163°, +54.0°, UV, IR, ^1H, ^{13}C, HRMS, 530.2883 $[M]^+$	3β,12α,20-tri-OH, 7α,8α-epoxy, 15,23-di-oxo, 26-CO_2H, $\Delta^{9(11),16}$	[243]
	Applanoxidic acid A, 220°, +88.0°, IR, UV, ^1H, ^{13}C, HRMS, 512.2723 $[M]^+$	3,12,23-tri-oxo, 26-CO_2H, 7α,8α-epoxy, 15α-OH, $\Delta^{9(11),20}$	[89]
	Applanoxidic acid B, 224–225°, +114.6°, IR, UV, ^1H, ^{13}C, 512.2774 $[M]^+$	3β-OH, 12,15,23-tri-oxo, 7α,8α-epoxy, 26-CO_2H, $\Delta^{9(11),20}$	[89]
	Applanoxidic acid C, 140–142°, +18.9°, UV, IR, ^1H, ^{13}C, HRMS, 511.2340 $[M]^+$	3,12,15,23-tetra-oxo, 20-OH, 7α,8α-epoxy, 26-CO_2H, $\Delta^{9(11),16}$	[89]
	Applanoxidic acid D, 206–207°, +11.1°, UV, IR, ^1H, ^{13}C, HRMS 528.2731 $[M]^+$	3β,20-di-OH, 12,15,23-tri-oxo, 26-CO_2H, $\Delta^{9(11),16}$	[89]
Ganoderma lucidum (Basidiomycete)	510 $[M]^+$	3,7,11,12,15,23-hexa-oxo, 26-CO_2H, Δ^8	[244]
	234–234.5°, +100.0°, IR, UV, ^1H, ^{13}C, EIMS, 514 $[M]^-$	24*E*, 3β,20-di-OH, 7,11,15-tri-oxo, 26-CO_2H, $\Delta^{8,24}$	[245]
Ganoderma sp. (Polyporaceae)	452 $[M]^+$	16α-OH, 24-Me, 26-CO_2H, $\Delta^{7,9(11),25(27)}$	[246]
Garuga pinnata (Burseraceae)	132–134°, IR, UV, ^1H, ^{13}C, EIMS, 458 $[M]^-$	3β,11β,16α-tri-OH, $\Delta^{7,24}$	[247]
Heinsia crinata (Rubiaceae)	IR, ^1H, 588 $[M]^+$	3β,16α-OH, 24-Me, 26-(amido-4′-hydroxy-isoleucine), $\Delta^{7,9(11)}$	[248]
Kadsura heteroclita (Leguminosae)	456 $[M]^+$	3,4-seco, 3,26-CO_2H, 24*Z*, $\Delta^{4(30),8,24}$	[249]
	456 $[M]^+$	3,4-seco, 14(13 → 12)abeo, 26-CO_2H, $\Delta^{9(11),4(30),13(18),24}$	[249]
	Isomanwuweizic acid, UV, IR, ^1H, ^{13}C, 2D, MS, CD, 454 $[M]^-$	3α-OH, 26-CO_2H, $\Delta^{9(11),24}$	[250]
	458 $[M]^+$	3-oxo, 12β-OH, $\Delta^{9(11)}$	[251]
	500 $[M]^+$	3-oxo, 12β-OAc, $\Delta^{9(11)}$	[251]
	458 $[M]^+$	3-oxo, 12α-OH, $\Delta^{9(11)}$	[251]
	500 $[M]^+$	3-oxo, 12α-OAc, $\Delta^{9(11)}$	[251]
Kadsura heteroclita, *K. longi pedunculata* (Leguminosae)	452 $[M]^+$	3-oxo, 26-CO_2H, $\Delta^{8,24}$	[252]
Neolitsia aciculata (Lauraceae)	Acetate, MS, 496.4289 $[M]^+$	3β-OH, 24,24-di-Me, $\Delta^{9(11),25}$	[253]
	Acetate, MS, 482.4107 $[M]^-$	3β-OH, 24β-Me, $\Delta^{9(11),25}$	[253]
	Acetate, MS, 482.4114 $[M]^+$	3β-OH, 24β-Et, $\Delta^{9(11),25}$	[253]
Penares sp. (Stellettidae)	452 $[M]^+$	3β-Me, 30-CO_2H, $\Delta^{8,24}$	[254]
Pistacia integerrima (Anacardiaceae)	Pistacigerrimones D, 464 $[M]^+$	3-oxo, 26-CO_2H, $\Delta^{1,5,8,24}$	[152]
	Pistacigerrimones E, 466 $[M]^+$	3-oxo, 13,14-seco, 26-CO_2H, $\Delta^{1,5,7,24}$	[152]
	496 $[M]^+$	3-oxo, 9β,26-di-CO_2H, 20*R*,24*R*, $\Delta^{1,7,24}$	[255]
	496 $[M]^+$	3-oxo, 9β,26-di-CO_2H, 20*R*,24*R*, $\Delta^{1,8,24}$	[255]
Poria cocos (Polyporaceae)	Poricoic acid A, 248–249° +22.0°, IR, UV, ^1H, ^{13}C, 498.3362 $[M]^+$	3,4-seco, 16α-OH, 3,21-di-CO_2H, $\Delta^{4(28),7,9(11),24(31)}$	[256]
	Poricoic acid B, 248–249°, +15.0°, IR, UV, ^1H, ^{13}C, EIMS 484 $[M]^-$	3,4-seco, 3,21-di-CO_2H, 16α-OH, 24-ethylene, $\Delta^{4(28),7,9(11),24}$	[256]
	Poricoic acid C, +40.0°, IR, UV, ^1H, ^{13}C, EIMS, HRMS, 482 $[M]^+$	3,4-seco, 3,21-di-CO_2H, $\Delta^{4(28),7,9(11),24(31)}$	[257]
	Poricoic acid D, +11.0°, IR, UV, ^1H, ^{13}C, FABMS, 514 $[M]^+$	3,4-seco, 16α,25-di-OH, 3.21-di-CO_2H $\Delta^{4(28),7,9(11),24(31)}$	[257]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Ebluricoic acid, 250–252°, +9.0°, IR, UV, ^1H, ^{13}C, 468 $[M]^+$	3β-OH, 20-CO_2H, $\Delta^{7,9(11),24(31)}$	[257]
	Trametnolic acid, 266–267°, +51.0°, IR, ^1H, ^{13}C, EIMS, 456 $[M]^+$	3β-OH, 21-CO_2H, Δ^{24}	[257]
	254–255°, +29.0°, IR, UV, ^1H, ^{13}C, EIMS, HRMS 454 $[M]^-$	3β-OH, 21-CO_2H, $\Delta^{7,9(11),24}$	[257]
Polyalthia suberosa (Annonaceae)	Suberosol, 179–182°, +107.0°, UV, IR, ^1H, ^{13}C, HRMS, 454 $[M]^+$	3β,15-di-OH, 24-methylene, $\Delta^{7,9(11)}$	[99]
Pseudolarix kaemteri (Pinaceae)	464 $[M]^+$	3-oxo, 23,26-epoxy, 27-CO_2H, $\Delta^{7,23,25}$	[258]
Betula sp. (Betulaceae)	X-ray, 470 $[M]^+$	3α-OH, 24β,25β-epoxy, 26-CO_2Me, $\Delta^{9(11)}$	[259]
Santiria trimera (Burseraceae)	217–218°, +56.0, IR, ^1H, ^{13}C, X-ray, EIMS, 454 $[M]^+$	3-oxo, 26-CO_2H, $\Delta^{7,24}$	[260]
	−21.0°, IR, ^1H, ^{13}C, EIMS, 512 $[M]^+$	3-oxo, 6β-OAc, 26-CO_2H, 20*R*, 24*E*, $\Delta^{7,24}$	[260]
	Friedolanostane		
Abies siberica (Pinaceae)	^1H, ^{13}C, 2D, CD, 466 $[M]^+$	24*Z*, 8(14 → 13)abeo, 17,13-friedo, 3,23-di-oxo, 26-CO_2H, $\Delta^{8,14(30),24}$	[261]
	^1H, ^{13}C, 2D, CD, 466 $[M]^+$	24*E*, 8(14 → 13)abeo, 17,13-friedo, 3,23-di-oxo,26-CO_2H, $\Delta^{8,14(30),24}$	[261]
	Lupane (**56**)		
Achillea mangifera (Compositae)	Manificol, 426 $[M]^+$	3β-OH, $\Delta^{12,20(29)}$	[262]
Adinophora stricta (Compositae)	540 $[M]^-$	3β-(isovalerate), 24-CO_2H, $\Delta^{20(29)}$	[263]
Artocarpus communis (Moraceae)	81–83°, ^1H, ^{13}C, IR, MS, 468 $[M]^+$	3β-OAc, $\Delta^{20(29)}$	[264]
Betula alleghaniensis (Betulaceae)	454 $[M]^-$	3-oxo, 28-OH, 30-CHO, $\Delta^{20(29)}$	[265]
	438 $[M]^+$	3,20-di-oxo, 29-nor	[265]
	454 $[M]^+$	3,20-di-oxo, 28-OH, 29-nor	[265]
	458 $[M]^+$	3-oxo, 20,28-di-OH	[265]
Betula lenta (Betulaceae)	440 $[M]^+$	3-oxo, 28-OH, $\Delta^{20(29)}$	[266]
	456 $[M]^+$	3β,28-di-OH, 30-CHO, $\Delta^{20(29)}$	[266]
Combretum liprosum (Combretaceae)	270–272°, IR, EIMS, ^{13}C, 458 $[M]^+$	3β,6β,16β-tri-OH, $\Delta^{20(29)}$	[267]
Cynanchum hankokianum (Asclepiadaceae)	Hancokinol, 229–230°, +16.2°, IR, ^1H, ^{13}C, 2D, X-ray, HREIMS, 426.3862 $[M]^+$	3β-OH, 9,13-di-Me, 25,26-di-nor, Δ^5	[268]
	Hancolupenone, 241–242°, +14.4°, IR, ^1H, ^{13}C, CD, HREIMS, 424.3698 $[M]^+$	3-oxo, 13β-Me, 26-nor, $\Delta^{9(11)}$	[269]
	Hankolupenol, 215–217°, +14.9°, IR, ^1H, ^{13}C, 2D, CD, EIMS, 426.3860 $[M]^+$	3β-OH,26-nor, $\Delta^{9(11)}$	[269]
	Hankolupenol hexacosanoate, 99–101°, +18.0°, IR, FABMS, FDMS, 804 $[M]^+$	3β-O-($COC_{25}H_{51}$), 26-nor, $\Delta^{9(11)}$	[269]
	^1H, ^{13}C, 2D, X-ray, 428 $[M]^+$	3β-OH, 13-Me, 26-nor, $\Delta^{9(11)}$	[270]
Cylicodiscus gabunensis (Leguminosae)	Cylicodiscic acid, 190°, IR, ^1H, ^{13}C, 2D, EIMS, 472 $[M]^+$	3β,28-di-OH, 27-CO_2H, $\Delta^{20(29)}$	[271]
Diospyros peregrina (Ebenaceae)	Peregrinol, 260–262°, UV, IR, ^1H, ^{13}C, 442.5659 $[M]^-$	3α,27-di-OH, $\Delta^{20(29)}$	[272]
Gleichenia japonica (Gleicheniaceae)	Tarolupenyl acetate, 512 $[M]^-$	3-OAc, 17,18-seco, 18,22-di-oxo	[273]
Gouania microcarpa (Rhamnaceae)	Gouanic acid, 305–308°, IR, ^1H, EIMS, 484 $[M]^+$	3-oxo, 27,28-di-CO_2H, $\Delta^{20(29)}$	[274]
Helicteres isora (Sterculiaceae)	556 $[M]^+$	3β,27-di-OAc, 28-CO_2Me, $\Delta^{20(29)}$	[275]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Hemiodismus indicus (Asclepiadaceae)	IR, ^1H, MS, 452 $[M]^+$	3-oxo, 21 → 28 lactone, Δ^{12}	[276]
Kokoona ochracea (Celastraceae)	Ochraceolide A, 223–225°, +31.0°, UV, IR, ^1H, ^{13}C, EIMS, HRMS, 452.3294 $[M]^+$	3-oxo, 30 → 21α lactone, $\Delta^{20(30)}$	[277]
	Ochraceolide B, 236–238°, +10.0°, IR, ^1H, ^{13}C, EIMS, HRMS, 468 $[M]^+$	3-oxo, 30 → 21α lactone, 20,29-epoxy	[277]
	Ochraceolide C, 236–238°, −25.0°, UV, IR, ^1H, ^{13}C, HRMS, EIMS, 466 $[M]^+$	3,6-di-oxo, 30 → 21α lactone, $\Delta^{20(29)}$	[277]
	Ochroceolide D, 253–256°, +10.0°, UV, IR, ^1H, ^{13}C, HRMS, 486 $[M]^+$	3-oxo, 20,29-di-OH, 30 → 21α lactone	[278]
	Ochraceolide E, 233–235°, +29.0°, UV, IR, ^1H, ^{13}C, EIMS, 468 $[M]^+$	3-oxo, 28-OH, 30 → 21α lactone, $\Delta^{20(29)}$	[278]
Maytenus canariensis (Celastraceae)	85–86°, −6.6°, IR, ^1H, ^{13}C, MS, 458 $[M]^+$	3β,28,30-tri-OH, $\Delta^{20(29)}$	[279]
	^1H, ^{13}C, EIMS, 456 $[M]^+$	3-oxo, 28,30-di-OH, $\Delta^{20(29)}$	[279]
Melilolus messanensis (Leguminosae)	Messagenin, 213–215°, −17.8°, IR, ^1H, ^{13}C, HRMS, 444 $[M]^+$	3β,28-di-OH, 20-oxo,30-nor	[280]
Paliurus ramosissimus (Rhamnaceae)	253.5–255.0°, +24.0°, IR, ^1H, ^{13}C, HRMS, 530.3640 $[M]^+$	3β,27-di-OH,1α,28-di-CO_2H	[281]
Pistacia lentiscus (Anacardiaceae)	160–161°, +69.7°, ^1H, ^{13}C, EIMS, 410 $[M]^+$	3-oxo, 28-nor, $\Delta^{20(29)}$	[282]
Plumeria obtusa (Apocynaceae)	Obtusalin, 194–196°, +67.9°, IR, MS, 442.3807 $[M]^+$	3β,27-di-OH, Δ^{12}	[283]
Pulsatilla chinensis (Ranunculaceae)	482 $[M]^+$	3-oxo, 23-OH, 28-CO_2H, $\Delta^{20(29)}$	[284]
Quercus spicata (Fagaceae)	Querspicatin B, 280°, +20.0°, IR, LUV, ^1H, ^{13}C, MS, 456 $[M]^+$	3β,9α-di-OH, 7-oxo, $\Delta^{20(30)}$	[285]
	Querspicatin A, 260°, +13.0°, IR, ^1H, ^{13}C, MS, 438 $[M]^-$	3β-(3′,4′-dihydroxy-cinnamoyloxy), 6α-OH, 7-oxo, $\Delta^{20(30)}$	[285]
Salicia cordata (Celastraceae)	140–142°, −5.0°, IR, ^1H, ^{13}C, 2D, EIMS, 456 $[M]^+$	3-oxo, 15,28-di-OH, $\Delta^{20(29)}$	[286]
Salvia montbretii (Labiatae)	UV, IR, ^1H, ^{13}C, X-ray 590.4172 $[M]^+$	3β-(*cis*-*p*-coumaroyloxy), 20-OH	[287]
	UV, IR, ^1H, ^{13}C, HRMS, X-ray, 590.4170 $[M]^+$	3β-(*trans*-*p*-coumaroyloxy), 20-OH	[287]
Stenocereus stellatus (Cactaceae)	16β-Hydroxystellatogenin 1, 255–258°, +15.0°, IR, ^{13}C, EIMS, 488 $[M]^+$	3β,16β,20α-tri-OH, 28 → 21 lactone	[288]
Zizyphus jujuba (Rhamnaceae)	Zizyberanalic acid, 263–265°, +3.0°, IR, ^1H, ^{13}C, EIMS, 470 $[M]^+$	2β-CHO, 3α-OH, A(1)-nor, 28-CO_2H, $\Delta^{20(29)}$	[289]
		Oleanane (**59**)	
Abrus precatorius (Leguminosae)	Abrisapogenol J, 223–224°, −67.0°, IR, ^1H, ^{13}C, EIMS, 456 $[M]^+$	3β,22β-di-OH, 11-oxo, $\Delta^{13(18)}$	[290]
Acacia auriculiformis (leguminosae)	Acaciagenin A, 192–193°, +54.0°, IR, UV, ^1H, ^{13}C, MS, 668 $[M]^-$	3β,16β-di-OH, 21β-(2,6-*trans*-2,6-di-methyl-8-hydroxy-2,6-octa-dienoloxy), 28-CO_2H, Δ^{12}	[291]
Adenocalymma alliaceum (Bignoniaceae)	252–253°, +85.0°, 456 $[M]^+$	3β,29-di-OH, 11-oxo, Δ^{12}	[292]
Aesculus indica (Hippocastanaceae)	Protoaescigenin, 308°, ^1H, ^{13}C, 2D, 506 $[M]^+$	3β,16α,21β,22α.24,28-hexa-OH, Δ^{12}	[293]
Alibertia edulis (Rubiaceae)	181–183°, IR, ^1H, ^{13}C, EIMS, 504 $[M]^+$	3β,19α,23,24-tetra-OH, 28-CO_2H, Δ^{12}	[294]
Anagallis arvensis (Primulaceae)	179–180.0°, FTIR, ^1H, ^{13}C, 2D, MS, 490.3615 $[M]^+$	3β,16α,18α,22α-tetra-OH, 28,13β-epoxy	[295]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Anagalligenone, 264–266°, −9.2°, ^1H, ^{13}C, MS, 472 $[M]^+$	3β,23-di-OH, 16-oxo, 28,13β-epoxy	[296]
Anamirta coculus (Menispermaceae)	284–286°, +37.1°, IR, ^1H, ^{13}C, HRMS, 502.3287 $[M]^+$	2α,3β,23-tri-OH, 11α,12α-epoxy, 28 → 13β lactone	[297]
Aster auriculatus (Compositae)	Auriculatone, IR, UV, ^1H, ^{13}C, X-ray, 426 $[M]^+$	3β-OH, 16-oxo, 28-nor, Δ^{12}	[298]
Asterella angusta (Compositae)	UV, IR, ^1H, ^{13}C, MS, 474 $[M]^+$	3α,21β,22α,28-tetra-OH, Δ^{12}	[299]
Atractylis carduus (Compositae)	470 $[M]^-$	3β-OH, 11α,12α-epoxy, 28 → 13β lactone	[300]
Austroplenkia populnea (Celastraceae)	246–249°, IR, ^1H, ^{13}C, 454 $[M]^+$	3-oxo, 20α-CO_2H, Δ^{12}	[191]
Barreria articularis (Tiliaceae)	22–25°, +78.0°, IR, ^1H, ^{13}C, MS, 454 $[M]^+$	3-oxo, 29-CO_2H, Δ^{12}	[301]
Berneuxia thibetica (Diapensiaceae)	Berneuxin, 488 $[M]^+$	3-oxo, 16α,21β,22α,28-tetra-OH, Δ^{12}	[302]
Chiococea alba (Rubiaceae)	285–287°, IR, ^1H, ^{13}C, MS, 454 $[M]^+$	3β-OH, 28-CO_2H, $\Delta^{12,15}$	[303]
Chenopodium polycephalum (Labiatae)	472 $[M]^+$	3β,16β,23,28-tetra-OH, $\Delta^{11,13}$	[304]
Cornulaca monocantha (Chenodopiaceae)	496 $[M]^+$	3β-OAc, 18 → 29 lactone, Δ^{12}	[305]
Commiphora merkeri (Burseraceae)	256°, +48.0°, UV, ^1H, ^{13}C, HRMS, 458.7307 $[M]^+$	2α,3β,23-tri-OH, Δ^{12}	[94]
Dacryodes normendii (Burseraceae)	195–200°, +41°, ^1H, ^{13}C, IR, EIMS, 454 $[M]^+$	3,4-seco, 3-CO_2H, 21-oxo, $\Delta^{4(23),12}$	[306]
Dodonea viscosa (Sapindaceae)	310–312°, UV, IR, ^1H, ^{13}C, MS, 588 $[M]^+$	3β,15α,21β,22α,28-penta-OH, 16α-angeloyloxy Δ^{12}	[307]
Dillenia popuana (Dilleniaceae)	Dillenic acid A, +177.2°, ^1H, ^{13}C, EIMS, 470 $[M]^+$	2α-OH, 3-oxo, 30-CO_2H, Δ^{12}	[308]
	Dillenic acid B, +71.3°, IR, ^1H, ^{13}C, EIMS, 470 $[M]^+$	2-oxo, 3β-OH, 30-CO_2H, Δ^{12}	[308]
	Dillenic acid C, +107.6°, ^1H, ^{13}C, 2D, 470.3312 $[M]^+$	1α-OH, 3-oxo, 30-CO_2H, Δ^{12}	[308]
Erythrina eriotriocha (Leguminosae)	28-Acetoxyerythrodiol, IR, UV, ^1H, ^{13}C, MS, 484 $[M]^-$	3β-OH, 28-OAc, Δ^{12}	[309]
Euphorbia chamaesyce (Euphorbiaceae)	124–125°, +16.0°, IR, ^1H, ^{13}C, HRMS, 440.3649 $[M]^+$	3,4-seco, 3-CO_2H, $\Delta^{4(23),18}$	[310]
Euonymus mupinensis (Celastraceae)	Mupinensisone 426 $[M]^+$	3-oxo, 29-OH, Δ^{12}	[311]
Glycyrrhiza echinata (Leguminosae)	472 $[M]^+$	3β,21α-di-OH,28-CO_2H, $\Delta^{11,13}$	[312]
Glycyrrhiza glabra (Leguminosae)	^1H, ^{13}C, 510 $[M]^+$	3β-OAc, 11-oxo, 30 → 18β lactone Δ^{12}	[313]
Glycyrrhiza pallidiflora (Leguminosae)	Glypallidifloric acid, 410 $[M]^+$	3β-OH, 30-CO_2H, $\Delta^{11,13(18)}$	[314]
Glycyrrhiza uralensis (Leguminosae)	Glyuranolide, ^1H, ^{13}C, 516 $[M]^+$	3β-OH, 11-oxo, 27-CO_2Me, 29 → 22α lactone, Δ^{12}	[315]
Glycyrrhiza yunnanensis (Leguminosae)	Glyyunnasapogenin C, 316–318°, UV, IR, ^1H, ^{13}C, MS, ORD, 468.3197 $[M]^+$	3β-OH, 16-oxo, 30-CO_2H, $\Delta^{11,13(18)}$	[316]
	Glyyunnasapogenin E, 218–220°, IR, ^1H, HRMS, 550.3535 $[M]^+$	3β,21α,24-tri-OH, 29-CO_2H, $\Delta^{11,13(18)}$	[316]
	Glyyunnasapogenin A, Me-ester, 276–277°, IR, ^1H, ^{13}C, MS, CD, ORD 550 $[M]^+$	3β,24-di-OH, 16-oxo, 29-CO_2H, Δ^{12}	[317]
	Glyyunnasapogenin B, 287–289°, IR, ^1H, ^{13}C, MS, CD, ORD, 552 $[M]^+$	3β,21α,24-tri-OH, 30-CO_2H, Δ^{12}	[317]
	188–190°, IR, UV, ^1H, 632 $[M]^+$	3β,21α-di-OAc, 29-CO_2Me, $\Delta^{11,13(18)}$	[318]
	534 $[M]^+$	18α-H, 3β,21α-di-OH, 29-CO_2H, $\Delta^{9(11),12}$	[319]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	520 $[M]^+$	3β,21α,29-tri-OH, $\Delta^{9(11),12}$	[319]
Helicteris isora (Sterculiaceae)	Isorin, 512 $[M]^+$	3-oxo, 27-OAc,28-CO_2H, Δ^{12}	[275]
Hoya australis (Asclepiadaceae)	IR, ^1H, EIMS, 412 $[M]^+$	2-CHO, 3,4-seco, 3-nor, $\Delta^{13(18)}$	[320]
	^1H, EIMS, 412 $[M]^+$	2-CHO, 3,4-seco, 3-nor, Δ^{12}	[320]
	EIMS, 414 $[M]^+$	2-OH, 3,4-seco, 3-nor, $\Delta^{13(18)}$	[320]
	EIMS, 414 $[M]^+$	2-OH, 3,4-seco, 3-nor, Δ^{12}	[320]
Hydrocotyle ranunculoides (Umbelliferae)	UV, IR, ^1H, ^{13}C, 2D, FABMS, 502 $[M]^+$	3-oxo, 15α,16α,21β,22α,28-penta-OH, $\Delta^{1,12}$	[321]
	IR, ^1H, ^{13}C, 504 $[M]^-$	3-oxo, 15α,16α,21β,22α,28-penta-OH, Δ^{12}	[321]
	IR, ^1H, ^{13}C, EIMS, 486 $[M]^+$	3-oxo, 17,22-seco, 22,23-di-OH, $\Delta^{12,16}$	[321]
Hyptis albida (Labiatae)	260°, −6.6°, IR, ^1H, ^{13}C, MS, 454 $[M]^+$	3β-OH, 28 → 13β lactone, Δ^{11}	[322]
Ilex rotunda (Aquifoliaceae)	>340°, +155.0°, FABMS, ^1H, ^{13}C, 502 $[M]^+$	3β,19α-di-OH, 23,28-di-CO_2H Δ^{12}	[323]
Lantana aculeata (Verbenaceae)	Lantadene D, 191–193°, +82.0°, UV, IR, MS, 540 $[M]^+$	3-oxo, 22β-isobutyroyloxy, 28-CO_2H, Δ^{12}	[324]
Lantana camara (Verbenaceae)	Lantadene A, X-ray, 552.35 $[M]^-$	3-oxo, 22β-(2-Me-isocrotonoyloxy), 28-CO_2H, Δ^{12}	[325]
Lantana indica (Verbenaceae)	298–300°, IR, ^1H, ^{13}C, EIMS, 472 $[M]^+$	3β,24-di-OH, 28-CO_2H, Δ^{12}	[326]
Leucas aspera (Labiatae)	Leucolactone 310–312°, IR, ^1H, ^{13}C, 2D, 472 $[M]^+$	3β,16α-di-OH, 28 → 13β lactone	[327]
Loeselia mexicana (Polemoniaceae)	^1H, 2D, X-ray, 656 $[M]^+$	3β,21β-di-OH, 16α,28-di-OAc, 22α-O-angeloyloxy, Δ^{12}	[328]
Machaerocereus eruea (Cactaceae)	Machaerogenin, 292–294°, +14°, EIMS, ^{13}C, 2D, 470 $[M]^+$	3β,30-di-OH, 28 → 21 lactone, Δ^{12}	[288]
Mallotus philippinensis (Euphorbiaceae)	Kamaladiol-3-acetate, 125°, +38.0°, IR, ^1H, ^{13}C, EIMS, 484 $[M]^+$	3β-OAc, 22β-OH, Δ^{18}	[329]
Marsdenia griffithii (Asclepiadaceae)	Griffethol, 490 $[M]^+$	3β,16β,21β,22α,28-penta-OH, Δ^{12}	[330]
Marsdenia globifera (Asclepiadaceae)	Marsglobiferin 240–243°, +41.8°, IR, ^1H, ^{13}C, 2D, 490 $[M]^+$	3β,16β,21β,22α,28-penta-OH, Δ^{12}	[331]
Miconia stenostachya (Melastomataceae)	3-*Epi*sumaresinolic acid, methyl ester, 223–224°, +29.8°, IR, ^1H, ^{13}C, EIHRMS, 528.3797 $[M]^+$	3α,6β-di-OH, 28-CO_2H, Δ^{12}	[332]
Minuartia guianensis (Caryophyllaceae)	246–248°, ^1H, ^{13}C, MS, X-ray, 440 $[M]^+$	3β-OAc, 13β,28-epoxy, Δ^{14}	[333]
Madhuca butyraceae (Sapotaceae)	Butyraceol 278–280°, IR, MS, ^1H, ^{13}C, EIMS 456 $[M]^+$	2α,3β,23-tri-OH, $\Delta^{5,12}$	[334]
Mucuna birdwoodiana (Leguminosae)	Mucunagenin A, 235–236°, +35.3°, ^1H, ^{13}C, EIMS, 518 $[M]^+$	1β,2α,3β,23-tetra-OH, 28-CO_2Me, Δ^{12}	[335]
Nothopanax davidii (Araliaceae)	Liangwanin A 542 $[M]^+$	3β-OH, 28,29-di-CO_2H, Δ^{12}	[336]
Olea europea (Oleaceae)	^{13}C, 542 $[M]^+$	2α-OH, 3β-OMe, 28-CO_2H, Δ^{12}	[337]
	^{13}C, 542 $[M]^+$	2α-OMe, 3β-OH, 28-CO_2H, Δ^{12}	[337]
Petroleum	GCMS, ^1H, ^{13}C, 372 $[M]^+$	24,28-di-nor, 18α-H	[338]
Pfaffia glomerata (Amaranthaceae)	Glomeric acid, 264–266°, +74.0°, UV, ^1H, ^{13}C, 2D, 468 $[M]^+$	3-oxo, 15α-OH, 28-CO_2H, $\Delta^{1,12}$	[339]
	Pfameric acid, 280–282°, +46.0°, UV, IR, ^1H, ^{13}C, 474 $[M]^+$	3β,16β,20β-tri-OH, 28-CO_2H,30-nor, Δ^{12}	[339]
Phlomis spectabillis (Labiatae)	284–285°, IR, UV, ^1H, ^{13}C, EIMS, 458 $[M]^+$	3α,19α,23,29-tetra-OH, 28-nor, $\Delta^{16,21}$	[340]
	268°, UV, IR, ^1H, EIMS, 450 $[M]^+$	3α,19α,29-tri-OH, 23-CHO, 28-nor, $\Delta^{16,21}$	[340]
Phytolacca acinosa (Phytolaccaceae)	560 $[M]^+$	2β,3β-di-OH, 23,30-CO_2Me, 28-CO_2H, Δ^{12}	[341]
Phytolacca esculenta (Phytolaccaceae)	504 $[M]^+$	2β,3β,23,30-tetra-OH, 28-CO_2H, Δ^{12}	[342]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Euculentagenin, 320–322°, IR, ^1H, ^{13}C, EIMS, 546 $[M]^+$	2β,3β,23-tri-OH, 11-oxo, 28-CO_2H, 30-CO_2Me Δ^{12}	[343]
Ploiarium alternifolium (Bonnetiaceae)	289–290°, −104.0°, FTIR, ^1H, ^{13}C, MS, 572.3856 $[M]^+$	3β-OBz, 28-CO_2H, $\Delta^{11,13(18)}$	[344]
	175–180°, +62.0°, IR, ^1H, ^{13}C, MS, 558.3718 $[M]^-$	3β-OBz, 28 → 13β lactone, Δ^{11}	[344]
Plumeria rubra (Apocynaceae)	235–237°, +7.0°, IR, ^1H, ^{13}C, MS, 472.3295 $[M]^-$	3α,6α-di-OH, 28-CO_2H Δ^{12}	[345]
	183–184°, +32.0°, IR, ^1H, ^{13}C, MS, 442.3841 $[M]^+$	3α,27-di-OH	[345]
Pistacia lentiscus (Anacardiaceae)	191–193°, +184.5°, ^1H, ^{13}C, EIMS, X-ray, 410 $[M]^+$	3β-OH, 28-nor, Δ^{12}	[282]
Rhoiptelea chiliantha (Rhoipteleaceae)	225–226°, +30.9°, ^{13}C, FAB-MS, 674 $[M]^+$	3β-OH, 27-caffeoyloxy, 28-CO_2H, Δ^{12}	[346]
Rubia cordifolia (Rubiaceae)	Rubiprasin A >300°, +12.8°, IR, ^1H, ^{13}C, MS, X-ray, 516 $[M]^-$	3β-OAc, 12-oxo, 13β,15α-di-OH	[347]
	Rubiprasin B, 277–280°, ^1H, ^{13}C, MS, X-ray, 500 $[M]^+$	3β-OAc, 12-oxo, 13β-OH	[347]
	Rubiprasin C, 171–173°, ^1H, ^{13}C, 2D, MS, 515 $[M]^+$	3β-OAc, 19α-OH, 28-CO_2H, Δ^{12}	[347]
Sabia schumanniana (Sabiaceae)	UV, IR, ^1H, ^{13}C, 442 $[M]^+$	3-oxo, 11α-OH, Δ^{12}	[348]
Salvia leucantha (Labiatae)	Salvitriol, 240–241°, IR, ^1H, MS, 456 $[M]^-$	3β,22β,28-tri-OH, $\Delta^{11,15}$	[349]
Sandoricum koetjape (Meliaceae)	Koetjapic acid, 296–298°, +114.2°, IR, ^1H, ^{13}C, 2D, HRMS 470.3398 $[M]^+$	3,4-seco, 1,30-CO_2H, $\Delta^{4(23),12}$	[88]
	255–256°, +85.3°, IR, ^1H, ^{13}C, HRMS 454.3444 $[M]^+$	3-oxo, 29-CO_2H, Δ^{12}	[88]
Schaefferia cuneifolia (Celastraceae)	442 $[M]^-$	3β,15α-di-OH, Δ^{12}	[350]
Sophora subprostrata (Leguminosae)	Subprogenin A, 267–269°, +36.7°, ^1H, ^{13}C, EIMS, 472 $[M]^+$	3β,24,29-tri-OH, 22-oxo, Δ^{12}	[351]
	Subprogenin B, 235–237°, +53.1°, ^1H, ^{13}C, EIMS, 488 $[M]^+$	3β,24,29-30-tetra-OH, 22-oxo, Δ^{12}	[351]
	Subprogenin C, Ester, 150–152°, +38.2°, ^1H, ^{13}C, EIMS 484 $[M]^+$	3β-OH, 22-oxo, 30-CO_2H, Δ^{12}	[351]
	Subprogenin D, 221–223°, +94.0°, ^1H, ^{13}C, EIMS, 484 $[M]^+$	3β-OH, 22-oxo, 29-CO^2H, Δ^{12}	[351]
Sonchus oleraceus (compositae)	484 $[M]^+$	3α-OH, 3,25-epoxy, 28-CO_2H, Δ^{18}	[352]
Spathodea campanulata (Bignoniaceae)	Spathodic acid, decom. at 280°, IR, ^1H, ^{13}C, EIMS, 488 $[M]^+$	3β,19α,23-tri-OH, 28-CO_2H, Δ^{12}	[353]
Stauntonia hexaphylla (Lardizabalaceae)	251–255°, +25.0°, IR, ^1H, ^{13}C, EIMS, 470 $[M]^-$	3α-OH, 11,12-epoxy, 17 → 13β-lactone	[354]
Stegnotaenia araliacea (Umbelliferae)	Steganogenin, 170.0°, −14.0°, IR, ^1H, 472 $[M]^+$	3β,22-di-OH, 17,22-seco,28-CO_2H, $\Delta^{12,16}$	[355]
Symplocos racemosa (Symplocaceae)	278–280°, +86°, IR, ^1H, ^{13}C, EIMS, 440 $[M]^-$	3-oxo, 24-OH, Δ^{12}	[356]
Terminalia chebula (Combretaceae)	480 $[M]^+$	2α,3β,19α,23,28-penta-OH, Δ^{12}	[357]
T. brellerica (Combretaceae)	Bellericagenin A, 297–298°, +37.2°, IR, ^1H, ^{13}C, EIMS, 504 $[M]^+$	2α,3β,7α,23-tetra-OH, 28-CO_2H, Δ^{12}	[358]
	Bellericagenin B, >300°, +33.4°, IR, ^1H, ^{13}C, EIMS, 520 $[M]^+$	2α,3β,19α,23,24-penta-OH, 28-CO_2H, Δ^{12}	[358]
Tetrapleura tetraptera (Leguminosae)	Echinocystic acid 3-*O*-sodium sulphate, 194–197°, IR, ^1H, ^{13}C, FABMS, 551 $[M]^+$	3β-$NaSO_4$, 16α-OH, 28-CO_2H, Δ^{12}	[359]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Thomanderasia laurifolia (Acanthaceae)	Thomandertriol, 289–291°, −48.0°, IR, ^1H, ^{13}C, EIMS, 458 $[M]^+$	2α,3α,19α-tri-OH, Δ^{12}	[360]
Timonius timon (Rubiaceae)	+40.3°, ^1H, ^{13}C, 2D, EIMS, HRFABMS 484 $[M]^+$	3β,6β,23-tri-OH, 28-CO_2H, Δ^{12}	[361]
	+20.5°, ^1H, ^{13}C, 2D, EIMS, HRFABMS. 508.3708 $[M]^+$	3β,6β,19α,23-tetra-OH, 28-CO_2H, Δ^{12}	[361]
Trichochereus bridgesii (Cactaceae)	Bridgesigenin A, >300°, −31.4°, IR, ^1H, ^{13}C, EIMS, 486.3337 $[M]^+$	3β,21β,30-tri-OH, 28 → 15β lactone, Δ^{12}	[362]
	Bridgesigenin B, >300°, −29.7°, IR, ^1H, ^{13}C, EIMS, 502.3286 $[M]^+$	3β,21β,22α,30-tetra-OH, 28 → 15β lactone, Δ^{12}	[362]
Tripterygium hypoglaucum (Celastraceae)	Hypoglauterpenic acid, 450 $[M]^+$	3β-OH, 28-CO_2H, $\Delta^{5,12}$	[363]
T. regeli (Celastraceae)	Regelide, 460 $[M]^+$	3-oxo, 22-OH, 29 → 22α-lactone, $\Delta^{11,13(18)}$	[364]
T. wilfordii (Celastraceae)	466 $[M]^+$	3β,22β-di-OH, 29-CO_2H, Δ^{12}	[365]
Vitex negundo (Verbenaceae)	+10.36°, UV, IR, EIMS, ^1H, ^{13}C, 550 $[M]^+$	2β,3α-di-OAc, 28-CO_2H, $\Delta^{5,12}$	[95]
	+61.9°, UV, IR, ^1H, ^{13}C, EIMS, 446 $[M]^+$	2α,3α-di-OH, 28-CO_2H, $\Delta^{5,12}$	[95]
	−13.33° UV, ^1H, ^{13}C, EIMS, 566 $[M]^+$	2α,3β-di-OAc, 18-OH, 28-CO_2H, $\Delta^{5,12}$	[95]
Vicoa indica (Compositae)	Vicosigenin 252–254°, IR, ^1H, ^{13}C, EIMS, 504 $[M]^-$	2β,3β,16β,23-tetra-OH, 28-CHO, Δ^{12}	[366]
Wisteria brachytotrys (Leguminosae)	Wistariasapogenol A, 265–267°, +53.9°, ^1H, ^{13}C, 2D, MS, 472.3572 $[M]^+$	3β,24,30-tri-OH, 22-oxo, Δ^{12}	[367]
	Wistariasapogenol B, 243–244°, +46.3°, IR, ^1H, ^{13}C, 2D, MS, 456 $[M]^+$	3β,22β,24-30-tetra-OH, Δ^{12}	[367]
Zanha africana (Sapindaceae)	Medicagenic acid, 2D, 486 $[M]^+$	2β,3β,16α,23-tetra-OH, 28-CO_2H, $\Delta^{13(18)}$	[368]
	D-Friedooleanane (Taraxane) (**60**)		
Bosistoa brassi (Rutaceae)	275–279°, −14.0°, IR, ^1H, ^{13}C, MS, 442 $[M]^+$	3β,7α-di-OH, Δ^{14}	[369]
Tamarix aphylla (Tamaricaceae)	^1H, ^{13}C, 2D, EIMS, 443 $[M]^+$	3α,28-di-OH, Δ^{14}	[370]
	D:B Friedooleanane (Glutinane) (**62**)		
Pentatropis spiralis (Asclepiadaceae)	428 $[M]^-$	7α-OH	[201]
	666 $[M]^+$	3β-palmitoyloxy, Δ^5	[201]
	D:C Friedooleanane (Multiflorane) (**61**)		
Binincasa hispida (Cucurbitaceae)	468 $[M]^+$	3β-OAc, $\Delta^{8(9)}$	[371]
Trichosanthus kirilowi (Cucurbitaceae)	456 $[M]^+$	3α,29-di-OH, 7-oxo, Δ^8	[372]
	Isokarounidiol, 246–248° UV, ^1H, ^{13}C, 440 $[M]^+$	3α,29-di-OH, $\Delta^{6,8}$	[373]
	Onocerane (**127**)		
Lycopodium obscurum (Lycopodiaceae)	414 $[M]^+$	26-nor, 8-oxo	[374]
	398 $[M]^+$	26,27-nor, 8,14-di-oxo	[374]
	Pfaffane (**128**)		
Pfaffia pulverulenta (Amaranthaceae)	Pulveric acid, 279–281°, +84.0°, UV, IR, ^1H, ^{13}C, 452 $[M]^+$	3,11-oxo, 28-CO_2H, Δ^{12}	[375]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	Deoxopulveric acid 232–234°, IR, ^1H, ^{13}C, 438 $[M]^+$	3-oxo, 28-CO_2H, Δ^{12}	[375]
	Oxopfaffic acid, 251–253 °, +56.0°, UV, IR, ^1H, ^{13}C, 454 $[M]^+$	3β-OH, 11-oxo, 28-CO_2H, Δ^{12}	[375]
	Serratane (**129**)		
Lycopodium obscurum (Lycopodiaceae)	260–262.5°, 562 $[M]^+$	16-oxo, 30-*O*-*p*-coumarate, Δ^{14}	[377]
	564 $[M]^+$	16-oxo, 30-*O*-*p*-coumarate	[377]
	550 $[M]^+$	30-*O*-*p*-coumarate	[377]
Picea jezoensis (Pinaceae)	227–229.5°, 1.0°, IR, ^1H, ^{13}C, EIMS, HREIMS, 454 $[M]^+$	3-oxo, 21β-OMe, Δ^{14}	[378]
	223–225.5°, IR, ^1H, ^{13}C, EIMS, HREIMS, 454 $[M]^+$	3-oxo, 21α-OMe, Δ^{13}	[378]
Pinus aremendii (Pinaceae)	288.5–291.6°, +23.6°, IR, ^1H, ^{13}C, MS, EIMS, 498 $[M]^+$	3β-OMe, 21α-OAc, Δ^{14}	[379]
	226–228°, −25.9°, IR, ^1H, ^{13}C, EIMS, HRMS 470 $[M]^+$	3β-OMe, 21-oxo, 30-OH Δ^{14}	[379]
	228–233°, +5.8°, ^1H, ^{13}C, EIMS, HRMS, CD, MS, 468 $[M]^+$	3β-OMe, 21-oxo, 30-CHO, Δ^{14}	[379]
	230–232°, −8.3°, IR, ^1H, ^{13}C, EIMS, HRMS, CD, 512 $[M]^+$	3β-OMe, 21α-OAc, 30-CHO, Δ^{14}	[379]
	Swertane (**55**)		
Swertia chirata (Gentianaceae)	278–279°, +24.0°, ^1H, ^{13}C, MS, 468 $[M]^+$	3β-OH, Δ^7	[213]
	230–231°, −16.8°, ^1H, ^{13}C, MS, 466 $[M]^+$	3β-OH, $\Delta^{7,9(11)}$	[380]
	Tirucallane (**130**)		
Aucounea klaimeana (Aucouneaceae)	438 $[M]^+$	3,23-di-oxo, 22-OH, $\Delta^{7,24}$	[381]
Cedrela ordorata (Meliaceae)	199–202°, −23.4°, IR, ^1H, ^{13}C, MS, 474 $[M]^+$	3-oxo, 23,24,25-tri-OH, Δ^7	[382]
Paramignya monophylla (Rutaceae)	169–171°, −67.0°, IR, ^1H, EIMS, 440 $[M]^+$	3-oxo, 23-OH, $\Delta^{7,24}$	[383]
	150–152°, −65.0°, IR, ^1H, HRMS, 456 $[M]^+$	3-oxo, 21,23-di-OH, $\Delta^{7,24}$	[383]
	151–152°, −29.0°, IR, ^1H, HRMS, 442 $[M]^+$	3β,23-di-OH, $\Delta^{7,24}$	[383]
	142–144°, −34.0°, IR, ^1H, HRMS, 458 $[M]^+$	3β,21,23-tri-OH, $\Delta^{7,24}$	[383]
Phellodrendron chinense (Rutaceae)	Phellochin, 488 $[M]^+$	3-oxo, 23,24-di-OH, 25-OMe, Δ^7	[384]
Pistacia integrrima (Anacardiaceae)	454 $[M]^+$	(20*R*), (24*R*), 3-oxo, 26-CO_2H, $\Delta^{1,24}$	[152]
Shilajit (Himalayan humus)	456 $[M]^+$	3β-OH, 26-CO_2H, $\Delta^{8,24}$	[385]
	456 $[M]^+$	3β-OH, 26-CO_2H, $\Delta^{7,24}$	[385]
Trichillia connaroides (Meliaceae)	3-Lipo Esisapelin A, IR, ^1H, ^{13}C, EIMS, 740, 712, 684, 656 $[M]^+$	3β-lipoloxy, 23α,24-di-OH, 24 → 21 lactone, Δ^7	[386]
T. prieuriana (Meliaceae)	Prieurone, 96–98°, IR, ^1H, ^{13}C, EIMS, 496 $[M]^+$	3-oxo, 12-OAc, 21,23-epoxy, $\Delta^{7,24}$	[387]
	29-Hydroxyprieurone, 165–168°, IR, ^1H, ^{13}C, EIMS, 512 $[M]^+$	3-oxo, 12-OAc, 29-OH, 21,23-epoxy, $\Delta^{7,24}$	[387]
Abutilon pakistanicum (Malvaceae)	Pakistanol, 112–114°, +32.9°, IR, ^1H, ^{13}C, FDMS, 426 $[M]^+$	24β-OH, Δ^{12}	[388]
Actinidia eriantha (Actinidiaceae)	488 $[M]^+$	2α,3β,24-tri-OH, 28-CO_2H, Δ^{12}	[389]
A. polygama (Actinidiaceae)	+44.0°, IR, ^1H, ^{13}C, EIMS, 504 $[M]^+$	2α,3α,23,24-tetra-OH, 28-CO_2H, Δ^{12}	[390]
	+34.8°, IR, ^1H, ^{13}C, EIMS, 486 $[M]^+$	2α,3α-di-OH, 24-CHO, 28-CO_2H, Δ^{12}	[390]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
	+30.8°, IR, ^1H, ^{13}C, EIMS, 546 $[M]^+$	2α,3α,24-tri-OH, 23,28-di-CO_2H, Δ^{12}	[390]
	+64.4°, IR, ^1H, ^{13}C, EIMS, 484 $[M]^+$	2α,3α,23-tri-OH, 28-CO_2H, $\Delta^{12,20(30)}$	[390]
	+19.6°, IR, ^1H, ^{13}C, SIMS, 657 $[M]^+$	3β-(*trans-p*-coumaroyloxy), 2α,23-di-OH, 28-CO_2H, Δ^{12}	[390]
	+22.2°, IR, ^1H, ^{13}C, EIMS, 486 $[M]^+$	2α,3α,24-tri-OH, 13β → 28-lactone, Δ^{11}	[391]
	−10.7°, IR, UV, ^1H, ^{13}C, SIMS, 634 $[M]^+$	3β-(*trans-p*-coumaroyloxy), 2α,24-di-OH, 28-CO_2H, Δ^{12}	[391]
Alyxia insularis (Apocynaceae)	584 $[M]^+$	3β-OAc, 11-oxo, 28-CO_2H, Δ^{12}	[392]
	542 $[M]^+$	3β-OH, 11-oxo, 28-CO_2H, Δ^{12}	[392]
Bursera delpechiana (Burseraceae)	BDGM-1, 235–237°, IR, UV, ^1H, ^{13}C, MS, ^1H, ^{13}C, MS, 526 $[M]^+$	3β-OAc, 11-oxo, 28-CO_2Me	[393]
	BDGM-2, 159–161°, IR, ^1H, ^{13}C, MS, 484 $[M]^-$	11-oxo, 28-CO_2Me, Δ^{12}	[393]
Bryophyllum pinnatum (Crassulaceae)	Bryophollone, 210°, ^1H, EIMS, 438 $[M]^+$	22-oxo, 30-nor, $\Delta^{9(11),19}$	[394]
Calotropis procera (Asclepiadaceae)	Isourasane 228–229°, +108°, IR, ^1H, ^{13}C, 2D, 468 $[M]^+$	3β-OAc, $\Delta^{19(29)}$ D/E ring *trans*	[395]
Chrysanthemum morifolium (Compositae)	680 $[M]^+$	3β-palmitoyloxy, 16β-OH, $\Delta^{20(21)}$	[396]
Corchorus depressus (Tiliaceae)	Codepressic acid, diacetate, 262–263°, IR, ^1H, ^{13}C, EIMS, 530 $[M]^+$	2α,3β-di-OAc, 20-OH, 24,28-di-CO_2H, Δ^{12}	[397]
	Codepressenic acid, diacetate, 277–278°, +67.0°, ^1H, ^{13}C, EIMS, 612 $[M]^+$	2α,3β,24-tri-OH, 28-CO_2H $\Delta^{12,20(21)}$	[397]
Coleus forskohlii (Labiateae)	Coleonolic acid, 245°, IR, ^1H, ^{13}C, 2D, MS, 470 $[M]^-$	2-OH, A(1)-nor, 28-CO_2H, $\Delta^{2,12}$	[398]
Cussonia natalensis (Araliaceae)	170°, IR, ^1H, ^{13}C, MS, 470 $[M]^+$	3-oxo, 23-OH, 28-CO_2H, Δ^{12}	[84]
Curculigo orchioides (Amaryllidaceae)	114°, IR, ^1H, ^{13}C, MS, 468 $[M]^+$	3-oxo, 28-CO_2H, 31-Me, Δ^{20}	[399]
Cynomorium songaricum (Balanophoraceae)	526 $[M]^+$	3β-(propanoic acid methyl ester), 28-CO_2H, Δ^{12}	[400]
Dacryodis normandii (Burseraceae)	205–210°, +64°, IR, ^1H, ^{13}C, EIMS, 454 $[M]^+$	3,4-seco, 3-CO_2H, 21-oxo, $\Delta^{4(23),12}$	[306]
Eriobotrya japonica (Rosaceae)	^1H, ^{13}C, 444 $[M]^+$	3β,6α,19α-tri-OH, 28-nor, Δ^{12}	[401]
	+18.2°, ^1H, ^{13}C, FABMS, 650 $[M]^+$	2α,3β,19α-tri-OH, 23-*trans-p*-coumaroyloxy, 29-CO_2H, Δ^{12}	[401]
	+13.3°, ^1H, ^{13}C, FABMS, 650 $[M]^+$	2α,3β,19α-tri-OH, 23-*cis-p*-coumaroyloxy, 28-CO_2H, Δ^{12}	[401]
	+1.2°, ^1H, ^{13}C, FABMS, 650 $[M]^-$	2α,19α-di-OH, 3-*O-trans*-caffeoyloxy, 28–CO_2H, Δ^{12}	[401]
	5.2°, ^1H, ^{13}C, FABMS 634 $[M]^+$	19α-OH, 3-*O-p*-coumaroyloxy 28-CO_2H, Δ^{12}	[401]
Eucalyptus tereticornis (Myrtaceae)	Tereticornate A 267–270°, +27°, ^1H, ^{13}C, FABMS, 631 $[M]^+$	3β-(3′-methoxycinnamoyl-oxy), 28 → 13β-lactone, Δ^{11}	[402]
	Tereticornate B 270–274°, +37.3°, ^1H, ^{13}C, FABMS, 600 $[M]^+$	3β-cinnamoyloxy, 28 → 13β lactone, Δ^{11}	[402]
Goreishi (Trogopterus xanthispes)	Goreishic acid I, 198–199°, +161.0°, UV, IR, ^1H, ^{13}C, 2D, EIMS, HRMS, 470 $[M]^+$	2α,3β-di-OH, 28-CO_2H, $\Delta^{12,18}$	[403]
	Goreishic acid II, 174–175°, 203.0, UV, ^1H, ^{13}C, 2D, HRMS, 456 $[M]^+$	2α,3β-di-OH, 23-nor, 28-CO_2H, $\Delta^{12,18}$	[403]
	Goreishic acid III, 188–190°, +266.0°, ^1H, ^{13}C, HRMS, 456 $[M]^+$	2α,3β-di-OH, 24-nor, 28-CO_2H, $\Delta^{12,18}$	[403]

Sources (family)	Name, mp. $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Hoya australis (Asclepiadaceae)	EIMS, 412 $[M]^+$	2-CHO, 3,4-seco, 3-nor, Δ^{12}	[320]
	EIMS, 412 $[M]^+$	2-CHO, 3,4-seco, 3-nor, Δ^{20}	[320]
	EIMS, 412 $[M]^+$	2-CHO, 3,4-seco, 3-nor, $\Delta^{20(29)}$	[320]
	EIMS, 414 $[M]^+$	2-OH, 3,4-seco, 3-nor, Δ^{12}	[320]
	EIMS, 414 $[M]^+$	2-OH, 3,4-seco, 3-nor, $\Delta^{20(30)}$	[320]
Hyptis suaveolens (Labiatae)	208–210°, +17.0°, IR, ^1H, ^{13}C, EIMS, 470 $[M]^+$	A(1)-nor, 2,19α-di-OH, 28-CO_2H, $\Delta^{2,12}$	[28]
Ilex rotunda (Aquifoliaceae)	Ilexolic acid A, 259–260°, +48.5°, ^1H, ^{13}C, FABMS 504 $[M]^-$	3β,19α,21β,23-tetra-OH, 28-CO_2H, Δ^{12}	[323]
Lobelia cardinalis (Lobeliaceae)	472 $[M]^+$	3β,21β-di-OH, 28-CO_2H, Δ^{12}	[404]
	470 $[M]^+$	3-oxo, 21β-OH, 28-CO_2H, Δ^{12}	[404]
Lantana camara (Verbenaceae)	Lantaiursolic acid, 556 $[M]^+$	3β-isovaleroyloxy, 19α-OH, 28-CO_2H, Δ^{12}	[405]
Lavandula spica (Labiatae)	223–226°, +81.4°, IR, ^1H, methyl ester, ^{13}C, 484 $[M]^+$	3β-formyloxy, 28-CO_2H, Δ^{12}	[406]
Leptosphaeria maculans (Pleosporaceae)	168–170°, −20.4°, IR, ^1H, EIMS, ^{13}C, 496 $[M]^-$	3α-OAc, 28-CO_2H, $\Delta^{18,20}$	[198]
Leptospermum scoparium (Myrtaceae)	186–188°, UV, ^1H, ^{13}C, EIMS, 648 $[M]^+$	2α-OH, 3β-(*trans*-ferulyl), 28-CO_2H, Δ^{12}	[407]
	UV, ^1H, EIMS, 648 $[M]^+$	2α-OH, 3β-(*cis*-ferulyl), 28-CO_2H, Δ^{12}	[407]
	^1H, ^{13}C, 648 $[M]^+$	2α-(*trans*-ferulyl), 3β-OH, 28-CO_2H, Δ^{12}	[407]
	200–203°, UV, ^1H, ^{13}C, EIMS, 572 $[M]^+$	2α-OH, 3β-(*cis*-*p*-coumaroyloxy), 28-CO_2H, Δ^{12}	[407]
Musanaga cecropoides (Cecropiaceae)	Cecropoic acid 514 $[M]^+$	2α-OAc, 3β-OH, 28-CO_2H, Δ^{12}	[408]
	Me-musagicate, 171–173°, IR, ^1H, ^{13}C, EIMS, 518 $[M]^-$	2α,3α,19α,22α-tetra-OH, 28-oate, Δ^{12}	[409]
Mucuna birdwoodiana (Leguminosae)	Mucagenin B, 165–166°, +58.9°, ^1H, ^{13}C, EIMS, 518 $[M]^-$	1β,2α,3β,23-tetra-OH, 28-CO_2Me, Δ^{12}	[335]
Nepeta eriostachia (Labratae)	Nepetoic acid, methyl ester, 172–174°, +15.0°, IR, ^1H, ^{13}C, EIMS, 500 $[M]^+$	2α-OMe, 3β-OH, 28-CO_2H, Δ^{12}	[410]
Patrinia villosa (Leguminosae)	568 $[M]^+$	3β-OH, 28-CO_2H, 23-sulphate, Δ^{12}	[411]
Plumeria obtusa (Apocynaceae)	Coumarobtusanoic acid, IR, UV, ^1H, ^{13}C, EIMS, 636 $[M]^-$	2α,3β-di-OH, 27-*p*-*trans* coumaroyloxy, 28-CO_2H	[412]
	Coumarobtusane, IR, UV, ^1H, ^{13}C, EIMS, 606 $[M]^+$	2α,3β-di-OH, 27-*p*-*trans*-coumaroyloxy	[412]
	Obtusin, 198–199°, UV, IR, ^1H, ^{13}C, 2D HRMS, 454.3460 [M-*p*-coumaric acid]$^+$	3β-OH-di-28-CO_2H, Δ^{12}, 24-(*p*-*E*-coumaroyloxy)	[413]
	Obtusilic acid, 290–291°, UV, IR, ^1H, ^{13}C, HRMS, 454.3461 [M-*p*-coumaric acid]$^+$	3β-OH, 30-CO_2H, Δ^{12}, 27-(*p*-*Z*-coumaroyloxy)	[413]
P. rubra (Apocynaceae)	Rubrinol, 442 $[M]^-$	3β,30-di-OH, Δ^{12}	[414]
Rosmarinus officinalis (Labiatae)	Rofficerone, IR, ^1H, ^{13}C, MS, 440 $[M]^+$	3-oxo, 20β-OH, Δ^{12}	[415]
Rubi fructus (Rubiaceae)	23-hydroxy tormentic acid 504 $[M]^-$	2α,3β,19α,23-tetra-OH, 28-CO_2H, Δ^{12}	[416]
Salvia mellifera (Labiatae)	+77.0°, IR, UV, ^1H, ^{13}C, EIMS, 438 $[M]^+$	3,11-di-oxo, Δ^{12}	[417]
	IR, ^1H, ^{13}C, EIMS, 440 $[M]^+$	3α-OH, 13β,28-epoxy, Δ^{11}	[417]
	136–137°, +115.0°, UV, IR, ^1H, ^{13}C, EIMS, 438 $[M]^-$	3-oxo, 13β,28-epoxy, Δ^{11}	[417]
Salvia paramiltoriorrhiza (Labiatae)	IR, UV, ^1H, ^{13}C, 488 $[M]^+$	2α,3β,24-tri-OH, 28-CO_2H, Δ^{12}	[418]

Sources (family)	Name, mp, $[\alpha]_D$, spectra/X-ray analysis reported.	Groups	References
Sanguisorba alpina (Rosaceae)	Alpinic acid, 123–126°, +47.7°, IR, ^{13}C, EIMS, 524 $[M]^+$	2-isobutyryloxy, 19α-OH,28-CO_2H, $\Delta^{1,12}$	[419]
	540 $[M]^+$	2-isobutyroyloxy, 19α,25-di-OH, 28-CO_2H, $\Delta^{1,12}$	[420]
Sanguisorba officinalis (Rosaceae)	285–287°, +42.0°, IR, UV, ^1H, ^{13}C, EIMS, 484 $[M]^+$	3,11-di-oxo, 19α-OH, 28-CO_2H, Δ^{12}	[421]
Scolymus hispanices (Compositae)		3β-tetrariacontanoyloxy, Δ^{12}	[422]
Scheffera octophylla (Araliaceae)	160–162°, +37°, IR, ^1H, ^{13}C, 2D, MS, 486 $[M]^-$	3α-OH, 23,28-di-CO_2H, Δ^{12}	[423]
Shorea robusta (Dipterocarpaceae)	^1H, ^{13}C, IR, 658 $[M]^+$	2α,3β,23-tri-OH, 11β-OMe, 28-CO_2H, Δ^{12}	[424]
	+31.0°, IR, ^1H, ^{13}C, EIMS, 454 $[M]^+$	3β-OAc, 28-nor, Δ^{12}	[425]
Symplocos racemosa (Symplocaceae)	81–82°, +112°, ^1H, IR, EIMS, 482 $[M]^+$	3-OAc, 28-OH, $\Delta^{12,18}$	[356]
	90–91°, +165°, IR, ^1H, EIMS, 452 $[M]^+$	3-oxo, 28-CO_2H, $\Delta^{12,18}$	[356]
Trypterigium hypoglaucum (Celastraceae)	Hypoglaulide, 468 $[M]^+$	3-oxo, 30 → 22α lactone, Δ^{12}	[426]
T. wilfordii (Celastraceae)	472 $[M]^+$	3β,22α-di-OH, 30-CO_2H, Δ^{12}	[427]
	488$[M]^+$	2α,3β-24-tri-OH, 28-CO_2H, Δ^{12}	[428]
Uncaria tomentosa (Rubiaceae)	+52.7°, MS, ^1H, ^{13}C, 2D, EIMS, 488 $[M]^+$	3β,6β,19α-tri-OH, 28-CO_2H, Δ^{12}	[429]
	−15.2°, MS, ^1H, ^{13}C, 2D, 502 $[M]^+$	3β,6β,19α-tri-OH, 23-CHO, 28-CO_2H, Δ^{12}	[429]
	+50.0°, ^1H, ^{13}C, 2D, MS, 472 $[M]^+$	3β,6β,19α-tri-OH, 23-nor, 24-exomethylene, 28-CO_2H, Δ^{12}	[429]
Ecdysanthera rosea (Apocynaceae)	578 $[M]^-$	3β-palimitoyloxy, D-friedo, 11α,12α-epoxy, Δ^{14}	[430]

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