CHAPTER 2

2. GENERAL CHEMICAL ASPECTS OF ALKALOIDS

2.1. General

Plants have been explored by chemist for their chemical compounds and their related medicinal values. Throughout this exploration many alkaloids and drugs were identified and studied. The studies have been aimed at compounds that are of the pharmaceutical interest in the scope of medicinal importance.

Phytochemical studies of Lauraceae plants have produced non-alkaloid (e.g. carbohydrates, lipids, amino acids, proteins, polyphenol, essential oils, terpenes, aromatic compounds) and alkaloid constituents. The production of those phytochemicals from the Lauraceae plants has been the subject of a number of comprehensive articles.[12-15]

Since the early stages of man, plants play an important role as medicine to the human race. Often the bioactive compounds in the plants that intrigue the chemist are the nitrogen containing bases called alkaloids. Alkaloids have complex molecule structure and they have significant pharmacology activities. Some alkaloids stimulate the central nervous system, while others cause paralysis. Some alkaloids are derived from relatively simple precursors such as phenylalanine, trytophan, “acetate-unit”, terpene units and methionine ornithine.

2.2. Alkaloids: Definitions

The term alkaloid is applied to nitrogen containing molecules belonging to one of the largest and most diverse families of naturally occurring compounds. It has been estimated that in excess of 6000 compounds with the alkaloid-like properties are known, comprises the largest single class of secondary plant substance. The nitrogen usually is part of heterocyclic system. These compounds are grouped together by the presence of nitrogen atom in their structure.[16]

The term alkaloid was coined in 1819 by the pharmacist W. Meisner and meant simply, alkali like (Middle English alcaly, from Medeval Latin alkali, from Arabic "alqaliy = ashes of stalwart, from qualey, to fry)[17]. Alkaloid derives from the word 'alkaline', which means a water soluble base.

A definition of alkaloid-like by Winsterstein and Trier's (1910) described as basic compounds that contain heterocyclic nitrogen, and are synthesized in plants from amino acids or their immediate derivatives in either plant or animal orign.[18]

An "alkaloid" is a substance with nitrogen in the molecule, connected to at least two carbon atoms and must have at least one ring, but not necessarily heterocyclic, that definition has been proposed by Nowacki and Nowacka in 1965. Alkaloids are grouped in three main categories based on knowledge and speculation about their biogenesis.[19]

Most alkaloids are colourless, crystalline compounds: e.g. coniines, but some such as nicotine and hygrine, are liquids. Most of them are optically active and the different active forms are usually found but not in different plants. Several examples of common alkaloid ring skeleton are illustrated in Table 2.1.

The present of alkaloids is detected either by precipitants or colour reagents. The more important precipitant are Mayer, Wagner, Dragendorff and Hager shown in Table 2.2[22]. The color reagents mostly consist of dehydrating, oxidizing or a combination of two.[23]

Alkaloids are often toxic to man and have many dramatic physiological, hence their wide used in medicine. For examples, cinchona alkaloids which, is present in the bark of *Cinchona* sp. and *Remijia* sp. consisted of quinine as their main constituents which has been known as anti malarial agent. Their biosynthetic precursors are always amino acid, other multi carbon units, e.g. acetate are also incorporated into the final structure of some alkaloids.[24]

Table 2.1: Example of Alkaloids Skeleton

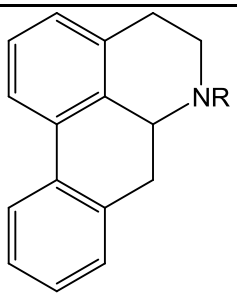
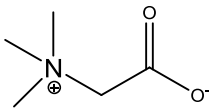
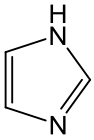
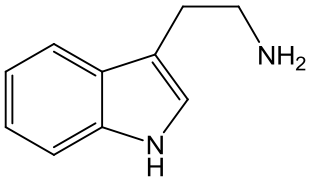
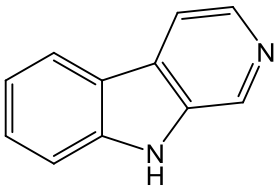
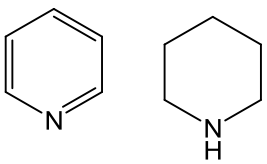
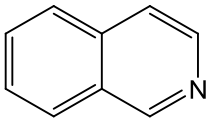
Class	**Generic structure**	**Examples**
Aporphine (Tyrosine derived)		Boldine
Betaines		Choline
Imidazole		Pilocarpine
Tryptamines		Serotonin
β-carbolines		Reserpine
Pyridine (Nicotinic acid derived)		Piperine
Isoquinoline (Tyrosine derived)		Morphine

Table 2.2: Reagents for detecting Alkaloids

Reagent	Composition of the reagent	Result
Meyer's reagent	Potassiomercuric iodide solution	Cream precipitate
Wagner's reagent	Iodine in potassium iodide	Reddish brown precipitate
Hager's reagent	A saturated solution of picric acid	Yellow precipitate
Dragendorff's reagent	Solution of potassium bismuth iodide	Orange or reddish-brown precipitate

2.3. Functions of Alkaloids

Although their biogenesis and metabolism have been studied in many cases, function of alkaloids is still vague and not really understood by the chemist. There are some proposed roles of alkaloids in plant metabolism, plant catabolism or plant physiology as listed below:-[25]

- As end product of the metabolism or waste products
- As storage reservoir of nitrogen for protein synthesis
- As protective agent for the plants against attack by predators (parasites or herbivore)
- As plants stimulants and regulators in activities such as growth, metabolism and reproduction.
- As a detoxification agent, which renders harmless certain substances, accumulation of which might cause damage to the plant.

2.4. Alkaloid Classification

Chemical, pharmacological, botanical properties must all consider in classifying a compounds as an alkaloids. The plant species in a same family or genus often produce bases with biogenetically similar structure, they have been conveniently classified by their origin (e.g. amyryllidaceae alkaloids) and structural type (e.g. bisbenzylisoquinoline alkaloids).[26] Alkaloids are grouped in three main categories (Scheme 2.1) based on both of knowledge and speculation about their biogenesis.[27](Scheme 2.2)

- **True Alkaloid**

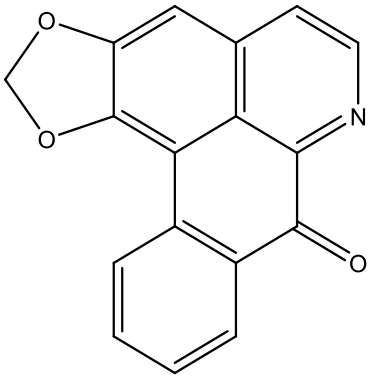
The true alkaloids are compound in which the nitrogen-containing heterocyclic system is derived from a biogenetic amine, formed by decarboxylation from an amino acid. They are usually found as salts in plant such as liriodenine **1** and morphine **2**

- **Pseudo Alkaloid**

Pseudo alkaloids are apparently unrelated to amino acid. They are nitrogen containing molecules but they have carbon skeletons derived from monoterpenes and other acetate derivatives and aliphatic polyketoacids such as coniine **3** and *β*-skytanthine **4**.

- **Proto Alkaloid**

These compound like true alkaloids, are derived from amino acid or biogenetic amines but they do not contain any heterocyclic system. They are represented in nature by biogenetic amine themselves and their methylated derivatives such as serotonin **5** and mescaline **6**



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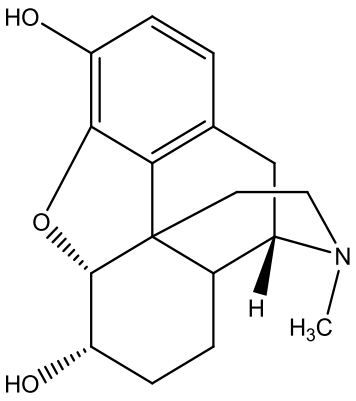

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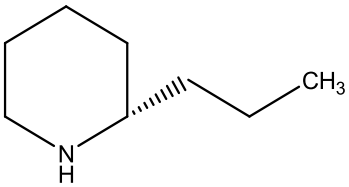

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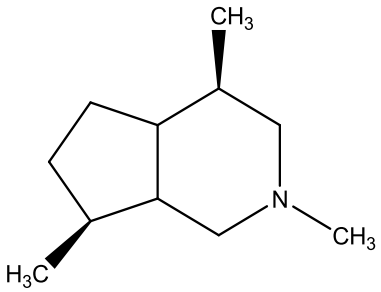

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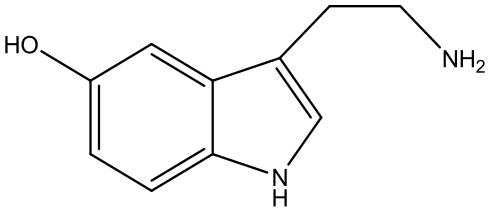

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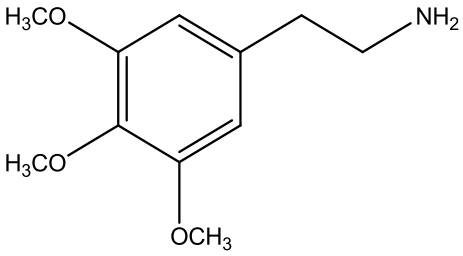

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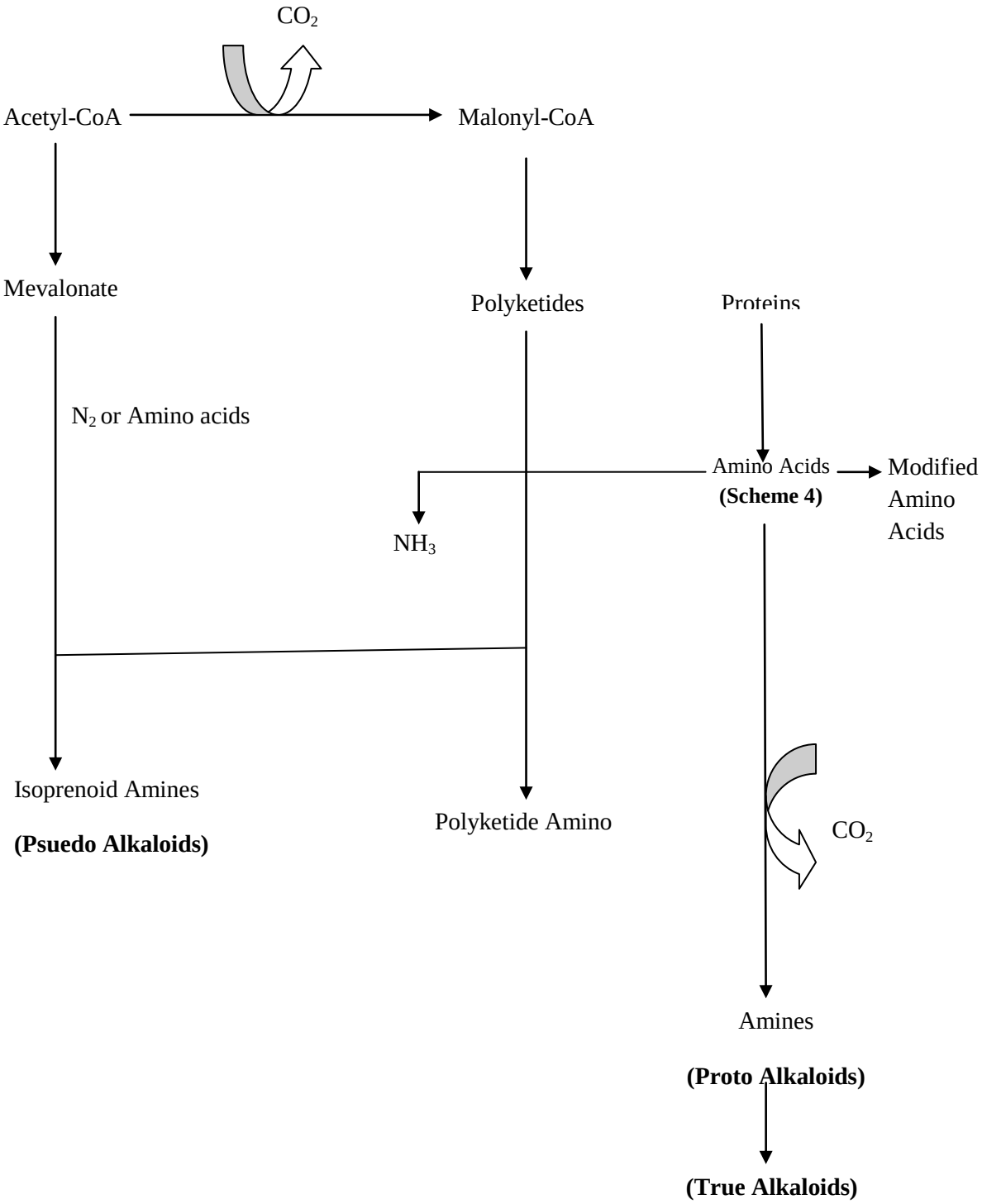
Scheme 2.1: Example of Alkaloids Based on Three Main Categories



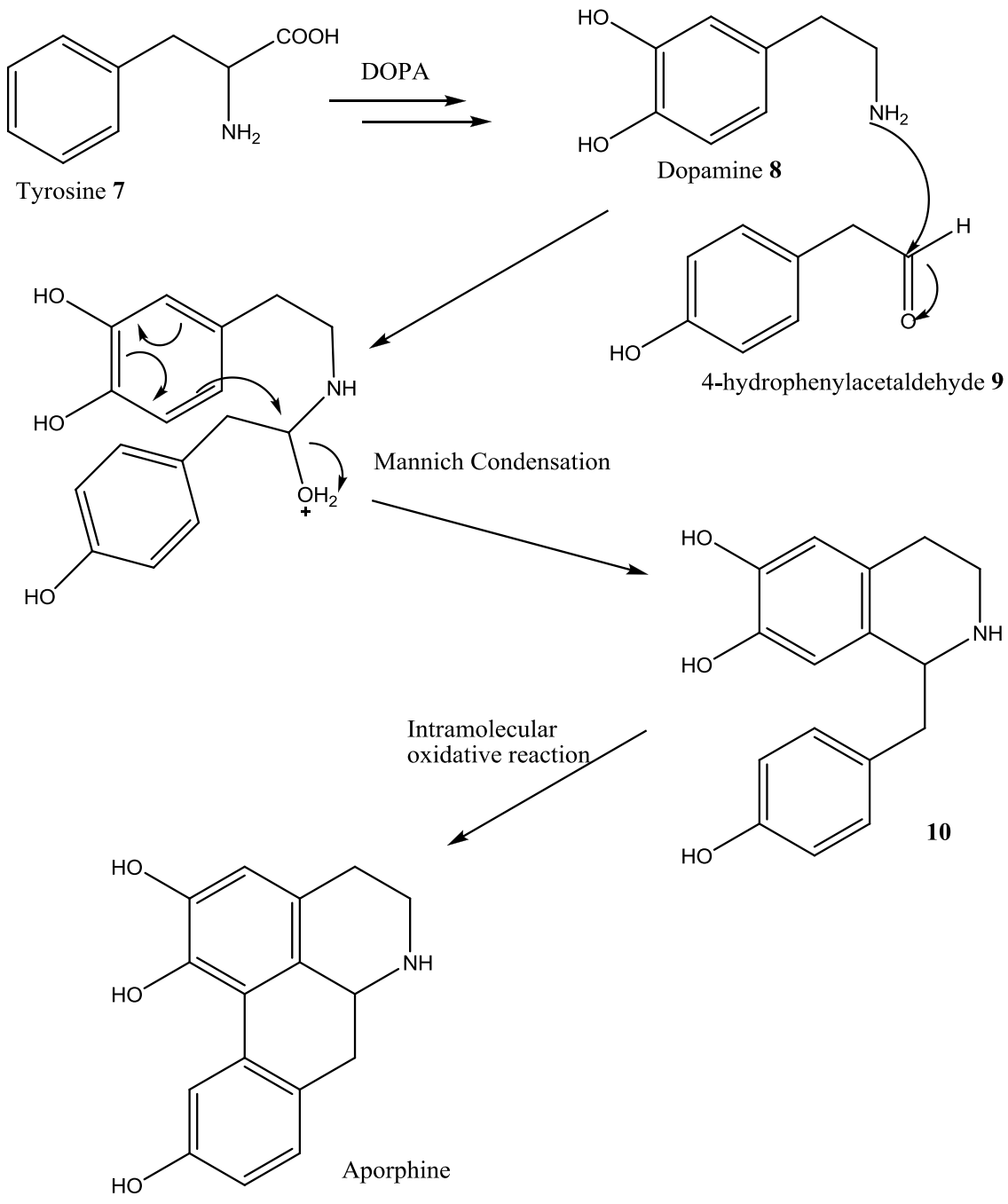
Scheme 2.2: Classification of Alkaloids based on Biogenesis Concept. [34]

Classification also can be done based on other factors such as; biogenesis, structural relationship, botanical origin and spectroscopic criteria. Examples for biogenesis classification are aporphine (Scheme 2.3) and bisbenzylisoquinoline (Scheme 2.4) type of alkaloids. Biosynthesis is the experimental study of the formation of secondary metabolites. Thus, biogenesis is the hypothetical speculation on the precursor – product relationship in a biosynthetic pathway. Biogenesis in the past 70 years has proved to be a very interesting and fruitful area of organic chemistry. Most of alkaloids of Lauraceae, are isoquinoline type derived from tetrahydrobenzylisoquinoline which originated from tyrosine.

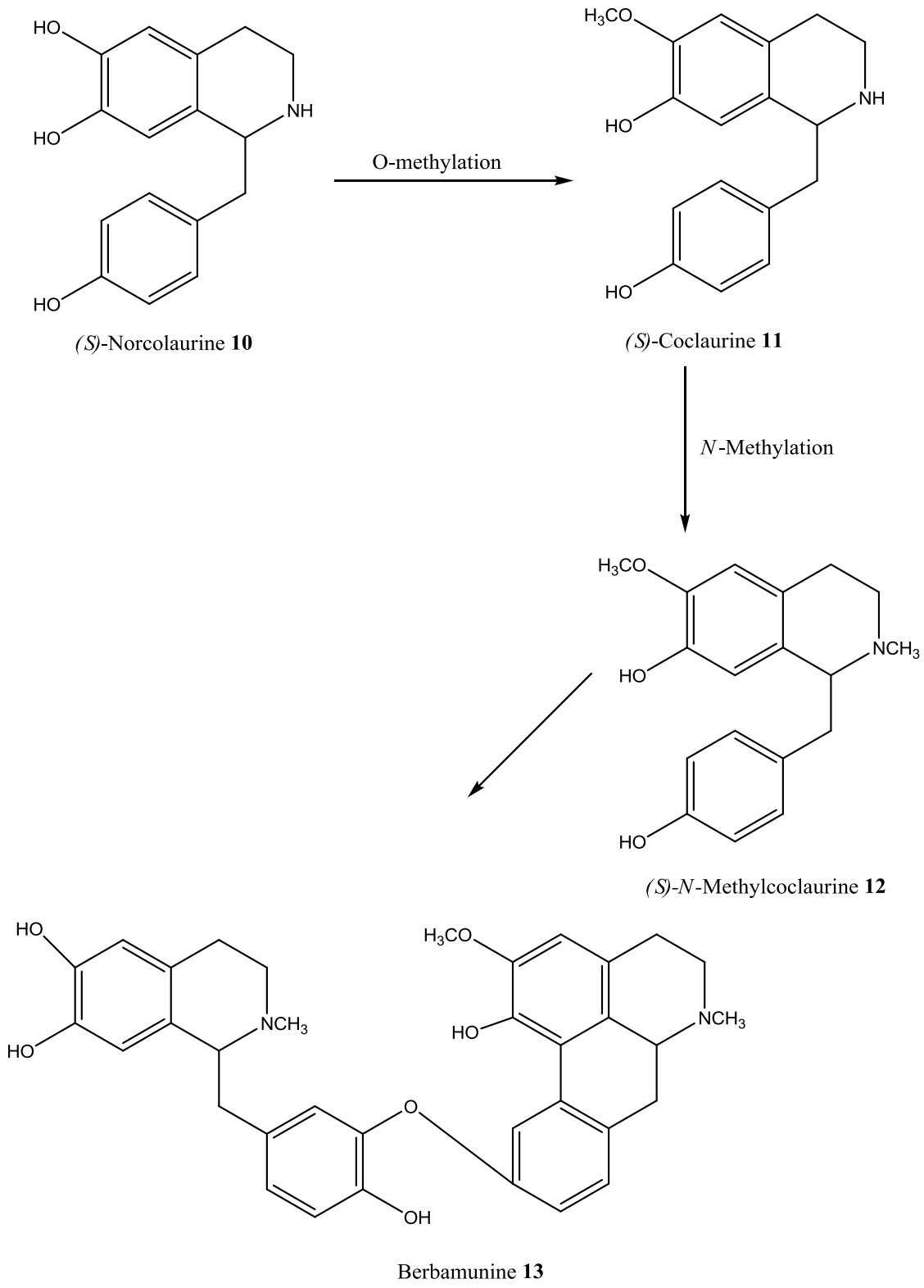
Experiment with labeled precursor and cell cultures showed that condensation between dopamine **8** and 4-hydrophenylacetaldehyde **9** from amino acid tyrosine **7** yielded the first alkaloid intermediate *(S)*-norcoclaurine **10**, which mark the first and central intermediate of isoquinoline alkaloids. Intramolecular oxidative reaction from the *(S)*-norcoclaurine **10** gives aporphine structure.[28, 29](Scheme 2.3)

Bisbenzylisoquinoline biosynthesis can be divided into three classes; biscoculaarines, cocularines-reticulines and bisreticulines. *(S)*-Norcoclaurine **10** can be change to *(S)*-coclaurine **11** by *O*-methylation for hydroxyl group at position 6. Most bisbenzylisoquinoline are formed through the condensation of two (*S)-N*-methyl coclaurine **12** or coclaurine units[28, 30]. The phenolic oxidative reactions, with two tetra hydrobenzylisoquinolines moieties are combined together through formation of diaryl ether bridge, as example here bisbenzylisoquinoline alkaloids berbamunine **13**. Following the initial dimerization, a second or third oxidative coupling may occur in this bisbenzylisoquinoline formation[31-33] (Scheme 2.4). The conclusion of biosynthetic

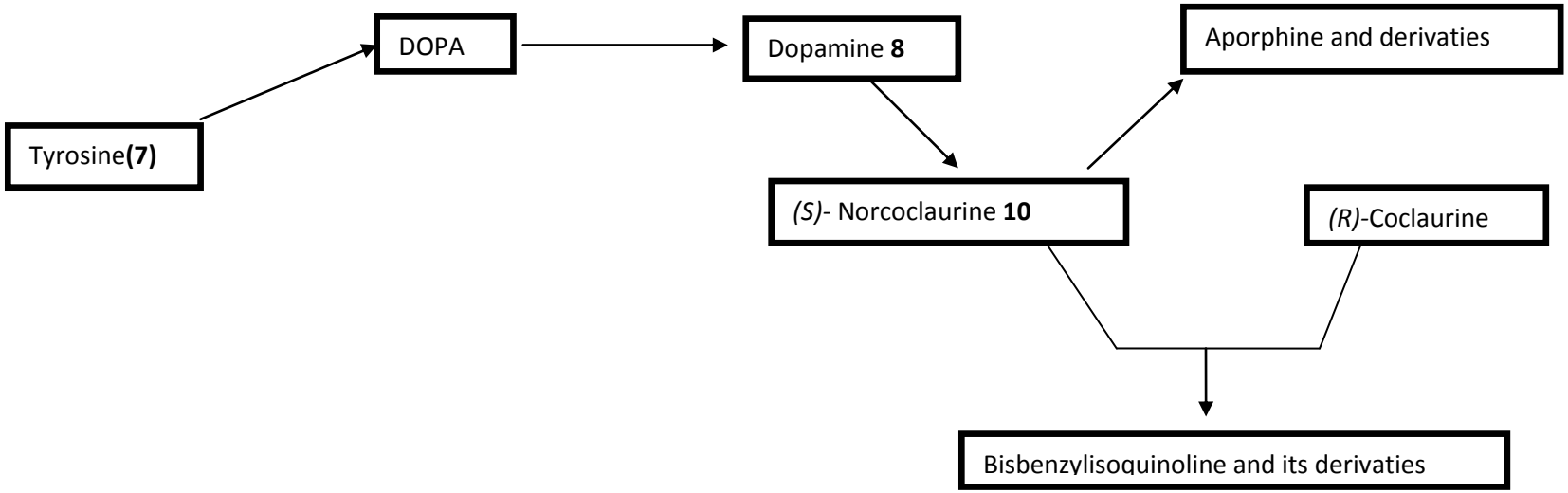
sequence leading from tyrosine to bisbenzylisoquinoline and aporphine is shown in (Scheme 2.5)[34]



Scheme 2.3: Biosynthesis of Aporphine Alkaloids from Amino Acid **7**



Scheme 2.4: Biosynthesis of Berbamunine from (*S*)-norcoclaurine **10**



Scheme 2.5: Biosynthetic Sequence Leading from Tyrosine to Bisbenzylisoquinoline and Aporphine[34]

2.5. Isoquinoline Type of Alkaloids

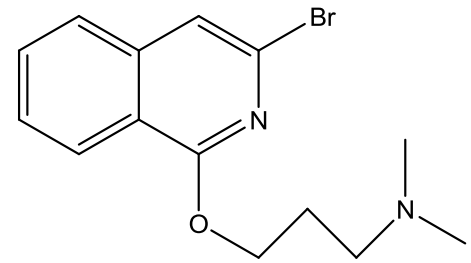
Isoquinoline is chemically known as benzo [c] pyridine or 2-benzanine. The alkaloids that possess isoquinoline skeletons are known as isoquinoline alkaloids. Isoquinoline groups may be further subdivided into several groups such as simple isoquinoline, benzylisoquinoline, bisbenzylisoquinoline, protobarbene, aporphine, oxoaporphine, phenantrene and miscellaneous isoquinoline type alkaloids. Various types of isoquinoline alkaloids maybe found in Lauraceae with aporphine being the major group of this type.[35]

The isoquinoline backbone is biosynthesized from the aromatic amino acid tyrosine **7**. Isoquinoline is a weak base with *pKa* of 8.6 and has unpleasant odour. Isoquinoline itself is a colourless hygroscopic liquid at room temperature. It is slightly soluble in water but well soluble in common organic solvents. The bisbenzylisoquinoline and aporphine alkaloids will be discussed briefly in the next section since the author has isolated this type of alkaloids from the species studied.

Isoquinoline alkaloids have important medicinal value. A number of these alkaloids is available as drugs. Example of isoquinoline derivatives with medicinal values are shown in Table 2.3.[22]

Table 2.3: Isoquinoline Alkaloids with Medicinal Value

Isoquinoline Alkaloids (Scheme 2.6)	**Medicinal uses**
Dimethisoquin **11**	Anaesthetic
Quinapril **12**	Antihypertensive agent
Papaverine **13**	Vasiladator
Morphine **14**	Narcotic analgesic



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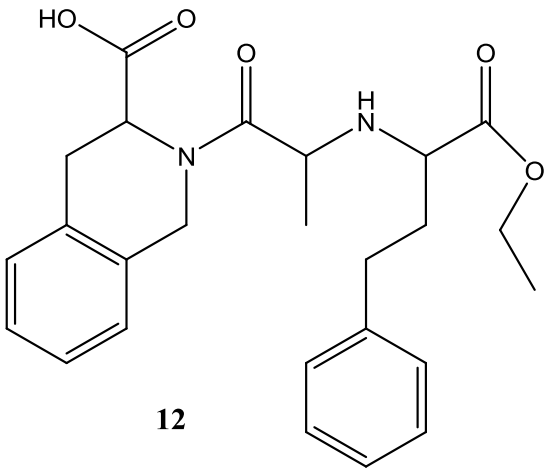

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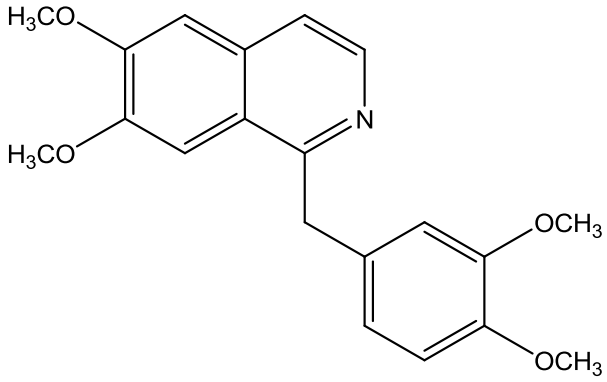

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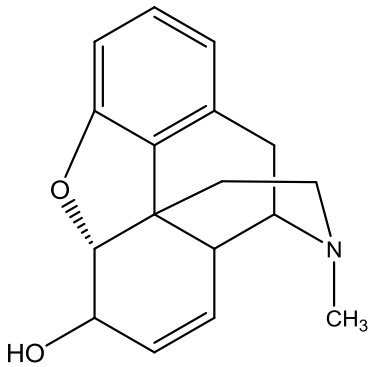

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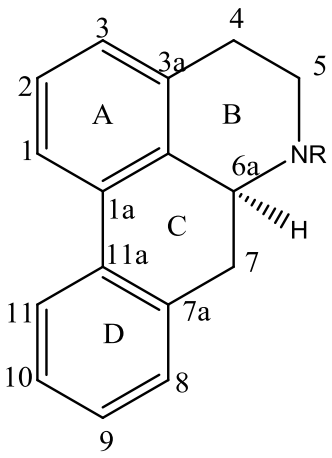
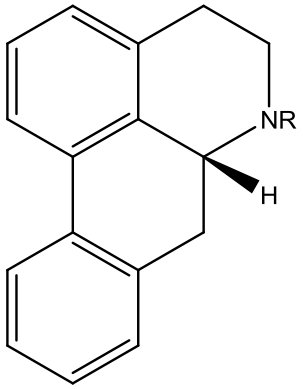
Scheme 2.6: Structures of Isoquinoline

2.5.1 Aporphine[36-39]

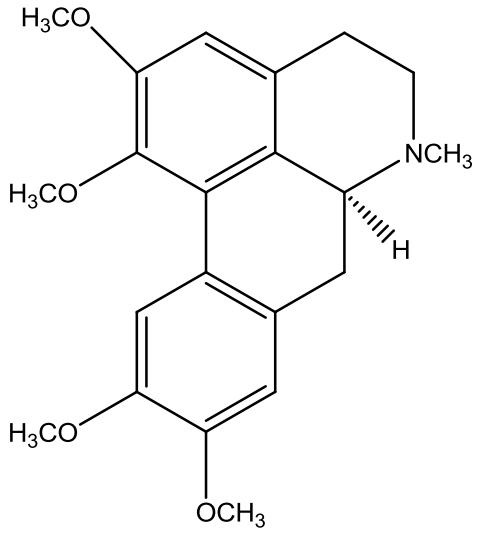
Aporphine alkaloids are the largest group within the isoquinoline alkaloids. For the naturally occurring aporphine alkaloids, positions 1 and 2 are always oxygenated and frequently other positions are also substituted with hydroxyl, methoxy, or methylene dioxy groups. *S*-(+)-Glaucine **15** and *S*-(+)-bulbocapnine **16** were among the first naturally occurring aporphines to have their structure elucidated and usually the natural alkaloids proved to be optically active, possessing either the *R* or *S* absolute configuration. The aporphine alkaloids contain a twisted biphenyl system. The molecule can exist in either absolute configuration *S* series or its mirror image *R* series. The numbering of aporphine skeleton is generally represented by the structure below.



H-6a-*(S)*



H-6a-*(R)*



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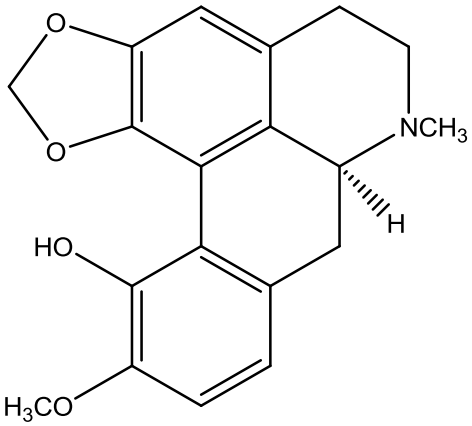

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2.5.2 Bisbenzylisoquinoline

Natural product chemist and pharmacognosists are interested in the bisbenzylisoquinoline alkaloids because of their diverse formulations and varied pharmological effects, for example tetrandine was reported to show verapamil-like calcium antagonistic, antiarrhythmic and platlet aggeregation-inhibiting actions,[40, 41] berbamine was suggested to show calcium channel blocking, isoproterenol and histamine as antagonizing actions[42,43]and obemegine possessed α-adrenoreceptor-blocking and hypotensive activities.[12]

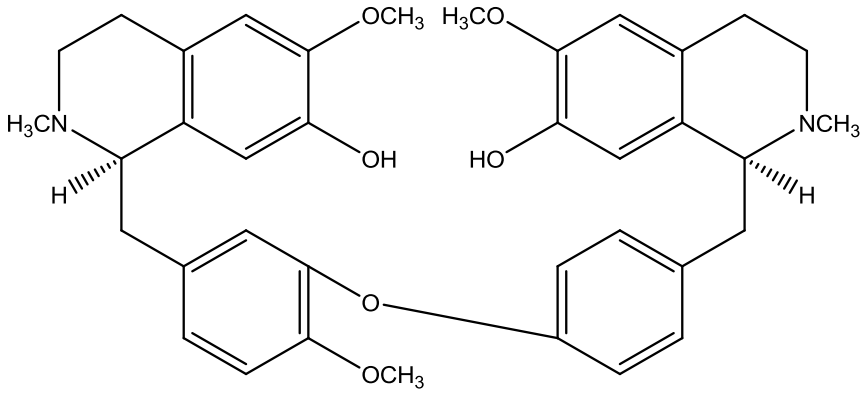
Bisbenzylisoquinoline alkaloids are made up of two benzylisoquinoline units linked by one or more ether bridges. In addition, direct carbon to carbon biphenyl linkages and methyleneoxyl linkages are also found. The isoquinoline portion is considered as 'head' of the monomer and the benzyl portion as the 'tail' of bisbenzylisoquinoline structure.[8, 35,44] The substituent on the aromatic rings may be hydroxyl or methoxy or methylenedioxy groups.

Another factor that adds complexity to the bisbenzylisoquinoline is that two asymmetric centres are usually present, and these may be *R* or *S* configuration. Thus, the challenge in the identification of a new bisbenzylisoquinoline is sometimes substantial, given the degree of variation of structural features which may be encountered, differing simply in the nature of the oxygenated substituent (OH, OCH_3, OCH_2O), or the oxidation state or degree of substitution of the two nitrogen atoms (imine, pyridine, NH, NCH_3 or tertiary amine), or yet in stereochemistry at the two asymmetric centers. [21]

Based on the differences of aromatic oxygen substituents, numbers of ether linkages and the nature of ether bridges (diaryl ether or benzyl phenyl ether), the bisbenzylisoquinoline alkaloids are classified into 5 groups and 27 subgroups. [21,45] Several example of the subgroups are listed below.

A. Alkaloids containing one diaryl ether linkage between C11 and C12'. This group belongs to the subgroups of type I, Ia, II, III, IV, V bisbenzylisoquinolines.

   Example: Thaligrisine **17**[46]



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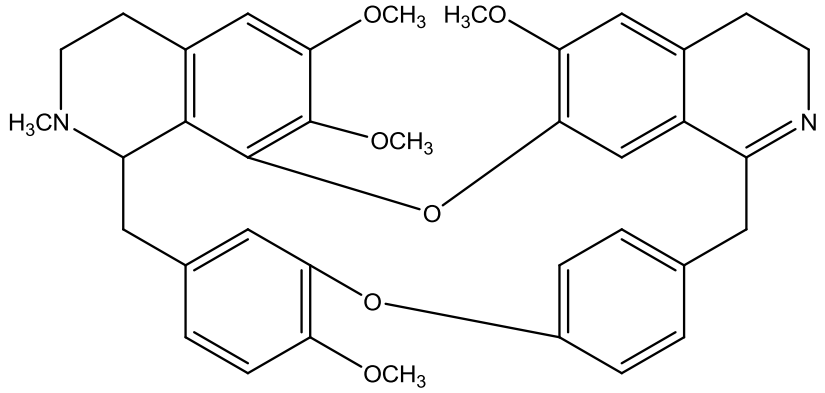
B. Alkaloids containing two diaryl ether linkages. All these types contain ether linkages between the aromatic rings of tetrahydrosioquinoline component and the benzyl rings. This group belongs to the subgroups of type VI, VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI bisbenzylisoquinoline. Example: Dehatrine **18**[47]



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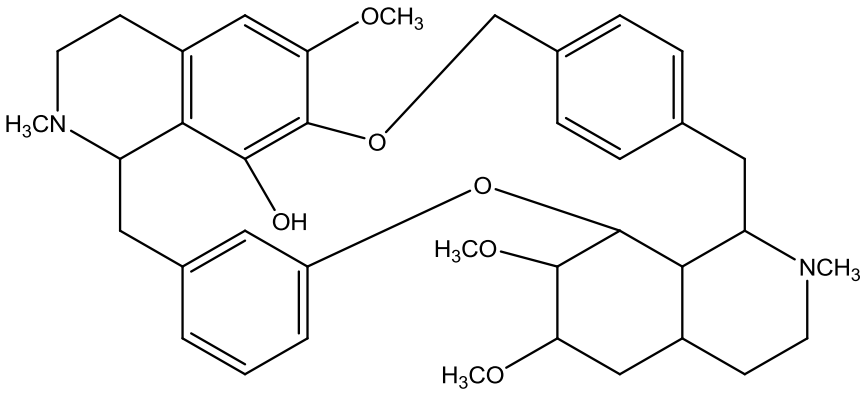
C. Alkaloids with one diaryl ether and one benzyl phenyl ether linkages. This group belongs to the subgroups of type XXII bisbenzylisoquinoline

Example: Cycleaneonine **19**[48]



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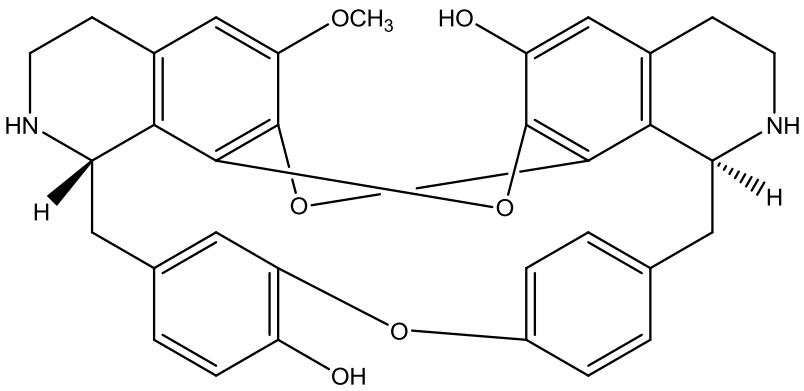
D. Alkaloids with three ether linkages. This group belongs to the subgroups of type XXIII, XXIV bisbenzylisoquinoline

Example: Cocsilinine **20**[49]



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E. Alkaloids containing two diaryl ether and one diphenyl benzyl ether linkages. This group belongs to the subgroups of type XXV, XXVI bisbenzylisoquinoline

Example: Insularine 2*α*-*N*-*Oxide* **21**[50]

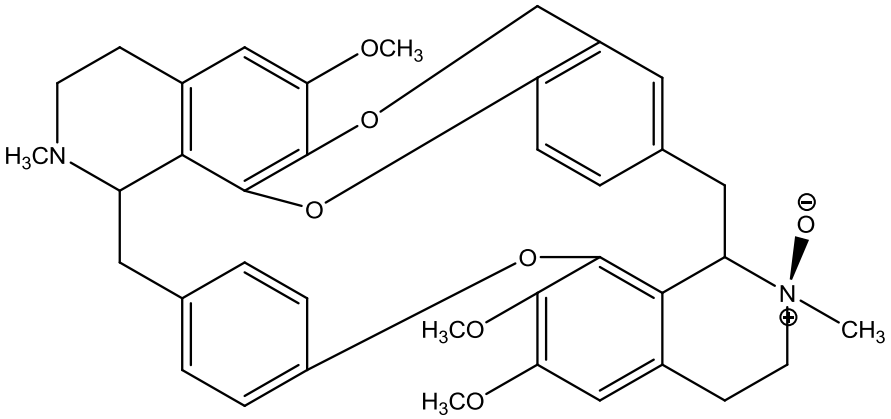

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Figure 2.00: Classification of Bisbenzylisoquinoline Alkaloids.[35]

2.6. Structure Elucidation of Alkaloids: General Method and Theory

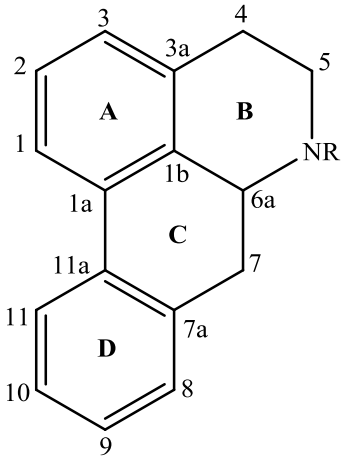
Most common methods applied for structural elucidation are:

^{1}H and ^{13}C NMR	:To detect number and peak of proton and carbon
Infrared spectroscopy	:To detect functional groups
Ultraviolet spectroscopy	:To detect conjugated systems
Mass spectroscopy	:Measures the mass-to-charge ratio of organic ions
Optical rotary dispersion	:Measures the change in rotary power of molecules

In the following section, the general spectral behavior of aporphine and bisbenzylisoquinoline will be discussed briefly.

2.6.1 Aporphine

Aporphine alkaloids consist of four rings (A, B, C, D). The numbering of aporphine skeleton is generally represented by the structure below.



2.6.2 ^{1}H NMR Spectroscopy

^{1}H NMR chemical shift of aporphine shows the high field shift of the methoxy group which is attached to C-1 and C-11 due to the anisotropic effect generated by π-electron system in the benzene ring. Benzene rings are magnetically very anistropic because applied magnetic fields readily generate currents in the π -electron. A proton held directly above or below the aromatic ring should be shielded. Normally, when position C-1 and C-11 are substituted; C-2 also substituted where the methoxy group at C-1 and C-11 will be sterically hindered thus result the push of methoxy proton out of the ring plane which is shielded area. In addition, the ring A and ring D are facing each other; hence the methoxy proton can arrange them on the adjacent ring, which happened to be a shielded zone, giving a more up field shift.[51]

The aromatic hydrogen at position C-11 is found downfield between δ 8.74-7.68. H-11 usually resonates at lower field δ 8.67-8.43 with respect to the other protons if a methoxy group substitutes C-1. The low field shift must be attributed not only to deshielding by the neighboring ring, but also to anisotropy effect of the C-O single bond or effects due to C-O electric dipoles as the hydrogen is held very close to the opposite oxygen atom from methoxy group. This O-H distance has been estimated to be ~1.9 Å, which could allow for hydrogen bonding. H-11 is shifted to δ 8.28-8.04 if they are also *ortho* to a methoxy group. H-3 normally resonates at a higher field when it is *ortho* to a hydroxyl or methoxy group. It is due to the inductive effect. When methoxy substituted at C-9, both proton in position 8 and 10 are shifted to a higher field. These values are in agreement with those expected for proton *ortho* to a methoxy or hydroxyl group.[52] The *N*-methyl resonates between δ 2.50-2.60 and the aliphatic protons of C-4, C-5 and C-7 displayed a complex absorption pattern between δ 2.40 and δ 4.44.[53, 54]

Table 2.4: General ^{1}H NMR Data (δ) of Aporphine Alkaloids in $CDCl_3$

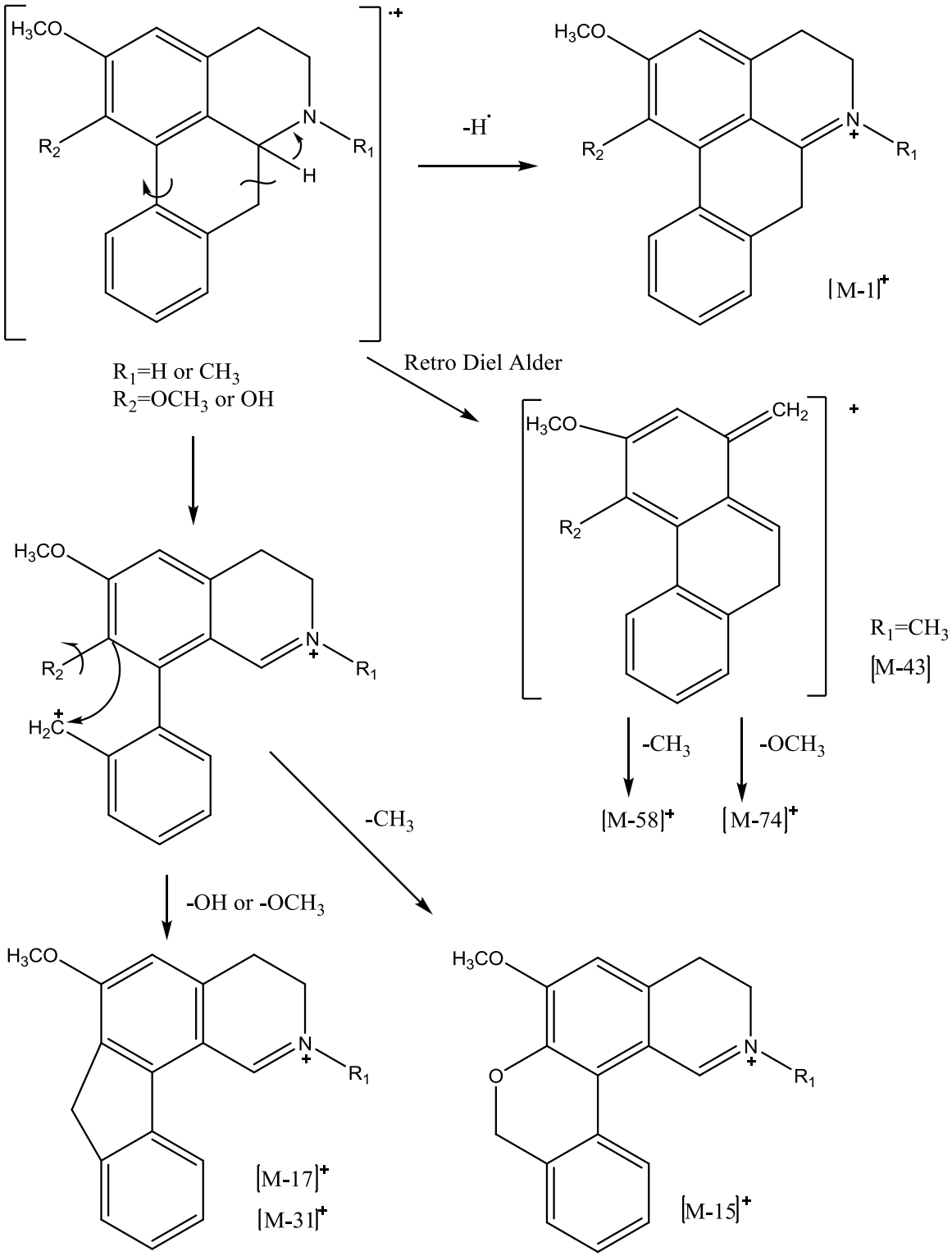
Position substituted	**Methoxy Group (δ)**	**Aromatic Proton (δ)**	***N*-methyl Group (δ)**	**Aliphatic Group (δ)**
C-1	3.70-3.55			
C-2	4.00-3.72			
C-3				
C-8		7.00-6.38		
C-9	4.00-3.72	7.00-6.38		
C-10	4.00-3.72			
C-11	3.72-3.65	8.74-7.68		
***N*-Me**			2.50-2.60	
C-4				2.40-4.44
C-5				2.40-4.44

2.6.3 ^{13}C NMR Spectroscopy

In ^{13}C NMR sp^2 carbon bearing hydrogen normally resonate at δ 105.0-112.0 while the sp^2 carbon at position 1a, 1b, 3a, 7a, and 11a appeared at δ 119.0-130.0. For sp^3 carbon at position 4 revealed at δ 28.0-30.0; C-7 resonates at δ 35.0; C-5 and C-6a δ 42.0 and δ 52.0 for aporphine and δ 53.0 and δ 62.0 for noraporphine respectively. The substituent carbon *N*-methyl group resonates at δ 43.0. Methoxy carbon signal appears at δ 56.0-62.0.

2.6.4 Mass Spectroscopy

In mass spectrum, the fragmentations of the aporphines are mainly due to the loss of hydrogen beside nitrogen [6a-H]. The $[M-1]^+$ peaks always serve as the base peak of the molecule. $[M-15]^+$, $[M-17]^+$ and the $[M-31]^+$ peak will also be observed due to the expulsion of the methyl, hydroxy, or methoxy group respectively. Aporphine compounds having the *N*-H or *N*-CH3 groups will display peaks at $[M-29]^+$ and $[M-43]^+$ respectively. The fragment loss is methylene imine group (CH_2=NR) which is expelled via a retro Diels Alder mechanism. The ion formed can further lose another methyl or methoxy to produce peaks at $[M-74]^+$,$[M-58]^+$,$[M-60]^+$ and $[M-44]^+$ peaks. The fragmentation patterns are shown in Scheme 2.7.[51, 54]



Scheme 2.7: The Principal Mass Fragmentation of Aporphine Alkaloids.

2.6.5 Ultraviolet Spectroscopy[55]

The zone of absorption in the ultraviolet region for the skeleton depends heavily on the substitution pattern around the aromatic area, not the nature of the substituent. The general observations are listed as below.

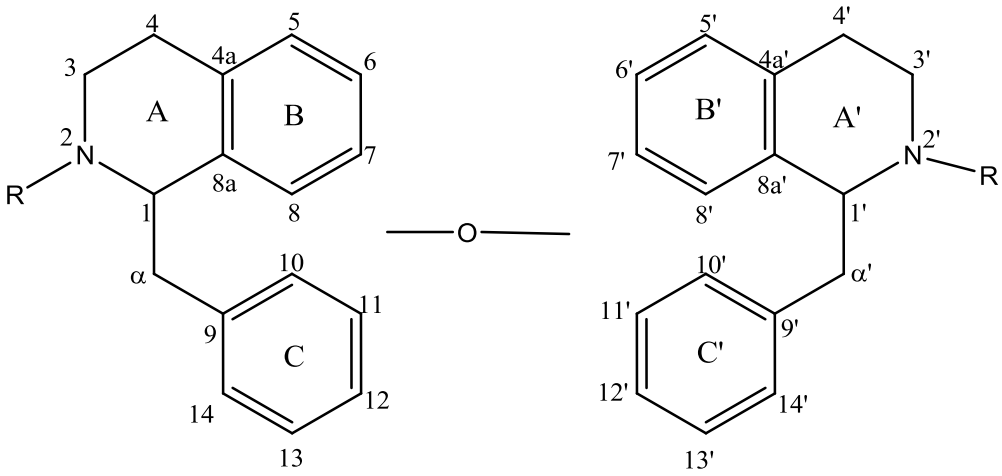
Table 2.5: Ultraviolet Absorptions for Aporphine Types

Substitution	**Maximum Absorption (nm)**
1, 2	234, 273, 312
1, 2, 9	233, 280, 305
1, 2, 10	226, 266, 275, 305
1, 2, 11	220, 265, 272, 300
1, 2, 9, 10	220, 282, 305
1, 2, 10, 11	220, 270, 305

In addition, the monophenolic aporphine at position C-3 and C-9 gives a shift at 315 nm and 350 nm in alkaline environment.

2.6.6 Bisbenzylisoquinoline

Bisbenzylisoquinoline consists of six rings (A, B, C, A', B', C'). The numbering of bisbenzylisoquinoline skeleton is generally represented by the structure below. Further discussion will be based on the spectra of bisbenzylisoquinoline containing one diaryl ether linkage; tail to tail (C11-*O*-C12') and two diaryl ether linkages; head to head and tail to tail type VI bisbenzylisoquinoline, since the author has isolated these two types of bisbenzylisoquinoline alkaloid.

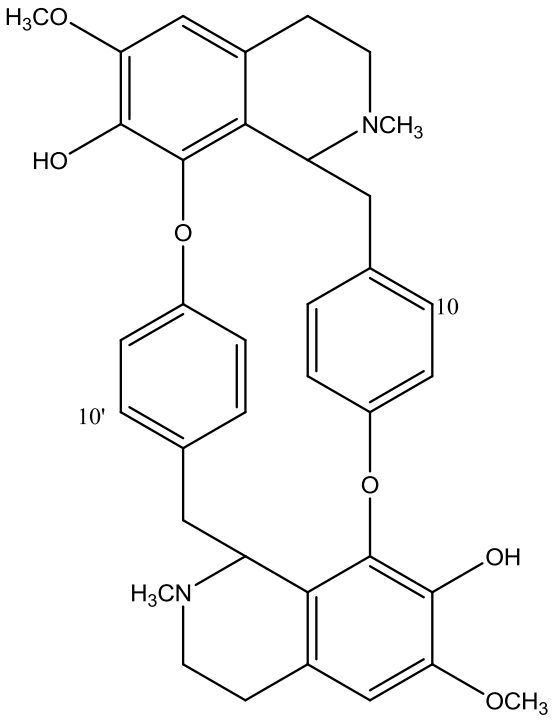


2.6.7 ^{1}H NMR Spectroscopy

The bisbenzylisoquinoline alkaloids are often very sensitive to temperature or variations in acidity or basictiy, making an exact comparison of spectra with literature values rather difficult.

The ^{1}H NMR spectra of isochondodendrine **22** show equivalence, due to symmetry of pairs of benzyl ring aromatic protons (e.g.: H10 and H10'). However, because of restricted rotation of benzyl rings, all four protons within either ring are nonequivalent.

The constant presence of ABX and AA'BB' system respectively assigned to the proton in the 10, 13, 14 and 10', 11', 13', 14' position.[56]



22

The *N*Me group attached to C-2 and C-2' will have the average chemical shifts in the region of δ 2.30 to 2.70. The methoxy group at position C-6 provides peak at δ 3.82 to 3.96 and usually there will be another methoxy at position C-6'. The chemical shift at this position is δ 3.49 to 3.95. The position at C-7' is methoxylated that always appears between δ 3.15 to 3.25 which is further up field than other positions.

The signal for H-1 is usually close to δ3.55 while for H-1' is near at δ4.20 but it will depend upon the nature of the oxygenated substituent on the ring A and ring A' so do aromatic protons. The peaks for H-1 and H-1' are difficult to observed since they are hidden beneath the singlet for the protons of the methoxyl groups between δ 3.60 and δ

4.05. H-1’ peaks always appeared as the doublet of the doublets and a singlet or a doublet for H-1.

A methoxyl group lying in the plane of the ring will have lower chemical shift than those of a methoxyl group above and below the ring due to an anisotropic effect generated by π-electron system in the benzene ring.[57] The presence of bulky substituent near a methoxyl group will tend to force it out of the aromatic plane. Therefore, its chemical shift will appear upfield. Whereas the same group at position 11’ has a chemical shift that slightly at the lower field.

2.6.8 ^{13}C NMR Spectroscopy

^{13}C NMR provides useful data on the confirmation and configuration of bisbenzylisoquinoline alkaloids. The sp^3 carbons (methylene) for position C4, C*α*, C3 usually appear at δ 22.0-50.0. The methoxy carbon signals appeared at normal field near δ 56.0 except for those which attached to C-7 which is sterically hindered, caused the signal to appear further upfield at δ 60.0. The *N*-methyl carbons are at δ 42.0 and they are practically equivalent in all compounds.

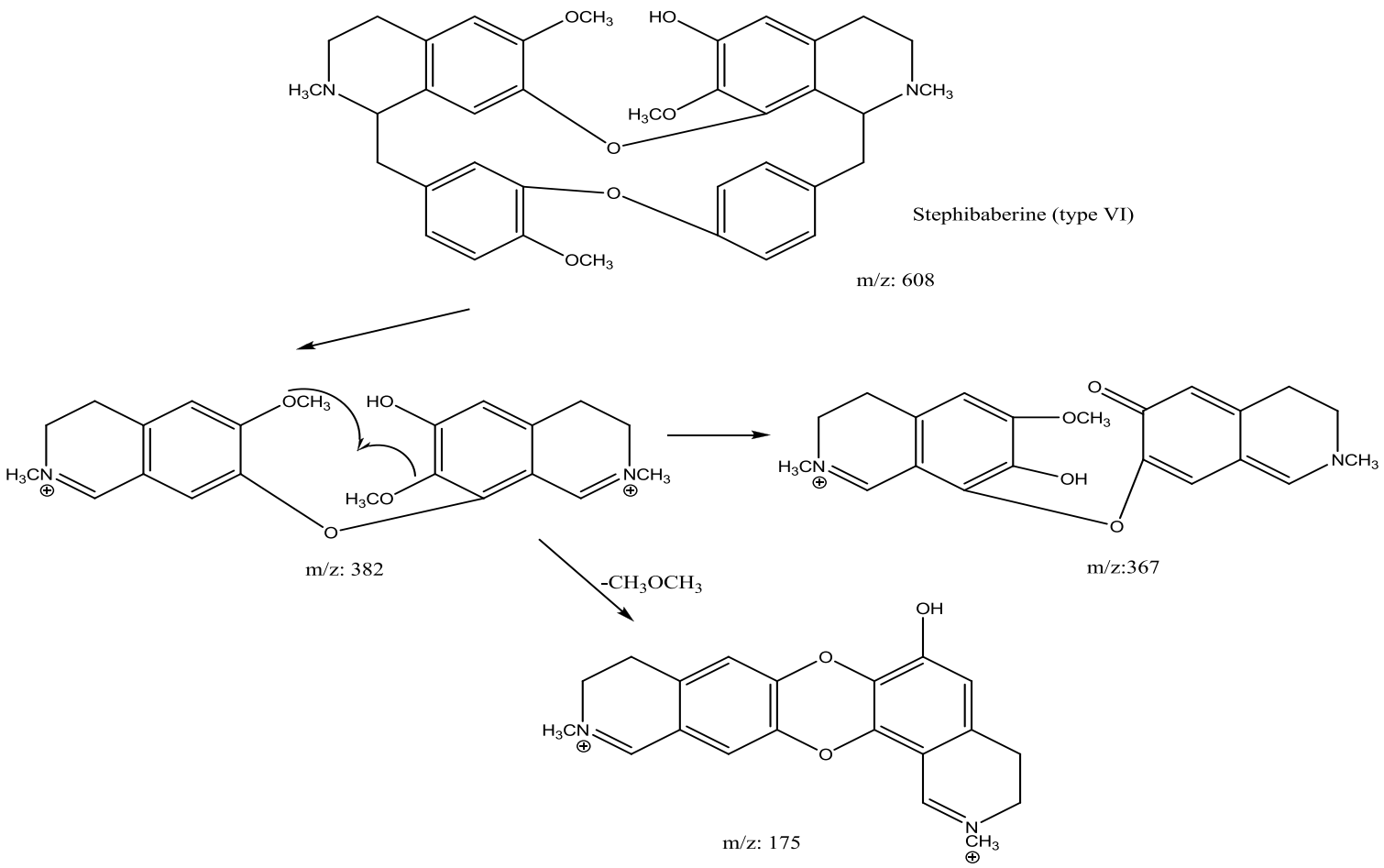
The chemical shift of carbon at position 1 and 1’ appeared further downfield at δ 64.0[58, 59]. The presence of an oxygen substituent at position 6, 6’, 7, 7’ and 12 will cause them to resonate further downfield at δ140-150. The sp^2 carbons (aromatic ring B, B’, C, C’) resonate at δ 111.0-130.0. As an example in ring C carbon resonate at 122.7 (C-10), 112.7 (C-13), and 126.2 (C-14).

2.6.9 Mass Spectroscopy

Mass spectroscopy is particularly useful in cases of dimers with usual structural features. Structural classification of bisbenzylisoquinoline alkaloids according to the number and the mode of the diaryl ether linkages are well correlated with their mass spectrometric fragmentations.

The mass spectra molecular ion of this type is 40 to 60% of the base peak and is always accompanied by $[M-1]^+$ and $[M-2]^+$ peaks. The most characteristic feature of the mass spectra is fragmentation through loss of ring C from the molecular ion.

High abundances of doubly charged ions are often observed in head to head coupled alkaloids. These fragments suggest that these ions may arise by generation of a singly charged radical cation, loss of benzyl radical and expulsion of a benzyl anion from the intermediate cation. The principal fragmentation for this type is shown in Scheme 2.8.[45]



Scheme 2.8: Mass Fragmentation of Stephibaberine

2.6.10 Ultraviolet Spectroscopy

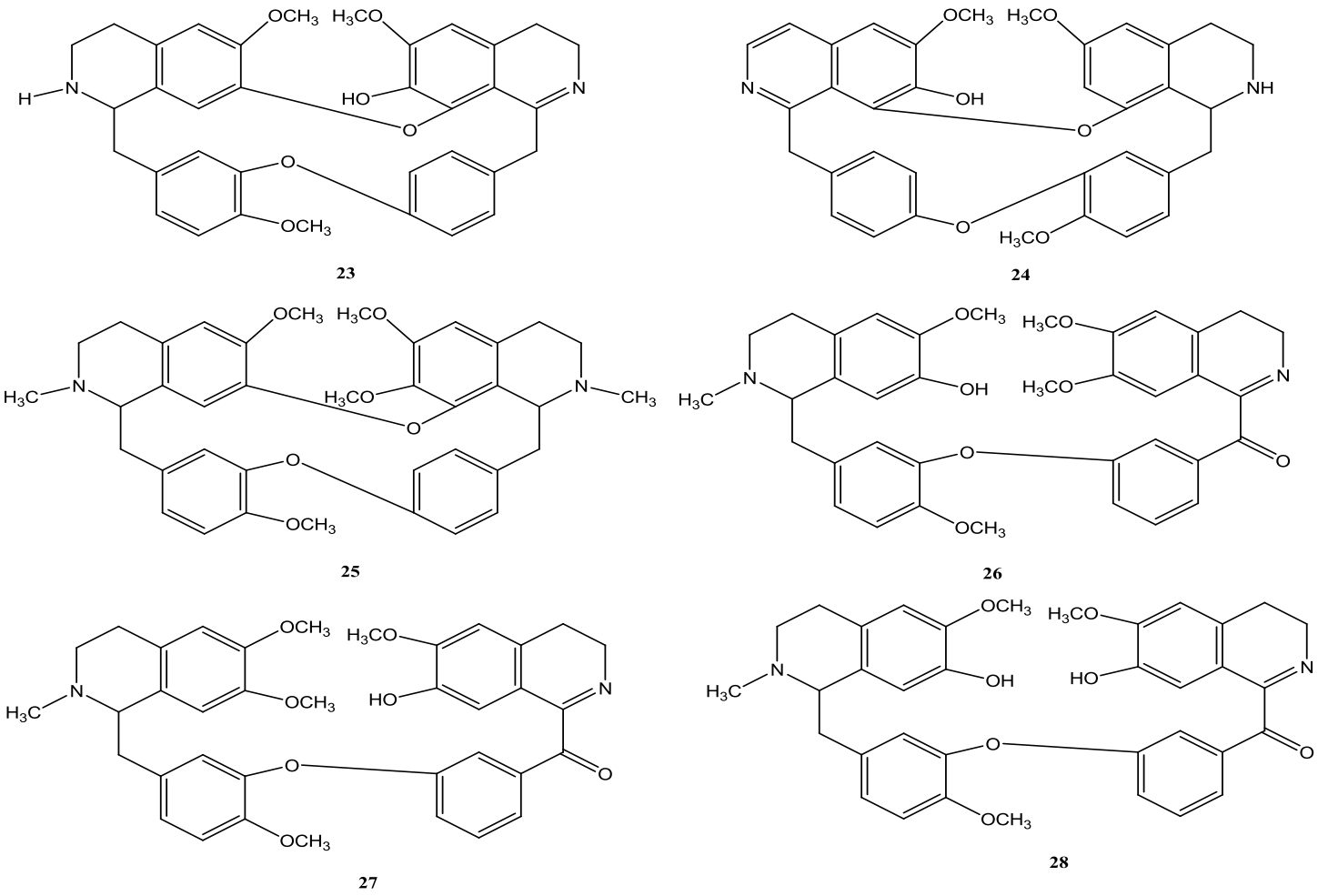
In UV-VIS spectroscopy the bisbenzylisoquinoline typically exhibit two UV maxima at approximately 283 and 261 nm.[60]

2.7. Alkaloids of Genus *Alseodaphne*

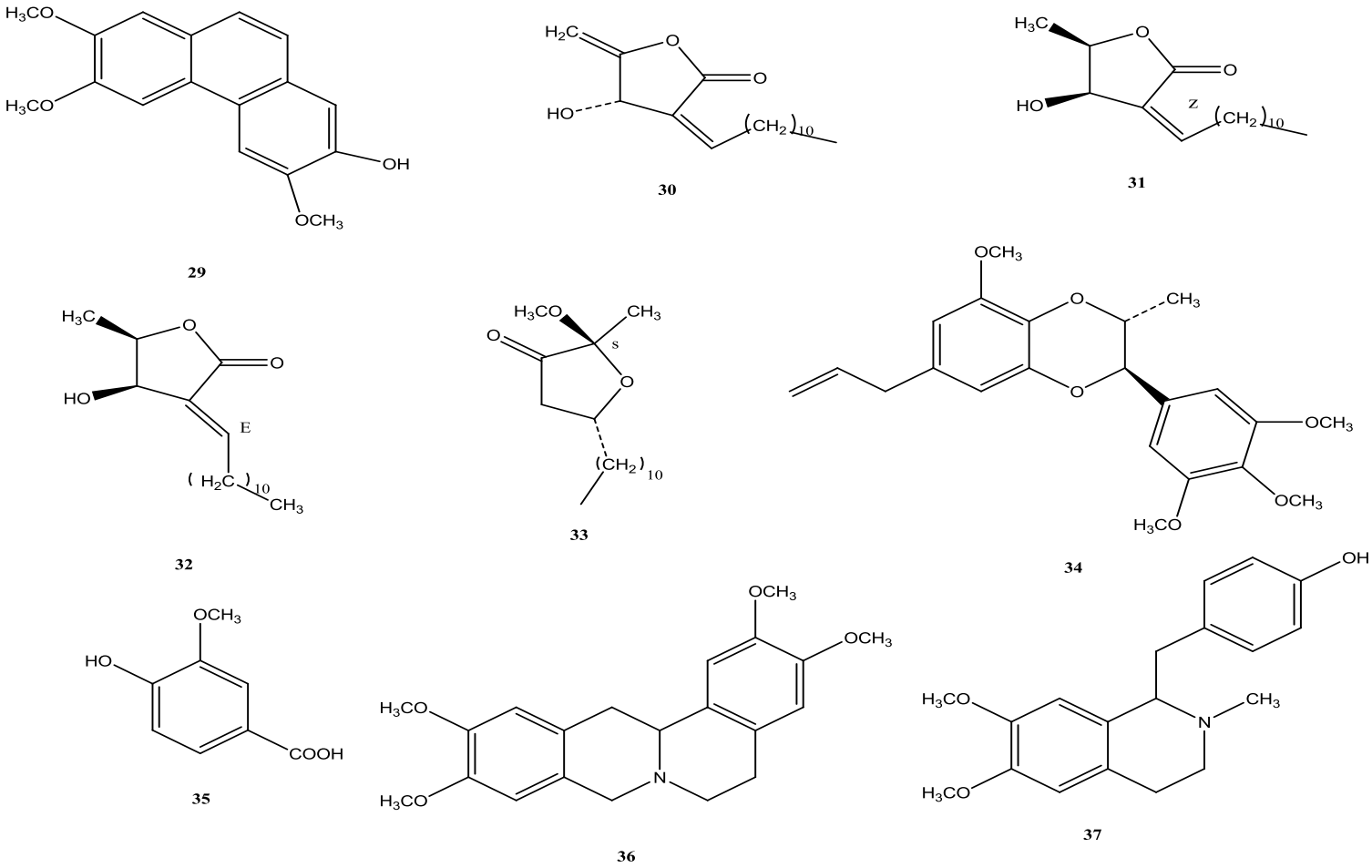
In phytochemical studies, only six *Alseodaphne* species have been reported before, namely *A. perakensis, A. semicarpifolia, A. archboldiana, A. hainanensis* Merr. and *A. corneri*. *Alseodaphne corneri* was first time reported by the author in 2009.[61] Research on the *Alseodaphne* species is still rare. In *Alseodaphne* species, isoquinoline types of alkaloids are the main alkaloidal constituents, such as aporphines and benzylisoquinolines, bisbenzylisoquinolines, morphinandienones and protoamines. Alkaloids isolated from the *Alseodaphne* species are shown below. Table 2.6 and Scheme 2.9

Table 2.6: Alkaloids Isolated from *Alseodaphne* Species

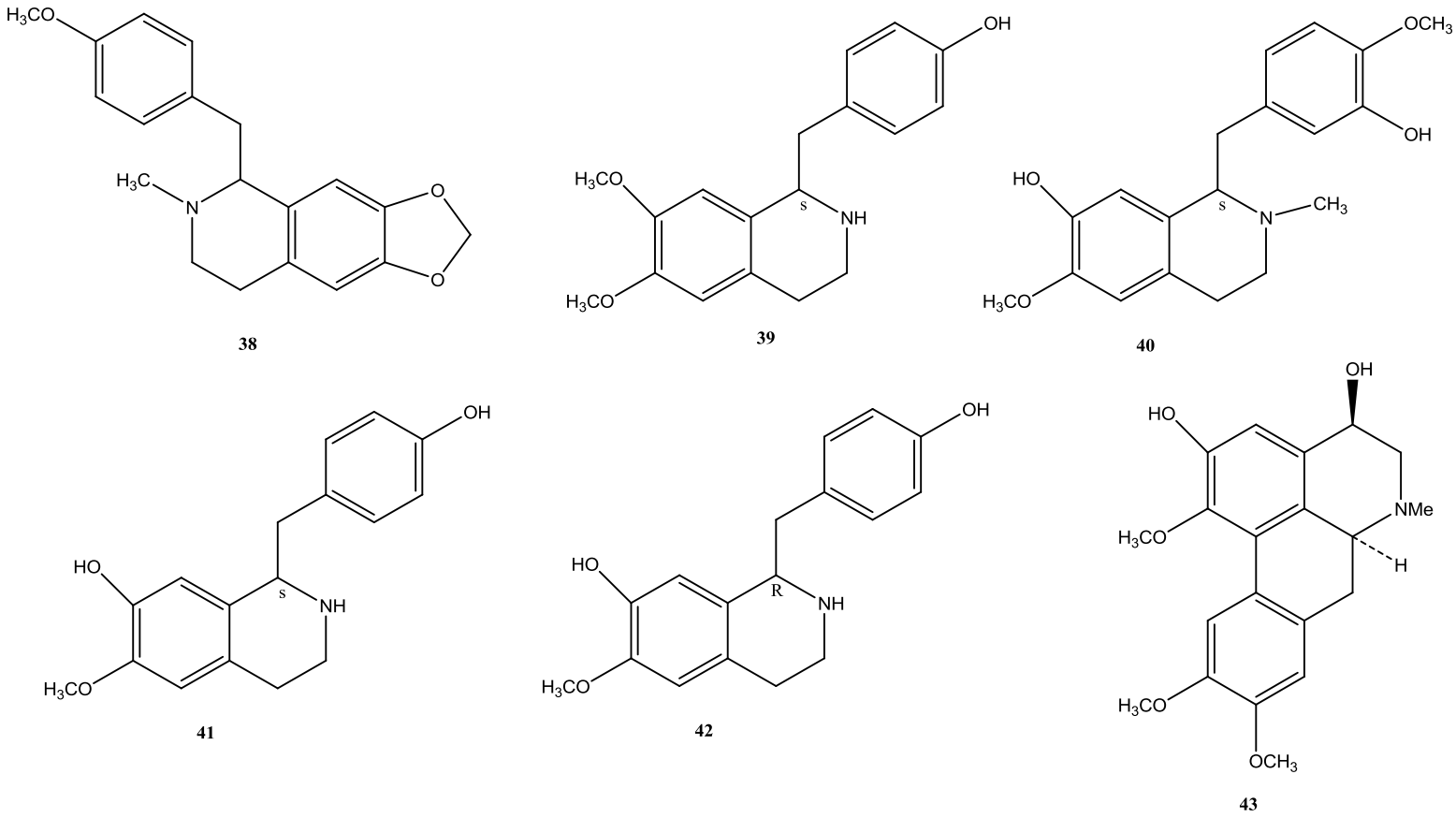
Plant	**Alkaloids isolated**
Alseodaphne corneri	3'-4'-dihydronorstephasubine **23**[61]
	Norstephasubine **24**[61]
	Gyrolidine **25**[61]
Alseodaphne perakensis	α-oxoperakensimines A **26**[62]
	α-oxoperakensimines B **27**[62]
	α-oxoperakensimines C **28**[62]
	Perakensol **29**[63]
Alseodaphne andersonii	Dihydroobtusilactone **30**[64]
	3-Epilitsenolide D1 **31**[64]
	3-Epilitsenolide D2 **32**[64]
	Alsedofuranone **33**[64]
Alseodaphne hainensis	Neolignan Eusiderin A **34**[65]
	4-hydroxy-3methoxy benzoic acid **35**[65]
	Xylopine **36**[66]
	Armepavine **37**[66]
	Doryafranine **38**[66]
Alseodaphne archboldiana	(-)-*N*-norarmepavine **39**[67]
	(+)-Reticuline **40**[67]
	(+)-Coclaurine **41**[67]
	(-)-Coclaurine **42**[67]
Alseodaphne semicarpifolia	Srilankine **43**[68]



Scheme 2.9: Alkaloids Isolated from *Alseodaphne* Species



Scheme 2.9: Alkaloids Isolated from *Alseodaphne* Species (Continued)



Scheme 2.9: Alkaloids Isolated from *Alseodaphne* Species (Continued)