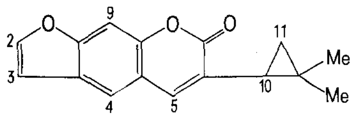
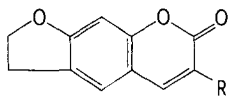
Structure of Clausindine, a New Coumarin from *Clausena indica* Oliv.

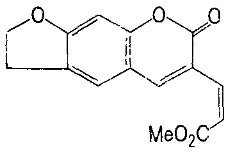
Isolation of the alkaloid 6-methoxyheptaphylline[1] and some furanocoumarins[2] from the roots of *Clausena indica* Oliv. has been recorded earlier. We wish to report the structure determination of a coumarin designated clausindine (I), $C_{16}H_{14}O_3$; M$^+$ 254, mp 128° isolated from the roots of the same plant. It showed UV λ_{max}^{EtOH} 248, 303 and 332 nm (log ε 4.3, 4.1 and 4.0) and IR ν_{max}^{nujol} 1720, 1620 and 1580 cm^{-1} bands characteristic of linear furanocoumarins. Its NMR-spectrum (100 MHz) showed the furan protons at δ 7.6 and 6.8 [d, 2 Hz each; C(2)- and C(3)-H] and the aromatic protons at δ 7.58 [C(4)-H] and 7.4 [C(9)-H]. The C(3)-proton showed ortho coupling and also long range coupling[3] with C(9)-H as shown by double resonance experiments. By irradiation of the proton at C(3), both the C(2)-H and C(9)-H were affected and irradiation of the C(9)-H at δ 7.4 affected only C(3)-H at δ 6.8. The attachment of a 5 carbon unit at C(6) of the furanocoumarin nucleus was deduced from the singlet C(5)-proton appearing at δ 7.35[4]. That the side chain consists of a gem-dimethylcyclopropane grouping was evident from the NMR-spectrum and also the base peak at m/e 199 by the loss of a C_4H_7 unit from the molecular ion. The methyl groups appeared as singlets at δ 0.9 and 1.3 and the C(10)-proton as a slightly split (< 1 Hz) triplet at δ 1.9 (6.5 Hz) and the C(11)-methylene protons of the cyclopropane at δ 0.8 (2 H; m). Irradiation at δ 1.9 affected the methylene protons as well as the C(5)-proton. Irradiation at δ 7.35 resulted in a sharp triplet at δ 1.9. Since the amount of clausindine was too small for degradation studies, confirmation of the structure was obtained by synthesis.



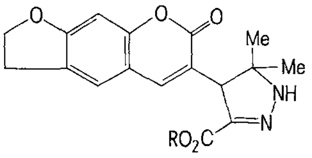
I



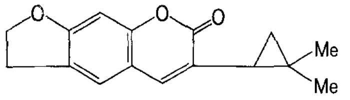
II : R = COOH
III : R = CHO



IV



V : R = Me
VI : R = H



VII

Dihydropsoralene-3-carboxylic acid (II), mp 246° obtained by the condensation of 6-hydroxy-5-formylcoumaran[5] with malonic acid was converted to the acid chloride and reduced to the corresponding aldehyde (III), mp 200°. Wittig reaction with carbomethoxymethylene triphenylphosphorane[6] provided the olefinic ester (IV) which on cycloaddition with diazopropane gave the pyrazoline (V), mp 242° (NH, 3340 cm^{-1})[7]. The ester (V) was hydrolyzed to give the carboxylic acid (VI) mp 185° which was pyrolyzed by heating with copper bronze and quinoline. Separation of the reaction mixture on thick layer silica gel gave (VII), mp 200° identical with dihydroclausindine obtained by mild reduction of (I) with 10% Pd/C. Clausindine is probably the first example wherein the ubiquitous isoprenoid unit is attached to the aromatic nucleus as a gem-dimethylcyclopropane grouping.

Zusammenfassung. Es wurde mit Clausindin ein neuartiges, Gemdimethylcyclopropan-Ring enthaltendes Cumarin aus den Wurzeln von *Clausena indica* Oliv. isoliert. Die Struktur (I) ist auf Grund spektraler Daten und der Synthese von Dihydroclausindin aufgeklärt worden.

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[8] Acknowledgment. We are grateful to Professor T. R. Govindachari for his interest in the work and Dr. S. Selvavinayakam for the analytical and spectral data. We also thank Dr. H. Fuhrer for the NMR-spectra.

Isolation of N-Isobutyl Deca-*trans*-2-*trans*-4-Dienamide from *Piper sylvaticum* Roxb.

The seeds of *Piper sylvaticum* Roxb. are often used as an effective drug in the treatment of asthma and chronic bronchitis in the Indian Ayurvedic system of medicine[1]. Investigation of the petrol (bp 60–80°) extract of its seeds has resulted in the isolation of a number of compounds. The characterisation of two of these, viz. 4',7-dimethoxy-5-hydroxy flavone and sylvatine, a new alkamide, has been previously described by us[2]. The present paper deals with the characterisation of a third compound (I) isolated from the petrol extract by chromatography over silica gel using petrol:benzene (1:1) as eluent. This compound, mp 75°, $[\alpha]_D$ 0°, was difficultly crystallisable as it was highly soluble in all organic solvents. It was extremely unstable in the solid state, decomposing within a few hours to a reddish gum on exposure to air, and hence had to be stored in sealed evacuated tubes. Its molecular formula was confirmed by analysis and mass spectrometry (M$^+$ 223) as $C_{14}H_{25}ON$. The UV-spectrum of the compound (λ_{max}^{EtOH}: 257 nm: log ε: 4.53) indicated a

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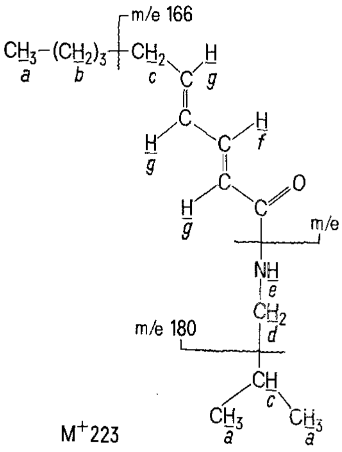
[2] A. Banerji and P. C. Ghosh, Tetrahedron *29*, 977 (1973).

sorbic chromophore[3,4]. The IR-spectrum showed the presence of a secondary amide, with an α, β-unsaturated conjugated diene system [ν_{max}^{Nujol}: 3300 cm^{-1} (–NH–), 1630 cm^{-1} (conjugated carbonyl), 1665 cm^{-1} (conjugated double bond)]. The presence of absorption bands at 849 and 878 cm^{-1} and a very strong one at 998 cm^{-1}, indicated that the α, β-unsaturated conjugated diene system had a *trans-trans*-configuration[4].

At this stage, the physical and spectral properties of our compound appeared to be similar to those of *N*-isobutyldeca-*trans*-2-*trans*-4-dienamide (I), a constituent of pellitorine[3], which had been previously isolated from some other *Piper* species by ATAL[5]. Since an authentic sample of this compound was not available, we had to undertake detailed spectral and chemical studies in order to confirm its structure. Our investigations, which provide additional information about this compound, are reported in the present communication.



M$^+$223

(I)

a 0.90δ (9H, m)

b 1.15–1.60δ (6H, diffuse m)

c 1.60–2.33δ (3H, m)

d 3.17δ (2H, *t*, $J = 6.5$ Hz, collapses to a doublet on deuteration)

e 6.57–6.98δ (1H, very broad s, disappears on deuteration)

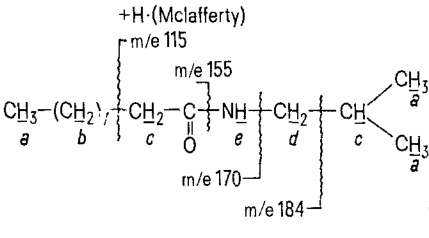
f 7.02–7.47δ (1H, m)

g 5.80–6.25δ (3H, m)

The 60 MHz NMR-spectrum ($CDCl_3$) of the amide, was consistent with structure (I).

On hydrogenation over ADAM's catalyst, (I) afforded a tetrahydroderivative (II), mp 40°, $C_{14}H_{29}ON$ (M$^+$ 227). (II) lacked the bands due to olefinic unsaturation at 1665, 998 and 878 cm^{-1} in its IR-spectrum (Nujol), the amide carbonyl band now appearing at 1655 cm^{-1}. The 60 MHz NMR-spectrum ($CDCl_3$) and the mass spectral fragmentation pattern of the tetrahydro-compound were consistent with its formulation as *N*-isobutyldecanamide (II).

Hydrolysis of (II) with concentrated hydrochloric acid in a sealed tube furnished decanoic acid and isobutylamine hydrochloride, mp 165°. *N*-isobutyldecanamide was synthesized from decanoyl chloride and isobutylamine in presence of 10% aqueous sodium hydroxide and found to be identical on comparison (mp, mmp, co-TLC, superimposable IR-spectra) with the tetrahydroderivative (II).



(II) M$^+$227

Base peak m/e 115

a 0.93δ (9H, m)

b 1.30 δ (14 H, br s)

c 1.50–2.40δ (3H, m)

d 3.11δ (2H, *t*, $J = 6.5$ Hz)

e 5.55–5.90δ (1H, broad s, disappearing on deuteration)

On the basis of the above spectral and chemical observations, the original compound could be assigned a structure (I). The structural assignment was in conformity with its mass spectral fragmentation pattern, the diagnostic peaks appearing at *m/e* 223 (M$^+$), 180 (M–C_3H_7), 166 (M–C_4H_9), 152, 151 (M–C_4H_9NH) (base peak), 96, 95 and 81. The NMR and mass spectra of (I) and its tetrahydroderivative (II), as well as the synthesis of the latter, have not been reported previously, and provide additional information about these compounds[6].

Zusammenfassung. Spektroskopische Strukturaufklärung eines Inhaltsstoffes (Alkaloid) aus *Piper sylvaticum* Roxb. mit teils synthetischer Beweisführung.

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[6] Acknowledgment. The authors thank Professor (Mrs.) A. CHATTERJEE, University of Calcutta, for laboratory facilities and helpful discussions; and Dr. NITYA NAND, CDRI, Lucknow, and Dr. S. C. PAKRASHI, I.I.E.M. ,Calcutta, for spectral measurements.

The Terpenoid Parts of Kamolone and Kamolol of *Ferula pennineruis*

The importance of biogenetic theory in terpene structure elucidation has been amply demonstrated[1]. We have recently applied the principles embodied in this theory to arrive at and establish the structure of reportedly unidentified sesquiterpene from *Citrus sinensis*, as 5β, 7β, 10α-selina-3,11-diene[2]. This note reports on the revised structures of kamolone and kamolol, the sesquiterpenoid coumarins of *Ferula pennineruis* Rgl. et Schmalh., which on the basis of extensive spectral and chemical degradation studies have been formulated[3] as (Ia) and (Ib) respectively. Subsequently, mass spectral fragmentation studies have been reported[4] in support of these structures.

Although the terpenoid parts of structures (Ia) and (Ib) are dissectable into isoprene units, nevertheless it is difficult to envisage their derivation from farnesyl pyrophosphate, the bonafide precursor of sesquiterpenes, by means of accepted mechanistic operations enunciated in the biogenetic isoprene rule[5,6]. A biogenetically more correct formulation of terpenoid moieties of kamolone and kamolol would be the structural variants represented in (IIa) and (IIb) respectively, which can be conceived as derivable from farnesyl pyrophosphate by oxidative cyclisation to an intermediate cation (III) involving drimane skeleton, followed by a 'friedo' rearrangement and finally deprotonation. The new structures (IIa) and