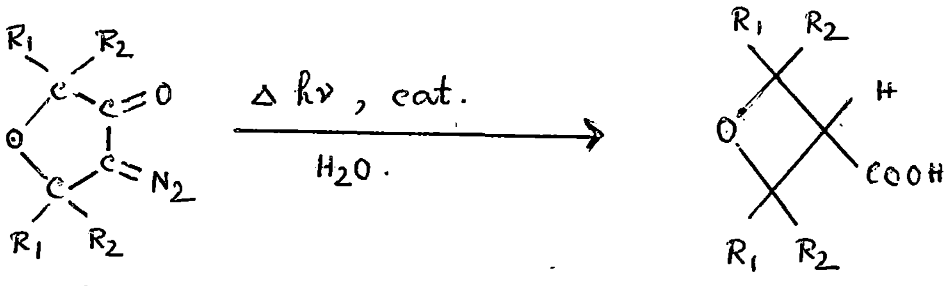
CHAPTER - II

Section A : Previous attempts toward the partial synthesis of ceanothic acid.

In 1965 Huneck[27] with a view to devising a method for the partial synthesis of ceanothic acid developed a procedure for contraction of Ring A in normal triterpenoids in order to achieve the synthesis of suitable A-nor carboxylic acids, a structural feature present in ceanothic acid. As originally demonstrated by Horner[28] and Sus et al[29], Wolff rearrangement can be implemented with cyclic diazo-ketones resulting in ring contraction under photochemical conditions. The photochemical variant proves very suitable for producing strained systems also[28c, 30]. The formation of the oxetane[31, 32] 33 can be considered as an example.



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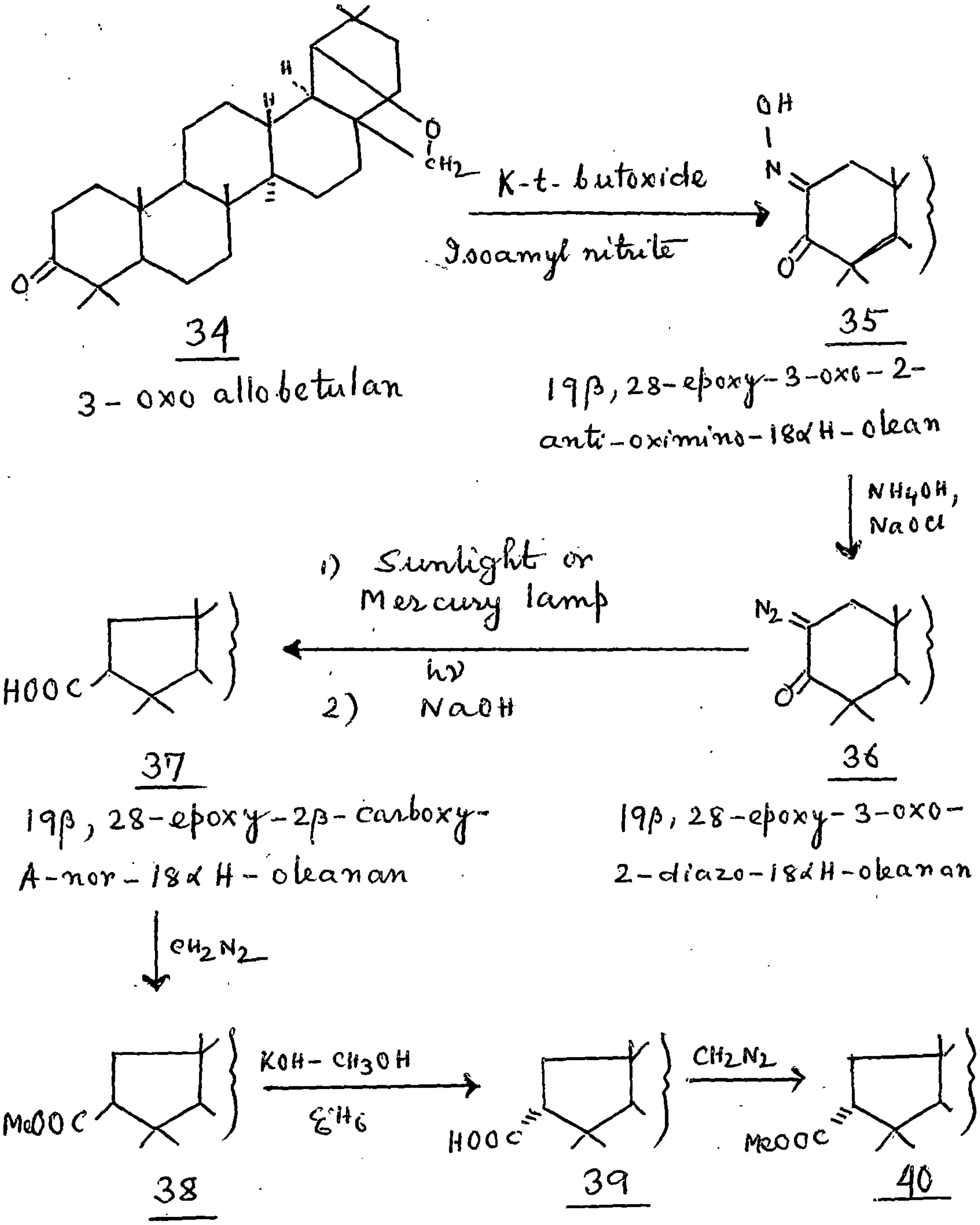
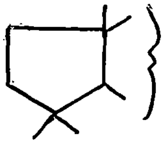
The first publication of Huneck[27a] reported the conversion of 3-oxo-allobetulan 34 to 19β,28-epoxy-2β-methoxycarbonyl-A-nor-18α H-oleanan 38 according to the following sequence



The β - isomer 38 on treatment with methanolic potassium hydroxide for 24 hours gave the 2α- carboxy derivative 39, which on methylation with diazomethane gave the α - carboxyl methyl compound 40. The structure of the acids 37 and 39 were established by their conversion to 19β, 28-epoxy-A-nor-18α H -oleanan 41.



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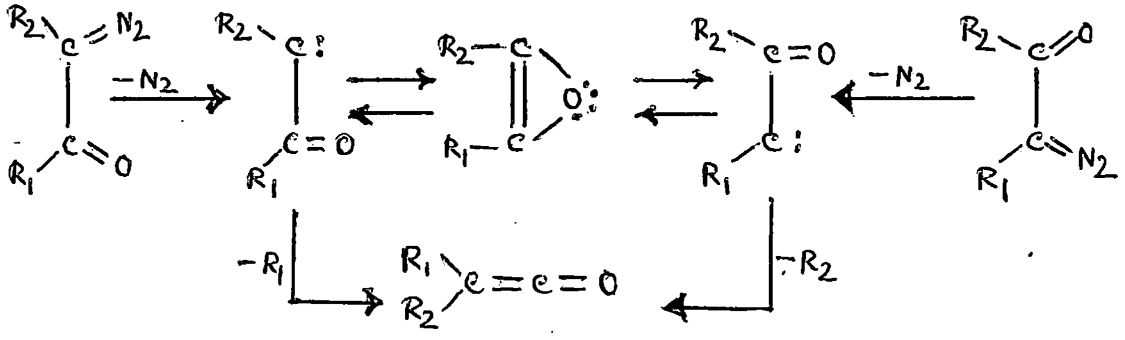
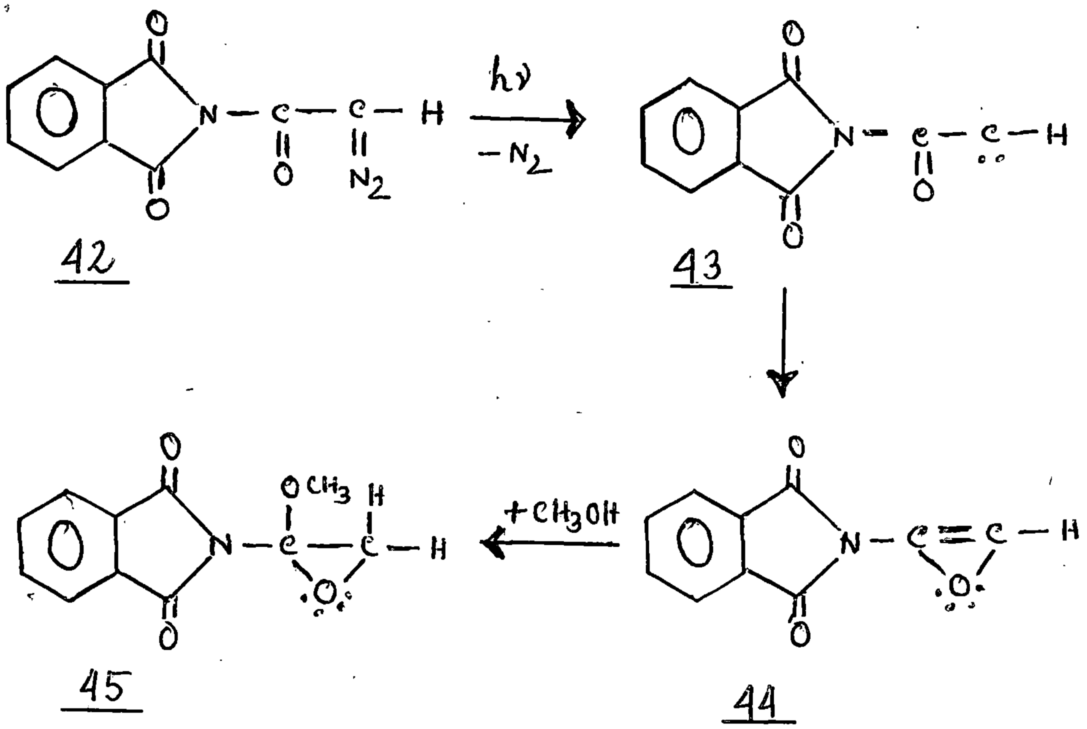
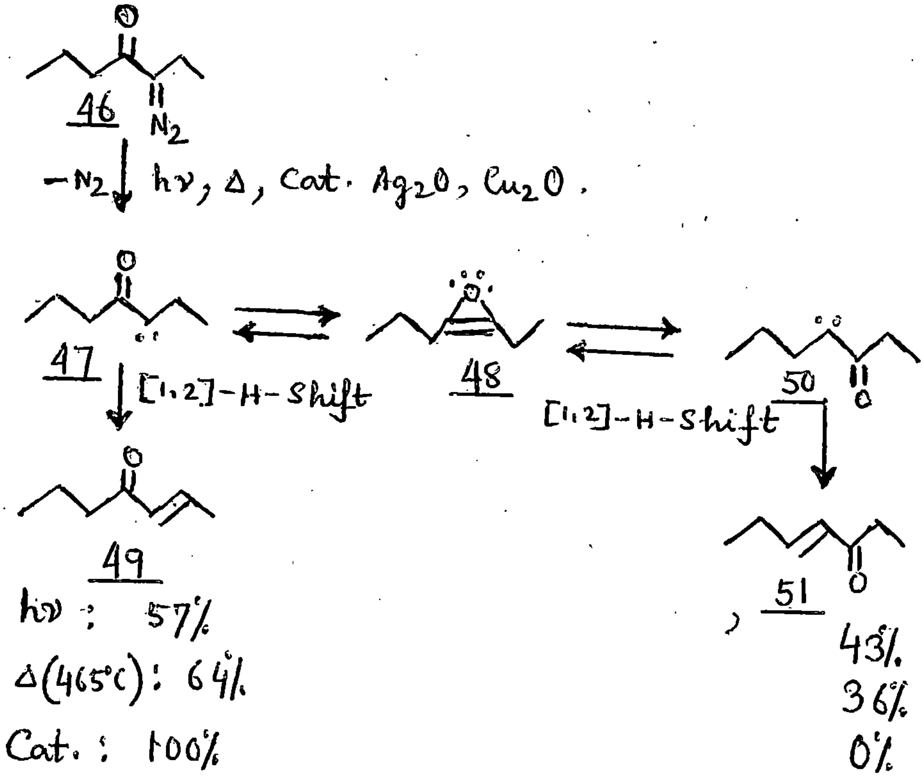
The intermediate α -oxo-carbene formed after nitrogen elimination changes itself with ring contraction to a ketene, which in a secondary reaction is converted to a carboxyl or its derivative. The oxirenes[33], anti-aromatic 4π electron systems formed by valence isomerisation of the primary fragments should possess similar energies to the α -oxo carbenes[34-36]. Conclusive proof of the intermediate appearance of oxirenes during photochemical Wolff rearrangement has been obtained with the aid of three independent methods employing isotopic labelling.



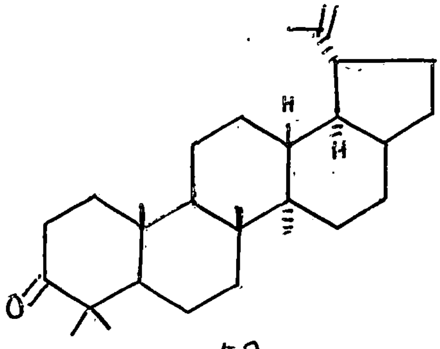
The extent of oxirene formation depends upon the conditions e.g. on the concentration of water[37,38]. The carbene-oxirene equilibrium makes it difficult to reach any conclusion regarding the migratory aptitude of the groups R_1 and R_2. In all systems investigated so far[39], however, the initial carbene formed after nitrogen elimination undergoes reaction. Oxirene participation could be ruled out on sensitised photolysis, on catalysis and on thermolysis in solution[37-41]. The trapping reaction yielding <u>45</u> strongly suggests that the oxirenes are true intermediates and not merely transition states[42].



proof of oxirene formation that is completely independent of the Wolff rearrangement was obtained with unsymmetrical α -diazo dialkyl ketones[43] and a number of special aryl substituted α - diazo ketones[44]



In another paper, Huneck[27b] reported the conversion of 3-oxo lupen -20(29) 52 to 2β-carboxy-A-nor-lupen-20(29) 53 following the same sequence of reactions described before.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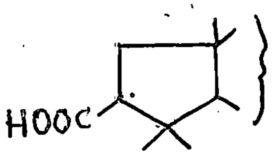
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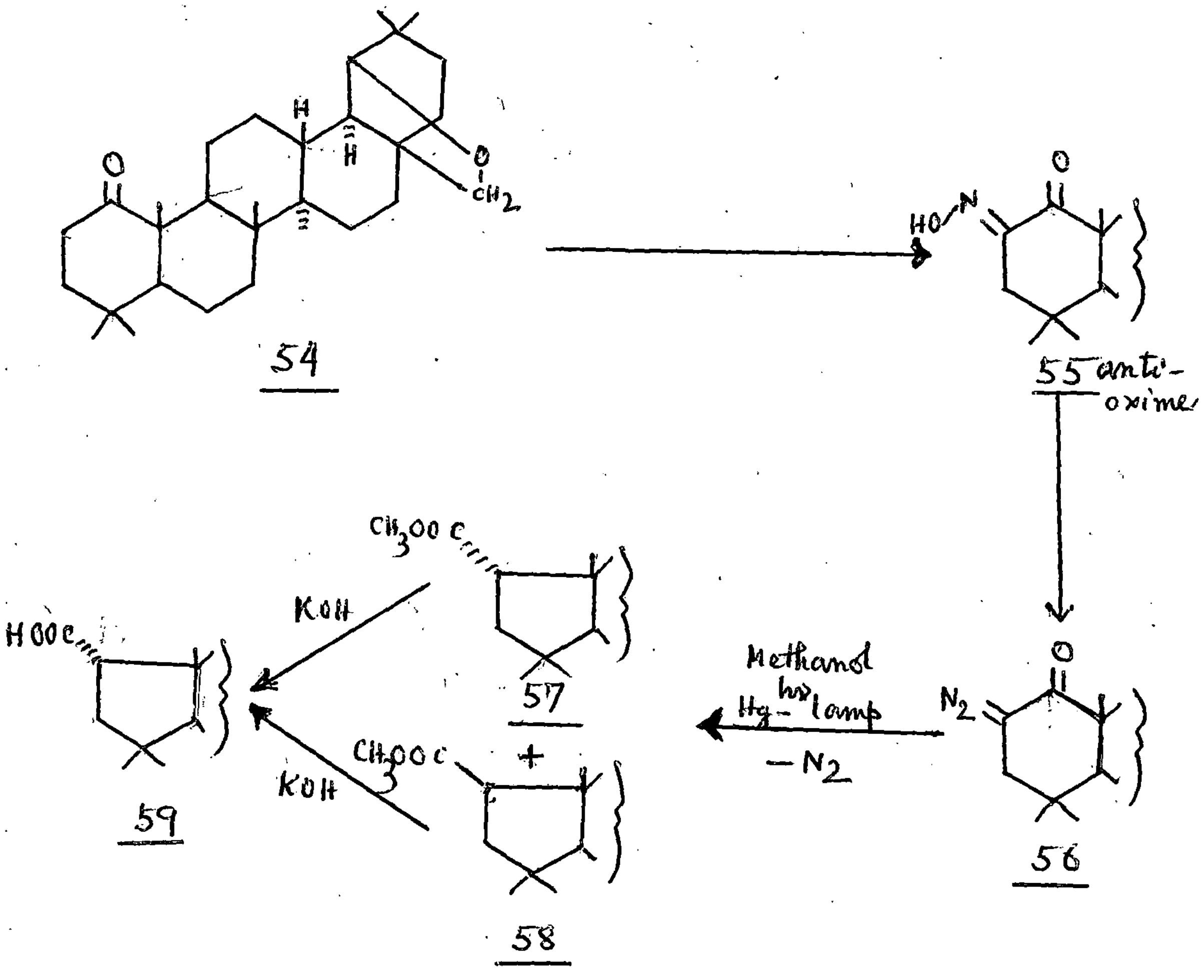
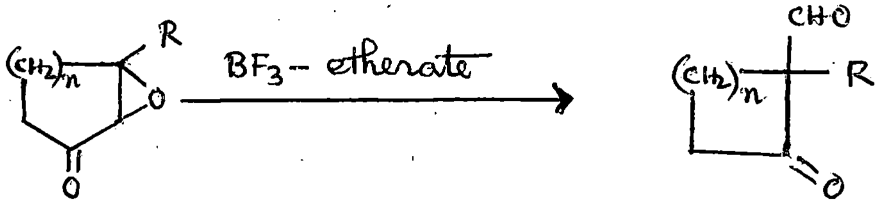
Methyl oleanonoic ester <u>54</u>[27b] by similar reactions gave a mixture of 2β - methoxycarbonyl-A-nor- Δ^{12}-oleanene-17-methylester and its 2α- epimer. They[27c] have also shown that the appropriate 1-oxo-triterpenoids can be converted to the A-nor-1- carboxy compounds by application of the same procedure. Thus 19β, 28-epoxy-1-oxo-18α H-oleanan <u>54</u> gave a mixture of 1α - methoxy carbonyl - 19β, 28 - epoxy-A-nor-18αH-oleanan <u>57</u> and 1β - methoxycarbonyl-19β, 28-epoxy-A-nor-18αH-oleanan <u>58</u>. The reaction path is shown below.

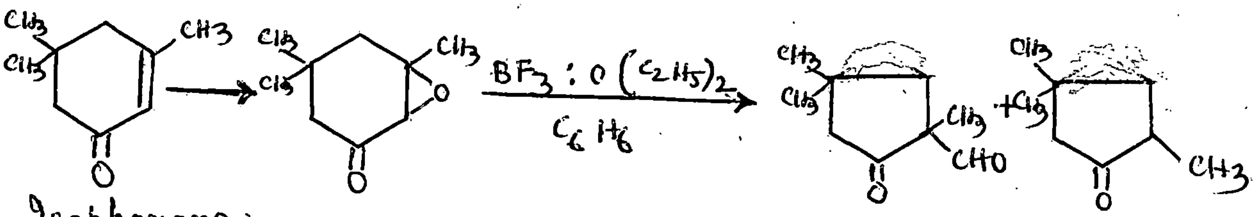


House and Wasson[45] have shown that, epoxy ketones of type 60 in the presence of BF_3- etherate undergo rearrangement with reduction in ring size of the cyclic ketone, and produced the keto - aldehyde 61



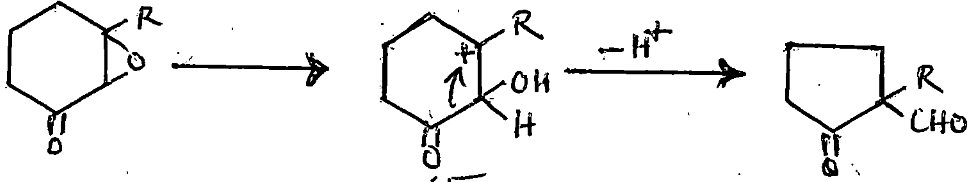
60 61

Thus isomerisation of a benzene solution of isophorone oxide 62 in the presence of boron-trifluoride etherate produced the keto aldehyde 63 in 33% yield accompanied by the ketone 64. The ketone 64 was presumably formed by the deformylation of 63 during the isolation



Isophorone 62 63 64

The reaction proceeds via the carbonium ion 65



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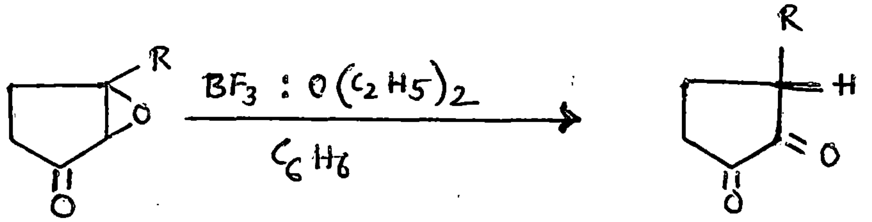
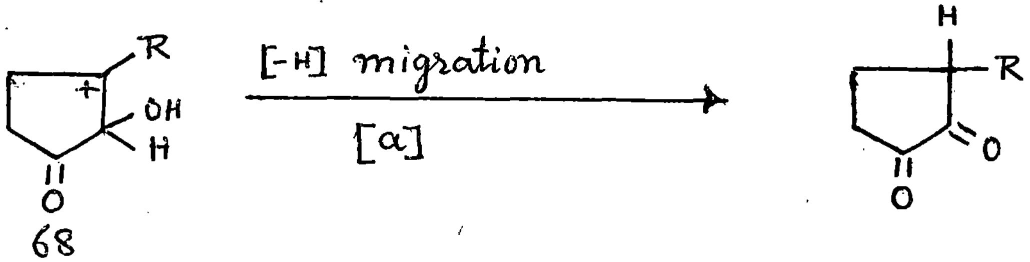
In order to study whether similar ring contractions could be achieved in the cyclopentanone series, the isomerisation of cyclopentenone oxide 66 was investigated. However, the only products which could be isolated were the enol forms of the α- diketone 67



66a, R = C_6H_5
66b, R = CH_3

67a, R = C_6H_5
67b, R = CH_3

These products could arise either by the formation of a carbonium ion 68 followed by hydrogen migration (path a) or by a concerted elimination reaction (path b)



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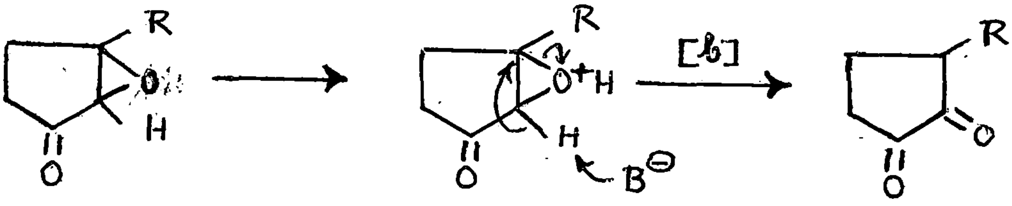
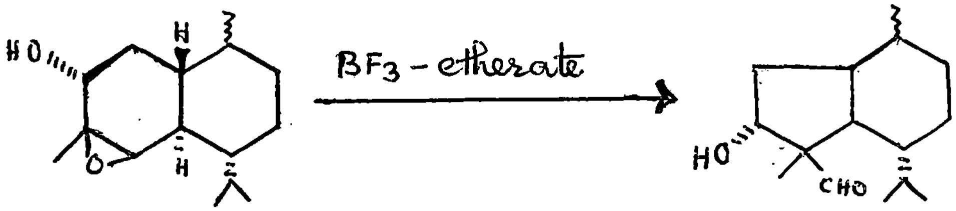


Kartha and Chakravarti[46] studied the action of BF_3-etherate on some sesquiterpene oxides and found that an aldehyde was formed through contraction from a six-membered ring to a five-membered ring. Dihydrokhusinol epoxide 69 on treatment with freshly distilled BF_3-etherate is converted to the crystalline hydroxy aldehyde 70.



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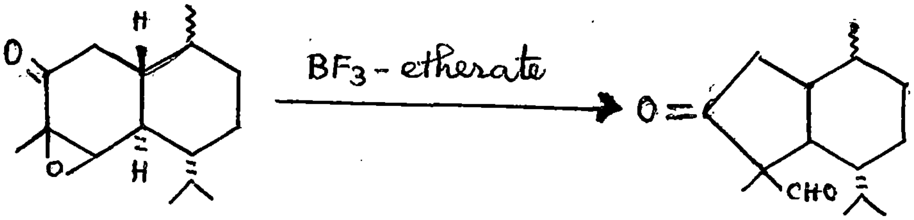
They studied the same reaction on the epoxy ketone 71 and observed that it rearranged to the keto aldehyde 72.



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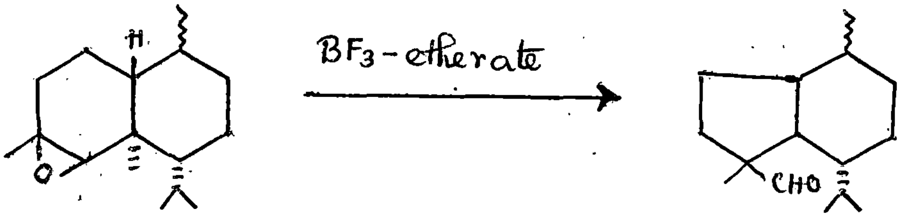
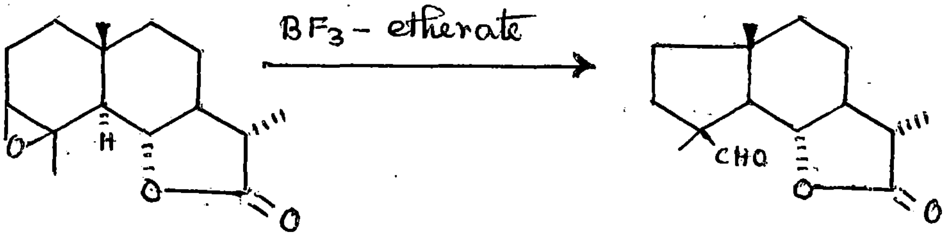
The epoxide of (-) dihydro -γ- cadinene 73 undergoes ring contraction to the aldehyde 74. α - Santenolide epoxide 75 also gave the aldehyde 76 by the action of BF_3- etherate.

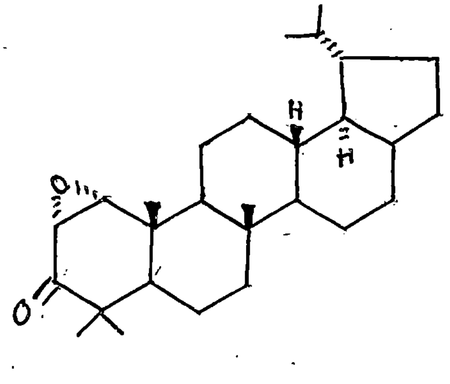


73 74



75 76

In 1968, Chatterjee and colleagues[47] attempted to prepare the keto aldehyde 77 by ring contraction of 1α,2α-epoxy lupanone (3) 78 by following the same procedure as described by House *et al*[45] and Kartha and coworkers[46]



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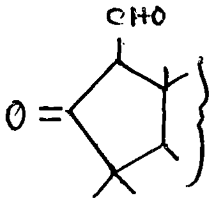

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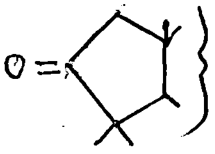
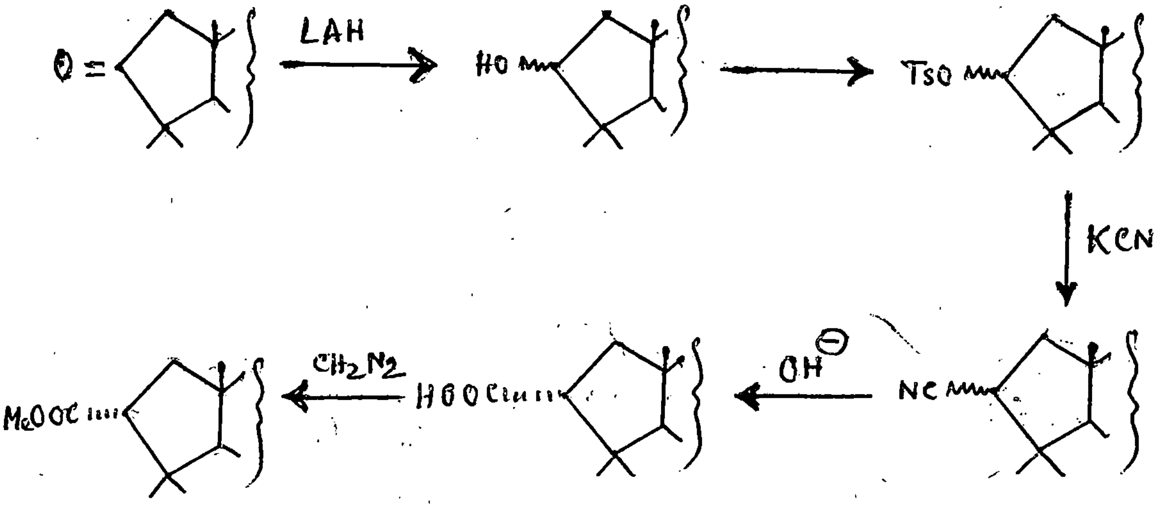


79

However, in this reaction, they could not isolate the keto aldehyde but obtained the ketone, A-nor-lupanone (2), 79 in good yield. Most probably the intermediate keto-aldehyde that is formed, easily loses the formyl group during the reaction. The object of their work was to develop a method for the partial synthesis of ceanothic acid starting from the keto-aldehyde 77. They, however, finally achieved the synthesis of 2α- methoxycarbonyl-A-nor-lupan 80 by following the sequence of reactions shown below.



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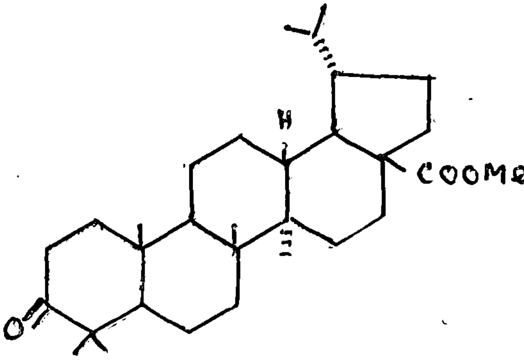
Section B : Partial synthesis of dimethyl dihydroceanothate starting from betulinic acid.

The objective of the present study was the design of a partial synthesis of dimethyl dihydroceanothate starting from methyl dihydrobetulinate. It was our intention to introduce the substituents in ring A (centres of as~~s~~ymmetry) step by step. Therefore, we were to devise a synthetic scheme involving an intermediate possessing only a single substituent (a single centre of assymetry) in correct stereochemistry in the five membered ring A. This intermediate must be converted into dimethyl dihydroceanothate in which the additional ring substituent in ring A is present in one particular "natural" configuration. With these basic requirements in view we explored two methods for the conversion of the six-membered ring A of methyl dihydrobetulonate 81 to the the β- keto ester - dimethyl dehydro dihydro~~methyl~~ceanothate 82.



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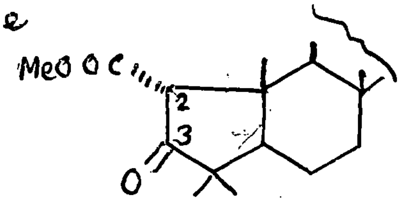
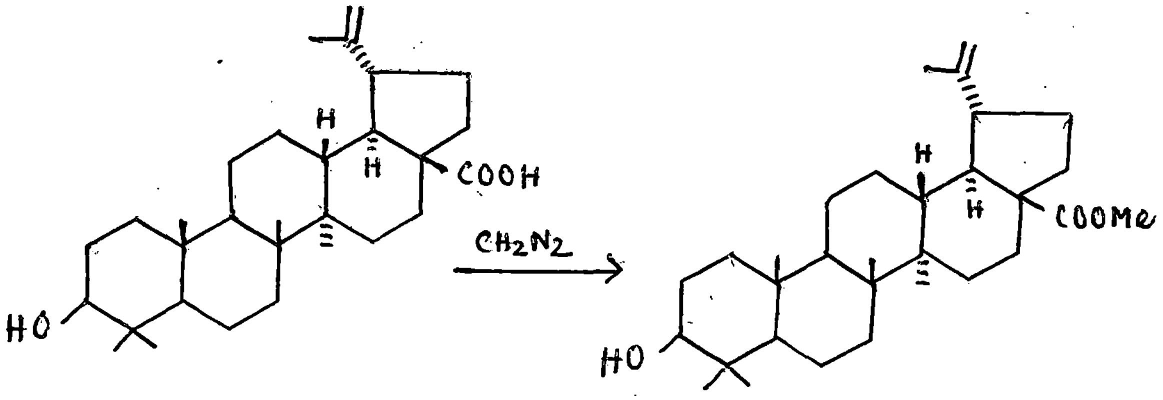


82

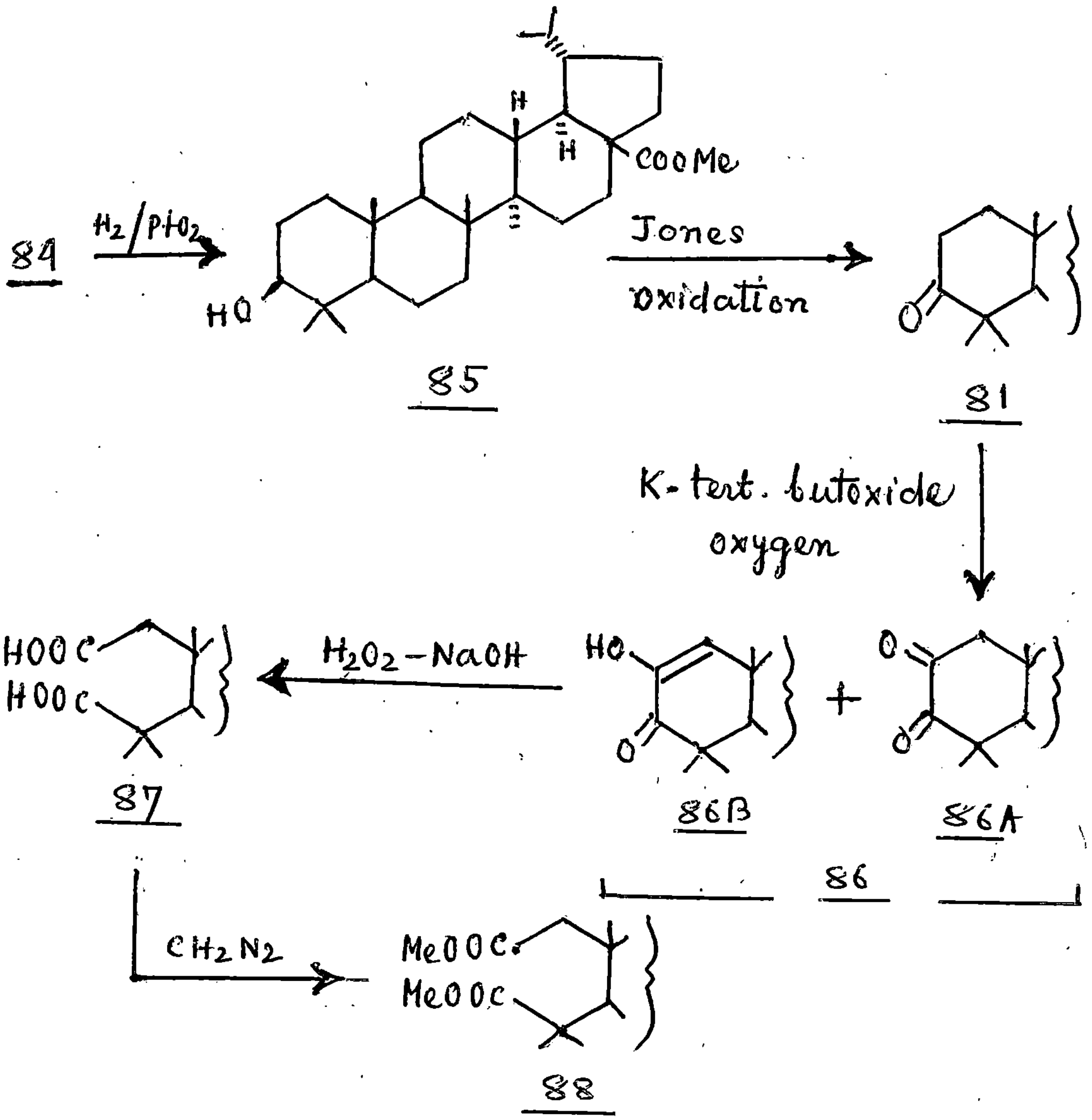
where the methoxy carbonyl group is in the natural α - configuration. The next step in the synthesis is to introduce a hydroxyl group at C - 3 in proper stereochemistry that is, with β - configuration. Eade et al[21] have already shown that dimethyl dehydroceanothate on reduction with sodium borohydydride gives a 1 : 1 mixture of dimethylceanothate and its C - 3 epimer which could be separated by column chromatography. We, therefore, thought that once we can achieve the sucessful development of a method for construction of skeleton 82, the next step, that is, accommodation of a β-OH group at C - 3 would not be very difficult.

The present work describes in detail the result of our synthetic work and successful development of a method for the partial synthesis of dimethyl dihydroceanothate.

The simplest synthetic pathway for the preparation of the β - ketoester would be Dieckmann condensation of the 2,3-seco-trimethyl ester 88 which was prepared by following the synthetic sequence shown below. The details are described in the following lines.



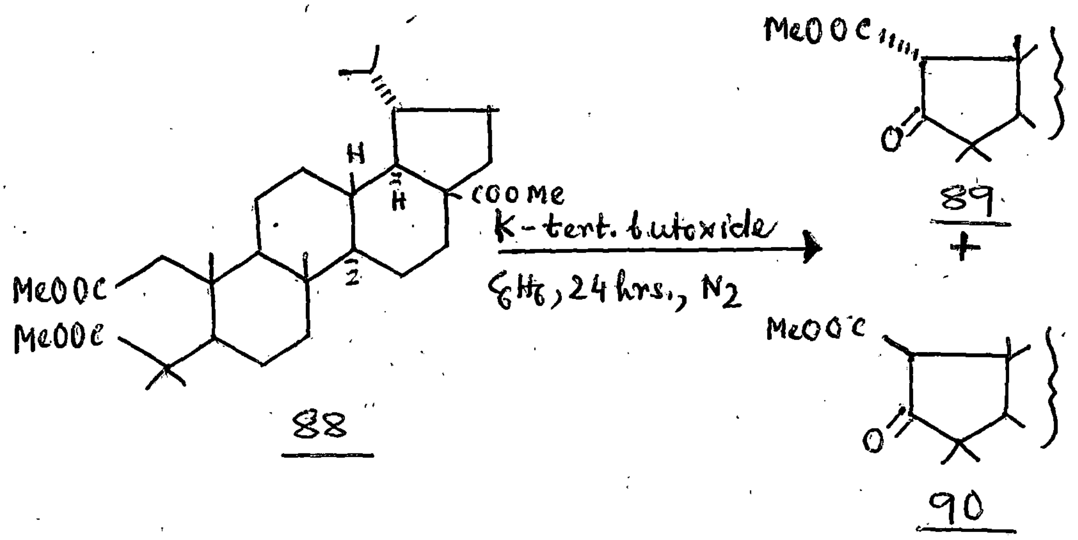
83 84



Betulinic acid 83 extracted from the bark of *Bischofia javanica Blume* on esterification with diazomethane gave methyl betulinate 84, m.p. 223-24°, $(\alpha)_D$ 5°, ν_{max}^{nujol} 3560 (OH), 1715 ($COOCH_3$), 1660 and 880 cm^{-1} (= CH_2), which on hydrogenation in presence of PtO_2 - catalyst afforded methyl dihydrobetulinate 85, m.p. 236-38°, ν_{max}^{nujol} 3560 (OH), 1715 cm^{-1} ($COOCH_3$).

Jones oxidation of methyl dihydrobetulinate gave methyl dihydrobetulonate 81, m.p. 202-4°, $(\alpha)_D$ 8°, $\nu^{\text{nujol}}_{\text{max}}$ 1730 ($COOCH_3$), 1708 cm^{-1} (CO). Autoxidation of 81 by passing a stream of oxygen in presence of potassium tertiary butoxide in tert. butanol furnished a product m.p. 131-33°, $(\alpha)_D$-1·96°, $\nu^{\text{nujol}}_{\text{max}}$ 3460 (OH), 1730 ($COOCH_3$), 1670, 1650, 860 cm^{-1}, λ_{max} 269 mμ (ϵ, 7532). It gave a positive ferric chloride coloration for diosphenol and showed two spots on chromatoplate indicating the presence of two tautomeric forms of the α-diketone 86 A and diosphenol 86 B. The disphenol 86 B on oxidation with hydrogen peroxide[48] in presence of sodium hydroxide gave the seco-acid 87, m.p. 175-77°, $\nu^{\text{nujol}}_{\text{max}}$ 1710 and 1690 cm^{-1} (COOH). The latter on esterification with diazomethane gave the desired trimethyl easer 88, m.p. 146-47°, $\nu^{\text{nujol}}_{\text{max}}$ 1745 ($COOCH_3$) and 1725 cm^{-1} ($COOCH_3$) identical with those reported in the literature[3,12].

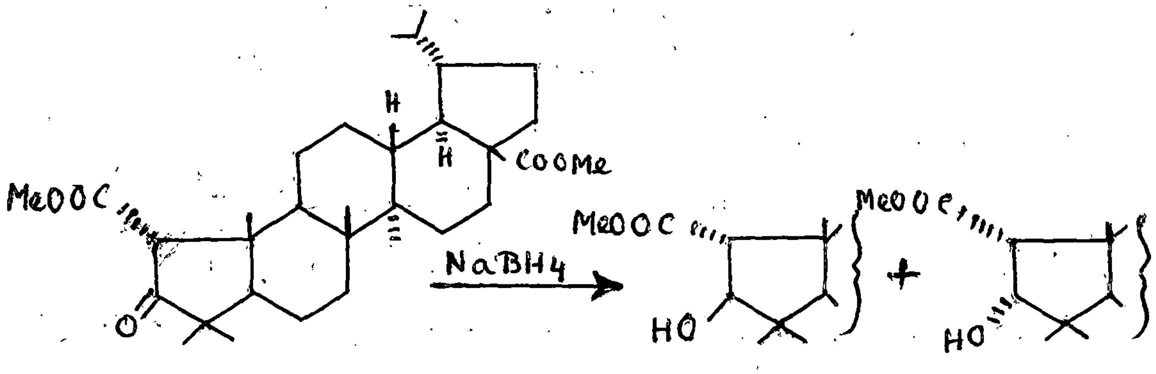
Dieckmann condensation of the trimethyl ester 88 was carried out by refluxing it for 24 hours in presence of potassium tertiary butoxide in benzene solution under nitrogen blanket[49,50]. Perfectly anhydrous condition was maintained and during the time of reflux a portion of benzene was removed with a Dean-stark trap. After the reaction was over the gummy product obtained after usual work up was chromatographed over deactivated alumina. The first three fractions of the pertoleum - benzene (3 : 2) eluate afforded a solid A, m.p. 190-92° and the next two fractions gave a solid B, m.p. 174-75°.



The solid A on crystallisation from methanol afforded fine colourless needles, m.p. 191-93° (TLC-homogeneous), $(\alpha)_D$ 89°, ν_{max}^{nujol} 1755 (cyclopentanone), 1725 cm^{-1} (CO_2Me) having the same m.p., rotation and IR spectra reported in the literature[21] for dimethyl dehydrodihydroceanothate, i.e. methyl 2α-methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate 89. The solid B on crystallisation from methanol furnished needle shaped crystals, m.p. 175-77° (TLC homogeneous), $(\alpha)_D$ 42°, ν_{max}^{nujol} 1750 (cyclopentanone), 1730 cm^{-1} (CO_2Me), has been assigned structure 90 as it had the same m.p., rotation and IR spectra as those reported in the literature[21] for methyl 2β-methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate.

The most significant point which we obsefved in this reaction was the high yield of the 2α-methoxycarbonyl isomer compared to its 2β-isomer. In a Dieckmann condensation starting from 273 mg of the seco-trimethyl ester 88 we obtained 170 mg of the 2α-methoxycarbonyl isomer 89 and only 10 mg of the β-isomer 90. This observation was at variance with those reported by Eade et al[21] who have stated that methyl 2α- methoxycarbonyl-3-oxo-A(1)-norlup-20(29)-en-28-oate (dimethyl dehydroceanothate) was rapidly epimerised by alkali to an equilibrium mixture containing 40% of starting material and 60% of the isomer epimeric at C - 2, methyl 2β-methoxycarbonyl-3-oxo-A(1)-norlup-20(29)-en-28-oate (dimethyl epidehydroceanothate). Thus the most important step in our synthetic goal, the preparation of β- ketoester 89, having been achieved, we next turned our attention to the next step in the synthesis, that is, introduction of the β-(OH) at C - 3.

The β- ketoester 89 on reduction with sodium borohydride in methanol-dioxan solution afforded an oily residue. The latter was chromatographed over deactivated alumina. The first two fractions of the pertoleum-benzene (2:3) eluate gave a solid C, m.p. 257-59° and further elution with the same solvent gave another solid D, m.p. 140-42°

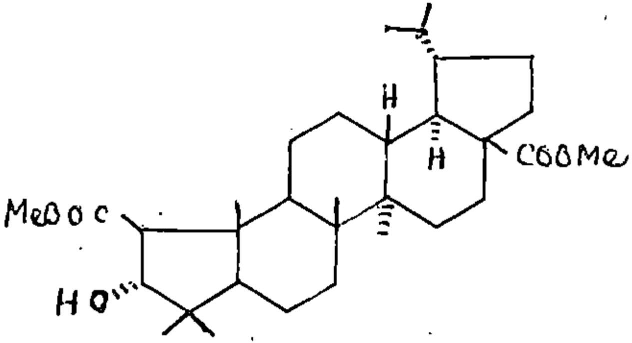


89 91 92

The solid C, m.p. 257-59° on crystalisation from methanol afforded colourless needles, m.p. 261-63°, $(\alpha)_D$ 22°, ν_{max}^{nujol} 3540 (OH), 1730 (CO_2Me), 1710 cm^{-1} (CO_2Me), and was found to be identical with an authentic sample of dimethyl dihydroceanothate[5] [methyl-3β-hydroxy-2α-methoxycarbonyl-A(1)-norlupan-28-oate] 91 supplied by Professor P. de Mayo (m.m.p, Co-TLC and IR comparison).

The solid D, on crystallisation from methanol gave crystals, m.p. 140-42°, ν_{max}^{nujol} 3560 (OH), 1745 (CO_2Me) and 1705 (CO_2Me). The yield of this compound was not sufficient for NMR studies. But by analogy with previous work[21], it is believed to be the C - 3 epimer of dimethyl dihydroceanothate

* Addendum : NMR spectrum of (E), m.p. 205-6° exhibited signals at δ 4.2 (1 H, d after D_2O, J.8.0 Hz; $C\underline{H}OH$), 3.65 (3 H, S; COOMe), 3.7 (3 H, S; COOMe), 2.25 (1 H, d, J.8.5 Hz, C-2 proton), the splitting pattern being almost similar to those recorded for methyl 3α-hydroxy-2β-methoxycarbonyl-A(1)-norlup-20(29)-en-28-oate[21]. The above NMR evidence permits the assignment of structure 92A for (E)



92A

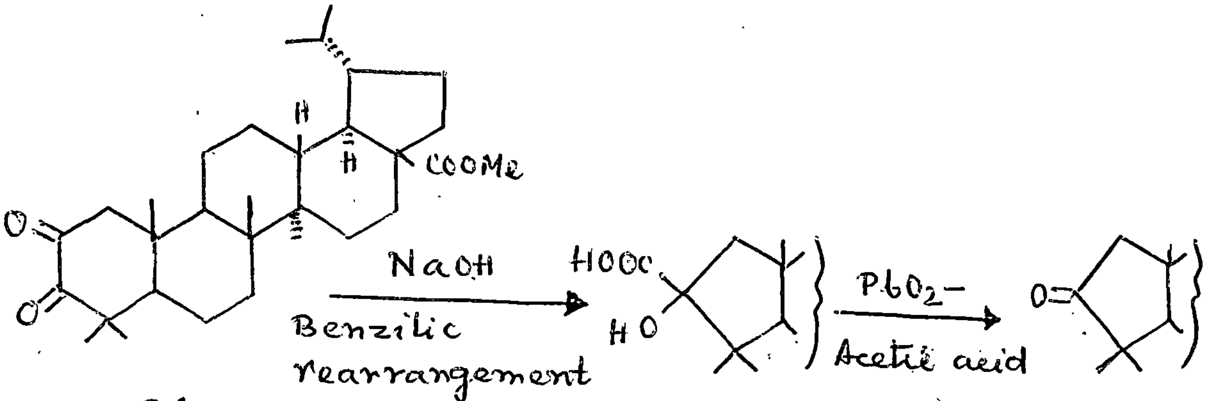
i.e. methyl-3α-hydroxy-2α-methoxycarbonyl-A(1)-norlupan-28-oate 92. Further work is in progress to prepare this isomer in sufficient quantity in order to enable us to study its NMR spectrum and establish its stereochemistry.

The β - ketoester [methyl 2β- methoxycarbonyl-3-oxo-A (1)- norlupan - 28 - oate], m.p. 175-77° was too insufficient for any further work.

In another run, Dieckmann condensation product of the trimethyl ester, was chromatographed over silica gel (E. Merck; Kieselgel-60) but separation of the isomeric β- ketoesters could not be achieved. We, therefore, reduced the mixture of β- ketoesters with sodium borohydride. The reduced product on chromatography over deactivated alumina first eluted a solid E, m.p. 203-4° (Petroleum : Benzene 2 : 3). Further elution with the same solvent gave a solid F which was seen to be a mixture of two compounds by TLC examination. On further chromatography we obtained two compounds 91 and 92 which were previously isolated directly from dimethyl dehydrodihydroceanothate 89. The solid E on crystallisation from acetone gave platelets, m.p. 205-6°, ν_{max}^{nujol} 3520 (OH), 1740 (CO_2Me) and 1705 cm^{-1} (CO_2Me).*

Investigation were also initiated in this laboratory for the preparation of the β - ketoester 91 and 92 by a second route. The method involved the preparation of the A-nor ketone

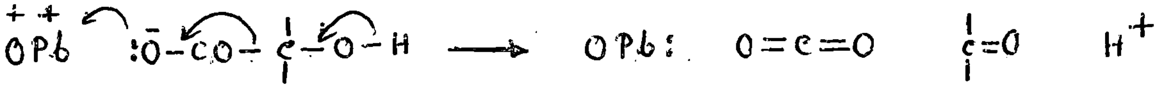
94, carbomethoxylation of which at C-2 would be expected to afford the β- ketoester 91 in proper stereochemistry. Since our previous results showed that in the Dieckmann condensation of the trimethyl ester 88, the 2α- methoxycarbonyl derivative 89 was obtained in high yield in the equilibrium mixture, we thought that, in the carbomethoxylation reaction, under the similar basic condition of the reaction, if successful, would also give the 2α- isomer 89 in the same ratio. With this end in view we prepared the A-nor ketone 94 starting from the diosphenol 86 by following the sequence shown below.



86 93 94

The diosphenol 86 in ethanol on refluxing with 10% alcoholic sodium hydroxide[48] undergoes a benzil-benzilic acid type of rearrangement and gave a product, m.p. 255-56°, ν_{max}^{nujol} 3440, 3340, 1720 cm^{-1} which has been assigned α-hydroxy carboxylic acid structure <u>93</u>. The latter on treatment with lead dioxide[51,52] in glacial acetic acid solution under mild reflux yielded a product <u>94</u>, m.p. 179-80°, $(\alpha)_D$ 75.4°, ν_{max}^{nujol} 1735 cm^{-1} (unresolved band for cyclopentanone and ester) and on expansion of the spectrum exhibited peaks at 1734 (cyclopentanone) and 1728 cm^{-1} (CO_2Me) having identical m.p., rotation and IR spectra as those reported in the literature for methyl decarboxydehydrodihydroceanothate[5], or A-nor- dihydrobetulonic acid methyl ester[12].

Probable mechanism[49] for the reaction is shown below.



Carbomethoxylation[53] of the A-nor ketone <u>94</u> with dimethyl carbonate was attempted using different bases, e.g. sodium methoxide, potassium tert. butoxide, sodium hydride under different experimental conditions (including different solvents). But in all cases the reaction was unsuccessful and we could isolate the starting material only, (see experimental). Further work is in progress in search of conditions for successful introduction of the -COOMe group at C-2.

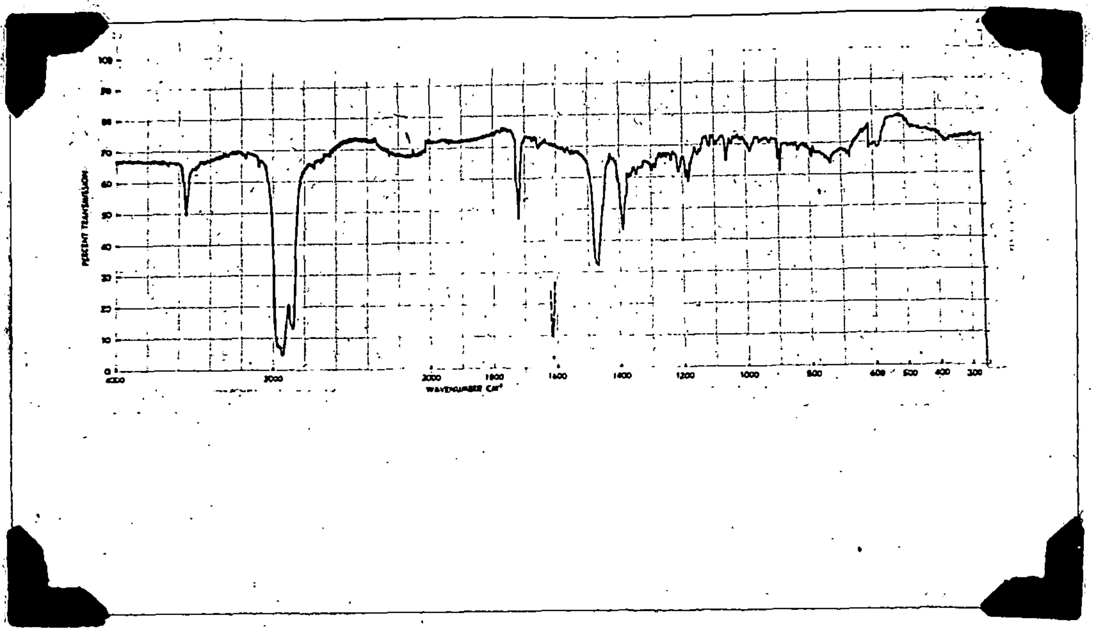


Fig. 1 : IR spectrum of methyl betulinate **84**

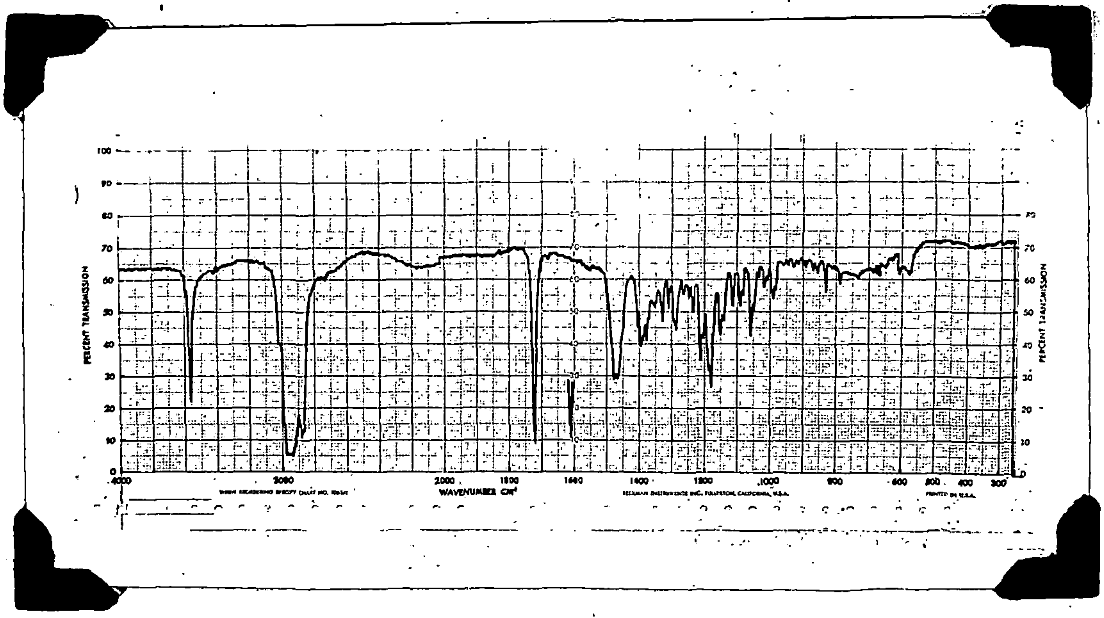


Fig. 2 : IR spectrum of methyl dihydrobetulinate **85**

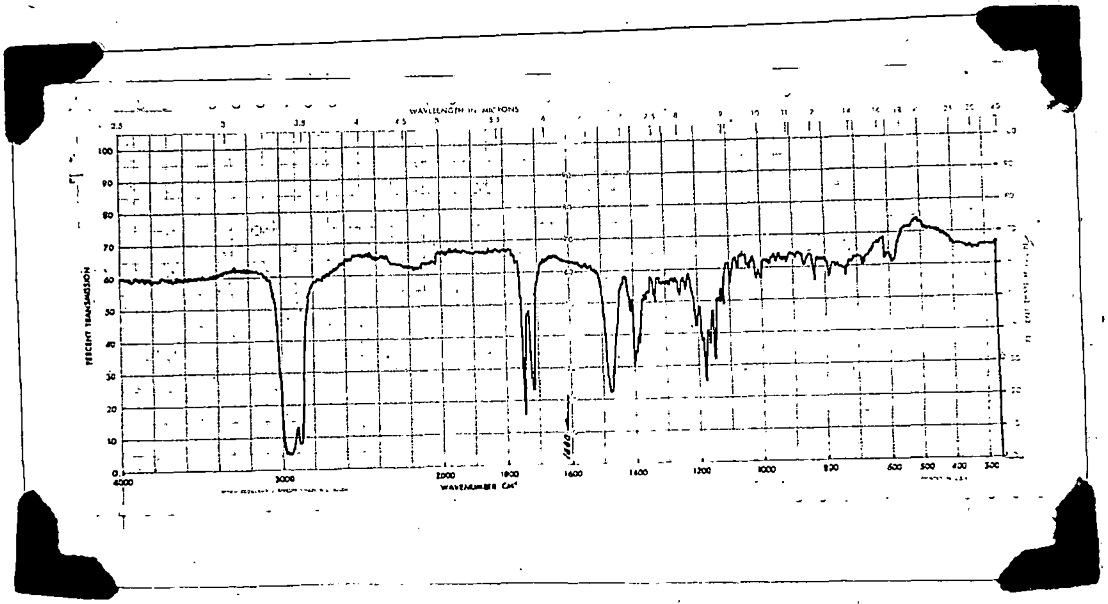


Fig. 3 : IR spectrum of methyl dihydrobetulonate 81

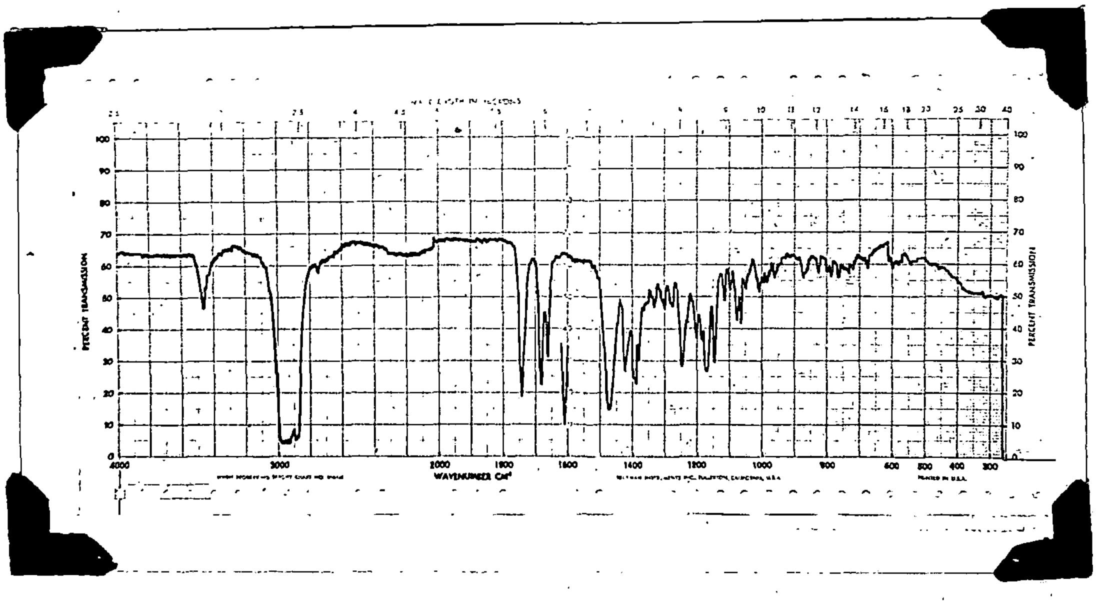


Fig. 4 : IR spectrum of diosphenol 86

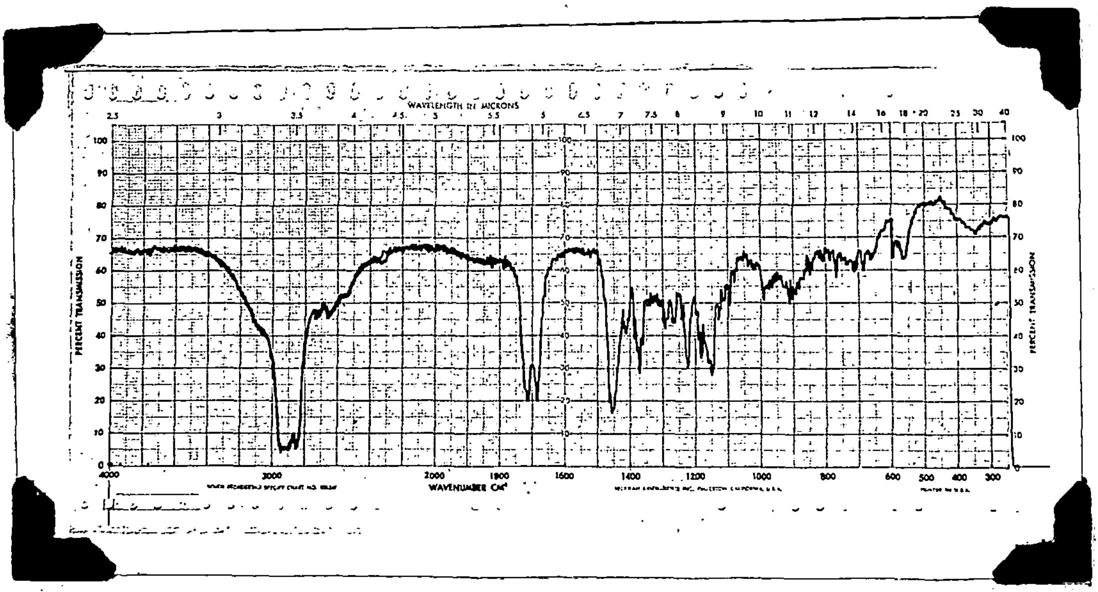


Fig. 5 : IR spectrum of seco A-acid 87

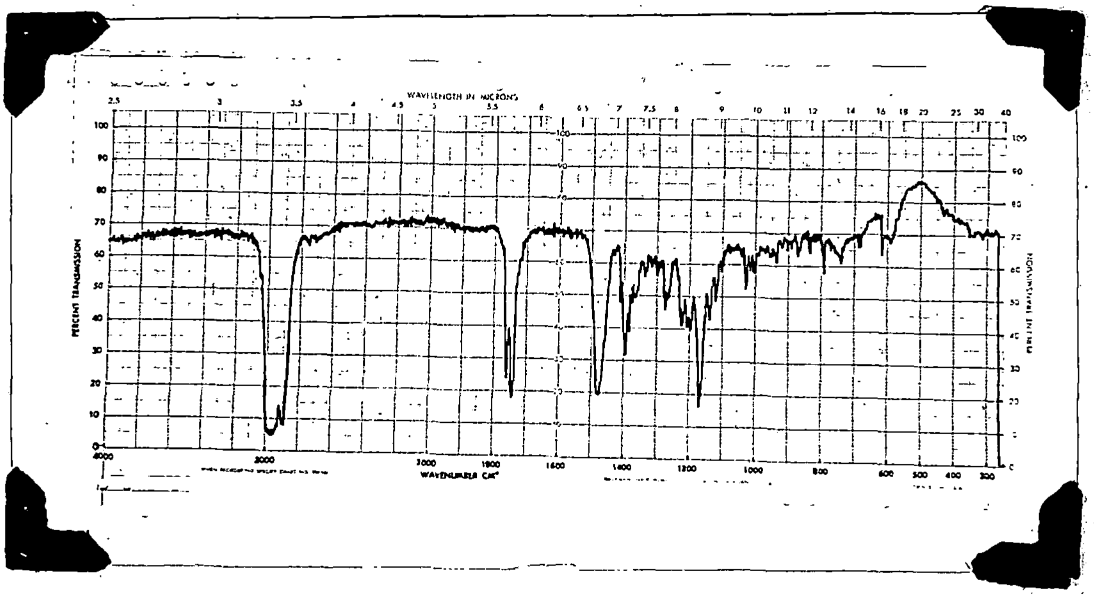


Fig. 6 : IR spectrum of trimethyl ester 88

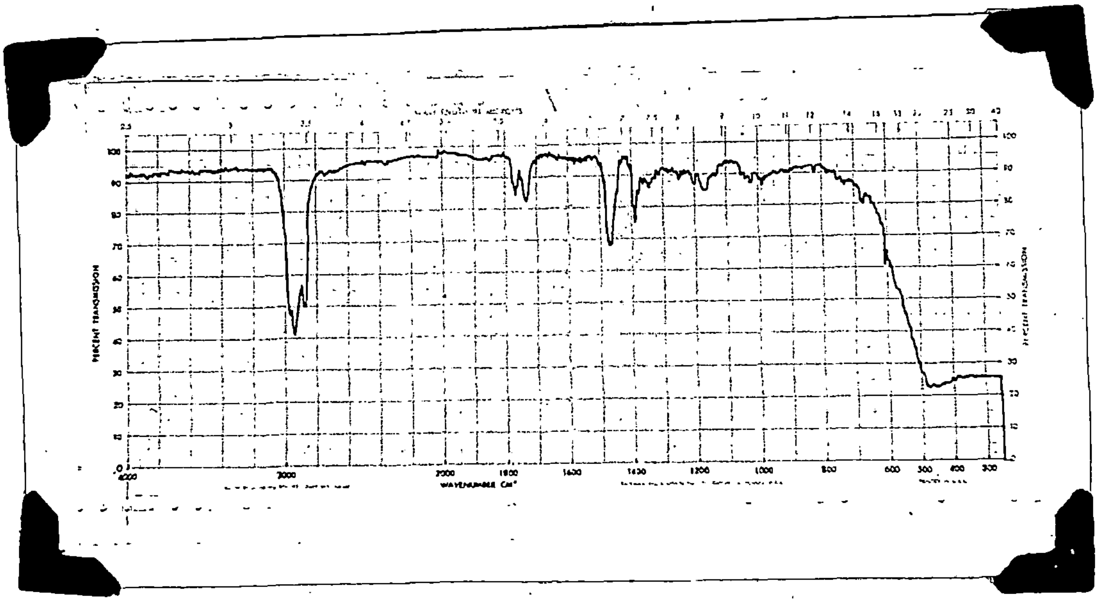


Fig.7 : IR spectrum of methyl 2α-methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate 89 (Sample insufficient).

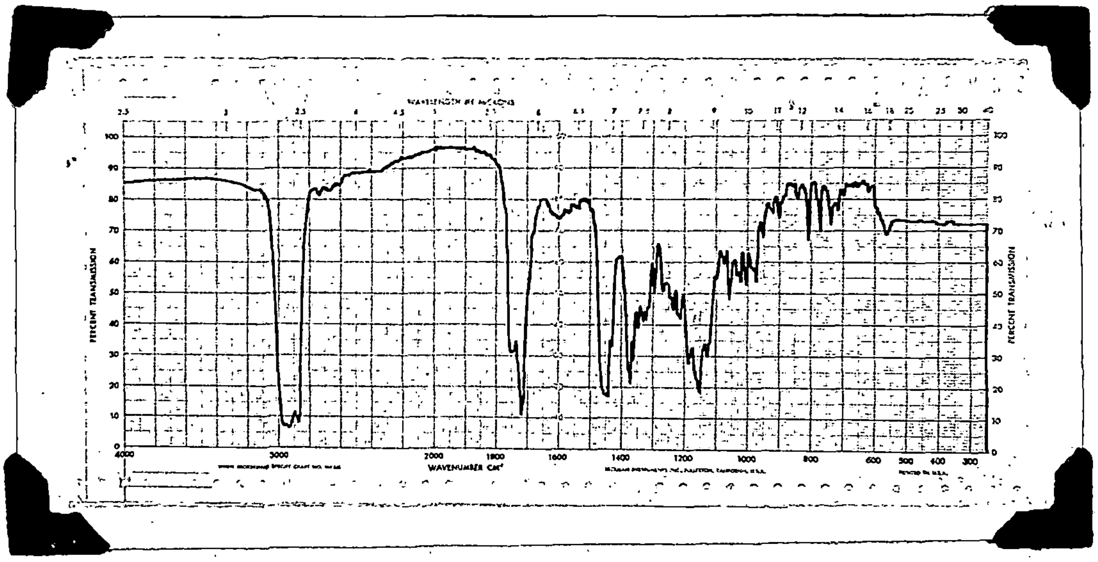


Fig.8 : IR spectrum of methyl 2α-methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate 89

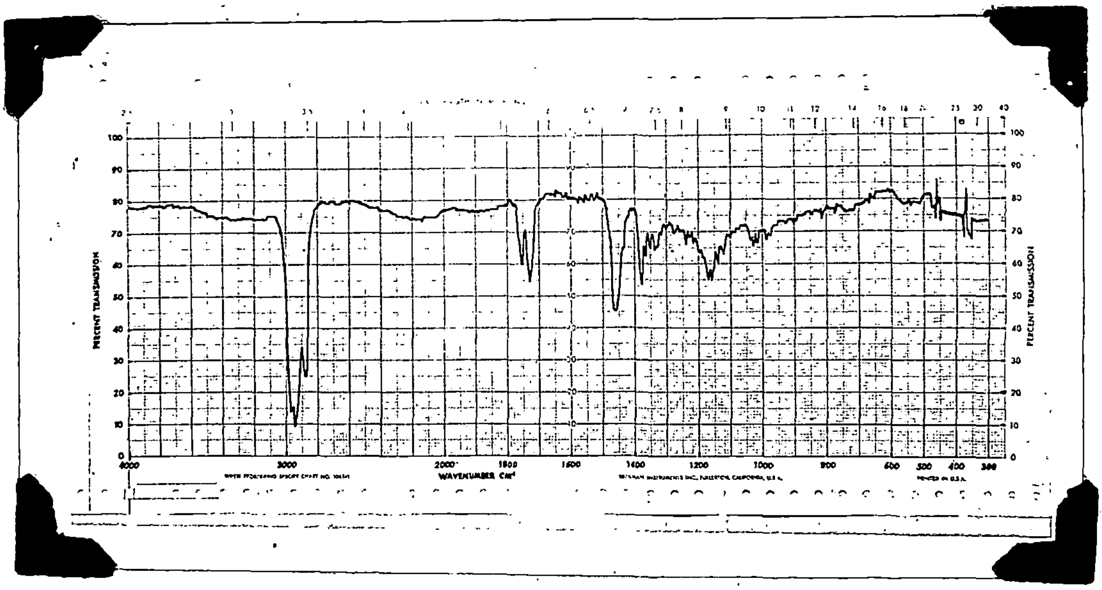


Fig. 9 : IR spectrum of methyl 2β-methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate 90

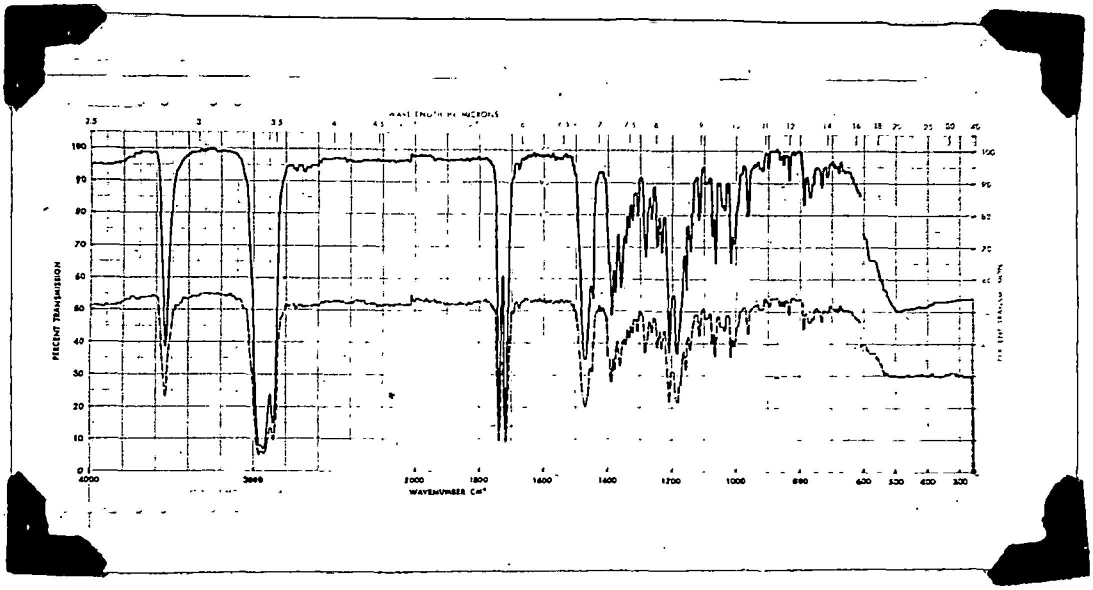


Fig. 10 : IR comparison of dimethyl dihydroceanothate 91 (solid line) with an authentic specimen (dotted line)

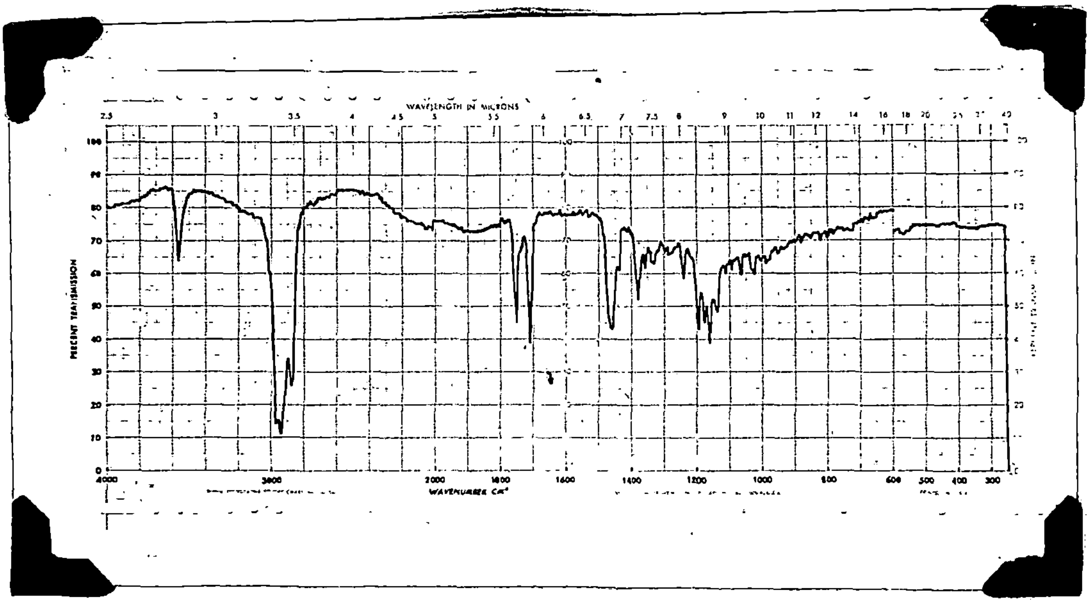


__Fig.11:__ IR spectrum of methyl 3α-hydroxy-2α-methoxycarbonyl-A(1)-norlupan-28-oate __92__

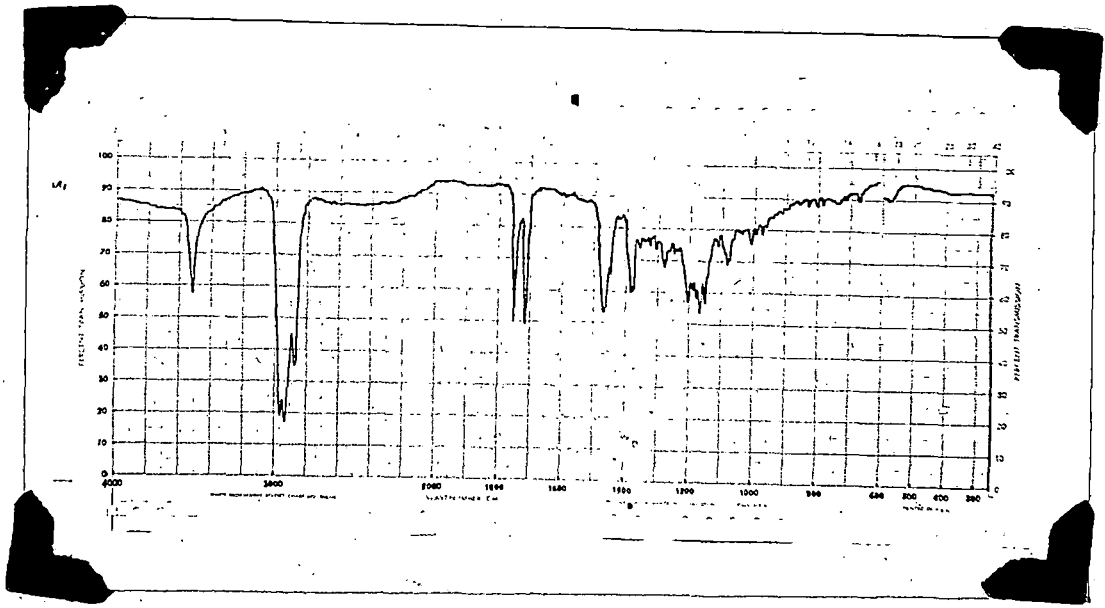


__Fig.12:__ IR spectrum of another epimer derived from β- ketoesters.

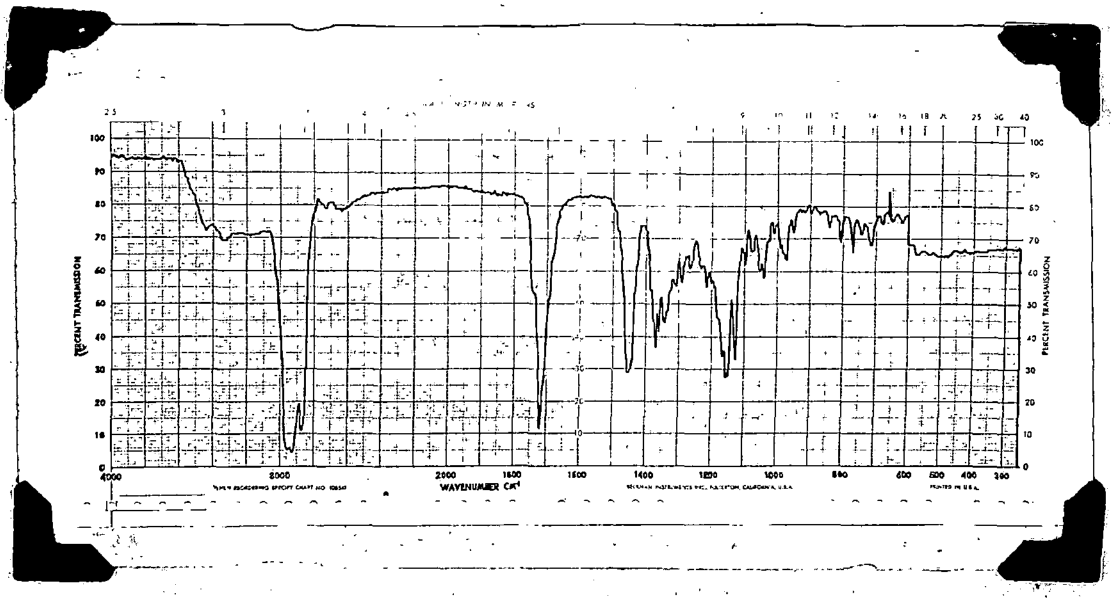


Fig. 13: IR spectrum of α-hydroxy carboxylic acid **93**

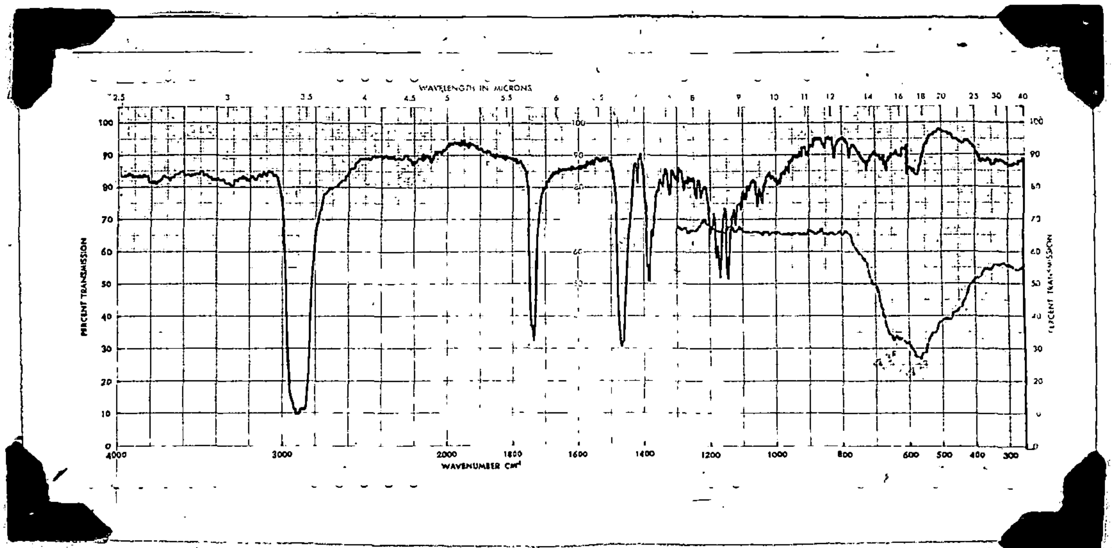


Fig. 14: IR spectrum of methyl decarboxydehydrodihydroceanothate **94**

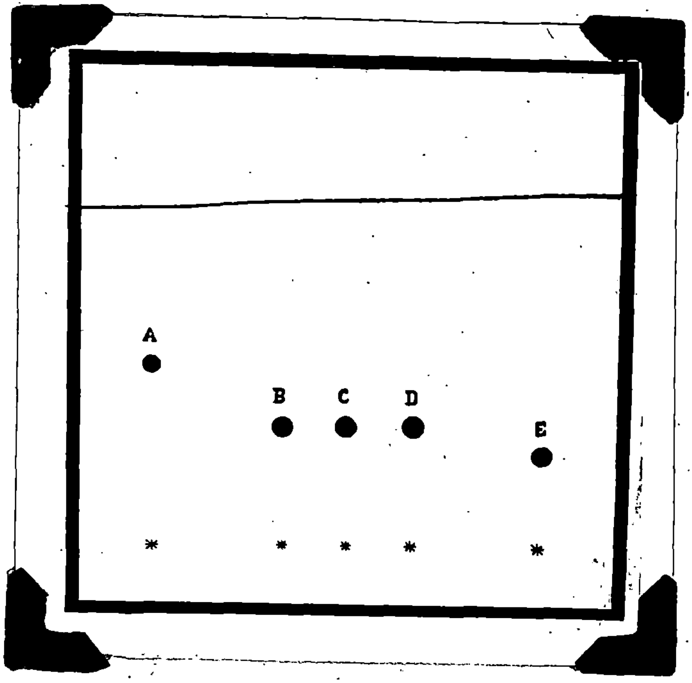


Fig. 15 : TLC of Dimethyl dihydroceanothate and its epimers on 12% $AgNO_3$ impregnated Silica gel (Kieselgel G; E. Merck) Plate :

Solvent used : Benzene
Developing agent : $Ac_2O-H_2SO_4$ (9:1)

A : A compound having m.p. 205-6° (Rf 0.53)

B : Dimethyl dihydroceanothate 91 (Rf 0.34)

C : Authentic Dimethyl dihydroceanothate (Rf 0.34)

D : Mixture of B and C (Rf 0.34)

E : Methyl - 3α- hydroxy-2α-methoxycarbonyl-A(1)-norlupan-28-oate 92 (Rf 0.25)

EXPERIMENTAL

Meling points are uncorrected. The petroleum used throughout the investigation had b.p. 60-80°. All optical rotations were determined in chloroform solution unless stated otherwise. NMR spectra were determined on Varian A-60 and HA-100 spectrophotometer using chloroform-d solution containing tetramethyl silane as reference. The IR spectra were recorded on Beckmann IR-20 spectrophotometer. UV absorption spectra were taken Ziess VSU-1 and UV Beckmann DU-2 spectrophotometers in 95% ethanol solution unless stated otherwise. TLC was done on chromatoplate of Silicagel G (E. Merck) and the spots were developed with H_2SO_4-H_2O (9:1) mixture.

Extraction of Bischofia javanica Blume : Isolation of betulinic acid 83 ;

Dried and powdered trunk bark of Bischofia javanica Blume (2 kg) was extracted with benzene in a Soxhlet apparatus for twenty hours. Benzene was distilled off and the gummy residue (9 gm) was taken up in ether (1 liter). The ether solution was washed with 10% aqueous sodium hydroxide solution (3X300 ml). The aqueous alkaline layer was thoroughly shaken with ether to remove any neutral material that might be present. The aqueous layer was acidified (1 liter) when some insoluble solids separated out. The acidified portion was extracted with ether, washed with water till neutral and then dried (Na_2SO4) Ether was removed when a gummy residue (2gm) of betulinic acid 83 was obtained.

Esterification of betulinic acid 83 : Preparation of methyl betulinate 84 :

To the crude acid 83 (3gm) dissolved in ether (250 ml) was added a solution of diazomethane in ether prepared from nitrosomethyl urea (1.5gm) and was kept overnight. Next day excess of diazomethane was destroyed with acetic acid (1 ml). The ether solution was washed with water, 10% sodium bicarbonate solution and again with water till neutral and then dried (Na_2SO_4). Evaporation of the ether yielded a gummy residue (1.5gm). This crude ester (1.5gm) dissolved in benzene (12 ml) was placed over a column of alumina (100 gm, deactivaled with 4 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents. (Table - III)

Table - III

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 4	Oil
Petroleum: benzene (4:1)	5 - 8	Nil
Petroleum: benzene (3:2)	9 - 14	Solid (1.2gm) m.p. 217-19°

Further elution with more polar solvent did not yield any solid material.

Solids obtained from the fractions 9–14, m.p. 217–19° (Table-III) were combined (1.2 gm), and crystallised from a mixture of chloroform and methanol to afford colourless needles of methyl betulinate <u>84</u>, m.p. 223–24°, $(\alpha)_D$ + 5°, identical with authentic sample (m.m.p and IR)

Found : C, 78.79; H, 10.52%

Calculated for $C_{31}H_{50}O_3$: C, 79.10; H, 10.71%

UV : No absorption in the region 220–3000 mμ

IR(nujol) : 3560 (–OH), 1715 (–$COOCH_3$), 1660 and 880 cm^{-1} (= CH_2) <u>Fig:1</u>

NMR: δ 4.8–4.9 (two doublets; = CH_2),
δ 3.75 (singlet – $COOCH_3$),
δ 2.01 (singlet, – CHOH),
δ 1.75 (sharp singlet, $H_2C = \underset{\substack{| \\ CH_3}}{C} -$) and
δ 1.00 (a tail singlet accounting for 15 protons, 5 CH_3)

<u>Hydrogenation of methyl betulinate 84 : Preparation of methyl dihydrobetulinate 85</u> :

Methyl betulinate (8 gm), dissolved in a mixture of ethyl acetate and acetic acid (100 ml each) was shaken in an atmosphere of hydrogen in presence of Pt-O_2 catalyst (0.2 gm) for three hours until absorption of hydrogen ceased. Ethyl acetate was removed by distillation and the solution was diluted with water whereby a white solid (7.5gm) separated out which was collected by filtration. Crystallisation from a mixture of chloroform and methanol furnished colourless needles of 85, m.p. 236-38°. This compound 85 was found to be identical with an authentic sample of methyl dihydrobetulinate (m.m.p. and IR)

Found :	C, 78.92; H, 11.23%
Calculated for $C_{31}H_{52}O_3$:	C, 78.76; H, 11.09%

UV: transparent in the region 220 to 300 mμ

IR: 3560 (OH), 1715 cm^{-1} (CO_2Me) Fig-2

Jones oxidation of methyl dihydrobelutinate 85 : Preparation of methyl dihydrobetulonate 81 :

To a solution of methyl dihydrobetulinate 85 (7gm) in pure acetone (1 liter) was added Jones reagent dropwise with shaking until a faint orange colour persisted. The mixture was kept at room temperature for 1 hour, diluted with water and extracted with ether. The ether layer was washed throughly with water, dried (Na_2SO_4) and the ether evaporated. The residue (5.9gm) dissolved in benzene (15ml) was chromatographed over a column of active alumina (360 gm). The chromatogram was developed with petroleum and then eluted with the following solvents (Table - IV)

Table - IV

Eluent	Fractions 50 ml each.	Residue on evaporation
Petroleum	1 - 4	Nil
Petroleum: benzene (4:1)	5-25	Solid, (5.7 gm) m.p. 197-99°

Further elution with more polar solvent did not yield any solid material.

Fractions 5-25 (5.7 gm) were combined and on crystallisation from methanol furnished needle shaped crystals of 81, m.p. 202-4°, $(\alpha)_D$ + 8°, identical with an authentic sample of methyl dihydrobetulonate (m.m.p and IR comparison)

Found :	C, 79.32; H, 10.86%
Calculated for $C_{31}H_{50}O_3$:	C, 79.10; H, 10.71%

IR : 1730 (CO_2Me), 1708 cm^{-1} (CO). Fig - 3

Autoxidation of methyl dihydrobetulonate 81 : Preparation of diosphenol 86 :

Methyl dihydrobetulonate 81 (2 gm) suspended in potassium tertiary butoxide in tertiary butonol (prepared from 6 gm potassium and 160 ml of tertiary butanol) was shaken in a stream of oxygen for 75 minutes. The reaction mixture was diluted with water and then 6 N hydrochloric acid was added till the solution was acidic. It was then extracted with chloroform (150 ml), washed with water till neutral and dried (Na_2SO_4). On removal of the solvent under reduced pressure, a yellowish gummy residue (1.8 gm) was obtained. This residue dissolved in benzene (10 ml) was placed over a column of alumina (120 gm, deactivated with 4.8 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents (Table - V)

Table - V

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 4	Nil
Petroleum: benzene (4:1)	5 - 15	Solid (1.6 gm) m.p. 126-29°

Further elution with more polar solvent did not yield any solid material.

Fractions 5-15 (1.6 gm) were combined and on crystallisation from a mixture of chloroform and methanol furnished colourless needles of 86, m.p. 131-33°, $(\alpha)_D$ - 1.96°. It gave a positive feric chloride coloration for diosphenol and showed two spots on chromatoplate. These were assumed to be due to tautomeric forms of the diketone 86A and diosphenol 86B.

Found :	C, 76.48; H, 10.01%
Calculated for $C_{31}H_{48}O_4$:	C, 76.82; H, 9.98%

UV : λ_{max} 269 mμ (ε, 7532)

IR : 3460 (OH), 1730 (CO_2Me), 1670
1650 860 cm^{-1} Fig-4

[illegible] : λ_{max} [illegible]

Hydrogen peroxide oxidation of diosphenol 86 : preparation of seco A - acid 87 :

Hydrogen peroxide (100 vol; 6 ml) mixed with 10% potassium hydroxide solution (12 ml) were added in three equal portions at intervals of 15 minutes to a solution of diosphenol 86 (700 mg) in ethanol (25 ml) in refluxing condition. After the mixture had been kept at 20° for 2 hours it was diluted with water, extracted with ether and washed with water till neutral. The aqueous portion was acidified with 6 N hydrochloric acid and extracted with ether and washed with water till neutral and dried (Na_2SO_4). On evaporation of the solvent it gave a solid residue (550 mg). Crystallisation of the product from a mixture of benzene - petroleum afforded colourless needles of 87, m.p. 175-7°.

Found : C, 72.06 ; H, 9.43%

Calculated for $C_{31}H_{50}O_6$: C, 71.78 ; H, 9.72%

IR : 1710 and 1690 cm^{-1} (COOH) Fig - 5

Esterification of seco A-acid 87 :

Preparation of trimethyl ester 88 :

The above acid 87 (500 mg) dissolved in ether (50 ml) was added a solution of diazomethane in ether prepared from nitrosomethylurea (500 mg) and was kept overnight. Next day excess of diazomethane was destroyed with acetic acid (1 ml). The ether solution was washed with water, 10% sodium bicarbonate solution and again with water till neutral and then dried (Na_2SO_4). Evaporation of the solvent yielded a gummy residue (480 mg). This product dissolved in benzene (5ml) was placed over a column of alumina (30 gm, deactivated with 1.2 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents (Table - VI)

Table - VI

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 3	Nil
Petroleum : benzene (4:1)	4 - 12	Solid (450 mg) m.p. 145 - 46°

Further elution with more polar solvent did not yield any solid material.

Fractions 4 -12 (450mg) were combined and on crystallisation from methanol afforded colourless needles of 88, m.p. 146-47°, [redacted] having identical m.p., [redacted] and IR spectra reported in the literature for the trimethyl ester[3,12] of the *seco*-A acid.

Found :	C, 72.32; H, 9.97%
Calculated for $C_{33}H_{54}O_6$:	C, 72.49; H, 9.95%

IR : 1745, 1725 cm^{-1} (CO_2Me) Fig - 6

Dieckmann condensation of trimethyl ester 88 : Preparation of methyl 2α- methoxy carbonyl-3-oxo-A(1)-norlupan-28-oate 89 and methyl 2β-methoxy carbonyl-3-oxo-A(1)-norlupan-28-oate 90:

Potassium (0.1 gm, 2.6 mg atom) was added to 10 ml of tertiary butanol and 10 ml of benzene (solvents dried for 24 - hours over calcium hydride) under nitrogen blanket and after all the potassium had reacted, a solution of 273 mg (0.5 m.mol) of the seco ester 88 in 10 ml of benzene was added with a syringe with stirring. The solution was then boiled under reflux (nitrogen atmosphere) with a Dean-Stark trap for 24-hours, during which time 10 ml of solvent was removed. The orange coloured solution was cooled, diluted with water, acidified with 6N hydrochloric acid and extracted with ether. The organic layer was washed with water, 5% sodium bicarbonate and water to neutrality and dried (Na_2SO_4). Evaporation of the solvent gave a gummy residue (200 mg). The product dissolved in benzene (5 ml) was placed over a column of alumina (20 gm, deactivated with 0.8 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents (Table - VII)

Table - VII

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 2	Nil
Petroleum: benzene (9:1)	3 - 4	Nil
Petroleum: benzene (4:1)	5 - 6	Nil
Petroleum: benzene (7:3)	7 - 8	Nil
Petroleum: benzene (3:2)	9 - 11	Solid (170 mg), m.p. 190-92°
	12 - 13	Solid (10 mg); m.p. 174-75°

Further elution with more polar solvent did not yield any solid material.

Fractions 9 - 11 (170 mg) were combined and on crystallisation from methanol afforded colourless needles of 89, m.p. 191-93°, $(\alpha)_D$ 89°, having identical m.p., rotation and IR spectra reported in the literature for dimethyl dehydrodihydroceanothate.[21]

Found : C, 74.69; H, 9.73%

Calculated for $C_{32}H_{50}O_5$: C, 74.67; H, 9.79%

IR : 1755 (cyclopentanone), 1725 cm^{-1} (CO_2Me) <u>Fig - 7</u> and

(Sample taken was insufficient)

1750 (cyclopentanone), 1720 cm^{-1} (CO_2Me) Fig - 8

Spectrum recorded for the compound obtained from the mother-liquor of the above sample.

Fractions 12-13 (10 mg) were combined and on crystallisation from methanol furnished needle shaped crystals of <u>90</u>, m.p. 175-77°, $(\alpha)_D$ + 42°, having similar m.p., rotation and IR spectra reported in the literature for methyl 2β- methoxy carbonyl-3-oxo-A(1)-norlupan-28-oate.

Found : C, 74.53; H, 9.92%

Calculated for $C_{32}H_{50}O_5$: C, 74.67; H, 9.79%

IR : 1750 (cyclopentanone), 1730 (CO_2Me) <u>Fig - 9</u>

<u>Sodium borohydride reduction of dimethyl dehydrodihydroceanothate [methyl 2α- methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate] 89 : Preparation of dimethyl dihydroceanothate [methyl 3β-hydroxy-2α-methoxycarbonyl-A(1)-norlupan-28-oate] 91 and its epimer 92</u> :

Sodium borohydride (70 mg) was added to a solution of dimethyl dehydrodihydroceanothate <u>89</u> (70 mg) in methanol (20 ml).

and dioxan (20 ml), stirred for 5 - hours and allowed to stand overnight at room temperature. Most of the solvents were removed under reduced pressure. The reaction mixture was diluted with water and then extracted with ether. The ethereal layer was washed till neutr~~y~~al and dried (Na_2SO_4). On removal of the solvent, a gummy residue (70 mg) was obtained. The product dissolved in benzene (3 ml) was placed over a column of alumina (10 gm, deactivated with 0.4 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents. (Table - VIII)

Table - VIII

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 2	Nil
Petroleum : benzene (9:1)	3 - 4	Nil
Petroleum : benzene (4:1)	5 - 6	Nil
Petroleum : benzene (7:3)	7 - 8	Nil
Petroleum : benzene (3:2)	9 - 10	Nil
Petroleum : benzene (1:1)	11- 12	Nil
Petroleum : benzene (2:3)	13-19	Solid (50 mg) (Mixture of two compounds)

Further elution with more polar solvent did not yield any solid material.

Fractions 13-19 (50 mg) were subjected to TLC separately and the first five fractions 13-17 showed two spots on chromatoplate indicating the mixture of two compounds and the last two fractions were homogeneous. However, all the fractions 13-19 were combined and rechromatographed through a column of alumina (20 gm) deactivated with 0.8 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents (Table - IX)

Table - IX

Eluent	Fraction 50 ml each	Residue on evaporation
Petroleum	1 - 2	Nil
Petroleum : benzene (9:1)	3 - 4	Nil
Petroleum : benzene (4:1)	5 - 6	Nil
Petroleum : benzene (7:3)	7 - 8	Nil
Petroleum : benzene (3:2)	9 - 10	Nil
Petroleum : benzene (1:1)	11-12	Nil
Petroleum : benzene (2:3)	13-14	Solid (10mg), m.p. 257-59°
	15-20	Solid (30mg), m.p. 138-40°

Further elution with more polar solvent did not yield any solid material.

Fractions 13-14 (10 mg) were combined and on crystallisation from methanol afforded colourless needles of 91, m.p. 261-63°, $(\alpha)_D$ + 22°. The compound was found to be identical with an authentic sample of dimethyl dihydroceanothate [methyl-3β-hydroxy-2α-methoxycarbonyl-A(1) norlupan-28-oate] supplied by de Mayo and Starratt (m.m.p.; IR and co- TLC)

Found : C, 74.32; H, 10.22%

Calculated for $C_{32}H_{52}O_5$: C, 74.38; H, 10.14%

IR : 3540 (OH), 1730 (CO_2Me), 1710 cm^{-1} (CO_2Me) Fig - 10

TLC : Rf 0.34 Fig - 15

Fractions 15-20 (30 mg) were combined and on crystallisation from methanol gave crystals, m.p. 140-42°, believed to be an epimer of dimethyl dihydroceanothate - methyl 3α-hydroxy-2α-methoxycarbonyl-A(1)-norlupan-28-oate 92. Further studies for establishing its stereochemistry by NMR could not be done for want of sufficient material.

Found : C, 74.57; H, 10.32%

Calculated for $C_{32}H_{52}O_5$: C, 74.38; H, 10.14%

IR: 3560 (OH), 1745 (CO_2Me), 1705 cm^{-1} (CO_2Me) Fig - 11

TLC : Rf 0.25 Fig - 15

sodium borohydride reduction could not be performed on methyl 2β- methoxycarbonyl-3-oxo-A(1)-norlupan-28-oate 90 due to paucity of sample.

Dieckmann condensation of trimethyl ester 88 :

Trimethyl ester 88 (273 mg) was subjected to Dieckmann condensation using the procedure described above (page 57). The reaction mixture after usual work up gave a gummy residue (220 mg). The product dissolved in benzene was placed over a column of silica gel (25 gm) (Merck; Kieselgel-60) developed with petroleum and was eluted with the following solvents, (Table - X).

Table - X

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 2	Nil
Petroleum : benzene (4:1)	3 - 4	Nil
Petroleum : benzene (3:2)	5 - 6	Nil
Petroleum : benzene (2 :3)	7 - 8	Nil
Petroleum : benzene (1:4)	9 - 10	Nil
Benzene	11-12	Nil
Benzene : Ether (4:1)	13-14	Semisolid (190 mg)

Further elution with more polar solvent did not yield any solid material.

Fractions 13-14 (19 mg) were combined but this material could not be induced to crystaliisation. The product showed two spots on chromatoplate indicating the presence of a mixture of two epimers 89 and 90.

Sodium borohydride reduction of the above mixture obtained in the Dieckmann condensation reaction (page 65):

The Dieckmann Condensation product (mixture of 89 and 90) (150 mg) was reduced with sodium borohydride (150mg) following the procedure described before (page). The reaction mixture after usual work up gave a gummy residue (125 mg). This product dissolved in benzene was placed over a column of alumina (20 gm, deactivated with 0.8 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents (Table - XI).

Table - XI

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 2	Nil
Petroleum : benzene (4:1)	3 - 4	Nil
Petroleum : benzene (3:2)	5 - 6	Nil
Petroleum : benzene (2:3)	7 - 8	Solid (40 mg).m.p. 203-4°
	9 - 10	Nil
	11-17	Solid (60 mg) (Mixture of two compounds)

Further elution with more polar solvent did not ~~(Mixture of two compounds)~~ yield any solid material.

Fractions 7-8 (40 mg) were combined and on crystallisation from acetone afforded colourless needles, m.p. 205-6^{o},

Found : C, 74.28; H, 10.27%

Calculated for $C_{32}H_{52}O_5$: C, 74.38; H, 10.14%

IR : 3520 (OH), 1740 (CO_2Me), 1705 cm^{-1} (CO_2Me) Fig - 12

TLC : Rf 0.53 Fig - 15

(homogeneous)

Fractions 11-17 (60 mg) were subjected to TLC separately and first five fractions 11-15 showed two spots on chromatoplate indicating the mixture of two compounds and the last two fractions 16-17 were homogeneous. However, all the fractions 11-17 were combined and rechromatographed over a column of alumina (20 gm, deactivated with 0.8 ml of 10% aqueous acetic acid) developed with petroleum and was eluted with the following solvents (Table - XII)

Table - XII

Eluent	Fractions 50 ml each	Residue on evaporation
Petroleum	1 - 2	Nil
Petroleum : benzene (3:2)	3 - 4	Nil
Petroleum : benzene (1:1)	5 - 6	Nil
Petroleum : benzene (2:3)	7 - 8	Solid (12 mg), m.p. 258-60°
	9 - 12	Solid (35 mg), m.p. 139-41°

Further elution with more polar solvent, did not yield any solid material.

Fractions 7-8 (12 mg) on crystalisation gave a product, m.p. 261-63° identical with a sample of methyl dihydroceanothate fractions 9-12 (35 mg) on crystallisation from methanol gave crystals m.p. 140-42°, identical with the product obtained before in the sodium borohydride reduction of the β-keto ester 89. (Page 59)

Benzilic acid rearrangement of diosphenol 86 : Preparation of α-hydroxy - carboxylic acid 93 :

The diosphenol 86 (500 mg) in ethanol (15 ml) was heated under reflux with 10% alcoholic sodium hydroxide (10 ml) for 5 hours. Most of the ethanol was removed under reduced pressure. The reaction mixture was cooled, diluted with water and then acidified with 6N hydrochloric acid. This acidified portion was taken up in ether and the ethereal solution was extracted with 1% sodium bicarbonate solution. The alkaline extract was acidified with 6N hydrochloric acid and extracted with ether and then with ethyl acetate. The combined extracts afforded a residue (425 mg) which was further purified by dissolution in 2% sodium bicarbonate solution followed by filtration, acidification and extraction. The resulting product (300 mg) on crystallisation from a mixture of chloroform and methanol furnished colourless needles of 93, m.p.255-56°.

Found :	C, 74.23; H, 9.88%
Calculated for $C_{31}H_{50}O_5$:	C, 74.06; H, 10.02%

IR : 3440, 3340, 1720 cm^{-1} <u>Fig - 13</u>

<u>Lead dioxide oxidation of α - hydroxy carboxylic acid 93 :</u>

<u>Preparation of methyl decarboxydehydrodihydroceanothate 94 :</u>

α- Hydroxy carboxylic acid <u>93</u> (1 gm) and Lead dioxide (1.0 gm) were suspended in glacial acetic acid (7 ml). The mixture was heated under mild reflux for 3-hours with occasional stirring. The excess of lead dioxide was filtered and the clear, straw-colored liquid was diluted. with water. This aqueous portion was extracted with ether, washed with 10% sodium bicarbonate solution, washed with water till neutral and then dried (Na_2SO_4). On removal of the solvent a solid residue (0.75 gm) was obtained which on crystallisation from a mixture of chloroform and methanol afforded needle shaped crystals of <u>94</u>, m.p. 179-80°, $(\alpha)_D$ 75.4°. This compound was found to be identical in all respect with the sample prepared by de Mayo and Starratt[5].

Found :	C, 78.96; H, 10.48%
Calculated for $C_{30}H_{48}O_3$:	C, 78.90; H, 10.59%

IR : 1735 cm^{-1} (unresolved band for cyclopentanone and ester)

On expansion : Two peaks at 1734 (cyclopentanone) <u>Fig-14</u>

and 1728 cm^{-1} (CO_2Me)

Attempted carbomethoxylation of methyl decarboxydehydrodihydroceanothate 94 using sodium methoxide :

A solution of 94 (456 mg, 1m mol) in dry benzene (3 ml) was added dropwise over 3-hour under nitrogen to a stirred mixture of .054 gm sodium methoxide (1 m.mol, prepared from .023 gm sodium and methanol in anhydrous condition) and 0.23 gm dimethyl carbonate in 5 ml dry benzene in a mild refluxing condition. After the addition of the ketone, the mixture was stirred for a further 2-hour in a refluxing condition. The reaction mixture was cooled in an ice-water bath and acidified with slight excess of aqueous acetic acid. The solvent was removed under reduced pressure and the residue was diluted with water and extracted with ether. The ether extract was washed with aqueous sodium bicarbonate to remove acetic acid, then with saturated brine, dried (Na_2SO_4) and freed from ether. A solid residue (400~~0~~ mg) was obtained. This product on crystallisation from a mixture of chloroform and methanol furnished colourless needles, of m.p. 179-80°. This compound was found to be identical with the starting material (m.m.p and IR comparison). Carbomethoxylation was also attempted using different solvents such as dioxane, toluene and dimethyl carbonate itself but in every case the reaction gave the same result.

Attempted carbomethoxylation[53] of methyl decarboxy dehydrodihydroceanothate 94 using potassium tert butoxide:

A solution of 0.3 gm (.0006 gm mol) of the ketone 94 in 0.5 ml tert. butanol was added under nitrogen to a mixture of 0.73 gm potassium tert.butoxide (.0065 gm. mol; prepared from 0.5 ml tert.butanol and 0.25 gm potassium in anhydrous condition) and 1 gm dimethyl carbonate. The whole solution was refluxed under nitrogen for 24-hours. The reaction mixture was cooled with an ice-water bath and acidified with a slight excess of acetic acid. The solvent was removed in vacuo and the residue was diluted with water and extracted with ether. The ether extract was washed with aqueous sodium bicarbonate to remove acetic acid, then with saturated brine, dried (Na_2SO_4) and solvent removed. A solid residue (250 mg) was obtained which on crystallisation from a mixture of chloroform and methanol gave crystals, m.p. 179-80°, identical in all respect with the starting material (m.m.p and IR)

Attempted carbomethoxylation[53] of methyl decarboxy dehydrodihydroceanothate using sodium hydride :

A solution of 0.5 gm of the ketone 94 in 30 ml benzene was added, under nitrogen, to a refluxing mixture of 0.15 gm sodium hydride and 1 gm of dimethyl carbonate. The rate of addition of the benzene solution of the compound was so adjusted that it corresponded to the rate of distillation by a distilling arrangement. This procedure was continued for 3-hours. The resulting slurrey was cooled in an ice-water bath and acidified with a slight excess of aqueous acetic acid. The solvent was removed under vacuo and the residue was diluted with water and extracted with ether. The ether extract was washed with aqueous sodium bicarbonate to remove acetic acid, then with saturated brine, dried (Na_2SO_4). Evaporation of ether gave a solid residue (465 mg) which on crystallisation from a mixture of chloroform and methanol gave crystals, m.p. 179-80°, identical in all respect with the starting material (m.m.p and IR). This reaction was also attempted in dry dimethylsulfoxide as well as in dimethylcarbonate alone but in each case the same result was obtained.

REFERENCES

1. P. L. Julian, J.Pikl and R. Dawson, *J.Amer.Chem.Soc.*, *60*, 77, 1938.
2. J. P. Boyer, R. A Eade, H. Locksley and J. J. H. Simes, *Aust.J.Chem.*, *11*, 236, 1958.
3. G. B. Guise, E. Ritchie and W. C. Taylor, *Aust.J.Chem.*, *15*, 314, 1962.
4. A. J. Birch, *J.Chem.Soc.*, 3593, 1960
5. P. de Mayo and A. N. Starratt, *Can.J.Chem.*, *40*, 788, 1962.
6. R. A. Abramovitch and G. Tertzakian, *Can.J.Chem.*, *39*, 1733, 1961.
7. L. M. Jackman, Application of nuclear magnetic resonance spectroscopy in organic chemisty, pergamon Press, 1959.
8. G. S. Davy, T. G. Halsall and E. R. H. Jones, *J.Chem.Soc.*, 2696, 1951.
9. P. W. Brian, J. F. Grove and J. MacMillan, *Fortschre.Chem.Org.Naturstoffe*, *18*, 350, 1960.
10. R. B. Woodward, *Festschrt.Arthur.Stoll.*, 524,1957.
11. L. Ruzicka, M. Brenner and E. Rey, *Helv.Chim.Acta.*, *24*, 515, 1941.

12. L. Ruzicka and O. Isler, Helv. Chim. Acta., 19, 506, 1936.

13. M. Karplus, J. Chem. Phys., 30, 11, 1959.

14. F. A. L. Anet, Can. J. Chem., 39, 789, 1961.

15. R. Mechoulam, Chemy. Ind., 1835, 1961.

16. R. A. Eade, G. Kornis and J. J. H. Simes, Chemy. Ind., 1195, 1962.

17. R. A Eade, G. Kornis and J. J. H. Simes, Aust. J. Chem., 17, 141, 1964.

18. R. Mechoulam, J. Org. Chem., 27, 4070, 1962.

19. P. Hirsja, Acta. Chem. Sca. 8, 12, 1954.

20. K. J. Crowley, Proc. Chem. Soc., 27, 1962.

21. R. A. Eade, P. K. Grant, M. J. A. McGrath, J. J. H. Simes and M. Wootton Aust. J. Chem., 24, 621, 1971.

22. F. B. Brutcher and W. Bauer, J. Amer. Chem. Soc., 84, 2236, 1962.

23. A. D. Cross and P. Crabbe, J. Amer. Chem. Soc., 86, 1221, 1964.

24. R. A. Eade, P. K. Grant, M. J. A. McGrath, J. J. H. Simes and M. Wootton, Chem. Commun., 1204, 1967.

25. J. Fishman, J.Amer.Chem.Soc., 87, 3455, 1965.

26. P. K. Grant and M. J. A. McGrath, Tetrahedron, 26, 1619, 1970.

27. a) S. Huneck, Chem.Ber., 98, 1837, 1965
    b) S. Huneck, Ibid. 98, 2284, 1965
    c) S. Huneck, Ibid. 98, 2291, 1965

28. a) L. Horner, E. Spietschka and A. Gross, Liebigs.Ann.Chem., 573, 17, 1951.
    b) L. Horner and E. Spietschka, Chem.Ber., 85, 225, 1952.
    c) L. Horner and E. Spietschka, Chem.Ber., 88, 934, 1955.
    d) L. Horner, W.Kirmse and K.Murth, Chem.Ber., 91, 430, 1958.
    e) L. Horner, K. Murth and H. G. Schmelrer, Chem.Ber., 92, 2953, 1959.

29. a) O. Süs, Lieligs.Ann.Chem., 556, 65, 85, 1944.
    b) O. Süs, Ibid. 557, 237, 1947.
    c) O. Süs, Ibid. 579, 133, 1953.
    d) O. Süs, Z. Wiss. Photgr., Photophysik. Photochem., 50, 11, 476, 1955.
    e) O. Süs, J. Munder and H. Steppan, Angew.Chem., 74, 985, 1962.

30. a) H. Meier and Klaus-Peter Zeller, Angew. Chem., 14, 32, 1975.

b) J. Bredt and W. Holz, J. Prakt. Chem., [2] 95, 133, 1917.

c) T. Gitson and W. F. Erman, J. Org. Chem., 31, 3128, 1966.

31. I. K. Korobitsyna and L. L. Rodina, Zh. Org. Khim., 1, 932, 1965.

32. I. K. Korobitoyna, L. L. Rodina and L. M. Stashkova, Khim. Geterotsiki. Soed., 2, 843, 1966; Zh. Obshch. Khim., 33, 3109, 1963.

33. W. G. Dauben and D. L. Whalen, Tetrahedron Letters, 3743, 1966.

34. M. J. S. Dewar and C. A. Ramsden, J. C. S. Chem. Comm., 688, 1973.

35. A. C. Hopkinson, J. C. S. Perkin II, 794, 1973.

36. J. G. Csizmadia et al., J. Amer. Chem. Soc., 95, 133, 1973.

37. K. P. Zeller, H. Meier, H. Kolshorn and E. Müller, Chem. Ber., 105, 1875, 1972.

38. J. Fenwick, G. Frater, K. Ogi and O. P. Strausz, J. Amer. Chem. Soc., 95, 124, 1973.

39. D. E. Thornton, R. K. Gosavi and O. P. Strausz, J. Amer. Chem. Soc., 92, 1768, 1970.

40. I. G. Csizmadia, J. Font and O. P. Strausz, J. Amer. Chem. Soc., 90, 7360, 1968.

41. G. Frater and O. P. Strausz, J. Amer. Chem. Soc., 92, 6654, 1970.

42. P. Heinrich and H. Meier, IV IUPAC Symp. Photochemistry, 163, 1972.

43. M. Regitz and J. Ruter, Chem. Ber., 102, 3877, 1969.

44. K. G. Nogai, Dissuration, Universitat Hannover 1972.

45. H. O. House and R. L. Wasson, J. Amer. Chem. Soc., 79, 1488, 1957.

46. C. C. Kartha and K. K. Chakravarti, Tetrahedron, 21, 139, 1965.

47. S. K. Kundu, A. Chatterjee and A. S. Rao, Chem. Ber., 101, 3255, 1968.

48. G. R. Chaudhury, T. G. Halsall and E. R. H. Jones, J. Chem. Soc., 2725, 1961.

49. B. Fuchs and H. J. E. Loewenthal, Tetrahedron, 11, 199, 1960.

50. H. R. Nace and A. H. Smith, J. Org. Chem., 38, 1941, 1973.

51. H. Conroy, J. Amer. Chem. Soc., 79, 1726, 1957.

52. A. S. Gupta and S. Dev, Tetrahedron, 27, 823, 1971.

53. a) S. J. Rhoads, J. C. Gilbert, A. W. Decora, T. R. Garland, R. J. Spangler and M. J. Urbighkit, Tetrahedron, 19, 1665, 1963.

b) J. A. Marshall, N. Cohen and K. R. Arenson, J. Org. Chem., 30, 762, 1965.

c) J. A. Marshall and N. Cohen, J. Org. Chem., 30, 3475, 1965.

d) E. J. Corey, Rajat B. Mitra and Hisashi Uda, 86, 485, 1964.

e) H. O. House, Modern Synthetic Reactions, W. A. Benjamin Inc., 1972, page - 546 and references cited thercin.