SUMMARY

The work embodied in this thesis has been divided into two parts.

PART - I

This part deals with the preparation and photochemistry of cross-conjugated cyclohexadienone ring A of friedelane triterpene and has been divided into four chapters.

CHAPTER - I

This chapter gives a short review on the photochemistry of cross-conjugated cyclohexadienones. Herein mainly structural aspects have been reviewed in a few sections.

CHAPTER - II

In this chapter mechanistic aspects of the cross-conjugated cyclohexadienone photochemistry are reviwed in brief in a few sections.

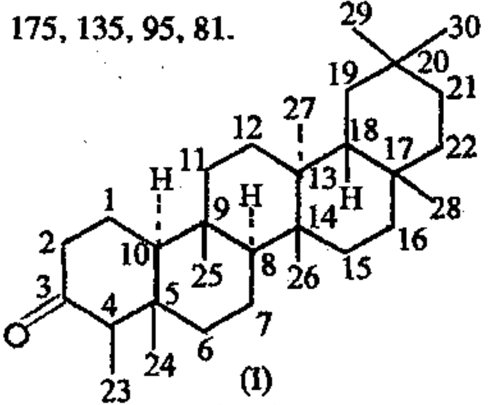
CHAPTER - III

This chapter deals with the present work on the preparation and photochemistry of cross-conjugated cyclohexadienone ring A of friedelane triterpene and has been divided into three sections.

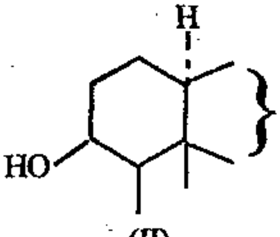
SECTION - A

This section describes the synthesis of the key compound, friedel-1(10), 3-dien-2-one (V), a cross conjugated cyclohexadienone system in ring A of friedelane, by a sequence of reactions using pentacyclic triterpene, friedelin (I) as the lead compound.

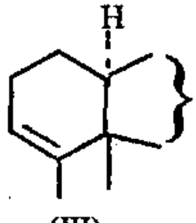
Friedelin (friedelan-3-one) $C_{30}H_{50}O$ (I) mp 260°-261°C obtained as the chief constituent from cork waste by extraction followed by purification by column chromatography, *was reduced by sodium borohydride to afford friedelan-3β-ol (II),* mp 282-284°C, IR(nujol) 3430 cm^{-1} (OH), $C_{30}H_{52}O$. Dehydration of (II) with phosphoryl chloride in pyridine on steam-bath for 4 hr gave the olefin, friedel-3-ene(III), $C_{30}H_{50}$, mp 265-266°C. IR spectrum displayed bands at 780 and 750cm^{-1} indicating the presence of a trisubstituted double bond. Compound (III) was subjected to two successive oxidations. The first oxidation with sodium dichromate in benzene-ACOH (1 : 1) at reflux temperature (4 hr) yielded (60%) the conjugated ketone, friedel-3-en-2-one (IV), $C_{30}H_{48}O$ (crystallised from ethyl acetate) mp 287-289°C . Its UV spectrum showed absorption maximum at 236 nm (ε7600) (MeOH), IR (nujol) 1658, 1620, 850, 720cm^{-1} (cyclohexenone chromophore). ^{1}H NMR (300 MHz, $CDCl_3$) gave signals for a vinyl proton at δ 5.65 (d, J ~ 1Hz, 1H), vinyl methyl 1.84(d, J ~ 1Hz, 3H) due to small splitting for allylic coupling, besides seven saturated tertiary methyls between 0.91 and 1.14, ^{13}C chemical shift values (75 MHz, $CDCl_3$) at 200.62 (C = O), two olefinic carbons at 172.06 and 125.32. In addition, signals for 27 saturated carbon atoms occured between 55.60 and 17.62. (IV) on further oxidation with DDQ in dry dioxane under nitrogen blanket at reflux temperature for 3 hr afforded the key compound (V), mp 280-281°C (crystallised from EtOAc) $C_{30}H_{46}O$. Combination of spectral data enabled to deduce its cross-conjugated cyclohexadienone structure. It showed UV maximum at 246 nm (MeOH) (ε 17150), IR (nujol) bands at 1646, 1610, 1584 and 890 cm^{-1}. ^{1}H NMR spectrum exhibited resonances for 7 saturated methyl groups between δ 0.92 to 1.25, one vinyl methyl at 1.95(d, J ~1Hz, 3H) and two olefinic protons at 6.11 (d, J ~ 1Hz, 1H) and 6.02 (1H, s). ^{13}C NMR spectrum displayed peaks at δ 187.55 (C = O),four olefinic carbons at 177.50, 167.29, 125.68, 121.86 and 25 saturated carbons between 50.16 to 17.73. EIMS exhibited molecular ion peak at m/z 422 (M^+ 48%) and prominent fragments at 407 ($M^+ - CH_3$), 298, 286, 271, 229, 203, 182, 175, 135, 95, 81.



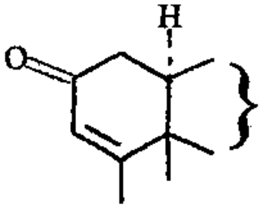
(I)
Friedelin
(friedelan-3-one)



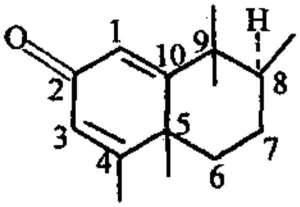
(II)
Friedelan-3β-ol



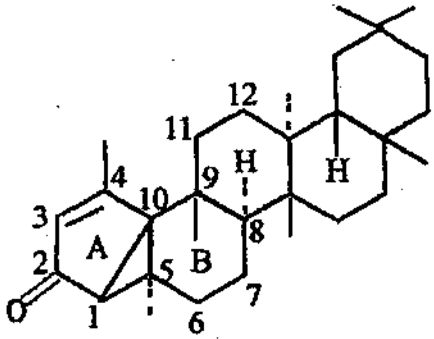
(III)
Friedel-3-en



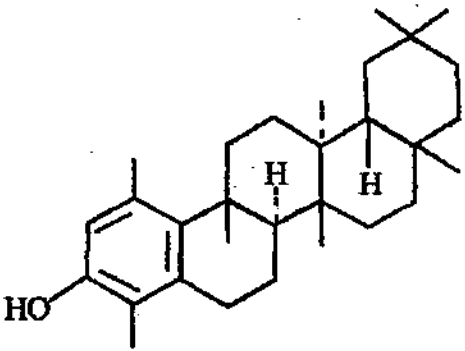
(IV)
Friedel-3-en-2-one



(V)
Friedel-1 (10), 3-dien-2-one



(VI)
Lumiketone
(Bicyclohex [3.1.0]enone type photoproduct)



(VII)
Phenolic product

SECTION - B

This section describes the photoirradiation of the synthesised key compound (V), isolation and elucidation of the structure of the major photoproduct, the bicyclo [3.1.0] hexenone (VI), also popularly known as the lumiproduct.

The photolysis of the cross-conjugated cyclohexadienone (V) at 254 nm (low-pressure mercury lamp) in dry dioxane at ambient temperature under nitrogen atmosphere for 15 min. was carried out. The progress of the photoreaction was monitored by TLC. Using pet ether-ethyl acetate (4:1) as eluent a colourless compound has been obtained, which on crystallisation from ethyl acetate afforded needles (VI), (62%), $C_{30}H_{46}O$, mp 305°C. Bicyclo [3.1.0] hexenone structure (also called popularly as lumiproduct) of (VI) was determined by combination of physical techniques. UV spectrum showed absorption maximum at 241 nm (MeOH) (ε 8200) (conjugated ketone), IR (nujol) at 1675, 1595cm^{-1} (cyclopentenone). A detailed analysis of ^1H NMR, ^{13}C NMR and EIMS enabled us to deduce the structure of (VI). ^1H NMR showed resonances at δ 5.65 (d, $J \sim 1Hz$, 1H) for olefinic proton and at 2.14 (d, $J \sim 1Hz$, 3H) for vinyl methyl goup and between 0.92 to 1.15 for sevent tertiary methyls. ^{13}C NMR revealed resonances at δ 206 (C = O), two elefinic carbons at 175 and 133, besides 27 sp^3 carbons between 58.80 and 16.84. EIMS registered molecular ion peak at m/z 422 (M^+, 73%) and other important fragmented ions at 407 ($M^+ - CH_3$), 298, 218, 204, 175, 161, 149, 136, 123, 109 and 95.

Since lumiproduct VI itself is photolabile, prolonged irradiation results in a complex reaction mixture.

Considerable attention has been directed to and works have been reported on the stereochemical aspect of cyclohexadienone photochemistry. This photoreaction appears to be stereospecific and proceed with inversion of configuration at the migrating carbon atom. Since conflicting and ambiguous results have occasionally been encountered, the problem of stereochemistry has to be resolved satisfactorily. In the light of currently accepted view the stereostructure of the lumiketone has been assigned to be (VI). The stereochemistry has also been discussed in the light of chiroptical measurements.

SECTION - C

This section describes the isolation and characterisation of the phenolic photoproduct (VII) obtained on irradiation of the key compound (V) for an extended period. Also it is formed as a secondary photoproduct upon irradiation of the lumiproduct (VI).

On carefully monitoring the photolysis by TLC it has been noticed that a second spot made its appearance on prolonged irradiation. The phenol (VII) was subsequently isolated as a white solid on silica gel chromatography. It was crystallised from ethyl acetate as needles mp 198°C. It exhibited absorption maximum at 281 nm (ε 2250) in UV spectrum and a strong IR band at 3320cm^{-1} indicative of phenolic OH group. Mass spectrum recorded a molecular ion peak at m/z 422 showing that (VII) is isomeric with (V) as well as (VI) and suggest to originate from an intramolecular photorearrangement. It was further substantiated by an accurate mass measurement in high resolution mass spectrum (HRMS, M$^+$ observed m/z 422.2501, calculated for $C_{30}H_{46}O$ m/z 422.2508) which supported the molecular formulation as $C_{30}H_{46}O$. Owing to the paucity of the material its NMR spectrum could not be recorded. Based on above-mentioned spectral observations coupled with currently accepted mechanistic considerations, we propose the structure (VII) for the phenolic product.

CHAPTER - IV

Experimental portion has been described in this chapter.

PART - II

This part deals with the preparation and molecular rearrangement of 2α, 3α-epoxy lupan-1-one catalysed by boron trifluoride and by ultraviolet irradiation and has been divided into three chapters.

CHAPTER - I

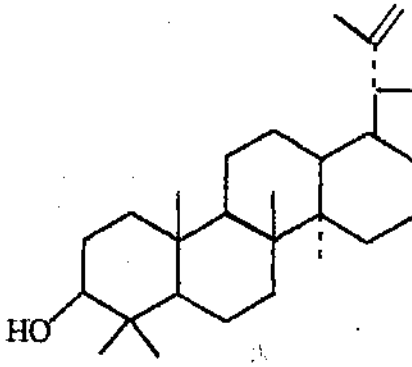
This chapter gives a short review on the molecular rearrangement of α,β-epoxy ketones, SECTION - A : induced by the Lweis acid, boron trifluoride-etherate and SECTION - B : induced by ultraviolet irradiation.

CHAPTER - II

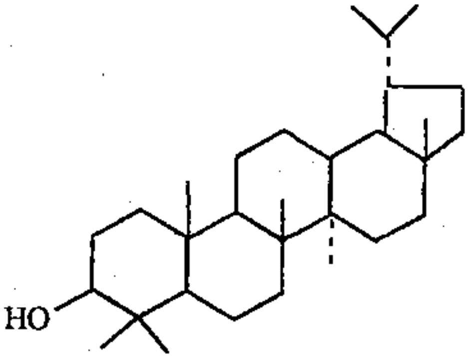
This chapter describes the present work on preparation and molecular rearrangement of 2α, 3α – epoxy lupan-1-one (XII) catalysed by boron trifluoride and by ultraviolet irradiation and has been presented in three sections.

SECTION - A

This section describes the synthesis of 2α, 3α-epoxy lupan-1-one (XII) using lupeol (VIII), a pentacyclic triterpene of lupan series, as the lead compound, obtained abundantly from the plant *Zanthoxylum budrunga* growing in North Bengal. Compound (VIII) on catalytic reduction furnished lupanol (IX) which on dehydration with phosphorus oxychloride in pyridine afforded lup-2-en(X). Oxidation of (X) with sodium dichromate in benzene-acetic acid mixture (1:1) yielded the conjugated ketone, lup-2-en-1-one (XI), λ_{max} 220nm, ν_{max} 1667cm^{-1}. Since the system 2-en-1-one of ring A in triterpenes is stable towards alkaline hydrogen peroxide, attempts to epoxidise the conjugated ketone (XI) with alkaline H_2O_2 had failed. Consequently, an alternative method had been adopted for the preparation of the epoxy ketone (XII). Lup-2-ene (X) on selenium dioxide oxidation in dioxane with a few drops of water added in it, gave the allylic alcohol, lup-2-ene-1α-ol (XIII). Compound (XIII) was epoxidised with metachloro-perbenzoic acid in chloroform to yield the epoxy alcohol, 2α, 3α-epoxy lupan-1α-ol(XIV). The key compoun, 2α, 3α-epoxy lupan-1-one (XII) was then prepared by the chromium trioxide-pyridine oxidation of (XIV). In ^{1}H NMR spectrum, appearance of resonances at δ 3.1 (doublet, $J = 4$Hz) and δ 3.27 (doublet, $J = 4$ Hz) enabled to assign 2α, 3α-epoxy ketone stereochemistry for (XII).



(VIII)



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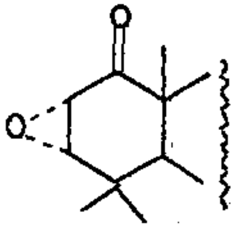
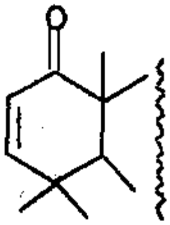
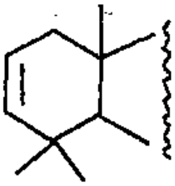


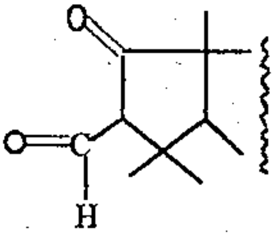
(XII)



(XI)



(X)



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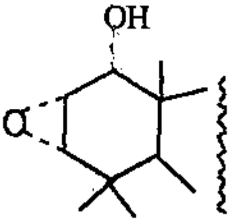
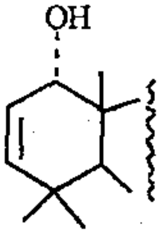
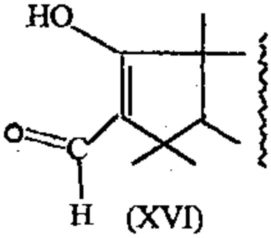


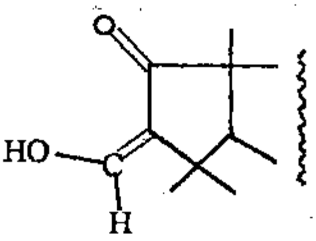
(XIV)



(XIII)



(XVI)



(XVII)

SECTION - B

This section deals with the molecular rearrangement of the synthesised α,β-epoxy ketone (XII) induced by the Lewis acid, BF_3 - Et_2O.

Boron trifluoride catalysed rearrangement of (XII) in dry benzene at ambient temperature afforded the ring A contracted keto aldehyde, 2-formyl-A-nor-lupan-1-one (XV) in 60% yield. It practically exists in solution as the enolised form (XVI). The structure of the rearranged product was deduced by the physical techniques UV, IR, NMR and mass spectra. Of the two possible enolised forms (XVI) and (XVII), the former one (XVI) was supported by aldehydic proton singlet at δ 9.4 in the ^1H NMR analysis.

The attack by BF_3 upon (XII) opens the epoxide ring to generate electron-deficient centre which subsequently undergoes rearrangement to afford ring-A contracted keto aldehyde (XV).

SECTION - C

This section deals with the photolysis of the epoxy ketone (XII). Since α,β-epoxy ketones are much susceptible to photochemical alteration, it was felt pertinent to irradiate (XII) and make a comparison of the light-induced rearranged product with that of acid-catalysed rearranged one (XV).

Irradiation of (XII) in dioxane with medium pressure mercurry lamp ($\lambda > 290$ nm) at ambient temperature under argon atmosphere for 0.5 hr. has been carried out. Isolation of the same keto aldehyde (XV) has been achieved in good yield (52%). The identity has been established by comparison of mp, mmp, UV, IR, ^1H NMR and mass determinations. Since the initial product (XV) is also photolabile, irradiation for an extended period results in a complex reaction mixture giving a low yield of (XV). The diradical generated from excited singlet manifold by homolysis of C_α-O bond rearranges to the keto aldehyde (XV) by a process in which the bond-migration and carbonyl formation steps are considered to be concerted.

CHAPTER - III

This chapter gives the description of the experimental portion.