THE SYNTHESIS AND PHOTOCHEMICAL

BEHAVIOUR OF BENZTROPONES AND

RELATED COMPOUNDS .

A thesis submitted to the university of Keele
in part fulfilment of the requirements for the
Degree of Doctor of Philosophy

by

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June 1984 .

In the name of God,the Beneficent,the Merciful .

To

My Sisters

Soraya , Sohaila   and

Mahshid

and............

In the Name of God , the Beneficent , the Merciful .

منت خدای را عزوجل که طاعتش موجب قربت است و به شکر اندرش مزید نعمت

هرنفس که فرو میرود ممد حیات است و چون برآید مفرح ذات پس در هر نفسی دو نعمت موجود است

و بر هر نعمتی شکری واجب .

از دست و زبان که برآید   کز عهده شکرش بدرآید .

بنی آدم اعضای یک دیگرند   که در آفرینش ز یک گهرند

چو عضوی بدرد آورد روزگار   دگر عضوها را نماند قرار

سعدی .

تقدیم - آنانکه احباب در راه خدا علیه ظلم جهاد کردند

تقدیم - خواهران گرامیم . ثریا . سهیلا و مهشید

The work in this thesis was carried
out by the author under the supervision
of Dr. G. Jones .

Hamid Sheikh .

Contents

Abstract

Our aim was to identify the possible factors which controlled the photochemical reactions of benztropones or more widely , annulated tropones,by synthesising benztropones with electron-donating and electron-withdrawing substituents on the benzene ring.These substituents are far enough away to have no steric effects ;thus , steric effects which might be important if there are substituent groups on the seven membered ring are eliminated and only electronic effects which can be transmitted from the benzene ring are left .

The first chapter of this work reports a review of previous syntheses of annulated tropones,unsubstituted on the tropone ring .

The second chapter deals with the synthesis of the methoxybenztropones(38),(247),(234) and (268), and 5H-benzo-cyclohepten-5-one(1) and its substituted derivatives,such as 3-amino-,3-nitro-,3-acetamido-,3-amino-2,4-dibromo- and 6,8-dinitro-5H-benzocyclohepten-5-one (270),(20),(21),(272), and (269) . The syntheses of 1-methyl-3-phenylcyclohepta(b)pyrrol--8-one(281),cyclohept(b)indol-10(5H)-one(8) and its methyl and ethyl derivatives (289),(285), as well as 4H-cyclohepta(b)furan-4-one(9) were also reported .

The third chapter is a review of photochemistry of tropones and annulated tropones .

Finally the fourth chapter reports the photochemistry of the benztropone and its substituted derivatives as well as tropones with fused hetero rings .

Acknowlegements

I would like to express my gratitude to Dr. G. Jones for his patience , encouragement , for reading the manuscript and for his supervision and many useful suggestions throughout the course of this research in the University of Keele .

My thanks are also due to Mr. T. Alston , Mr. S. Hudson, Mr. G. Evans , Mr. D.E. Mountford and Mr. J. Clew for their technical assistance .
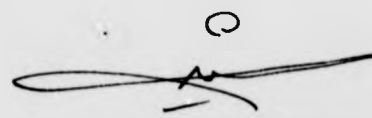
I am very grateful to Dr. B. Abarca for her unlimited assistance and all staff members and the friends of Chemistry Department for giving the advantage of using the facilities during the year 1983 , in the Faculty of Pharmacy in University of Valencia .

I would like to express my appreciation to F. Mojarrad for typing this thesis and her help with drawings.

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I am also grateful to my parents,Monireh and Hassan, for their whole-hearted support , patience and understanding throughout the period of this research.

Last , but not least , my wife , Fatemeh , for her enthusiasm , tolerance and support during the past few years.

H. Sheikh

Nomenclature

Names,structures and numbering of the following compounds will be adopted according to the method used in   Chemical Abstracts   .
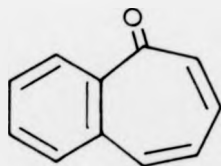
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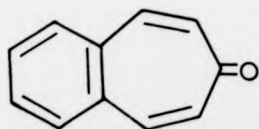
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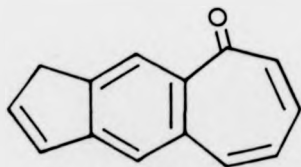
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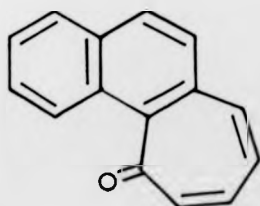
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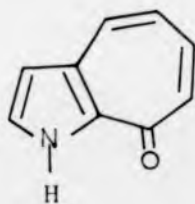
(5)   8H-Cyclohepta(b)pyrrol-8-one
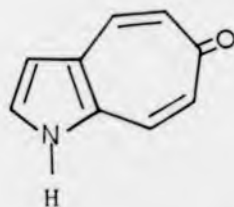
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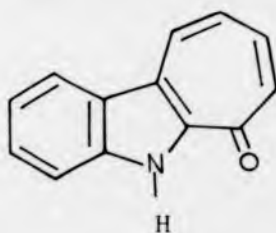
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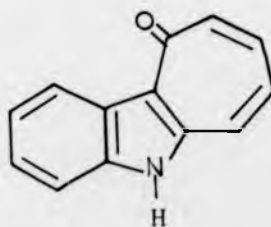
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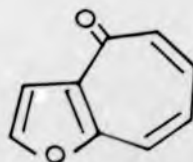
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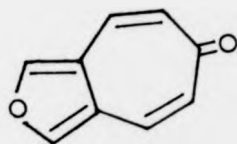
(10)   6H-Cyclohepta(c)furan-6-one
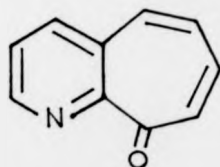
(11a)   9H-Cyclohepta(b)pyridin-9-one
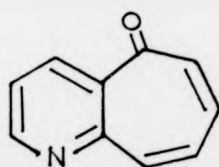
(12a)   5H-Cyclohepta(b)pyridin-5-one
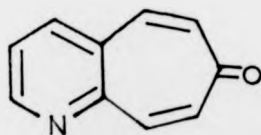
(13a)   7H-Cyclohepta(b)pyridin-7-one

Chapter 1

Introduction

A review of previous syntheses of
benztropones together with the syntheses of
annulated tropones unsubstituted on the
tropone ring .

The syntheses of benztropolones and tropones
have been a subject of interest and controversy , nevertheless
less attention has been paid towards the synthesis of
5H-benzocyclohepten-5-one (1) , specially with substituents
on the benzene ring . An attempt has been made to include only
those papers that relate to the substituted
5H-benzocyclohepten-5-ones and the tropones with fused hetero
rings , which are significant to the present work and not include
those which are related to the benztropolones .

The syntheses of benztropones can be divided into the
four groups :

    (I)-   From 9-hydroxy-5H-benzocyclohepten-5-one .

    (II)-   Those which start from conversion of the
6,7,8,9-tetrahydro-5H-benzocyclohepten-5-ones by bromination
and dehydrobromination sequences .

    (III)- Those which start from a direct oxidation of
5H-benzocycloheptene .

    And finally (IV)- those which start from tetralones .

5H-Benzocyclohepten-5-one

In 1957 Rennhard and Eschenmoser [1] reported the preparation of 5H-benzocyclohepten-5-one(1).The synthesis starts from 9-hydroxy-5H-benzocyclohepten-5-one(2 a).

Treatment of the benztropolone (2 a)with isobutylalcohol gave 9-isobutoxy-5H-benzocyclohepten-5-one(3a).Subsequent reduction of the isobutyl ether(3a) with lithium aluminium hydride followed by treatment with sulfuric acid, yielded 5H-benzocyclohepten-5-one(1) (Scheme 1).

Scheme 1
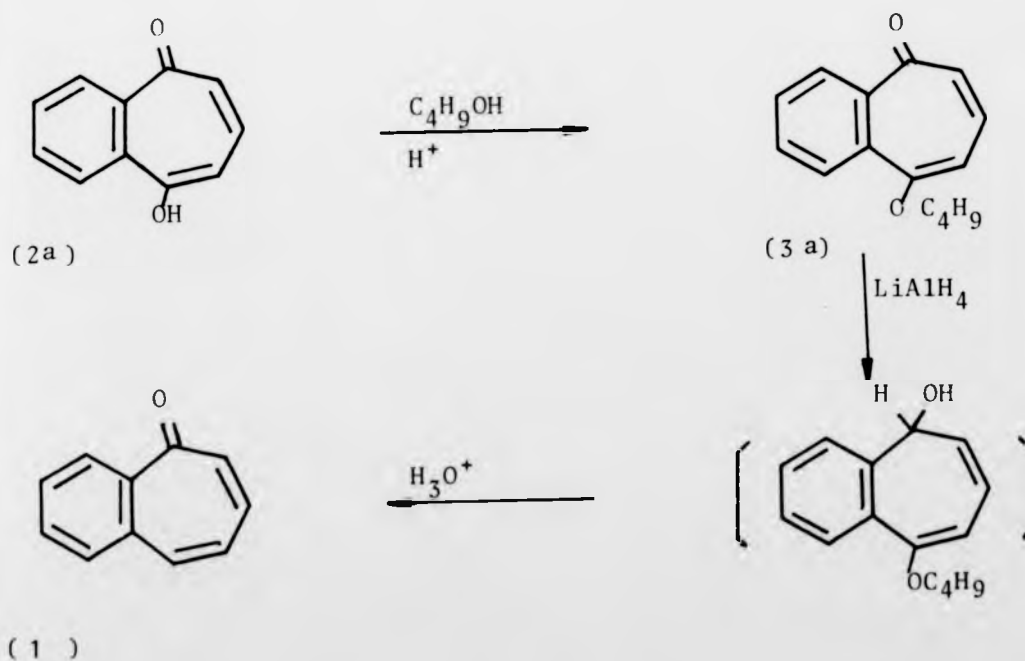
The 9-hydroxy-5H-benzocyclohepten-5-one(2a) itself was first prepared by Buchanan [2]. The synthesis starts from the condensation [3] of diethyl phthalate with diethyl glutarate followed by hydrolysis and decarboxylation to give the benzocycloheptadione(4a). The diketone(4a) was converted into its bis-enol acetate(5a) by treatment with isopropenyl acetate. The diacetate(5a) was brominated with N-bromosuccinimide, and then was hydrolysed to give the 9-hydroxy-5H-benzocyclohepten-5-one(2a) (Scheme 2).

Scheme 2
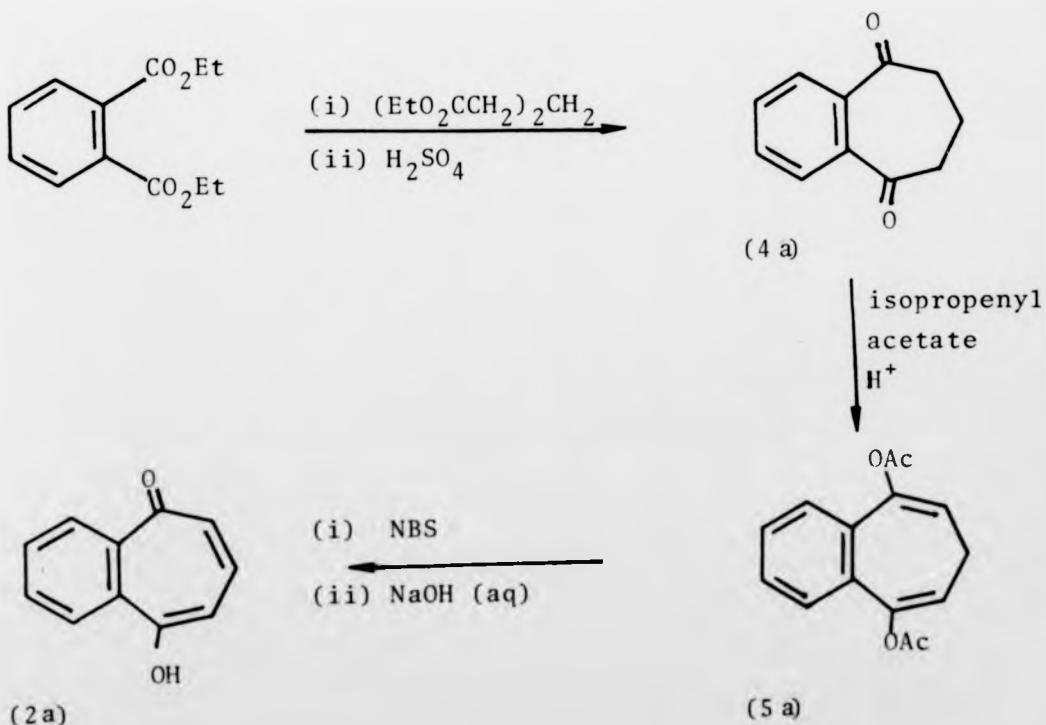
A convenient synthesis of 5H-benzocyclohepten-5-one
(1) has proceeded from 6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one (6) by bromination and dehydrobromination sequences.

Three routes from the bicyclic ketone (6) were given
by Buchanan and Lockhart [4,5] .

The first and preferred route was by bromination
using bromine in carbon tetrachloride to give 6-bromo-6,7,8,9-
-tetrahydro-5H-benzocyclohepten-5-one(7a) followed by
further bromination at position nine by N-bromosuccinimide
giving 6,9-dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one
(8a) . Dehydrobromination of the dibromo ketone (8a) with
collidine afforded the 5H-benzocyclohepten-5-one (1) .

The second route [6] was by bromination using
N-bromosuccinimide to give 9-bromo-6,7,8,9-tetrahydro-
-5H-benzocyclohepten-5-one (9a) followed by dehydrobromination
with collidine to give the 6,7 -dihydrocyclohepten-5-one (10a) .
Subsequent oxidation of compound(10a) with selenium dioxide
gave 5H-benzocyclohepten-5-one (1) .

The third route [7] was by bromination of
6,7-dihydrocyclohepten-5-one(10a) with N-bromosuccinimide
in carbon tetrachloride followed by dehydrobromination
gave 5H-benzocyclohepten-5-one (1) (Scheme 3) .

Scheme 3
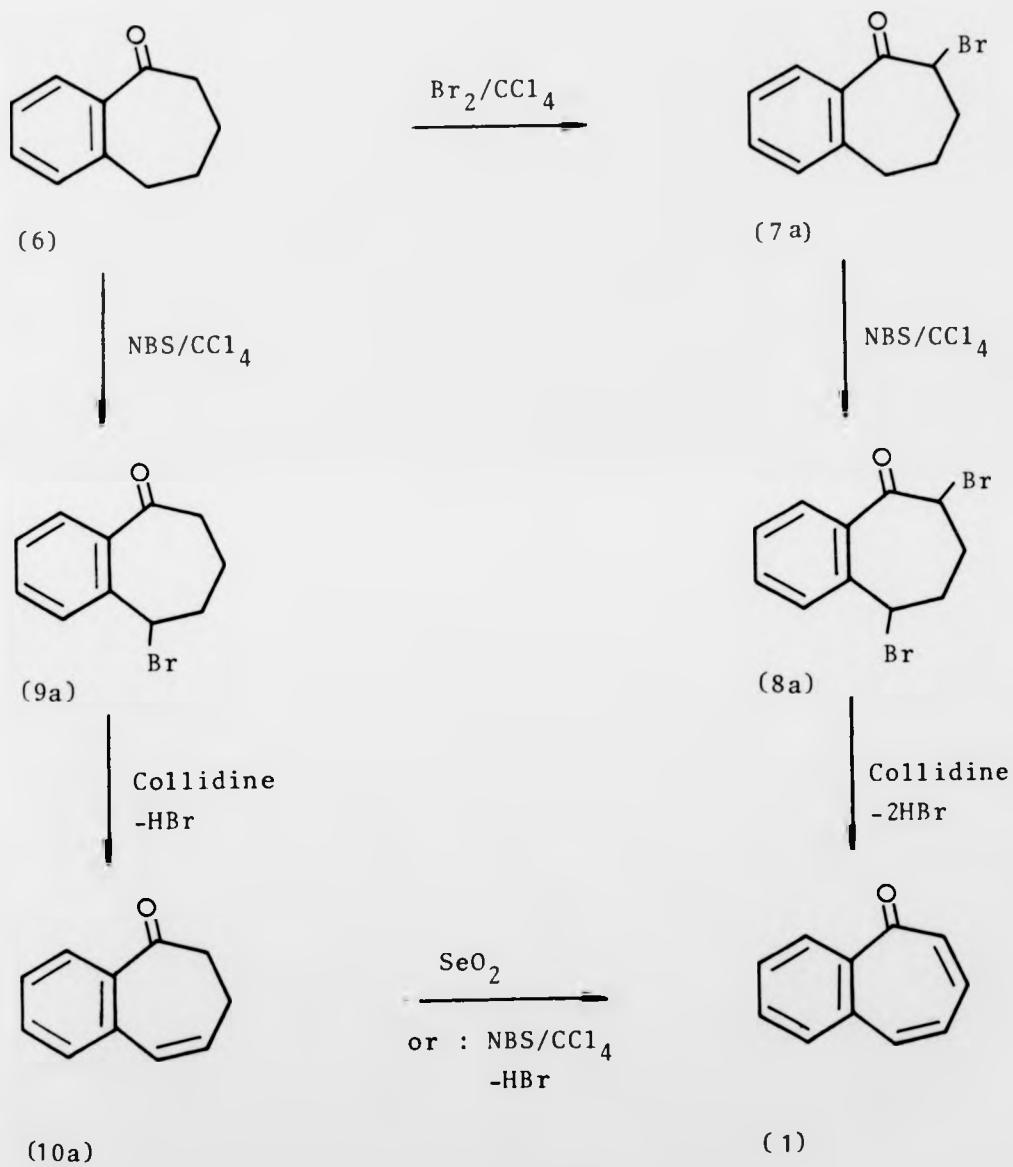
In 1966 Proctor et al [6] reported the preparation

of 2-acetoxy-5H-benzocyclohepten-5-one(14) from

2-methoxy-6,7,8,9-tetrahydrobenzocyclohepten-5-one(11).

The compound (11) was demethylated in good yield by using

aluminium bromide in refluxing benzene to give

2-hydroxy-6,7,8,9-tetrahydrobenzocyclohepten-5-one(12).

The 2-hydroxy compound (12) was reacted with acetic anhydride

to yield 2-acetoxy-6,7,8,9-tetrahydrocyclohepten-5-one(13).

Bromination by N-bromosuccinimide and dehydrobromination

by collidine was repeated twice to yield the

2-acetoxy-5H-benzocyclohepten-5-one(14) (Scheme 4).

Scheme 4
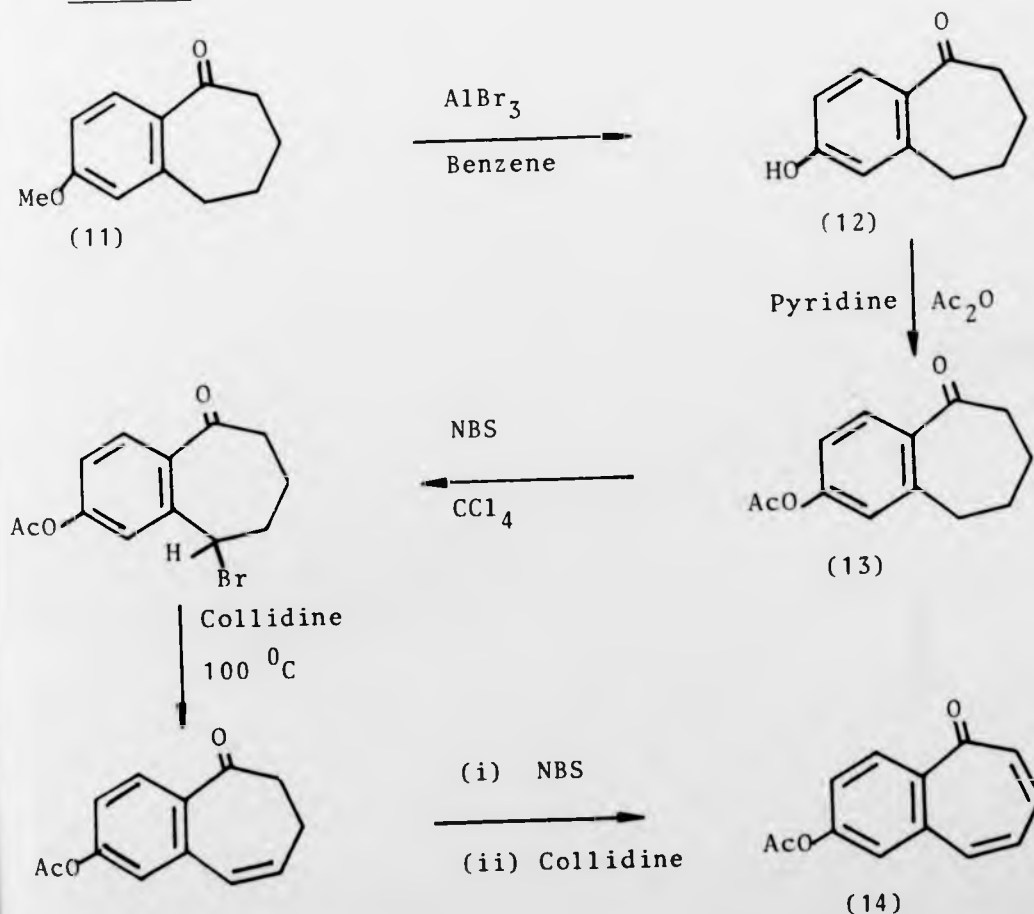
The most convenient synthesis of 5H-benzocyclohepten-
-5-one(1) was reported by Collington and G. Jones[7] in 1968.
They prepared a number of benzocyclohepten-5-ones(1,20 and 21)
from different 6,7,8,9-tetrahydro-5H-benzocyclohepten-5-ones
(6,15 and 16).The ketone(6) and 3-nitro compound(15) were
brominated by bromine(2 Moles) in carbon tetrachloride to give
the corresponding dibromoketones(17,18).In the case of
3-acetamido compound(16),they used phenyltrimethylammonium
tribromide(PTAB) to avoid nuclear bromination of aromatic ring.
All three dibromoketones were dehydrobrominated by lithium chloride
in boiling dimethylformamide(DMF)to give the corresponding
5H-benzocyclohepten-5-one(1,20 and 21) (Scheme 5).

Scheme 5

Br_2/CCl_4
R= H or NO_2

PTAB
R= CH_3CONH

(6) R= H
(15)R= NO_2
(16)R= CH_3CONH

(17) R= H
(18) R= NO_2
(19) R= CH_3CONH

LiCl/DMF

(1) R= H
(20) R= NO_2
(21) R= CH_3CONH
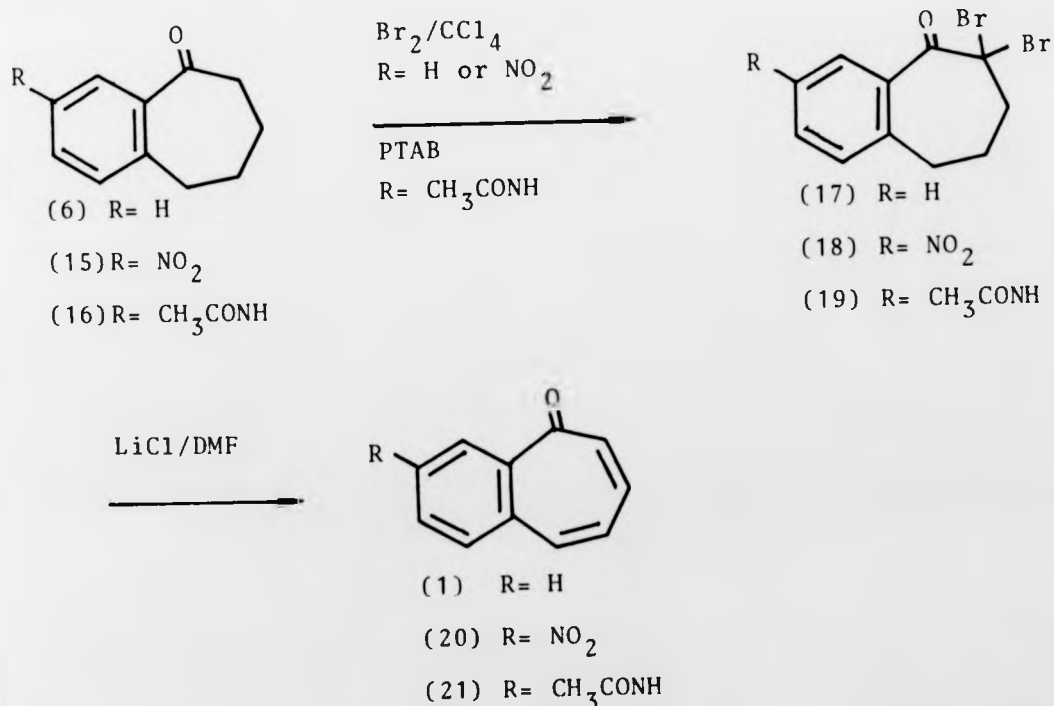
In 1972 Srivastava and Dev [8] observed a direct oxidation
of 5H-benzocycloheptene(24) by selenium dioxide in buffered
aqueous dioxane to give the 5H-benzocyclohepten-5-one(1, 13%)
and 7H-benzocyclohepten-7-one(2, 27%).The synthesis started
from the ketone(6).The bicyclic ketone(6) was reduced by
lithium aluminium hydride to give the alcohol(22)which was
then dehydrated to the dihydro compound(23) [9] .Bromination
with N-bromosuccinimide in carbon tetrachloride with subsequent
elimination of hydrogen bromide gave 5H-benzocycloheptene
(24) (Scheme 6).

Scheme 6

(6)

$LiAlH_4$

(22)

p-TsOH
Benzene

NBS

CCl_4

(24)

(23)

SeO_2

(1)   +   (2)
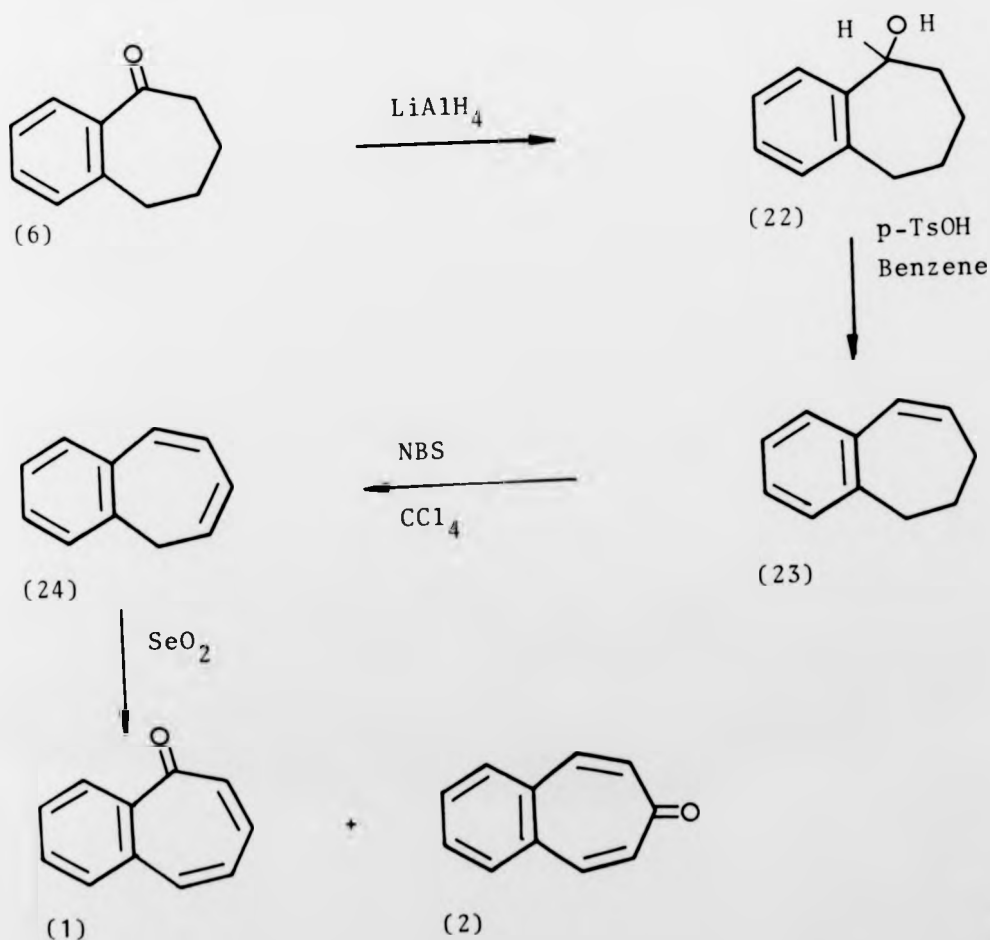
The reaction of dibromocarbene and 1-methoxynaphthalene (25) has been reported [10] to yield 6-bromo-5H-benzocyclohepten--5-one(27) as the major product , but in 1972 Moncur and Grutzner [11] have repeated the reaction by refluxing 1-methoxynaphthalene (25) and phenyl(tribromomethyl)mercury in dry benzene.They have isolated 8-bromo-5H-benzocyclohepten-5-one(26) (Scheme 7) .

Scheme 7

(25)   (26)

In agreement with this, Ebine et al [12] reported the reaction of 8-bromo-5H-benzocyclohepten-5-one(26) with maleic anhydride (140^0C) to give an adduct, which was hydrolysed to diacid(28) , whose n.m.r. spectrum is identical to that published. This product could rise from compound(26) but not from (27) . These results indicated that dibromocarbene adds to 3,4 double bond of 1-methoxynaphthalene rather than 1,2 double bond.

(28)   (27)
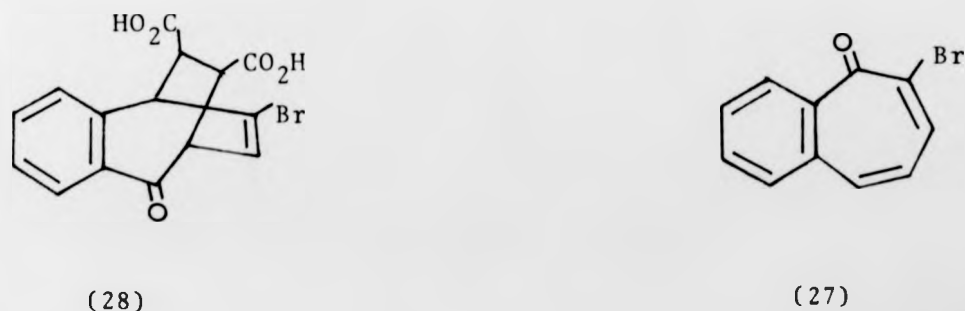
The chemical behavior of difluorocyclopropyl acetates,generated by addition of difluorocarbene to enol acetate of aliphatic, alicyclic and aromatic ketones,has been investigated by Crabbe´et al[13] in 1973. The difluorocyclopropane adducts of substituted tetralones(33,34) were formed by addition of difluorocarbene to the enol acetates(31,32) obtained from tetralones(29,30). Reaction of the acetoxydifluorocyclopropanes (33,34)with 2% sodium hydroxide in methanol yields exclusively a 2:3 mixture of 1(or 2)-methoxy-6,6-difluoro-6,7,8,9-tetrahydro-5H--benzocyclohepten-5-ones(35,36) and 1(or 2)-methoxy-5H--benzocyclohepten-5-ones(37,38) respectively, thus making this sequence is a new and efficient synthetic approach to the benztropones system. An attempt was made to isolate the crystalline intermediate(39) by treatment of the difluoromethylene adduct(34) with ammonium hydroxide in dioxane solution at room temperature.The fluoro enone(39) is then converted quantitively into tropone(38) when exposed to a 2% methanolic sodium hydroxide solution.Various attempts (sodium hydroxide,lithium chloride, etc)to convert the difluoro ketone(36) into the benztropone(38) were unsuccessful,thus showing the former not to be an intermediate in the conversion of the acetoxydifluorocyclopropane(34) into the benztropone(36) under these reaction conditions (Scheme 8).

Scheme 8

(29) $R^1=OCH_3$, $R^2=H$

(30) $R^1=H$, $R^2=OCH_3$

(31) $R^1=OCH_3$, $R^2=H$

(32) $R^1=H$, $R^2=OCH_3$

(33) $R^1=OCH_3$, $R^2=H$

(34) $R^1=H$, $R^2=OCH_3$

(39) $R^1=H$, $R^2=OCH_3$

(35) $R^1=OCH_3$, $R^2=H$

(36) $R^1=H$, $R^2=OCH_3$

(37) $R^1=OCH_3$, $R^2=H$

(38) $R^1=H$, $R^2=OCH_3$
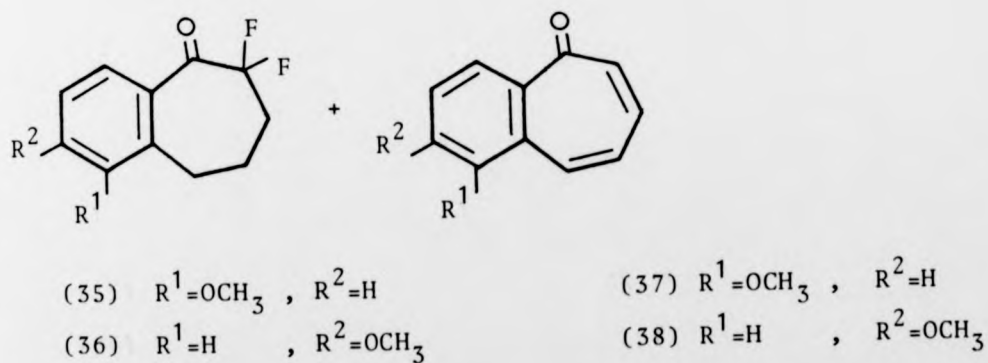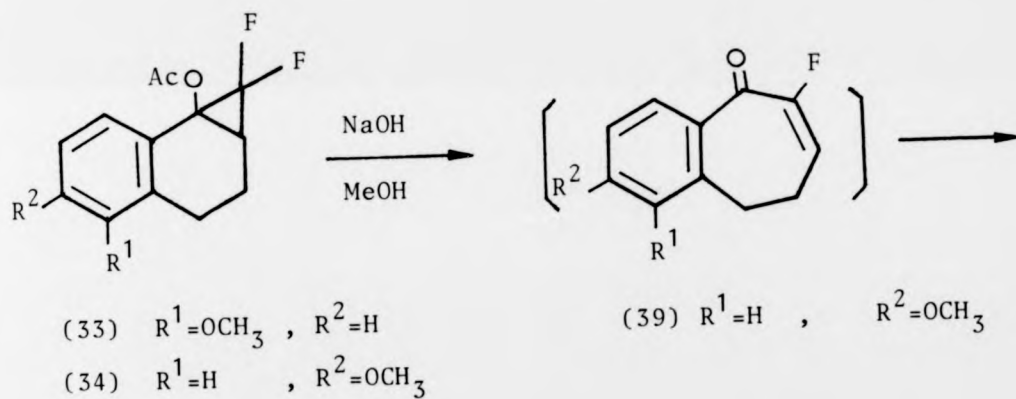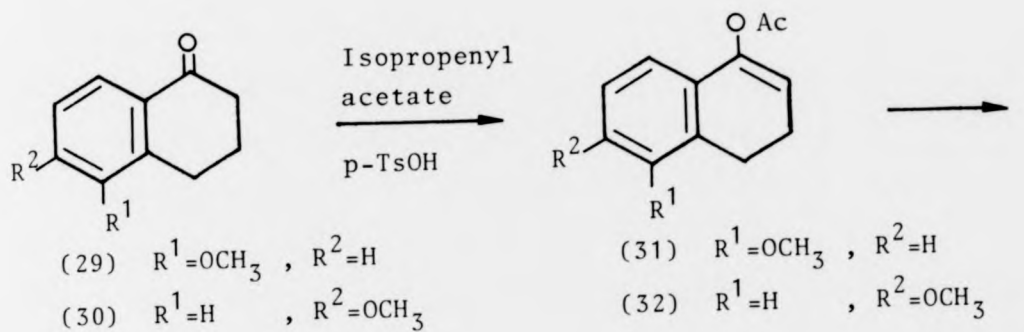
In 1975 Ebine et al [14] reported another method
of synthesizing 5H-benzocyclohepten-5-one(1) from the
easily avaiable α-tetralone(40) by ring expansion of
the six-membered ring compound. In the presence of an acid
catalyst α-tetralone(40) was converted with ethyl orthoformate
into 1-ethoxy-3,4-dihydronaphthalene(41). The enol-ether(41)
reacted with dihalocarbene to give dihalocarbene adduct(42).
The adduct(42) was treated with aqueous silver tetrafluoroborate
to give the 6-halo-ketone(43). The compound(43) was dehydro-
halogenated with lithium chloride in dimethylformamide to
give the 5H-benzocyclohepten-5-one(1) (Scheme 9).

Scheme 9

(40)   (41)

(42)   (43)   (1)
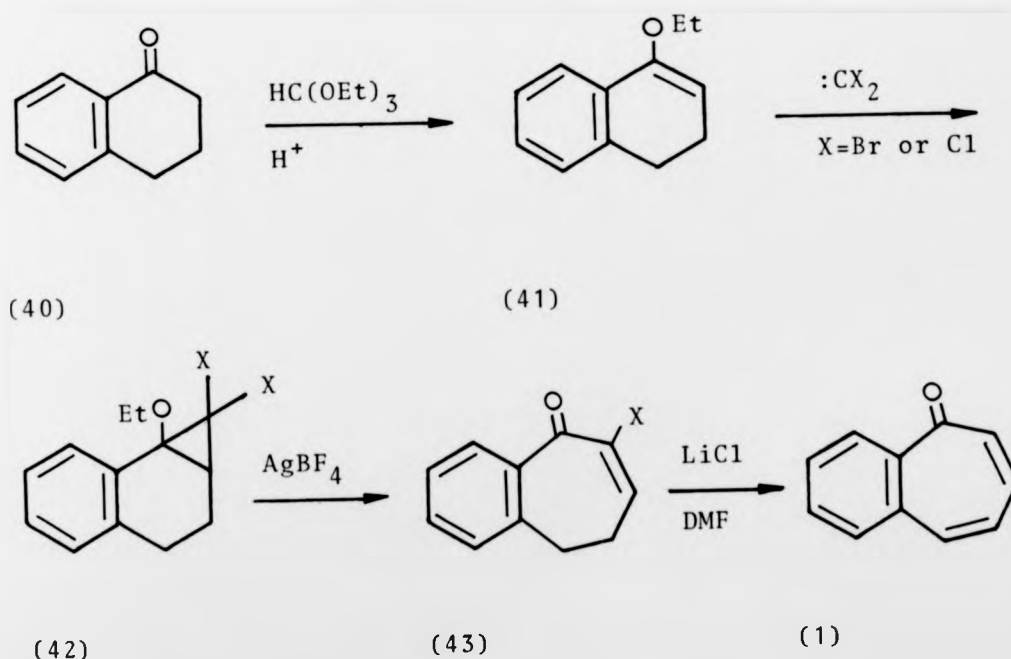
A similar route was adopted by Proctor et al [15]
in 1979 ,in their synthesis of 3-acetoxy(or hydroxy)-2-
-methoxy-benzocyclohepten-5-one(46 or 47),to those
via 6,6-dibromo-ketone   ,in this case compound(45).

Hydrogenation [16] of 5-(4-hydroxy-3-methoxyphenyl)penta-
-2,4-dienoic acid, formed from the condensation of
4-benzyloxy-3-methoxybenzaldehyde [17] with methyl crotonate,
gave 5-(4-hydroxy-3-methoxyphenyl)valeric acid   .The valeric
acid was then cyclised with polyphosphoric acid to give
3-hydroxy-2-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one, which was acetylated to acetoxy compound(44) with
acetic anhydride.Bromination by bromine in carbon tetrachloride
and dehydrobromination by lithium chloride in DMF gave
the acetoxy compound(46) (Scheme 10).

Scheme 10

(44)   (45)

(46)   (47)
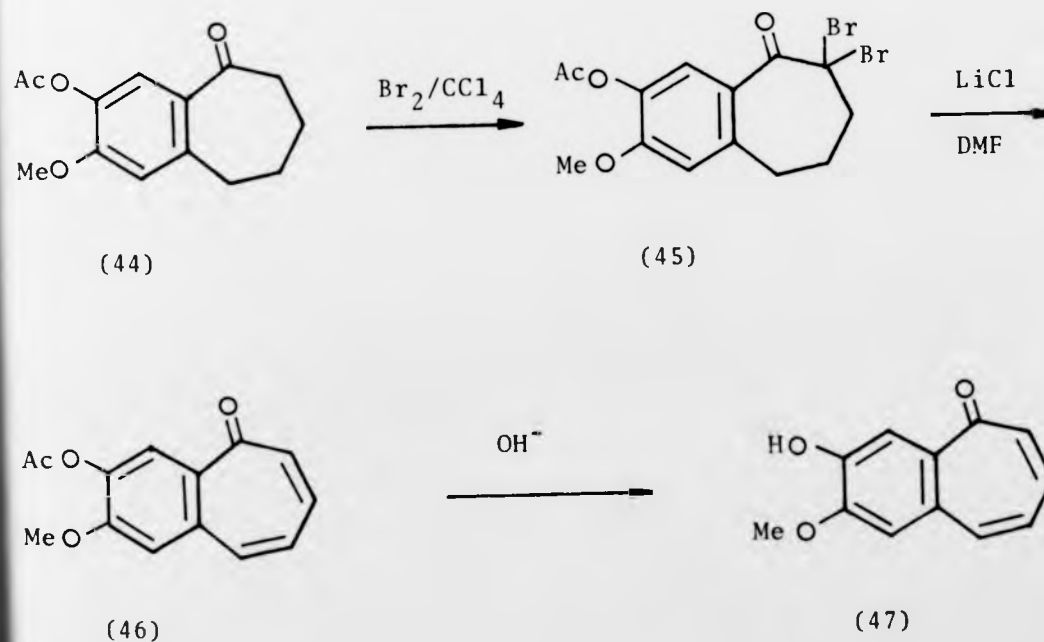
Another report in the same year was given by
Carpenter,Peesapati and Proctor [18] .They studied the
effect of replacing the hydroxyl group of compound(47)
with a nitro group.This was achieved via 2-methoxy-6,7,8,9-
-tetrahydro-5H-benzocyclohepten-5-one(11),which was
nitrated by cupric nitrate in acetic anhydride to give
a mixture of the 2-methoxy-3-nitro compound(48) and
the 2-methoxy-1-nitro compound(49).The nitro ketone(48)
was separated by column chromatography and then brominated
by bromine in carbon tetrachloride and dehydrobrominated
with silver acetate in acetic acid to give
2-methoxy-3-nitro-5H-benzocyclohepten-5-one(50) (Scheme 11).

Scheme 11

(11)   (48)

(50)
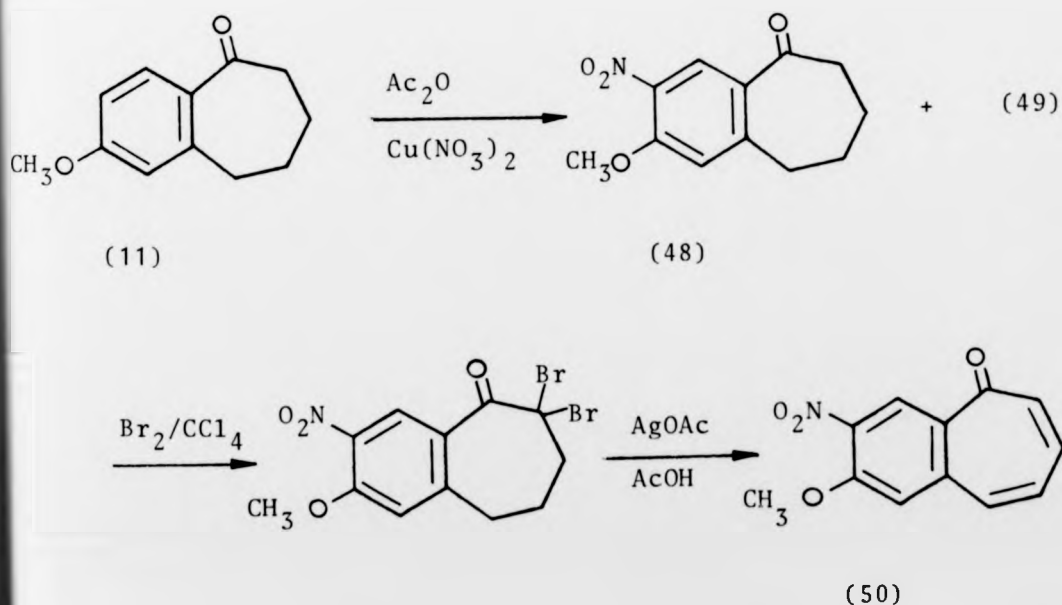
7H-Benzocyclohepten-7-ones

The first reported synthesis of 7H-benzocyclohepten-7-one(2) was in 1910 by Thiele and Weitz [19] . Condensation of o-phthalaldehyde with acetonedicarboxylate gave 6,8-dicarbethoxy-7H-benzocyclohepten-7-one(51) , which was subsequently hydrolysed and partially decarboxylated to monocarboxylic acid(52) . The acid (52) heated with 5% HCl at 200 ^{0}C for five hours to give 7H-benzocyclohepten-7-one(2)(Scheme 12).

Scheme 12
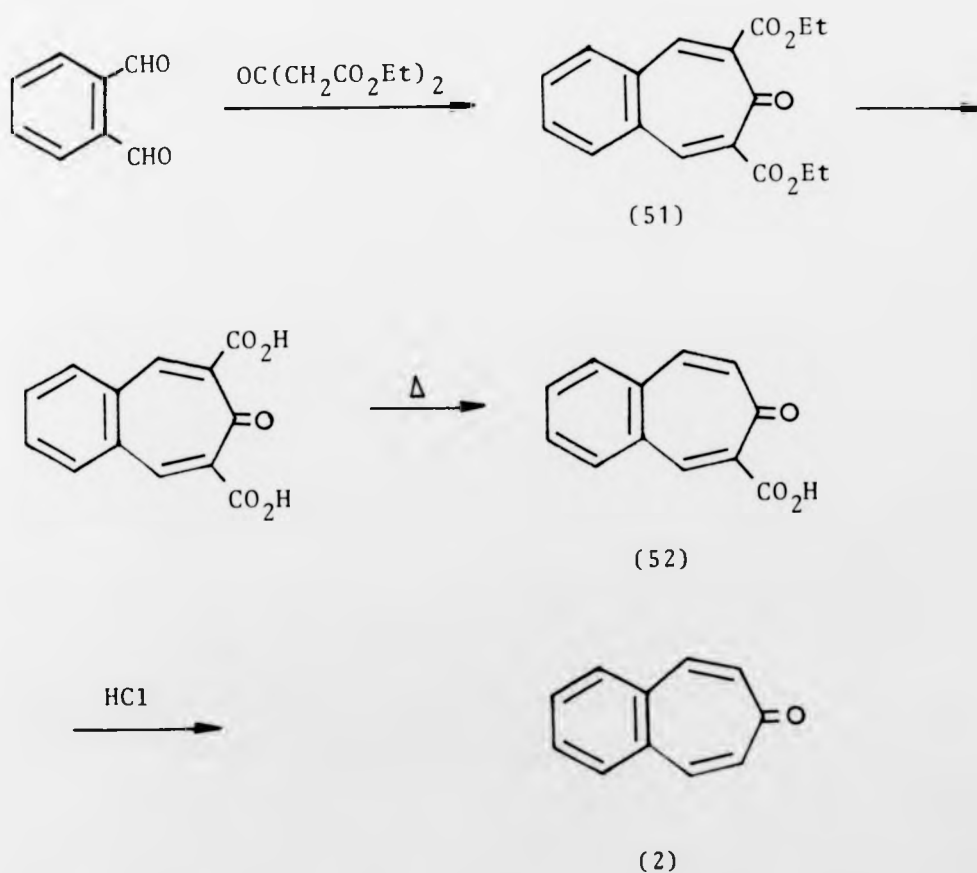
In 1955 Eschenmoser et al [20] reported the conversion
of 5H-benzocyclohepten-5-one to 7H-benzocyclohepten-7-one (2)
The ketone(1) was reduced to the alcohol (52a)with lithium
aluminium hydride followed by treatment with sulphuric acid
to give the benztropylium salt(53).The salt(53) was treated
with base and subsequent oxidation with chromium trioxide
in pyridine yielded approximately a 1:1 ratio of
5H-benzocyclohepten-5-one(1) and 7H-benzocyclohepten-7-one(Scheme 13).

Scheme 13

(1)   (52a)

(53)   (2)
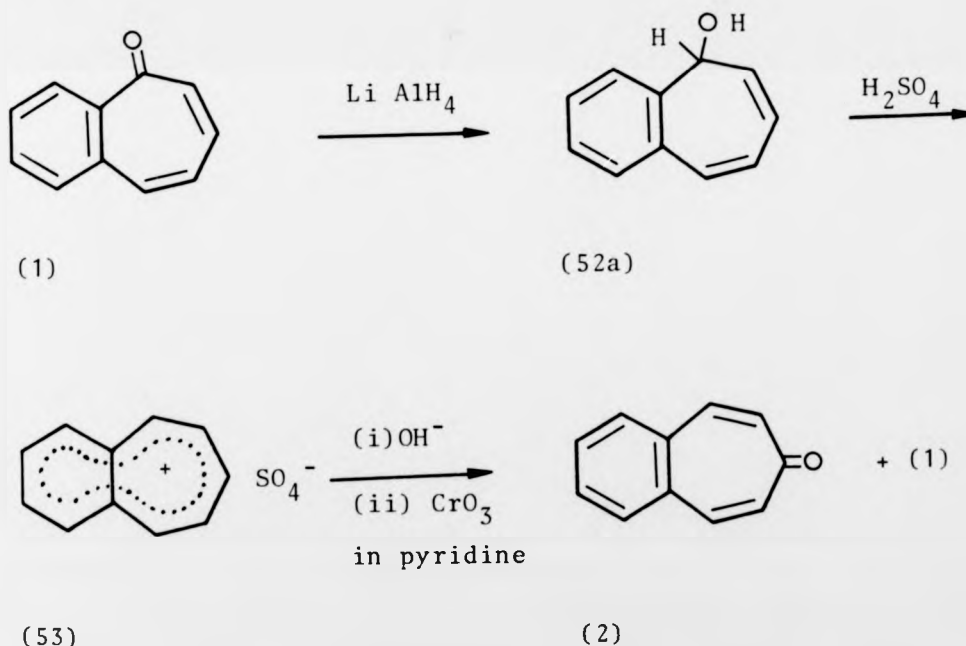
As mentioned previously Srivastava and Dev [8] reported
that oxidation of 5H-benzocycloheptene(24)with selenium dioxide
gave a mixture of 5H-benzocyclohepten-5-one(1) and
7H-benzocyclohepten-7-one(2) (Scheme 6) .

In 1973 Battiste et al [21] developed a new method
for synthesizing 7H-benzocyclohepten-7-one(2) from the
benzyne-furan adduct(54).Treatment of this adduct with
dichlorocarbene yielded the 2,3-benzobicyclo(4.1.0)heptane
(55).The subsequent ring expansion of the dichlorocyclopropane
adduct(55) to benzocyclohepten-6-ene(56)occurred, on boiling
under reflux with nitrobenzene.The compound(56)was reduced
by lithium aluminium hydride to give the chlorodiene(57).Treatment
of the chlorodiene(57)with concentrated sulphuric acid gave the
chlorobenztropylium ion and subsequently
7H-benzocyclohepten-7-one(2) (Scheme 14) .

Scheme 14

$CHCl_3$ /NaOH

$PhCH_2N(Et)_3$

(54)

Cl
Cl

165 ^0C

$PhNO_2$

(55)

H
Cl
Cl

$LiAlH_4$

(56)

Cl

H_2SO_4

(57)

Cl

H_2O

(2)
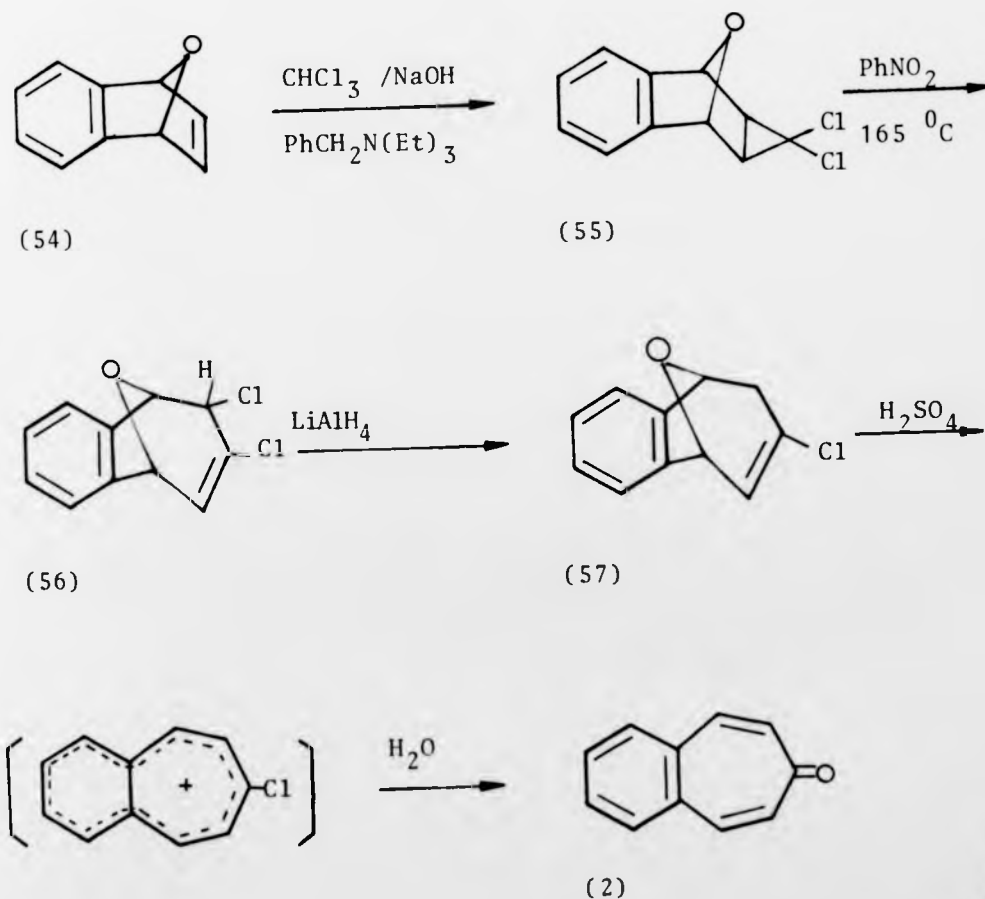
In 1975 Ewing and Paquette [22] have focused on the
fact that 7H-benzocyclohepten-7-one(2) is a bisdehydro
derivative of 5,6,8,9-tetrahydro-7H-benzocyclohepten-7-one
(60),and have gained simple access to the compound(60) in
51% overall yield by bisalkylation of readily available
o-xylylene dibromide [23] (58) with lithio tert-butyl acetate
and subsequent Dieckmann cyclization and then decarboxylation .
Bromination of the tetrahydrotropone(60) with bromine in
carbon tetrachloride gave the 6,8-dibromo ketone which
was then dehydrobrominated by lithium chloride in boiling
dimethylformamide to give the 7H-benzocyclohepten-7-one(2)
(Scheme 15).

Scheme 15

(58)   (59)

(60)   (2)
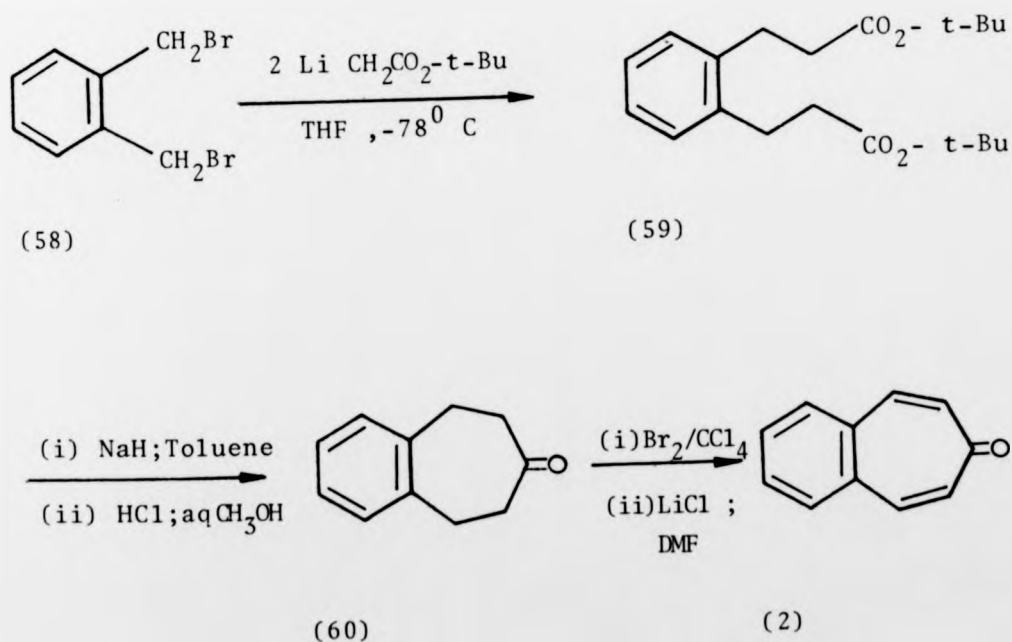
A direct conversion of o-phthalaldehyde to 7H-benzocyclohepten-7-one(2) was achieved by Walfe et al[24] in 1976.Treatment of triphenylphosphineacetylmethylene(61) with 1.2 equivalents of n-butyllithium in tetrahydrofuran at -78 ^{0}C under a nitrogen atmosphere resulted in abstraction of a methyl proton to form the ylide anion, lithiotriphenylphosphineacetylmethylene(62).Reaction of o-phthalaldehyde with a tetrahydrofuran solution of ylide (62) afforded 7H-benzocyclohepten-7-one(2) (Scheme 16).

Scheme 16

$$(C_6H_5)_3 \ P^+ \ C^-HCOCH_3 \quad \xrightarrow[\text{THF,-78 } ^0C,N_2]{\text{n-Bu Li}} \quad \left[(C_6H_5)_3 \ P^+ \ C^-HCOC^-H_2\right] Li^+$$

(61)   (62)

(62)   +   [o-phthalaldehyde] $\xrightarrow{\text{THF}}$ [benzocycloheptenone]

(2)
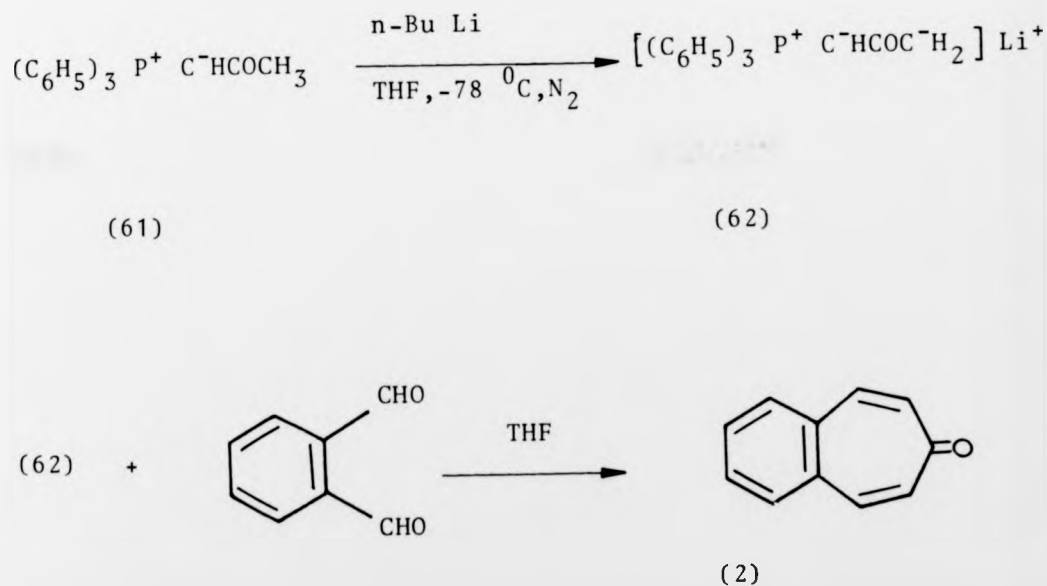
In 1978 Fohlish et al[25] reported some modification
to the method of Thiele and Weitz.They hydrolysed the
diester(51)by boiling it under reflux with aqueous sodium
hydroxide This gave a mixture of the dicarboxylic acid(63)
and the monocarboxylic acid(64).Complete conversion to
the monocarboxylic acid was achieved by heating the mixture
of carboxylic acid in butanol until evolution of carbon
dioxide ceased.Heating the acid(64)at 250^0 with copper powder
effected the decarboxylation giving the
7H-benzocyclohepten-7-one(2)in 57% yield (Scheme 17).

Scheme 17

(51)

(63)   R= CO_2H

(64)   R= H

(2)
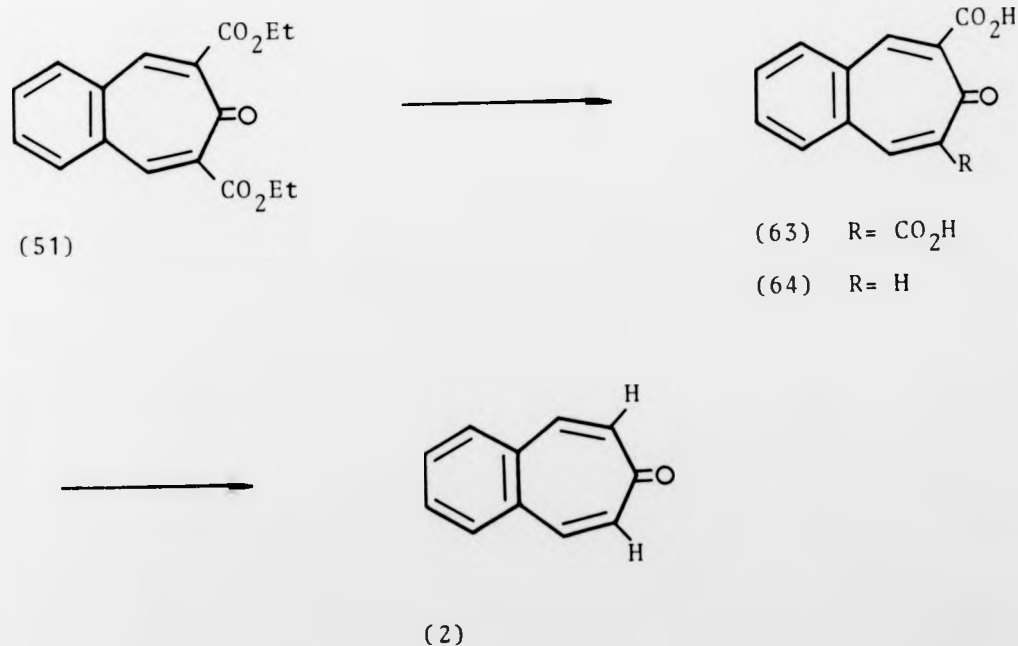
1H-2,3-Dihydro-cyclohept(f)inden -5-one   and

3H-cyclohept(f)inden-5-one

In 1972 Patwardhan and Dev [26] reported a method for synthesizing 3H-cyclohept(f)inden-5-one(3) which started from γ-(5-hydrindyl)-butyric acid.The acid cyclized by polyphosphoric acid [27] to give 6,7-cyclopentano-1-tetralone(65).Conversion of the tetralone(65)to the enol-ether(66) was carried out using triethylorthoformate with Amberlyst-15 as a catalyst [28].The enol-ether(66)was reacted with dibromocarbene to give the dibromocarbene adduct(67).Dehydrobromination rearrangement of this carbene adduct(67) by heating with active alumina [29] gave 1H-2,3-dihydro-cyclohept(f)inden-5-one(68).Bromination by N-bromosuccinimide gave the mono-bromotropone(69).Treatment of this compound(69)with silver nitrate in dimethylsulphoxide gave the 3H-cyclohept(f)inden-5-one(3) (Scheme 18).

Scheme 18
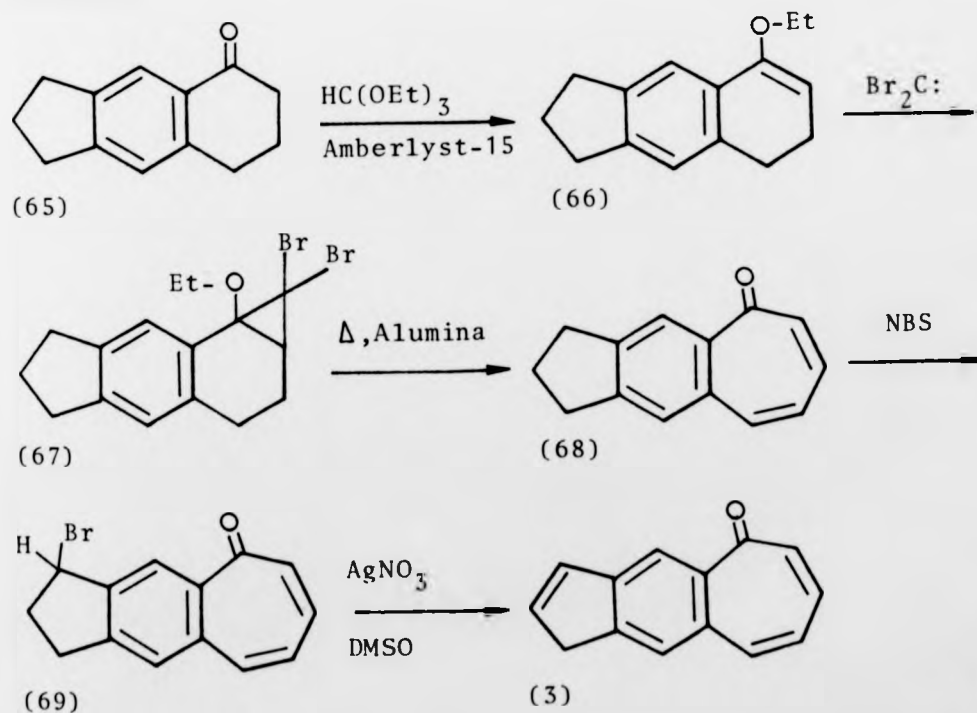
11H-Cyclohepta(a)naphthalen-11-one

The synthesis of 11H-cyclohepta(a)naphthalen-11-one
(4) was reported by Elad and Ginsburg [30] in 1957.

Catalytic reduction of the diketone [31] (70)
to the ketone (71) removed the carbonyl group conjugated
the aromatic nuc leus.Stepwise bromination by
N-bromosuccinimide in carbon tetrachloride and
dehydrobromination was repeated to yield the
11H-cyclohepta(a)naphthalen-11-one (4) (Scheme 19).

Scheme 19

(70)   (71)

(4)
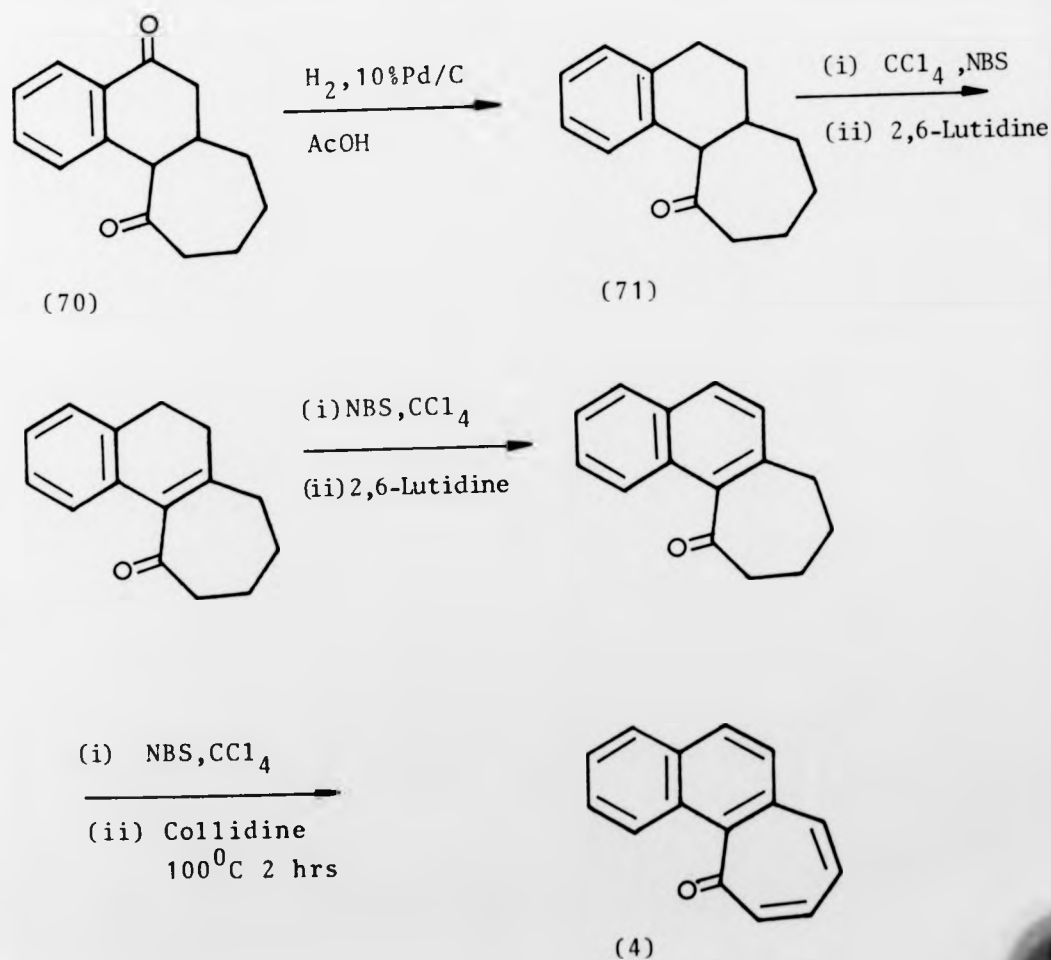
7H-Cyclohepta(a)naphthalen-7-one

The synthesis of the naphthotropone(78) was reported
by Julia et al [32,33] in 1956 .Conversion of the ketone(72) to
the   ketal(73)was carried out using ethyl orthoformate.
Subsequent reduction of the ester group with lithium
aluminium hydride followed by acid hydrolysis gave ketol(74).
Conversion of the ketol(74)with p-toluenesulphonyl chloride
gave the tosylate(75)which was then cyclized to
naphtho(1,2')bicyclo(4,1,0)-hepten-3-one(76).The ketone(76)
was then ring expanded to give 8,9-dihydro-7H-cyclohepta(a)-
naphthalen-7-one(77),which was subsequently oxidized with
selenium dioxide to the naphthotropone(78) (Scheme 20).

Scheme 20
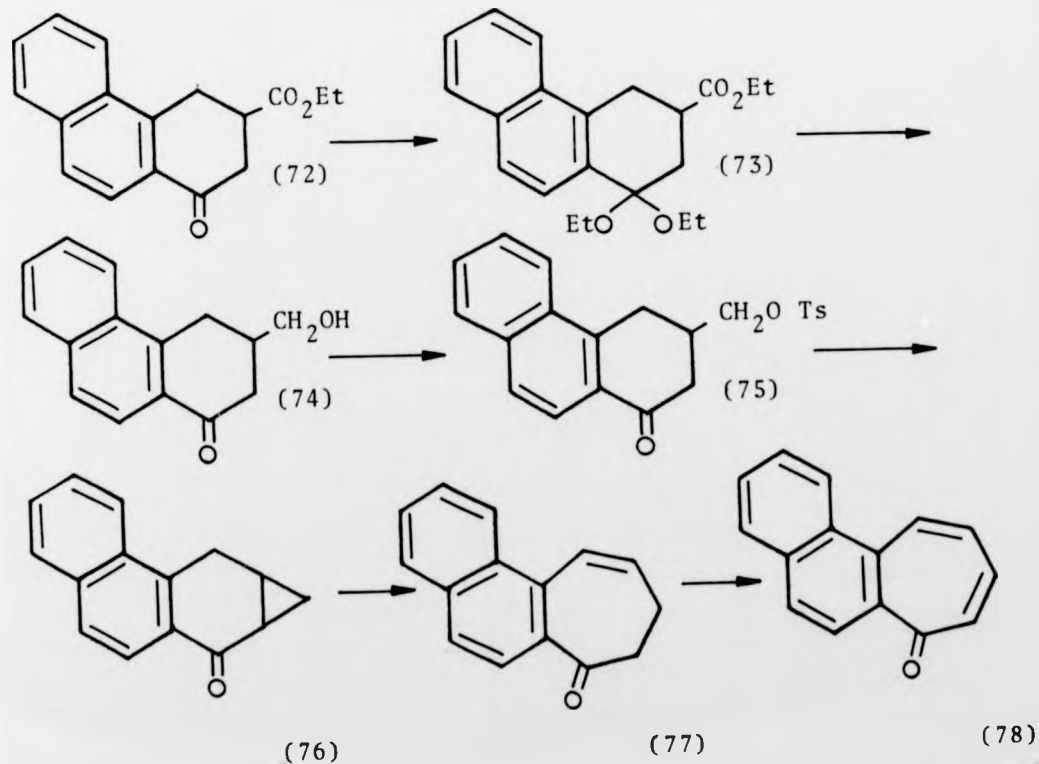
8H-Cyclohepta(b)naphthalen-8-one

Naville ,Strauss and Heilbronner [34] in 1960 reported the synthesis of 8H-cyclohepta(b)naphthalen-8-one(81). Condensation of naphthalene-2,3- dicarboxaldehyde(79)with diethyl acetone dicarboxylate gave 7,9-dicarbethoxy-8H-cyclohepta(b)naphthalen-8-one(80) which was subsequently hydrolysed and decarboxylated to 8H-cyclohepta(b)naphthalen-8-one(81) by refluxing with methanolic potassium hydroxide (Scheme 21) .

Scheme 21

(79)

(80)   (81)
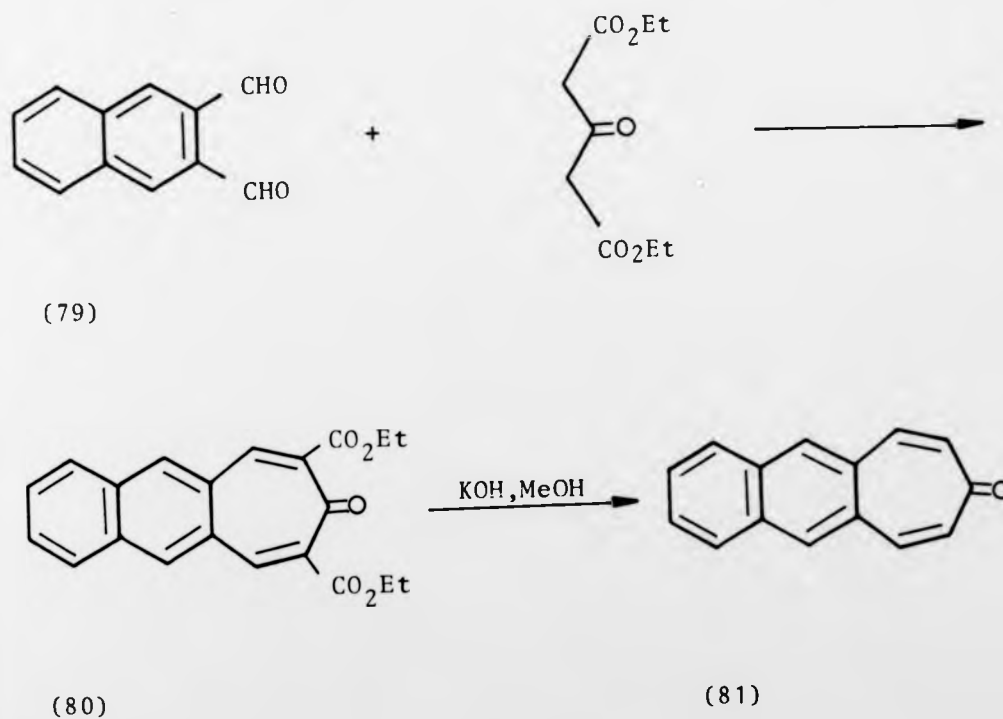
1,2-Diphenyl-7H-cyclohepta(f)-2-benzothiophen-
(or 2-isobenzofuran)-7-one

In 1979 Villessot and Lepage [35] reported the syntheses of 1,2-diphenyl-7H-cyclohepta(f)-2-benzothiophen-7-one(86) and 1,2-diphenyl-7H-cyclohepta(f)-2-isobenzofuran-7-one(87).Reaction of benzo(c)thiophen dialdehyde (82) with acetone gave the thienobenzotropone(86).Under similar conditions,the isobenzofuran dialdehyde(83) gave only a poor yield of the isobenzofurotropone (87).The latter(87) was prepared by a two-step reaction sequence starting from the adduct(84). This adduct(84) readily obtained from compound(83)and N-phenylmaleimide which was subsequently condensed with acetone to give the adduct(85).Pyrolysis of the adduct(85) gave the isobenzofurotropone (87) (Scheme 22) .

Scheme 22

(82) Z=S

(83) Z=O

(86) Z=S

(87) Z=O

(84)

(85)
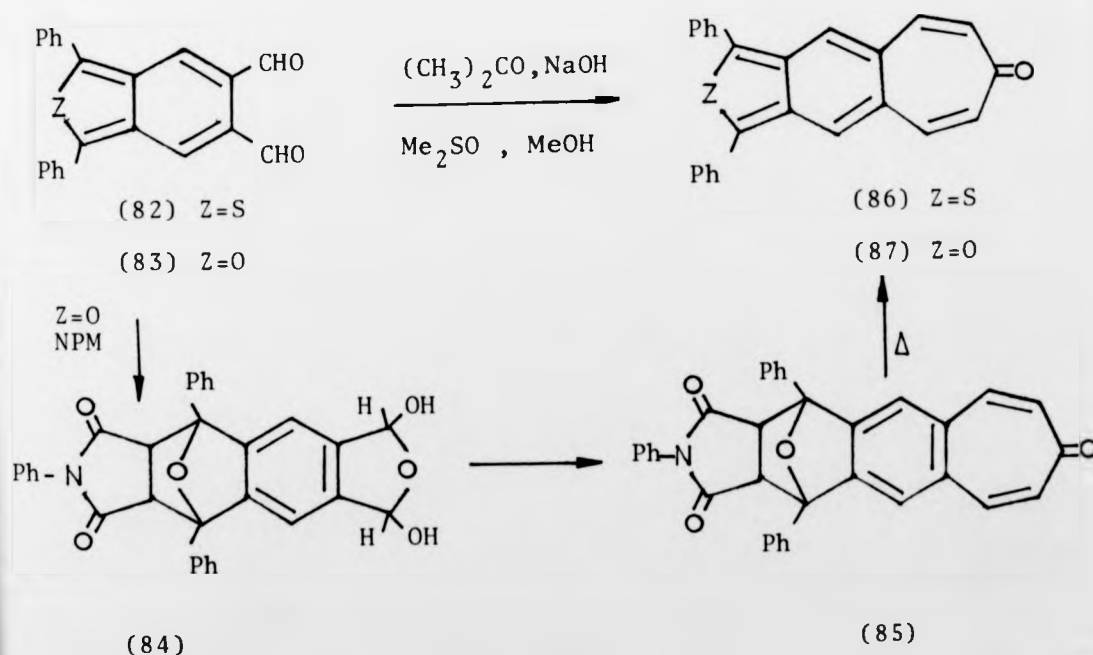
Cycloheptapyrrolones

The syntheses of cycloheptapyrrolones can be divided into four groups .

(I)- Those which start from the conversion of cycloheptafuranones .

(II)- Those which start from 4-methoxybenzyl--2-aryl-N-alkylaminoacetonitriles .

(III)-Those which start from pyrrole moeity .

And finally (IV)-those which start from a tropone .

Conversion of cycloheptafuranones to cycloheptapyrrolones

N-Alkyl-2-methylcycloheptapyrrol-8-ones

The synthesis of N-alkyl-2-methylcycloheptapyrrol-8-one (89)was reported by Takeshita,Chisaka and Mametsuka [36] in 1980 . Conversion of 2-methylcyclohepta(b)furan-8-one(88) [37] to N-alkyl-2-methylcycloheptapyrrol-8-one(89)was carried out by heating with alkylamines.When bulky amines were used 2-alkylamino--3-(2-oxopropyl)tropones(90) were obtained as by products. However , compound(88) did not react with ammonia or t-butylamine under comparable conditions (Scheme 23) .

Scheme 23

R=	Me	Et	$(CH_2)_2Me$	$CHMe_2$	Cyclohexyl
Yields of compound (89)	76%	70%	85%	45%	14%
Yields of compound (90)	0%	0%	4%	18%	12%
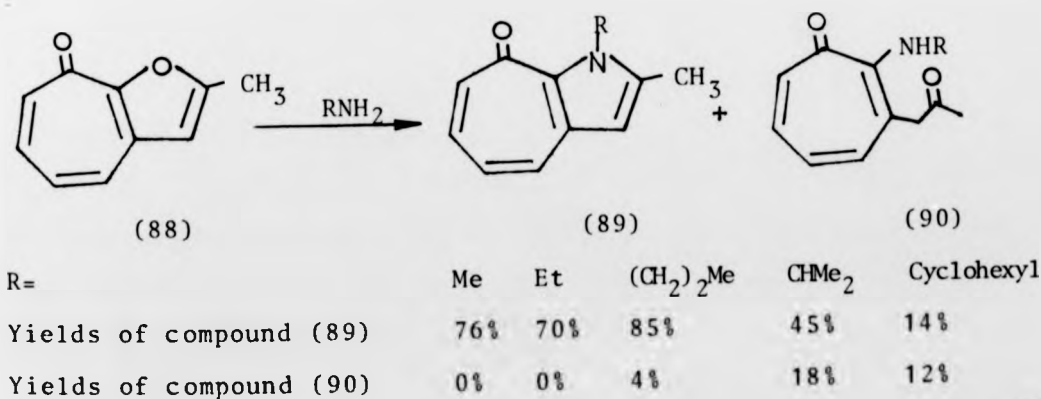
1-Methylcyclohepta(b)pyrrol-4-one

The synthesis of 1-methylcyclohepta(b)pyrrol-4-one(93) was reported by Crabbe'et al [38] in 1980 . Treatment of the 5,6,7,8 -tetrahydrocyclohepta(b)furan-4-one(91)with methylamine in methanol under pressure afforded the 1-methyl-5,6,7,8-tetrahydrocyclohepta(b)pyrrol-4-one(92).The pyrrole(92)was then dehydrogenated with 2,3-dichloro-5,6-dicyano- -1,4-benzoquinone to give 1-methylcyclohepta(b)pyrrol-4-one (93)(Scheme 24) .

Scheme 24

(91) (92) (93)
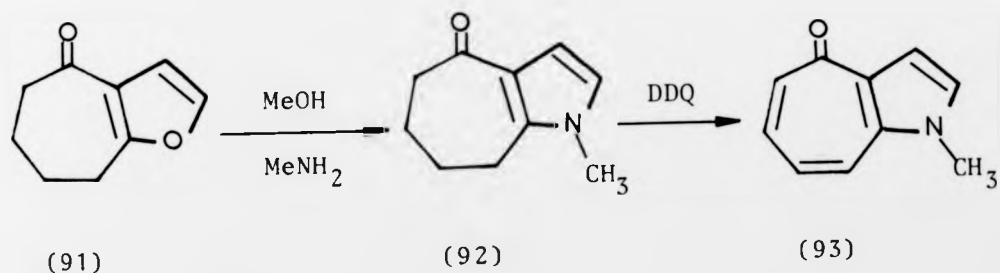
Conversion of N-4-methoxybenzyl- and N-3,4-dimethoxybenzyl- -aminoacetonitriles to cycloheptapyrrolones

1-Aryl-N-methylcyclohepta(c)pyrrol-6-ones

In 1980 Waigh [39] reported the synthesis of 2-aryl-N-methyl- cyclohepta(c)pyrrol-6-ones (97,98 and 99).N-4-Methoxybenzyl- and N-3,4-dimethoxybenzylaminoacetonitriles(94,95 and 96) with both

2-aryl and N-alkyl substituents undergo o-demethylation
and rearrangement with elimination of ammonium in very
strongly acidic conditions,such as concentrated sulphuric
acid to give 2-aryl-1-methylcyclohepta(c)pyrrol-6-ones
(97,98 and 99) (Scheme 25).

Scheme 25

(94) R=H,   Ar=Ph

(95) R=OMe,Ar=Ph

(96) R=OMe,Ar=DMP

(97)R=H,   Ar=Ph

(98)R=OMe, Ar=Ph

(99)R=OMe, Ar=3,4-dimethoxyphenyl
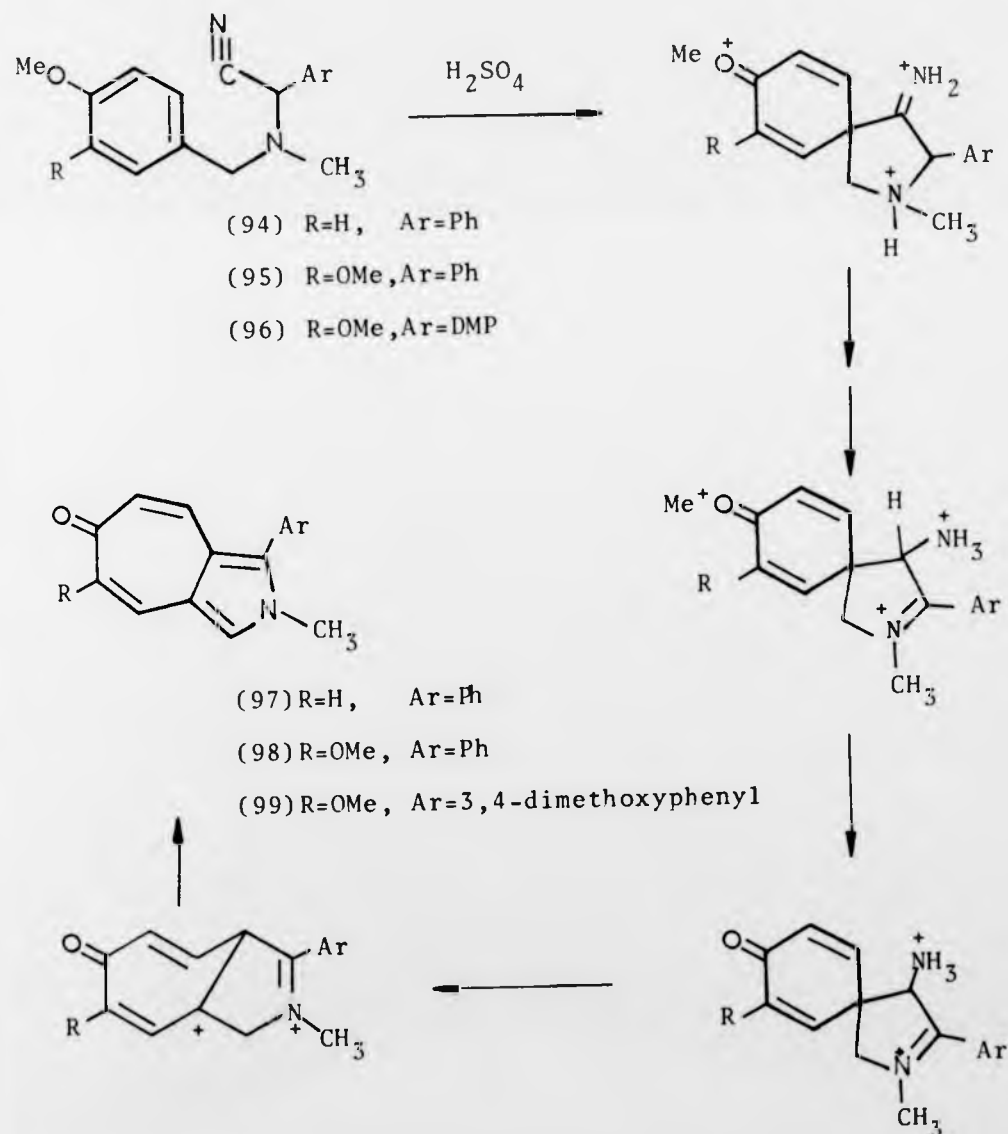
Synthesis starting from a pyrrole

1,3-Dimethyl-2-phenylcyclohepta(c)pyrrol-6-one

The synthesis of 1,3-dimethyl-2-phenylcyclohepta(c)pyrrol-
-6-one(101) was reported by Ginesina,Kivokurtseva and
El´tsov [40] in 1969 .The 3,4-diformyl-2,5-dimethyl-1-phenylpyrrole
(100) could be condensed with acetone to afford
1,3-dimethyl-2-phenylcyclohepta(c)pyrrol-6-one(101)(Scheme 26).

Scheme 26

(100)   (101)
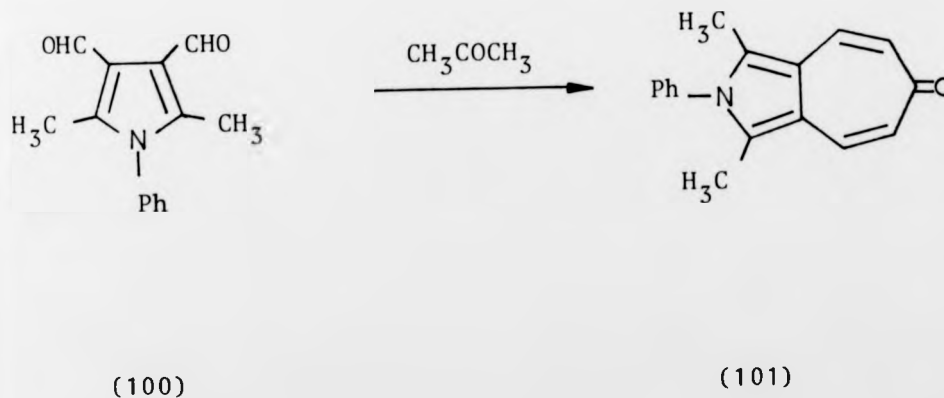
6H-2-Methylcyclohepta(c)pyrrol-6-one

The synthesis of 6H-2-methylcyclohepta(c)pyrrol-6-one
(106) was reported by Duflos et al [41] in 1973 .Reduction of
1-methyl-3,4-dicarboethoxypyrrole (102) gave diol(103) which
was then oxidized to the dialdehyde(104)by using silver carbonate .
Condensation of the dialdehyde with dimethyl 1,3-acetone-
dicarboxylate gave the diester(105)which after hydrolysis
and subsequent decarboxylation gave the
6H-2-methylcyclohepta(c)pyrrol-6-one(106) (Scheme 27).

Scheme 27
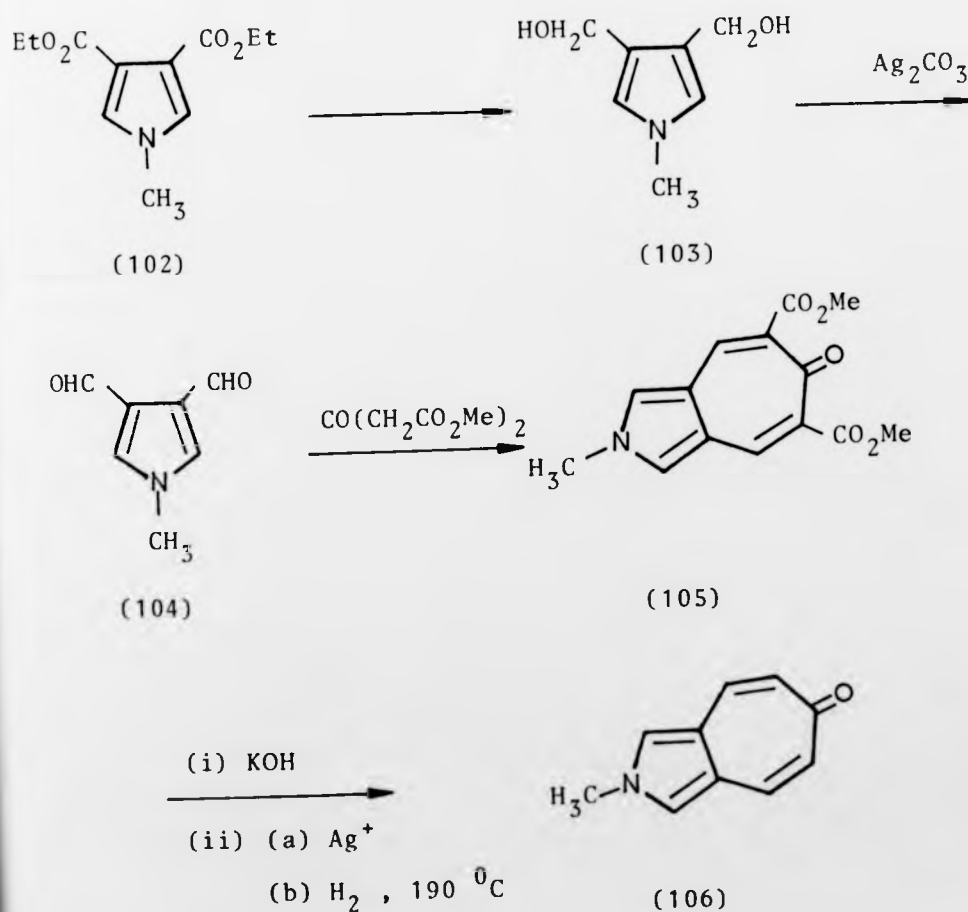
1-Methylcyclohepta(b)pyrrol-6-one

In another report also in 1973 , Duflos et al[42] were able to synthesize 1-methylcyclohepta(b)pyrrol-6-one(112).The synthesis start from 1-methyl-2,3-diformylpyrrole(109) which was prepared in four steps by the following route .The aldehyde function of methyl-2-formyl-1-methylpyrrole-3-carboxylate(107)was protected as an acetal enable the ester to be reduced to an alcohol using lithium aluminium hydride .After hydrolysis of the acetal , the alcohol(108) was oxidized with silver carbonate to give 1-methyl-2,3-diformylpyrrole(109).Condensation of the pyrrole(109) with dimethyl acetonedicarboxylate gave 6H-1-methyl-5,7--dicarbomethoxycyclohepta(b)pyrrol-6-one(110).The ester was hydrolysed to the acid (111) which was then decarboxylated to give the pyrrole (112) (Scheme 28) .

Scheme 28

(107)

(108)

(109)

(110) R=CH$_3$
(111) R=H

(112)
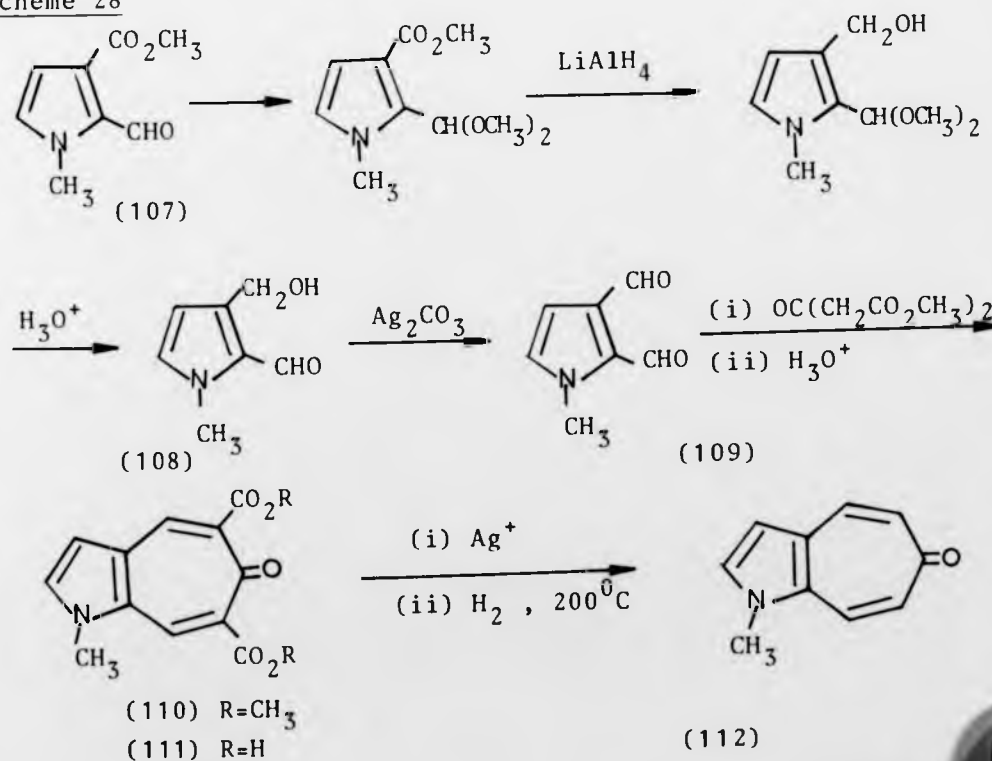
1,3-Dimethyl- and 1,2,3-trimethylcyclohepta(c)pyrrol-6-one

The synthesis of pyrroles(119 and 120) was reported by Kreher et al [43] in 1975.The α-substituted heterocyclic dialdehyde(115,116)required for the synthesis are accessible from 2,5-dimethyl- and 1,2,5-trimethylpyrrole(113,114)by formylation with dimethylformamide and phosphorus oxychloride.Condensation of diethyl(or dimethyl) acetonedicarboxylate with both the pyrroles (115 and 116) occurred readily in the presence of triethylamine to give the diesters(117,118) which with subsequent hydrolysis and decarboxylation gave the pyrrolotropones(119,120).Condensation of acetone and 1,3-diphenylacetone with the trimethylpyrrole(116) could only be achieved under forcing condition,such as morphine and potassium hydroxide,to give pyrrolotropones(120,120 a)(Scheme 29).

Scheme 29

(113) R=H
(114) R=CH$_3$

(115) R=H
(116) R=CH$_3$

(117) R=H,   X=CO$_2$Et
(118) R=CH$_3$, X=CO$_2$Et
(119) R=H,   X=H
(120) R=CH$_3$, X=H
(120a) R=CH$_3$, X=Ph
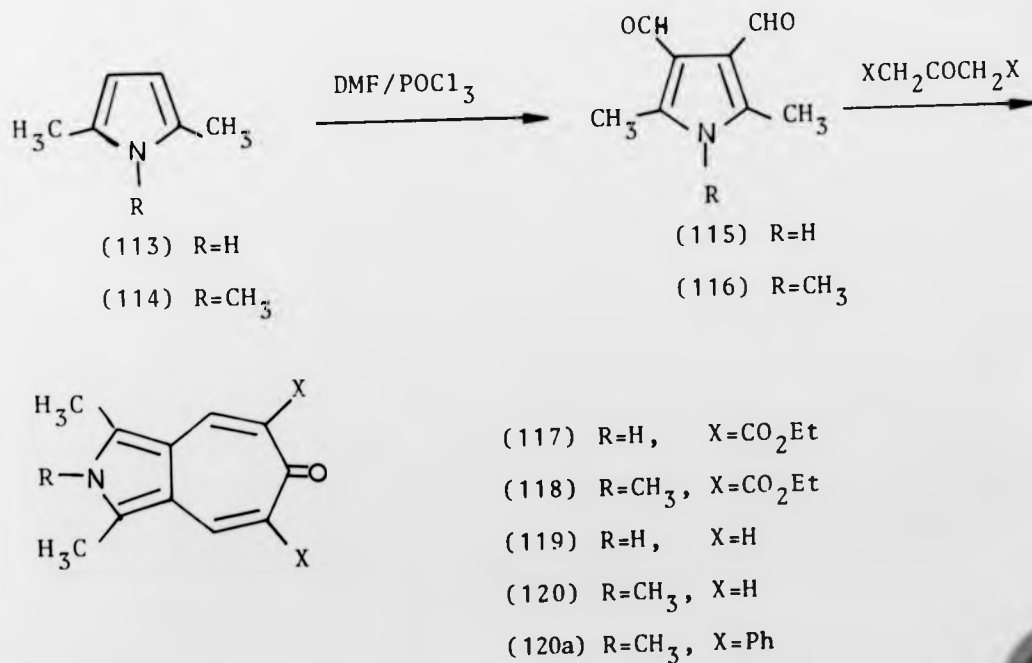
In 1976 Jones and Santokh [44] reported a similar synthesis of 2H-1,3-dimethylcyclohepta(c)pyrrol-6-ones. Condensation of 3,4-diformyl-2,5-dimethylpyrrole(113) with acetone was carried out in aqueous methanol in the presence of sodium hydroxide at 25 ^{0}C to give the 2H-1,3-dimethylcyclohepta(c)pyrrol-6-one(119). A number of the 5,7-substituted-1,2-dimethylcyclohepta(c)pyrrol-6-ones (120-125) were also prepared in 60-65% yield by the base catalyzed condensation of the pyrroloaldehyde with 1,3-disubstituted acetones   (Scheme 30).

Scheme 30
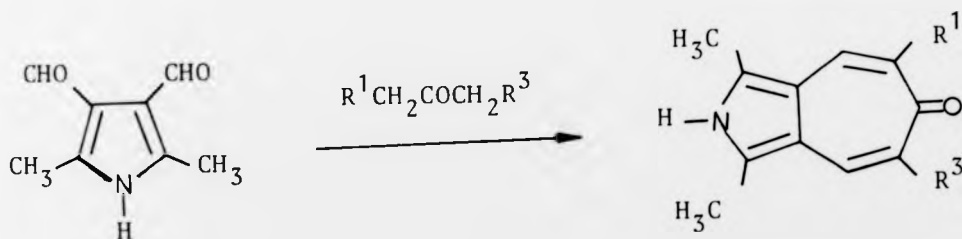
(113)

(119) $R^1 = R^3 = H$

(120-123) $R^1 = R^3 = CH_3$; Ph ; CO_2Me ; CO_2H .

(124-125) $R^1 = H$; $R^3 = Me$ or Ph

Syntheses starting from   tropones

Substituted-1,8-dihydrocyclohepta(b)pyrrole-8-one

An improved process for preparation of cyclohepta(b)pyrrol-
-8-ones [45] is based on the treatment of substituted tropolones
with ammonia or substituted amines or,alternatively,with amides
and potassium carbonate .Thus 5,7-dibromo-3-acetonyltropolone(126)
was mixed and stirred with formamide and potassium carbonate to
give 5,7-dibromo-2-methyl-1,8-dihydrocyclohepta(b)pyrrol-8-one(129).
The synthesis of substituted cycloheptapyrrol-8-one(130-132)starting
from 3-acetonyltropolone(127) or also 3-phenacyltropolone (128)
was reported by Nakazawa et al [46] in 1969.Reaction of 3-acetonyl-
tropolone(127)with liquid ammonia(or formamide)in the presence
of potassium carbonate and also with methylamine(or N-methylformamide)
gave 2-methyl or 1,2-dimethyl-1,8-dihydrocyclohepta(b)pyrrol-8-one
(130,132)respectively.Similarly treatment of 3-phenacyltropolone
(128) with formamide gave 2-phenyl-1,8-dihydrocyclohepta(b)pyrrol-
-8-one(131) (Scheme 31) .

Scheme 31

(126) R=CH$_3$, R^1=H,R^2=CH$_3$,R^3=Br (using HCONH$_2$ or NH$_3$)   (129)
(127) R=CH$_3$, R^1=H,R^2=CH$_3$,R^3=H   (using HCONH$_2$ or NH$_3$)   (130)
(128) R=Ph , R^1=H,R^2=Ph ,R^3=H   (using HCONH$_2$)   (131)
(127) R=CH$_3$, R^1=CH$_3$,R^2=CH$_3$,R^3=H(using CH$_3$NH$_2$ or HCONHCH$_3$)(132)
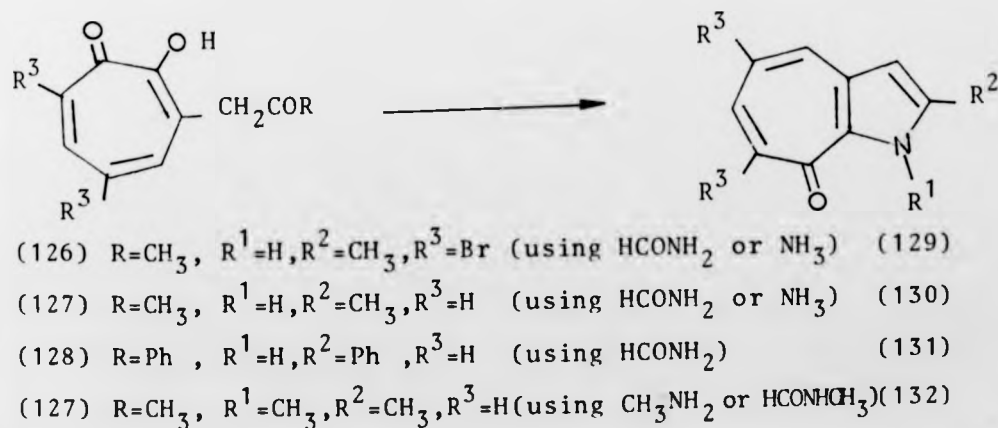
6,7,8,9,10,11-Hexahydro-5H-dicyclohepta(b,d)pyrrol-5-one

The synthesis of 6,7,8,9,10,11-hexahydro-5H-dicyclohepta-(b,d)pyrrol-5-one(138)and 2,3,4,5-tetrahydro-1H-cyclohepta-(b)indol-6-one(137)was reported by Yamane et al [47] in 1975 . Reaction of cycloheptanone or cyclohexanone with 2-hydrazino-tropone(133) gave cycloheptanone 2-troponylhydrazone(135) and cyclohexanone 2-troponylhydrazone (134) respectively. Cyclization of the hydrazones (135,134) was effected by heating in dilute sulphuric acid to afford the pyrrolotropones(138,137). Similarly the 2-troponylhydrazone of N-benzyl-4-piperidone(136) was easily converted to the 2,3,4,5-tetrahydro-1H-2 -(phenyl-methyl)-cyclohepta(4,5)pyrrolo(3,2-c)pyridin-6-one(139)(Scheme 32).

Scheme 32

$n=1$ or 2
$X=CH_2$ or NCH_2Ph

(133)

(134) $n=1$, $X=CH_2$

(135) $n=2$, $X=CH_2$

(136) $n=1$, $X=NCH_2Ph$

H_2SO_4

(137) $n=1$, $X=CH_2$

(138) $n=2$, $X=CH_2$

(139) $n=1$, $X=NCH_2Ph$
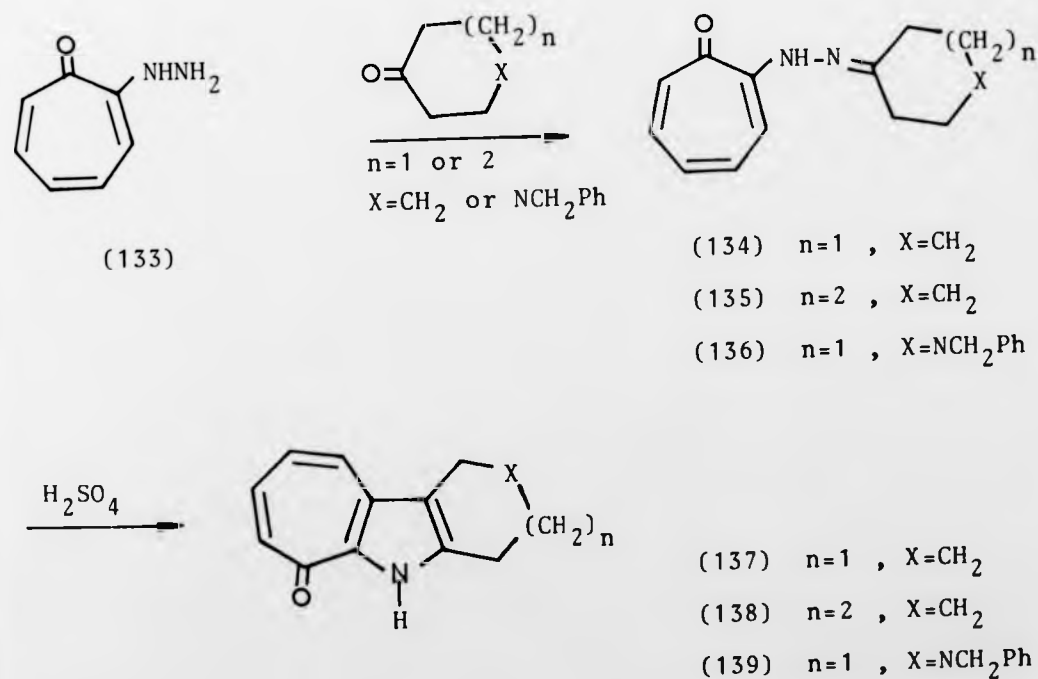
3-Phenylcyclohepta(b)pyrrol-8-one

The synthesis of 3-phenylcyclohepta(b)pyrrol-8-one(141) was reported by Yamane,Fujimori,Sin and Nozoe[48] in 1977. Condensation of 2-hydrazinotropone(133)with phenylacetaldehyde gave the phenylacetaldehyde troponylhydrazone(140). Cyclization of the hydrazone(140)was effected by heating in aqueous sulphuric acid to give the 3-phenylcyclohepta(b)-pyrrol-8-one(141) (Scheme 33) .

Scheme 33

(133)   PhCH$_2$CHO   (140)

H$_3$O$^+$ (141)
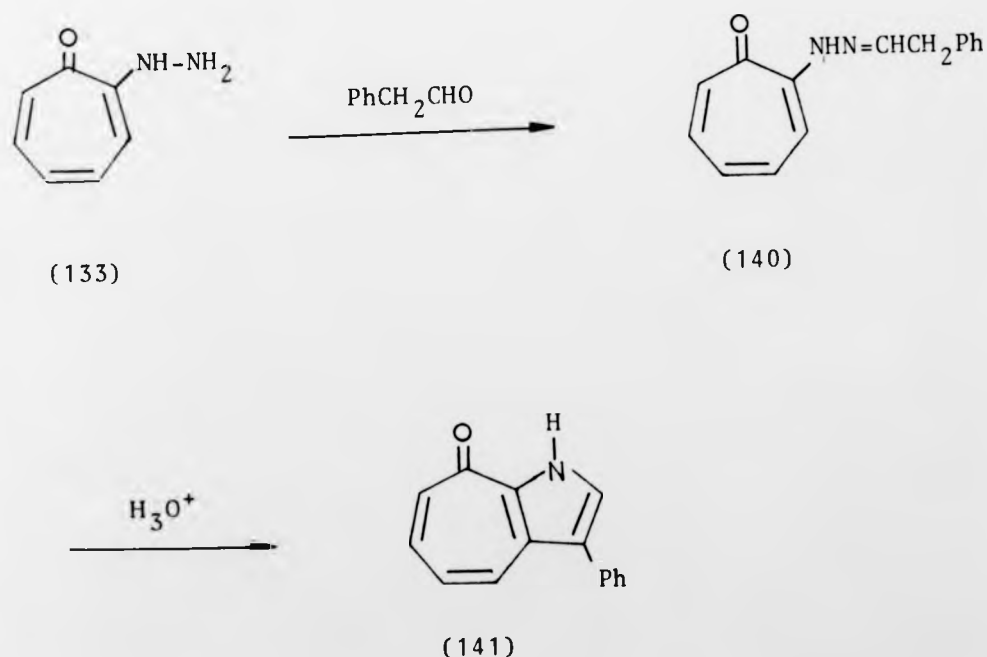
Synthesis starting from cycloheptanedione monophenylhydrazone

5H-cyclohept(b)indol-6-one

In 1973 Yamane et al [47] synthesized 7,8,9,10-terahydro-
-5H-cyclohepta(b)indol -6-one(143) from cycloheptanedione
monophenylhydrazone(142) [49,50] .From this Yamane and Fujimori [51]
were able to prepare 5H-cyclohept(b)indol-6-one(7) in 1977 by
using Collington and Jones ' method for bromination/
dehydrobromination (Scheme 39) .

Scheme 39

(142)　　　　　　　　　　　(143)　　　　　　　　　(7)
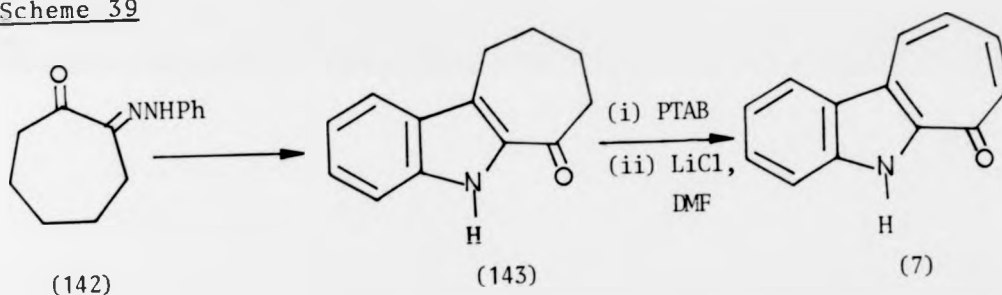
From photolysis of 2,2´-diisocyanobiphenyl and acridine-N-oxide

The synthesis of 5H-cyclohept(b)indol-6-one(7)was reported
by de Jong and Boyer [52] in 1972.Photolysis of 2,2´-diisocyano-
biphenyl(144)yieled a mixture of 10-isocyanocyclohept(b)indole
(145) and 6-aminocyclohept(b)indole(146).Reaction of the amine
(146) with alcoholic alkali afforded the indolotropone(7)(Scheme 40).

Scheme 40

(144)　　　　　　　　　　　(145)　　　　　　　　　　(146)

(146) $\xrightarrow{\text{NaOH,EtOH}}$ (7)
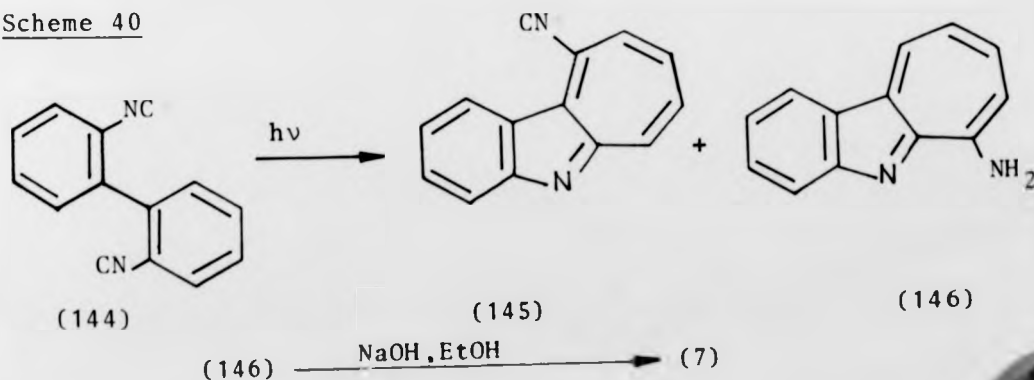
Cycloheptindoles

The synthesis of cycloheptindoles can be divided into five groups :

(I)-Those which start from dehydrogenation of pyrrolotropones.

(II)-Those which start from conversion of the cycloheptanedione monophenylhydrazone to 7,8,9,10-tetrahydro-5H-cyclohept(b)indol--6-one and subsequent bromination/dehydrobromination procedure.

(III)-Those which start from the phtolysis of 2,2'-diisocyanobiphenyl and also acridine-N-oxide.

(IV)-Those which start from selective oxidation of 5,6,7,8,9,10--hexahydrocyclohept(b)indole at position 10 to 6,7,8,9-tetrahydro-cyclohept(b)indol-10-(5H)-one,followed by bromination and dehydrobromination.

And finally (V)-the synthesis of 5-methylcyclohept(b)-indol-8-one from 1-methyl-2-formylindole.

Conversion of pyrrolotropone to the 5H-cyclohepta(b)indol-6-one

As mentioned previously (Scheme 32), 2,3,4,5-tetrahydro-1H--cyclohept(b)indol-6-one(137)is obtained by application of Fischer's indole synthesis.Yamane et al [47] also dehydrogenated this pyrrolotropone (137)with either chloranil or DDQ to give 5H cyclohept(b)indol-6-one(7)(Scheme 34).

Scheme 34

Chloranil

or   DDQ

(137)   (7)
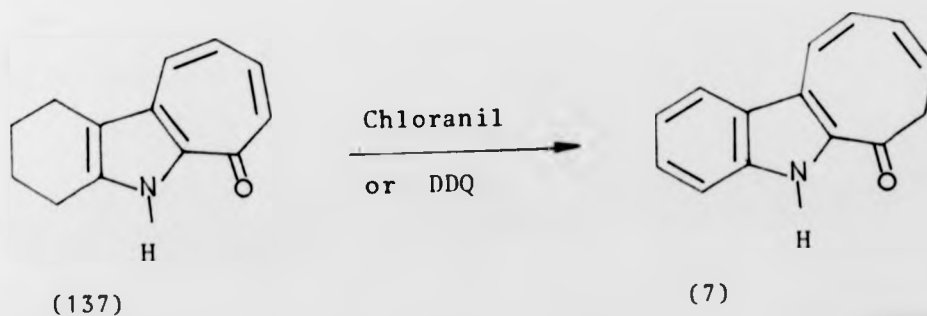
Irradiation of acridine-N-oxide(147) gave under various
conditions,some   of,5H-cyclohept(b)indol-6-one(7)   and
5H-cyclohept(b)indol-10-one(8) along with other products [53,54] .
Trapping experiments for the primary products were reported
by Yamada et al [55,56] . In order to trap some of ,these products
a solution of acridine-N-oxide(0.2% in dry benzene) was irradiated[**] .
As soon as all the N-oxide was consumed, the irradiation was
terminated and solution was then subjected rapidly to the
following reaction in the dark :
(I)-stirred for several hours after addition of methanol   containing
5%   triethylamine.
(II)-Flashed with HCl gas for a few minutes.
These results were compared, with that obtained by the longer
irradiation experiment(III).The results from all these reactions
are listed below(Table 1).

Though the actual isolation of the intermediate(149)
has not been achieved as yet,its structure can be deduced as
the oxazepine(149),which reacts with solvent to give the
additional product(152).Formation of the isomeric products
(8,7,151)is believed to be as follows:
the oxazinridine(148)derived from the photo-excited
N-oxide(147)tautomerizes to the more stable 1,2-oxazepine(149) .
The oxazepine then undergoes further thermal rearrangement
via the spiro compound(150)to give the products(8,7,151)(Scheme 41).

**-Photolyses were carried out in an immersion apparatus with
Pyrex filter and 450 W high-pressure mercury arc lamp.

Scheme 41
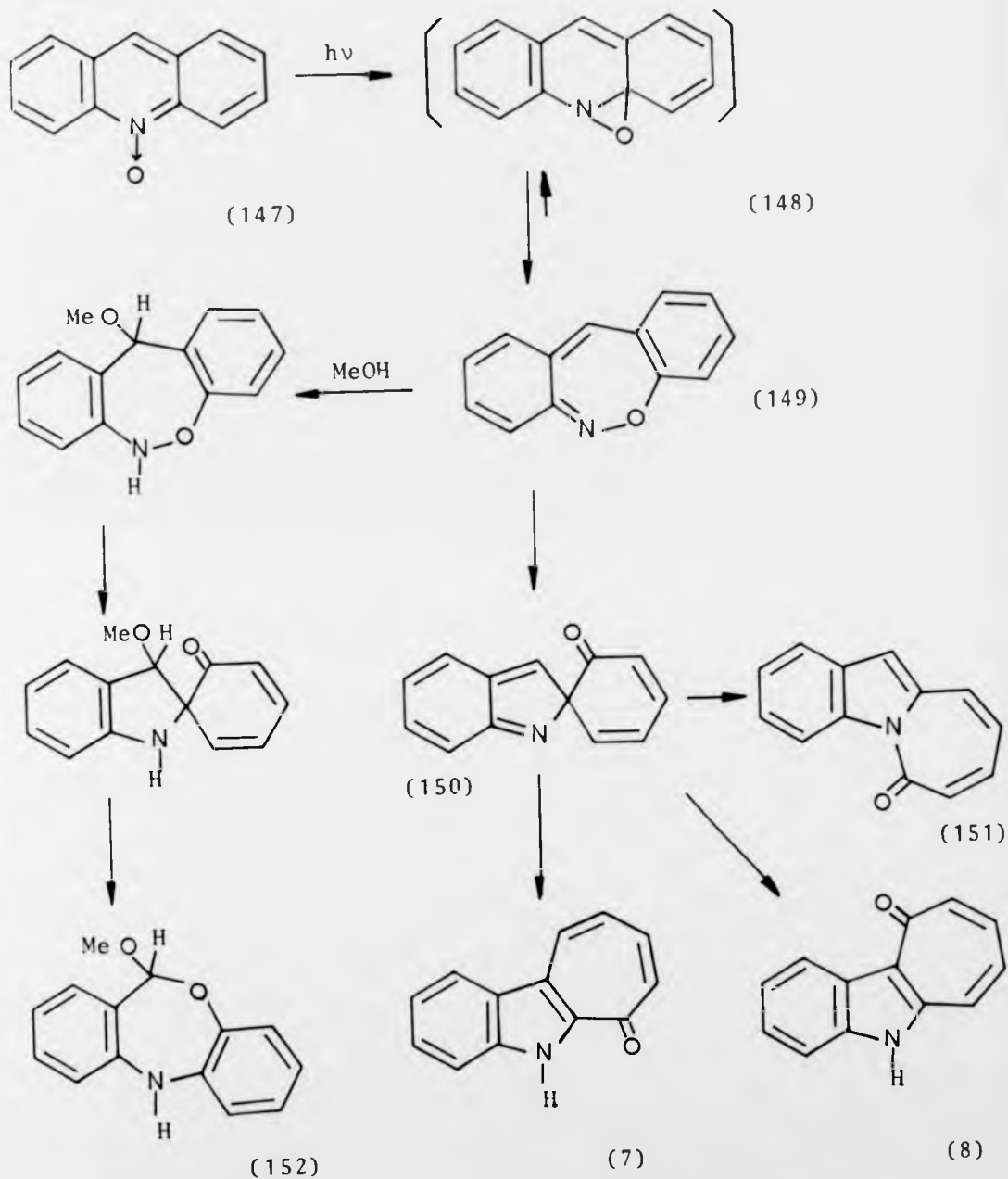
Table 1 Trapping experiments for the primary-products

Comp.	(147)	(151)	(8)	(7)	(152)
(I)	5%	2%	10%	10%	60%
(II)	3%	2%	60%	10%	-
(III)	-	5%	30%	20%	-

From selective oxidation of

5,6,7,8,9,10-hexahydrocyclohept(b)indole

In 1976 , Yamane and Fujimori [51] reported the synthesis of 5H-cyclohept(b)indol-10-one from 5,6,7,8,9,10-hexahydro-cyclohept(b)indole(153).Selective oxidation of the latter (153) with DDQ at room temperature in wet dioxane gave 6,7,8,9-tetrahydro-cyclohept(b)indol-10(5H)-one(154). Subsequent bromination and dehydrobromination of the ketone(154) gave 5H-cyclohept(b)indol-10-one(8) (Scheme 42) .

Scheme 42

DDQ,wet dioxane

(153)

(154)

(i) PTAB

(ii) LiCl,DMF

(8)
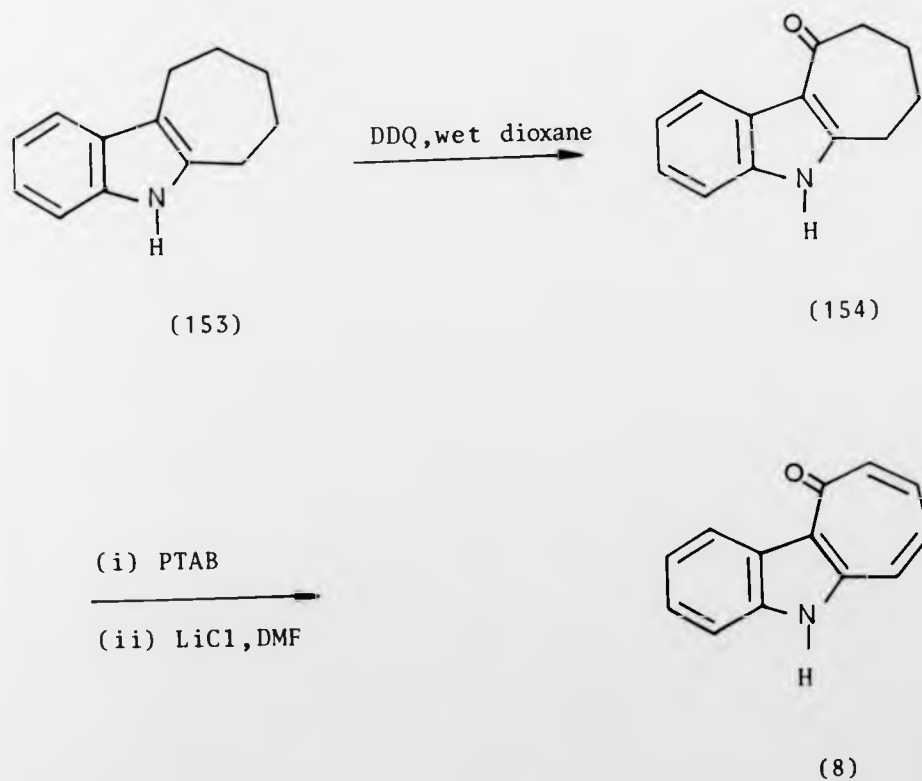
Conversion of 1-methyl-2-formylindole to the indolotropone

5-Methyl-cyclohept(b)indole-8-one

In 1980 Dulflos et al [57] synthesized 1-methyl-2,3-diformyl-indole(158)and from this they were able to prepare 5H-methyl--cyclohept(b)indol-8-one(161).Treatment of 1-methyl-2-formyl-indole(155)with phosphorus oxychloride and dimethylformamide afforded 1-methyl-2-dichloromethyl-3-formylindole(156).Reaction of the dichloro compound with sodium methoxide yielded the acetal (157),which was subsequently hydrolysed to give 1-methyl-2,3--diformylindole(158).Treatment of the dialdehyde(158) with methyl acetonedicarboxylate gave the diester(159),which was hydrolysed to the diacid(160).Decarboxylation of the diacid(160) with copper powder afforded the 5-methylcyclohept(b)indol-8-one (161) (Scheme 43).

Scheme 43

(155)   DMF/POCl$_3$ (156)   CH$_3$ONa

(157)   H$^+$ (158)   O=C(CH$_2$CO$_2$CH$_3$)$_2$

(159)   HCl   (160)

Cu powder / Δ (161)
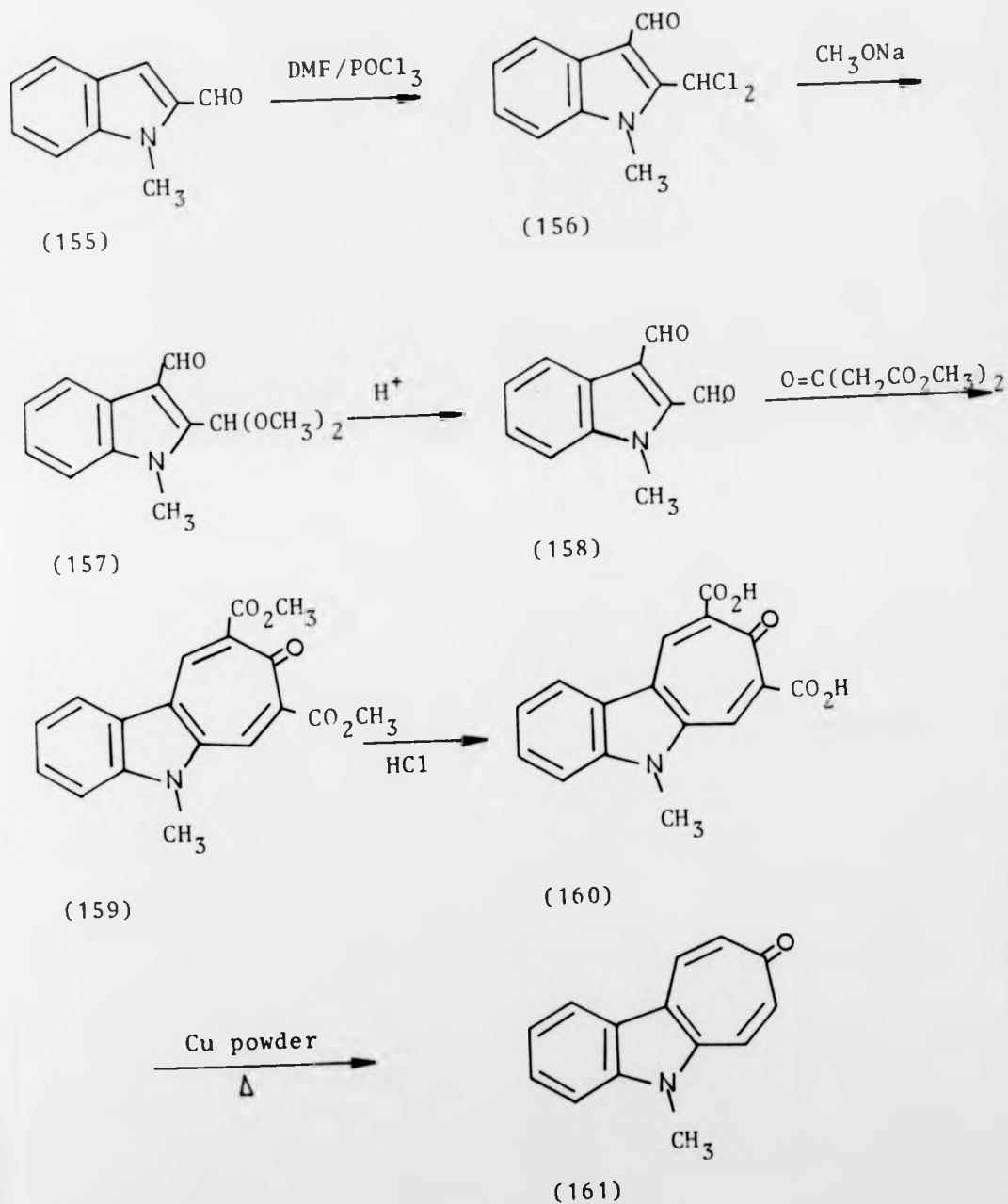
Cycloheptafuranones

As with the synthesis of cycloheptapyrrolones, the synthesis of cycloheptafuranones can be divided into two main groups,that is ,either starting from a tropone or those which start from a furan.

Syntheses starting from a tropone

2-Methyl-8H-cyclohepta(b)furan-8-one

In 1965, Takase [58] ,synthesized 7-acetonyltropolone(164) and from this he was able to prepare 2-methyl-8H-cyclohepta(b)-furan-8-one(165).Condensation of 3-bromotropolone(162) with ethyl acetonacetate yielded 3-acetyl-8-hydroxy-2H-cyclohepta(b)-furan-2-one(163),which on treatment with aqueous sodium hydroxide gave 7-acetonyltropolone(164).The acetonyltropolone was then cyclized with concentrated sulphuric acid to give the 2-methyl-8H-cyclohepta(b)-8-one(165) (Scheme 44).

Scheme 44

(162)

$CH_3COCH_2CO_2C_2H_5$

(163)

NaOH(aq)

(164)

conc. H_2SO_4
Δ

(165)
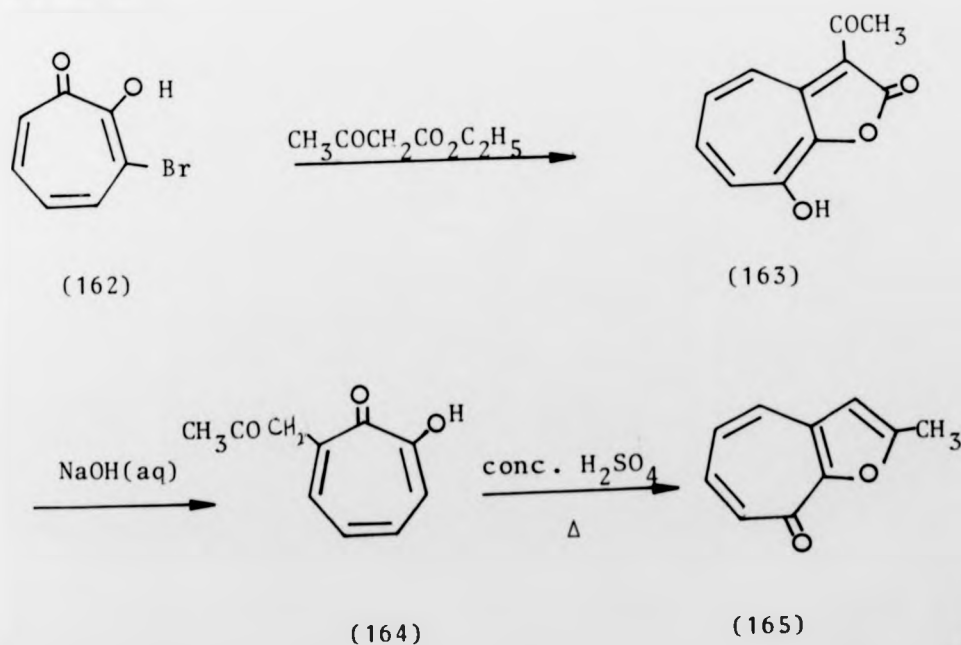
The syntheses of 2-methoxy and 2-phenyl-8H-cyclohepta(b)-furan-8-one(165 and 170)starting from tropolone tosylate(166) were reported by Nakazawa,Sato and Soma [46] in 1969.Reaction of tropolone tosylate(166) with ethyl acetoacetate gave 3-acetyl -8-hydroxy-2H-cyclohepta(b)furan-2-one(167),which was hydrolysed to give 3-acetonyltropolone(127).Reaction of the latter(127)with benzylamine gave the tropone(165) and some 1-benzyl-2-methyl-1,8-dihydropyrrol-8-one(168).Similarly condensation of tropolone tosylate(166)with ethyl 3-benzoyl-ethanoate gave 3-benzoyl -8-hydroxy-2H-cyclohepta(b)furan-2-one (169),hydrolysis of which gave a mixture of 3-phenacyltropolone (128) and 2-phenyl-8H-cyclohepta(b)furan-8-one(170)(Scheme 45).

Scheme 45
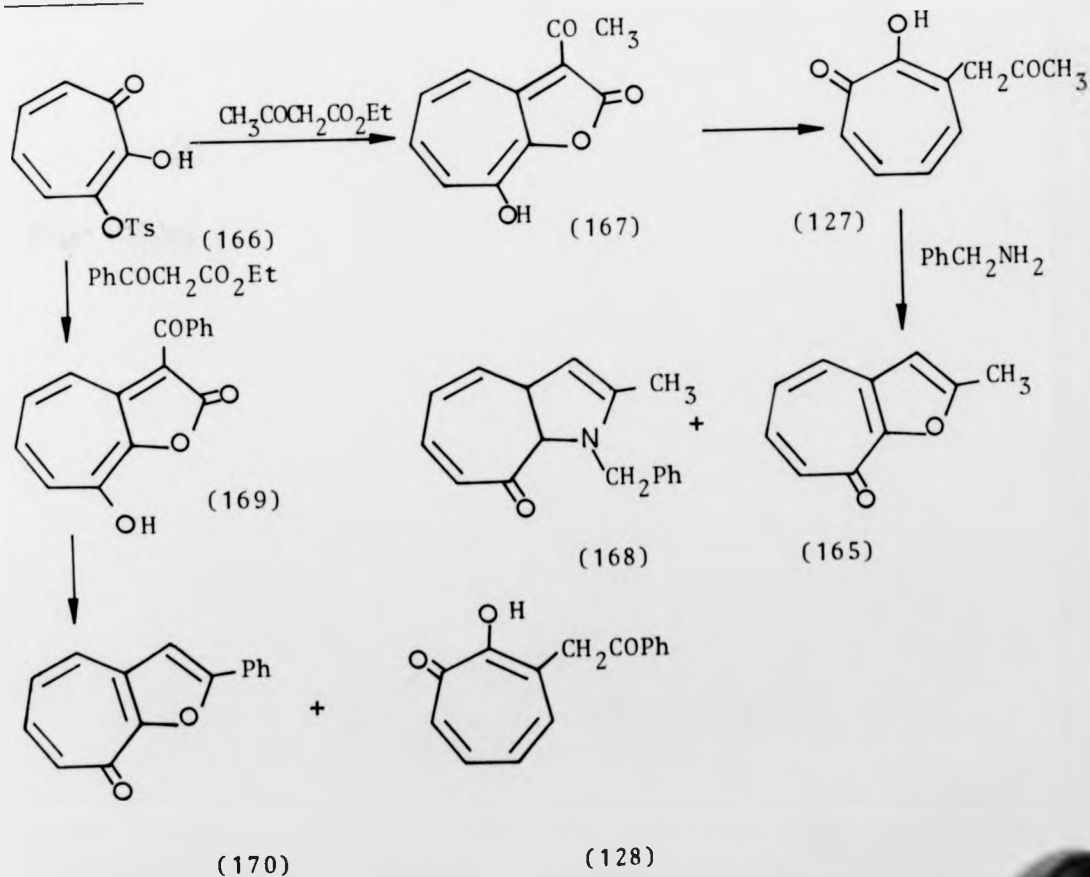
In 1974 Pryde,Zsindely and Schmid [59] reported the thermal rearrangement of 2-propargyloxycycloheptatrien one(172) in mesitylene in an evacuated bomb at 170 ^{0}C for 100 minutes to give the 2-methoxy-8H-cyclohepta(b)furan-8-one(165).The compound (172),itself was prepared by treating of propargyl bromide with tropolone(171).The mechanism of formation of cyclized product (165) is believed to be as follows:a (3,3) sigmatropic rearrangement,followed by enolization and subsequent cyclization gave the dipolar compound(173),which then undergoes a hydrogen shift to give the tropone(165) (Scheme 46).

Scheme 46
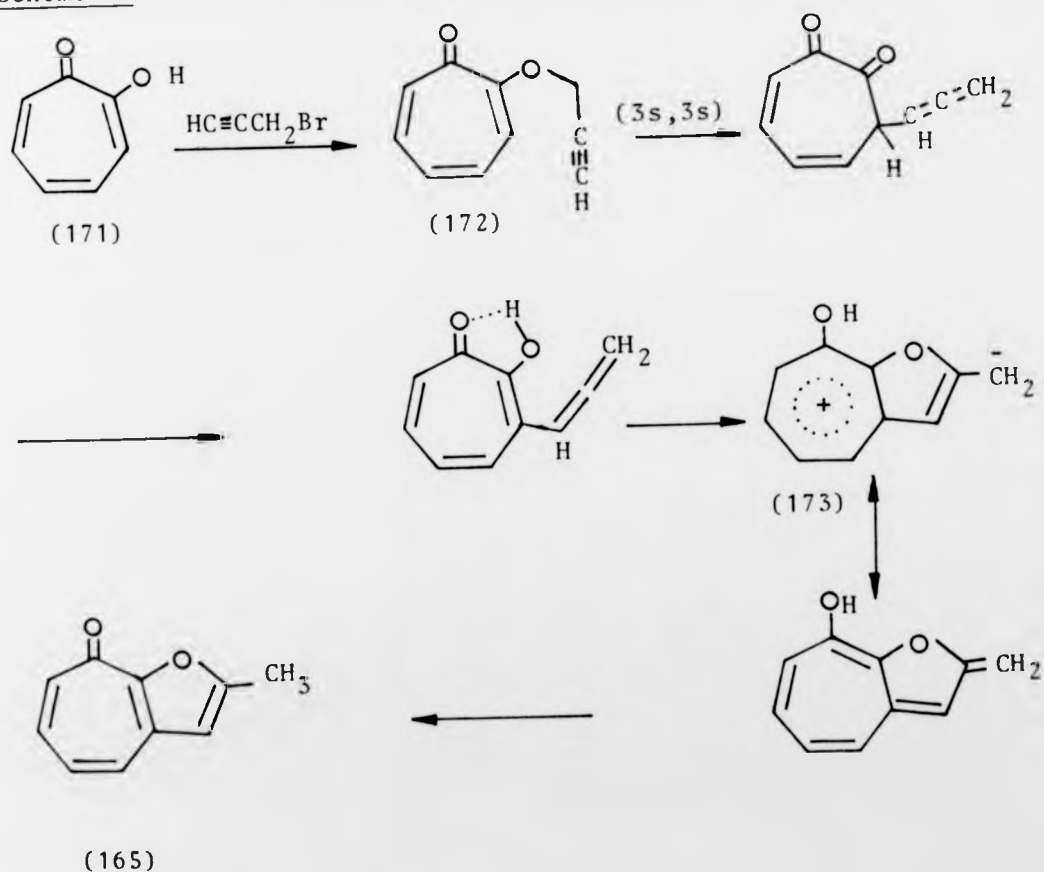
3-Phenyl(or 3-methyl)-8H-cyclohepta(b)furan-8-one

The synthesis of 3-methyl-(or 3-phenyl)-8H-cyclohepta-(b)furan-8-one(178 and 179) was reported by Imafuku et al [60] in 1980.Reaction of 6,6-dimethyl-fulvene(173) or 6-methyl-6--phenylfulvene(174)with dichloroacetylchloride and triethylamine in hexane afforded the bicyclo(3.2.0)heptafulvenone(175) which was hydrolysed[61] to the 3-isopropenyltropolone(176) and 3-(1-phenylvinl)tropolone(177)respectively.Cyclodehydrogenation of the tropolones(176 and 177) can be effected either by DDQ or by treatment with performic acid followed by aqueous sodium hydroxide, giving the furotropones(178 and 179) respectively(Scheme 47).

Scheme 47

(173) R=CH$_3$
(174) R=Ph

(175)

(176) R=CH$_3$
(177) R=Ph

(178) R=CH$_3$
(179) R=Ph
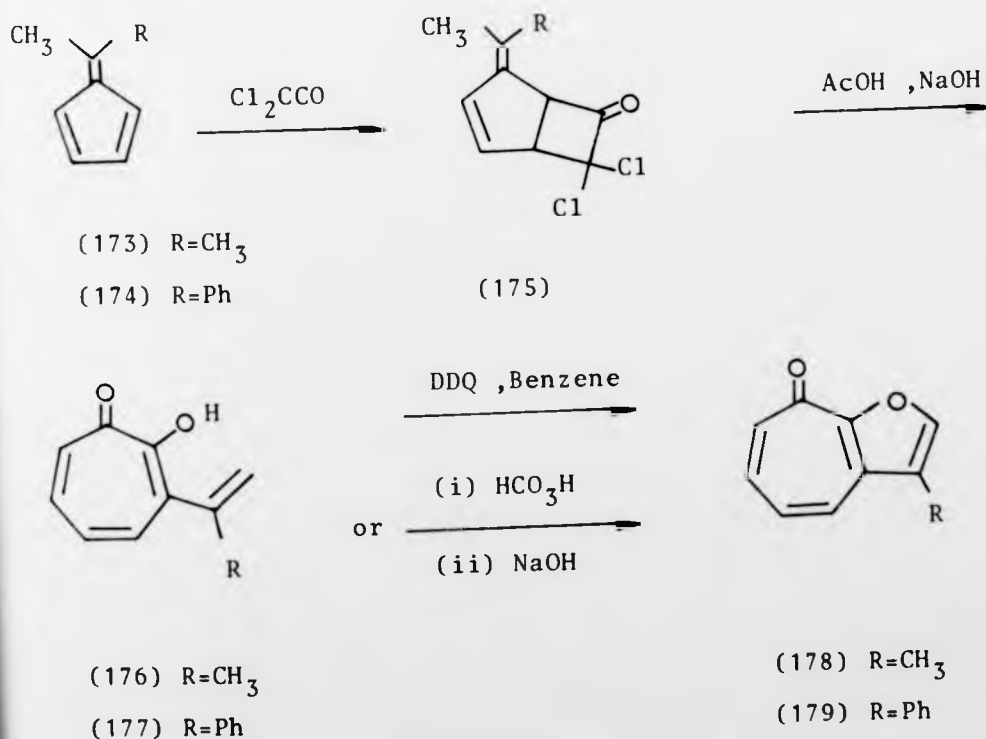
Syntheses starting from a furan

4H-Cyclohepta(b)furan-4-one

The synthesis of 4H-cyclohepta(b)furan-4-one(9) was
reported by G. Jones and et al [62] in 1973.Cyclisation of
5-(2-furyl)valeryl chloride(180) was effected by tin tetrachloride
in carbon disulfide to give the 5,6,7,8-tetrahydro-4H-cyclohepta-
(b)furan-4-one(181).The ketone(181) was brominated by using
phenltrimethylammonium tribromide(PTAB)to give 5,5-dibromoketone
(182),which was then dehydrobrominated with lithium carbonate
in boiling dimethyl formamide to give the
4H-cyclohepta(b)furan-4-one(9)(Scheme 48).

Scheme 48

(180)

(181)

(182)

(9)
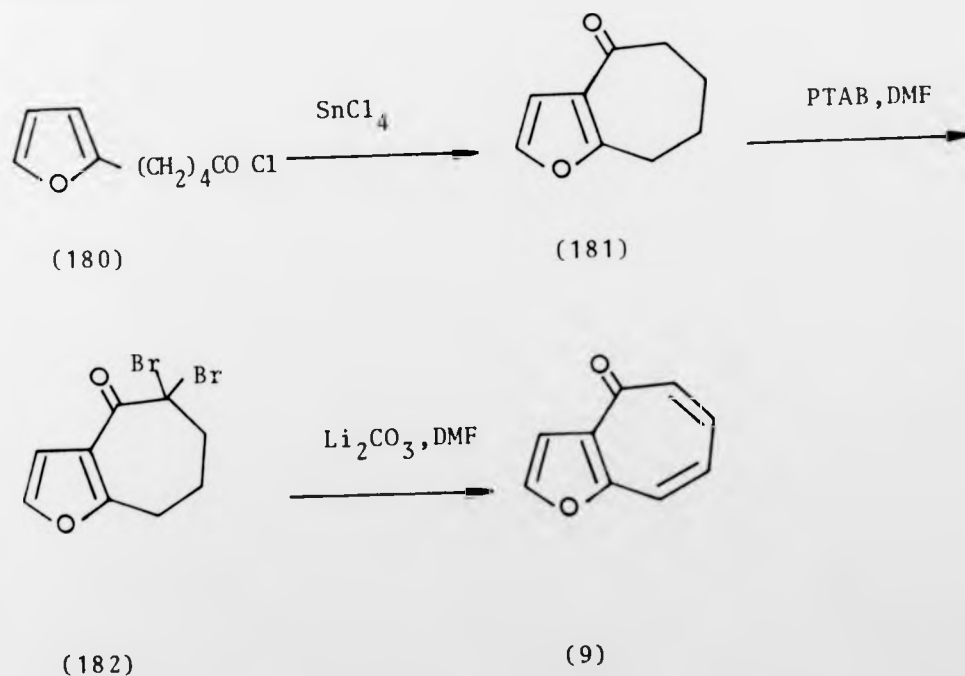
6 H -Cyclohepta(c)furan-6-one

The first synthesis of 6H-cyclohepta(c)furan-6-one(10) was reported by Cook and Forbes [63] in 1968.Condensation of the 3,4-dialdehyde(183)with acetone in aqueous ethanolic sodium hydroxide gave directly the furotropone(10).They also prepared the furotropone(10) by the following route.Condensation of the dialdehyde(183) with diethyl acetonedicarboxylate gave 5,7-diethoxycarbonyl-6H-cyclohepta(c)furan-6-one(184),which was subsequently hydrolysed to the diacid(185).The diacid(185) was then decarboxylated by heating for three hours in a seal tube at 175-180 ^{0}C with 0.5M HCl to give the required furotropone(10)(Scheme 49)

Scheme 49

(183)

OC(CH$_2$CO$_2$Et)$_2$
+ piperidine

Acetone
———————————
EtOH + NaOH(aq)

(10)

175-180 ^{0}C

20% H$_2$SO$_4$,100^{0}C

(184)   (185)
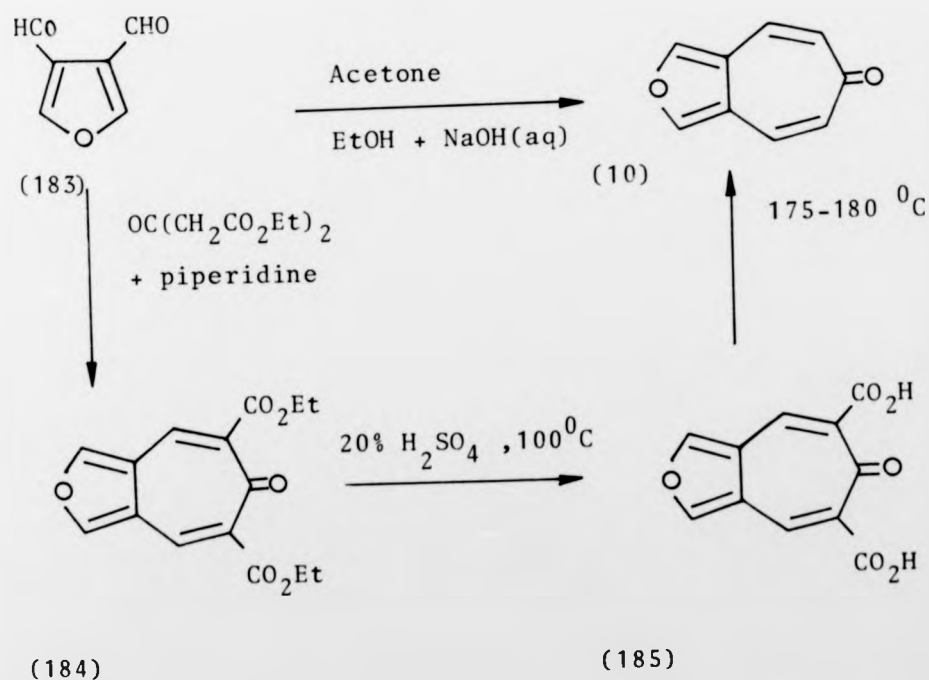
6H-Cyclohepta(b)furan-6-one

The synthesis of 6H-cyclohepta(b)furan-6-one (187) was similarly reported by Borai, Guilard and Fournari [64]. Condensation of furan-2,3-dialdehyde(186) with acetone in the presence of base afforded 6H-cyclohepta(b)furan-6-one (187) (Scheme 50) .

Scheme 50

(186)   (187)
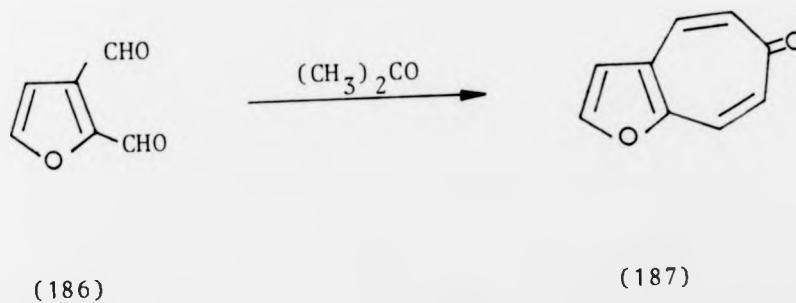
2-Hydroxy-6H-benzo(b)cyclohepta(d)furan-6-one

In 1962 Seto and Sato [65] reported the synthesis of
2-hydroxy-6H-benzo(b)cyclohepta(d)furan-6-one (191) .
Reaction of tropolone(171)with p-benzoquinon gave a mixture of
5-(4´-hydroxyphenoxy)tropolone(188) and 3-(p-benzoquinonyl)-
tropolone(189).The quinone(189)was separated and then reduced
with hydrogen using palladium on charcoal as a catalyst to
give the dihydrophenyltropolones (190), which was dehydrated
with p-toluenesulphonic acid to the benzocycloheptafuranone
(191) (Scheme 51)

Scheme 51

(171)   (188)   (189)

(191)   (190)
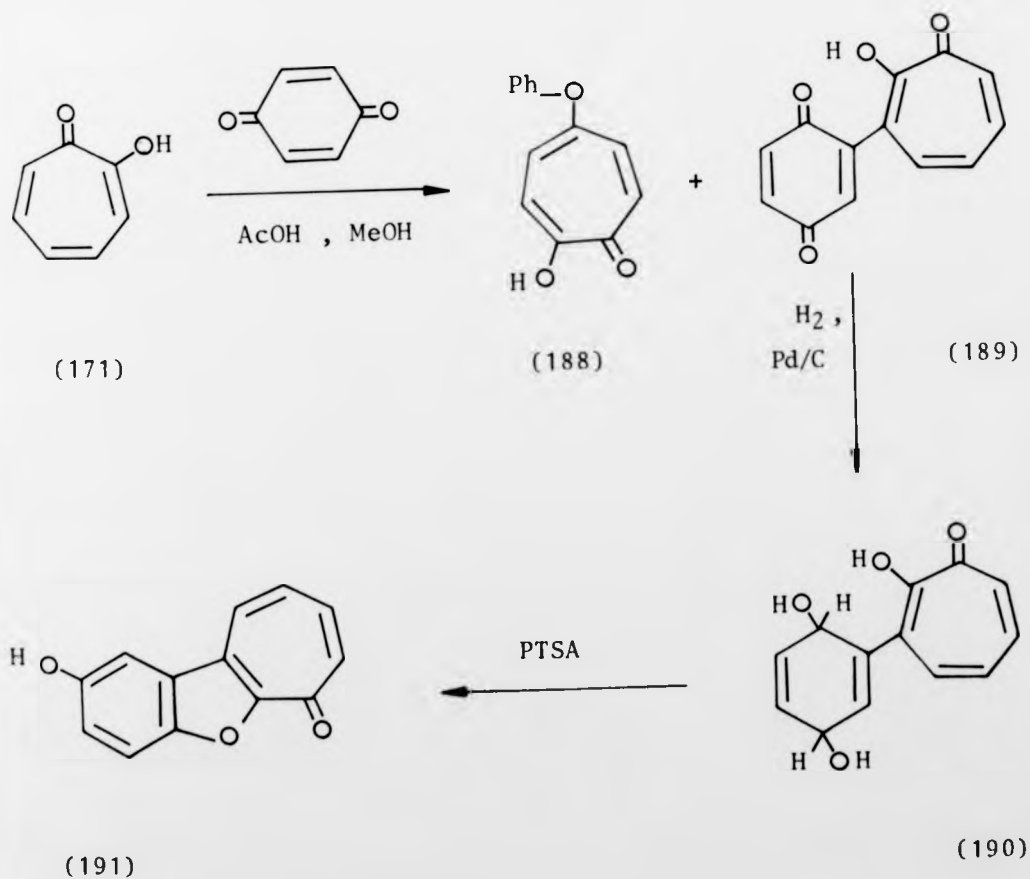
2-Methylbenzo(b)cyclohepta(d)furan-8-one (and -10-one)

The synthesis of 2-methylbenzo(b)cyclohepta(d)-furan-8-one(197) and 2-methylbenzo(b)cyclohepta(d)furan-10-one (198)was reported by Bladon et al [66] in 1966 .

Ditropyl ether(192) heated with p-cresol on a steam bath gave the 2-tropyl-p-cresol(193) .Treatment of the latter (193) with triphenylmethyl perchlorate yielded the 6-hydroxy-m-tolyltropylium perchlorate(194) .Subsequent hydrolysis of the perchlorate(194)with aqueous sodium hydrogen carbonate gave 2-methylbenzo(b)cyclohepta(d)furan(195),which on subsequent treatment with triphenylmethyl perchlorate gave the tropylium perchlorate(196) .The salt (196)was then hydrolysed with aqueous sodium hydrogen carbonate and gave three products; the two isomeric benzofurotropones (197 and 198) and some of the furan (195)(Scheme 52) .

Scheme 52
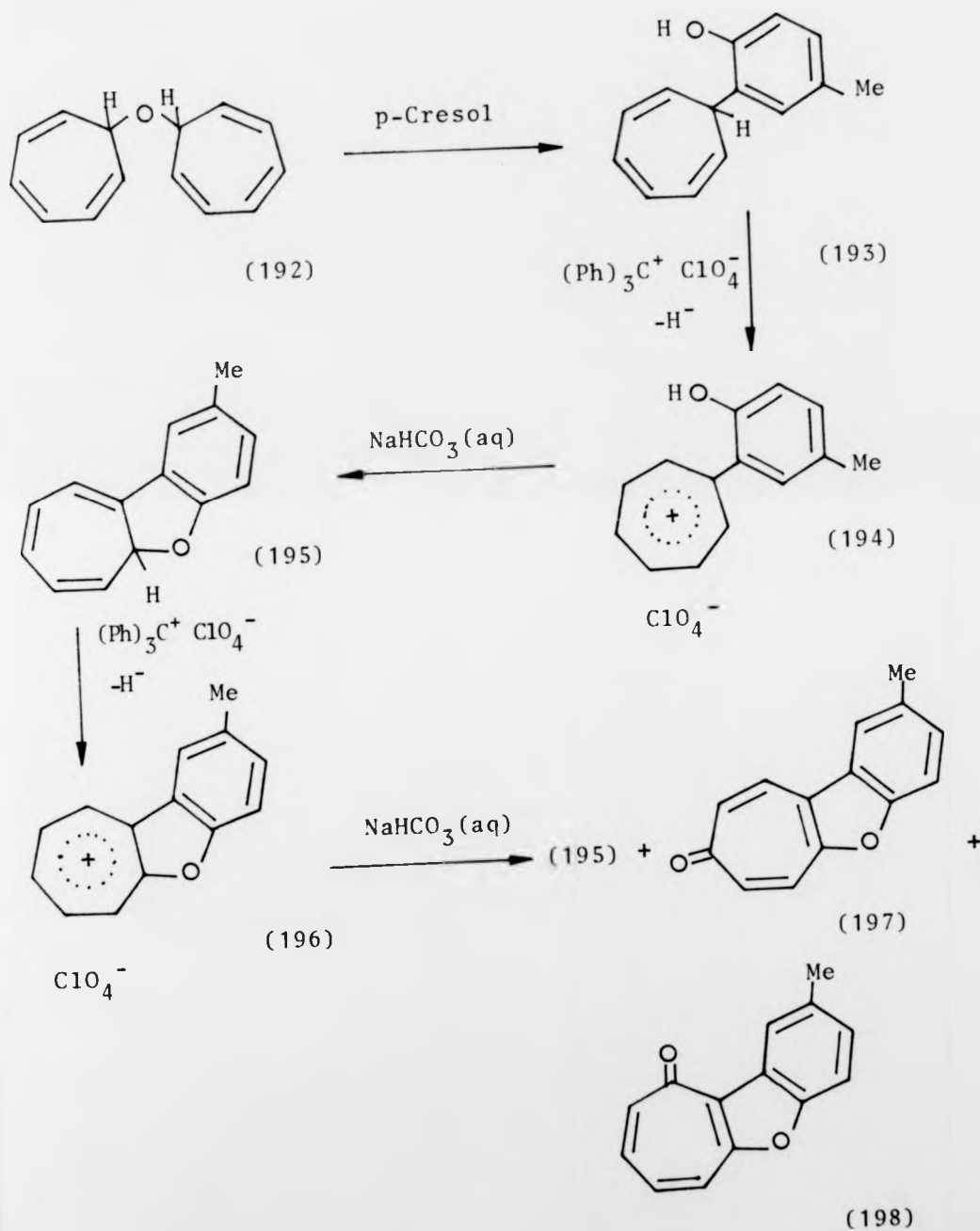
Cycloheptathiophenones

4H-Cyclohepta(b)thiophen-4-one and its 2-methyl derivative

The synthesis of 2-methyl-4H-cyclohepta(b)thiophen-4-one (204)was reported by G. Jones and et al [62].Acylation of 2-methylthiophene with the glutaric anhydride gave the keto-acid (199),which was subsequently reduced by the Huang-Minlon procedure [67] to the pentanoic acid (200).The acid chloride of the acid(200)was cyclized with tin tetrachloride to give the cyclic ketone(201).Bromination of the latter with PTAB gave the dibromo-derivative(202),which was then dehydrobrominated with lithium chloride or carbonate in boiling dimethylformamide (DMF)to give the thienotropone(204).The same procedure starting from the thiophene was used by G. Jones and M.J.Robinson [68] in 1977 to prepare 4H-cyclohepta(b)thiophene(203)(Scheme 53).

Scheme 53

R= H or CH$_3$

(199)

(200)   (201)   PTAB/THF

(i) SOCl$_2$ (ii) SnCl$_4$

(202)   LiCl/DMF   (203) R=H ; (204) R=Me
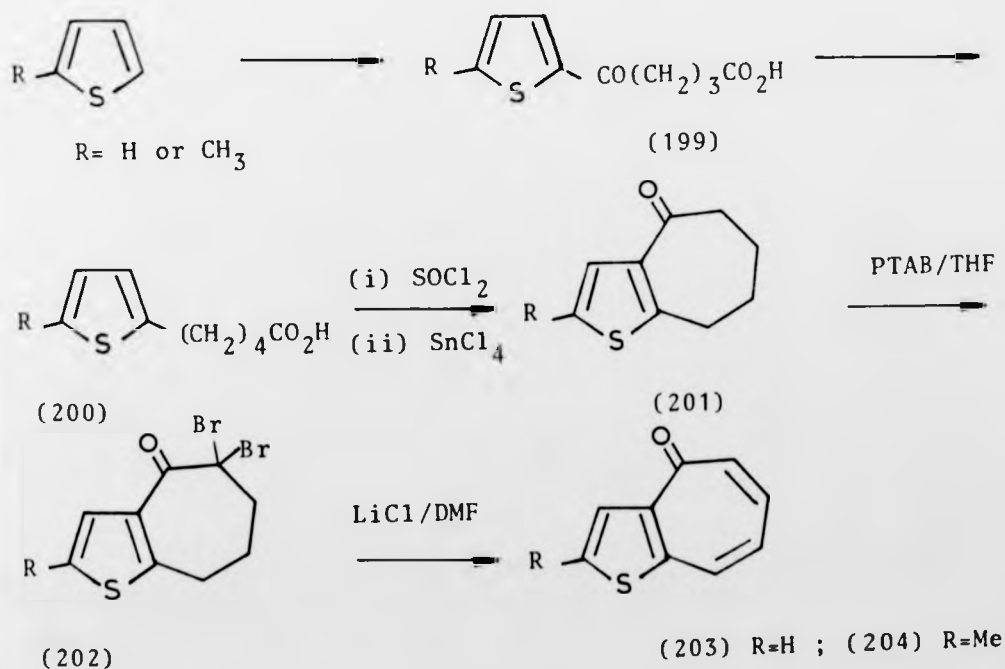
6H-Cyclohepta(c)thiophen-6-one and 6H-cyclohepta(b)thiophen-6-one

The synthesis of 1,3-dimethyl-6H-cyclohepta(c)-thiophen-6-one(206)was reported by Ginesina,Kivokurtseva and El ' Tsov [40] in 1969 .Condensation of 3,4-diformyl-2,5--dimethylthiophene(205) with acetone gave the cycloheptathiophenone(206)(Scheme 54) .

Scheme 54

(205)   (206)
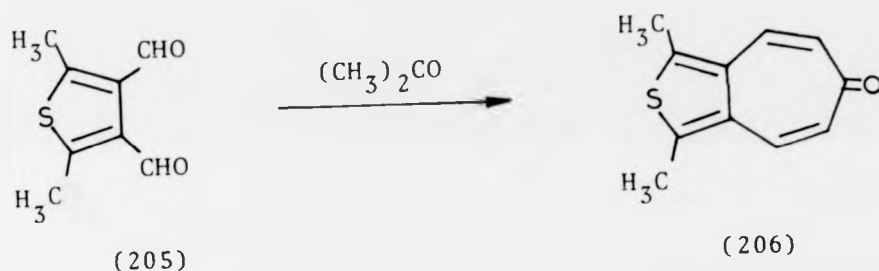
A similarly; condensation of 3,4-diformylthiophene [69] (207)with acetone gave the 6H-cyclohepta(c)thiophen-6-one [70] (208)(Scheme 55) .

Scheme 55

(207)   (208)
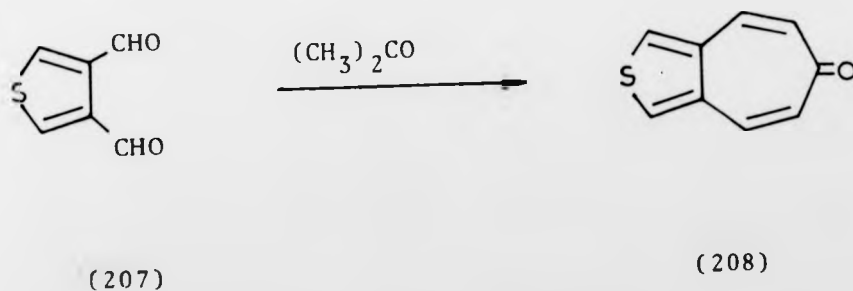
In 1971 Guilard and Fournari [69] reported the synthesis
of 6H-cyclohepta(b)thiophen-6-one(212).The aldehyde function
of the 2-formyl-iodothiophen(209)was protected a diethylacetal
enabling the iodothiophene(210)to be formylated to the
formylthiophene(211)by using n-butyllithium in dimethylformamide.
Condensation of the formylthiophene(211)with acetone,subsequent
acid hydrolysis and the ring closure gave the
cyclohepta(b)thiophen-6-one(212)(Scheme 56).

Scheme 56
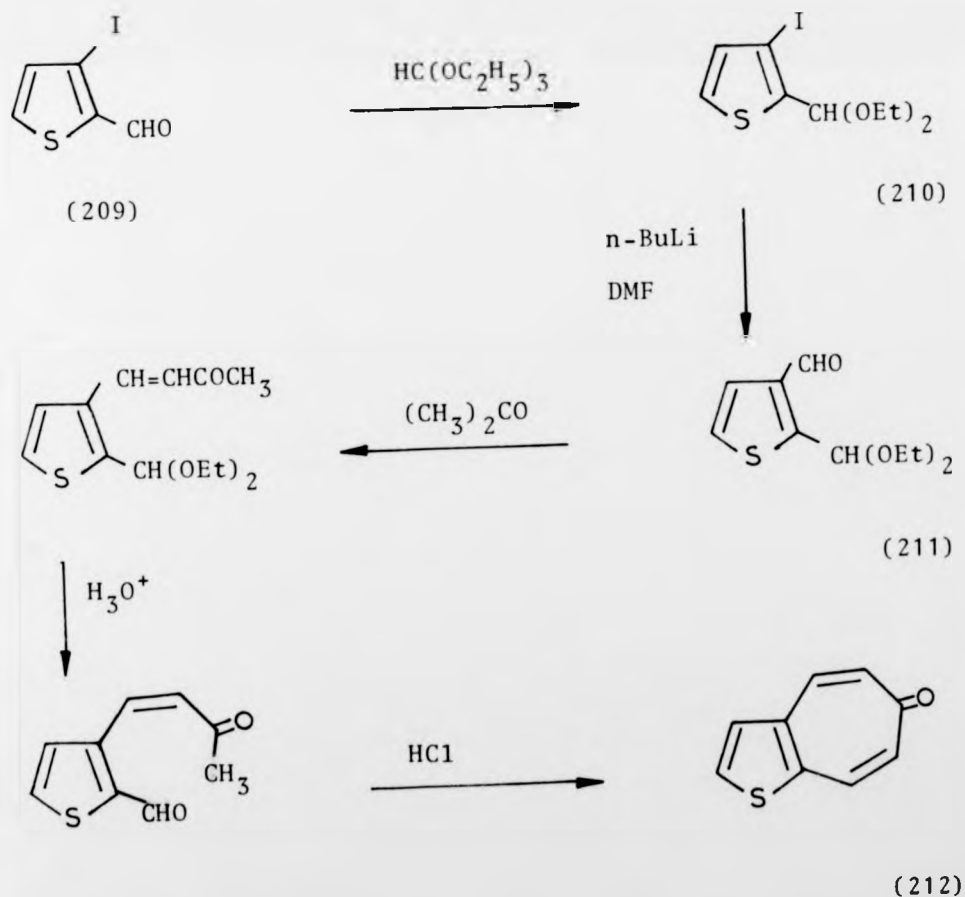
They also reported [69] a second route to the
6H-cyclohepta(b)thiophen-6-one(212). Condensation of
2,3-diformylthiophene [71] (213) with diethyl 1,3-acetone-
dicarboxylate yielded diethyl 5,7-6H-cyclohepta(b)thiophen-6-one
dicarboxylate(213a). Subsequent hydrolysis and decarboxylation
gave the 6H-cyclohepta(b)thiophen-6-one(212)(Scheme 57).

Scheme 57

(213)

(212)   R=H

(213a) R=CO$_2$Et
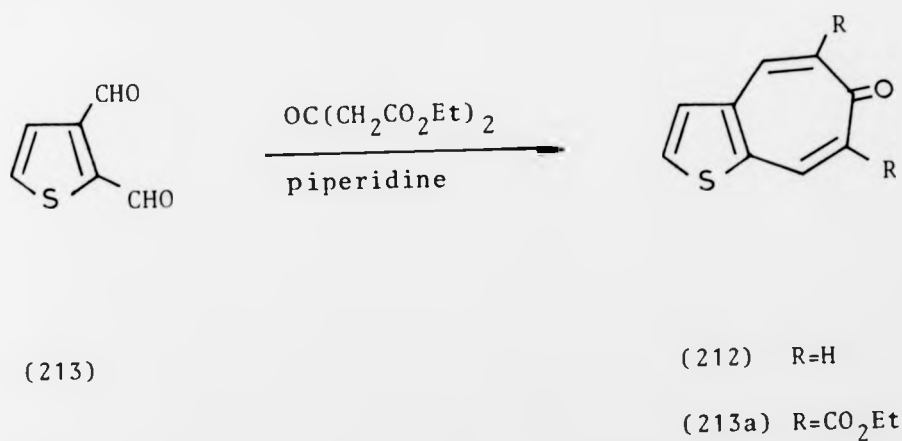
Cycloheptapyridinones

9H-Cyclohepta(b)pyridin-9-one and its three isomers

In 1973 G. Jones et al [62] reported the synthesis of
9H-cyclohepta(b)pyridin-9-one(11a).The N-oxide(215) of
6,7,8,9-tetrahydro-5H-cyclohepta(b)pyridine [72,73] (214),when
treated with acetic anhydride,gave the 9-acetoxycyclohepta-
(b)pyridine(216),which was hydrolysed to the alcohol(217).
Reaction between the alcohol(217) and N-bromosuccinimide
gave in low yield the ketone(218)and two other products.
Bromination of the ketone(218)by PTAB gave in low yield,the
dibromo-ketone(219),which was subsequently dehydrobrominated
by lithium carbonate in boiling dimethylformamide to give the
9H-cyclohepta(b)pyridin-9-one(11a)(Scheme 58).

Scheme 58

$$\text{(214)} \xrightarrow[\text{AcOH}]{H_2O_2} \text{(215)} \xrightarrow[\text{(ii) KOH (217) R=H}]{\text{(i)Ac}_2O \text{ (216) R=Ac}}$$

(214)   (215)

(216) R=Ac   (218)

(217) R=H

(219)   (11a)
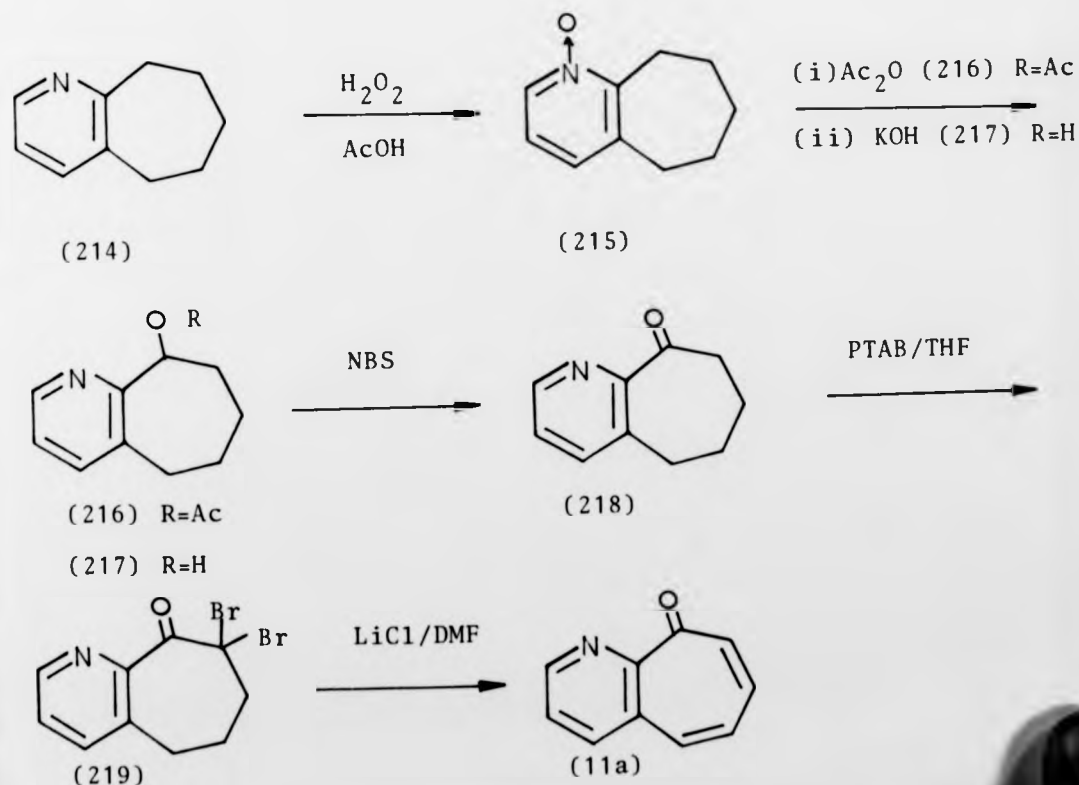
Very recently M.G.Hicks and G. Jones [74] have
synthesized the other three isomers of 9H-cyclohepta-
(b)pyridin-9-one(11a). Oxidation of the cycloheptapyridine
(214) with chromium trioxide reagent,gave in moderate yield,
a mixture of 6,7,8,9-tetrahydro-5H-cyclohept(b)pyridine-5-one
(220) and unchanged starting material.The route of Ayerst
and Schofield [75] was followed to prepared the
6,7,8,9-tetrahydro-5H-cyclohepta(c)pyridine(222). Oxidation
of the cyclohepta(c)pyridine(222)was carried as for the
cyclohepta(b)pyridine(214) using the method of Sugimoto,
Kagita and Tanaka [76] . In this case both isomeric ketones(223
and 226) were formed but still some unchanged starting material
was recovered. Bromination of the ketones (220,223 and 226)
was best effected by treatment with N-bromosuccinimide
using azobiisobutyronitrile as a radical generator to give
the corresponding dibromo-ketones(221,224 and 227).

Dehydrobromination was carried out in the usual manner
with lithium carbonate in boiling dimethylformamide to
give 5H-cyclohepta(b)pyridin-5-one (12a) ,
5H-cyclohepta(c)pyridin-5-one(225) and
9H-cyclohepta(c)pyridin-9-one(228) respectively (Scheme 59).

Scheme 59

(214)

Cr O$_3$

(220) R=H
(221) R=Br

(12a)

(222)

Cr O$_3$

(223) R=H
(224) R=Br

(226) R=H
(227) R=Br

(225)

(228)
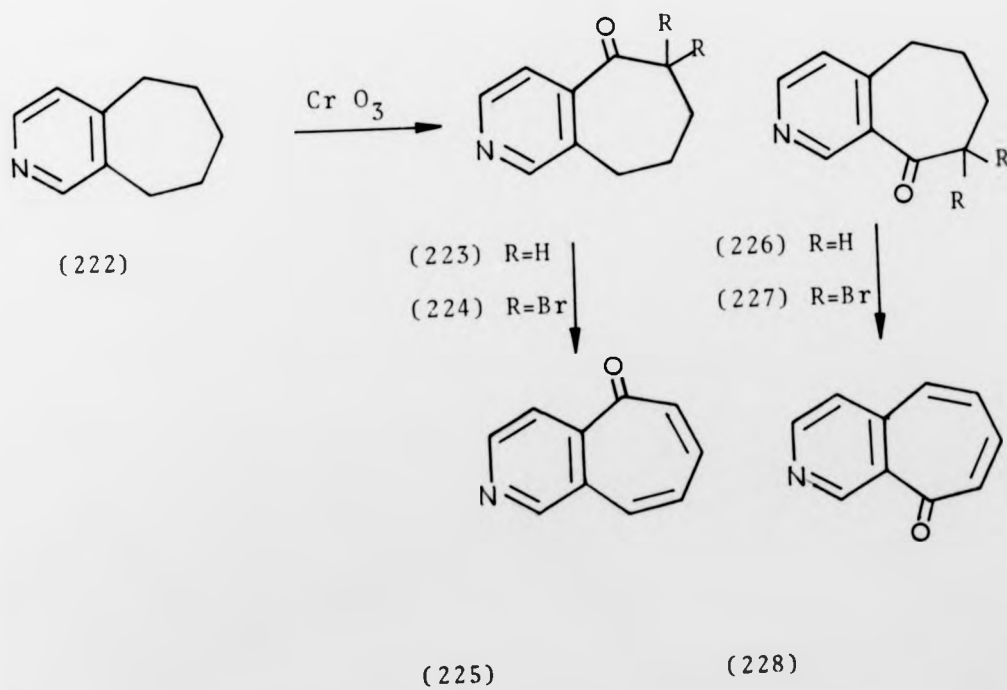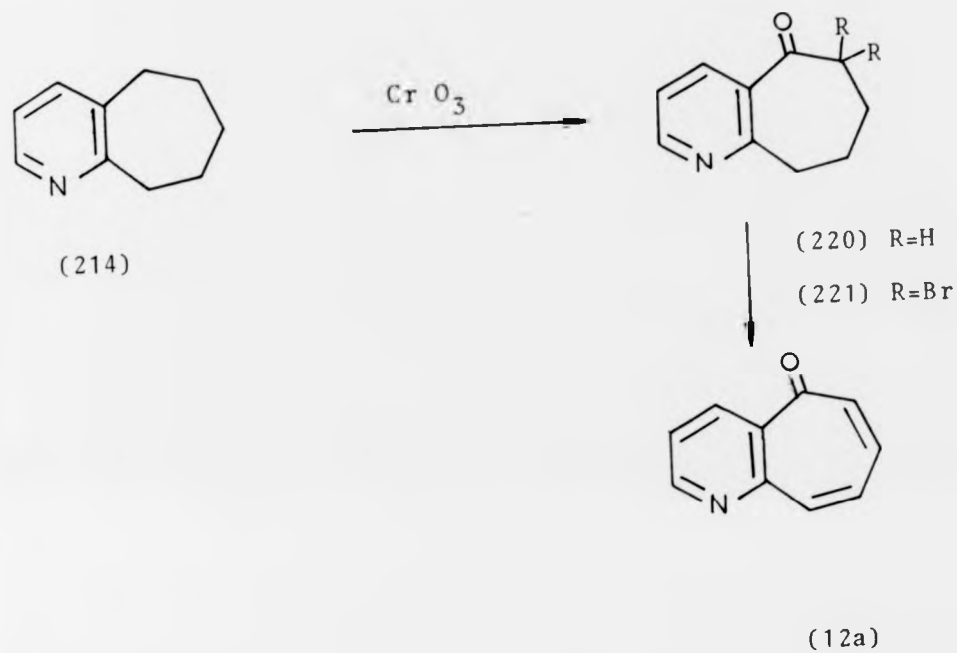
7H-Cyclohepta(b)pyridin-7-one

The synthsis of 7H-cyclohepta(b)pyridin-7-one (13a) was reported by Duflos et al [77] in 1973 .

2,3-Diformylpyridine(229) condensed with diethyl 1,3-acetonedicarboxylate to give diethyl 6,9-7H-cyclohepta-(b)pyridin-7-one dicarboxylate(230) . This was subsequently hydrolysed and decarboxylated to give the 7H-cyclohepta(b)pyridin-7-one (139)(Scheme 60).

Scheme 60

(229)

OC(CH$_2$CO$_2$Et)$_2$

Benzene , OH$^-$

(230)

H$_3$O$^+$

(i) Ag$^+$

(ii)H$_2$/220 ^{0}C

(13a)
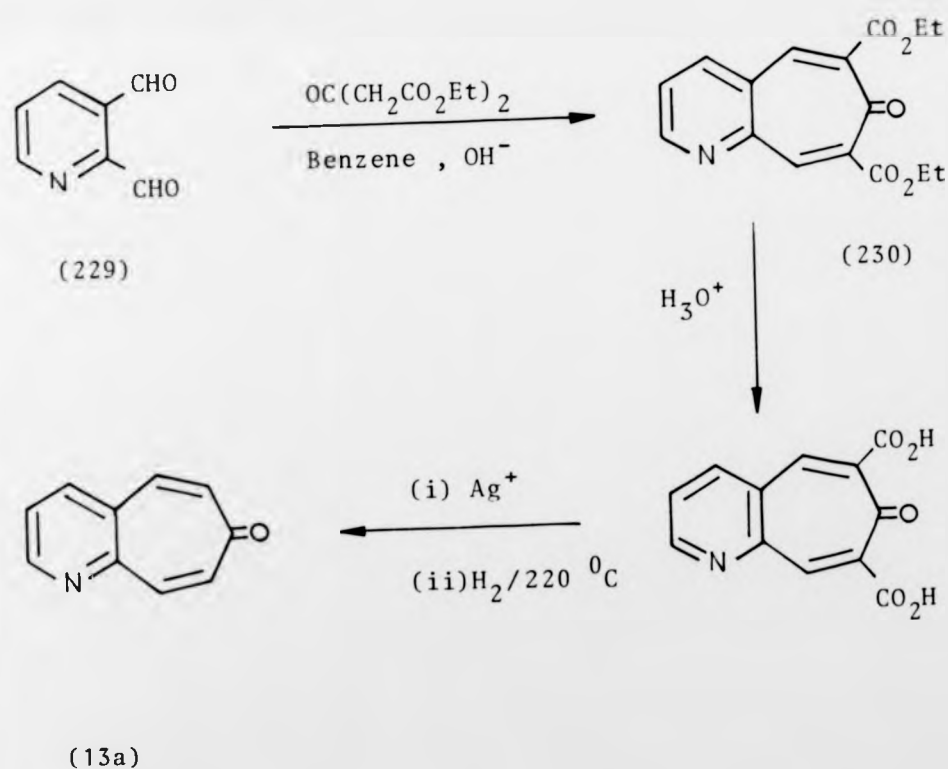
Chapter 2

Results and discussion

Synthesis of 2-methoxy-5H-benzocyclohepten-5-one(38)

Prior to this work 2-methoxy-5H-benzocyclohepten-5-one (38) had been prepared in two different routes with poor overall yields. In 1972 Srivastava and Dev [8] reported synthesis of methoxybenzocycloheptenones starting from the 2-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(11) . Reduction of the tetrahydro-compound(11) by lithium aluminium hydride gave the alcohol(231)which was then dehydrated to give dihydro-compound(232).Bromination with N-bromosuccinimide(NBS) in carbon tetrachloride with subsequent elimination of hydrogen bromide yielded 3-methoxy-5H-benzocycloheptene(233)along with two other products. Oxidation of 3-methoxy-5H-benzocycloheptene (233) with selenium dioxide gave , 1.6% of 2-methoxy-5H-benzo-cyclohepten-5-one(38);10% of 3-methoxy-5H-benzocyclohepten-5-one (234);20% of 2-methoxy-7H-benzocyclohepten-7-one(235) and 0.2% of 6-methoxy-1-naphthaldehyde (Scheme 61) .

It must be noted that the spectroscopic evidence quoted by Srivastava and Dev [8] did not clearly prove the structure ; in particular the [1]H n.m.r. spectral details could not be used to distinguish between the 2-methoxy-and the 3- methoxy-benztropones .

Scheme 61

(11)

LiAlH$_4$

(231)

p-TsOH

Benzene

(232)

NBS/CCl$_4$

(233)

Se O$_2$

(38)

+

(234)

+

(235)

+

CHO
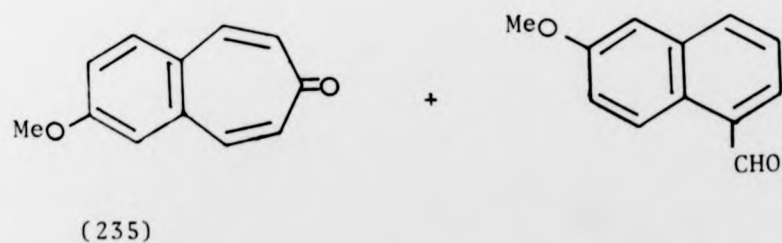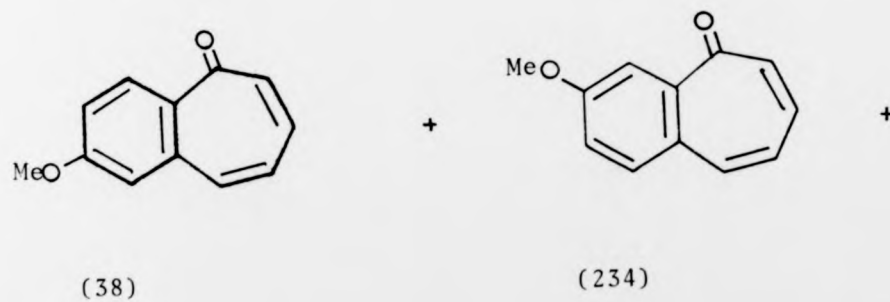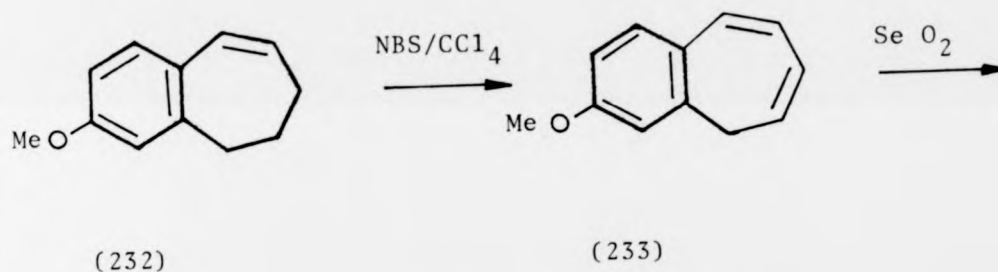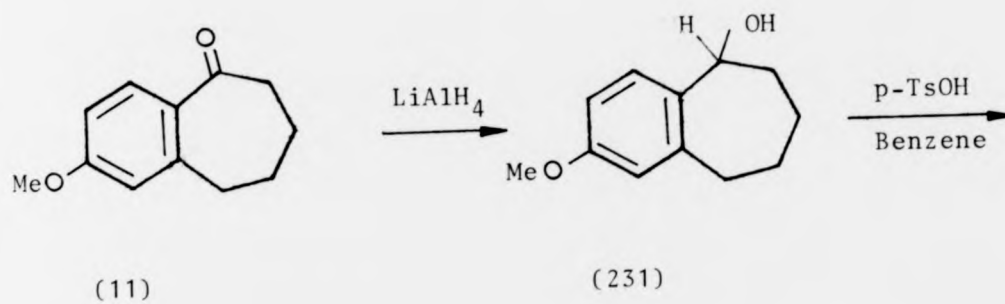
As stated above Crabbe´et al [13] synthesized
2-methoxy-5H-benzocyclohepten-5-one(38) from
6-methoxy-1-tetralone(30). Treatment of the enol acetate
(32) with sodium chlorodifluoroacetate yielded the
1-acetoxy-6-methoxy-1,2-difluoromethylene-1,2,3,4-tetrahydro-
naphthalene(34),on boiling under reflux with methanolic sodium
hydroxide elimination of two moles of hydrogen fluoride
yields 2-methoxy-5H-benzocyclohepten-5-one(38)(Scheme 62).

Scheme 62

(30)   (32)

(34)   (38)
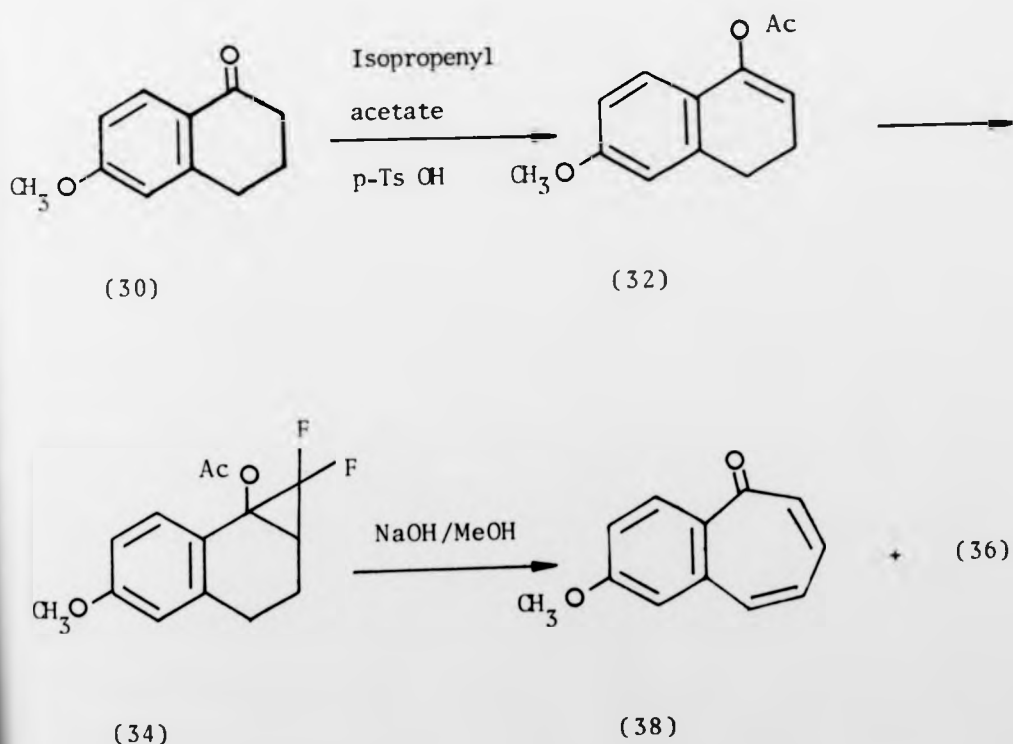
The starting materials employed during our synthesis of 2-methoxy-5H-benzocyclohepten-5-one(38)was diethyl ethylidenemalonate(236).Fones [78] found that diethyl ethylidenemalonate(236)can be obtained directly from the condensation of one mole of acetaldehyde with one mole of diethyl malonate in the presence of acetic anhydride. Following his procedure,diethyl ethylidenemalonate(236) was prepared in 75% yield and was subsequently characterized by its physical and ^{1}H n.m.r. spectral data(Scheme 63).

Scheme 63

$$CH_3-CO-H \quad + \; H_2C(CO_2Et)_2 \quad + \quad (CH_3-CO)_2O \quad \longrightarrow$$

$$\underset{CH_3}{\overset{H}{>}}C=C\underset{CO_2Et}{\overset{CO_2Et}{<}} \quad + \quad 2\ CH_3CO_2H$$
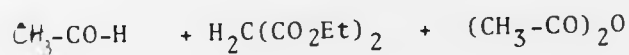
(236)

By a modification of the reported method [80] for the condensation of aromatic aldehyde with diethyl ethylidene-malonate(236), 3-methoxycinnamylidenemalonic acid(237) was prepared [79]. A solution of freshly prepared benzyltrimethyl-ammonium hydroxide was stirred for 48 hours at room temperature with m-methoxybenzaldehyde and diethyl ethylidenemalonate(236). The reaction mixture was diluted with water refluxed for two hours,cooled,acidified,and then the yellow product was crystallized to give the pure 3-methoxycinnamylidenemalonic acid(237)(Scheme 64).

The infra-red spectrum showed two characteristic bands at 1700 Cm^{-1} due to the C=O bond and another band at 1600 Cm^{-1} which can be attributed to the C=C bond .

The ^{1}H n.m.r. spectrum exhibited a sharp singlet at δ 3.9 p.p.m. which could be assigned to the three protons of methoxy group and a multiplet at δ 8.45-6.8.p.p.m. due to the seven aromatic protons and diene protons.

Scheme 64

(236)   (237)

The route of Horton and Pitchforth [79] was followed, with the exception of the hydrogenation which was carried out using palladium-charcoal catalyst instead of the prescribed Raney nickel,to give   3-(m-methoxyphenyl)propylmalonic acid (238) (Scheme 65) .

The infra-red absorption frequency of the carbonyl groups was at 1710 Cm^{-1} and another band at 1610 Cm^{-1} can be attributed to a C=C bond stretching mode within the ring system .

The ^{1}H n.m.r. spectrum showed resonances for ten protons in the alkane region and a multiplet at δ 7.35-6.60 p.p.m. which can be attributed to the four aromatic protons .

Scheme 65

(237)   (238)
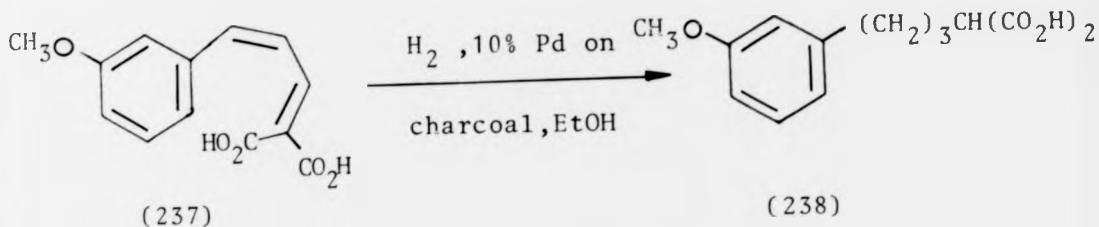
The malonic acid(238) was placed in a claisen distillation flask and decarboxylated by distillation in vacuo to give 5-(m-methoxyphenyl)valeric acid(239);the latter was obtained in good yield and was subsequently characterized by its [1]H n.m.r. spectral data (Scheme 66)

The [1]H n.m.r. spectrum showed eleven protons in the alkane region . A multiplet which occurred at δ 2.80-2.20 p.p.m. is due to four protons of two methylenes at positions 2- and 5- of the valeric acid(239) and another multiplet at δ 1.8-1.6 p.p.m. due to two methylene groups at positions 3- and 4- of the valeric acid(239)

Scheme 66

(238)   (239)
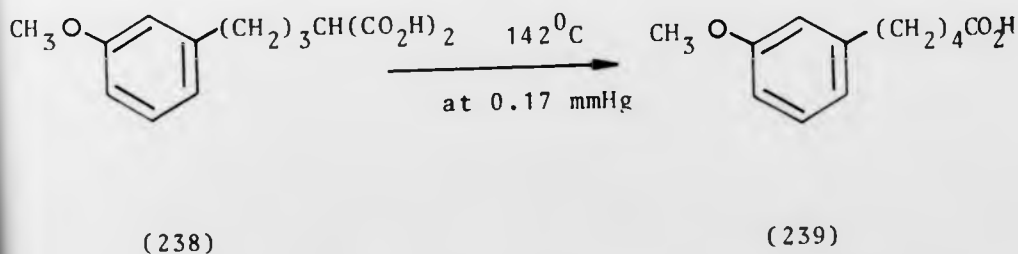
There have been two reported syntheses of
2-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(11)
The first route due to Khan and Proctor [6] , involved the
conversion of the valeric acid(239) to acid chloride by
using phosphorus pentachloride,followed by cyclization of the
acid chloride with anhydrous stannic chloride in dry benzene.

The second route ,which we used, was by Horton and
Pitchforth[79] , and is much more applicable to large scale
preparative work.The valeric acid(239)was added to the mixture of
phosphorus pentoxide and 85% orthophosphoric acid
(polyphosphoric acid) and heated at 100 ^{0}C with vigorous
stirring for six hours.The reaction mixture was poured into
ice-water and then extracted with ether.Evaporation of ether
and distillation of crude product yielded pure
2-methoxy-6,7,8,9-tetrahydro-5H-bezocyclohepten-5-one(11)
in good yield (Scheme 67).

The infra-red spectrum showed three characteristic
peaks, one at 1680 Cm^{-1} attributed to the C=O bond stretching
mode within the ring system ,one at 1580 Cm^{-1} which can be
assigned to the C=C bond stretching mode in the benzene
ring, and one at 1247 Cm^{-1} due to OCH_3 bond stretching.

The ^{1}H n.m.r. spectrum showed resonance for eight
protons in the alkane region and three protons in the aromatic
region and a singlet at δ 3.75 p.p.m. due to the three protons
of methoxy group at position 2 . A doublet at δ 7.72-7.54
p.p.m. due to H4, exhibits a downfield shift,this deshielding
arising probably from the anisotropy of the carbonyl group

at position 5 . A muliplet at δ 6.78-6.54 p.p.m. could be
assigned to the two protons at positions 1 and 3 . This
observation confirms that the ketone is 2-methoxy-6,7,8,9-tetrahydro-
-5H-benzocyclohepten-5-one (11) and not 4-methoxy-6,7,8,9-tetrahydro-
-5H-benzocyclohepten-5-one .

Scheme 67

Polyphosphoric acid

CH_3O——$(CH_2)_4CO_2H$

(239)

CH_3O—— (11)
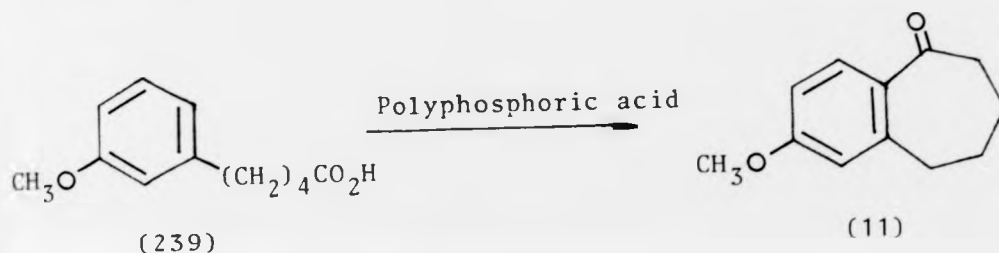
Bromination and dehydrobromination of
2-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(11)

During attempts to synthesis 11-methylazepino(1,2-a)-
indol-10-one(242) and 1,2,3-tribromopyrrolo(1,2-a)azepin-9-one
(245),Collington and G. Jones [7, 81] discovered that cyclic
ketones of the general type (240 and 243) can be brominated
in high yield to give 9,9-dibromo-7,8,9,10-tetrahydro-11-
-methyl-6H-azepino (1 ,2-a)indol-10-one(241) and
1,2,3,8,8-pentabromo-6,7,8,9-tetrahydro-5H-pyrrolo(1,2-a)-
azepin-9-one(244). They subsequently described how the
azepino indolone (242) and the pyrroloazepinone (245)
can be prepared in high yield by the one step double
dehydrobromination of the corresponding α,α-dibromoketones
(241 and 242) using lithium chloride in boiling dimethylformamide
(Scheme 68) .

It will be shown that these sequences of double bromination and double dehydrobromination reactions; can be applied to the synthesis of benztropones and its derivatives.

Scheme 68

(240) R=H

(241) R=Br

(242)

(243) R=H

(244) R=Br

(245)
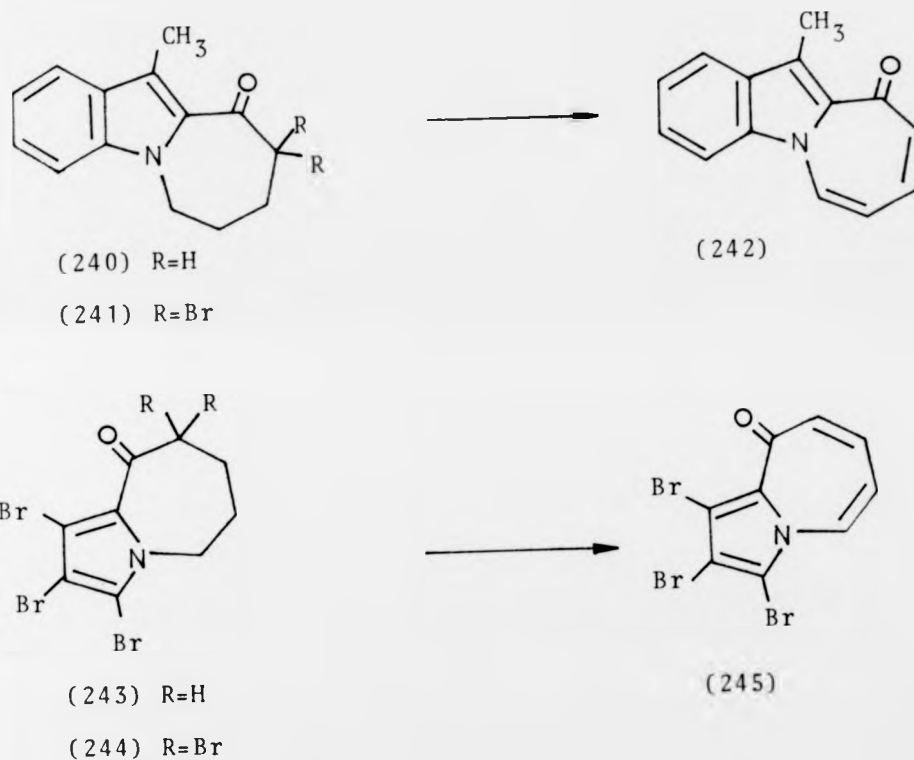
Marquet and et al [82] have successfully used phenyltrimethylammonium tribromide (PTAB) for the selective α-bromination of a ketone in the presence of a double bond and it was hoped that the use of the reagent on the bicyclic ketone(11) would avoid the possibility of bromination on the benzene ring.

A solution of 2-methoxy-6,7,8,9-tetrahydro-5H-
-benzocyclohepten-5-one(11) in tetrahydrofuran was treated
with two molar equivalents of PTAB at room temperature.
The solution became warm and insoluble phenyltrimethylammonium
bromide slowly precipitated .After stirring for 24 hours
the solution was filtered and evaporated giving
6,6-dibromo-2-methoxy-tetrahydro-5H-benzocyclohepten-5-one
(246)(Scheme 69).

The absence of any peaks in the δ 5-6 p.p.m. of
the ^{1}H n.m.r. spectrum and the presence of two multiplets
due to 6 protons in the alkyl region show that both
bromine atoms are on the same carbon atom.The most downfield
signal was a single proton doublet at δ 7.42-7.30 p.p.m. ,
$J_{3,4}$=9Hz ,allocated to the H4.The extra downfield shift
in the H4 resonance is probably due to the proximity of
the carbonyl group at position 5 .

The mass spectrum peak at m/e 350,348 and 346(M^+)
in the ratio 1:2:1 , relating to the two isotopes of
bromine in three possible combination,confirming that the
compound (246) contains two bromine atoms.

The infra-red absorption spectrum has peaks at
1680,1600 and 1100 Cm^{-1} which are characteristic of this
class of compound .

Scheme 69

(11)   PTAB/THF   (246)
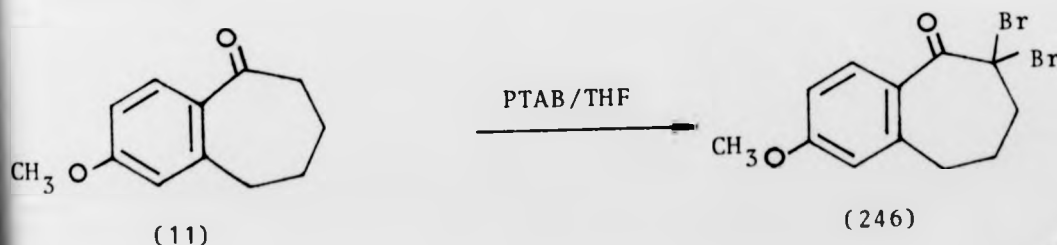
A solution of 6,6-dibromo-2-methoxy-6,7,8,9-
-tetrahydro-5H-benzocyclohepten-5-one(246)with 4 molar
equivalents of anhydrous lithium chloride was boiled in
dimethylformamide for 4 hours. Removal of the dimethylformamide
under reduced pressure gave a crude residue which was then
distilled from a bulb tube to give the pure
2-methoxy-5H-benzocyclohepten-5-one(38)(Scheme 70).

The carbonyl absorption in the infra-red was
at 1640 Cm^{-1} .

The ^1H n.m.r. spectrum showed a doublet ($J_{3,4}$= 9Hz) at
the lowest field δ8.5-8.4 p.p.m. which is considerd to be H4
with an ortho splitting by H3.The multiplet between
δ 6.7 and 6.5 p.p.m. is assinged to H8 and another multiplet
between δ 7.4 and 6.9 p.p.m. which integrates for 5 protons
must then be due to the protons around the seven ring membered
ring and to H1 and H3 .

The mass spectrum shows the molecular ion to be at
m/e 186 which is correct   for 2-methoxybenztropone (38).

The carbonyl resonance in the ^{13}C n.m.r. spectrum
occurs at δ186.9 p.p.m. consistent with a conjugated carbonyl
group,all other resonances occurring in the aromatic and alkene regions.

Scheme 70

(246)   (38)
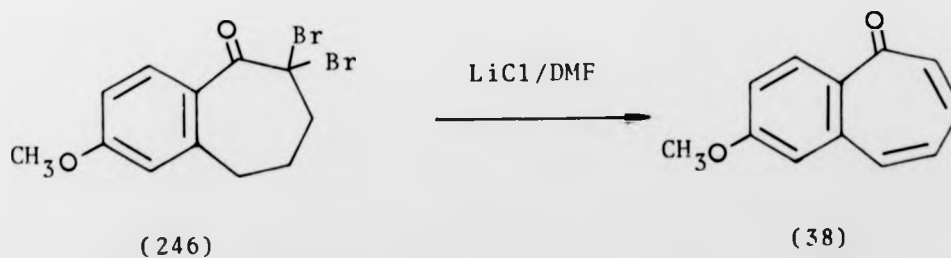
When a solution of 2-methoxy-6,7,8,9-tetrahydro-
-5H-benzocycloheoten-5-one(11)in carbon tetrachloride
was boiled with 4 molar equivalents of bromine for one hour,
removal of the solvent gave a light brown oil which solidified
on trituration with light petroleum   and identified
as a mixture of dibromo(246) and tribromo(246a) derivatives.
Subsequent dehydrobromination of the mixture with anhydrous
lithium chloride in boiling dimethylformamide for 3 hours
followed by removal of the dimethylformamide under reduced
pressure gave a brown residue which was found by thin layer
chromatography to be a mixture of two compounds. An attempt
was made to crystallise the mixture ,but this failed and
the mixture was eventually separated by p.l.c. .

The compound from the lower band was shown from
spectral evidence to be 2-methoxy-5H-benzocyclohepten-5-one(38).

The upper band was extracted to give a yellow solid
which was identified as 2-methoxy-6-bromo-5H-benzo-
cyclohepten-5-one(247)(Scheme 71) .

Scheme 71

(11)   (246)   (246a)

(247)   (38)
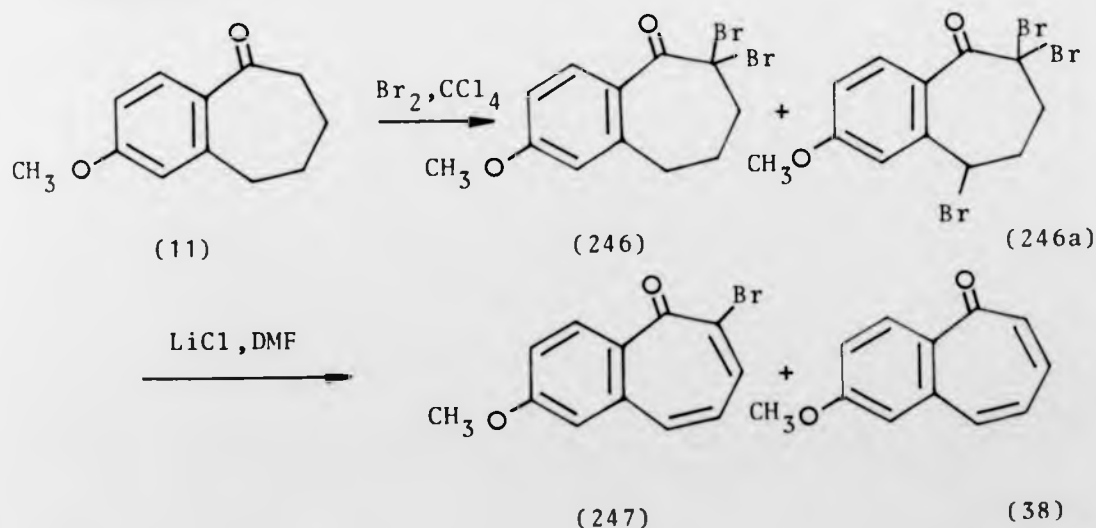
A similar occurrence was reported by Collington and G. Jones [83,84] ,dehydrobromination of 6,6-dibromo--6,7,8,9-tetrahydrobenzocyclohepten-5-one(17) with sodium chloride in boiling dimethylformamide gave a mixture of products the main one being 5H-benzocyclohepten-5-one(1) and 6-bromo-5H-benzocyclohepten-5-one(27).They have postulated that the 6-bromo-5H-benzocyclohepten-5-one(27) was produced by bromination of the 5H-benzocyclohepten-5-one (1) by bromine formed during the reaction.Treatment of the benztropone(1) with either hydrogen bromide or bromoacetone in dimethylformamide had no effect but when bromine in dimethylformamide was used the 6-bromo-5H-benzocyclohepten-5-one (27) was formed (Scheme 72) .

Scheme 72

(6)   (17)

(1)   (27)
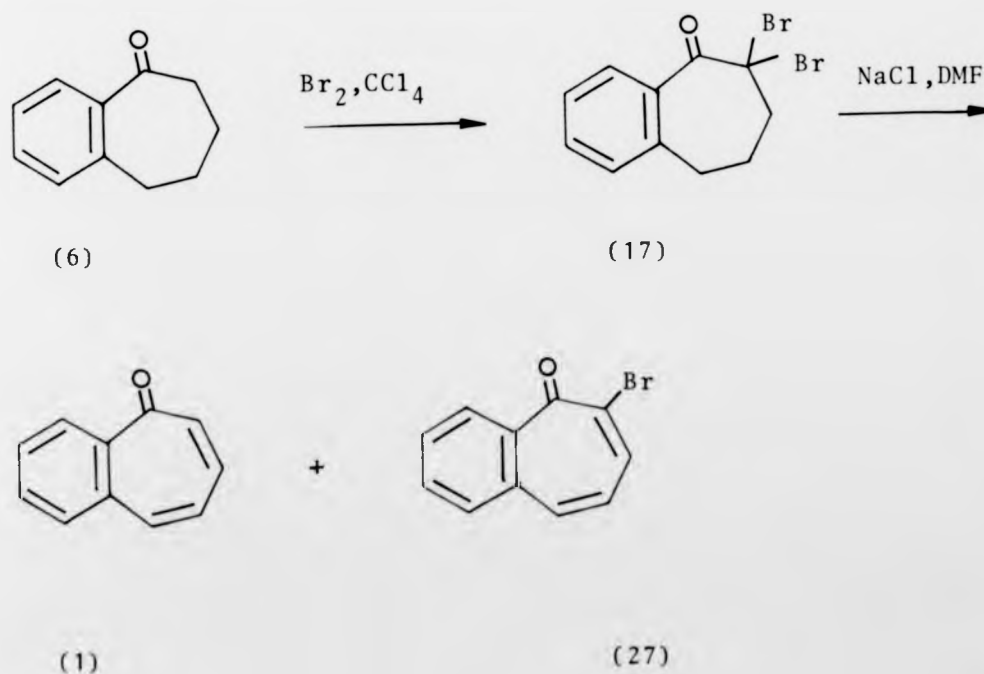
The mass spectrum of 2-methoxy-6-bromo-5H-benzocyclohepten-5-one(247) shows two peaks at m/e 266 and 264 (M^+) in a ratio of 1:1 confirming that the compound possesses one bromine atom.

The infra-red absorption spectrum has peaks at 1640,1610,1584 Cm^{-1} which are characteristic of this class of compound.

The ^1H n.m.r. spectrum showed a doublet at lowest field δ 8.56-8.47 p.p.m.considered to be H4 with ortho splitting by H3. The quartet* at δ 7.95-7.85 p.p.m.was assigned to H7 adjacent to the bromine atom and has coupling constants of $J_{8,7}=$ 9 Hz and $J_{7,9}=0.7Hz$. The multiplet between δ 6.6 and 6.4 p.p.m. ($J_{8,9}=11.7$ Hz) was assigned to H8 by direct comparison with the position of H8 in 2-methoxy-5H-benzocyclohepten-5-one(38).If the bromine substituent was in position 9 , it would be most likely for proton 8 to be deshielded sufficiently to appear further downfield.

The ^{13}C n.m.r. spectrum is similar to that of the 2-methoxy-5H-benzocyclohepten-5-one(38),with the exception that one of the alkene peaks, that at δ111.9 p.p.m. is now a singlet in the off resonance spectrum.

* doublet of doublets

Synthesis of 3-methoxy-5H-benzocyclohepten-5-one(234)

The starting materials employed during the synthesis
of 3-methoxy-5H-benzocyclohepten-5-one(234) were benzene
and glutaric anhydride(248) . Somerville and Allen [85]
reported benzene can be acylated directly by the condensation
of glutaric anhydride (248) in the presence of aluminium
chloride. Following their procedure , 4-benzoyl-n-butyric acid
(249) was prepared in 45% yield and was subsequently
characterized by its physical and [1]H n.m.r. spectral data
(Scheme 73) .

Scheme 73

(248)   (249)
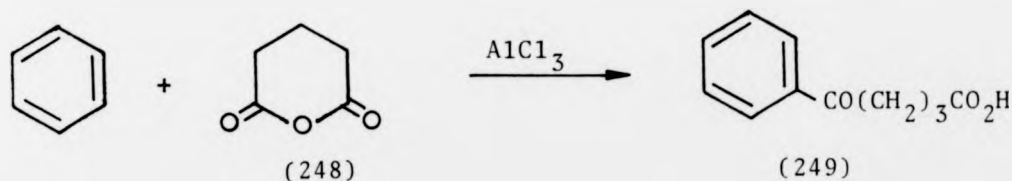
The 4-benzoyl-n-butyric acid (249) was reduced to the
5-phenylvaleric acid [85] (250) by the Huang-Minlon modification[87,88]
of the Wolff-Kishner reaction,in which the keto-acid (250) ,
hydrazine hydrate, and potassium hydroxide, were heated under
reflux in 2,2´-dihydroxydiethyl ether (Scheme 74) .

The 5-phenylvaleric acid (250) was then cyclized [86] by
an internal Friedel-Crafts acylation,by heating it with
polyphosphoric acid(PPA) to give 6,7,8,9-tetrahydro-5H-benzo-
cyclohepten-5-one(6) (Scheme 74) .

The ^{1}H n.m.r. spectrum shows resonances for eight
protons in the alkane region and four protons in the
aromatic region.A multiplet at δ 7.80-7.50 p.p.m. due
to H4 exhibited a downfield shift,this deshielding arising
probably due to the anisotropy of the carbonyl group
at position five .

Scheme 74

(249)   (250)

(6)
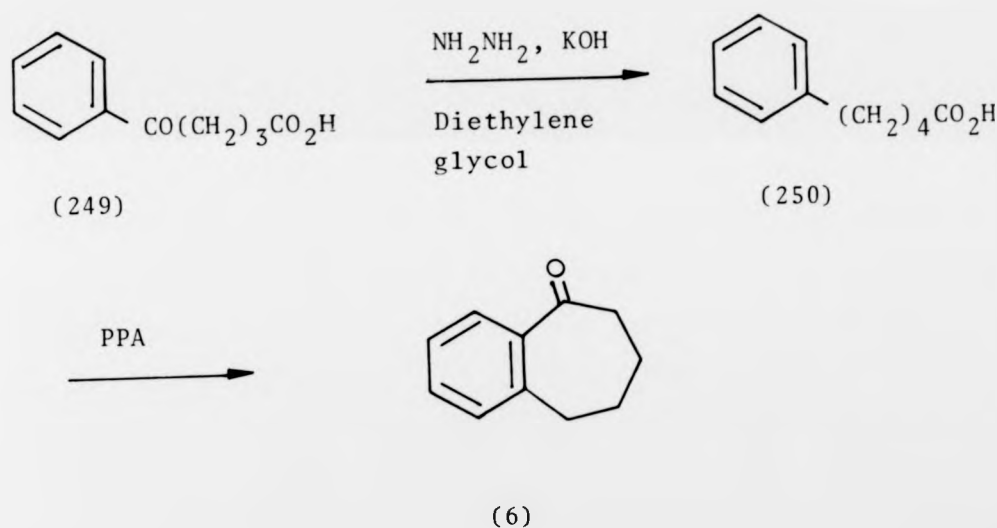
Smith and Berry [89] have prepared 3-nitro-6,7,8,9-tetrahydro-
- 5H -benzocyclohepten-5-one (15)from the 6,7,8,9-tetrahydro-5H-
benzocyclohepten-5-one(6) by nitration with fuming nitric
acid at low temperature (Scheme 75).This synthesis was
repeated and the product (15) was identified by its ^{1}H n.m.r.
spectral data . The aromatic protons were split distinctly
into the three separate protons.The signal due to H4 was
shifted furthest downfield to δ 8.1 p.p.m. and was recognised

its weak meta-coupling ($J_{2,4}=2$ Hz) to H2 . H2 showed a
doublet of doublets resulting from coupling with H1 and H4
($J_{4,2}=2$ Hz and $J_{1,2}=8$ Hz) , while H1 is coupled only to
H2 ($J_{2,1}=8$ Hz) .

Scheme 75

(6)   (15)
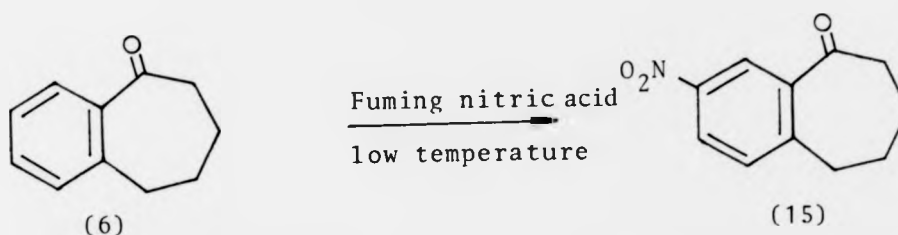
If the temperature was allowed to rise during the
nitration the product was 2-(3-carboxypropyl)-5-nitrobenzoic acid
(15a)(Scheme 76),which was identified by its [1]H n.m.r. spectrum
data .The most downfield signal was a proton doublet at
δ 8.4 p.p.m. allocated to H6 .The extra downfield shift
in the H6 resonance is probably due to the proximity of
carbonyl and nitro groups at positions one and five respectively.

Scheme 76

(6)   (15a)
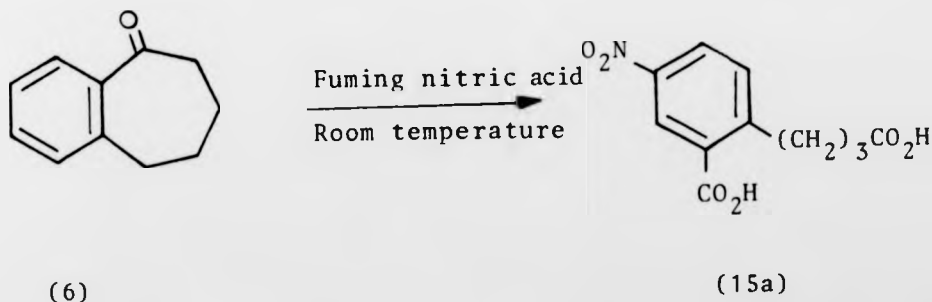
In 1975 Johnston , Povall and Entwistle [90] developed
a method for conversion of nitro aromatic compounds to
their amino aromatic compounds.Treatment of 4-methoxy-
-2,5-dinitroanisole(251)with boiling cyclohexene and
palladium-charcoal yielded 3,6-dimethoxy-5-nitroaniline(252).
The reduction was effected rapidly,selectively and in high
yield by transfer of hydrogen from cyclohexene to the
aromatic nitro compound via the palladium-charcoal catalyst
(Scheme 77) .

Scheme 77

(251)   (252)
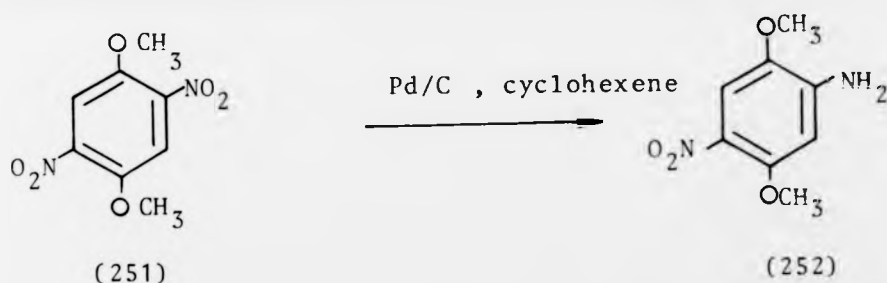
By treatment of 3-nitro-6,7,8,9-tetrahydro-5H-benzo-
cyclohepten-5-one(15) with cyclohexene and palladium-charcoal ,
3-amino-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(253)
was prepared (Scheme 78) .

The ^{1}H n.m.r. spectrum shows resonances for eight
protons in the alkane region and the aromatic protons exhibit
upfield shifts .

Scheme 78

(15)   (253)
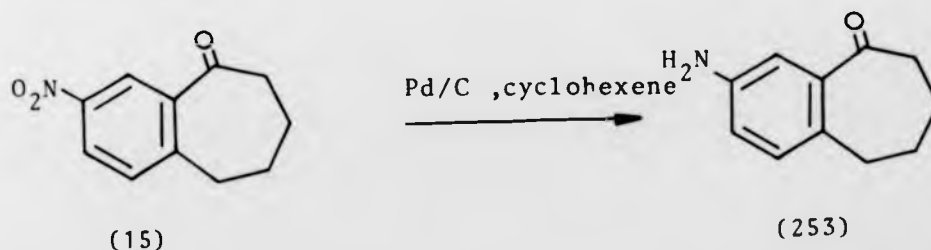
The 3- amino-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one (253) was then used to prepare 3-hydroxy-6,7,8,9-
-tetrahydro-5H-benzocyclohepten-5-one (254) [89] .The diazonium
salt was made in situ and this was heated to produce the
phenol (254) (Scheme 79) .

The methylation of 3-hydroxy-6,7,8,9-tetrahydro-
-5H-benzocyclohepten-5-one(254)was carried out in chloroform
using dimethyl sulphate and sodium hydroxide to give
3-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one
(255) [6] (Scheme 79) .

Scheme 79

(253)

$NaNO_2/H_2SO_4$

(254)

$(CH_3)_2SO_4$

(255)
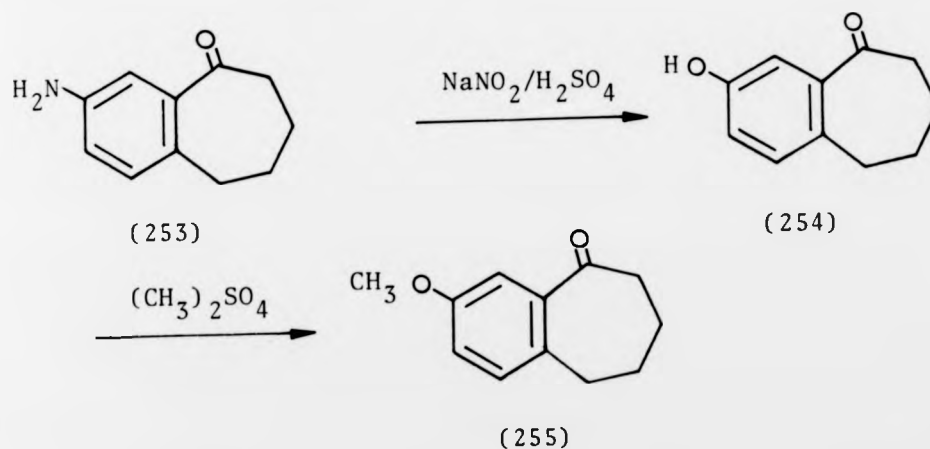
Bromination of 3-methoxy-6,7,8,9-tetrahydro-5H-benzo-
cyclohepten-5-one(255) was best effected by treatment with
phenyltrimethylammonium tribromide using tetrahydrofuran as a
solvent. After addition of a few drops of acetone, the filtered
solution was evaporated . An [1]H n.m.r. spectrum of the crude
product showed some 3-methoxy-6-bromo-6,7,8,9-tetrahydro-5H-
-benzocyclohepten-5-one (256a) to be present.Separation of the mixture

on a chromatotron (petroleum eluent) gave the two pure
monobromo and dibromo derivatives (256a and 256)(Scheme 80) .

The mass spectrum of the dibromoketone (256) contained
peaks at 350,348 and 346(M^+) in the ratio of 1:2:1 confirming
that the compound contained two bromine atoms .

Subsequent dehydrobromination of the dibromoketone(256)
with anhydrous lithium chloride in boiling dimethylformamide
for two hours, followed by removal of dimethylformamide under
reduced pressure gave an oil which was purified on a
chromatotron (eluent ethyl acetate/petroleum, 1:9) to give
the 3-methoxybenztropone (234)(Scheme 80) .

The mass spectrum shows the molecular ion to be at
m/e 186 which is correct for 3-methoxybenztropone (234).

The infra-red absorption spectrum has peaks at
1600,1645 and 1660 Cm^{-1} .

The ^1H n.m.r. spectrum showed a doublet ($J_{2,4}$=3 Hz) at
the lowest field δ 8.0 p.p.m. due to H4 with meta splitting
by H2 . H2 showed a doublet of doublets resulting from
coupling with H1 and H4 ($J_{1,2}$=8.6 Hz,$J_{4,2}$=3 Hz),while H1
is coupled only to H2 ($J_{1,2}$=8.6 Hz).Another doublet at
δ 7.35-7.25 p.p.m. considered to be due to H9.It was
distinguished from H1 and H2 by its major coupling constant
($J_{8,9}$=11.3 Hz). A multiplet at δ 7.1-7.0 p.p.m. integrated
for two protons and is due to H6 and H7 . And finally H8
occurs as a doublet of doublets of doublets at δ 6.7-6.5 p.p.m.
resulting from coupling with H7 ,H9 and H6 ($J_{8,7}$=7 Hz,
$J_{8,6}$=2.2 Hz and $J_{8,9}$=11.3 Hz) .

Scheme 80

(255)   PTAB/THF →   (256a)   +   (256)

(256)   LiCl/DMF →   (234)
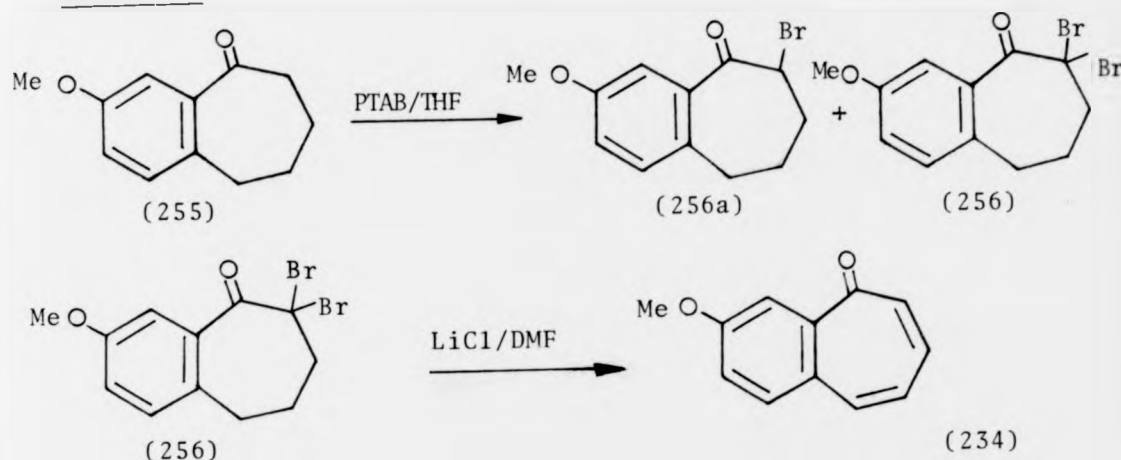
Attempts to synthesize 1-methoxy-5H-benzocyclohepten-5-one

In order to prepare 5-(2-methoxyphenyl)valeric acid(259),
the stage before cyclisation to cyclic ketone,the
2-methoxybenzaldehyde and diethyl ethylidenemalonate(236)
were employed as starting materials.

By the modification of the reported method used by Horton
and Walker [91,92] 2-methoxycinnamylidenemalonic acid(257)
was prepared . Condensation of 2-methoxybenzaldehyde with
diethyl ethylidenemalonate (236) and benzyltrimethylammonium
hydroxide gave 2-methoxycinnamylidenemalonic acid (257)(Scheme 81).

The infra-red spectrum showed two characteristic
bands at 1725 and 1600 Cm^{-1} .

The exchangeable peak at δ 9.28-8.90 p.p.m. in the
^{1}H n.m.r. spectrum is consistent with compound being an acid.

The hydrogenation of 2-methoxycinnamylidenemalonic acid
(257)was carried out using palladium charcoal catalyst to
give 3-(2-methoxyphenyl)propylmalonic acid(258)(Scheme 81).

The ^{1}H n.m.r. spectrum showed resonances for ten protons

protons in the alkane region .A multiplet at δ 7.1-6.6 p.p.m.
integrated for four protons and is due to the aromatic protons.

The 3-(2-methoxyphenyl)propylmalonic acid (258) was
then decarboxylated in a claisen distillation flask by
distillation under vacuo to give the 5-(2-methoxyphenyl)valeric
acid [92] (259) in good yield (Scheme 81).

The ^{1}H n.m.r. spectrum showed eleven protons in the
alkane region.A multiplet occurred at δ 2.7-2.2 p.p.m. is due
to the four protons of two methylene groups at positions
two and five of the valeric acid(238) and another multiplet
at δ 7.3-6.2 p.p.m. was due to four aromatic protons.

Scheme 81

(236)   (257)

(258)   (259)
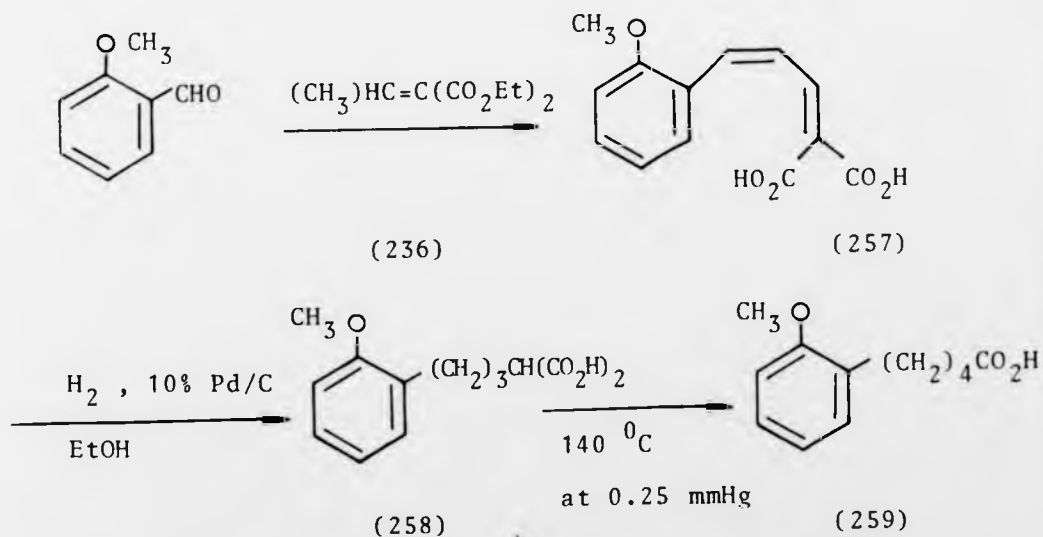
Since 1-methoxy-6,7,8,9-terahydro-5H-benzocyclohepten-
-5-one was desired as an important intermediate which can be
easily brominated and then dehydrobrominated to give the
corresponding 1-methoxy-5H-benzocyclohepten-5-one,the
cyclisation of 5-(2-methoxyphenyl)valeric acid(259) was
investigated.Attempted cyclisation of 5-(2-methoxyphenyl)valeric

acid(259) by a mixture of phosphorus pentoxide and 85%
orthophosphoric acid gave a crude product.It was found that
this crude product could not be purified by recrystallization
but purification was eventually carried out by a careful
chromatographic separation to give the pure product(260)(Scheme 82)
which was identified as a dimer(260) by its ^{1}H n.m.r.
spectral data .

The ^{1}H n.m.r. spectrum exhibited a doublet of doublets
at δ 8.0-7.9 p.p.m. which could be assigned to the two protons
a (see formula) . These two protons are the only ones showing
coupling to other ortho(b; $J_{a,b}$=8.5 Hz) and meta(c; $J_{a,c}$=2.2 Hz)
protons.The extra downfield shift is due to the proximity of
the carbonyl group. The meta-coupling occurred between the
protons at positions c δ 7.7 p.p.m. , and the protons at
positions a . The ortho-coupling occurred between the protons
at positions b δ 7.0-6.9 p.p.m. and protons at positions a .
The methoxy protons showed as a singlet at δ 3.95 p.p.m. .
Two multiplets between δ 2.9-2.5 and 1.8-1.7 p.p.m. each
integrating for eight protons were due to two (CH_2CO) and
two (CH_2Ar) groups and to the other two (CH_2CH_2) groups.
This observation confirms that the ketone is a dimer (260)
and not 1-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one .
This reaction has been reported by Gardner,Horton,Thompson
and Twelves [92,93] to give a high-melting neutral product,
insoluble in common solvents.Bien later
reported [94] the formation of dimer (260), but no spectral
data were given to support   the alleged structure.

Scheme 82

(259)   (260)
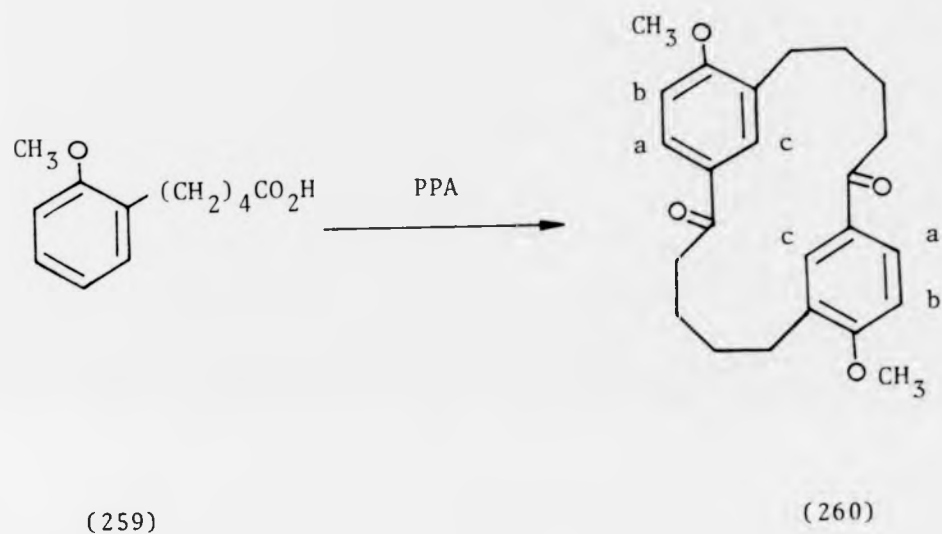
Synthesis of 1-methoxy-4-methyl-5H-benzocyclohepten-5-one(268)

Since cyclisation of 5-(2-methoxyphenyl)valeric acid (259) with polyphosphoric acid gave the dimer (260) it was decided to block the para position of the phenyl group in 5-(2-methoxyphenyl)valeric acid (259). In order to prepare 5-(2-methoxy-5-methylphenyl)valeric acid(265)necessary for cyclisation to the cyclic ketone(266) p-hydroxytoluene was employed as a starting material . A mixture of p-hydroxytoluene and dimethyl sulphate in acetone was heated under reflux to give p-methoxyanisole [95] (261) (Scheme 83) .

The ^{1}H n.m.r. spectrum exhibited a singlet at δ 3.66 p.p.m. which could be assigned to the methoxyl group .

Formylation of p-methyl anisole (261) was carried out with zinc cyanide and dry hydrogen chloride to give 5-methyl-2-methoxybenzaldehyde [96] (262).

The ^{1}H n.m.r. spectrum showed a singlet at δ 10.4 p.p.m. due to the proton of the formyl group and a doublet at δ 7.55 p.p.m. attributed to H6 ($J_{4,6}$= 3 Hz).Meta- and ortho-coupling occurred between H4 δ 7.4-7.2 and H3 δ 6.8-6.7 p.p.m. ($J_{4,6}$=3 Hz and $J_{4,3}$=10 Hz , doublet of doublets).

Scheme 83

(261)   (262)
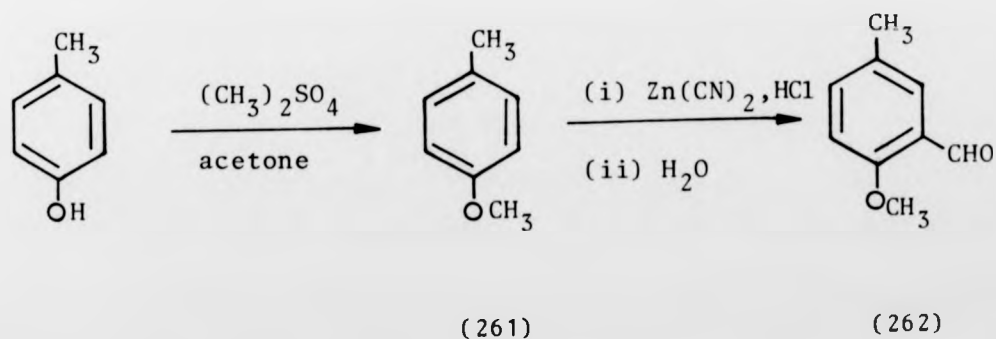
Condensation of 5-methyl-2-methoxy-benzaldehyde(262)
with diethyl ethylidenemalonate (236) and benzyltrimethyl-
ammonium hydroxide gave 5-methyl-2-methoxycinnamylidenemalonic
acid(263)(Scheme 84) .

The infra-red spectrum showed two characteristic bands
at 1710 and 1612 Cm^{-1} .

The exchangeable peak centred at δ 9.3 p.p.m. in the
^{1}H n.m.r. spectrum is consistent with the compound being
an acid .A multiplet at δ 8.1-6.7 p.p.m. integrating for
six protons must be due to aromatic and diene protons.

Hydrogenation of 5-methyl-2-methoxycinnamylidenemalonic
acid (263) was carried out using palladium-charcoal catalyst
to give 3-(2-methoxy-5-methylphenyl)propylmalonic acid (264)
(Scheme 84) .

The ^{1}H n.m.r. spectrum showed resonances for thirteen
protons in the alkane region . A multiplet at δ 7.2-6.4 p.p.m.
integrating for three protons and must be due to the aromatic
protons.

Decarboxylation of 3-(2-methoxy-5-methylphenyl)propylmalonic
acid(264)in a Claisen distillation flask in   vacuo gave
5-(2-methoxy-5-methylphenyl)valeric acid (265)(Scheme 84) .

^{1}H n.m.r. spectrum showed fourteen protons in the alkane
region.A multiplet occurred at δ7.1-6.5 p.p.m. due to the
three protons of aromatic group.

Cyclisation of 5-(2-methoxy-5-methylphenyl)valeric acid
(265) was successfull using a mixture of phosphorus pentoxide
and 85% orthophosphoric acid giving 1-methoxy-4-methyl-6,7,8,9-
-tetrahydro-5H-benzocyclohepten-5-one(266)(Scheme 84) .

The infra-red spectrum showed three characteristic peaks ; at 1688 Cm^{-1} attributed to C=O bond stretching mode within the ring system, at 1594 Cm^{-1} which can be assigned to the C=C bond stretching mode in the benzene ring, and at 1190 Cm^{-1} due to OCH_3 bond stretch.

The ^1H n.m.r. spectrum exhibited two doublets at $\delta 7.0$-6.8 and 6.7-6.6 p.p.m. which could be assigned to H3 and H2 respectively ($J_{2,3}$=8.4 Hz) . Two singlets at $\delta 3.7$ and 2.2 p.p.m. are due to methoxyl and methyl protons . Two multiples at δ 3.9-2.4 and 1.9-1.5 p.p.m. can be assigned to the four protons at positions six and nine and to four protons at positions seven and eight respectively .

Scheme 84

(262)　　　　(236)　　　　　　　(263)

(264)　　　　　　　　　　　　　　(265)

(266)
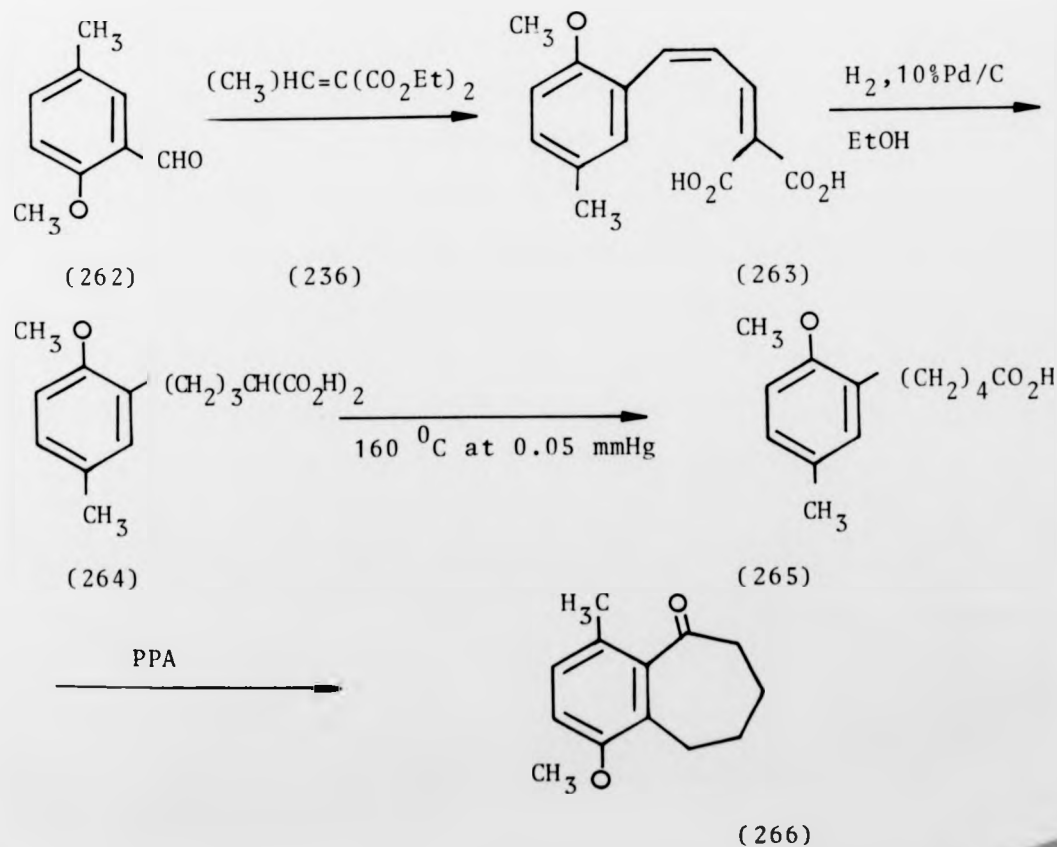
The 1-methoxy-4-methyl-6,7,8,9-tetrahydro-5H-benzo-
cyclohepten-5-one(266) in tetrahydrofuran was treated with
phenyltrimethylammonium tribromide at room temperature .
Progress of this reaction was followed by using t.l.c. .
The desired product (267) has the largest R_f value followed by mono-
brominated ketone,which in turn is followed by the starting
material . The resulting   product (267) was difficult to
crystallise and purification required column chromatography,
giving the pure 6,6-dibromo-1-methoxy-4-methyl-6,7,8,9-tetrahydro-
-5H-benzocyclohepten-5-one(267)(Scheme 85).

The mass spectrum peaks at m/e 364 , 362 and 360(M^+) in a
ratio of 1:2:1 , relating to the two isotopes in their three
possible combinations, confirming that the compound(267)contains
two bromine atoms.

The infra-red absorption spectrum has peaks at 1716 ,
1605 and 1275 Cm^{-1} which are characteristic of this class
of compound .

The absence of any peaks in the δ 5-6 p.p.m. of the ^{1}H n.m.r.
spectrum and the presence of two multiplets due to six protons
in the alkane region showed that both bromine atoms are on
the same carbon atom .

Scheme 85

(266)   (267)

The 6,6-dibromo-1-methoxy-4-methyl-6,7,8,9-tetrahydro-
-5H-benzocyclohepten-5-one(267) was then treated with lithium
chloride in boiling dimethylformamide to give the
1-methoxy-4-methyl-5H-benzocyclohepten-5-one(268) which was
eventually purified by p.l.c. (Scheme 86) .

The mass spectrum shows the molecular ion to be at m/e 200
which is correct for compound(267) .

The frequency of the carbonyl absorption in the infra-red
was at 1650 Cm^{-1} .

The ^{1}H n.m.r. spectrum showed a quartet at the lowest field
δ 7.9-7.8 p.p.m. considered to be due to H9 . It was
distinguished from protons H3 and H2 by its major coupling
constant ($J_{8,9}$=11.8 Hz) . It is further downfield probably due
to being adjacent to aromatic ring and also being deshielded
by carbonyl group at position five . Two doublets at
δ 7.3-7.2 p.p.m. and 6.9-6.8 p.p.m. could be assigned to
H3 and H2 respectively.A complex multiplet between δ6.8 and 6.5 p.p.m.
which integrates for three protons must be due to the protons
around the seven membered ring .Two singlets at δ 3.8 and 2.4
p.p.m. are due to methoxyl amd methyl protons respectively.

The carbonyl resonance in the ^{13}C n.m.r. spectrum occurs
at δ 192.8 p.p.m. consistent with a conjugated carbonyl,
all other resonances occurring in the aromatic and
alkene regions along with two peaks at δ 56.0 and 22.9
p.p.m. due to the methoxyl and methyl carbons respectively.

Scheme 86

(267)   (268)
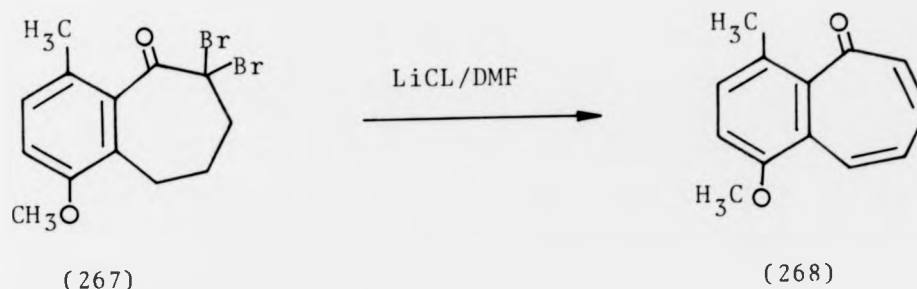
Syntheses of 5H-benzocyclohepten-5-one(1) and of

6,8-dinitro-5H-benzocyclohepten-5-one (269)

The 6,6-dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one [83] (17) was prepared in almost quantitative yield by
brominating a carbon tetrachloride solution of the
6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(6).

The position of bromine atoms was confirmed by
the ^{1}H n.m.r. spectrum which showed the seven and nine
methylene groups as broadened triplets between δ 3.00 and 2.60
p.p.m. .

Heating the dibromoketone (17) with an excess of
lithium chloride in boiling dimethylformamide gave
5H-benzocyclohepten-5-one [83] (1) in   good yield(Scheme 87).

The infra-red absorption spectrum has peaks at 1640,
1609 and 1589 Cm^{-1} which are characteristic of this class
of compound.

The ^{1}H. n.m.r. spectrum of 5H-benzocyclohepten-5-one(1)
has been analysed by Bertelli, Gering and Herbelin [97] .

The multiplet at δ 8.5-8.3 p.p.m. is assumed to be H4
shifted downfield due to the anisotropic deshielding effect

of the carbonyl group in position five.The other three
aromatic protons occur as a multiplet at δ 7.7-7.5 p.p.m. .
A quartet atδ 7.3-7.1 p.p.m. is attributed to H9 which
has a major coupling constant of $J_{8,9}=11.3$ Hz and a minor
coupling constant of $J_{7,9}=1.2$ Hz . H6 and H7 give a complex
pattern between δ 7.0 and 6.8 p.p.m. from which $J_{7,8}=8.3$ Hz ,
$J_{6,8}=1.2$ Hz and $J_{6,7}=11.5$ Hz . Another multiplet at highest
field δ6.7-6.5 p.p.m. must then be due to H8 .

The carbonyl resonance in the ^{13}C n.m.r. spectrum occurs
at 187.4 p.p.m. consistent with a conjugated carbonyl, all
other resonances occurring in the aromatic and alkene regions.

Buchanan and Lockhart [5] have prepared
6,8-dinitro-5H-benzocyclohepten-5-one (269) from
5H-benzocyclohepten-5-one(1) by nitration with concentrated
nitric acid and sulphuric acid at room temperature .This
reaction was repeated and the product purified by column
chromatography (Scheme 87) .

The infra-red absorption spectrum showed strong
absorption at 1525 and 1332 Cm^{-1} due to asymmetrical and
symmetrical stretching of the nitro group .

The ^{1}H n.m.r. spectrum showed two doublets ($J_{7,9}=1.2$ Hz)
centred at δ 8.9 p.p.m. and 8.6 p.p.m. considered to be
due to H7 and H9 . These protons were shifted downfield
from the remainder of the aromatic protons due to the
inductive effect of the nitro groups at positions six and
eight .

Scheme 87

(6)

$2Br_2/CCl_4$

(17)

LiCl/DMF

(1)

HNO_3

H_2SO_4

(269)
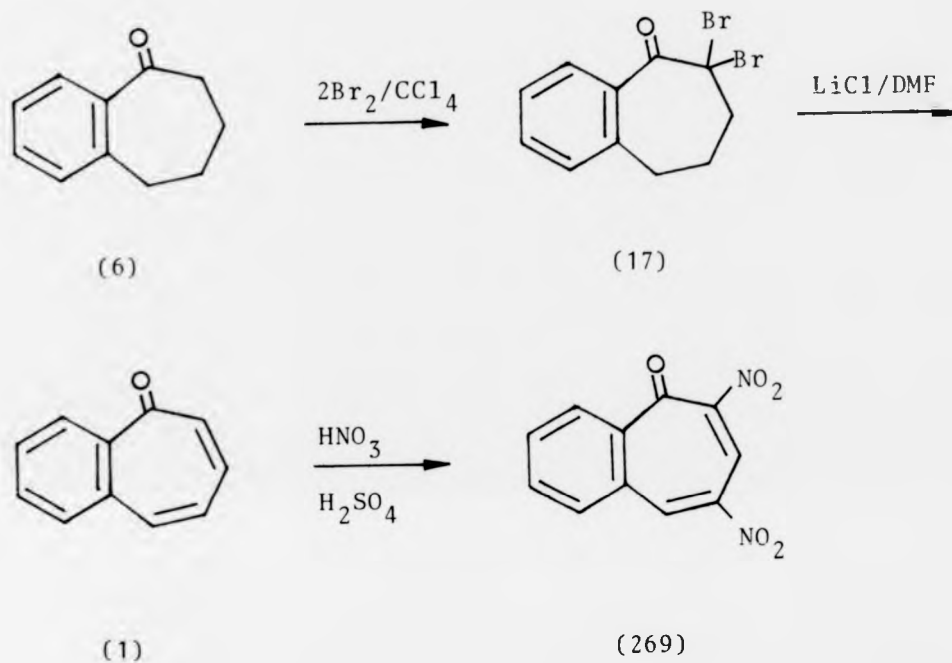
Syntheses of 3-nitro-5H-benzocyclohepten-5-one(20)and

3-amino-5H-benzocyclohepten-5-one(270)

Treatment of 3-nitro-6,7,8,9-tetrahydro-5H-
-benzocyclohepten-5-one(15) with bromine gave
3-nitro-6,6-dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one [83] (18)as a colourless solid (Scheme 88) .

The infra-red absorption spectrum showed a carbonyl
stretching frequency at 1710 Cm^{-1} , and strong absorptions
at 1610 and 1342 Cm^{-1} due to the asymmetrical and symmetrical
stretching of the nitro group.

The ^1H n.m.r. spectrum again showed a broadened
multiplet between $\delta 3.2$ and 2.7 p.p.m. attributed to the
methylene groups at positions 7 and 9 .

The nitrodibromoketone (18) was dehydrobrominated
by lithium chloride in refluxing dimethylformamide to
give 3-nitro-5H-benzocyclohepten-5-one [83] (20) in good
yield (Scheme 88).

The infra-red absorption spectrum has peaks
at 1641,1602 and 1584 Cm^{-1} which are characteristic of
benztropones .

The doublet ($J_{2,4}$=2.4 Hz) at δ 9.3-9.2 p.p.m. is
considered to be H4 with meta splitting by H2 . The quartet
at δ 8.5-8.3 p.p.m. is due to H2 and has a major coupling
constant of $J_{1,2}$=8.7 Hz . H1 ocucurs as a doublet at
δ 7.8-7.7 p.p.m. .The multiplet between δ 7.5 and 6.9 p.p.m.
which integrates for four protons must then be due to the
protons around the seven membered ring .

The carbonyl resonance in the ^{13}C n.m.r. spectrum
occurs at 186.1 p.p.m. consistent with a conjugated carbonyl,

all other resonances occuring in the aromatic and alkene regions.

The conversion of 3-nitro-5H-benzocyclohepten-5-one (20) to the 3-amino-5H-benzocyclohepten-5-one(270) was then successfully carried out by the treatment with boiling cyclohexene and a palladium-charcoal catalyst(Scheme 88) .

The infra-red absorption spectrum has peaks at 3430,3350 and 1380 Cm^{-1} due to NH_2 stretch and deformation, and a carbonyl peak at 1660 Cm^{-1} .

The ^1H n.m.r. spectrum showed a doublet ($J_{2,4}$=2.3 Hz) at δ 7.8-7.7 p.p.m. which is due to H4 with meta splitting by H2 . The signal due to H1 occurs as a doublet($J_{1,2}$=8.5 Hz) at δ 7.5-7.4 p.p.m. and that due to H9 as a quartet at δ 7.3-7.2 p.p.m. having a major coupling constant of $J_{9,8}$=11.4 .The multiplet between δ 7.1 and 6.9 p.p.m. which integrates for two protons must then be due to H2 and H7 .Another quartet between δ 6.8 and 6.7 p.p.m. was assigned to H6 and a complex octet occurred at δ 6.6-6.4 p.p.m. due to H8 .

The carbonyl resonance in the ^{13}C n.m.r. spectrum occurs at δ 186.0 p.p.m. consistent with a conjugated carbonyl,all other resonances occuring in the aromatic and alkene regions.

Scheme 88

(15)

2Br$_2$/CCl$_4$

(18)

LiCl/DMF

(20)

Cyclohexene

Pd/C

(270)
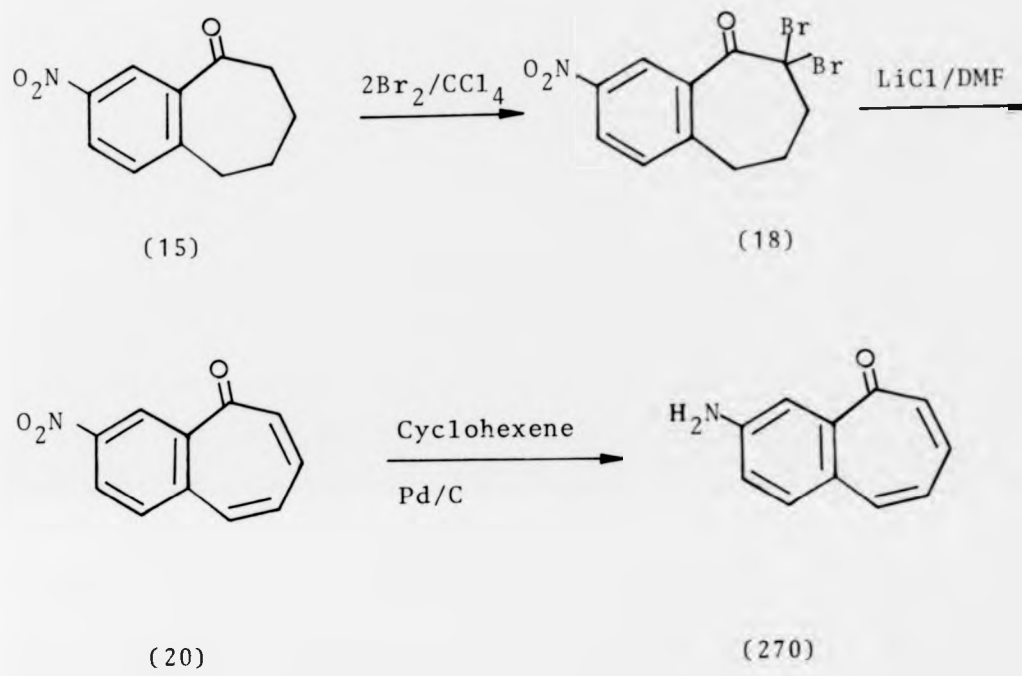
Syntheses of 3-acetamido-5H-benzocyclohepten-5-one(21)and
3-amino-2,4-dibromo-5H-benzocyclohepten-5-one(272)

The 3-acetamido-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one [89] (16) was obtained by reaction of 3-amino-6,7,8,9-
-tetrahydro-5H-benzocyclohepten-5-one(253)with acetyl chloride
in pyridine (Scheme 89) .

To avoid the possibility of nuclear bromination the
acetamidoketone(16) in tetrahydrofuran was treated with
phenyltrimethylammonium tribromide at room temperature   to
give 3-acetamido-6,6-dibromo-6,7,8,9-tetrahydro-5H-benzo-
cyclohepten-5-one(19)(Scheme 89) .

The ^{1}H n.m.r. spectrum agian showed broadened triplets between
$\delta 3.00$ and 2.50 p.p.m. attributed to the methylene groups at
positions 7 and 9 . The NH proton, which was shown to
exchange on shaking with D_2O , appeared as a rather broad
singlet centred at $\delta 8.50$ p.p.m. .

The dibromoketone(19) was then easily dehydrobrominated
with lithium chloride in boiling dimethylformamide to give
3-acetamido-5H-benzocyclohepten-5-one(21) .Due to its low
solubility in chloroform the ^{1}H n.m.r. spectrum was carried
out in trifluoroacetic acid .However protonation caused
many signals to overlap and a definite assignment of the
individual aromatic protons was not possible .Proof of the
desired structure was obtained from analysis and the infra-red
spectrum which shows peaks at 3416 Cm^{-1} due to NH stretch ,and
at 1690 and 1640 Cm^{-1} comparable with those obtained in the
other tropones (Scheme 89) .

The carbonyl resonance in the [13]C n.m.r. spectrum occurs at δ 185.9 p.p.m. consistent with a conjugated carbonyl,all other resonances occurring in the aromatic and alkene region apart from two peaks at δ 168.5 and δ 24.0 p.p.m. due to the carbonyl and methyl carbons of the acetamido group at position three .

Scheme 89

(253) (16)

(19) (21)

(270)
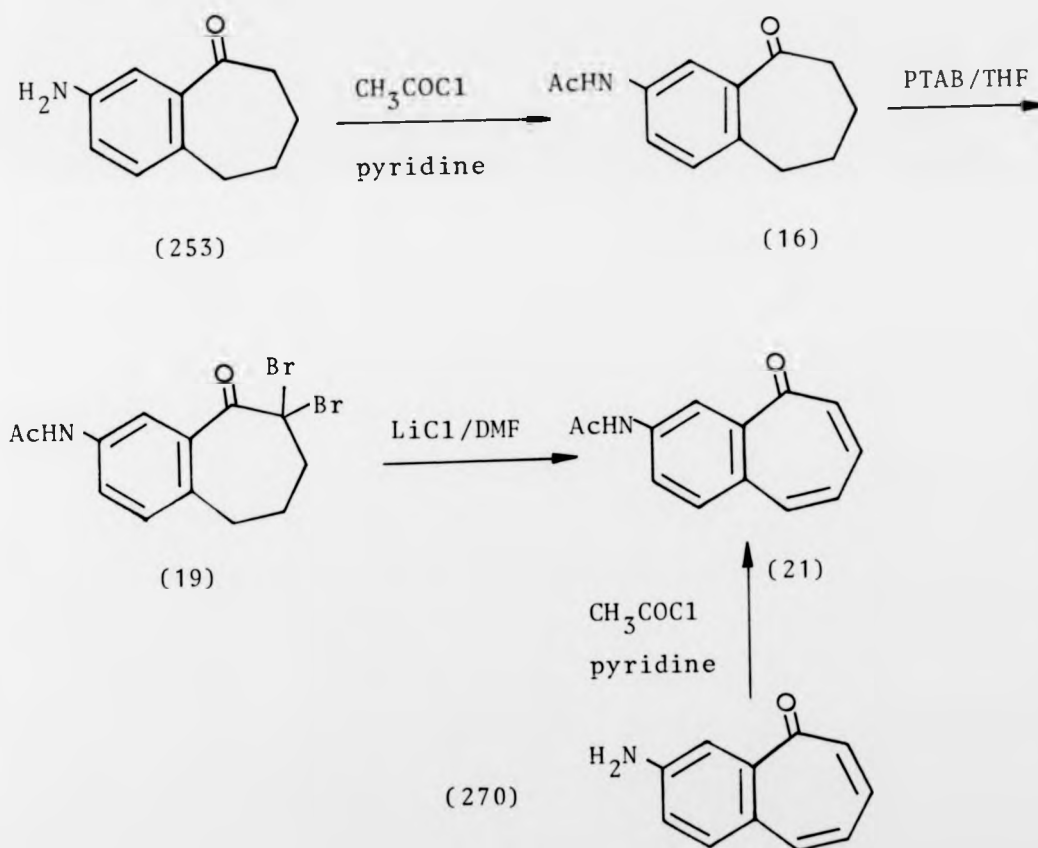
The 3-acetamidobenztropone(21)was also synthesized by reaction of 3-amino-5H-benzocyclohepten-5-one(270) with acetyl chloride in pyridine (Scheme 89) .

Bromination of 3-amino-6,7,8,9-tetrahydro-5H-benzo-
cyclohepten-5-one(253) with four equivalents of bromine in
carbon tetrachloride gave 3-amino-2,4,6,6-tetrabromo-
-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(271) .

The ^{1}H n.m.r. spectrum again showed broadened triplets
between δ 2.82 and 2.35 p.p.m. attributed to the methylene groups
at positions 7 and 9   .The NH_2 protons appeared as a rather
broadened singlet centred at δ 4.72 p.p.m.   .

The dibromoketone (271) was subsequently dehydrobrominated
with lithium chloride in boiling dimethylformamide to give
3-amino-2,4-dibromo-5H-benzocyclohepten-5-one(272),which
was purified by coloumn chromatography(Scheme 90) .

The mass spectrum peaks at m/e 331, 329 and 327(M^+)
in the ratio of 1:2:1 ,relating to the two isotopes in their
three possible combination, confirmed that the compound (272)
contains two bromine atoms .

The ^{1}H n.m.r. spectrum showed a singlet at lowest
field δ 7.56 p.p.m. due to H1 moved downfield by deshielding
by bromine atoms at positions two and four . A doublet of
doublets at δ 7.00-6.82 p.p.m. is due to H9 which has a
major coupling constant of $J_{8,9}$=11.2 Hz . The multiplet
between δ 6.76 and 6.2 p.p.m. which integrates for three protons
must then be due to the protons around the seven membered
ring .

Scheme 90

(253)   (271)

(272)
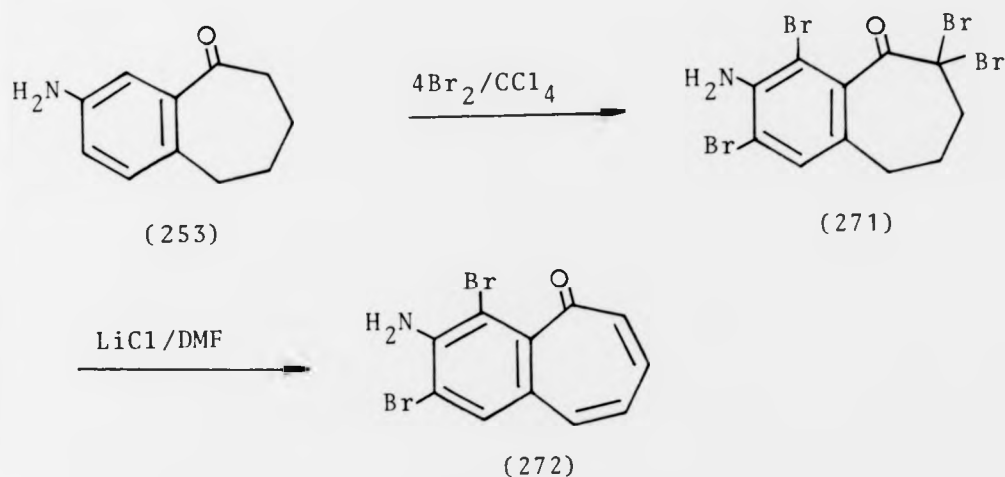
Syntheses of 2-acetamido-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one(276) and of methyl 6,7,8,9-tetrahydro-5H-benzocyclohepten-2-
-carboxylate (280)

Since 2-acetamido-6,7,8,9-tetrahydro-5H-benzocyclohepten-
-5-one (276) was desired as an intermediate in route to
2-acetamido-5H-benzocyclohepten-5-one ,the intermediate(276)
was synthesized by the following route ; 3-nitrobenzaldehyde
and diethyl ethylidenemalonate(236) were employed as starting
materials.

Condensation of 3-nitrobenzaldehyde with diethyl
ethylidenemalonate(236) and benzyltrimethylammonium hydroxide
yielded the 3-nitrocinnamylidenemalonate acid (273) in
good yield (Scheme 91) .

The infra-red absorption spectrum showed strong
absorption at 1520 and 1332 Cm^{-1} due to asymmetrical and
symmetrical stretching of the nitro group .

The ^{1}H n.m.r. spectrum of the pure material was
comparable with those of the other cinnamylidenemalonic
acids previously described . The acid protons   were
shown to exchange on shaking with D_2O ,appeared as a
singlet centred at δ 9.25 p.p.m.   .

The hydrogenation of 3-nitrocinnamylidenemalonic acid
(273) was carried out using a palladium-charcoal catalyst to
give 3-(m-aminophenyl)propylmalonic acid (274)(Scheme 91) .

The malonic acid(274) was then decarboxylated by heating
in vacuo in a claisen distillation flask.Heating the resulting
crude product of distillation with acetic anhydride on a
steam bath for one hour gave 3-(m-acetamidophenyl)valeric acid
(275) (Scheme 91) .

Cyclisation of 3-(m-acetamidophenyl)valeric acid(275)
by a mixture of phosphorus pentoxide and 85% phosphoric acid
gave 2-acetamido-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one [98,99]
(276)(Scheme 91) .

The ^{1}H n.m.r. spectrum shows a resonance   for
eleven protons in the alkane region and three protons in the
aromatic region , and a broad singlet at δ 9.2 p.p.m.
due to the NH proton .

The synthesis was not carried through to the
benztropone due to circumstances beyond the author 's control .

Scheme 91

(236)   (273)

(274)

(275)   (276)
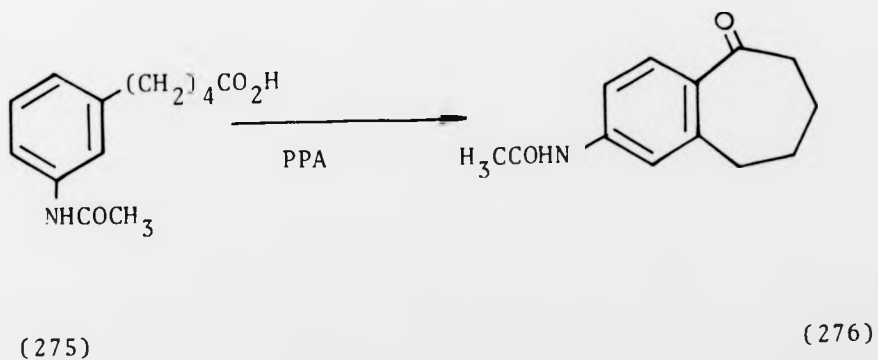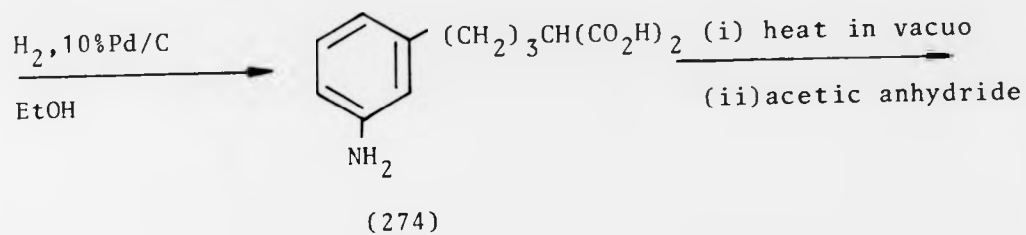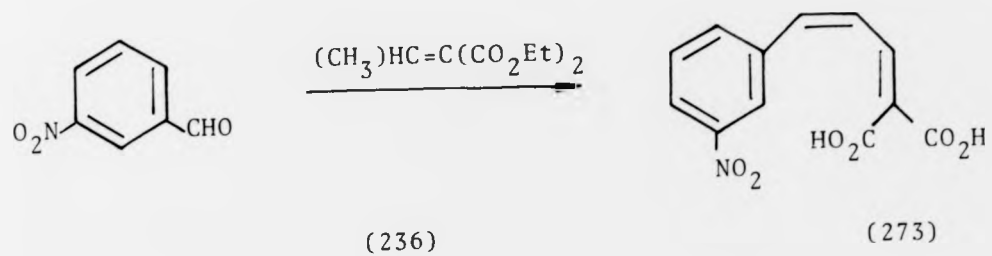
Another incomplete synthesis was that of
methyl 5H-benzocyclohepten-5-one-2-carboxylate and
methyl 5H-benzocyclohepten-5-one-3-carboxylate . For this
methyl 6,7,8,9-tetrahydro-5H-benzocyclohepten-2-carboxylate
(280) was desired as an intermediate .This compound(280) could
undergo bromination at the positions five or nine by reaction
with one molar equivalent of N-bromosuccinimide [62,98] .
Subsequent hydrolysis of the resulting mono-bromo compound
to the alcohol and subsequent oxidation would give the required
methyl 6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one-2(or -3)-
-carboxylate .

An alternative synthetic route [51,74 98] would be by
direct oxidation of compound (280) in which the oxidation
would be expected to occur at the positions five or nine
to give directly methyl 6,7,8,9-tetrahydo-5H-benzocyclohepten-5-
-one-2(or -3)-carboxylate .

In these cases the substituent at positions two or three
would be an electron-withdrawing group ,otherwise difficult
to obtain.

The 6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(6)
was reduced to the 6,7,8,9-tetrahydro-5H-benzocycloheptene
(277) by the Huang-Minlon modification[87] in which the
cyclic ketone(6) ,hydrazine hydrate and potassium hydroxide
were heated under reflux in 2,2´-dihydroxydiethyl ether
(Scheme 92) .

The ^{1}H n.m.r. spectrum showed resonances for ten protons in the alkane region and a singlet at δ 6.9 p.p.m. due to the phenyl protons .

Friedel-Crafts acylation was carried out by reaction of 6,7,8,9-tetrahydro-5H-benzocycloheptene(277) with acetyl chloride in a stirred suspension of anhydrous aluminium chloride to give 2-acetyl-6,7,8,9-tetrahydro-5H--benzocycloheptene [99] (278)(Scheme 92) .

The infra-red frequency of the carbonyl group in the 2-acetyl-compound(278) is 1680 Cm^{-1} .

The 2-acetyl-6,7,8,9-tetrahydro-5H-benzocycloheptene (278) was then converted into 6,7,8,9-tetrahydro-5H--benzocycloheptene-2-carboxylic acid(279)[101] by reaction with potassium iodide-iodine reagent and sodium hydroxide. Subsequent methylation of the acid(279) was carried out with diazomethane to give methyl 6,7,8,9-tetrahydro-5H-benzocycloheptene--2-carbonate (Scheme 92) .

The infra-red absorption spectrum has peaks at 1683 , 1606 and 1240 Cm^{-1} .

The ^{1}H n.m.r. spectrum showed resonances for ten protons in the alkane region and a singlet at δ3.7 p.p.m. due to three protons of the methyl group . The aromatic protons were found in two regions,H1 and H3 shifted furthest to δ7.8-7.6 p.p.m..A doublet ($J_{3,4}$=8.5 Hz) at δ 7.2-7.0 p.p.m. must then be due to H4 .

Scheme 92

(6)   (227)

(278)   (279)

(280)
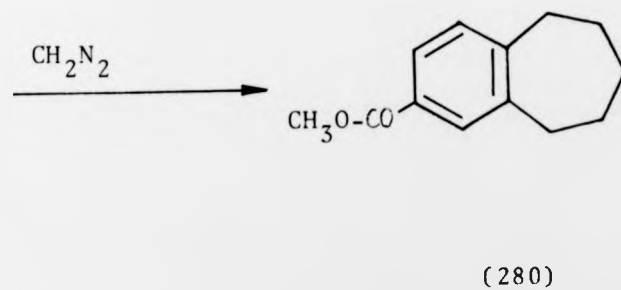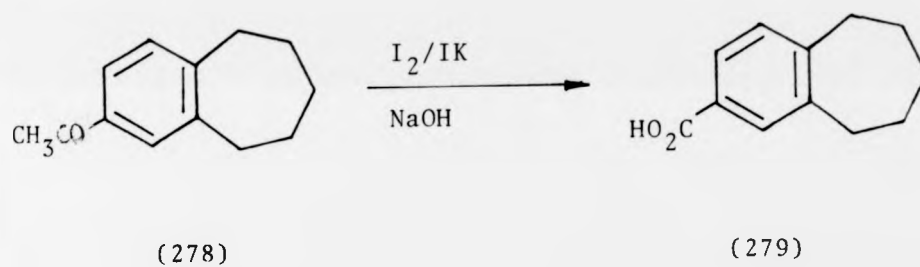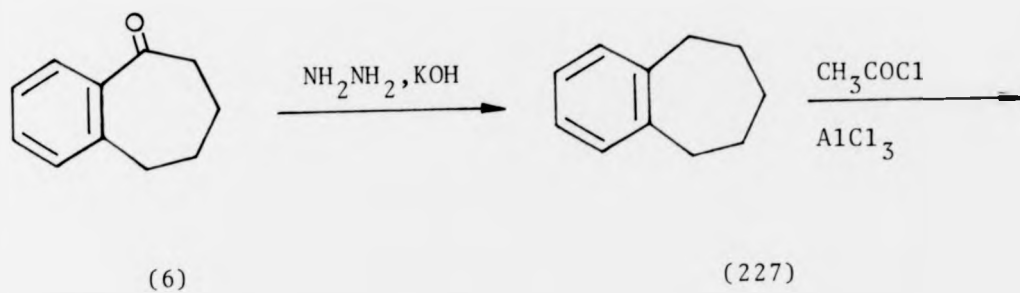
A number of tropones with annulated heterocyclic rings were also prepared for an examination of their photochemical properties.

Synthesis of 1-methyl-3-phenylcyclohepta(b)pyrrol-8-one(281)

As mentioned above , K. Yamane et al [48] reported the synthesis of 3-phenylcyclohepta(b)pyrrol-8-one [102] (141) . Addition of phenylacetaldehyde to 2-hydrazinotropone(133) gave phenylacetaldehyde troponyl hydrazone(140),treatment of which with aqueous sulphuric acid gave the pyrrolotropone (141)(Scheme 33) .

A sample of the pyrrolotropone(141) was supplied by professor K. Yamane

The carbonyl resonance in the [13]C n.m.r. spectrum occurs at δ 176.4 p.p.m. consistent with a conjugated carbonyl , all other resonances occurring in the aromatic and alkene regions .

Methylation of 3-phenylcyclohepta(b)pyrrol-8-one(141) was carried out by reaction of pyrrolotropone(141) with methyl iodide and sodium hydride in boiling 1,2-dimethoxy-ethane (DME) to give 1-methyl-3-phenylcyclohepta(b)pyrrol-8--one(281) which was purified by p.l.c. plates (Scheme 93) .

The infra-red absorption spectrum has peaks at 1638 , 1550 and 1520 Cm^{-1} .

The [1]H n.m.r. spectrum exhibited a doublet of doublets at δ7.6-7.5 p.p.m. due to H4 with a major coupling constant of $J_{4,5}$=10.8 Hz . H5 occurs as a distinct octet at δ 6.7-6.5 p.p.m. resulted from coupling with H4, H6 and H7 ($J_{4,5}$=10.8 Hz , $J_{5,6}$=6.9 Hz and $J_{5,7}$ =2.3 HZ) .Two multiplets

at δ 7.5-7.4 p.p.m. and δ7.2-7.0 p.p.m. which integrate
for six and two protons respectively , must then be due to
the phenyl protons and H2 , and to H6 and H7 respectively .

The carbonyl resonance in the ^{13}C n.m.r. spectrum
occurs at δ178.4 p.p.m. consistent with a conjugated carbonyl,
all other resonances occurring inthe aromatic and alkene
regions apart from a peak at δ 38.8 due to the methyl carbon.

Scheme 93

(141)   (281)
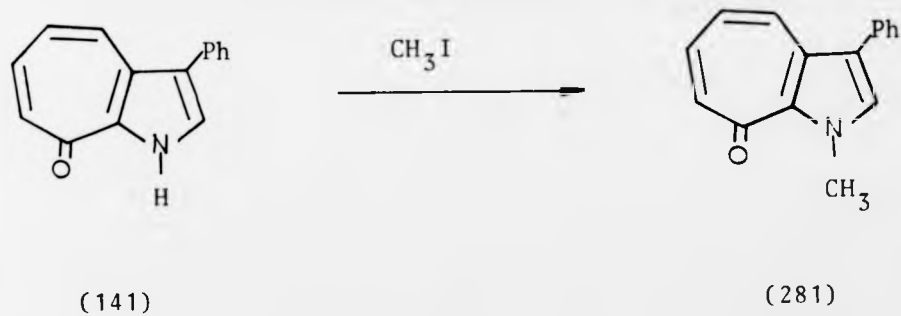
Synthesis of 5-ethylcyclohept(b)indol-10(5H)-one (285),

5-methylcyclohept(b)indol-10(5H)-one (289)   and

cyclohept(b)indol-10(5H)-one (8)

As stated above (Scheme 42) in 1976 Yamane and
Fujimori [51] and later in 1977 Oikawa and Yonemitsu [100]
reported the selective oxidation of the 5,6,7,8,9,10-hexahydro-
cyclohept(b)indole(153) and 5-methyl-6,7,8,9,10-hexahydro-
cyclohept(b)indole(286) with DDQ in aqueous tetrahydrofuran[100]
(or dioxane [51]) at room temperature to give 6,7,8,9-tetrahydro-
cyclohept(b)indol-10(5H)-one (154) and 5-methyl-6,7,8,9-tetra-
hydrocyclohept(b)indol-10(5H)-one (287) (Scheme 94) .

Using Collington and Jones '   bromination/
dehydrobromination procedure[7] Yamane and Fujimori [51] also
synthesized cyclohept(b)indol-10(5H)-one (8) and
5-methylcyclohept(b)indol-10(5H)-one(289) (Scheme 94).

For the synthesis of 5-ethylcyclohept(b)indol-10(5H)-one
(285) we used a similar route .

Ethylation of 5,6,7,8,9,10-hexahydrocyclohept(b)indole
(153) was carried out by reaction of the cyclohept(b)indole
(153)with ethyl p-toluenesulphonate and sodium hydride in
boiling xylene to give 5-ethyl-6,7,8,9,10-hexahydrocyclohept(b)-
indole(282) .

Treatment of the 5-ethyl-6,7,8,9,10-hexahydrocyclohept(b)-
indole(282) with two equivalents of DDQ in aqueous
tetrahydrofuran at room temperature under a nitrogen
atmosphere readily gave 5-ethyl-6,7,8,9-tetrahydrocyclohept(b)-
indol-10(5H) -one (283) (Scheme 94) .

The infra-red absorption frequency of the carbonyl

group in the compound (283) is at 1645-1600 Cm^{-1} .

The ^{1}H n.m.r. spectrum shows thirteen protons in the alkane region and the multiplet at δ 8.4-8.2 p.p.m. is assumed to be H1 which was shifted downfield from the remainder of the aromatic protons at δ 7.1-7.0 due to the anisotropic deshielding effect of the carnonyl group in position ten.

Bromination of 5-ethyl-6,7,8,9-tetrahydrocyclohept(b)-indol-10(5H)-one (283) was best effected by treatment with phenyltrimethylammonium tribromide in tetrahydrofuran to give 6,6 -dibromo-6,7,8,9-tetrahydro-5-ethylcyclohept(b)indol-10(5H)--one (284) (Scheme 94) .

The mass spectrum of the dibromoketone(284) contained peaks at 432 , 430, and 428 (M^+) in the ratio 1:2:1 confirming that the compound contained two bromine atoms .

The ^{1}H n.m.r. specrum again showed a broadened triplet between δ3.2 and 2.8 p.p.m. attributed to the methylene groups at positions 6 and 8 .

Subsequent dehydrobromination of the dibromoketone (284) with anhydrous lithium chloride in boiling dimethylformamide gave 5-ethylcyclohept(b)indol-10(5H)-one (285)(Scheme 94) .

The mass spectrum shows the molecular ion to be at m/e 268 which is correct for the compound(285) .

The infra-red absorption spectrum has peaks at 1635, 1565 and 1480 Cm^{-1} .

The ^{1}H n.m.r. spectrum showed a multiplet with major coupling constant of ($J_{1,2}$=7.3 Hz) at lowest field at δ9.1-8.9 p.p.m. is considered to be H1 . A multiplet between δ 7.5 and 6.6 p.p.m. which integrates

for seven protons must then be due to the protons

around aromatic and the seven membered rings .

The carbonyl resonance in [13]C n.m.r. spectrum occurs

at δ182.7 p.p.m. consistent with a conjugated carbonyl,

all other resonances occurring in the aromatic and alkene

regions apart from two peaks at δ38.0 and δ 14.6 p.p.m.

due to methylene and methyl carbons .

Similarly 5-methylcyclohept(b)indol-10(5H)-one(289)

and cyclohept(b)indol-10(5H)-one(8) were also prepared

by oxidation,bromination and dehydrobromination sequences

from 5-methyl-6,7,8,9,10-hexahydrocyclohept(b)indole(286)

and 5,6,7,8,9,10-hexahydrocyclohept(b)indole(153)(Scheme 94).

Scheme 94

(282)	R=Et
(286)	R=CH$_3$
(153)	R=H

DDQ/THF

(283)	R=Et
(287)	R=CH$_3$
(154)	R=H

PTAB/THF

(284)	R=Et
(288)	R=CH$_3$
(290)	R=H

LiCl/DMF

(285)	R=Et
(289)	R=CH$_3$
(8)	R=H
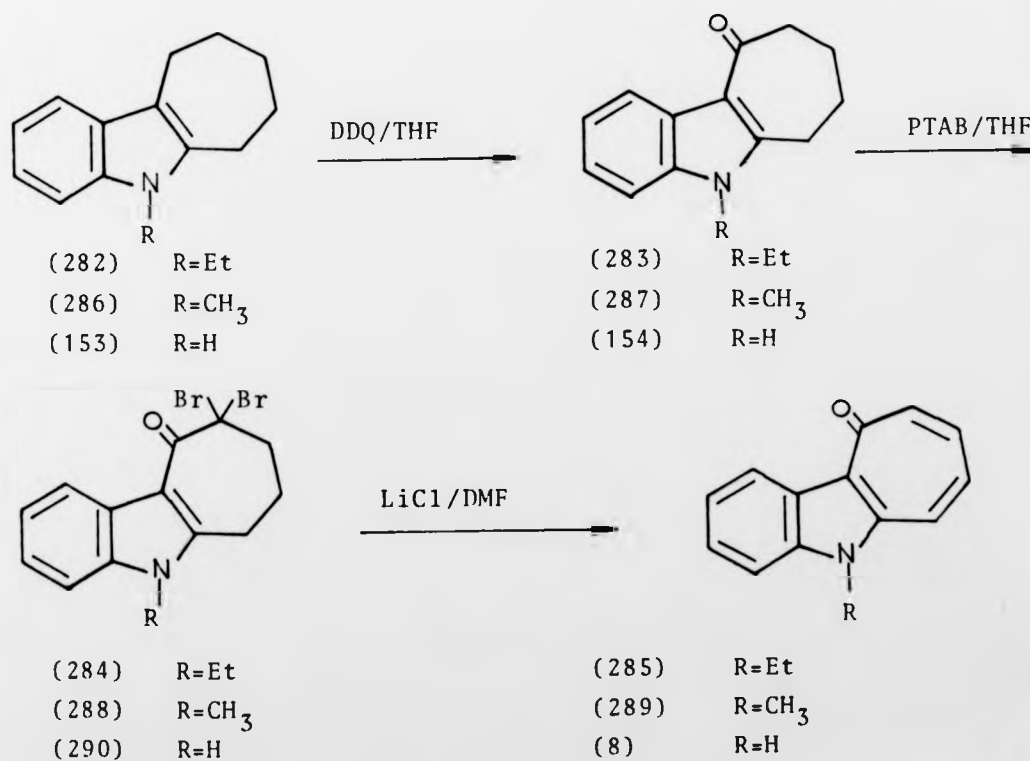
Synthesis of 4H-cyclohepta(b)furan-4-one(9)

As mentioned previously G. Jones et al [62] reported
a synthesis of 4H-cyclohepta(b)furan-4-one(9) . They used
Collington and G. Jones ' general synthesis of tropones [7] ,
via dehydrobromination of a 5,5-dibromo-ketone(182) using
lithium salts in boiling dimethylformamide (Scheme 48) .

In order to prepare 4H-cyclohepta(b)furan-4-one(9)
2-furaldehyde and acetaldehyde were employed as   starting
materials .

Condensation of 2-furaldehyde and acetaldehyde
in the presence of sodium hydroxide gave 2-furylacrylaldehyde[130]
(291)(Scheme 95) .

Condensation of 2-furylacrylaldehyde(291) with ethyl acetate
in the presence of sodium wire yielded ethyl 5-(2-furyl)-
pentadienoate [104] (292)(Scheme 95) .

The hydrogenation of 5-(2-furyl)pentadienonate(292) was
carried out using Raney nickel in ethanol to give
ethyl 5-(2-furyl)valerate [104] (293) (Scheme 95) .

The ^{1}H n.m.r. spectrum showed resonances for three protons
of furyl group and thirteen protons in alkane region.

The ethyl 5-(2-furyl)valerate (293) was hydrolysed
to 5-(2-furyl)valeric acid [105] (294)and then converted to the
5-(2-furyl)valeryl chloride [105] (180) by reaction with
thionyl chloride in diethyl ether .

Cyclisation of 5-(2-furyl)valeryl chloride (180) was carried out by reaction with tin tetrachloride in carbon disulfide to give 5,6,7,8-tetrahydro-4H-cyclohepta(b)furan--4-one [105] (181) (Scheme 95) .

Bromination of the ketone (181) was best effected by treatment with phenyltrimethylammonium tribromide to give 5,5-dibromo-5,6,7,8-tetrahydro-4H-cyclohepta(b)furan-4-one (182) [62] (Scheme 95) .

The ^{1}H n.m.r. again showed a broadened triplet between $\delta 3.2$ and 2.8 p.p.m. attributed to the methylene groups at positions 6 and 8 .

Dehydrobromination of the dibromo-ketone (182) was carried out with lithium carbonate in boiling dimethylformamide to give 4H-cyclohepta(b)furan-4-one(8) [62] (Scheme 95) .

The ^{1}H n.m.r. spectrum showed two doublets at δ 7.4 and 7.2 p.p.m. due to the protons at positions 2 and 3. Two doublet of doublets at $\delta 7.4$ and 7.1 p.p.m. due to the protons at positions 8 and 5 , and finally two multiplets centred at $\delta 7.25$ and 6.85 p.p.m. due to the protons at positions 6 and 7 respectively .

Scheme 95
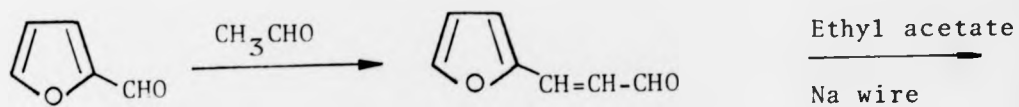
(291)
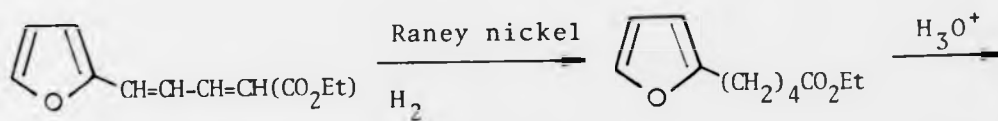
(292)   (293)
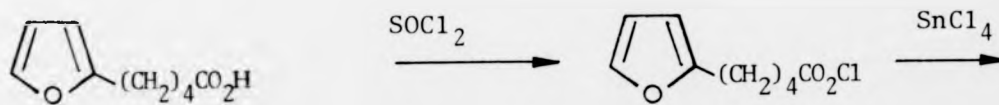
(294)   (180)
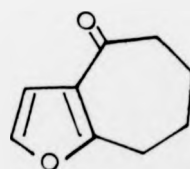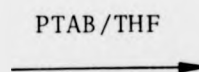
(181)   (182)
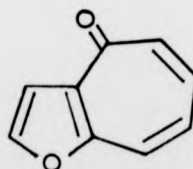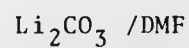
(9)

Chapter 3

Introduction

A review of the previous photochemistry of
tropones and annulated tropones .

Photochemistry

The review of the photochemistry or a number of tropones , substituted benztropones , and tropones with fused hetero rings follows .

Colchicine

The first reported photochemistry reaction of a troponoid compound was published in 1865 when Hubler [106] reported that solutions of colchicine (295) turned brown on standing in sunlight .

Later Forbes [107] in 1955 reported the photochemical isomerization of colchicine (295) . Colchicine is one of the more complex tropolones , and was converted in aqueous solution by sunlight into three photoisomers , the β- and γ- lumicolchicines(296),(297) and the α-isomer . These results demonstrate that the tropolone ring has been involved in the transformation (Scheme 96).

It is necessary to consider first the photochemistry of much simpler troponoid compounds in order to learn what sort of transformations are allowed .

Scheme 96

(295)

Sunlight

8 to 10 weeks
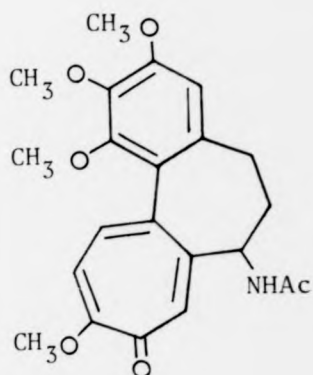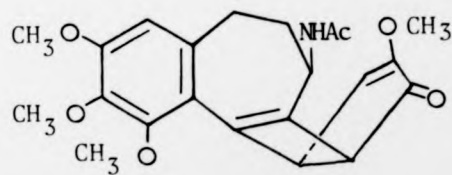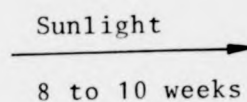
β-Lumicolchicine

(296)
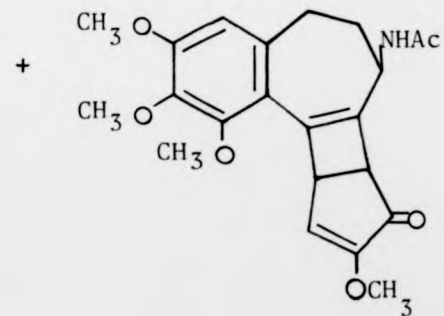
γ-Lumicolchicine

(297)

-124-

α-Tropolone methyl ether

In 1960 Forbes and Ripley [108] reported the photolysis of α-tropolone methyl ether (298) in aqueous solution to give the methyl ester of 4-oxo-2-cyclopentene-1-acetic acid (299) (Scheme 97) .

Scheme 97

(298)   (299)
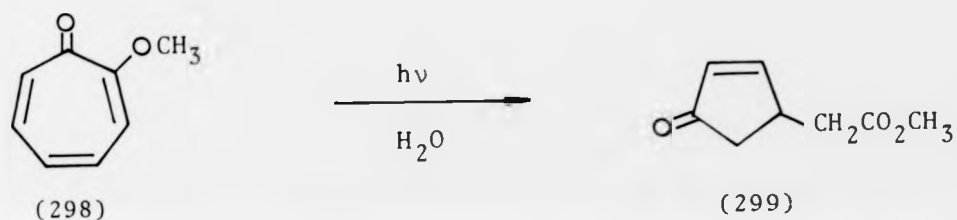
Dauben et al [109] subsequently reported that the irradiation of α-tropolone methyl ether (298) in methanol gave rise initially to a bicyclic system(300) of the type predicted by Chapman and Pasto [110] which underwent rearrangement to another bicyclic system(301).Addition of water followed by further irradiation leads to formation of the methyl ester compound(299) as previously reported by Forbes and Ripley [108] (Scheme 98) .

Scheme 98

(298)   (300)

(301)   (299)
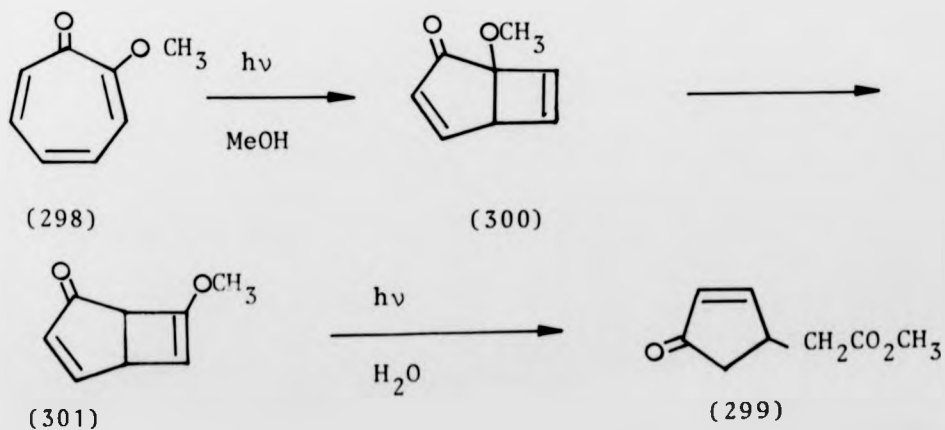
The mechanism for this sequence of reactions is defined clearly by the photochemical rearrangements of 4-methyltropolone methyl ether (302) and 6-methyltropolone methyl ether (303) . They gave ketoester products (304) and (305) under similar conditions. The mechanism is shown in Scheme (99) .

Scheme 99

(298) R=H R^1=H
(302) R=Me R^1=H
(303) R=H R^1=Me

(305) R=H R^1=Me
(299) R=H R^1=H
(304) R=Me R^1=H
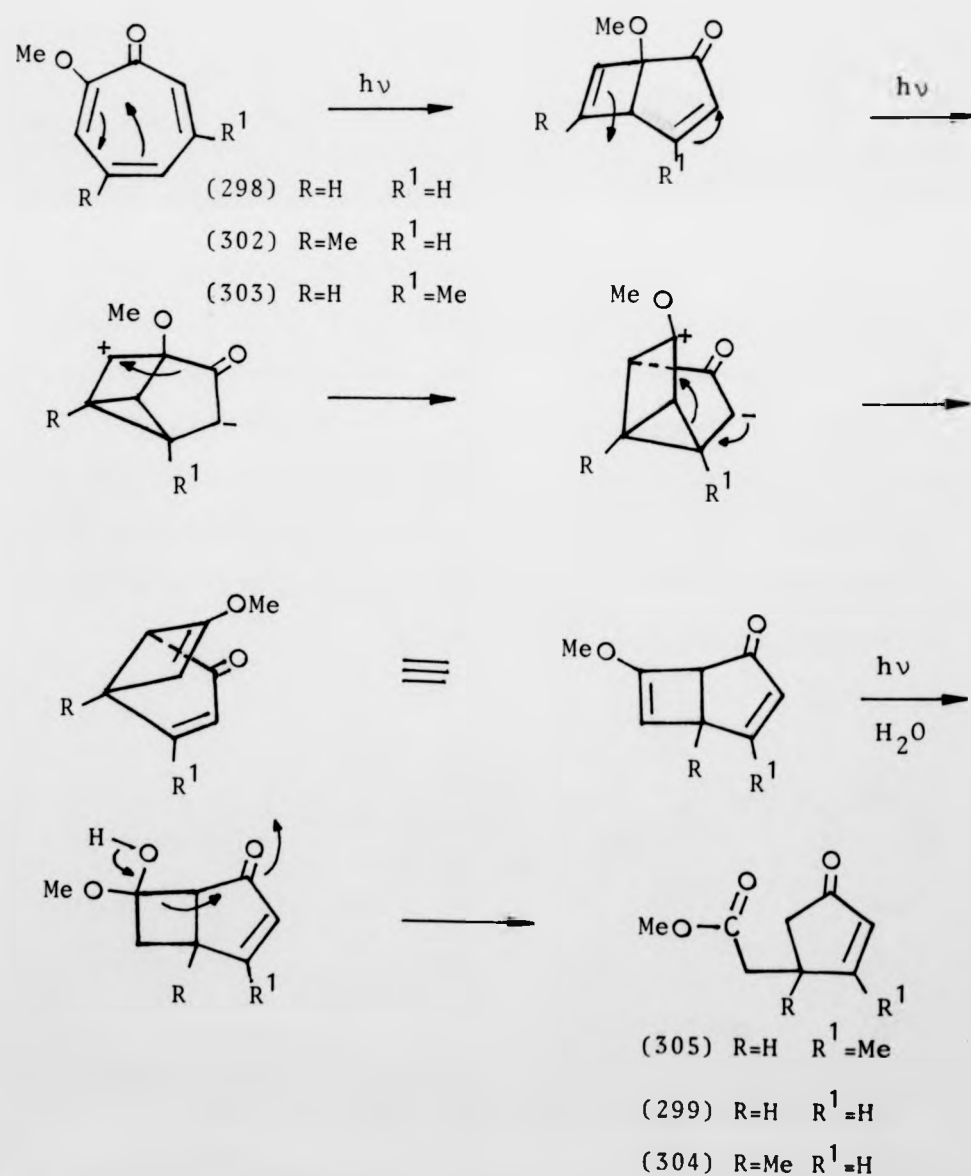
Further investigations of these photolyses by Chapman and Lassila [111] in 1968 have shown that the 1-methoxy-3,6-bicyclo(3,2,0)heptadiene-2-one(300) could undergo photochemical rearrangement to the 7-methoxy-3,6-bicyclo(3,2,0)heptadiene-2-one(301)via a ketene intermediate(306).The presence of such an intermediate(306) was indicated by the appearance of a band in the infra-red spectrum of the reaction mixture at 2118 Cm^{-1}, which appeared after two minutes ' irradiation and reached a maximum after 1 to 3 hours.This band was observable only when the photolysis was carried out at temperatures below -70 ^{0}C (Scheme 100) .

Scheme 100

(300)   (306)

(301)
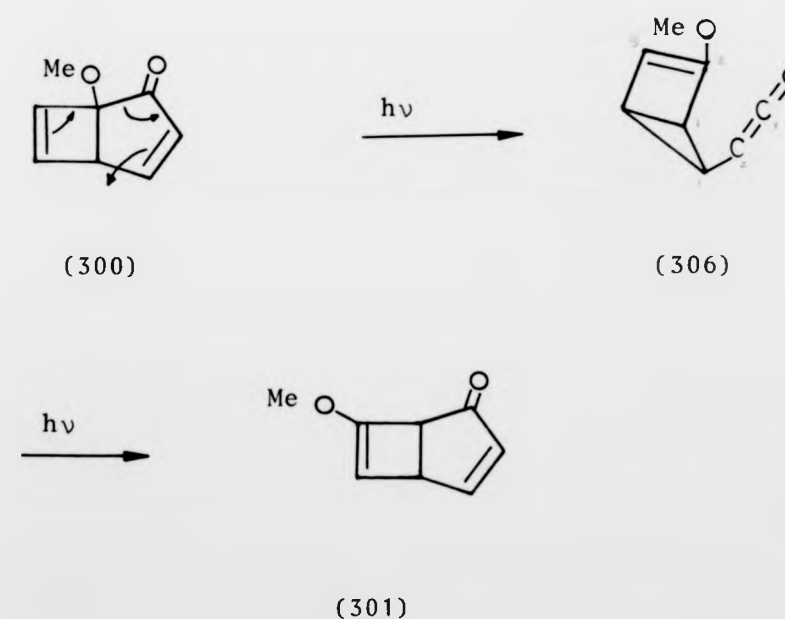
γ-Tropolone methyl ether

γ-Tropolone methyl ether (307) was reported by
Chapman and Pasto[110] to give one product,5-methoxy-3,6-
-bicyclo(3,2,0)heptadiene-2-one(309),plus a quantity of
polymeric material.The mechanism proposed could in principle
lead to either of the two bicyclic ketones(309) and(311),
but it was felt that the intermediate (308) would be stabilised
by having the positive charge on the carbon atom carrying the
methoxyl group,whereas the intermediate(310) would not,and
this difference accounted for the formation of only one
bicyclic ketone(309) in this case (Scheme 101) .

Scheme 101
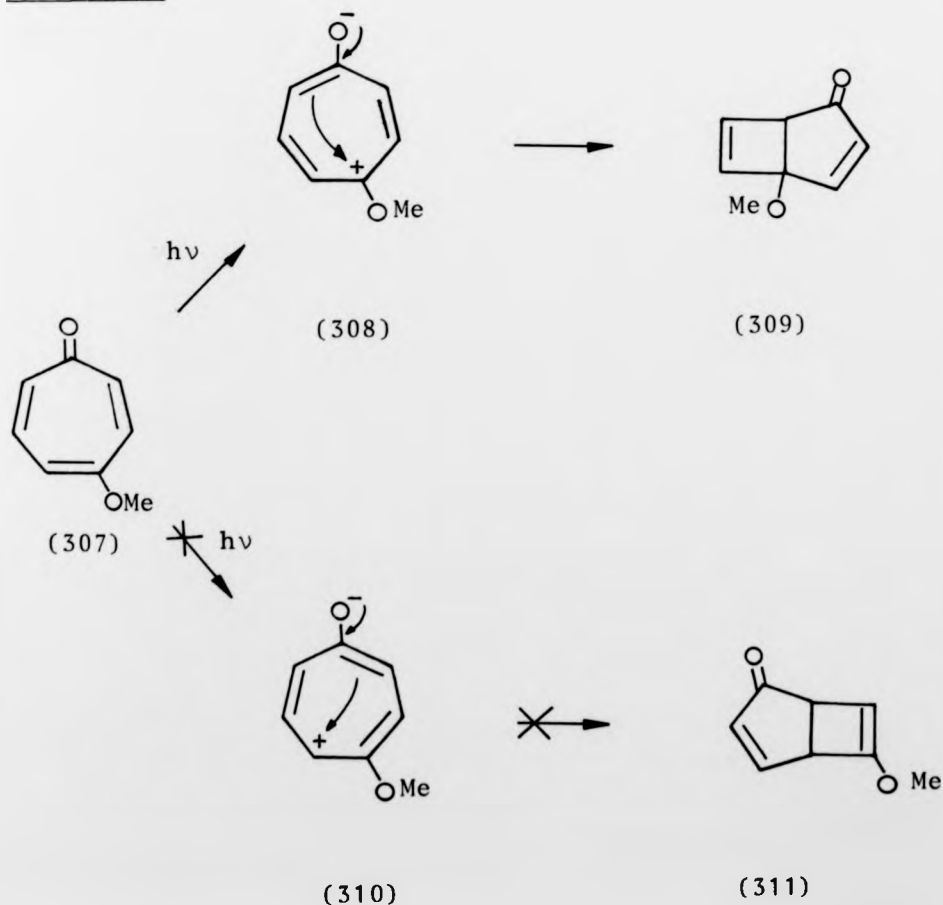
It is worthwhile to mention that neither
β-tropolone methyl ether nor tropone itself undergo the
photoisomerisation described above .

Tropone

In spite of the use of a variety of solvents for the
photolysis of tropone(312) itself ,to date no simple
bicyclic photoproducts have been isolated . On the other
hand, a large number of photodimers have been identified .

In 1966 Mukai et al [112] reported the first example
of (6+6) π-type cycloaddition of tropone(312). In 2N sulfuric
acid or water,tropone dimerizes in low yield (7.5 %) to the
trans diketone(313) . This dimer is converted back to tropone
(312) thermally in 60% yield (Scheme 102) .

Photodimerization of tropone (312) in acetonitrile
was reported by Kende [113] in 1966 , but the (6+6) dimer
is not obtained.Three products , the (6+4)(314) , (6+2)(315),
and (4+2)(316) cycloadducts, are formed instead (Scheme 102).
Upon heating , dimer (314) reverts to tropone, while
neither dimer(315) nor dimer (316) undergo thermal conversion
to tropone (Scheme 102) .

Scheme 102

(312)

hν
CH₃CN

hν
Δ
H₂O or H₂SO₄

+ (314)

(313)

+ (315)

(316)
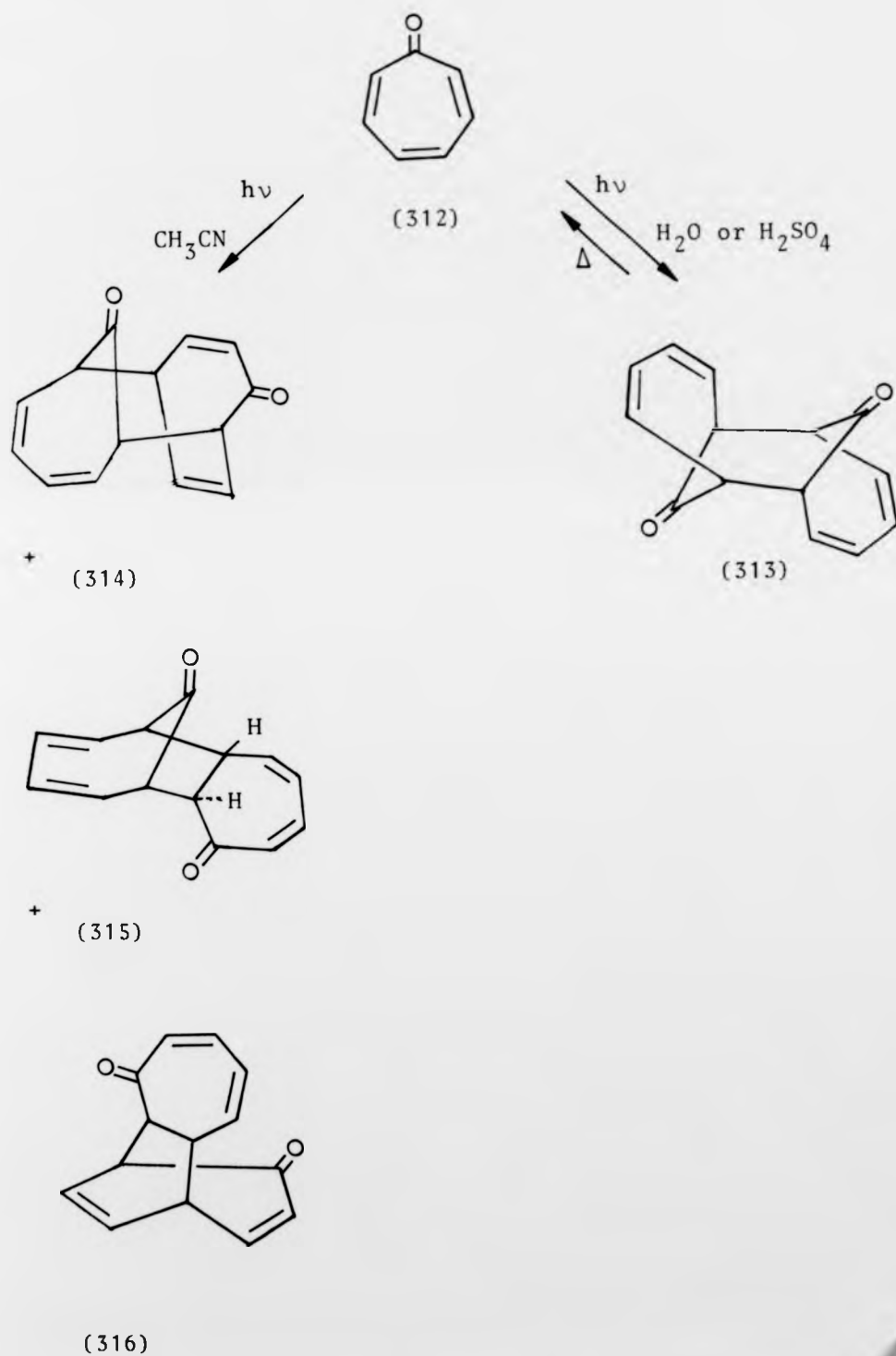
2,3,6-Trimethoxy-5H-benzocyclohepten-5-one and

2,3,4,6-tetramethoxy-5H-benzocyclohepten-5-one

Forbes and Griffiths [114] in 1966 found that irradiation
of an ethanolic solution of the 2,3,6-trimethoxy-5H-benzo-
cyclohepten-5-one(317) under nitrogen gave a complex mixture
of products, from which was isolated the photoisomer(318)(Scheme 103).
Later work by Forbes et al [115] showed that irradiation
of 2,3,4,6-tetramethoxy-5H-benzocyclohepten-5-one(319) in an
aprotic solvent (benzene , cyclohexane or methylene chloride)
under nitrogen gave the tricyclic ketone (320) as a major
product (Scheme 103) .

Scheme 103

(317)   R=H

(319)   R=OMe

(318) R=R^2=H   R^1=OMe

(320) R=R^2=OMe   R^1=H
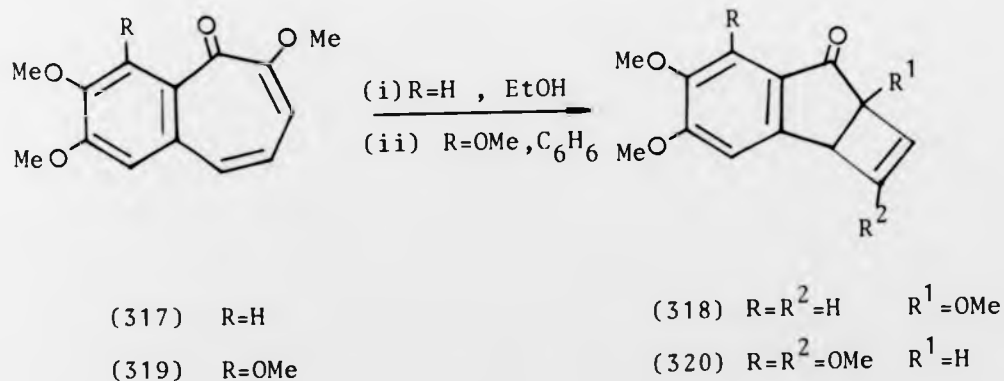
5H-Benzocyclohepten-5-one

In 1969 Collington and G. Jones [83] reported the
first photoisomerization of an unsubstituted annulated
tropone. Irradiation of methanolic solution of 5H-benzo-
cyclohepten-5-one(1) with a mercury-vapour lamp gave the
2a,7a-dihydrocyclobut(a)inden-7-one(321) and a dimer of
as yet undetermined structure (Scheme 104)

Scheme 104

(1)   (321)
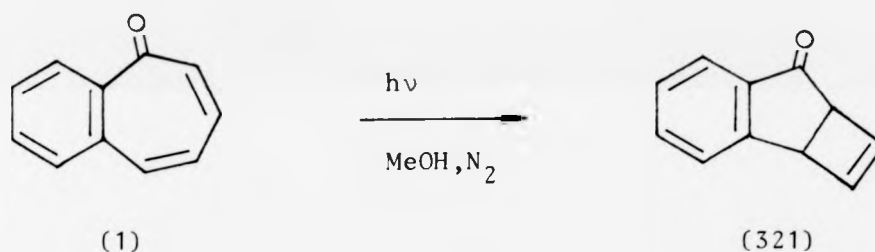
6-Hydroxy-5H-benzocyclohepten-5-one

In 1970 Ebine et al [116] reported a new type of
photochemical valence isomerization of 6-hydroxy-5H-benzo-
cyclohepten-5-one(322). Irradiation of a dilute solutions of
compound(322) in methanol with pyrex filtered light resulted in the
formation of an unusual isomer of structure(323).This reaction
represents a novel type of photorearrangement of
6-hydroxy-benzocyclohepten-5-one(322) and may be explained
either by the initial formation of(324) followed by rearrangement
to(323),or by a mechanism in which(325) is postulated as an
intermediate(Scheme 105) .

Scheme 105

(322)

hν
─────────────
Dilute solution of
MeOH

(323)

(324)

(325)
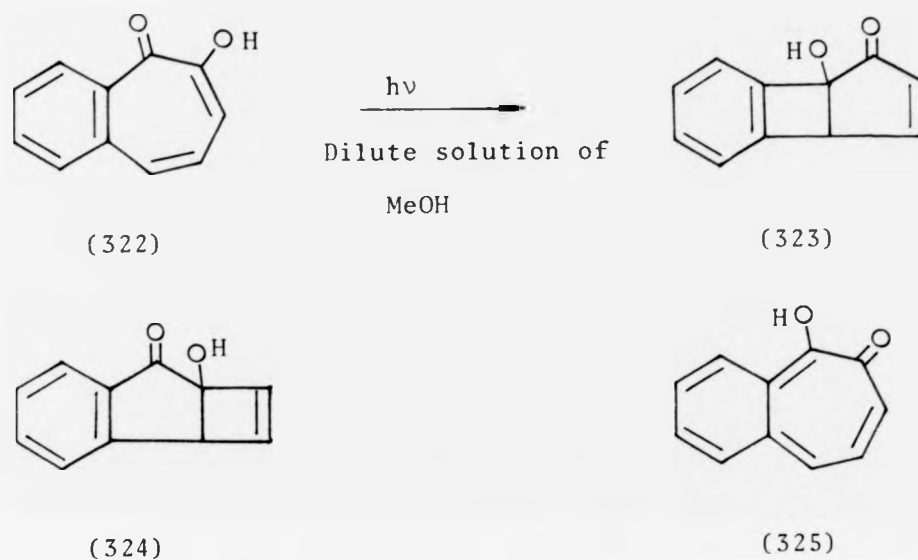
7-Hydroxy-5H-benzocyclohepten-5-one

In 1971 Yoshioka and Hoshino[117] reported the irradiation of 7-hydroxy-5H-benzocyclohepten-5-one(326). Irradiation of the benztropone(326) in methanol gave the ester (327) with a small amount of the polycyclic ketone (328)(Scheme 106).

Scheme 106

(326)   (327)   (328)
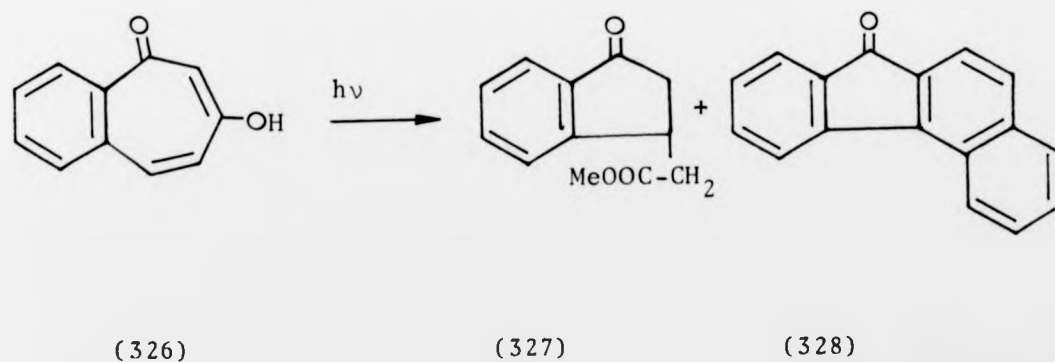
A mechanism for the formation of the ester(327) was postulated, addition of methanol to the tricyclic ketone(329) followed by a rearrangement gave the ester(327)(Scheme 107).

Scheme 107
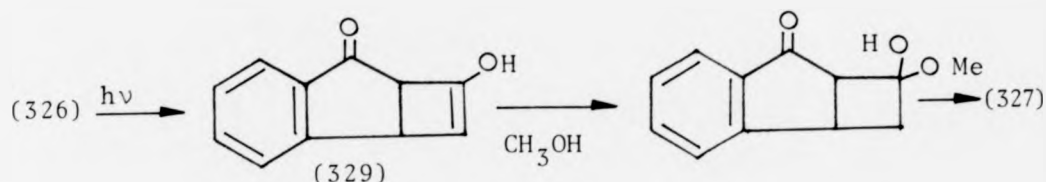
Cyclohepta(b)thiophen-4-ones

In 1977 G. Jones and Robinson [68] reported the photochemistry of some cyclohepta(b)thiophen-4-ones (203), (204),(330) and (334) .

Irradiation of methanolic solutions of the cyclohepta(b)thiophen-4-ones(203),(204) and (330) gave ($\pi_4 + \pi_2$) dimers (331-333), formed by the reaction of the 5,6-bond of the thienotropone with the 5,7-diene system of another . The dimers were found to be of the head-to-head type having a trans junction (Scheme 108) .

Scheme 108

(203)	$R=R^1=R^2=H$	(331)
(330)	$R=R^1=H$ $R^2=Me$	(332)
(204)	$R=Me$ $R^1=R^2=H$	(333)
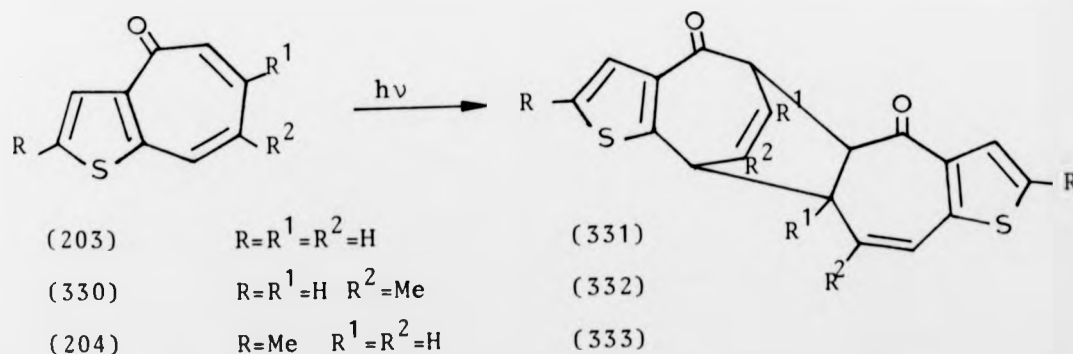
Irradiation of 2,6-dimethylcyclohepta(b)thiophen-4-one (334) leads to an intramolecular electrocyclic disrotatory reaction,giving the tricyclic ketone(335),which provided indirect evidence that the 5,6-bond is involved in dimer formation,since a 6-methyl group is seen to suppress dimerisation (Scheme 109) .

Scheme 109

(334)   (335)
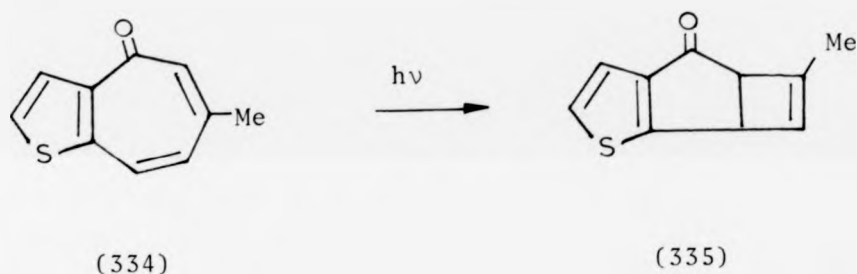
Pyridotropones

Recently M. G. Hicks and G. Jones [74] have studied the photochemistry of some pyridotropones. On irradiation the pyridotropones(11a,12a,225 and 228) were shown to be largely unreative.Three of the four isomers gave only polymeric material ,the 5H-cyclohepta(b)pyridin-5-one(12a) gave a dimer of as yet undetermined structure .Thus it appears that the nitrogen atom causes too much deactivation for the ring closure reaction to occur .

6-Methyl-7H-benzocyclohepten-7-one

Mukai and et al[118] studied the photochemistry of
6-methyl-7H-benzocyclohepten-7-one(336).

Irradiation of the benztropone(336) gives the $(\pi_2+\pi_2)$
dimer (337) and the dehydrogenated product(338) .The dimerisation
is not solvent sensitive , since a variety of solvents give
the same products in identical yield (Scheme 110) .

Scheme 110

(336)   (337)   +

(338)
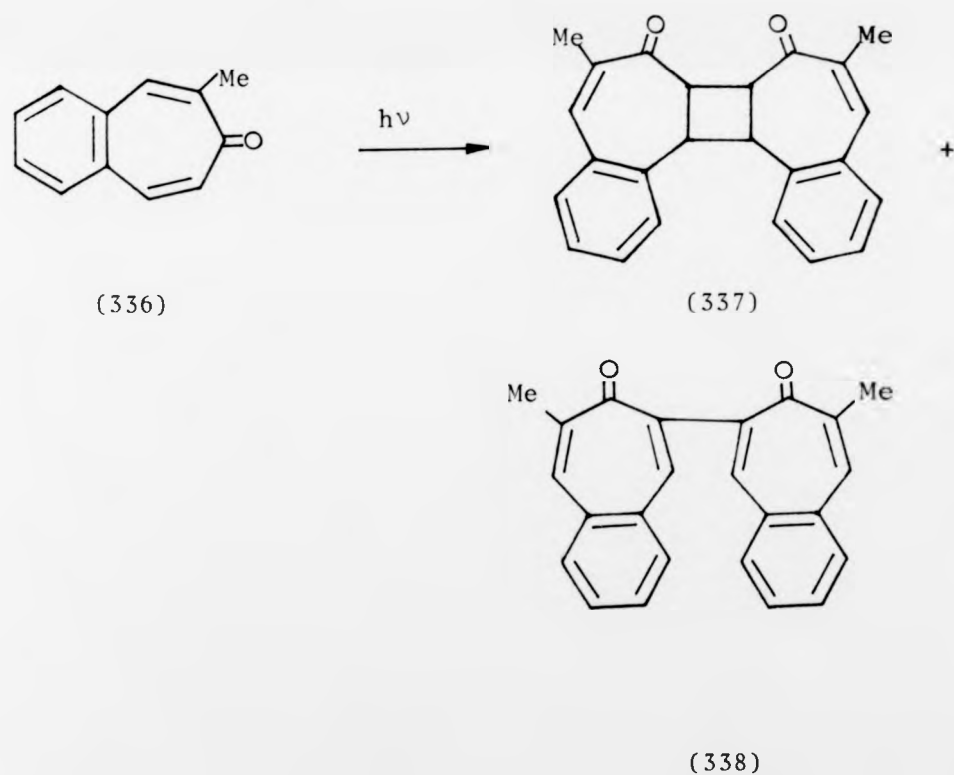
Chapter 4

Results and discussion

Apart from a communication by Collington and G. Jones[83] on the unsubstituted 5H-benzocyclohepten-5-one(1) the photosensitivity of substituted 5H-benzocyclohepten-5-ones and of tropones with fused hetero rings appears to have passed unreported .For closer study of photo-reactivity of a number of substituted benztropones and related hetero compounds has been investigated.The photochemical results are as follows :

1-Methoxy-4-methyl-5H-benzocyclohepten-5-one (268)

A solution of 1-methoxy-4-methyl-5H-benzocylohepten-5-one (268) in absolute methanol was irradiated with a Hanovia medium pressure mercury lamp while the flask was flushed with nitrogen.Samples were taken and evaporated at intervals for t.l.c. and ^{1}H n.m.r. examination .Irradiation was stopped after 26 hours when the concentration of new component remained constant.Removal of the solvent under reduced pressure gave a brown gum which was triturated with dried diethyl ether and then filtered .The combined filtrates was evaporated to give a pale yellow solid which was chromatographed on preparative plates using toluene /ethyl acetate (80:20) as eluent; some 3-methoxy-6-methyl-2a,7a-dihydrocyclobut(a)inden-7-one(339) was found in addition to polymeric material left on the base line (Scheme 111) .

The major photoproduct(339) had a molecular weight of 200 and was hence an isomer of compound (268) .

The tricylic compound(339) showed characteristically high frequency carbonyl absorption at 1700 Cm^{-1} .

The two doublets δ 7.1-7.0 and 6.9-6.8 p.p.m.
can be attributed to the protons at positions five and
four respectively . Spin decoupling of any of the four
separated protons at positions 2,1,2a,7a causes simplification
of the other three protons, for example irradiation at
δ 3.78-3.74 p.p.m. (H7a) causes the distorted octet(ddd)
at δ 6.65-6.62 p.p.m. to collapse to doublet of doublets
which could be attributed to the proton at position two
by analogy with similar structures [83,119] , and also collapses
the doublet of doublets at δ 6.35-6.31 p.p.m. (H1)
to a doublet and changes the signal due to the proton at position
2a (δ 4.3-3.2 p.p.m.) .Spin decoupling of the signal due to
the proton at position 2 causes the distorted octet (ddd,H7a)
to collapse to a distinguishable doublet of doublets
as well as simplifying the signals for the other two protons.
Thus the two distorted octets at δ 6.65-6.62 p.p.m. and
δ 3.78-3.74 p.p.m. are both doublets of doublets of doublets.
Significantly irradiation of the proton at position 2a causes
no changes on proton at position 1 ; this indicated that the
coupling constant of proton 1 and 2a is undetectable.
Thus result the following coupling constants $J_{2,1}$=2.44 Hz
$J_{2,2a}$=0.85 Hz ,$J_{2,7a}$=very small ,$J_{7a,1}$=0.85 Hz and
$J_{7a,2a}$=2.80 Hz .

The fully decoupled ^{13}C spectrum shows that there are
thirteen carbon atoms present in the molecule.Comparison with
the off resonance decoupled spectrum gives five quaternary
carbon atoms .The two farthest downfield signals are both

due to quaternary carbon atoms, which occur at
δ 203.7 p.p.m. consistent with carbonyl carbon resonance,
and at δ154.5 p.p.m. due to quaternary aromatic carbon 3
bonded to the methoxyl group .

Scheme 111

(268)　　　　　　　　　　　　　　　　(339)
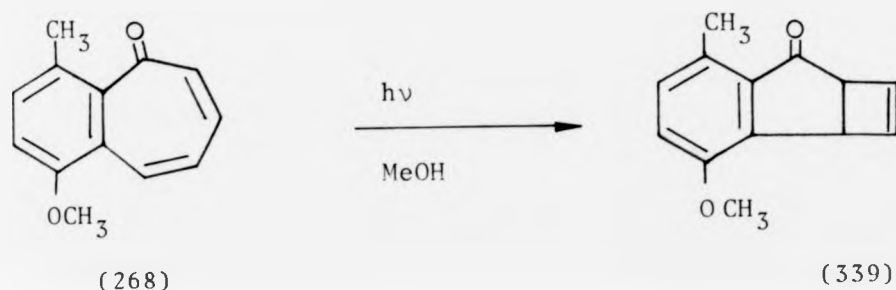
2-Methoxy-5H-benzocyclohepten-5-one(11)　and its 6-bromo derivative

On irradiation the 2-methoxybenztropone(11) and
2-methoxy-6-bromo-5H-benzocyclohepten-5-one(247) were shown
to be largely unreactive .Thus it appears that when the methoxyl
group is meta to C9 there is insufficient activation for the
ring closure to occur . On repetition of irradiation for
several times ,on one occasion only was a trace amount of
4-methoxy-2a,7a-dihydrocyclobut(a)inden-7-one(340) detected
(Scheme 112) .

The infra-red spectrum of the photoisomer(340)
showed a carbonyl stretching frequency at 1702 Cm^{-1} which
could be compared with that of 1-indanone [120] at 1710 Cm^{-1}.

The [1]H n.m.r. spectrum is also consistent with compound
being the tricyclic ketone(340) .

-140-

Scheme 112

(11)　　　　　　　　　　　　　　　(340)
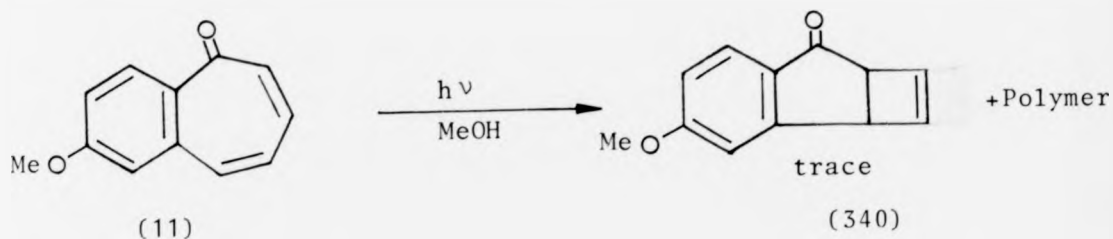
3-Methoxy-5H-benzocyclohepten-5-one (234)

Irradiation of the 3-methoxybenztropone (234) was
carried out for 48 hours in a solution of methanol under a
nitrogen atmosphere . Over this period the solution turned
cloudy ; the precipitate however proved to be polymeric
material. The solid material recovered from the ether extract
was a yellow waxy compound and subsequently was purified by
bulb distillation to give the photoproduct(341) (Scheme 113).

The compound(341) had a molecular weight of 186
and was hence an isomer of compound(234).

The tricyclic compound(341)showed characteristically
high frequency carbonyl absorption at 1700 Cm^{-1} which is
also consistent with the compound(341) .

The ^{1}H n.m.r. spectrum of the pure material was comparable
with those of the other tricyclic compounds previously described.

Scheme 113

(234)　　　　　　　　　　　　　　　(341)
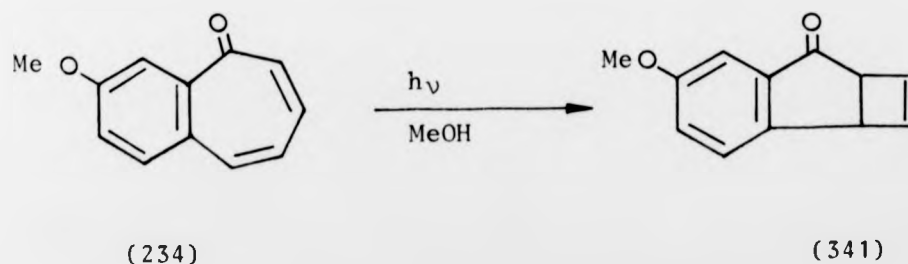
3-Acetamido-5H-benzocyclohepten-5-one (21) and

5H-benzocyclohepten-5-one (1)

A methanolic solution of the 3-acetamidobenztropone (21) was irradiated using a Hanovia medium pressure mecury lamp. Irradiation was stopped when the photochemical product concentration remained constant. The pure 5-acetamido- -2a,7a-dihydrocyclobut(a)inden-7-one (342) was separated on preparative plates from polymeric material ,which was mostly left on the base line (Scheme 114) .

The compound (342) showed a molecular weight of 213 and was hence an isomer of compound(21).

The infra-red absorption frequency of the carbonyl group in the tricyclic compound was at 1710 Cm^{-1} .

From the ^1H n.m.r. spectrum it was possible to assign individually all the protons around the tricyclic compound(342). The doublet of doublets ($J_{3,4}$=8.3 Hz and $J_{6,4}$=2Hz) at δ 8.0-7.9 p.p.m. is considered to be the proton at position four. The two doublets at δ 7.7 and δ 7.4-7.3 p.p.m. are assigned to the protons at positions six and three respectively . The broad doublet of doublets at δ 6.29-6.26 p.p.m. was assigned to the proton at position one with coupling constants of $J_{1,2}$=2.5 Hz and $J_{1,7a}$=0.98 Hz . The doublet at δ 6.59-6.56 p.p.m· was considered to be the proton at position two with a major coupling constant of $J_{1,2}$=2.5 Hz. Another broad doublet of doublets at highest field δ 3.82-3.79 p.p.m. was assigned to the proton at position **7a**

with coupling constants of $J_{7a,2a}=2.9$ Hz and $J_{7a,1}=0.98$ Hz . The broad doublet at $\delta 4.29-4.26$ p.p.m. must then be due to proton at position 2a .

The fully decoupled ^{13}C spectrum shows that there are thirteen carbon atoms present in the molecule. Comparison with the off-resonance decoupled spectrum gives five quaternary carbon atoms . The three signals furthest downfield are due to quaternary carbon atoms ,in which the carbonyl resonances occur at $\delta 201.9$ and 169.0 p.p.m. consistent with carbon at position seven and the carbonyl group of the acetamide respectively , and at $\delta 146.5$ p.p.m. due to the quaternary aromatic carbon of position five , bonded to the acetamido group .

Scheme 114

(21)   (342)
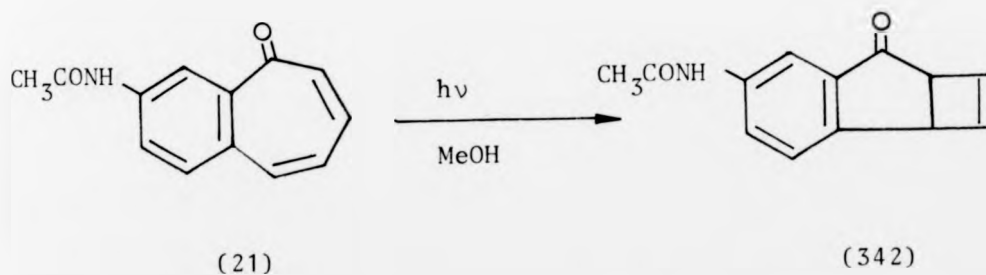
Irradiation of 5H-benzocyclohepten-5-one (1) also gave the 2a,7a-dihydrocyclobut(b)inden-7-one (321) as reported by Collington and G. Jones [85] (Scheme 104) .

Other substituted 5H-benzocyclohepten-5-ones and

the tropones with fused hetero rings

When a methanolic solution of 3-nitro-5H-benzo-
cyclohepten-5-one (20) or 6,8-dinitro-5H-benzocyclohepten-
-5-one(269) was irradiated under similar conditions , the
product after work up showed some starting material   and
polymeric material   however in the cases of 3-amino-   or
3-amino-2,4-dibromo-5H-benzocyclohepten-5-one(270) and (272),
3-phenylcyclohepta(b)pyrrol-8-one(141) and its methyl
derivative (281) ,cyclohept(b)indol-10(5H)-one(8) and
its methyl and ethyl derivatives (289) and (285) and finally
4H-cyclohepta(b)furan-4-one(9) only polymeric material
were formed .

Conclusion

Examination of the results which we have obtained
from irradiation of annulated tropones has demonstrated
a differential photoreactivity within a class of annulated
tropones. The methoxybenztropones (268,11,247 and 234)
appear to show an alternating effect , dependent on the
position of the methoxyl group . When the methoxyl group is
in a position where the groups electron-donating ability
can influence the alkene chain, that is , ortho or para to
C9 the photoreaction is enhanced . When the methoxyl group
is meta to C9 the photoreaction is suppressed and proceeds
slowly in poor yield . Similar differential reactivity has been
known for a long time in the photochemistry of tropolone
methyl ethers . On irradiation α- and γ-tropolone methyl ethers
(298,307) give bicyclic photoproducts (300,309) whereas
β-tropolone methyl ether (343) shows no such reaction .
Chapman has attributed this differential reactivety to the
possible stabilization of a dipolar intermediate (344,345)
by methoxyl group (Scheme 115) . In the cases of
α- and γ-tropolone methyl ethers (298 and 307) collapse of
the intermediate gives the observed photoproducts .

Scheme 115

(298)   (344)   (300)

(307)   (345)   (309)

(343)   (344)
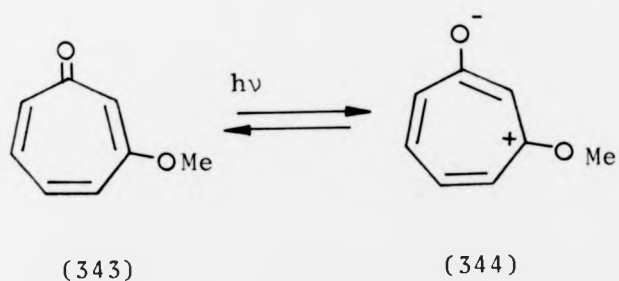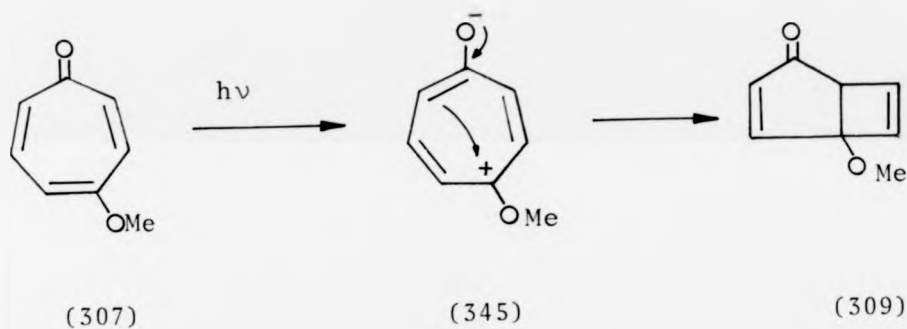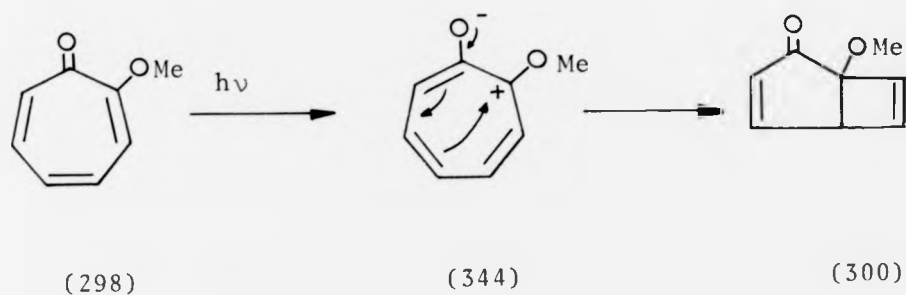
If one can postulate that similar zwitterionic
intermediates exist   for the methoxytropones (268),(11),(247)
and (234) ; the photoproducts would be in good agreement
with those of tropolone methyl ethers (Scheme 116) .

In the case of the aminobenztropone(270)which apparently does not fit with the above suggestion, one may suppose that the intermediate   would by futher consecutive reactions proceed towards polymer .

In the case of the nitrobenztropone(20) again it is very obviously rationalized through the intermediate (347) much less stabilised than those of the methoxybenztropones (345) and (346)(Scheme 116) .

If electron-donating ability of the aminobenztropone (270) is reduced by converting the amino group to an acetamido group,the photoproduct also seems to modify from polymer to tricyclic ketone (342).This may indicate that very electron-donating groups such as the amino group and very electron-withdrawing groups such as the nitro group can both suppress the course of reaction towards the desired photoproducts whereas the moderate electron-donating groups such as methoxyl or acetamido would enhance the reaction towards the desired tricyclic ketone .

In the case of the aminodibromobenztropone(272) it might first converted to the aminobenztropone(270) and then polymerized since Soumillion and Wolf [127] have shown that the chlorobenzene can undergo photoreduction to benzene in methanol . It is worthwhile to mention that no trace of the aminobenztropone(270) could be detected when the aminodibromobenztropone(272) was irradiated .

Reduction of the nitrobenzene derivatives to the corresponding aminobenzene derivatives are also known [128] but during the irradiation of the nitrobenztropone(20) no trace of the aminobenztropone(270) could be detected .

Scheme 116

(345)

(346)

(347)
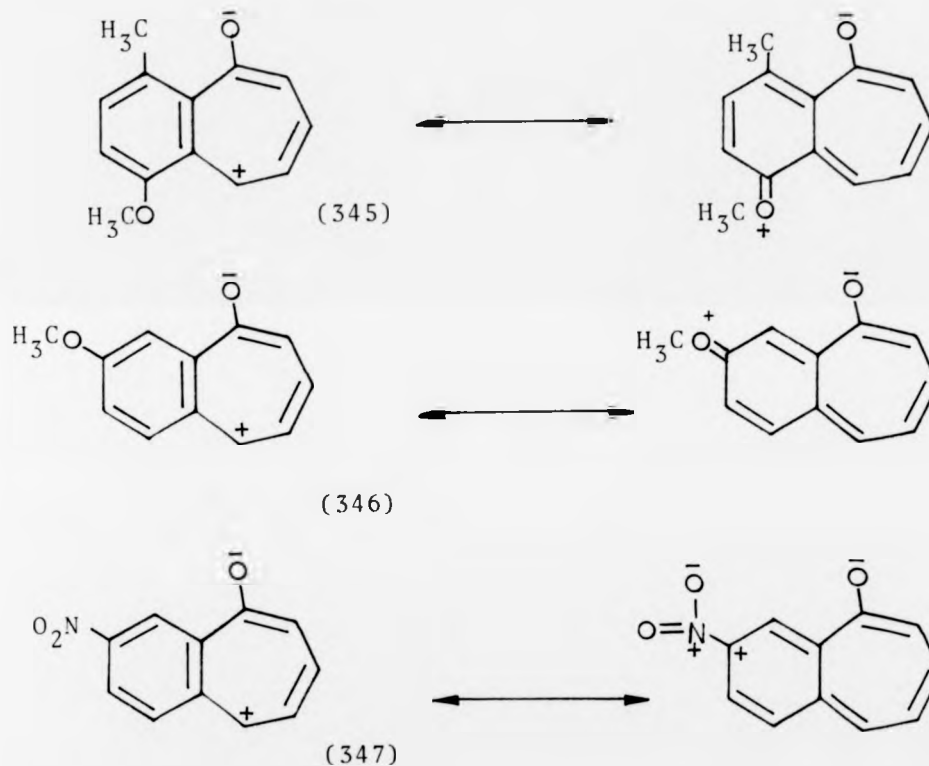
On irradiation the pyrrolotropones (141 and 281), indolotropones(8,285 and 289) and the furotropone(9) yielded only polymeric materials.Since the pyrrolotropones(141) and (281) and the furotropone(9)are like the thienotropones(203), (204) and (330),electron rich they might have been expected to be photoreactive. Similar resonance structures to those

shown for the methoxybenztropones(Scheme 116) can be drawn
for the furotropone (9) (Scheme 117) or pyrrolotropones
(141 and 281)or indolotropones(8,285 and 289),but pyrroles
and furans are generally accepted as having a more localized
elecron distribution than thiophens and as having more
diene character , and then may lead to a greater tendency to
polymerisation ,which compete successfully with the
electrocyclization.

Scheme 117
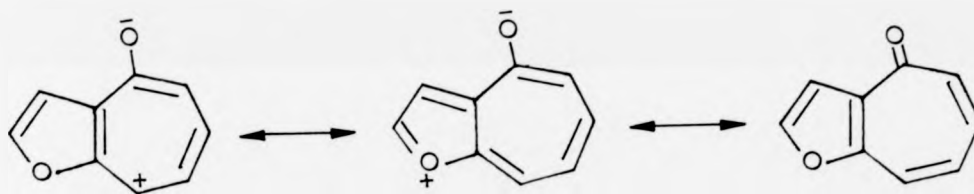
(9)

Chapter 5

Experimental
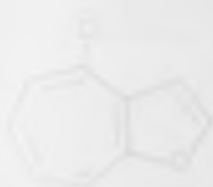
Preliminary notes

Melting points were determined on a Kofler hot-stage apparatus and are uncorrected.

Infrared absorption spectra were recorded on a Perkin-Elmer 420 spectrophotometer.Solids were recorded either as solutions or as potassium bromide discs or as nujol mulls .

Nuclear magnetic spectra were routinely measured on a Hitachi Perkin-Elmer R.24 and / or R.24 B instrument at 60 MHz .

Carbon 13 n.m.r. spectra and proton n.m.r. spectra at 100 MHz were recorded on a Jeol FX100 Fourier Transform instrument . Chemical shift values are quoted in delta (δ) values in p.p.m. with respect to tetramethyl silane as internal standard.

Mass spectra were recorded on a Hitachi Perkin-Elmer RMU-6 instrument and A.E.I. MS12 instrument.Exact mass measurements were carried out by PCMU (Harwell) .

Micro-analyses were carried out on a Perkin-Elmer 240 carbon/hydrogen/nitrogen analyser.

Ultraviolet and visible absorption spectra were recorded on a Perkin-Elmer 402 spectrophotometer .

Column chromatography was carried out using either silica gel (60-120 mesh) or Woelm alumina (neutral grade) . The activity values quoted refer to the Brockmann scale .

Thin layer chromatography was carried out on 20 X 5 Cm glass plates coated with Merck Kieselgel HF_{254}.   components were visualized under U.V. light.Preparative layer chromatography (P.L.C.) was performed on 40 X 20 Cm glass plates coated with a 1.5 mm layer of Kieselgel HF $_{254}$.   .The separate

components were visualized under U.V. light ,scraped off
the plates and extracted three times with boiling methanol.
The methanol solution was evaporated ,the residue taken up in
dichloromethane,filtered and evaporated .

Abbreviations used :

s	singlet
d	doublet
dd	doublet of doublets
t	triplet
q	quartet
m	multiplet

3- Methoxycinnamylidenemalonic acid (237)

A solution of sodium hydroxide (17 g) in methanol (170 ml) was added to a flask containing benzyltrimethylammonium hydroxide (77.6 g) .The solution was left to stand overnight.It was then filtered by suction,and sodium chloride formed as by-product was washed with a small portion of methanol.m-Methoxybenzaldehyde (11.8 g) and diethyl ethylidenemalonate[78] (36.6 g) were added to the above base.The flask was swirled,and stirred for 48 hrs at room temperature.It was then diluted with 500 ml of water,refluxed for 2 hrs,cooled and acidified with hydrochloric acid.After standing at 5 ^{0}C for 24 hrs,yellow crystals were obtained. These were filtered,washed with cold water and dried on a steam bath.Purification of crude crystals by crystallization from benzene-ethyl acetate (25:75) gave the compound (237) as canary yellow crystals (23.9 g, 99%).

m.p. 201-202 ^{0}C Lit[79] 202 ^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

11.5	s	2H	$(CO_2H)_2$
8.45-6.88	m	7H	Other protons
3.9	s	3H	OCH_3

I.R.ν_{max} (Nujol) 1700(CO),1600 and 1230 cm^{-1}

3-(m-Methoxyphenyl)propylmalonic acid (238)

A solution of 3-methoxycinnamylidenemalonic acid (237) (23.9 g) in ethanol (1200 ml) and palladium 10% on charcoal (1.2 g), was placed in a two litre Buchner flask equipped with a rubber bung and teflon coated magnetic stirrer.The mixture was hydrogenated at atmospheric pressure

and room temperature,and hydrogenation continued until hydrogen absorption had ceased and the yellow colour of the reaction mixture had disappeared.The mixture was filtered , the residue washed with ethanol,and the solvent evaporated off to give the compound (238) (24 g, 98%) as a pale yellow oily liquid.

^{1}H N.M.R.   (CDCl$_3$) δ

10.2	s	2H	$(CO_2H)_2$
7.35-6.6	m	4H	Aromatic protons
3.72	s	3H	OCH_3
3.70-3.32	t	1H	CH
2.70-2.50	t	2H	$PhCH_2$
2.20-1.60	m	4H	$(CH_2)_2$

I.R. ν_{max}(Neat)   1710(CO).1610,1260 cm^{-1}

5-(m-Methoxyphenyl)valeric acid(239)

3-(m-Methoxyphenyl)propylmalonic acid(238) (23.9 g) was placed in a Claisen distillation flask and decarboxylated in vacuo.The expected compound(239) was obtained as colourless liquid (15.8 g, 80%).

b.p.   142 ^{0}C/0.17 mm Hg   Lit[79] 200 ^{0}C/1 mm Hg

^{1}H N.M.R.   (CDCl$_3$) δ

9.50	s	1H	CO_2H
7.30-6.70	m	3H	Aromatic protons
3.72	s	3H	OCH_3
2.80-2.20	m	4H	$PHCH_2$ and CH_2CO_2H
1.80-1.60	m	4H	$(CH_2)_2$

I.R. ν_{max}(CHCl$_3$)   1700(CO) and 1280 cm^{-1}

2-Methoxy- 6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(11)

5-(m-Methoxyphenyl)valeric acid(239) (15.8 g) was added
in portions (5 x 3g) at 15 minute intervals to a mixture of
phosphorus pentoxide (61.7 g) and 85% orthophosphoric acid
(39.5 ml),which had been heated for 4 hrs to dissolve the
phosphorus pentoxide.The mixture was heated at 100 ^{0}C for
6 hrs with vigorous stirring.Within 25 minutes an amber-brown
homogeneous solution was obtained.The colour changed to
cherry-red after 40 minutes.The reaction mixture was poured
into ice-water and allowed to stand overnight.After extraction
with ether and removal of the acidic material with 5%
sodium hydroxide,the organic layer was dried over magnesium
sulphate and the solvent removed by evaporation under reduced
pressure to give a brownish oily liquid which was distilled under
vacuum   to give the compound(11) (13.3 g, 94%).

m.p.   57-58 ^{0}C   Lit[79] 58-59 ^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

7.72-7.54	d	1H	H on C4 $J_{3,4}$=9Hz
6.78-6.54	m	2H	2H on C1 and C3
3.75	s	3H	OCH$_3$
3.01-2.20	m	4H	4H on C6 and C9
2.01-1.40	m	4H	4H on C7 and C8

I.R. ν_{max}(Nujol)   1680(CO),1580 and 1247 cm^{-1}

6,6-Dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(246)

Phenyltrimethylammonium tribromide (3.75 g) was added in
ten portions(0.3g),at 10 minutes intervals,to a solution of
2-methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(11)(1 g)

in anhydrous tetrahydrofuran (100ml) at room temperature and the mixture was stirred for 24 hrs . The excess of phenyltrimethylammonium tribromide was destroyed by addition of a few drops of acetone . The mixture was filtered and phenyltrimethylammonium bromide collected was washed with a little tetrahydrofuran . The combined filtrates were evaporated in vacuo . A light brown oil was obtained and solidified on trituration with petroleum ether. Crystallisation from methanol gave pure compound (246) (1.17 g, 62%) .

m.p.	82.5-83 ^{0}C		
Analysis	$C_{12}H_{12}Br_2O_2$		
Found	C 41.73%		H 3.44%
Required	C 41.37		H 3.44

^{1}H N.M.R. (CDCl$_3$) δ

7.42-7.30	d	1H	H on C4 $J_{3,4}$=9 Hz
6.82-6.52	m	2H	2H on C1 and C3
3.80	s	3H	OCH$_3$
2.90-2.60	t	2H	2H on C7
2.20-1.60	m	4H	4H on C9 and C8

I.R. ν_{max} (CHCl$_3$)   1680(CO),1600 and 1100 cm^{-1}

2-Methoxy-6,6,9-tribromo- and

6,6-dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one

(246 a and 246)

Bromine (6.4g) in carbon tetrachloride (15 ml) was
added dropwise to a stirred solution of the ketone(11)(3.8 g)
in carbon tetrachloride (50 ml).After addition,the solution
was boiled for 1 hr,cooled and the solvent removed under
reduced pressure.The light brown oil which solidified on
trituration with light petroleum was identified as the di-
and tribromoketone (7.4 g), mixed m.p. 75-78 ^{0}C.Pure
tribromoketone(246a) was crystallised from methanol.

m.p.		75-76.5 ^{0}C		
Analysis		$C_{12}H_{11}Br_3O_2$		
Found		C 34.03%	H 2.58%	
Required		C 33.72	H 2.58	

^{1}H N.M.R. (CDCl$_3$) δ

7.43-7.31	d	1H	H on C4	$J_{3,4}$=9 Hz
6.82-6.52	m	2H	2H on C1 and C3	
5.30-5.10	m	1H	CHBr	
3.80	s	3H	OCH$_3$	
2.90-2.59	t	2H	2H on C7	
2.20-1.58	m	2H	2H on C8	

2-Methoxy-5H-benzocyclohepten-5-one(38) and

2-methoxy-6-bromo-5H-benzocyclohepten-5-one(247)

A mixture of the di- and tribromoketone(246 and 246 a
(7.3 g),anhydrous lithium chloride(3.65 g) and DMF(450 ml)

2-Methoxy-6,6,9-tribromo- and

6,6-dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one

(246 a and 246)

Bromine (6.4g) in carbon tetrachloride (15 ml) was
added dropwise to a stirred solution of the ketone(11)(3.8 g)
in carbon tetrachloride (50 ml).After addition,the solution
was boiled for 1 hr,cooled and the solvent removed under
reduced pressure.The light brown oil which solidified on
trituration with light petroleum was identified as the di-
and tribromoketone (7.4 g), mixed m.p. 75-78 ^{0}C.Pure
tribromoketone(246a) was crystallised from methanol.

m.p.   75-76.5 ^{0}C

Analysis $C_{12}H_{11}Br_3O_2$

Found   C 34.03%   H 2.58%

Required   C 33.72   H 2.58

^{1}H N.M.R. (CDCl$_3$) δ

7.43-7.31	d	1H	H on C4	$J_{3,4}$=9 Hz
6.82-6.52	m	2H	2H on C1 and C3	
5.30-5.10	m	1H	CHBr	
3.80	s	3H	OCH$_3$	
2.90-2.59	t	2H	2H on C7	
2.20-1.58	m	2H	2H on C8	

2-Methoxy-5H-benzocyclohepten-5-one(38)   and

2-methoxy-6-bromo-5H-benzocyclohepten-5-one(247)

A mixture of the di- and tribromoketone(246 and 246 a
(7.3 g),anhydrous lithium chloride(3.65 g) and DMF(450 ml)

was boiled and stirred under nitrogen atmosphere for 3
hrs. The mixture was cooled and the DMF removed under
reduced pressure.Water was added,the aqueous solution
extracted with diethyl ether.The combined ethereal extracts
were dried over magnesium sulphate and then distilled to
give a brown oil.The oil was distilled in a bulb tube to
give a yellow oil which solidified after a few minutes.The
mixture was separated by p.l.c. .To obtain better resolution
the plates were immersed three times into the solvent
(ethyl acetate- toluene ,10:90)with drying after each
immersion.The following bands were obtained.

Band (I) (R_f=0.22) was obtained as yellow prisms.
It was identified as 2-methoxy-5H-benzocyclohepten-5-one
(38)(2.62 g) .

This compound was also prepared by similar procedure
from pure 2-methoxy-6,6-dibromo-6,7,8,9-tetrahydro-
-benzocyclohepten-5-one (246)(0.7 g) which gave compound
(38)(0.26 g,70%).

m.p.	71-72 ^{0}C		
Analysis	$C_{12}H_{10}O_2$		
Found	C 77.59%	H 5.41%	
Required	C 77.42	H 5.38	

^{1}H N.M.R. (100 MHz, CDCl$_3$) δ

8.52-8.43	d	1H	H on C4	$J_{3,4}$=9.0 Hz
7.40-6.90	m	5H	Other protons	
6.70-6.50	m	1H	H on C8	
3.90	s	3H	OCH$_3$	

I.R. ν_{max} (CHCl$_3$)   1640(CO),1615,1580,1320

          1280,1120 cm^{-1}

U.V. λ_{max} (log$_{10}\varepsilon$)(EtOH)

          232 (4.29),277 (4.44),

          325 (3.58),350 (3.40) n.m.

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

          186.9(s), 162.1(s), 138.9 (d)

          137.7(s), 136.5(d), 134.5 (d)

          133.1(d), 132.6(s), 126.7 (d)

          117.9(d), 115.6(d), 55.3 (q) p.p.m.

Band (II) (R$_f$=0.38) was obtained as yellow needles,
which were crystallised from methanol to give
2-methoxy-6-bromo-5H-benzocyclohepten-5-one(247) (1.15 g)

m.p.   156-157 ^{0}C

Analysis   C$_{12}$H$_9$Br O$_2$

   Found   C 54.25%   H 3.40%

   Required C 54.33   H 3.51

^{1}H N.M.R. (100MHz,CDCl$_3$) δ

   8.56-8.47   d   1H   H on C4

   7.95-7.85   dd   1H   H on C7

   7.34-7.25   dd   1H   H on C9

   7.32-7.20   dd   1H   H on C3

   7.06-7.03   d   1H   H on C1

   6.60-6.40   dd   1H   H on C8

$J_{1,3}$=2.4 Hz, $J_{3,4}$=9.0 Hz,$J_{7,8}$=9.0 Hz, $J_{7,9}$=0.73 Hz

$J_{8,9}$=11.7 Hz

   3.94   s   3H   OCH$_3$

I.R. ν_{max} (CHCl$_3$) 1640(CO),1610 and 1584 cm^{-1}

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

180.4 (s), 162.1 (s), 138.6 (d),

137.2 (d), 134.5 (d), 133.6 (s),

130.5 (s), 124.2 (d), 118.7 (d),

114.9 (d), 111.9 (s) 55.7 (q) p.p.m.

Photolysis of 2-methoxy-5H-benzocyclohepten-5-one(38)

A solution of compound(11) (0.74 g) in methanol (800 ml) was irradiated by a Hanovia medium pressure lamp,through a pyrex filter and under a nitrogen atmosphere for 36 hrs. Removal of solvent gave a brown gum,which was separated by p.l.c. (ethyl acetate-toluene,10:90) into 3 bands:

Band (I)- starting material(38) (0.18 g).

Band (II)- polmeric material (0.42 g).

Band (III) (R$_f$=0.55) was triturated with ether giving a small quantity of pale yellow material,which was identified to be the photochemical isomer,

4-methoxy-2a,7a-dihydrocyclobut(a)inden-7-one(340) (0.06 g ,8%)

Analysis C$_{12}$H$_{10}$O$_2$

Found C 77.33% H 5.44%

Required C 77.42 H 5.38

^{1}H N.M.R. (CDCl$_3$) δ

7.72-7.56	d	1H	H on C6	$J_{5,6}$=9 Hz
6.96-6.76	m	2H	2H on C5 and C3	
6.56-6.52	m	1H	H on C2	$J_{1,2}$=3 Hz
6.36-6.28	dd	1H	H on C1	$J_{1,7a}$=1.2 Hz
4.28-4.22	d	1H	H on C2a	$J_{2a,7a}$=3 Hz
3.91-3.74	m	4H	OCH$_3$ and H on C7a	

$$I.R.\nu_{max} \quad (CHCl_3) \qquad 1702 \quad cm^{-1}$$

Photolysis Of 2-methoxy-6-bromo-5H-benzocyclohepten-5one(247)

Carried out as described above for compound (38) on compound(247) (0.8 g) irradiating for 80 hrs. Removal of solvent gave some starting material (247) (0.1 g) and a brown polymeric material from which nothing could be isolated.

4-Benzoyl-n-butyric acid(249)

4-Benzoyl-n-butyric acid(249) prepared in 45% yield from glutaric anhydride(248) (100 g) , benzene (453 g) and aluminium chloride (258 g) as described by Somerville and Allen[85] .

m.p.   126 ^{0}C   Lit[85] 126-127 ^{0}C

^{1}H N.M.R.   (CDCl$_3$) δ

10.0	s	1H	CO_2H
8.2-7.7	m	3H	3H on C2, C4 and C6
7.5-7.1	m	2H	2H on C3 and C5
3.1-2.9	t	2H	$\underline{CH_2}CO_2H$
2.6-1.8	m	4H	Other protons

I.R. ν_{max} (CHCL$_3$)   *   1705 and 1685 cm^{-1}

5-Phenylvaleric acid(250)

A mixture of hydrazine hydrate (143.6 g) in water (56 ml) and potassium hydroxide (148.2 g) was added to solution of 4-benzoyl-n-butyric acid(249) (123 g) in 2,2´-dihydroxydiethyl ether (1664 ml) and left refluxing for 1 hr. The condenser was removed and the excess hydrazine and water distilled off untill the temperature of the

solution had reached 184-200 ^{0}C,and refluxing was continued
for about 3 hrs.The mixture was cooled ,poured into a mixture
excess HCl and ice and then extracted with ether and dried
($MgSO_4$).Removal of ether and distillation of the residue
under reduced pressure gave compound(250) (72.4 g, 63.5 %)

b.p.   145-150 ^{0}C/0.35 mm Hg Lit[86] 186^{0}C/0.65mm Hg

^{1}H N.M.R. (CCl_4) δ

9.15	s	1H	CO_2H
7.2	s	5H	Aromatic protons
2.8-2.2	m	4H	$ArCH_2$ and CH_2CO_2H
1.9-1.5	m	4H	CH_2CH_2

I.R. ν_{max} ($CHCl_3$)   1705(CO),1280 cm^{-1}

6,7,8,9-Tetrahydro-5H-benzocyclohepten-5-one(6)

Compound(6)prepared in 77% from 5-phenylvaleric acid(250)
(30 g),phosphorus pentoxide (181 g) and orthophosphoric acid
(116 ml) as described for compound (11)

b.p.   77-79 ^{0}C/0.1 mm Hg   Lit[86] 77-79 ^{0}C/0.1mmHg

^{1}H N.M.R. (CCl_4) δ

7.8-7.5	m	1H	H on C4
7.4-6.9	m	3H	3H on C1, C2 and C3
3.0-2.4	m	4H	4H on C6 and C9
2.0-1.6	m	4H	4H on C7 and C8

I.R. ν_{max} (Neat)   1675(CO),1600 and 1260 cm^{-1}

3-Nitro-6,7,8,9 -tetrahydro-5H-benzocyclohepten-5-one(15)

Compound(15) prepared in 85% yield as a white solid from
compound(6) (6 g) and fuming nitric acid (17.5 ml) (note 1).

m.p.   92-93 ^{0}C   Lit[89] 92-92.8 ^{0}C

Note one

       If the temperature was suddenly raised a yellow gas evolved and after pouring the mixture into   ice-water a pale brown solid precipitated and filtered . The crude product was crystallised from water to give 2-(3-carboxypropyl)-5-nitrobenzoic acid (15a)(5.9 g, 62%) .

m.p.	122-123 ^{0}C		
Analysis	$C_{11}H_{11}NO_6$		
Found	C 52.25%	H 4.31%	N 5.89%
Required	C 52.17	H 4.35	N 5.53

^{1}H N.M.R.   (CDCl$_3$) δ

10	s	2H	2(CO$_2$H)	
8.40	d	1H	H on C6	$J_{6,4}=2$ Hz
8.20-8.05	dd	1H	H on C4	$J_{3,4}=8$ Hz
7.35-7.20	d	1H	H on C3	
3.10-2.55	m	4H	ArCH$_2$ and CH$_2$CO$_2$H	
2.15-1.78	m	2H	CH$_2$	

3-Amino-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(253)

The method of Jonhston,Povall and Entwistle [90] was employed.Cyclohexene (41 g) and palladium 10% on charcoal (2 g) were added to the compound (15) (12.5 g) dissolved in ethanol (350 ml).The reaction mixture was heated vigorously under reflux.After 18 hrs ,examination of t.l.c. plate showed one component,indicating that the reaction had reached completion.The catalyst was filtered off and washed with hot ethanol.The solvent was evaporated off and the residue was crystallised from ethanol to give the pure compound(253) (8.5 g, 80%) as brownish yellow crystals.

m.p.   103-104 ^{0}C   Lit[89] 104-105 ^{0}C

1H N.M.R.   (CDCl$_3$) δ

6.98-6.94	d	1H	H on C4	$J_{2,4}=3$ Hz
6.84-6.70	d	1H	H on C1	$J_{1,2}=8$ Hz
6.70-6.54	dd	1H	H on C2	
3.80-3.50	s	2H	NH$_2$	
2.90-2.54	m	4H	4H on C6 and C9	
1.90-1.60	m	4H	4H on C7 and C8	

3-Hydroxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5one(254)

Prepared in 76% yield from compound(253) as described by Smith and Berry [89].

m.p.   98-99 ^{0}C   Lit[89] 98-99 ^{0}C

3-Methoxy-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(255)

Prepared in 90% yield from compound(254) as described by Khan,Proctor and Rees [6].

b.p.   105-107 ^{0}C/0.1 mm Hg   Lit[6]   120-124^{0}C/0.4 mm Hg

6,6-Dibromo-3-methoxy- and 6-bromo-3-methoxy-
-5H-6,7,8,9-tetrahydrobenzocyclohepten-5-one (256 and 256 a)

A stirred solution of the methoxyketone(255)(1.3 g)
in tetrahydrofuran(50 ml) was treated with PTAB(7 g) over a
period of several hrs,and the mixture stirred overnight.After
addition of a few drops of acetone,the filtered solution was
evaporated. An ^{1}H N.M.R. spectrum of the crude product
showed some monobrominated derivatives to be present.Separation
of the mixture on a chromatotron.(petroleum eluent) gave the two
products.

6-Bromo-3-methoxy-5H-6,7,8,9-tetrahydrobenzocyclohepten-
-5-one(256 a) .

b.p.(bulb tube)   130 ^{0}C /0.05 mmHg

Analysis $C_{12}H_{13}BrO_2$

    Found   C 53.2%   H 5.0%

    Required   C 53.55   H 4.85

^{1}H N.M.R.   (CDCl$_3$)

    7.3-6.8   m   3H   Aromatic protons

    5.0-4.7   dd   1H   CHBr

    3.8   s   3H   OCH$_3$

    3.0-2.7   m   2H   ArCH$_2$

    2.6-1.7   m   4H   CH$_2$CH$_2$

        6,6-Dibromo-3-methoxy-5H-6,7,8,9-

- tetrahydrobenzocyclohepten-5-one(256) (1.5 g 63%).

    b.p.(bulb tube)   140 ^{0}C /0.05 mmHg

Analysis	$C_{12}H_{12}Br_2O_2$		
Found	C 41.4%	H 3.45%
Required	C 41.4	H 3.45

^{1}H N.M.R. (CDCl$_3$) δ

7.2-6.9	m	3H	Aromatic protons
3.8	s	3H	OCH$_3$
3.0-2.5	m	4H	4H on C7 and C9
2.2-1.7	m	2H	2H on C8

3-Methoxy-5H-benzocyclohepten-5-one(234)

Dehydrobromination using lithium carbonate (1 g) and dibromoketone(256)(1 g) in DMF(50 ml) gave after work-up an oil,separated on a chromatotron(eluent,ethyl acetate- -petroleum ,1:9) to give the 3-methoxybenztropone(0.49 g,91%).

b.p.(bulb tube)   105-110 ^{0}C/0.05 mmHg

^{1}H N.M.R. (C$_6$H$_6$ -D$_6$) δ

8.0	d	1H	H on C4	
7.6	d	1H	H on C1	$J_{1,2}=8.6$ Hz
7.35-7.25	d	1H	H on C9	$J_{8,9}=11.3$ Hz
7.3-7.2	dd	1H	H on C2	$J_{2,4}=3$ Hz
7.1-7.0	m	2H	2H on C6 and C7	$J_{6,7}=12.1$ Hz
6.7-6.5	ddd	1H	H on C8	$J_{7,8}=7$ Hz $J_{6,8}=2.2$Hz

I.R. ν_{max} (Neat)   1645 and 1600 cm^{-1}

U.V.λ_{max} ($\log_{10}\epsilon$) (EtOH)

375(3.80),333(3.94),320(3.98),

250(4.47),233(4.46) n.m.

Photolysis of 3-methoxy-5H-benzocyclohepten-5-one(234)

  Carried out as described above for compound(38)
on compound (243) (0.52 g) irradiating for 48 hrs.
Removal of the solvent under reduced pressure gave a brown
solid.The solid was extracted with diethyl ether and
undissolved material filtered off.Evaporation of ether
gave a residue ,which was purified by bulb distillation
(0.05/mm Hg, 128-130 ^{0}C) giving the pure
5-methoxy-2a,7a-dihydrocyclobut(a)inden-7-one(341) (0.13 g,25%).

^{1}H N.M.R. (CDCl$_3$) δ

7.60-7.20	m	3H	Aromatic protons
6.75-6.70	d	1H	H on C2 $J_{1,2}=3$ Hz
6.52-6.45	m	1H	H on C1
4.47-4.20	d	1H	H on C2a $J_{2a,7a}=3$ Hz
4.10-3.95	m	4H	OCH$_3$ and H on C7a

I.R. ν_{max} (CHCl$_3$) 1700 cm^{-1}

Analysis	$C_{12}H_{10}O_2$			
Found	C	77.35%	H	5.60%
Required	C	77.40	H	5.40

* *

2-Methoxycinnamylidenemalonic acid (257)

  This compound prepared in 82% yield ,as described for
the compound(237),from 2-methoxybenzaldehyde (6.8 g) and
diethyl ethylidenemalonate(257) (18.7 ml).The product(257)
crystallised from benzene-ethyl acetate.

m.p.   201-202 ^{0}C   Lit[92] 201-202 ^{0}C

Analysis $C_{13}H_{12}O_5$

   Found   C 62.64%   H   4.68%

   Required   C 62.90   H   4.83

^{1}H N.M.R. (DMSO-D_6) δ

9.28-8.9   s   2H   2 CO_2H

8.10-6.76   m   7H   Other protons

3.85   s   3H OCH_3

I.R. ν_{max} (Nujol)   1725(CO),1635,1605 and 1385 cm^{-1}

3-(2-Methoxyphenyl)propylmalonic acid(258)

This compound prepared in 98% yield,as described for the compound(238), from hydrogenation of compound(257).

m.p.   115 ^{0}C   Lit[92] 115-116 ^{0}C

^{1}H N.M.R.   (CDCl$_3$) δ

10.25   s   2H   2 CO_2H

7.12-6.68   m   4H   Aromatic protons

3.72   s   3H OCH_3

3.55-3.25   m   1H   CH

2.80-2.40   m   2H $ArCH_2$

2.10-1.55   m   4H $(CH_2)_2$

I.R. ν_{max} (Nujol)   1745-1700(CO),1600,1250 cm^{-1}

5-(2-Methoxyphenyl)valeric acid(259)

This compound prepared in 83% from the compound (259) by distillation in vacuo.

b.p.   136-140 ^{0}C/0.25 mm Hg

m.p.   82-83 ^{0}C   Lit[92] 78-81 ^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

10.30	s	1H	CO$_2$H
7.3-6.2	m	4H	Aromatic protons
3.7	s	3H	OCH$_3$
2.7-2.2	m	4H	ArCh$_2$ and CH$_2$CO$_2$H
1.8-1.5	m	4H	CH$_2$CH$_2$

I.R. ν_{max} (CHCl$_3$) 1707(CO) and 1280 cm^{-1}

Attempted cyclization of
5-(2-methoxyphenyl)valeric acid(259)

Cyclization was carried out, as described for compound (11) ,from 5-(2-methoxyphenyl)valeric acid(259) (5.1 g), phosphorus pentoxide (22.6 g) and orthophosphoric acid (14.5 ml).On addition of mixture into an ice-water the colour changed to purple.The flocculent mixture was extracted with benzene and dried over magnesium sulphate and the solvent was evaporated off.The residue was chromatographed on alumina (IV),eluting with toluene-petroeum ether(30:70) to give white crystals .The ^{1}H N.M.R. suggested that the compound formed was a dimer (260) (2.55 g, 56%) which was crystallized from benzene.

m.p.	203-205 ^{0}C		Lit[94] 205 ^{0}C
Analysis	C$_{24}$H$_{28}$O$_4$		
Found	C 75.48%	H 7.31%	
Required	C 75.48	H 7.36	

^{1}H N.M.R.   (100 MHz, CDCl$_3$)   δ

8.06-7.95	dd	2H	2H on Ca and Cá	$J_{a,b}$=8.5 Hz
7.77-7.95	d	2H	2H on Cc and Cć	$J_{a,c}$=2.2 Hz
7.07-7.75	d	2H	2H on Cb and Cƀ	
3.95	s	6H	2 (OCH$_3$)	
2.92-2.55	m	8H	2 (CH$_2$CO)and 2 (ArCH$_2$)	
1.81-1.72	m	8H	2 (CH$_2$CH$_2$)	

I.R. ν$_{max}$ (CHCl$_3$)   1668 and 1602 cm^{-1}

***

4-Methylanisole (261)

Prepared in 92% yield from p-hydroxytoluene (162 g),
dimethyl sulphate (189 g) and sodium hydroxide (60 g) in
acetone (400 ml).

b.p.   40 ^{0}C/0.25 mm Hg   Lit[95] 174 ^{0}C/760 mm Hg

^{1}H N.M.R.   (CDCl$_3$) δ

7.08-6.92	d	2H	2H on C3 and C5	$J_{2,3}$=8.6
6.76-6.61	d	2H	2H on C2 and C6	
3.66	s	3H	OCH$_3$	
2.24	s	3H	CH$_3$	

5-Methyl-2-methoxybenzaldehyde(262)

Zinc cyanide (52 g)was added to a solution of
4-methylanisole (261) (30 g) in benzene (75 ml).The mixture
was cooled,stirring was commenced and dry HCl was passed into
the reaction mixture for 1 hr.After this treatment ,the reaction
was cooled,and stirring continued.Anhydrous aluminium chloride
(45 g) was added slowly,HCl was again passed into the reaction

vessel while the mixture was heated at 40-45 ^{0}C for 3-4 hrs.
The reaction mixture was added to an excess of HCl (10%),
this resulted in the precipitation of the imide hydrochloride.
The mixture was refluxed for 1 hr, this caused rapid
decomposition with the formation of an oily product, the aldehyde.
The aldehyde (262) was extracted with chloroform, dried over
sodium solphate and finally purified by distillation under
reduced pressure (30 g, 80%).

b.p.   250-252 ^{0}C   Lit[96]   250-252 ^{0}C

^{1}H N.M.R.   (CDCl$_3$)   δ

10.4	s	1H	CHO	
7.55	d	1H	H on C6	$J_{4,6}$=3 Hz
7.40-7.18	dd	1H	H on C4	$J_{3,4}$=10 Hz
6.82-6.75	d	1H	H on C3	
3.86	s	3H	OCH$_3$	
2.30	s	3H	CH$_3$	

5-Methyl-2-methoxycinnamylidenemalonic acid((263)

This compound prepared in 76% yield, as described for the
compound(237), from 5-methyl-2-methoxybezaldehyde(262),
diethyl ethylidenemalonate(236) and base in methanol. The
product(263) crytallised from benzene-ethyl acetate.

Analysis $C_{14}H_{14}O_5,H_2O$

Found   C   60.35%   H   6.13%

Required   C   60.05   H   5.76

m.p.   140 ^{0}C

^{1}H N.M.R. (Acetone-D_6) δ

9.5-9.1	s	2H	$C(CO_2H)_2$
8.10-6.75	m	6H	Aromatic protons
3.88	s	3H	OCH_3
2.28	s	3H	CH_3

I.R. ν_{max} (Nujol)   1710(CO),1612 and 1230 cm^{-1}

3-(2-Methoxy-5-methylphenyl)propylmalonic acid(264)

This compound prepared in 99% yield ,as described for the compound (238),from hydrogenation of compound(263).

^{1}H N.M.R. (CDCl$_3$) δ

10.3	s	2H	2 X CO_2H
7.2-6.4	m	3H	Aromatic protons
3.75	s	3H	OCH_3
3.74-3.30	m	2H	CH
2.75-2.40	m	2H	$ArCH_2$
2.28	s	3H	CH_3
1.55-2.20	m	4H	CH_2CH_2

5-(2-Methoxy-5-methylphenyl)valeric acid(265)

This compound prepared in 91% yield from the compound(264) by distillation in vacuo.

b.p.	160 ^{0}C/0.05 mm Hg
m.p.	47-48 ^{0}C
Analysis	$C_{13}H_{18}O_3$
Found	C 70.34% H 8.14%
Required	C 70.27 H 8.10

^{1}H N.M.R. (CDCl$_3$) δ

9.01	s	1H	CO$_2$H
7.1-6.6	m	3H	Aromatic protons
3.72	s	3H	OCH$_3$
2.7-2.3	m	7H	ArCH$_2$, CH$_2$CO$_2$H and CH$_3$
1.8-1.5	m	4H	CH$_2$CH$_2$

I.R. ν_{max} (CHCl$_3$)   3300-3500(OH),1710(CO).1600,1410

and 930 cm^{-1}

1-Methoxy-4-methyl-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(266)

Cyclization was carried out,as described for compound (11), from 5-(2-methoxy-5-methylphenyl)valeric acid (265)(4.2 g) phosphorus pentoxide (20.5 g) and orthophosphoric acid (13 ml).

The reaction mixture was poured into   ice-water and then extracted with benzene and dried over magnesium sulphate. Removal of the solvent in vacuo gave a residue ,which was chromatographed on alumina (IV),eluting with benzene-petroleum ether (20:80) to give the compound (266) (2.0 g , 52%) as a pale yellow liquid.

Analysis	C$_{13}$H$_{16}$O$_2$		
Found	C 76.23%	H 7.62%	
Required	C 76.47	H 7.89	

^{1}H N.M.R. (CDCl$_3$) δ

7.00-6.84	d	1H	H on C3	$J_{2,3}$=8.4 Hz
6.74-6.60	d	1H	H on C2	
3.70	s	3H	OCH$_3$	
3.90-2.40	m	4H	ArCH$_2$ and CH$_2$CO	
2.18	s	3H	CH$_3$	
1.90-1.50	m	4H	CH$_2$CH$_2$	

I.R. ν_{max} (Neat)   1688(CO),1594,1580,1480,1430,1190 cm^{-1}
1090

6.6-Dibromo-1-methoxy-4-methyl-

-6,7,8,9 -tetrahydro-5H-benzocyclohepten-5-one(267)

Bromination was carried out,as described for the compound (246),from compound (266)(6.39 g) and phenyltrimethylammonium tribromide (6.4 g) in anhydrous tetrahydrofuran (170 ml).The reaction mixture was then filtered and the insoluble quaternary salt washed with a small portion of dried THF ,and the combined filtrates evaporated off under reduced pressure to give a brown oil. The gummy material was chromatographed on alumina(IV),eluting with benzene-petroleum ether(40:60),and then crystallised chloroform-petroleum ether(20:80) to give the pure compound (267)(3.1 g, 98%) as colourless prisms .

m.p.	73-74 ^{0}C	
Analysis	$C_{13}H_{14}Br_2O_2$	
Found	C 43.09%	H 3.78%
Required	C 43.12	H 3.90

^{1}H N.M.R. (CDCl$_3$) δ

7.02-6.89	d	1H	H on C3	$J_{2,3}$=8.4 Hz
6.79-6.74	d	1H	H on C2	
3.70	s	3H	OCH$_3$	
3.50-3.20	m	2H	CH$_2$CBr$_2$	
2.70-2.40	m	2H	ArCH$_2$	
2.20	s	3H	CH$_3$	
2.02-1.60	m	2H	2H on C8	

I.R. ν_{max} (Nujol)   1716(CO),1605,1480,1385,1585 ,
1275 and 975 cm^{-1}

1-Methoxy-4-methyl-5H-benzocyclohepten-5-one(268)

The mixture of dibromoketone(267)(3.0 g),anhydrous lithium chloride(1.3 g) and anhydrous dimethylformamide(THF) (300 ml) was refluxed and stirred under a nitrogen atmosphere.

The extent   of the reaction was followed by U.V. spectroscopy every 30 minutes.After 4 hrs there was no significance differences between the spectra, which indicated that   the reaction had   reached completion.The mixture was cooled and the DMF removed under reduced pressure.Water was added and the aqueous solution extracted with chloroform. The combined extracts were dried with magnesiun sulphate and distilled under reduced pressure to yield a brownish-black gum,which was eventually purified by p.l.c. plates, (R_f=0.3, ethyl acetate-toluene, 10:90) to give the pure product (268)(1.4 g, 83%) as a pale yellow oil.

Analysis	$C_{13}H_{12}O_2$		
Found	C 77.64%	H	6.22%
Required	C 77.97	H	6.04

^{1}H N.M.R. (100 MHz, $CDCl_3$) δ

7.92-7.87	dd	1H	H on C9	$J_{8,9}$=11.8 Hz,$J_{7,9}$=1.9 Hz
7.35-7.26	d	1H	H on C3	$J_{2,3}$=8.4 Hz
6.95-6.87	d	1H	H on C2	
6.81-6.50	m	3H	3H on C6,C7 and C8	
3.86	s	3H	OCH_3	
2.41	s	3H	CH_3	

I.R. ν_{max} $(CHCl_3)$ 3020,2970,2940,2840,1650(CO),1620 1590,1468,1420,1415,1310,1295,1270 1250 and 1115 cm^{-1}

U.V. λ_{max} ($\log_{10}$ ε) (EtOH)

200(4.25),235(4.24),285(3.81) and

338(3.38)

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

192.8 (s), 154.5 (s),139.7 (s),

133.3 (d), 133.1 (d),131.9 (d),

129.0 (d), 128.5 (s),125.3 (d),

124.5 (s), 110.8 (d),56.0 (q),

22.9 (q) p.p.m.

Photolysis of

1-methoxy-4-methyl-5H-benzocyclohepten-5-one(268)

Carried out as described above for compound (38) on the compound (268) (0.65 g)irradiating for 26 hrs.Removal of the solvent under reduced pressure gave a brown gum,which was triturated with ether and filtered.The combined filtrates were evaporated under reduced pressure to give a yellow solid,which was chromatographed on p.l.c. plates (R_f=0.44, toluene- - ethyl acetate ,80:20).The ^{1}H N.M.R. spectrum indicated the product to be the photochemical isomer, 3-methoxy-6-methyl-2a,7a-dihydrocyclobut(a)inden-7-one(339) (0.26 g, 40 %).

m.p.	88-89 ^{0}C		
Analysis	$C_{13}H_{12}O_2$		
Found	C 77.79%	H	6.21%
Required	C 77.97	H	6.04

^{1}H N.M.R. (100 MHz , $CDCL_3$) δ

7.11-7.02	d	1H	H on C5
6.94-6.85	d	1H	H on C4
6.65-6.62	o	1H	H on C2
6.35-6.31	dd	1H	H on C1
4.31-3.92	m	1H	H on C2a
3.86	s	3H	OCH_3
3.78-3.74	o	1H	H on C7a
2.53	s	3H	CH_3

$J_{1,2}=2.44$ Hz, $J_{1,7a}=0.85$ Hz, $J_{2,2a}=0.85$ Hz

$J_{2,7a}=0.37$ Hz , $J_{2a,7a}=2.80$ Hz , $J_{4,5}=8.5$ Hz

I.R. ν_{max} $(CHCl_3)$ δ 3000,2940,2830,1700(CO),

1585,1500,1280 and 1265 cm^{-1}

U.V. λ_{max} (log_{10} ϵ) (EtOH)

201(4.22),224(4.30) and 262(3.74) n.m.

^{13}C N.M.R. $(CDCl_3)$ δ (multiplicity)

203.7 (s),154.5 (s),144.5 (d),

142.1 (s),136.2 (d),135.3 (s),

131.0 (s),130.8 (d),114.8 (d),

55.8 (q),55.4 (d),44.1 (d),

17.4 (q) p.p.m.

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6,6-Dibromo-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(17)

Bromine (4 g) in carbon tetrachloride was added dropwise
to stirred solution of the bicyclic ketone (6)(2 g) in
carbon tetrachloride (20 ml).The solution was boiled for a
further one hr,cooled and the solvent removed under reduced
pressure .The pure dibromoketone (17) (3.8 g, 91%) was
crystallised from petroleum ether as colourless solid.

m.p.		42-44 ^{0}C		Lit[83]	42-43 ^{0}C

^{1}H N.M.R. (CCl_4) δ

7.8-7.1	m	4H	Aromatic protons
3.0-2.6	m	4H	$ArCH_2$ and CBr_2CH_2
2.3-1.7	m	2H	2H on C8

I.R. ν_{max} $(CHCl_3)$ 1705(CO) cm^{-1}

5H-Benzocyclohepten-5-one(1)

A mixture of the dibromoketone (17)(3.2 g),anhydrous lithium chloride (1.7 g) and dimethylformamide (DMF) (100 ml) was refluxed and stirred under a nitrogen atmosphere,for 4 hrs. The mixture was cooled,and the DMF removed under reduced pressure.Water was added and the aqueous solution extracted with ether.The combined etheral extracts were dried over magnesium sulphate and distilled under reduced pressure to give the 5H-benzocycloheten-5-one (1) (1.4 g, 92%).

b.p.   106^{0}C/0.04 mm Hg   Lit[83] 111^{0}C/0.2 mm Hg

^{1}H N.M.R. $(CDCl_3)$ δ

8.5-8.3	m	1H	H on C4
7.7-7.4	m	3H	3H on C1,C2 and C3
7.3-7.1	dd	1H	H on C9 $J_{8,9}=11.3$ Hz ,$J_{7,9}=1.2$ Hz
7.0-6.8	m	2H	2H on C6 and C7
6.7-6.5	m	1H	H on C8

I.R. ν_{max}(Neat)   1640,1609 and 1589 cm^{-1}

U.V. λ_{max} $(\log_{10}\varepsilon$)   (EtOH)

229 (4.33),260 (s), 307 (s)

320 (3.81),343 (s) n.m.

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

187.4 (s),138.8 (d),138.1 (s),

135.4 (d),135.1 (s),134.8 (d),

133.3 (d),131.6 (d),130.0 (d),

129.7 (d),126.0 (d) p.p.m.

Photolsis of 5H-benzocyclohepten-5-one(1)

Carried out as decribed above for the compound (38) on
the 5H-benzocyclohepten-5-one(1) (0.78 g).Irradiation was
stopped when the concentration of new components remained
constant.Evaporation of the solvent left a brown gum,which
was separated by p.l.c. (ethyl acetate-toluene,5:95) into
three bands :

(I)-5H-Benzocyclohepten-5-one (1)(0.1 g, R_f=0.56)

(II)-Polymeric material

Band (III) was triturated with diethyl ether giving
a small quantity of solid which had a m.p. of 206-207 ^{0}C
(Lit[83] ,dimer,m.p. 206-210 ^{0}C).The ether soluble material
was distilled in a bulb tube to give the photochemical isomer,
2a,7a-dihydrocyclobut(a)inden-7-one(321) (89 mg, 11.4%)

b.p. 80 ^{0}C/0.02 mm Hg Lit[83] 80 ^{0}C/0.02 mm Hg

^{1}H N.M.R. (CDCl$_3$) δ

7.7-7.0	m	4H	Aromatic protons	
6.5-6.4	d	1H	H on C2	$J_{1,2}$=3 Hz
6.3-6.1	m	1H	H on C1	
4.3-4.2	d	1H	H on C2a	$J_{2a,7a}$=3 Hz
3.7-3.6	m	1H	H on C7a	

I.R. ν_{max} (CHCl$_3$)   1704 cm^{-1}

U.V. λ_{max} (log$_{10}$ ϵ) (EtOH)

215(4.17),248(3.98) and 295(3.37) n.m.

6,8-Dinitro-5H-benzocyclohepten-5-one(269)

The tropone(1) (0.65 g)was added to concentrated sulphuric acid (20 ml) and nitric acid (5 ml),the solution was kept at room temperature for 24 hrs.The mixture was poured on ice,filtered and then washed with water.The pure dinitro compound (269)(0.5 g,50%),was chromatographed on alumina (IV) ,eluting with ethyl acetate ,which was then crystallised from acetic acid.

m.p.   163-165 ^{0}C   Lit[5] 165^0C

^{1}H N.M.R. (DMSO-D_6) δ

9.00-8.95	d	1H	H on C7	$J_{7,9}$= 1.2 Hz
8.64-8.58	d	1H	H on C9	
8.50-8.30	m	1H	H on C4	
8.10-7.50	m	3H	3H on C1,C2 and C3	

I.R. ν_{max} (Nujol)   1525 and 1332 cm^{-1}

Photolysis of 6,8-dinitro-5H-benzocyclohepten-5-one(269)

Carried out as described above for the compound (38) on the compound (269) (0.5 g) irradiating for 72 hrs.Removal of the solvent gave some starting material (269)(0.04 g) and a brown polymeric material from which nothing could be isolated.

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6,6-Dibromo-3-nitro-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one (18)

A solution of bromine (1.6 g) in carbon tetrachloride (20 ml) was added dropwise to stirred solution of the nitroketone(15) (2 g) in carbon tetrachloride (200 ml). Stirring was continued for a futher 15 hrs, and then the solvent removed under reduced pressure ,and the residue was crystallised from ethanol to give the dibromonitroketone(18)(3.3 g,91%).

m.p.   86-87 ^{0}C   Lit[83]   86 ^{0}C

^{1}H N.M.R.   (CDCl$_3$)   δ

8.7-8.4	m	2H	2H on C4 and C2
7.7-7.4	d	1H	H on C1 $J_{1,2}$= 8 Hz
3.2-2.7	m	4H	ArCH$_2$ and CBr$_2$CH$_2$
2.4-1.9	m	4H	2H on C8

I.R. ν_{max} (CHCl$_3$)   1710(CO),1610 and 1342   cm^{-1}

3-Nitro-5H-benzocyclohepten-5-one(20)

Prepared as described for 5H-benzocyclohepten-5-one(1), from the dibromoketone(18)(3.6 g),lithium chloride(1.7 g)and dry DMF (200 ml).The nitrobenzocycloheptenone(20)(1.5 g,75%) was crystallised from methanol as pale yellow needles.

m.p.   169-171 ^{0}C   Lit[83]   169-172 ^{0}C

Analysis   C$_{11}$H$_7$NO$_3$

Found	C 65.48%	H 3.41%	N 6.89%
Required	C 65.67	H 3.48	N 6.97

^{1}H N.M.R.   (100 MHz, CDCl$_3$)   δ

9.26-9.23	d	1H	H on C4	$J_{2,4}$=2.4 Hz
8.49-8.38	dd	1H	H on C2	$J_{1,2}$=8.7 Hz
7.86-7.77	d	1H	H on C1	
7.43-6.86	m	4H	4H on C6-9	

I.R. ν_{max} (CDCl$_3$)   1641,1602 and 1584 cm^{-1}

U.V. λ_{max} (log$_{10}$ ε)(EtOH)

                  219(4.31),253(4.30),346(4.20) n.m.

^{13}C N.M.R.   (CDCl$_3$)   δ   (multiplicity)

           186.1(s),148.0(s),139.8(s),139.3(s),

           137.0(d),136.6(d),135.4(d),134.9(d),

           129.8(d),126.4(d),125.7(d)   p.p.m.

Photolysis of 3-nitro-5H-benzocyclohepten-5-one(20)

Carried out as described above for the compound (38) on 3-nitro-5H-benzocyclohepten-5-one(20) (0.60 g).Monitoring of the photolysis by t.l.c. and ^{1}H N.M.R. examination showed decreasing amounts starting material with formation of only polymeric material.Finally after 96 hrs irradiation some starting material(20) (0.09 g) and a brown polymeric material remained.

3-Amino-5H-benzocyclohepten-5-one(270)

A mixture of cyclohexene (8.2 g),palladium 10% on charcoal and 3-nitro-5H-benzocyclohepten-5-one(20) (2 g) in ethanol (350 ml) was heated vigorously under reflux.After 15 hrs , examination bv t.l.c. plate indicated   that the reaction had reached completion.The catalyst was filtered and washed with hot ethanol .The solvent was evaporated under reduced pressure to yield the crude product,which was crystallised from ethanol to give the aminobenzocycloheptenone(270)(1.4 g,79%) as reddish brown prisms.

m.p.	150-152 ^{0}C				
Analysis	$C_{11}H_9NO$				
Found	C 76.98%	H	5.17%	N	8.29%
Required	C 77.19	H	5.26	N	8.19

^{1}H N.M.R. (100 MHz,CDCl$_3$) δ

7.75-7.70	d	1H	H on C4	$J_{2,4}$=2.3 Hz
7.57-7.48	d	1H	H on C1	$J_{1,2}$=8.5 Hz
7.34-7.23	dd	1H	H on C9	$J_{8,9}$=11.4 Hz
7.19-6.99	m	2H	2H on C2 and C7	
6.86-6.75	dd	1H	H on C6	$J_{6,7}$=10.7 Hz
6.60-6.41	o	1H	H on C8	$J_{7,8}$=7.8 Hz
4.20-3.80	s	2H	NH$_2$	

I.R. ν_{max} (Nujol) 3430,3350(NH),1660(CO),1615
1570 and1520 cm^{-1}

U.V. λ_{max} (log$_{10}$ ε) (EtOH)

243 (4.28),268 (4.40),360 (4.06)

and 434 (3.84) n.m.

^{13}C N.M.R. (DMSO-D$_6$ and CDCl$_3$) δ (multiplicity)

186.0 (s),151.1 (s),140.0 (s),

139.8 (d),136.6 (d),135.9 (d),

132.2 (d),125.9 (s),121.0 (d),

119.2 (d),111.9 (d) p.p.m.

Photolysis of 3-amino-5H-benzocyclohepten-5-one(270)

The 3-amino-5H-benzocyclohepten-5-one(270)(0.7 g)
in methanol (800 ml) was irradiated for 17 hrs.Removal of
the solvent gave a light brown polymeric material from
which nothing could be isolated.

3-Acetamido-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(16)

This compound prepared in 80% yield from the aminoketone(253) (2.1 g) in pyridine (30 ml) and acetyl chloride (1.9 g).The pale yellow solid was filtered and washed with water,and crystallised from ethanol to give the pure acetamidoketone(16).

m.p.   103-104 ^{0}C   Lit[89] 103-104 ^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

9.35	s	1H	NH
7.85-7.60	m	2H	2H on C4 and C2
7.05-6.90	d	1H	H on C1 $J_{1,2}$=8 Hz
2.95-2.50	m	4H	4H on C6 and C9
2.20	s	3H	CH$_3$
1.90-1.55	m	4H	4H on C7 and C8

I.R. ν_{max} (CHCl$_3$)   3416,3320 and 1675 cm^{-1}

3-Acetamido-6,6-dibromo--6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(19)

This compound prepared in 82% yield from the acetamidoketone(16)(2.2 g) in tetrahydrofuran (150 ml), and phenyltrimethylammonium tribromide (7.5 g) as described for the compound (246).It was crystallised from ethanol.

m.p.   136-138 ^{0}C   Lit[83] 136-138 ^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

8.5	s	1H	NH
8.3-7.1	m	3H	Aromatic protons
3.0-2.5	m	4H	4H on C7 and C9
2.18	s	3H	CH$_3$
2.4-1.8	m	2H	2H on C8

I.R. ν_{max} (CHCl$_3$)   3416,3320 and 1690 cm^{-1}

3-Acetamido-5H-benzocyclohepten-5-one(21)

Method one

The acetamidodibromoketone(19)(1.9 g) was dehydrobrominated with lithium chloride (0.84 g) in boiling dimethylformamide (300 ml) in the usual way giving the acetamidobenzocycloheptenone(21) as yellow needles(1 g 95%). It was crystallised from methanol.

Method two

Acetyl choride (0.9 g) was added dropwise to an ice-cooled solution of the 3-amino-5H-benzocyclohepten-5-one(270)(1 g) in pyridine(20 ml).The reaction mixture was left stirring for 2 hrs,then the mixture poured into a mixture of ice and HCl.The yellow crystals were filtered and washed with water and crystallised from methanol to give the compound(21) (1 g,82%).

m.p.	214-215 ^{0}C			Lit[83] 214-215 ^{0}C
Analysis	C$_{13}$H$_{11}$NO$_2$			
Found	C 73.38%	H 5.08%	N 6.28%	
Required	C 73.24	H 5.16	N 6.57	

^{1}H N.M.R. (CF$_3$CO$_2$H) δ

9.48-9.10	m	2H	NH and H on C4
8.72-7.60	m	6H	Other protons
2.45	s	3H	CH$_3$

I.R. ν_{max} (CHCl$_3$)   3416,3310,1690,1640 and 1612 cm^{-1}

U.V. λ_{max} (log$_{10}$ ϵ)(EtOH)

207 (4.04),242 (4.42),

330 (3.99) and 375 (3.72) n.m.

^{13}C N.M.R. (DMSO-D_6) δ (multiplicity)

     185.9 (s),168.5 (s),141.4 (s),

     138.8 (s+d) two overlapping resonances,

     136.0 (d),135.5 (d),133.8 (d),

     130.7 (s),124.7 (d),122.9 (d),

     118.2 (d),24.0 (q) p.p.m.

Photolysis of 3-acetamido-5H-benzocyclohepten-5-one(21)

Carried out as described above for the compound (38)
on the acetamidobenzocycloheptenone(21) (0.43 g) irradiating
for 30 hrs when the concentration of new component remained
constant. Removal of the solvent under reduced pressure
gave a brown gum,which was triturated with ether and filtered.
The combined filtrate was evaporated under reduced pressure
to give a pale yellow solid , which was chromatographed
on p.l.c. plates (R_f=0.18, toluene-ethyl acetate,90:10).

The ^1H N.M.R. spectrum indicated the product to be
the photochemical isomer,

5 acetamido-2a,7a-dihydrocyclobut(a)inden-7-one(342)(0.15 g, 35%).

m.p.	173-174 ^0C					
Analysis	$C_{13}H_{11}NO_2$					
Found	C 73.12%	H	5.17%	N	6.76%
Required	C 73.24	H	5.16	N	6.57

^{1}H N.M.R.   (100 MHz, CDCl$_3$) δ

9.0	s	1H	NH	
8.01-7.91	dd	1H	H on C4	$J_{5,4}=8.3$ Hz
7.79-7.77	d	1H	H on C6	$J_{4,6}=2$ Hz
7.40-7.32	d	1H	H on C3	
6.59-6.56	d	1H	H on C2	$J_{1,2}=2.5$ Hz
6.29-6.26	dd	1H	H on C1	$J_{1,7a}=0.98$ Hz
4.29-4.26	d	1H	H on C2a	$J_{2a,7a}=2.9$ Hz
3.82-3.79	dd	1H	H on C7a	
2.08	s	3H	CH$_3$	

I.R. ν_{max} (CHCl$_3$)　　　　3430,1710-1685(CO),1615,1370,

1325 and 1295 cm^{-1}

U.V. λ_{max} (log$_{10}$ ε) (EtOH)

224 (4.40),247 (4.14),

and 306 (4.05) n.m.

^{13}C N.M.R. (Acetone-D$_6$) δ (multiplicity)

201.9 (s),169.0 (s),148.6 (s),

146.5 (d),140.2 (s),138.5 (s),

136.5 (d),127.0 (d),126.4 (d),

115.0 (d),56.7 (d),48.1 (d),

24.1 (q)   p.p.m.

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3-Amino-2,4.6,6-tetrabromo-

-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(271)

Bromine (6.4 g) in carbon tetrachloride (20 ml) was
added dropwise into stirred solution of the aminoketone(253)
(1.8 g) in carbon tetrachloride (100 ml).After addition ,
stirring was continued for a futher 12 hrs. Evaporation of
the solvent under reduced pressure and removal of the acidic

material(HBr) with 5% sodium hydrogen carbonate allowed extraction with dichloromethane. The combined extracts were dried with sodium sulphate and distilled off to the crude aminotetrabromoketone(271)(3.5 g,71%) as a brown oily material.

^{1}H N.M.R. (CDCl$_3$) δ

7.10	s	1H	H on C1
4.72	s	2H	NH$_2$
2.82-2.35	m	4H	4H On C7 and C9
2.10-1.72	m	2H	2H on C4

I.R. ν_{max} (CHCl$_3$)   3000,2950,2870, 1728(CO),1575 cm^{-1}

3-Amino-2,4-dibromo-5H-bezocyclohepten-5-one(272)

The aminotetrabromoketone(271)(3.5 g) was subsequently dehydrobrominated with lithium chloride (1.2 g) in boiling dimethylformamide (150 ml) in the usual way giving the 3-amino-2,4-dibromo-5H-benzocyclohepten-5-one(272)(0.94 g, 40%), which was chromatographed on alumina (IV),eluting with petroleum ether-ethyl acetate (90:10).It was crystallised from methanol.

m.p.	78-79 ^{0}C			
Analysis	C$_{11}$H$_7$Br$_2$NO			
Found	C 39.47%	H 2.23%	N 4.21%
Required	C 40.12	H 2.12	N 4.25

^1H N.M.R. (CDCl$_3$) δ

7.56	s	1H	H on C1	
7.00-6.82	dd	1H	H on C9	$J_{8,9}$=11.2 Hz
6.76-6.20	m	3H	3H on C6-8	
5.20-4.95	s	2H	NH$_2$	

I.R. ν_{max} (CHCl$_3$)   3434,3352,1662(CO) and 1616 cm^{-1}

Photolysis of 3-amino-2,4-dibromo-5H-benzocyclohepten-5one(272)

The aminodibromobenzocycloheptenone(272) (0.5 g)
in methanol (800 ml) was irradiated for 20 hrs in the
usual way as described for the compound (38). Removal of
the solvent give a light brown polymeric material from which
nothing could be isolated.

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m-Nitrocinnamylidenemalonic acid (273)

This compound prepared in 79% yield ,as described
for the compound (237), from m-nitrobenzaldehyde (22.7 g) ,
diethyl ethylidenemalonate(236)(39 ml) and base in methanol.
The product(273) crystallised from benzene-ethyl acetate .

m.p.   156 ^{0}C

^1H N.M.R. (Acetone-D$_6$) δ

9.52	s	2H	C(CO$_2$H)$_2$
8.45	m	1H	H on C2
8.23-8.12	m	1H	H on C4
7.98-7.62	m	5H	Other protons

I.R. ν_{max} (Nujol)   1725,1605,1520 and 1345 cm^{-1}

3-(m-Aminophenyl)propylmalonic acid(274)

This compound(274) prepared in 92% yield ,as described for the compound (238),from hydrogenation of m-nitrocinnamylidenemalonic acid(273)(13 g). It was crystallised from methanol.

m.p.		146-147 ^{0}C		
Analysis		$C_{12}H_{15}NO_4$		
Found		C 60.73%	H 6.44%	N 6.02%
Required		C 60.75	H 6.37	N 5.90

^{1}H N.M.R. (DMSO-D$_6$) δ

8.70	s	4H	2 X CO_2H and NH_2
7.0-6.2	m	4H	Aromatic protons
3.7-3.4	m	1H	CH
3.1-2.6	m	2H	$ArCH_2$
2.4-1.8	m	4H	CH_2CH_2

I.R. ν_{max} (Nujol)   1680-1550(CO) cm^{-1}

5-(m-Acetamidophenyl)valeric acid(275)

3-(m-Aminophenyl)propylmalonic acid(274)(10.7 g) was placed in a Claisen distillation flask and decarboxylated by heating in vacuo . To the resulting crude product (5-(m-aminophenyl)valeric acid) was added water (25 ml) and acetic anhydride (25 ml),and the mixture was warmed on a steam bath for 1 hr.The solution was cooled and filtered. The expected product was washed with water and crystallised from aqueous ethanol to give the valeric acid(275)(6.4 g,68%).

m.p.   138-139 ^{0}C   Lit[99] 138-139 ^{0}C

^{1}H N.M.R.   (DMSO-D$_6$)   δ

10.5	s	1H	CO$_2$H
9.50	s	1H	NH
7.7-6.8	m	4H	Aromatic protons
2.8-2.2	m	4H	ArCH$_2$ and CH$_2$CO
2.1	s	3H	CH$_3$
1.8-1.5	m	4H	CH$_2$CH$_2$

I.R. ν_{max} (CHCl$_3$)   1705 and 1280 cm^{-1}

2-Acetamido-6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(276)

Cyclisation was carried out ,as described for the compound(11),from the 5-(m-acetamidophenyl)valeric acid(275) (4.7 g),phosphorus pentoxide (30 g) and orthophosphoric acid (20 ml) . The pure product(276)(2.4 g,56%) was crystallised from aqueous ethanol.

m.p.   115-116 ^{0}C   Lit[99]   116-117 ^{0}C

^{1}H N.M.R.   (CDCl$_3$)   δ

9.22	s	1H	NH
7.80-6.90	m	3H	Aromatic protons
2.94-2.44	m	4H	ArCH$_2$ and CH$_2$CO
2.16	s	3H	CH$_3$
1.90-1.52	m	4H	CH$_2$CH$_2$

I.R. ν_{max} (CHCl$_3$)   3414,3320 and 1676 cm^{-1}

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6,7,8,9-Tetrahydro-5H-benzocycloheptene(277)

Reduction of the cyclic ketone (6) was carried out as described for the compound (250),from 6,7,8,9-tetrahydro-5H-benzocyclohepten-5-one(6)(6.4 g) and a mixture of hydrazine hydrate(10 g) and potassium hydroxide (9 g) in 2,2´-dihydroxydiethyl ether(150 ml).The crude product was distilled under reduced pressure to give the compound (277)(5.5 g, 92%).

b.p. 95-98^{0}C/760 mm Hg Lit ^{121} 99-100 ^{0}C/ 760 mm Hg

^{1}H N.M.R. (CDCl$_3$) δ

6.9	s	4H	Aromatic protons
2.85-2.60	m	4H	2 (ArCH$_2$)
1.80-1.45	m	6H	(CH$_2$)$_3$

I.R. ν$_{max}$ (Neat) 3060,3010,2930,1600 and 1490 cm^{-1}

2-Acetyl-6,7,8,9-tetrahydro-5H-benzocycloheptene(278)

Acetyl chloride (9.9 g) was added dropwise during 15 minutes to stirred suspension of anhydrous aluminium chloride (16.8 g) in carbon tetrachloride(150 ml) with cooling in an ice-bath(0-5 ^{0}C). The compound (277)(13 g) in carbon tetrachloride (40 ml) was added dropwise over a period of 3 hrs into the above suspension with keeping temperature below 5 ^{0}C . After addition stirring was continued for a further 1 hr,and then reaction mixture was poured into ice and HCl(1:1). The organic layer was washed with water and then dried with sodium sulphate. Evaporation of the solvent and distillation of the residue gave the pure compound (278)(16.2 g, 96%).

b.p. 139-143 ^{0}C/2 mm Hg Lit ^{122} 180 ^{0}C/22 mm Hg

^{1}H N.M.R.   (CDCl$_3$) δ

7.72-7.50	m	2H	2H on C1 and C3	
7.14-7.00	d	1H	H on C4	$J_{3,4}$=8.5 Hz
2.95-2.65	m	4H	2 (ArCH$_2$)	
2.50	s	3H	CH$_3$	
1.99-1.35	m	6H	3 (CH$_2$)	

I.R. ν_{max} (Neat)   2930,2860,1608(CO),

1570,1280,1260 and 1200 cm^{-1}

2-Carboxylic acid-6,7,8,9-tetrahydro-5H-benzocycloheptene(279)

Sodium hydroxide solution (120 ml,10%) and then
potassium iodide-iodine reagent[123] was added dropwise to
stirred solution of the compound (278)(15 g) in dioxane(600 ml)
until a definite dark colour of iodine persists. Reaction mixture
was left 5 minutes and then warmed in water bath at 60^{0}C .
The iodoform was filtered off and the excess of iodine removed
by solution of sodium bisulfite. The solution was acidified and
a   pale yellow precipitate filtered and then crystallised
from methanol to give the pure compound(279).

m.p.   177-178 ^{0}C   Lit [124,101] 178-179^{0}C

Analysis   C$_{12}$H$_{14}$O$_2$

Found   C 75.95%   H 7.47%

Required   C 75.78   H 7.36

^{1}H N.M.R.   (DMSO-D$_6$) δ

8.90	s	1H	CO$_2$H	
7.75-7.55	m	2H	2H on C1 and C3	
7.16-7.02	d	1H	H on C4	$J_{3,4}$=8.5 Hz
2.96-2.65	m	4H	2 (ArCH$_2$)$_2$	
1.99-1.35	m	6H	3 (CH$_2$)$_3$	

I.R. ν_{max} (Nujol)   1675(CO),1606 and 1290 cm^{-1}

Methyl

6,7,8,9-tetrahydro-5H-benzocyclohepten -2-carboxylate (280)

The ethereal solution of diazomethane (0.63 g) was added dropwise to the solution of compound (279)(2.9 g) until gas evolution ceased (left over night). Evaporation of the solvent and distillation of residue in the bulb tube under reduced pressure gave the pure compound(280)(3 g,97%).

b.p.	110-115 ^{0}C /0.15 mm Hg
Analysis	$C_{13}H_{16}O_2$
Found	C 76.25% H 7.94%
Required	C 76.47 H 7.84

^{1}H N.M.R. (CDCl$_3$) δ

7.84-7.64	m	2H	H on C1 and C3
7.22-7.00	d	1H	H on C4 $J_{3,4}$= 8.5 Hz
3.70	s	3H	CH_3
2.92-2.55	m	4H	2 ($ArCH_2$)
1.99-1.35	m	6H	3 $(CH_2)_2$

I.R. ν_{max} (Nujol)   1683(CO),1606 and 1240 cm^{-1}

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3-Phenylcyclohepta(b)pyrrol-8-one(141)[48,102]

m.p.   188-189 ^{0}C   Lit[48] 188-189^{0}C

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

176.4(s),138.4(s),136.6(d),133.8(d),
133.4(s),132.0(d),129.3(d)*,128.5(d)*,
126.9(d),126.8(s),126.2(s),125.2(d),
123.5(d) p.p.m.

*-Two overlapping resonances.

I.R. ν_{max} (Nujol)   1675(CO),1606 and 1290 cm^{-1}

Methyl

6,7,8,9-tetrahydro-5H-benzocyclohepten -2-carboxylate (280)

The ethereal solution of diazomethane (0.63 g) was added dropwise to the solution of compound (279)(2.9 g) until gas evolution ceased (left   over night). Evaporation of the solvent and distillation of residue in the bulb tube under reduced pressure gave the pure compound(280)(3 g,97%).

b.p.   110-115 ^{0}C /0.15 mm Hg

Analysis $C_{13}H_{16}O_2$

    Found   C 76.25%   H 7.94%

    Required   C 76.47   H 7.84

^{1}H N.M.R. (CDCl$_3$) δ

    7.84-7.64   m   2H   H on C1 and C3

    7.22-7.00   d   1H   H on C4 $J_{3,4}$= 8.5 Hz

    3.70   s   3H CH_3

    2.92-2.55   m   4H   2 (ArCH$_2$)

    1.99-1.35   m   6H   3 (CH$_2$)$_2$

I.R. ν_{max} (Nujol)   1683(CO),1606 and 1240 cm^{-1}

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3-Phenylcyclohepta(b)pyrrol-8-one(141)[48,102]

m.p.   188-189 ^{0}C   Lit[48] 188-189^{0}C

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

        176.4(s),138.4(s),136.6(d),133.8(d),

        133.4(s),132.0(d),129.3(d),128.5(d),

        126.9(d),126.8(s),126.2(s),125.2(d),

        123.5(d) p.p.m.

    *-Two overlapping resonances.

Photolysis of 3-phenylcyclohepta(b)pyrrol-8-one(141)

3-Phenylcyclohepta(b)pyrrol-8-one(141)(0.44 g)
in methanol (900 ml) was irradiated for 10 hrs in the
usual way as described for the compound(38). Removal of
the solvent give a light brown polymeric material,from
which nothing could be isolated.

1-Methyl-3-phenylcyclohepta(b)pyrrol-8-one(281)

3-Phenylcyclohepta(b)pyrrol-8-one(141)(0.66 g) in
1,2-dimethoxyethane(DME)(60 ml)was heated under reflux
for 10 hrs with methyl iodide (0.42 g) and sodium hydroxide
(0.15 g) .After 20 hrs further methyl iodide was added
and the mixture allowed to reflux for 20 hrs.Progress of the
reaction was observed by using t.l.c. . The mixture was
cooled and the DME removed under reduced pressure. Water
was added and the aqueous solution extacted with chloroform.
The combined extracts were dried over anhydrous sodium sulphate
and then the solvent evaporated off under reduced pressure
to give a brown gum,which was chromatographed on p.l.c.
plates (toluene-ethyl acetate ,90:10) to give the pure
compound(281)(0.45 g,63%) as pale brown solid.

m.p.	109-110 ^{0}C				
Analysis	$C_{16}H_{13}NO$				
Found	C	81.93%	H	5.76%	N	6.06%
Required	C	81.70	H	5.53	N	5.95

^{1}H N.M.R. (100 MHz ,CDCl$_3$)   δ

7.63-7.52	dd	1H	H on C4	$J_{4,5}$=10.8 Hz
7.45-7.41	m	6H	H on C2 and phenyl protons	
7.25-7.04	m	2H	2H on C6 and C7	
6.74-6.55	ddd	1H	H on C5	$J_{5,6}$=6.9Hz;$J_{5,7}$=2.3Hz
4.31	s	3H	CH$_3$	

I.R. ν_{max} (KBr)   1638,1550 and 1525 cm^{-1}

^{13}C N.M.R. (CDCl$_3$)   δ (multiplicity)

178.4 (s),136.3 (d),135.9 (s),

134.5 (d),133.1 (s),130.8 (d),

130.4 (d),129.3 (d)*,128.9(d)*,

127.7 (s),126.8 (d),124.3 (s),

122.6 (d),33.8 (q) p.p.m.

*-Two overlapping resonances.

Photolysis of 1-methyl-3-phenylcyclohepta(b)pyrrol-8-one(281)

1-Methyl-3-phenylcyclohepta(b)pyrrol-8-on(281)(0.33 g)
was irradiated in methanol by the procedure described before.
Monitoring of the photolysis by t.l.c. and ^{1}H N.M.R.
examination showed decreasing amounts of starting material
with the formation of only polymeric material,until finally
after 9 hrs irradiation only the latter remained.

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Cycloheptanone phenylhydrazone

Cycloheptanone (74 g) and phenylhydrazine (71 g) were heated together on a water-bath for 10 minutes and then cooled ,the pale yellow product solidified and then crystallised from ethanol to give colourless product (128 g,96%), as needles.

m.p.   72-73 ^{0}C   Lit[125] 72^{0}C

5,6,7,8,9,10-Hexahydrocyclohept(b)indole(153)

A mixture of cycloheptanone phenylhydrazone (18 g), water(360 ml) and concentrated sulphuric acid (20 ml) was heated on a water-bath for 45 minutes,with frequent shaking. The product gradually separated out and was practically pure. It was washed during filteration with water, and purified by crystallisation from ethanol to give the compound(153)(11 g,74%) as shiny colourless plates.

m.p.   146-147 ^{0}C   Lit[125] 144 ^{0}C

5-Ethyl-6,7,8,9.10-hexahydrocyclohept(b)indole(282)

A mixture of compound(153)(5.6 g),ethyl p-toluenesulphonate (6.1 g)and NaH(1 g)in xylene was heated under reflux for 15 hrs. The mixture was cooled,filtered and the filtrate washed with ether.The solvent was evaporated off under reduced pressure to give the crude product ,which was crystallised from ethanol to give the pure compound(282)(6.2 g,97%) as yellow prisms.

m.p.	61-62 ^{0}C					
Analysis	$C_{15}H_{19}N$					
Found	C	84.32%	H	8.99%	N	6.56%
Required	C	84.45	H	8.98	N	6.57

^1H N.M.R. $(CDCl_3)$ δ

7.45-7.20	m	1H	H on C1
7.01-6.82	m	3H	Aromatic protons
4.25-3.70	q	2H	NCH_2 J=8 Hz
2.92-2.55	m	4H	4H on C6 and C10
1.92-1.42	m	6H	6H on C7-9
1.31-1.06	t	3H	CH_3

5-Ethyl-6,7,8,9-tetrahydrocyclohept(b)indol-10(5H)-one(283)

2,3-Dichloro-5,6-dicyano-1,4-benzoquinone(DDQ)(11 g) in 100 ml of tetrahydrofuran was added dropwised to an ice-cooled solution of the compound(282)(5.2 g) in 275 ml of 90% aqueous tetrahydrofuran with stirring. The reaction was carried out under a nitrogen atmosphere. The reaction mixture first turned blue,after few minutes it changed to a brownish-red colour.The stirring was continued for 2 hrs,then the solvent evaporated off under reduced pressure.The remaining residue was extracted with ethyl acetate ,and purified by passing through an alumina column(IV) to give almost pure product. The product was futher purified by crystallisation from cyclohexane to the compound(283)(4.5 g 81%) as pale yellow crystals.

m.p.   97-98 ^0C

Analysis $C_{15}H_{17}NO$

Found	C	79.19%	H	7.51%	N	6.39%
Required	C	79.26	H	7.54	N	6.16

^1H N.M.R. (CDCl$_3$) δ

8.43-8.25	m	1H	H on C1
7.10-7.04	m	3H	Aromatic protons
4.26-3.75	q	2H	NCH$_2$ J =8 Hz
3.02-2.60	m	4H	4H on C6 and C9
2.08-1.60	m	4H	4H on C7 and C8
1.36-1.16	t	3H	CH$_3$

I.R. ν_{max} (CHCl$_3$)   1645-1600(CO), and 1615 cm^{-1}

9,9-Dibromo-6,7,8,9-tetrahydro-5-ethylcyclohept(b)indol-10(5H)-one (284)

Bromination was carried out,as described for the compound(246),from the ketone(283)(2 g) and phenyltrimethylammonium tribromide (6.4 g) in anhydrous tetrahydrofuran (300 ml).The combined filtrates were evaporated off in vacue to give a gummy material ,which was chromatographed on alumina(IV),eluting with benzene-petroleum ether (10:90).The product (284)(3.1 g, 91%) was crystallised from chloroform-petroleum ether(40:60), as pale yellow crystals.

m.p.	124-125 ^{0}C			
Analysis	C$_{15}$H$_{15}$Br$_2$NO			
Found	C 47.07%	H 3.83%	N 4.01%	
Required	C 46.77	H 3.92	N 3.63	

^{1}H N.M.R. (CDCl$_3$) δ

8.36-8.18	m	1H	H on C1
7.80-7.10	m	3H	Aromatic protons
4.24-3.86	q	2H	NCH$_2$ J =8 Hz
3.20-2.85	m	4H	4H on C6 and C8
2.36-1.80	m	2H	2H on C7
1.46-1.20	m	3H	CH$_3$

I.R. ν_{max} (CHCl$_3$)   2966,1664,1512 and 1432 cm^{-1}

U.V. λ_{max} (log$_{10}$ ε)(EtOH)   260(4.03) and 337(4.01) n.m.

5-Ethylcyclohept(b)indol-10(5H)-one(285)

The dibromoketone(284)(3.3 g) was dehydrobrominated with lithium chloride (1.4 g) in boiling dimethylformamide (300 ml) in the usual way giving the indolotropone (285) (1.85 g,96 %), which was crystallised from chloroform-petroleum ether(90:10) as shiny yellow prisms.

m.p.	117-118 ^{0}C	
Analysis	C$_{15}$H$_{13}$NO	
Found	C 80.88% H 5.70%	N 6.15%
Required	C 80.69 H 5.87	N 6.27

^{1}H N.M.R. (100 MHz, CDCl$_3$) δ

9.10-8.99	m	1H	H on C1 J$_{1,2}$=7.3 Hz
7.58-6.82	m	7H	Other protons
4.47-4.29	q	2H	NCH$_2$ J =8 Hz
1.45-1.33	t	3H	CH$_3$

I.R. ν_{max} (CHCl$_3$)   1635(CO),1565 and 1480 cm^{-1}

U.V. λ_{max} (log$_{10}$ ε)(EtOH)   241(4.34),295(4.33),378(3.96) n.m.

^{13}C N.M.R. (CDCl$_3$) δ (multiplicity)

182.7 (s),140.3 (d),139.9 (s),

137.7 (s),131.6 (d),127.8 (d),

126.7 (d),125.9 (s),124.9 (d),

124.3 (s),122.6 (d),122.3 (d),

108.8 (d),38.0 (t),14.6 (q) p.p.m.

Photolysis of 5-ethylcyclohept(b)indol-10(5H)-one(285)

5-Ethylcyclohept(b)indol-10(5H)-one (285)(0.45 g) was irradiated in methanol(800 ml) by procedure described before.Monitoring of the photolysis by t.l.c. and ^{1}H N.M.R. examination showed decreasing amounts of starting material with formation of only polymeric material,unlil finally after 7 hrs irradiation only the latter remained.

5-Methyl-6,7,8,9,10-hexahydrocyclohept(b)indole(286)

This compound prepared (11.3 g,95%),as described for the compound(282), from the compound (153)(11 g), methyl p-toluenesulphonate(11 g) and sodium hydride(2.8 g) in xylene.The crude was crystallised from ethanol to give the pure compound (286) as yellow prisms.

m.p.	48-49 ^{0}C			Lit[126] 50 ^{0}C
Analysis	C$_{14}$H$_{17}$N			
Found	C 84.30%	H 8.33%	N 7.04%	
Required	C 84.37	H 8.60	N 7.03	

5-Methyl-6,7,8,9-tetrahydrocyclohept(b)indole-10(5H)-one(287)

Oxidation was carried out,as described for the compound
(283),from the compound (286)(4 g) and DDQ (10.9 g) in
275 ml of 90% aqueous tetrahydrofuran.The product(3.5 g,82%)
was further purified by crystallisation from ethanol.

m.p.   132-134 ^{0}C   Lit[100] 132-134^{0}C

I.R. ν_{max} (Nujol)   1635(CO),1615 and 1605 cm^{-1}

9,9-Dibromo-6,7,8,9-tetrahydro-5-methylcyclohept(b)indol-10(5H)-one (288)

Bromination was carried out ,as described for the
compound(246),from the ketone(287)(2.13 g)   and
phenyltrimethylammonium tribromide (7.5 g) in tetrahydrofuran
(400 ml).The pure dibromoketone(288)(2.9 g,78%) was
crystallised from methanol.

m.p.   173-174 ^{0}C   Lit[51] 173^{0}C

5-Methylcyclohept(b)indol-10(5H)-one(289)

The dibromoketone(288)(1.9 g)was dehydrobrominated
with lithium chloride (0.85 g) in boiling dimethylformamide
(250 ml)in the usual way giving the indolotropone(289)
(0.52 g, 89%),which was crystallised from methanol.

m.p.   169-170 ^{0}C   Lit[51] 169-170 ^{0}C

Photolysis of 5-methylcyclohept(b)indol-10(5H)-one(289)

The indolotropone(289)(0.42 g) in methanol(900 ml)
was irradiated for 7 hrs in the usual way as described
for the compound(38). Removal of the solvent gave a light
brown polymeric material,from which nothing could be isolated.

6,7,8,9-Tetrahydrocyclohept(b)indol-10(5H)-one(154)

Oxidation was carried out ,as described for the compound(283),from the compound(153)(5 g) and DDQ (12 g) in 297 ml of 90% aqueous tetrahydrofuran. The product(154)(4.8 g,90%) was futher purified by crystallisation from ethanol.

m.p. 220-221 ^{0}C Lit[100] 221-220 ^{0}C

I.R. ν_{max} (Nujol) 3155 and 1600(CO) cm^{-1}

9,9-Dibromo-6,7,8,9-tetrahydrocyclohept(b)indol-10(5H)-one(290)

Bromination was carried out ,as described for the compound(246),from the ketone(154)(2 g,) and phenyltrimethylammonium tribromide(7.5 g) in tetrahydrofuran (350 ml).The pure dibromoketone(290)(3 g ,87%) was crystallised from methanol.

m.p. 183-184 ^{0}C Lit[51] 182-184 ^{0}C

Cyclohept(b)indol-10(5H)-one(8)

The dibromoketone(290)(1.8 g) was dehydrobrominated with lithium chloride(0.84 g) in boiling dimethylformamide (200 ml) in the usual way giving the indolotropone(8) (0.94 g,97%),which was crystallised from methanol as yellow prisms.

m.p. 285-286 ^{0}C Lit[51] 285-286^{0}C

Photolysis of cyclohept(b)indol-10(5H)-one(8)

The indolotropone(8)(0.5 g) was irradiated in methanol(1000 ml) for 8 hrs in the usual way as described for the compound (38). Removal of the solvent gave a light brown polymeric material,from which nothing could be isolated.

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2-Furylacrylaldehyde(291)

2-Furaldehyde(34.5 g) and acetaldehyde(101.2 g)were added to a solution of sodium hydroxide(10 g) and water (2000 ml). The mixture was heated on a water-bath to 40 ^{0}C, then after 5 minutes cooled to 25 ^{0}C,and extracted with chloroform. The combined extracts were dried over magnesium sulphate and distilled under reduced pressure to yellow oil.Distillation of the residue under vacuo gave the pure product(291)(30.8 g,70%),which was crystallised from benzene-petroleum ether, as yellow needles.

m.p. 52-53 ^{0}C Lit[103] 53^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

9.62-9.48	d	1H	CHO
7.54	m	1H	H on C5
7.46-6.30	m	4H	Other protons

I.R. ν_{max} (CHCl$_3$) 1675(CO),1630,1550 and 1120 cm^{-1}

Ethyl 5-(2-furyl)pentadienoate(292)

The aldehyde(291)(61 g) in dried ethyl acetate (98 g) was added slowly to the ice-bath cooled mixture of sodium wire (11.2 g) in ethyl acetate (196 g).The mixture was left with occasional shaking at room temperature for 24 hrs. The mixture was cooled and a mixture of glacial acetic acid (30 g)and water was added and the aqueous solution extracted with dichloromethane.The combined extracts were dried over sodium sulphate and then the solvent removed,and the residue distilled under vacuo to give the pure ester(292)(69 g,72%).

b.p. 120 ^{0}C/0.5 mm Hg Lit[104] 145-150 ^{0}C/ 10 mm Hg

^{1}H N.M.R. (CCl$_4$) δ

7.34	m	1H	H on C5
7.20-5.75	m	6H	Other protons
4.35-3.96	q	2H	CH$_2$ J =8 Hz
1.40-1.25	t	3H	CH$_3$

I.R. ν_{max} (Neat)   3100,2970,1700(CO),1615 , 1560 and 1365 cm^{-1}

Ethyl 5-(2-furyl)valerate(293)

This compound(293) prepared in 88% yield,as described for the compound(238),from hydrogenation of the ester (292) (25 g).

b.p.   100-110 ^{0}C/2 mm Hg   Lit[105]   77-78 ^{0}C/1 mm Hg

^{1}H N.M.R. (CDCl$_3$) δ

7.20-7.06	m	1H	H on C5
6.16-6.05	m	1H	H on C3
5.90-5.82	m	1H	H on C4
4.20-3.85	q	2H	CH$_2$ J =8 Hz
2.80-2.48	m	2H	CH$_2$CO$_2$
2.38-2.10	m	2H	ArCH$_2$
1.90-1.48	m	4H	CH$_2$CH$_2$
1.35-1.08	t	3H	CH$_3$

I.R. ν_{max} (Neat)   2930,1730(CO),1590 and 1370 cm^{-1}

5-(2-Furyl)valeric acid(294)

The mixture of ester(293)(23 g),sodium hydroxide(9.2 g), methanol (60 ml) and water (23 ml) was heated under reflux for 3 hrs. The mixture was cooled and then acidified with HCl. The aqueous solution extracted with ether,and the combined extracts were dried over sodium sulphate,then the solvent

removed,and the residue was distilled under vacuo to give
the acid(294)(15.7 g,85%) which was solidified and then
crystallised from petroleum ether.

    m.p.   43-44 ^{0}C   Lit[105] 44-45^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

10.1	s	1H	CO$_2$H
7.28-7.25	m	1H	H on C5
6.30-6.20	m	1H	H on C3
6.00-5.92	m	1H	H on C4
2.80-2.20	m	4H	ArCH$_2$ and CH$_2$CO$_2$
1.90-1.40	m	4H	CH$_2$CH$_2$

I.R. ν_{max} (Nujol)   1705(CO) and 1590 cm^{-1}

5-(2-Furyl)valeryl chloride(180)

Thionyl chloride (6.37 g) was added to an ice-bath
cooling solution of the acid(294)(9.1 g) in dried ether(50 ml).
The mixture was heated under reflux for 5 hrs.The excess of
thionyl chloride and ether was removed under nitrogen
atmosphere.The residue was distilled under vacuo to give
the valeryl chloride(180)(5.84 g,58%).

    b.p.   65-70 ^{0}C/0.1 mm Hg Lit[105] 95 ^{0}C /3 mm Hg

^{1}H N.M.R. (CDCl$_3$) δ

7.30-7.25	m	1H	H on C5
6.32-6.22	m	1H	H on C3
6.06-5.02	m	1H	H on C4
3.00-2.45	m	4H	ArCH$_2$ and CH$_2$CO$_2$
1.90-1.50	m	4H	CH$_2$CH$_2$

I.R. ν_{max} (Neat)   1800(CO) and 1600 cm^{-1}

5,6,7,8-Tetrahydro-4H-cyclohepta(b)furan-4-one(181)

The valeryl chloride (180)(4.84 g) in carbon disulfide
(15 ml)and freshly distilled tin tetrachloride (3.4 ml)
in carbon disulfide(15 ml) were simultaneously and separately
dropped into boiling stirred carbon disulfide (150 ml,60^0C).
The mixture was boiled at 60 ^{0}C for a further 1 hr when the
addition had reached completion.The excess of tin tetrachloride
and carbon disufide was distilled off (80 ^{0}C),to 10 ml of
its volume. Ice-water was added to the residue(10 ml),and
then extracted with ether.The combined extracts were dried
over sodium sulphate,and then the solvent removed,and the
residue was distilled under vacuo the cycloheptafuranone(181)
(2.3 g,59%).

b.p.   65-70 ^{0}C/0.2 mm Hg

m.p.   42-43 ^{0}C   Lit[105] 43-44 ^{0}C

^{1}H N.M.R. (CDCl$_3$) δ

7.20-7.08	d	1H	H on C2	$J_{2,3}$= 2 Hz
6.66-6.65	d	1H	H on C3	
3.10-2.54	m	4H	ArCH$_2$ and 2H on C5	
2.12-1.76	m	4H	4H on C6 and C7	

I.R. ν_{max} (Neat)   3120,2930,1725(CO),1660

1580 and 1420 cm^{-1}

5,5-Dibromo-5,6,7,8-tetrahydro-4H-cyclohepta(b)furan-4-one(182)

Bromination was carried out,as described for the compound
(283),from the cycloheptafuranone(181)(2.1 g) and
phenyltrimethylammonium tribromide (21 g) in tetrahydrofuran
(200 ml).The pure dibromoketone(182)(2.5 g,59%) was
crystallised from methanol.

m.p.   112-113 ^{0}C   Lit[62]   113-114 ^{0}C

^{1}H N.M.R.   (CDCl$_3$) δ

7.30-7.20	d	1H	H on C2	$J_{2,3}=2$ Hz
6.80-6.70	d	1H	H on C3	
3.20-2.88	m	4H	4H on C6 and C8	
2.40-2.04	m	2H	2H on C7	

I.R. ν_{max} (CCl$_4$)   1670   cm^{-1}

4H-Cyclohepta(b)furan-4-one (9)

The dibromoketone (182)(1.54 g) was dehydrobrominated with lithium carbonate(1.5 g) in boiling dimethylformamide (100 ml) in the usual way giving the furotropone(9) (0.36 g, 50%),which was distilled in bulb-tube.

m.p.   38-39 ^{0}C   Lit[62]   39-41 ^{0}C

^{1}H N.M.R.   (CDCl$_3$) δ

7.70	d	1H	H on C2	$J_{2,3}=2$ Hz
7.48	dd	1H	H on C8	$J_{7,8}=11$ Hz,$J_{6,8}=1$ Hz
7.25	m	1H	H on C6	
7.22	d	1H	H on C3	
7.15	dd	1H	H on C5	$J_{5,6}=12$ Hz,$J_{5,7}=1.5$ Hz
6.85	m	1H	H on C7	

I.R. ν_{max} (CCl$_4$)   1630 and 1595   cm^{-1}

Photolysis of 4H-cyclohepta(b)furan-4-one(9)

The furotropone(9)(0.3 g) in methanol (800 ml) was irradiated for 7 hours in the usual way,as described for the compound(38).Removal of the solvent gave a light brown polymeric material,from which nothing could be isolated .

Chapter 6

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