3-Propyl-2-hexanone (XIII). A 95% yield of 3-propyl-2-hexanone, n_D^{25} 1.4190, d_{25} 0.817, b.p. 52° (6 mm.), was obtained by the hydrogenation of 360 ml. of 3-allyl-5-hexen-2-one in the presence of 1 g. of 5% platinum on alumina.

3-Allyl-3-propyl-2-hexanone (XV). To a solution of 0.87 mole of sodium *tert*-amylate dissolved in 500 ml. of toluene was added 0.9 mole of 3-propyl-2-hexanone at a reaction temperature of 50° (at a lower temperature the *tert*-amylate tended to precipitate from the toluene). Allyl bromide was added slowly so that the reaction temperature was maintained between 50–80°. The mixture was refluxed for 1 hr., water washed, dried with potassium carbonate, and distilled. There were recovered 0.27 mole of 3-propyl-2-hexanone and 0.52 mole of XV, n_D^{25} 1.4470, d_{25} 0.861, b.p. 82° (4 mm.). The compound was not obtained chromatographically pure but contained about 7% of what was believed to be the isomeric 4-propyl-8-nonen-5-one.

Anal. Calcd. for $C_{12}H_{22}O$: C, 79.06; H, 12.17. Found: C, 79.31; H, 12.15.

2-(1-Methylallyl)cyclohexanone (VI). The autoclave was charged with 220 ml. of a mixture containing 2 moles of crotyl alcohol and 1 mole of cyclohexanone. The charge was catalyzed with 0.09 g. phosphoric acid and heated for 3 hr. at 240–250°. The crude reaction mixture was flash distilled at reduced pressure and the final 56 ml. was shown by vapor phase chromatography to have two components present in about equal amounts. The 56-ml. portion was carefully distilled through a vacuum-jacketed column and collected in seven fractions containing 6 to 12 ml. each. Except for a part of fraction 1, all fractions were collected at 101.5–102° (19 mm.). Fraction 3 contained about equal amounts of the two materials and fraction 7 contained 5–15% of the component which had the shorter retention time on the chromatographic column, with the balance being the component with the longer retention time. The physical properties of fraction 3 were n_D^{25} 1.4688, d_{25} 0.924 and for fraction 7, n_D^{25} 1.4698, d_{25} 0.926.

Anal. Calcd. for $C_{10}H_{15}O$: C, 78.89; H, 10.60. Found for fraction 3: C, 79.28: H, 10.77. Found for fraction 7: C, 78.96; H, 10.76.

The infrared spectrograms for both fractions were almost identical and consistent for the structure of VI. It is believed that the two components are diastereoisomers of VI.

2-Crotylcyclohexanone. In the manner already described, 0.9 mole of cyclohexanone was alkylated with 0.9 mole of crotyl bromide in the presence of 0.8 mole of sodium *tert*-amylate at 10–20°. The reaction mixture was water washed and distilled. A 53% yield of 2-crotylcyclohexanone was obtained, n_D^{25} 1.4713, d_{25} 0.925, b.p. 87° (6 mm.).

Anal. Calcd. for $C_{10}H_{16}O$: C, 78.89; H, 10.60. Found: C, 79.02; H, 10.67.

The infrared spectrum was consistent with the structure of 2-crotylcyclohexanone.

Allyl-substituted cyclopentanones. From a 3:1 molar stock solution of allyl alcohol and cyclopentanone, a 150-ml. sample was put in the autoclave with 0.18 g. of phosphoric acid. The material was heated for 2 hr. at 240–250°. There was a 95% conversion of the cyclopentanone and a 42% yield of 2-allylcyclopentanone, 20% 2,2-diallylcyclopentanone, and a 37% yield of 2,5-diallylcyclopentanone. The 2-allylcyclopentanone, n_D^{24} 1.4582, d_{24} 0.924, b.p. 62° (10 mm.), was the same as the material previously prepared.[1]

Chromatographically pure samples of the 2,2- and 2,5-diallylcyclopentanones were obtained by distillation of the combined products of several experiments through a 4-ft. vacuum-jacketed distillation column packed with $^1/_8$-in. glass helices. 2,2-Diallylcyclopentanone had n_D^{25} 1.4760, d_{25} 0.929, b.p. 85° (7 mm.).

Anal. Calcd. for $C_{11}H_{16}O$: C, 80.44; H, 9.82. Found: C, 80.10; H, 9.76.

2,5-Diallylcyclopentanone had n_D^{25} 1.4683, d_{25} 0.912, b.p. 91° (7 mm.).

Anal. Calcd. for $C_{11}H_{16}O$: C, 80.44; H, 9.82. Found: C, 80.02; H, 9.74.

Acknowledgment. The author is grateful to J. H. Brown, Jr., Professor Lewis F. Hatch, and H. Spell for their advice and help.

FREEPORT, TEX.

[CONTRIBUTION FROM WALKER LABORATORY, RENSSELAER POLYTECHNIC INSTITUTE]

Indan Analogs of Hexestrol and Diethylstilbestrol[1]

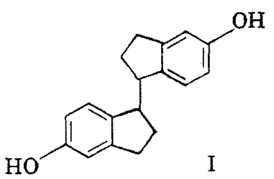
CHARLES A. PANETTA[2] AND STANLEY C. BUNCE

Received June 16, 1961

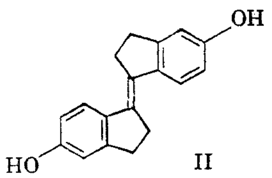
meso-5,5′-Dihydroxy-1,1′-biindan (I), an indan analog of hexestrol, has been prepared from 5-methoxy-1-indanone by conversion to its ketazine, hydrogenation to 5,5′-dimethoxy-1,1′-azoindan, and pyrolysis. Both racemic and *meso*-5,5′-dimethoxy-1,1′-biindan were formed (VI); the latter was demethylated to form *meso*-5,5′-dihydroxy-1,1′-biindan (I).

The syntheses of 5,5′-dimethoxy-1,6′-biindan (VII), 6,6′-dimethoxy-5,5′-biindan (VIII), 5-bromo-6-methoxyindan, 5-iodo-6-methoxyindan, 4-iodo-5-methoxyindan, 5-chloro-6-methoxyindan, 5-nitro-1-indanone, 5-methoxy-1-indenecarboxylic acid (X), 2,2′-diiodo-3,3′-dihydroxy-1,1′-biindan (XII), and 2-(α-chloroacetyl)-5-methoxy-1-indanone (IX) are also reported.

Our interest in the preparation and properties of compounds structurally similar to the estrogenic hormones[3] led us to attempt the preparation of 5,5′-dihydroxy-1,1′-biindan (I) and 5,5′-dihydroxy-$\Delta^{1,1'}$-biindan (II), which are indan analogs of the artificial estrogens, hexestrol, and diethylstilbestrol.



I



II

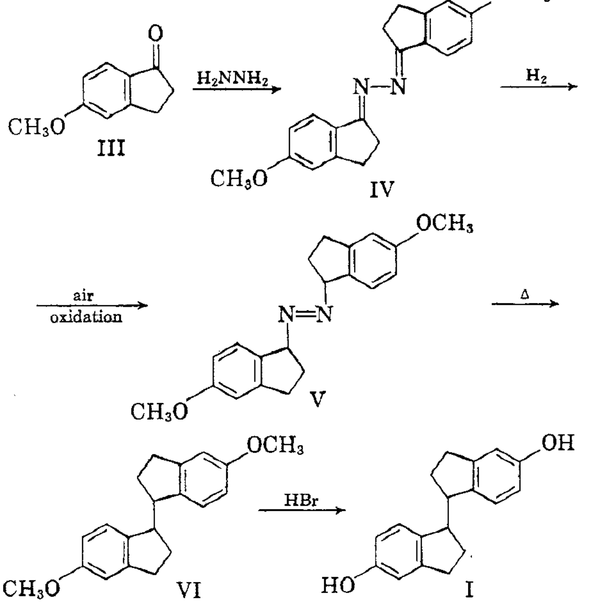
---

[1] Abstracted from the Ph.D. thesis of Charles A. Panetta, Rensselaer Polytechnic Institute, 1960.

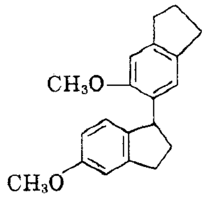
[2] Present address: Chemical Development Department, Bristol Laboratories Inc., Syracuse, N. Y.

[3] For the previous paper in this series see J. G. Bennett, Jr., and S. C. Bunce, *J. Org. Chem.*, **25**, 73 (1960).

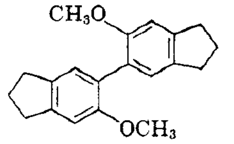
meso-5,5′-Dihydroxy-1,1′-biindan (I) was successfully prepared beginning with 5-methoxy-1-indanone (III). For the preparation of this intermediate, the simplest starting material was 5-indanol, which was methylated with dimethyl sulfate in 92.5% yield. Oxidation of 5-methoxyindan with chromic acid produced a 68% yield of 5-methoxy-1-indanone (III). This is a much shorter route than was previously used[4] to prepare this ketone. 5-Methoxy-1-indanone was treated with hydrazine to form its ketazine (IV) in 96.5% yield. In a procedure similar to that used by Földi and Fodor for the preparation of hexestrol,[5] the ketazine (IV) was hydrogenated to form a tetrahydroazine which was not isolated, but oxidized with air to yield two isomers of 5,5′-dimethoxy-1,1′-azoindan (V) in a total yield of 60%. These isomers are thought to be the *meso* and racemic rather than the geometrical forms of the azoindan, since most of the known azo compounds exist primarily in the more stable *trans* form and the *cis* form has been obtained only by special treatment of the *trans* form.[6,7] Both of these isomers easily decomposed on heating to form a mixture of racemic and *meso*-5,5′-dimethoxy-1,1′-biindans (VI) in 58% total yield. The mixture was separated by crystallization and the higher-melting isomer, presumed to be the *meso* compound, was demethylated with hydrobromic acid to give a 66% yield of *meso*-5,5′-dihydroxy-1,1′-biindan (I). The lower-melting isomer, *dl*-5,5′-dimethoxy-1,1′-biindan was not easily demethylated by this method. The over-all yield of *meso*-5,5′-dihydroxy-1,1′-biindan was 7%.



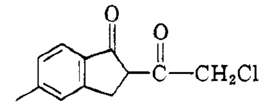
An attempted preparation of 5,5′-dimethoxy-1,1′-biindan (VI) by the cobaltous chloride-Grignard reagent coupling procedure of Wilds and McCormack[8] gave a small yield of 5,5′-dimethoxy-1,6′-biindan (VII). A mixture of 5-methoxyindan, 1-bromo-5-methoxyindan, and 5-bromo-6-methoxyindan was obtained by the reaction between 5-methoxyindan and *N*-bromosuccinimide. The components could not be separated because of the instability of 1-bromo-5-methoxyindan and the mixture was therefore treated with ethylmagnesium bromide and anhydrous cobaltous chloride. The yield of 5,5′-dimethoxy-1,6′-biindan was 3% based on the amount of material not recovered as 5-methoxyindan.



VII



VIII



IX

In order to prove that 6,6′-dimethoxy-5,5′-biindan (VIII) was not the product of the above reaction, it was prepared by the reaction between 5-bromo-6-methoxyindan, anhydrous cobaltous chloride, and ethylmagnesium bromide. The yield was 26% based upon the amount of bromomethoxyindan not recovered.

A comparison of the infrared spectra of 5,5′-dimethoxy-1,6′-biindan (VII), 5,5′-dimethoxy-1,1′-biindan (VI), and 6,6′-dimethoxy-5,5′-biindan (VIII) showed the first to have more bands in common with each of the latter two than the latter two spectra have in common with each other; this supported our tentative conclusions about the structure of VII.

5-Methoxy-1-indancarboxylic acid was an intermediate which might be used in several routes to coupled products. Its preparation was attempted by way of 5-methoxy-1-indancarboxaldehyde. However, when 5-methoxy-1-indanone was treated with sodium methoxide and ethyl chloroacetate, the product of the reaction, obtained in 60% yield, was not an aldehyde. It had a melting point very near that of 5-methoxy-1-indanone and was converted to that compound on heating with sodium hydroxide solution. Infrared absorptions indicated hydroxyl (3450 cm.$^{-1}$), carbonyl (1690 cm.$^{-1}$), and ether (1260 cm.$^{-1}$) functions, and solubility in sodium hydroxide, but not sodium bicarbonate, indicated a phenol or enol, and

---

(4) C. K. Ingold and H. A. Piggott, *J. Chem. Soc.*, **123**, 1469 (1923).

(5) Z. Földi and G. von Fodor, *Ber.*, **74**, 589 (1941).

(6) G. S. Hartley, *Nature*, **140**, 281 (1937).

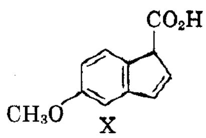
(7) G. S. Hartley, *J. Chem. Soc.*, 633 (1938).

(8) A. L. Wilds and W. B. McCormack, *J. Org. Chem.* 45 (1949).

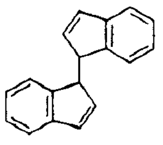
a ferric chloride test confirmed this. Unsaturation and chlorine reactive to sodium iodide in acetone were present, but not aldehyde or ester functions. The cleavage by base indicated a β-dicarbonyl function, and the compound was assigned the structure of 2-(α-chloroacetyl)-5-methoxy-1-indanone (IX).

The isolation of this compound indicates that the carbonyl group of the ketone is very unreactive due to the partial neutralization of its electrophilic character by the resonance effect of the methoxy group. The unusually low reactivity of the carbonyl group in 5-methoxy-1-indanone was shown also by its inability to form a cyanohydrin addition product and its failure to react with 5-(or 6-)methoxy-1-indenylmagnesium bromide.

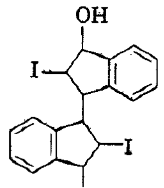
An attempt was made to prepare 5-methoxy-1-chloroindan for use in possible coupling reactions. When 5-methoxyindan was treated with sulfuryl chloride and benzoyl peroxide according to the general method of Kharasch and Brown for the preparation of benzylic chlorides,[9] there were obtained a 17% yield of a solid which was shown, by its oxidation and by its hydrolysis, to be 5-chloro-6-methoxyindan, and an oil which after reaction with magnesium and carbonation produced 5-methoxy-1-indenecarboxylic acid (X). The formation of this acid can be explained if 1-chloro-5-methoxyindan was present in the oil and suffered dehydrohalogenation with subsequent isomerization of the double bond prior to metalation and carbonation. The other possible product, 6-methoxy-1-indenecarboxylic acid, is a known compound[10] with a melting point quite different from the acid that was isolated.



X



XI



XII

When an attempt was made to couple 5-methoxyindan using iodine and ethylmagnesium bromide by the method that Grignard and Courtot used for the coupling of indene,[11] 4-iodo-5-methoxyindan was the only product isolated. The yield was 2%. The structure of the iodomethoxyindan was indirectly proven when the only other possible product, 5-iodo-6-methoxyindan, was prepared from 5-methoxyindan by iodination with silver trifluoroacetate[12] and its structure confirmed by oxidation to the known 5-iodo-4-methoxyphthalic anhydride. It differed from the 4-iodo-5-methoxyindan in both melting point and infrared spectrum.

1,1′-Biindene (XI)[11] was used in attempts to place substituents on the 5,5′-positions. Attempted nitrations were unsuccessful. Iodination with iodine and silver trifluoroacetate according to the iodination method used by Beaton and Tucker[12b] for the iodination of tetrahydrofluoroanthrene produced a product which was indicated by infrared data, classification tests, elemental analysis, and a *p*-nitrobenzoate derivative to be 2,2′-diiodo-3,3′-dihydroxy-1,1′-biindan (XII). The hydroxyl groups were probably introduced by way of addition of the trifluoroacetate ion to the alicyclic ring followed by hydrolysis.

It has been shown by Greene, Davies, and Horsfall[13] that *p*-nitrotoluene can be coupled to *p,p*′-dinitrobibenzyl in the presence of potassium hydroxide and air at elevated temperatures, and it was hoped that 5-nitroindan, in a similar reaction, might form 5,5′-dinitro-1,1′-biindan. 5-Nitroindan was prepared by the method of Lindner and Bruhin.[14] Its treatment with potassium hydroxide and air at elevated temperatures gave an insoluble brown solid that seemed to be the result of complete decomposition. No 5-nitroindan could be recovered except when the reaction temperature was kept below room temperature.

Many routes leading to 5,5′-dihydroxy-$\Delta^{1,1'}$-biindan (II) were attempted, but none was successful. An attempt was made to apply the procedure for coupling of bromides using sodium in liquid ammonia that was developed by Kharasch and Kleiman[15] for the preparation of diethylstilbestrol. When the oily mixture of the bromomethoxyindans was treated in the same manner only colored, impure solids could be obtained which resisted purification.

The coupling of diazo compounds with sulfur dioxide has been found useful for the preparation of diethylstilbestrol dimethyl ether[16,17] and other coupled unsaturated compounds.[3] The hydrazone of 5-methoxy-1-indanone was prepared; when it was treated with yellow mercuric oxide, little color developed indicating a low concentration of the diazo compound. Subsequent treatment of the reaction mixture with sulfur dioxide followed by heating produced the azine of 5-methoxy-1-indanone (IV) instead of 5,5′-dimethoxy-$\Delta^{1,1'}$-biindan.

The thermal decomposition of 5-methoxy-1-

---

[9] M. S. Kharasch and H. C. Brown, *J. Am. Chem. Soc.*, **61**, 2142 (1939).

[10] O. Süs, *Ann.*, **579**, 133 (1953).

[11] (a) V. Grignard and C. Courtot, *Compt. rend.*, **154**, 361 (1912); (b) *Compt. rend.*, **152**, 272 (1911).

[12] (a) A. L. Henne and W. F. Zimmer, *J. Am. Chem. Soc.*, **73**, 1362 (1951); (b) J. M. Beaton and S. H. Tucker, *J. Chem. Soc.*, 3870 (1952).

[13] A. G. Greene, A. H. Davies, and R. S. Horsfall, *J. Chem. Soc.*, 91, 2076 (1907).

[14] J. Lindner and J. Bruhin, *Ber.*, **60**, 435 (1927).

[15] M. S. Kharasch and M. Kleiman, *J. Am. Chem. Soc.*, **65**, 11 (1943).

[16] L. I. Smith and K. L. Howard, *Org. Syntheses*, Coll. Vol. III, 351 (1955).

[17] L. v. Vargha and E. Kovacs, *Ber.*, **75**, 794 (1942).

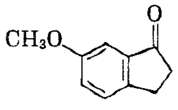
indanone azine, the bimolecular reduction of 5-methoxy-1-indanone with magnesium and magnesium iodide, and the bimolecular dehydrogenation of 5-methoxyindan using sulfur were all attempted, but in no case was any biindan isolated.

Base-catalyzed condensations of 5-substituted indans with 1-indanone derivatives were attempted as possible routes for the preparation of 5,5′-dihydroxy-$\Delta^{1,1'}$-biindan (II). Cope and Field[18] have condensed 1-indanone and ethyl cyanoacetate. Following similar procedures, 5-methoxy-1-indanone was used in attempts at condensation with 5-nitroindan and 5-methoxyindan and 5-nitro-1-indanone, which was prepared by the chromic acid oxidation of 5-nitroindan in 29% yield, was used in the same manner with 5-nitroindan. Neither 5-nitroindan, which was believed to have the more active methylene group in the 1-position, nor 5-methoxyindan reacted with 5-methoxy-1-indanone. 5-Nitroindan did not react with 5-nitro-1-indanone; 5-methoxy-1-indanone under the basic conditions apparently entered into a self-condensation reaction which produced a yellow water-soluble solid. The chemical properties, infrared spectrum, and analytical data indicated this to be a diacetoxydimethoxyhydroxybiindan, but its structure has not been unequivocally determined.

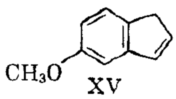
As 4,4′-diaminostilbene has been prepared by refluxing *p*-nitrotoluene, hydrazine, and potassium hydroxide in diethylene glycol,[19] 5-nitroindan was treated similarly in an effort to prepare 5,5′-diamino-$\Delta^{1,1'}$-biindan. Besides 5-aminoindan, a basic compound was isolated which did not contain unsaturation and was thought to be 5,5′-diamino-1,1′-biindan. It was unstable and became colored on standing.

The dehydrogenation of *meso*-5,5′-dimethoxy-1,1′-biindan was attempted without success in order to prepare the unsaturated biindan. Bibenzyl and the dimethyl ether of *meso*-hexestrol were used as model compounds to find the best reaction conditions. While stilbene could be prepared in 20% yield from bibenzyl by heating for six hours at 330–360° with 10% palladium on powdered charcoal, the dimethyl ether of *meso*-hexestrol could not be dehydrogenated using that catalyst, 5% platinum on powdered charcoal, or sulfur. Other unsuccessful attempts to dehydrogenate the dimethyl ether of *meso*-hexestrol have been reported.[20]

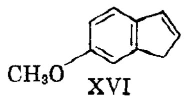
Another attempt to prepare the unsaturated biindan (II) involved the preparation of 5-methoxyindene which might react with ethylmagnesium bromide to form 5-methoxy-1-indenylmagnesium bromide. This compound might be added to 5-methoxy-1-indanone to form a tertiary alcohol which should easily be dehydrated to an unsaturated biindan. 6-Methoxy-1-indanone (XIV) was reduced according to the method of Huckel *et al.* for the reduction of 1-indanone[21] and the resulting alcohol was dehydrated by distillation with potassium bisulfate[22]; the anticipated product was 5-methoxyindene (XV).



XIV



XV



XVI

Ingold and Piggott have reported the isolation of the same methoxyindene from the distillation of either the 5- or the 6-methoxy isomers of 1-indanamine hydrochloride.[4] However, Koelsch and Scheiderbauer more recently have reported one instance of the successful separation and identification of 5- and 6-substituted indenes[22] and we believed that avoiding alkaline conditions might permit us to isolate 5-methoxyindene. The product obtained from the reduction and dehydration of 6-methoxy-1-indanone was unsaturated, but it could also be isolated by the reduction and dehydration of 5-methoxy-1-indanone. Both products were probably 6-methoxyindene (XVI), which we believe to be the more stable isomer. It did not isomerize when heated with aqueous potassium hydroxide.

The 6-methoxyindene seemed to form a Grignard derivative, but no reaction of this derivative with 5-methoxy-1-indanone was observed.

EXPERIMENTAL[23]

5-Methoxy-1-indanone (III). 5-Methoxyindan was prepared from 5-indanol[24] by the slow addition of 142 ml. (188 g., 1.5 moles) of technical dimethyl sulfate to 134 g. (1.0 mole) of 5-indanol in 10% solution in acetone in the presence of 570 g. (4.0 moles) of 44% potassium hydroxide solution. After separation of the organic layer and distillation of acetone, 137 g. (92%) of 5-methoxyindan, b.p. 75–77° at 0.6 mm., n_D^{20} 1.5424 (lit.[25] b.p. 233–234° at 760 mm., n_D^{20} 1.5425) was obtained.

A solution of 30 g. (0.3 mole) of chromic acid and 120 ml. of 80% acetic acid was added in portions, at 25–35° to a stirred solution of 14.8 g. (0.1 mole) of 5-methoxyindan and 420 ml. of acetic acid. After 4 hr. the mixture was diluted to

---

(18) A. C. Cope and L. Field, *J. Am. Chem. Soc.*, **71**, 1589 (1949).

(19) Huang-Minlon, *J. Am. Chem. Soc.*, **70**, 2802 (1948).

(20) H. Bretschneider, A. de Jonge-Bretschneider, and N. Ajtai, *Ber.*, **74**, 571 (1941).

(21) W. Huckel, M. Sachs, J. Yantschulewitsch, and F. Nerdel, *Ann.*, **518**, 155 (1935).

(22) C. F. Koelsch and R. A. Scheiderbauer, *J. Am. Chem. Soc.*, **65**, 2311 (1943).

(23) Boiling points are uncorrected. Melting points, unless otherwise noted, were obtained by the capillary method with a thermometer calibrated with reference compounds [S. C. Bunce, *Anal. Chem.*, **25**, 825 (1953)]. Elemental analyses were performed by Drs. G. Weiler and F. B. Strauss, Microanalytical Laboratory, 164 Banbury Road, Oxford, England, unless otherwise noted.

(24) We are indebted to Union Carbide Chemicals Co. for supplies of 5-indanol and 4-indanol.

(25) *Dictionary of Organic Compounds*, I. Heilbron and H. M. Bunbury, Eds.-in-Chief, Vol. II, Oxford University Press, New York, N. Y., 1953, p. 771.

twice its volume with water, extracted with chloroform, and the chloroform solution was washed with 10% sodium bicarbonate and dried. After removal of the chloroform, recrystallization from water or methanol gave 13.1 g. (81%) of white needles, m.p. 108.4–109.4°, of 5-methoxy-1-indanone.

5-Methoxy-1-indanone formed an oxime melting at 151–153°, uncor., (lit.,[4] m.p. 151°) and a semicarbazone melting at 235–238° dec., uncor. (lit.[4] m.p. 239°).

5-Methoxy-1-indanone azine (IV). A solution of 5.0 g. (0.1 mole) of 85% hydrazine hydrate and 10 ml. of absolute alcohol was added to a hot solution of 25.9 g. (0.16 mole) of 5-methoxy-1-indanone, 30 ml. of absolute alcohol, and 10 ml. of acetic acid. A solid separated almost immediately and was recrystallized from benzene to yield 24.7 g. (96.5%) of yellow needles of 5-methoxy-1-indanone azine, m.p. 212.8–214.5° dec.

Anal. Calcd. for $C_{20}H_{20}N_2O_2$: C, 74.97; H, 6.29; N, 8.74. Found: C, 74.79; H, 6.23; N, 8.66.

5,5′-Dimethoxy-1,1′-azoindan (V). 5-Methoxy-1-indanone azine, 6.2 g. (0.02 mole), 0.3 g. of platinum oxide,[26] 15 ml. of acetic acid, and 85 ml. of methanol were shaken under 3 atm. of hydrogen for 53 hr. The filtered solution was air-oxidized by allowing it to evaporate or alternatively by forcing a vigorous stream of air through it and 4 g. (60%) of a white solid was collected. This was recrystallized from methanol to produce white platelets of 5,5′-dimethoxy-1,1′-azoindan, m.p. 133.3–134.3° dec. with gas evolution.

Anal. Calcd. for $C_{20}H_{22}N_2O_2$: C, 74.51, H, 6.88; N, 8.69. Found: C, 74.62; H, 6.96; N, 8.85.

Concentration of the methanol filtrate precipitated an equal amount of white prisms of another isomer of 5,5′-dimethoxy-1,1′-azoindan, m.p. 79.1–81.7° dec. with gas evolution at 130°.

Anal. Calcd. for $C_{20}H_{22}N_2O_2$: C, 74.51; H, 6.88; N, 8.69. Found: C, 74.48; H, 6.82; N, 8.31, 8.80.

5,5′-Dimethoxy-1,1′-biindan (VI). Slow heating to 140° of 3.3 g. (0.01 mole) of recrystallized 5,5′-dimethoxy-1,1′-azoindan (either isomer) resulted in vigorous gas evolution. The melt was then heated to 190° before it was dissolved in hot methanol, treated with charcoal, filtered, and allowed to cool slowly. Cream-colored crystals, 0.8 g., of *meso*-5,5′-dimethoxy-1,1′-biindan separated and were recrystallized from ethanol to give dull golden needles, m.p. 146.7–147.7°.

Anal. Calcd. for $C_{20}H_{22}O_2$: C, 81.60; H, 7.53. Found: C, 81.64; H, 7.47.

The filtrate was diluted with 1 ml. of water and refrigerated; 0.5 g. of a cream-colored solid separated and was recrystallized from ethanol to yield white needles of *dl*-5,5′-dimethoxy-1,1′-biindan, m.p. 112.1–112.9°.

Anal. Calcd. for $C_{20}H_{22}O_2$: C, 81.60; H, 7.53; Found: C, 81.52; H, 7.34.

Further dilution of the filtrate precipitated 0.4 g. of a cream-colored solid, m.p. 88–103°, which was probably a mixture of the isomers. The total yield of biindans was 1.7 g. (58%).

meso-5,5′-Dihydroxy-1,1′-biindan (I). A mixture of 0.5 g. (0.0017 mole) of *meso*-5,5′-dimethoxy-1,1′-biindan, 8.5 ml. of acetic acid, and 3.5 ml. of 48% hydrobromic acid was refluxed for 10 hr. and poured into 50 ml. of water. The mixture was cooled to precipitate a brown solid, which was dissolved in hot benzene and decolorized with charcoal. After concentration, 0.3 g. (66%) of *meso*-5,5′-dihydroxy-1,1′-biindan precipitated. Recrystallization from ethanol and water and then from benzene and petroleum ether (b.p. 80–100°) produced cream-colored needles, m.p. 200.2–201.3° dec.

Anal. Calcd. for $C_{18}H_{18}O_2$, C, 81.17; H, 6.81. Found: C, 80.96; H, 6.95.

Attempted demethylation of *dl*-5,5′-dimethoxy-1,1′-biindan by the same method produced a trace of a yellow solid, m.p. 182.2–183.8° dec., insufficient for an elemental analysis.

1-Bromo-5-methoxyindan and 5-bromo-6-methoxyindan. About 500 ml. of azeotropically-dried carbon tetrachloride, 37 g. (0.25 mole) of 5-methoxyindan, 44.5 g. (0.25 mole) of *N*-bromosuccinimide, and a trace of benzoyl peroxide were slowly brought to reflux, at which time a vigorous reaction began. The cooled and filtered mixture was washed with 5% sodium bicarbonate, and water, and dried. The carbon tetrachloride was removed *in vacuo* below 30° and the dark, oily residue when diluted with ethanol and cooled, precipitated a white solid. Recrystallization from ethanol gave white crystals of 5-bromo-6-methoxyindan, m.p. 35.2–35.9° (uncor.).

Anal. Calcd. for $C_{10}H_{11}OBr$: C, 52.88; H, 4.88; Br, 35.19. Found: C, 52.97; H, 4.77; Br, 35.00.

Oxidation of 1 g. of 5-bromo-6-methoxyindan with alkaline potassium permanganate[27] gave a solid, m.p. 188–192° (uncor.), which contained bromine and which was dehydrated by refluxing for 1 hr. with acetic anhydride to produce 4-bromo-5-methoxyphthalic anhydride, m.p. 170.9–172.4° (uncor.) (lit.,[28] m.p. 166–168°) after recrystallization from acetic acid.

The oil which remained after separation of some of the 5-bromo-6-methoxyindan gave positive Beilstein and silver nitrate tests and easily decomposed with loss of hydrogen bromide. It was assumed that it was composed mainly of 1-bromo-5-methoxyindan with some unchanged 5-methoxyindan and some unseparated 5-bromo-6-methoxyindan. It was stored at Dry Ice temperature.

5,5′-Dimethoxy-1,6′-biindan (VII). To the stirred Grignard reagent prepared from 20.4 g. (0.85 mole) of magnesium turnings, 90.0 g. (0.83 mole) of distilled ethyl bromide, and 710 ml. of dry ether was added 5.2 g. (0.04 mole) of anhydrous cobaltous chloride powder[29]; then an ether solution of 98.9 g. (0.46 mole) of 1-bromo-5-methoxyindan (unrefined oil from the *N*-bromosuccinimide bromination of 5-methoxyindan) was added during a 25-min. period. The dark-colored mixture was poured into ice and hydrochloric acid and extracted with ether. The ether solution was washed with 5% hydrochloric acid and saturated salt solution and dried. After the ether was removed, the residue was distilled at 0.05 to 0.10 mm., yielding 44.9 g. of 5-methoxyindan, b.p. 41–52° and 8.1 g., b.p. 52–230° which crystallized after being dissolved in acetone and ethanol. Two recrystallizations from acetone using charcoal gave 1.1 g. (3% based on amount of material not recovered as 5-methoxyindan) of 5,5′-dimethoxy-1,6′-biindan, m.p. 140.7–141.7°.

Anal. Calcd. for $C_{20}H_{22}O_2$: C, 81.60; H, 7.53. Found: C, 81.33, 81.56; H, 7.54, 7.65.

A second solid was obtained also which melted at 160–180° dec. and gave a negative Beilstein test, but it was not possible to purify this solid further.

6,6′-Dimethoxy-5,5′biindan (VIII). Following the method Kharasch and Fields[30] employed for the coupling of *o*-bromophenetole, 13.0 g. (0.057 mole) of 5-bromo-6-methoxyindan was dissolved in 30 ml. of dry ether and added dropwise to 1.4 g. (0.06 mole) of magnesium. The solution was refluxed for 3 hr. and then poured into a flask containing 0.39 g. (0.003 mole) of anhydrous cobaltous chloride[29] and 3.3 g. (0.03 mole) of ethyl bromide. After the spontaneous

---

(26) R. Adams, V. Voorhees, and R. L. Shriner, *Org. Syntheses*, Coll. Vol. I, 463 (1941).

(27) R. L. Shriner, R. C. Fuson, and D. Y. Curtin, *The Systematic Identification of Organic Compounds*, Fourth Ed., Wiley, New York, 1956, p. 250.

(28) M. Tomita and C. Tani, *J. Pharm. Soc. Japan*, 62, 481 (1942); *Chem. Abstr.*, 45, 4729 (1951).

(29) This was obtained from the hexahydrate by grinding to a fine powder and heating overnight in a vacuum oven at 120°.

(30) M. S. Kharasch and E. K. Fields, *J. Am. Chem. Soc.*, 63, 2316 (1941).

refluxing subsided, the mixture was heated for 1 hr. and poured into 150 ml. of ice water and 5 ml. of acetic acid. The ether layer was washed with 10% sodium carbonate solution and dried. The ether was removed and the residual oil (7.6 g.) was distilled at 0.01 mm. to give 4.3 g. of 5-bromo-6-methoxyindan, b.p. 55–75°, and then 3.0 g. of a viscous oil, b.p. 75–160°. The latter was dissolved in an acetone, ethanol, and methanol mixture and cooled to Dry Ice temperature to precipitate a white solid. Recrystallization from petroleum ether (b.p. 80–100°), and from methanol produced white needles of 6,6′-dimethoxy-5,5′-biindan, m.p. 95.4–96.1°.

Anal. Calcd. for $C_{20}H_{22}O_2$: C, 81.60; H, 7.53. Found: C, 81.66; H, 7.49.

2-(α-Chloroacetyl)-5-methoxy-1-indanone (IX). To a cooled mixture of 8.1 g. (0.05 mole) of 5-methoxy-1-indanone, 9.5 ml. (11.0 g., 0.09 mole) of ethyl chloroacetate, and 50 ml. of dry ether, 4.9 g. (0.09 mole) of commercial sodium methoxide was added during a 1.75-hr. period. After stirring at room temperature for 21 hr., the ether solution was poured into 6 ml. of concd. hydrochloric acid and 40 ml. of cold water, then washed with saturated sodium bicarbonate solution and saturated salt solution. Evaporation of the dried ether solution gave 7.4 g. of a tan solid which was recrystallized from ethanol to produce cream-colored needles, m.p. 110.5–111.2°, of 2-(α-chloroacetyl)-5-methoxy-1-indanone.

Anal. Calcd. for $C_{12}H_{11}O_3Cl$: C, 60.50; H, 4.65; Cl, 14.85. Found: C, 60.80, 61.00; H, 4.59, 4.71; Cl, 15.08, 15.14.

2-(α-Chloroacetyl)-5-methoxy-1-indanone (2 g.) was heated at 48° for 17 hr. with 1.2 g. of sodium hydroxide in 30 ml. of water. The mixture was acidified to Congo Red with 6*N* hydrochloric acid and extracted with benzene. The dried benzene solution was concentrated and the residue was heated at 150° for 4 hr. White needles (0.6 g.) of 5-methoxy-1-indanone, m.p. 109.5–110.5° (uncor.), sublimed. Material which did not sublime gave a nearly equal amount of a reddish brown solid, m.p. 147–160°, which could not be purified.

5-Chloro-6-methoxyindan and 5-methoxy-1-indenecarboxylic acid. (X). Sulfuryl chloride 8 ml. (0.1 mole) was added dropwise during a 10-min. period at 0–10° to 14.8 g. (0.1 mole) of 5-methoxyindan, 10 ml. of chloroform, and 0.1 g. of benzoyl peroxide. The dark mixture was allowed to come to room temperature slowly and then stand overnight. After heating on a steam bath *in vacuo*, the residual oil was distilled to obtain a mixture of an oil and solid, b.p. 99–109° at 0.1 mm. Recrystallization of the solid from ethanol produced white platelets, m.p. 47.4–48.4° (uncor.), of 5-chloro-6-methoxyindan; yield, 3.1 g. (17%).

Anal. Calcd. for $C_{10}H_{11}OCl$: C, 65.75; H, 6.07; Cl, 19.41. Found: C, 65.78; H, 5.93; Cl, 19.26.

5-Chloro-6-methoxyindan gave a positive Beilstein test, but negative silver nitrate and sodium iodide tests. Oxidation with alkaline potassium permanganate[27] produced 1.2 g. of 4-chloro-5-methoxyphthalic acid, m.p. 163.0–165.8° after recrystallization from acetic acid. This was dehydrated by refluxing for 1 hr. in acetic anhydride; the product was recrystallized from acetic acid and then from petroleum ether (b.p. 80–100°) to give 4-chloro-5-methoxyphthalic anhydride, m.p. 152.8–153.5° (lit.[31] for 3-chloro-4-methoxyphthalic anhydride, m.p. 172.5–173.0°).

Anal. Calcd. for $C_9H_5O_4Cl$: C, 50.85; H, 2.37; Cl, 16.68. Found: C, 50.84; H, 2.37; Cl, 16.40.

5-Chloro-6-methoxyindan, 1.8 g. (0.01 mole), was demethylated by refluxing with 50 ml. of acetic acid and 20 ml. of 48% hydrobromic acid for 10 hr. The mixture was poured into 300 ml. of ice water, and the precipitated solid was recrystallized from petroleum ether (b.p. 30–60°) to produce 5-chloro-6-indanol, m.p. 36.2–40.7° (uncor.) (lit.,[32] m.p. 37–40°). This sample gave a positive ferric chloride test.

The oily distillate (7.2 g.) from the sulfuryl chloride-5-methoxyindan reaction mixture gave a positive silver nitrate test. It was dissolved in dry ether and added dropwise to 1.0 g. of magnesium turnings. Although no spontaneous reaction was evident, the mixture was stirred at room temperature for two days, and then added to finely crushed Dry Ice. After warming to 0°, 25% sulfuric acid was added and the ether layer was separated, washed with 10% sodium hydroxide solution, and dried. The ether was removed and the residual oil (5.9 g.) was apparently mostly 5-methoxyindan and dissolved 5-chloro-6-methoxyindan. The alkaline washings were acidified and extracted with ether. The dried ether solution gave 0.5 g. of a solid which when recrystallized from water, produced white needles of 5-methoxy-1-indenecarboxylic acid, m.p. 121.8–122.6°.

Anal. Calcd. for $C_{11}H_{10}O_3$: C, 69.40; H, 5.26. Found: C, 69.31; H, 4.94.

Attempted coupling of 5-methoxyindan using iodine and ethylmagnesium bromide; preparation of 4-iodo-5-methoxyindan. An ether solution of ethylmagnesium bromide, prepared from 0.2 mole of ethyl bromide, was added dropwise to a boiling mixture of 14.8 g. (0.1 mole) of 5-methoxyindan in 150 ml. of dry xylene. The ether was thus distilled and the remaining mixture was refluxed for 10 hr. A solution of 21.0 g. (0.083 mole) of iodine and 150 ml. of dry xylene added to the cooled mixture was completely decolorized. The resulting mixture was stirred overnight and then washed with 40% sodium bisulfite solution and 10% sodium hydroxide solution. The xylene was removed *in vacuo* and the residue was distilled to give 3.3 g. (22.3%) of impure 5-methoxyindan, b.p. 116–130° at 22 mm., $n_D^{23.2}$ 1.5432, an intermediate halogen-containing fraction, b.p. 130–183° at 22 mm., and a 7.2-g. fraction, b.p. 110–130° at 15 mm., which solidified and which was recrystallized first from acetone, methanol, and water and then from acetone and methanol. This compound was indicated by sodium fusion to contain iodine, but it did not react with alcoholic silver nitrate. A third recrystallization from methanol produced white platelets of 4-iodo-5-methoxyindan (0.6 g.), m.p. 74.0–75.0°.

Anal. Calcd. for $C_{10}H_{11}OI$: C, 43.82; H, 4.05; I, 46.30. Found: C, 43.78; H, 4.31; I, 46.31.

5-Iodo-6-methoxyindan. To a stirred mixture of 1.5 g. (0.01 mole) of 5-methoxyindan in 20 ml. of carbon tetrachloride, and 2.5 g. (0.01 mole) of iodine, 2.5 g. (0.01 mole) of silver trifluoroacetate prepared by the procedure of Henne and Finnegan[33] was added in portions at reflux temperature. The carbon tetrachloride solution was separated from silver iodide, which was extracted with carbon tetrachloride and the combined solutions were washed with sodium bisulfite solution, dried, and evaporated. The residue, recrystallized from ethanol gave 5-iodo-6-methoxyindan, m.p. 39.0–39.4° (uncor.).

Anal. Calcd. for $C_{10}H_{11}OI$: C, 43.82; H, 4.05; I, 46.30. Found: C, 44.22; H, 4.03; I, 46.15.

Alkaline permanganate oxidation[27] of this compound followed by dehydration of the product with acetyl chloride, yielded cream-white crystals of 5-iodo-4-methoxyphthalic anhydride from acetic acid, m.p. 168.6–169.9° (lit.[34] m.p. 168°).

Attempted iodination of 1,1′-biindene; preparation of 2,2′-diiodo-3,3′-dihydroxy-1,1′-biindan (XII). 1,1′-Biindene was prepared in 28% yield according to the method of Grignard and Courtot.[11] Silver trifluoroacetate was added to a heated solution of 2.3 g. (0.01 mole) of 1,1′-biindene, 5.0 g. (0.02 mole) of iodine, and 60 ml. of carbon tetrachloride until the iodine color disappeared (10.2 g., 0.046 mole required).

---

(31) C. A. Buehler and R. L. Pruett, *J. Am. Chem. Soc.*, **73**, 5506 (1951).

(32) Sterling Drug, Inc., Brit. Patent, **770,593**, (1957); *Chem. Abstr.*, **51**, 15584 (1957).

(33) A. L. Henne and W. G. Finnegan, *J. Am. Chem. Soc.*, **72**, 3806 (1950).

(34) R. Grewe, *Ber.*, **71**, 907 (1938).

The mixture was filtered and the residue was extracted with hot carbon tetrachloride. The combined carbon tetrachloride solutions were washed with water, dried, and concentrated to a residue which was dissolved in a hot acetone, alcohol, and water mixture and allowed to cool. A tarry brown solid was first to separate, but after the filtrate was concentrated and cooled, yellow crystals of 2,2′-diiodo-3,3′-dihydroxy-1,1′-biindan (0.5 g.) were isolated. Recrystallizations from benzene and then from acetone and water produced white needles, m.p. 188.8–189.4° dec. with iodine sublimation.

Anal. Calcd. for $C_{18}H_{16}O_2I_2$: C, 41.73; H, 3.09; I, 48.99. Found: C, 41.13; H, 3.18; I, 49.10.

2,2′-Diiodo-3,3′-dihydroxy-1,1′-biindan did not react with potassium dichromate, ferric chloride, bromine in carbon tetrachloride, or potassium permanganate solutions. The preparation of a *p*-nitrobenzoate derivative was attempted[35]; a pure white solid was produced which melted over a wide range (197° to over 300°) with iodine sublimation. Its infrared spectrum showed the absence of a hydroxyl group band and the presence of nitro and carbonyl group absorptions.

Hydrazone of 5-methoxy-1-indanone. 5-Methoxy-1-indanone, 26.4 g. (0.16 mole), 150 ml. of absolute alcohol, and 20.5 g. (0.64 mole) of 95% hydrazine were refluxed for 13.5 hr. The mixture was poured into 300 ml. of ice water and after filtering and washing with cold water, 21.1 g. (75%) of 5-methoxy-1-indanone hydrazone, m.p. 107–110° (uncor.) remained.

Anal. Calcd. for $C_{10}H_{12}N_2O$: C, 68.16; H, 6.86; N, 15.90. Found: C, 68.40; H, 7.14; N, 15.55.

Heating the hydrazone for a short time alone or in benzene changed it to the azine of 5-methoxy-1-indanone (IV), m.p. 212.8–214.5° dec. The hydrazone reacted with acetone to form the mixed azine of acetone and 5-methoxy-1-indanone, which separated as a white solid, m.p. 82.0–85.5° (uncor.), after recrystallization from petroleum ether (b.p. 30–60°).

Anal. Calcd. for $C_{13}H_{16}N_2O$: C, 72.19; H, 7.46; N, 12.95. Found: C, 72.46; H, 7.65; N,[36] 12.93.

Attempted preparation of 5-methoxy-1-diazoindan and subsequent reaction with sulfur dioxide. 5-Methoxy-1-indanone hydrazone, 8.8 g. (0.05 mole), 32.5 g. (0.15 mole) of yellow mercuric oxide, and 100 ml. of petroleum ether (b.p. 30–60°) were shaken in a glass-stoppered bottle for 24 hr. at room temperature. Anhydrous sulfur dioxide was passed into the filtered solution for 5 min., the petroleum ether was removed, and the residue was boiled with water for 1 hr., cooled, and extracted with chloroform. The chloroform extracts were dried and concentrated to dryness. On recrystallization of the solid residue from ethanol, a small quantity of yellow needles was obtained, m.p. 210–214° dec. (uncor.), whose mixed melting point with an authentic sample of the azine of 5-methoxy-1-indanone (IV) was not depressed.

The petroleum ether-insoluble material from the mercuric oxide reaction was extracted with cold benzene. Sulfur dioxide was passed into the solution for 5 min. and the heavy yellow precipitate which resulted was collected and boiled with 300 ml. of water for 1 hr. The solid was collected again and dried. It weighed 3.3 g. and melted at 212–215° dec. (uncor.); this also was the azine of 5-methoxy-1-indanone (IV).

5-Nitro-1-indanone. The 5-nitroindan used was prepared by the method of Lindner and Bruhin.[14] Starting with indan, obtained in 89% yield by platinum oxide-catalyzed hydrogenation of indene (Neville Chemical Co.) at 25° and 3 atm. and purified by treatment with sulfuric acid, there were obtained 27% of 5-nitroindan and 8% of 4-nitroindan, as well as poorly-separated mixtures of the two isomers.

A solution of 7.5 g. (0.075 mole) of chromic acid and 30 ml. of 80% acetic acid was added, in portions with stirring, to 4.1 g. (0.025 mole) of 5-nitroindan in 100 ml. of acetic acid at a temperature below 35°. Stirring was continued for 26.5 hr., after which the mixture was poured into 300 ml. of ice water. 5-Nitroindan, 0.7 g. (17.1%) precipitated and was collected by filtration. The filtrate was extracted with chloroform and the chloroform solution was washed with 5% sodium bicarbonate solution and concentrated to a yellow oil which easily crystallized. Recrystallization from ethanol gave 1.3 g. (29%) of 5-nitro-1-indanone, m.p. 133.1–134.1°.

Anal. Calcd. for $C_9H_7NO_3$: C, 61.01; H, 3.98; N, 7.91. Found: C, 60.91; H, 3.79; N, 8.22.

5-Nitro-1-indanone reacted with 2,4-dinitrophenylhydrazine reagent to form an orange-red 2,4-dinitrophenylhydrazone, m.p. 254–258° dec. (uncor.). An oxime of 5-nitro-1-indanone was also prepared[37] and recrystallized from ethanol, m.p. 192.2–192.8° dec.

Anal. Calcd. for $C_9H_8N_2O_3$: C, 56.25; H, 4.20; N, 14.58. Found: C, 55.79; H, 4.21; N, 14.88.

Attempted condensation of 5-nitroindan with 5-methoxy-1-indanone. 5-Nitroindan, 9.3 g. (0.057 mole), 2.7 g. (0.045 mole) of acetic acid, 0.88 g. (0.011 mole) of dry ammonium acetate, and 25 ml. of dry benzene were refluxed for 1 hr. A solution of 9.2 g. (0.057 mole) of 5-methoxy-1-indanone, 2.7 g. (0.045 mole) of acetic acid, and 50 ml. of dry benzene was added dropwise during an 11.5-hr. period, along with four 0.8-g. portions of dry ammonium acetate. After reflux for 6 additional hr., the mixture was washed with water which extracted a yellow color. The organic layer was dried, diluted with petroleum ether (b.p. 80–100°), and treated with charcoal; removal of the solvents left 6.3 g. of 5-nitroindan. The yellow water solution was diluted with saturated salt solution to precipitate a yellow solid, which gave a negative 2,4-dinitrophenylhydrazine test. After two recrystallizations from acetone and water, the solid, 0.1 g., melted at 232.0–233.2° dec. with gas evolution.

Anal. Calcd. for $C_{24}H_{26}O_7$: C, 67.59; H, 6.15. Found: C, 67.85, 67.53; H, 6.27, 6.48.

When the above procedure was repeated, but without 5-nitroindan, the same compound was obtained.

Attempted coupling of 5-nitroindan using hydrazine and potassium hydroxide; preparation of 5-aminoindan. A mixture of 16.3 g. (0.1 mole) of 5-nitroindan, 180 ml. of triethylene glycol, 28.0 g. (0.5 mole) of potassium hydroxide, and 19.4 ml. (20.0 g., 0.4 mole) of 85% hydrazine hydrate was refluxed for 3 hr., cooled, diluted with water, and steam distilled until 400 ml. of distillate was collected. The ether extract of the distillate was dried over sodium hydroxide, then saturated with anhydrous hydrogen chloride. 5-Aminoindan hydrochloride, 0.9 g. (5.3%), m.p. 280.3–283.9° precipitated. The acetylation[38] of this solid produced white plates of 5-acetaminoindan from ethanol and water, m.p. 106.5–107.5° (lit.,[39] m.p. 106°).

In another run, the reaction mixture was extracted with ether and the ether solution was washed with saturated salt solution and 2*N* hydrochloric acid. The acidic washings were made alkaline with 10% sodium hydroxide solution and extracted with ether. After the ether solution was washed with saturated salt solution, dried, and the solvent removed, a mixture of an oil and crystalline solid remained. Acetone was used to wash the crystals and they were recrystallized from acetone using charcoal. Cream-white plates of what was believed to be 5,5′-diamino-1,1′-biindan separated, m.p. 234.8–235.7° dec. with sublimation. Elemental analyses could not be made because of insufficient amounts of material and because the solid darkened on standing. It did not decolorize potassium permanganate solution.

Attempted preparation of 5-methoxyindene (XV); *preparation of 6-methoxyindene* (XVI). 6-Methoxy-1-indanone (XIV) was prepared in 4.3% over-all yield by the four-step procedure of Ingold and Piggott,[4] starting with 1-indanone.

---

[35] Ref. 27, p. 212, procedure No. 10.

[36] Analysis by George E. Cartier, of this laboratory.

[37] Ref. 27, p. 255, method B.

[38] Ref. 27, p. 226, procedure 21A.

[39] W. Borsche and G. John, *Ber.*, **57**, 656 (1924).

A mixture of 2.4 g. (0.015 mole) of 6-methoxy-1-indanone, 50 ml. of absolute ethanol, and 0.55 g. of platinum oxide[26] were shaken under 3 atm. of hydrogen for 3.5 hr. The ethanol was removed from the filtered mixture, and the residue was dehydrated by distillation from a crystal of potassium bisulfate. A yellow oil was collected, b.p. 220–240°, $n_D^{24.3}$ 1.5746, wt. 1.2 g. (55%) (lit.[4] for 5- or 6-methoxyindene, b.p. 236°). It gave a positive potassium permanganate test in acetone.

When the reduction and dehydration was repeated using 2.4 g. (0.015 mole) of 5-methoxy-1-indanone, 1.4 g. of a yellow oil was collected, b.p. 230–245°, $n_D^{24.5}$ 1.5730. Its infrared spectrum was identical to that of the first methoxyindene. Boiling this compound with 20 ml. of 5% potassium hydroxide solution for 15 min. did not change its infrared spectrum.

Preparation of 6-methoxy-1-indenylmagnesium bromide and subsequent treatment with 5-methoxy-1-indanone. Ethylmagnesium bromide was prepared from 0.25 g. (0.01 mole) of magnesium, 1.1 g. (0.01 mole) of ethyl bromide, and 10 ml. of dry ether in the usual manner. A solution of 1 g. (0.007 mole) of 6-methoxyindene and 10 ml. of dry ether was added at such a rate as to keep the Grignard mixture refluxing vigorously. The mixture was refluxed for 15 min. and then 1.1 g. (0.007 mole) of 5-methoxy-1-indanone and 40 ml. of dry ether were added. No obvious reaction was observed and the mixture was refluxed for 0.5 hr. A saturated solution of ammonium chloride was added dropwise, the ether solution separated and the solvent was removed. The residue (1.6 g.) consisted of recovered 5-methoxy-1-indanone, m.p. 98.0–107.5°, and an oil which was probably recovered 6-methoxyindene.

Acknowledgment. Support of the junior author, C. A. P., by a Sterling-Winthrop Research Institute fellowship for two years is acknowledged with gratitude.

TROY, N. Y.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, HOLLINS COLLEGE]

Aromatic and Hindered Ketals[1]

ALEXEJ B. BOŘKOVEC

Received July 3, 1961

A series of aromatic and aliphatic ketals containing bulky alkoxy groups was synthesized. The interaction of ketals with Lewis acids was studied and the effect of α-hydrogen upon the stability and reactivity of ketals was demonstrated.

The alcohol interchange and the ketone interchange reactions[2] are suitable for the preparation of a wide variety of ketals. The method is particularly useful for ketals of secondary alcohols[3] although the yields tend to diminish with the increasing size of the alkoxy group.

In the present work the effect of the size of the groups attached to the central carbon atom of the ketal upon the ease of preparation and reactivity of the product was studied. Ketals of aliphatic ketones are easily pyrolyzed especially in the presence of an acid catalyst[4,5] to unsaturated ethers. This reaction depends upon the presence of a hydrogen attached to the carbon next to the central carbon of the ketal (α-hydrogen). A ketal without an α-hydrogen, dimethoxydiphenylmethane, was prepared by the ketone interchange reaction and its properties were compared to those of a ketal with an α-hydrogen, 2,2-dimethoxypropane. While the latter decomposes to a significant extent on distillation at 80°,[6] the dimethoxydiphenylmethane can be distilled without extensive decomposition at 290°.

The interaction of the two ketals with Lewis acids at moderate temperatures is even more instructive. 2,2-Dimethoxypropane forms a crystalline addition compound with both ferric chloride and antimony pentachloride, but the two oxonium compounds decompose rapidly even at room temperature to complex mixtures containing polymers of isopropenyl methyl ether. Dimethoxydiphenylmethane, on the other hand, forms with the same reagents crystalline addition products which are stable at room temperature and decompose only in contact with moisture to benzophenone, methanol, and the Lewis acid.

The effect of the alkoxy groups upon the reactivity of the ketal is much less obvious. The introduction of an amino group in the alkoxy moiety increased the stability of the ketal, which was apparently due to the basicity of the nitrogen. The amino ketals can be precipitated as dihydrochlorides from their ethereal solutions by dry hydrogen chloride.[7] 2,2-Bis(β-chloroethoxy)propane was used as a starting material for the preparation of the amino ketal.

$$(CH_3)_2C(OCH_2CH_2Cl)_2 + 4\,HNR_2 \longrightarrow (CH_3)_2C(OCH_2CH_2NR_2)_2 + 2\,NHR_2{\cdot}HCl \quad (1)$$

Several reactions were attempted with ammonia (R = H), but although good yields of ammonium

---

(1) Presented in part before the Virginia Academy of Science on May 12, 1961 in Lexington, Va.

(2) N. B. Lorette and W. L. Howard, *J. Org. Chem.*, **25**, 521 (1960).

(3) W. L. Howard and N. B. Lorette, *J. Org. Chem.*, **25**, 525 (1960).

(4) D. B. Killian, G. F. Hennion, and J. A. Nieuwland, *J. Am. Chem. Soc.*, **57**, 544 (1935).

(5) H. P. Crocker and R. H. Hall, *J. Chem. Soc.*, 2052 (1955).

(6) The pyrolysis can be prevented by the addition of a small amount of a base to the ketal; however, in the presence of an acid or a Lewis acid, it can be quantitative.

(7) F. F. Blicke and G. R. Toy, *J. Am. Chem. Soc.*, **76**, 4615 (1954).