iodide was added a solution of 2 g. of 2,3-dianisyl-2-butene in 30 cc. of ether, the solvent was removed and the residue heated in an oil-bath to about 170° for forty minutes. Upon working up in the usual way, there was obtained colorless prisms, m. p. 194–196°.

Anal. Calcd. for $C_{16}H_{16}O_2$: C, 79.93; H, 6.71. Found: C, 80.25; H, 7.08.

3,4-bis-(*p*-Hydroxyphenyl)-3-hexene (VI).—Demethylation of 2.0 g. of crude 3,4-dianisyl-3-hexene (V) gave 0.8 g. of pure diethylstilbestrol, m. p. 167–169°.

Anal. Calcd. for $C_{18}H_{20}O_2$: C, 80.56; H, 7.51. Found: C, 80.92; H, 7.07.

Summary

1. The Newman method of pinacolic reduction was applied to acetophenone, *p*-methoxyacetophenone and *p*-methoxypropiophenone. There were obtained excellent yields of the corresponding pinacols.

2. 2,3-Diphenyl-2-butene, 2,3-bis-(*p*-hydroxyphenyl)-2-butene and 3,4-bis-(*p*-hydroxyphenyl)-3-hexene were synthesized from these pinacols, improving the previous procedures.

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[CONTRIBUTION FROM THE DEPARTMENT OF INDUSTRIAL CHEMISTRY, FACULTY OF ENGINEERING, KYÔTO UNIVERSITY]

The Preparation of Synthetic Estrogens. II. The Synthesis of Hexestrol and its Homologs

BY KEIITI SISIDO AND HITOSI NOZAKI

One of the most important synthetic routes to hexestrol and related compounds involves the condensation of two molecules of *p*-α-bromopropylanisole (or the chloro derivative) with elimination of halogen. Magnesium, sodium, a Grignard reagent in the presence of cobaltous chloride, and other reagents have been used to effect the condensation.[1] All of these require the use of anhydrous conditions. According to Quelet[2] the α-halogenoalkylanisoles are more stable in the presence of moisture and accordingly a method which would not require the absence of water might have some advantages.

It is of interest that metallic iron powder is capable to act as a dehalogenating agent in the presence of water. Ogata, Turuta and Oda[3] have treated benzyl chloride, benzal chloride as well as benzo trichloride with iron powder in a large amount of hot water and obtained bibenzyl, stilbene and μ,μ′-dichlorostilbene, respectively. Model experiments on this condensation of α-chloroethylbenzene as well as of *p*-(α-chloroethyl)-anisole gave 2,3-diphenylbutane and 2,3-dianisylbutane, respectively, in 5–15% yields. With anethole hydrochloride[4] or hydrobromide the yield of the *meso* form of 3,4-dianisylhexane was 10 or 15%, respectively. It is to be pointed out that the recovered anethole was not subtracted in this calculation, as its purity was not determined. Demethylation of this product by heating with a Grignard reagent[5] gave hexestrol in good yield and in very pure state.

Although the yields realized from the present modification are not always superior to others, this method is believed to possess some merits in the simplicity and in the easy treatment, etc. The possibility of improving the yield by the use of very fine powder of iron or reduced iron in this condensation has been opened for a further research, which is now under way in our Laboratory.

Bretschneider and others[6] have prepared a metamer of hexestrol, 2,3-bis-(*p*-hydroxy-*o*-tolyl)-butane, and discovered that its estrogenic potency is of the same order as that of diethylstilbestrol or hexestrol. We have now prepared the same compound by means of our method from the hydrochloride of *p*-vinyl-*m*-methylanisole synthesized from *m*-cresol methyl ether.[7]

Experimental[8]

2,3-Diphenylbutane.—To a suspension of 12 g. of ordinary iron powder in 140 cc. of water heated at 95–98° was added with stirring 30 g. of α-chlorothylbenzene during ten minutes. The mixture was stirred for an additional three hours at the same temperature. The reaction product was extracted with benzene and the extract was fractionated. At 145–155° and 13 mm. came over 9.3 g. of colorless oil which solidified slowly. Repeated recrystallizations from alcohol yielded 3.6 g. of *meso*-2,3-diphenylbutane, m. p. and mixed m. p. 125.5°.

2,3-Dianisylbutane.—Dry hydrogen chloride was passed into a solution of 10 g. of *p*-vinylanisole containing about 10% of *o*-isomer[2,7] in 45 cc. of ligroin cooled in ice–salt mixture. The reaction solution was washed with ice-cooled water and subjected immediately to the condensation process. To a suspension of 4.2 g. of iron powder in 50 cc. of water the ligroin solution of the chloroethylanisole was added slowly with stirring at 85°. This required about thirty minutes, during which time the ligroin was removed from the vessel through a downward condenser. In the course of this, the ligroin solution contained in the dropping funnel was cooled with several pieces of crushed ice added directly in order to prevent the decomposition of the

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[1] For a review of these and other syntheses of hexestrol see Solmssen, *Chem. Rev.*, **37**, 481 (1945).

[2] Quelet, *Compt. rend.*, **202**, 956 (1936).

[3] Ogata, Turuta and Oda, *Bull. Inst. Phys. Chem. Research* (*Tôkyô*), **21**, 616 (1942) (in Japanese).

[4] Orndorff and Morton, *Am. Chem. J.*, **23**, 194 (1900). *Cf.* the fact that even the uniformity and the structure of the hydrochloride are not certain because of its unstableness.

[5] Kuwada and Sasagawa, *J. Pharm. Soc. Japan*, **60**, 27 (1940). *Cf.* U. S. Patent 2,252,696, August 19, 1941, and Späth, *Monatsh.*, **35**, 319 (1914).

[6] Bretschneider, de Jonge-Bretschneider and Ajtai, *Ber.*, **74** 571 (1941).

[7] Quelet, *Bull. soc. chim.*, **7**, 196 (1940).

[8] Microanalyses by Misses Yasuko Meizyô and Kenko Ogawa of our Laboratory.

chloro compound and to supply the water escaped together with the ligroin. The reaction mixture was heated now under an upward condenser for additional three hours at 95–98° and extracted with benzene. Fractional distillation of the product gave 4.3 g. of semi-solid mass boiling at 185–205° and 10 mm. This was recrystallized from methanol–ligroin and colorless prisms melting at 132.5–133.5° resulted. Mixtures of the product with a known sample of 2,3-dianisylbutane, which we had prepared[9] from 2,3-dianisyl-1,3-butadiene, melted without depression. As 2,3-dianisylbutane described by Dodds, *et al.*,[10] is said to have the m. p. 87–88°, our substance seems to be an isomeric compound, probably of the *meso* form.

Anal. Calcd. for $C_{18}H_{22}O_2$: C, 79.96; H, 8.20. Found: C, 79.87; H, 8.46.

2,3-bis-(*p*-Methoxy-*o*-tolyl)-butane.—A solution of 10 g. of *p*-vinyl-*m*-methylanisole[7] in 50 cc. of ligroin was saturated with dry hydrogen chloride at −18 to −10° and treated with 5 g. of iron powder in 60 cc. of water as above. After recrystallization from alcohol 1.6 g. or 16% yield of pure colorless plates of the m. p. 142° was obtained.

Anal. Calcd. for $C_{20}H_{26}O_2$: C, 80.50; H, 8.78. Found: C, 80.91; H, 8.79.

The demethylation of the product with methylmagnesium iodide[5] yielded a free phenolic substance of m. p. 188–189° and the acetylation of the latter compound gave colorless plates of diacetate melting at 164°.

Anal. Calcd. for $C_{22}H_{26}O_4$: C, 74.55; H, 7.40. Found: C, 74.67; H, 7.56.

The melting points and other properties of these substances were found to be in accord with those reported by the Hungarian investigators.[6]

3,4-Dianisylhexane.—Twenty-five grams of anethole dissolved in 110 cc. of ligroin was saturated with dry hydrogen chloride. Upon working up the product with 15 g. of iron powder in 150 cc. of water as above, 8 g. of a distillate at 180–210° and 4 mm. was obtained. The first fraction of this vacuum distillation consisted of about 12 g. of anethole which could be employed in the next batch. The product crystallized out from methanol–ligroin and recrystallizations from petroleum ether gave 2.4 g. of colorless plates, m. p. 144°, in accord with the m. p. of the *meso* compound reported in the literature.

When the same procedure was repeated with hydrogen bromide instead of the chloride, the yield of 3.8 g. was obtained.

Anal. Calcd. for $C_{20}H_{26}O_2$: C, 80.50; H, 8.78. Found: C, 80.12; H, 8.51.

3,4-bis-(*p*-Hydroxyphenyl)-hexane (Hexestrol).—Demethylation of 3,4-dianisylhexane with a Grignard reagent yielded colorless plates, m. p. 186°, which value agreed with that of the literature.

Anal. Calcd. for $C_{18}H_{22}O_2$: C, 79.96; H, 8.20. Found: C, 79.70; H, 8.32.

On acetylation the diacetate was obtained, m. p. 140–141°.

Acknowledgment.—In preparing these reports I and II we are indebted to the Editorial Board of This Journal for the courtesy of checking the literature references since 1941 (except those of Japan) which we are not able to obtain even now in our city.

Summary

Hexestrol and 2,3-bis-(*p*-hydroxy-*o*-tolyl)-butane were prepared by the condensation of hydrochlorides (or hydrobromide) of anethole and *p*-vinyl-*m*-methylanisole, respectively, by the action of metallic iron powder in a water suspension followed by the demethylation.

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[9] Unpublished result.

[10] Dodds, *et al.*, *Proc. Roy. Soc.* (*London*), **B132**, 83 (1944).

[Contribution from Chemical and Physical Research Laboratories, The Firestone Tire and Rubber Co.]

X-Ray Diffraction Study of Some Synthetic Rubbers at Low Temperatures

By E. E. Hanson and G. Halverson

The use of the powerful X-ray diffraction method for the study of high polymers had its inception in 1925 with the experiments of Katz[1] on natural rubber. He observed that the X-ray diffraction pattern of stretched rubber consisted of a broad halo with a superposed set of discrete spots characteristic of crystallites oriented in the direction of stretching. Hauser and Rosbaud[2] observed that the diffraction pattern of frozen unstretched rubber consisted of sharp concentric rings characteristic of a randomly oriented polycrystalline material. From such X-ray data have been determined the unit cell of the rubber crystallite,[3-7] the arrangement and the shape of the molecular segments in the unit cell and the size and shape of the rubber crystallites.[8,9] In addition, the X-ray diffraction method has yielded important information regarding the structures of a host of other polymers,[10] particularly those of the plastics and fibers, most of which give well developed fiber diagrams. Examples of synthetic rubber polymers which crystallize upon stretching are neoprene,[11] polyisobutylene,[12] and thiokol.[13] However, it is unfortunate that the majority of the synthetic rubber polymers give only an amorphous halo and therefore the X-ray diffraction method can give correspondingly little information regarding the structures of these polymers.

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[2] E. A. Hauser and P. Rosbaud, *Kautschuk*, **3**, 17 (1927).

[3] E. A. Hauser and H. Mark, *Kolloid Chem. Beihefte*, **22**, 63 (1926).

[4] H. Mark and G. von Susich, *Kolloid-Z.*, **46**, 11 (1928).

[5] W. Lotmer and V. H. Meyer, *Monatsh.*, **69**, 115 (1936).

[6] E. Sauter, *Z. physik. Chem.*, **B36**, 405 (1937).

[7] A. A. Morss, This Journal, **60**, 237 (1938).

[8] S. D. Gehman and J. E. Field, *J. Applied Phys.*, **15**, 371 (1944).

[9] Review articles covering the field are: S. D. Gehman, *Chem. Rev.*, **26**, 203 (1940); C. W. Bunn, "Advances in Colloid Science," Vol. II, Interscience Publishers, Inc., New York, N. Y., 1946.

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[12] C. S. Fuller, C. J. Frosch and N. R. Pape, This Journal, **62**, 1905 (1940).

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