THE ortho-ALKYLATION OF CATECHOL

I. S. Belostotskaya, N. L. Komissarova, É. V. Dzhuaryan, and V. V. Ershov

The existing methods of obtaining alkylcatechols reduce basically to the alkylation of catechol with olefins and alcohols in the presence of acid catalysts. As a rule, this gives only 3,5-di- or 4-monoalkyl-catechols. So far as concerns compounds containing only alkyl substituents adjacent to the hydroxy groups (3-mono- and 3,6-dialkyl derivatives), no direct methods for their production exist. Consequently, some o-alkylcatechols have been obtained by indirect methods [1, 2]. It is known that o-alkylphenols can easily be obtained with aluminum isopropoxide or phenoxide and similar catalysts [3, 4].

In the present work we have effected the selective ortho-alkylation of catechol and its $4-CH_3$ homolog with olefins in the presence of the titanium salt of the corresponding catechol at $100-150^\circ$ and a pressure of 16 atm and have obtained the corresponding 3-mono- and 3,6-dialkyl derivatives in high yields.



The alkylation of catechol with isobutylene takes place most easily. On using isopentene and styrene, in addition to the ortho-derivatives (mono- and di-) a small amount of 4-alkyl-substituted products is formed. The structure of the compounds obtained has been shown by their PMR spectra, which enable the position of the alkyl group in the aromatic ring to be established unambiguously. Thus, in the case of a di-ortho-substituted catechol (for example, 3,6-di-tert-butylcatechol), the PMR spectrum has singlets at 6.59 ppm (phenyl protons), 5.11 ppm (hydroxyl protons), and 1.31 ppm (protons of the tert-butyl groups) in a ratio of 1:1:9. In the case of the isomeric 3,5-di-tert-butylcatechol, which we synthesized by the method of Schulze and Flaig [5], the PMR spectrum contained signals at 6.75 and 6.58 ppm (phenyl protons), 5.34 and 4.93 ppm (hydroxyl protons), and 1.33 and 1.19 ppm (protons of tert-butyl groups). The IR spectrum of each of the compounds obtained has a band in the 3450-3500 cm⁻¹ region which is characteristic for catechol derivatives [6]. It must be mentioned that the product with mp 83-84° described previously [7], which was obtained by the alkylation of catechol with isobutylene in the presence of aluminum isopropoxide was, according to our results, 3,5-di-tert-butylcatechol.

EXPERIMENTAL METHOD

The IR spectra were taken of the substances in the form of tablets with KBr, and the PMR spectra were taken of solutions in CCl_4 with hexamethyldisiloxane as internal standard.

<u>Titanium Salt of Catechol.</u> A mixture of 11 g of freshly-distilled $TiCl_4$, 13.7 g of catechol, and 80 ml of xylene was boiled for 20 h. The dark brown precipitate was filtered off, washed with xylene, and dried in vacuum. The yield of salt was 21.6 g (66%). Aluminum isoproposide was obtained by a published method [8].

<u>3,6-Di-tert-butylcatechol</u>. An autoclave was charged with 82.5 g of catechol, 80 ml of xylene, 2.3 g of titanium catecholate, and 150 ml of isobutylene. The reaction was performed at 100° for 1.5 h (maximum pressure 16 atm). After the end of the reaction, the solvent was evaporated off, and the alkylate was

Institute of Chemical Physics of the Academy of Sciences of the USSR. Translated from Izvestiya Akademii Nauk SSSR, Seriya Khimicheskaya, No. 7, pp. 1594–1596, July, 1972. Original article submitted December 2, 1970.

© 1973 Consultants Bureau, a division of Plenum Publishing Corporation, 227 West 17th Street, New York, N. Y 10011. All rights reserved. This article cannot be reproduced for any purpose whatsoever without permission of the publisher. A copy of this article is available from the publisher for \$15.00.

distilled in vacuum. The yield of 3,6-di-tert-butylcatechol was 157.4 g (96%); bp 141-145° (5 mm); mp 96-96.5° (from hexane). A mixture of the substance with 3,5-di-tert-butylcatechol had mp 69.5-70°. Found: C 75.85; H 9.83%. $C_{14}H_{22}O_2$. Calculated: C 75.63; H 9.97%.

<u>3-tert-Butylcatechol</u>. Similarly, 82.5 g of catechol and 70 ml of isobutylene gave 3-tert-butyl-catechol with a yield of 110.3 g (89%); bp 97-98° (1 mm). Found: C 72.07; H 8.55%. $C_{10}H_{14}O_2$. Calculated: C 72.26; H 8.49%. In addition, 4-tert-butylcatechol and 3,6-di-tert-butylcatechol were isolated in small amounts.

<u>3-tert-Butyl-5-methylcatechol</u>. Similarly, 19.1 g of 4-methylcatechol, 0.46 g of catalyst, and 30 ml of isobutylene gave 3-tert-butyl-5-methylcatechol; yield 25.2 g (91%), bp 120-123° (1 mm); mp 60-61° (from hexane). Found: C 73.23; H 8.96%. C₁₁H₁₆O₂. Calculated: C 73.26; H 8.94%.

<u>3,5-Di-tert-butylcatechol.</u> A. By the method of Schulze and Flaig [5], 11 g of catechol and 25 ml of tert-butanol in the presence of 10 ml of conc. H_2SO_4 gave 18 g (81%) of 3,5-di-tert-butylcatechol; bp 140-145° (5 mm); mp 99-100° (from hexane).

B. A mixture of 82.5 g of catechol, 6.3 g of aluminum isopropoxide, 51 ml of xylene, and 145 ml of isobutylene was heated in an autoclave at 175° (maximum pressure 34 atm) for 1.5 h. This gave 9 g of catechol and 131.2 g (80%) of 3,5-di-tert-butylcatechol; bp 144-149° (5 mm); mp 99-100° (from hexane). The IR and NMR spectra, and the TLC behavior [9] of the samples obtained by the two methods showed that they were identical; a mixture did not depress the melting point.

<u>3-tert-Pentylcatechol</u>. Under the conditions described for the preparation of 3,6-di-tert-butylcatechol, 78 g of catechol, 152 g of isopentene, and 2.2 g of titanium catecholate gave 99.7 g (78%) of 3tert-pentylcatechol; bp 107-113° (1 mm); mp 24-25° (from hexane). Found: C 73.30; H 9.12%. $C_{11}H_{16}O_2$. Calculated: C 73.26; H 8.94%. In addition, 10.9 g (8.6%) of 4-tert-pentylcatechol was isolated; bp 133-136° (1 mm); mp 47-49° (from hexane). Found: C 73.36; H 8.96%. $C_{11}H_{16}O_2$. Calculated: C 73.26; H 8.94%.

Alkylation with Styrene. A mixture of 21 g of catechol, 0.65 g of titanium catecholate, and 20 ml of xylene was heated to 100°C, and 41.6 g of styrene was added dropwise. After three hours' heating at 100-150°, vacuum distillation yielded: 1) 10.8 g (27%) of 3-(1'-phenylethyl)catechol; bp 168-172° (2 mm). Found: C 78.14; H 6.71%. $C_{14}H_{14}O_2$. Calculated: C 78.48; H 6.58%. 2) 3.6 g (9%) 4-(1'-phenylethyl)catechol; bp 190-194° (2 mm); mp 77-78° (from hexane). Found: C 78.52; H 6.84%. $C_{14}H_{14}O_2$. Calculated: C 78.48; H 6.58%. 3) 32.2 g (61%) 3,6-di(1'-phenylethyl)catechol; bp 238-240° (2 mm). Found: C 82.89; H 6.88%. $C_{22}H_{22}O_2$. Calculated: C 83.01; H 6.96%.

CONCLUSIONS

1. A method for the selective ortho-alkylation of catechol has been developed.

2. A number of new compounds have been obtained in this way, including the previously inaccessible sterically-hindred 3,6-di-tert-butylcatechol.

LITERATURE CITED

- 1. R. Christenson, C. Parris, and E. Parter, US Patent No. 2874141 (February 17, 1959); Chem. Abstr., 53, 9727i (1959).
- 2. S. Tamura, H. Okubo, and H. Kaneta, Nippon Nogei Kagaku Kaishi, 28, 4 (1954).
- 3. R. Stroh, R. Seydel, and W. Hahn, Angew. Chemie, 69, 699 (1957).
- 4. A. Kolka, J. Napolitano, A. Filbey, and G. Ecke, J. Organ. Chem., 22, 642 (1957).
- 5. H. Schulze and W. Flaig, Liebigs. Ann. Chem., 575, 231 (1952).
- 6. W. Beckerling, C. M. Frost, and W. Fowkes, Analyt. Chem., 36 (13), 2412 (1964).
- 7. G. G. Ecke and A. Kolka, US Patent No. 3075832 (1958); Chem. Abstr., 59, 12707d (1963).
- 8. Organikum Organisch-Chemisches Grundpraktikum, VEB Deutscher Verlag der Wissenschaften, 5th ed., Berlin, 1965 [Russian translation], Mir (1965), p. 614.
- 9. I. S. Belostotskaya, N. L. Komissarova, É. V. Dzhuaryan, and V. V. Ershov, Izv. Akad. Nauk SSSR, Ser. Khim., 2816 (1971).