The alkali-soluble portion gave 0.9 g. of a compound (isoderritol) which crystallized from methyl alcohol in light yellow plates, melting at 150°.

Anal. Subs., 0.0728, 0.0773: CO_2, 0.1814, 0.1925; H_2O, 0.0381, 0.0409. Subs., 0.0209: AgI, 0.0268. Calcd. for $C_{21}H_{22}O_6$: C, 68.07; H, 5.99; $2OCH_3$, 16.75. Found: C, 67.93, 68.00; H, 5.81, 5.88; OCH_3, 16.93.

Summary

Hydrogenation of rotenone results in the formation of a neutral and an acid compound as primary products.

The neutral compound is dihydrorotenone and is formed by the simple reduction of an unsaturated bond. Dihydrorotenone melts at 164°, instead of 216° as recorded by Kariyone.

The acid is easily separated from the reaction mixture and has the same empirical formula as dihydrorotenone, $C_{23}H_{24}O_6$.

On further reduction, both compounds yield the same end-product, an acid containing four more hydrogen atoms than rotenone. It seems likely that the molecule of rotenone is first simultaneously reduced in two places, while further hydrogenation results in the acid, $C_{23}H_{26}O_6$.

Contrary to Butenandt, dihydrorotenone is converted into dihydroderritol and dihydrorotenol by treatment with zinc in alkaline alcoholic solution.

Isorotenone yields isoderritol and isorotenol by the same treatment. From these results, it follows that the formation of derritol is independent of the presence of an unsaturated bond in rotenone.

The preparation and properties of some other rotenone derivatives are described.

WASHINGTON, D. C.

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE COLLEGE OF LIBERAL ARTS OF NORTHWESTERN UNIVERSITY]

SYNTHESIS IN THE DIPHENYL ETHER SERIES. I. PREPARATION OF SOME SIMPLE DERIVATIVES[1]

BY C. M. SUTER

RECEIVED MAY 2, 1929 PUBLISHED AUGUST 7, 1929

Since diphenyl ether is now readily available, a further study of its derivatives and their preparation from the parent substance seems desirable. Most of such derivatives previously prepared have been made by the reaction between the salt of a phenol and an aromatic halogen compound.[2]

The preparation of *o*- and *p*-nitrodiphenyl ether by the nitration of

---

[1] Presented before the Division of Organic Chemistry at the Columbus meeting of the American Chemical Society, May, 1929.

[2] See Raiford and Colbert, THIS JOURNAL, **48,** 2652 (1926), for recent work and bibliography.

diphenyl ether has been investigated by Mailhe and Murat,[3] who used fuming nitric acid in acetic acid solution. They claimed complete separation of the two isomers by freezing out the para derivative. No yields were reported. The *p*-nitro isomer was also obtained by Ryan and Drumm[4] in their nitration of diphenyl ether with nitrogen oxides or nitric acid, but no satisfactory method of preparation was indicated.

The method of Mailhe and Murat was found to be unsatisfactory because of the formation of alkali-soluble products and the necessity of using a large excess of nitric acid. Addition of sulfuric acid to the nitrating mixture increased the formation of tar. A very suitable method was found in the use of acetic anhydride as a solvent for the diphenyl ether, the nitric acid being added in acetic acid solution. This method was studied in detail to find the optimum conditions for a high yield of the mononitro derivatives. A table of results and details of the method are given in the experimental part.

The ortho and para isomers are not readily separable by fractional distillation as their boiling points at 20 mm. are only 4° apart. The para isomer is only partially separated by cooling to 0°, the remaining oil containing about 25% of this product. Since the amines obtained by reduction of this mixture are easily separated by the difference in solubilities of their sulfates, further purification of the nitro compounds was not attempted.

The corresponding nitriles were prepared from the two amines. These upon hydrolysis gave the acids which have been previously prepared by other methods.[5]

The bromination of diphenyl ether has been previously studied by Mailhe and Murat,[6] who reported a mixture of bromo and dibromo derivatives in which the bromine entered only the para positions. The structure of these compounds was proved by Le Fèvre and co-workers.[7] Repetition of the bromination using equimolecular quantities of bromine and the ether gave only 47% of *p*-bromodiphenyl ether, the rest of the bromine forming the dibromo derivative and a trace of higher brominated product. The large amount of dibromo compound formed indicates that the presence of a bromine atom in one ring inhibits only slightly the entrance of a second bromine atom in the other ring. This is in contrast to the influence of the nitro group, since in nitration of diphenyl ether it is possible to obtain a high yield of mononitro derivatives with the formation of comparatively little dinitro compounds.

[3] Mailhe and Murat, *Compt. rend.*, **154,** 715 (1912).

[4] Ryan and Drumm, *Sci. Proc. Roy. Dublin Soc.*, **17,** 313 (1924); *C. A.*, **18,** 1655 (1924).

[5] Ullmann and Zlokasoff, *Ber.*, **38,** 2112 (1905); Griess, *ibid.*, **21,** 980 (1888).

[6] Mailhe and Murat, *Compt. rend.*, **154,** 601 (1912).

[7] Le Fèvre, Saunders and Turner, *J. Chem. Soc.*, 1168 (1927).

Bromination of the *p*-nitro- and *p*-acetaminodiphenyl ethers gave only the compounds containing the bromine in the second para position, indicating that in general in diphenyl ether derivatives the tendency for bromine to enter the ortho position is small.

Experimental

Nitration of Diphenyl Ether.—Best results were obtained as follows. A solution of 100 cc. (2.4 moles) of fuming nitric acid (sp. gr. 1.52) in 300 cc. of glacial acetic acid was added over a period of two hours to a well-stirred solution of 340 g. (2 moles) of diphenyl ether in 400 cc. of acetic anhydride kept in a water-bath at a temperature of 25–30°. After three and a half hours longer the reaction mixture was poured into water, the precipitated oil washed twice and distilled under reduced pressure. The mononitro compounds came over at 193–210° (uncorr.) at 14 mm., a mixture of 50 g. of dinitro isomers remaining in the distilling flask; yield, 370 g. or 86% of the theoretical.

From 700 g. of the mononitro mixture kept at 0° overnight was obtained 270 g. of practically pure *p*-nitrodiphenyl ether by filtering and washing the crystals with methyl alcohol. Since reduction indicated about 25% of para isomer in the remaining oil, 54% of the original mixture was the para derivative. After two crystallizations from the same solvent the melting point was 57°; reported, 56, 60–61°.

The effect of various changes in the above method of nitration upon the yield obtained is indicated in Table I.

TABLE I

CONDITIONS AND YIELDS

$(C_6H_5)_2O$, moles	$(C_6H_5)_2O$ solvent, cc.	HNO_3, moles	HNO_3 solvent, cc.	Nitro, %	Dinitro, %	$(C_6H_5)_2O$ recovered, %
0.5	AcOH, 200	2.5	None	26	Trace	42
.5	AcOH, 75	1.5	AcOH, 100	36	Trace	14 (0.5 mole H_2SO_4)
.5	Ac_2O, 100	0.75	Ac_2O, 100	82	10	Trace
.5	Ac_2O, 100	1.0	Ac_2O, 100	62	33	None
.5	Ac_2O, 100	2.5	Ac_2O, 100	Trace	106	None (some trinitro?)
2.0	Ac_2O, 400	2.0	AcOH, 300	71	5	15
2.0	Ac_2O, 400	2.4	AcOH, 300	86	10	2
2.0	Ac_2O, 400	2.7	AcOH, 300	78	18	None
2.0	Ac_2O, 300	2.4	AcOH, 300	77	8	13
2.0	Ac_2O, 400	3.0	AcOH, 400	78	15	None

The first two reactions were run at 45–50°, the others at 25–30°. In the reactions involving 2 moles of the ether the time of the reaction was five hours and twenty minutes. In the others it was about three hours.

***p*-Aminodiphenyl Ether.**—This was prepared by two methods: reduction of the nitro compound with iron powder and hydrochloric acid, or by the use of zinc and calcium chloride in a water–alcohol mixture. The latter gave the better results. To a well stirred mixture of 80 g. of zinc dust and 20 g. of calcium chloride in 75 cc. of water and 200 cc. of 95% alcohol on a steam-bath was added slowly 43 g. (0.2 mole) of the nitro compound. The reaction was very vigorous. After an hour the mixture was filtered to remove zinc oxide and unchanged zinc. The filtrate upon cooling deposited a few crystals of the hydrazo compound. These were removed and the solution diluted with water, which gave a light yellow mass of the amine; yield, 37 g., theoretical amount of crude product; m. p. 75–80°; reported m. p. 83.5° for the pure amine.[8] The crude product was readily purified by distillation, b. p. 187–189° (corr.) at 14 mm.

o-**Aminodiphenyl Ether.**—This was prepared similarly to the method given for the para isomer by reducing the mixture of nitro compounds, dissolving the mixed amines in hydrochloric acid and precipitating the *p*-amine as the sulfate, which is practically insoluble in cold water.[9] The yield in a typical run was 54% of ortho and 21% of para derivative. The *o*-amine distilled at 172–173° (corr.) at 14 mm., m. p. 44–45°; previously reported, 44°.[10]

The acetyl derivative solidified only after standing for several days. Recrystallized from dilute methyl alcohol, the melting point was 81°.

Anal. Calcd. for $C_{14}H_{13}O_2N$: N, 6.17. Found: N, 6.02, 6.16.

p-**Cyanodiphenyl Ether.**—Thirty-seven grams of finely-divided *p*-aminodiphenyl ether was warmed on a steam-bath with 60 cc. of concentrated hydrochloric acid and 150 cc. of water. The suspension of amine hydrochloride was cooled to 0° and diazotized with 15 g. of sodium nitrite in 40 cc. of water. After half an hour the mixture was neutralized with sodium carbonate and poured into a cold solution of 25 g. of commercial cuprous cyanide in 25 g. of sodium cyanide and 150 cc. of water. The copious brown precipitate first formed evolved nitrogen when warmed to room temperature. The remaining oil was taken up with benzene, the benzene evaporated and the oil distilled, giving 15 g. of light yellow oil, b. p. 187–188° (corr.) at 14 mm. This gave a low nitrogen analysis.

Anal. Calcd. for $C_{13}H_9ON$: N, 7.17. Found: N, 6.65, 6.74.

Upon standing the oil partially solidified. The crystals were recrystallized from petroleum ether, giving colorless needles, m. p. 47°.

Anal. Calcd. for $C_{13}H_9ON$: N, 7.17. Found: N, 7.10.

Since the crude product gave a slight test for chlorine, the impurity present was probably *p*-chlorodiphenyl ether, as its boiling point would be close to that of the nitrile.

Upon hydrolysis with alcoholic potassium hydroxide the acid was formed in theoretical amount, m. p. 159–161°, which checks that previously obtained.[11]

o-**Cyanodiphenyl Ether.**—This was prepared similarly to the *p*-cyano derivative. The *o*-amine hydrochloride is readily soluble, which facilitates diazotization; yield, 15 g. of yellow oil, b. p. 188° (corr.) at 14 mm. Analysis for nitrogen gave low results.

Anal. Calcd. for $C_{13}H_9ON$: N, 7.17. Found: N, 6.75, 6.88.

The nitrile on hydrolysis gave the acid (m. p. 113°), which has previously received considerable attention because it offers a method for preparing xanthone.[12]

p-**Bromo**-*p*-**nitrodiphenyl Ether.**—This has been previously prepared from *p*-bromophenol and *p*-nitrochlorobenzene.[2] Fifty grams of bromine was added slowly with stirring to a solution of 64.5 g. of *p*-nitrodiphenyl ether in 150 cc. of carbon tetrachloride. The mixture was then refluxed to complete the reaction. The solvent was evaporated and the residue recrystallized from 300 cc. of methyl alcohol; yield, 82 g. of white needles, m. p. 64°; reported previously, 65–66°.

p-**Bromo**-*p*-**aminodiphenyl Ether.**—This was prepared by Le Fèvre and co-workers[7] but was not obtained in a pure state. The following method of preparation was found to be satisfactory: 29.4 g. of nitro compound was dissolved in 100 cc. of 95% alcohol,

---

[8] Ullmann and Sponagel, *Ann.*, **350**, 105 (1906).

[9] Haeussermann and Teichmann, *Ber.*, **29**, 1446 (1896).

[10] Ullmann, *ibid.*, **29**, 1881 (1896).

[11] Griess, *ibid.*, **21**, 980 (1888).

[12] Graebe, *ibid.*, **21**, 502 (1888).

18 g. of iron powder added and 10 cc. of concentrated hydrochloric acid run into the well-stirred mixture slowly. After four hours on the steam-bath, the mixture was filtered hot, the filtrate diluted with water and the precipitated amine recrystallized from methyl alcohol; yield, 22 g. or 84%; m. p. 109°.

Anal. Calcd. for $C_{12}H_{11}ONBr$: N, 5.28. Found: N, 5.32, 5.28.

***p*-Bromo-*p'*-acetaminodiphenyl Ether.**—This was prepared in two ways: by bromination of the acetaminodiphenyl ether and by acetylating the amine. One cc. of bromine was added to 4.5 g. of the acetyl derivative dissolved in 30 cc. of acetic acid and the solution warmed for a minute. Upon cooling, the hydrobromide salt of the desired product crystallized out, 3.1 g. of slightly yellow product, m. p. 180–183° (uncorr.), which lost its hydrogen bromide upon standing. Dilution of the filtrate gave 1.8 g. of the bromo-acetamino compound, which was also obtained by recrystallizing the hydrobromide salt from dilute alcohol, m. p. 162–163° (corr.).

Anal. Calcd. for $C_{14}H_{12}O_2NBr$: N, 4.57. Found: N, 4.59, 4.64.

Bromination of Diphenyl Ether.—To a solution of 85 g. (0.5 mole) of diphenyl ether in 100 cc. of carbon tetrachloride was added 80 g. (0.5 mole) of bromine slowly with occasional shaking. Hydrogen bromide was steadily evolved. When the reaction was complete. the solvent was distilled off and the residue fractionated under diminished pressure. There were obtained 20 g. of diphenyl ether, 59 g. of *p*-bromodiphenyl ether, b. p. 160–165° at 14 mm., and a residue of the dibromo derivative soluble in petroleum ether, together with a trace of higher brominated products insoluble in petroleum ether.

Summary

1. The nitration of diphenyl ether has been studied in detail and a satisfactory method for preparing the mononitro derivatives outlined.
2. Ortho and para aminodiphenyl ethers are easily separated by the difference in solubility of their sulfates.
3. A number of bromine derivatives of diphenyl ether have been prepared.
4. A bromine atom in one ring of diphenyl ether affects only slightly substitution in the second ring, which is in contrast to the influence of the nitro group.

EVANSTON, ILLINOIS