A 1000-ml round-bottomed, three-necked flask equipped with a mechanical stirrer, a thermometer, and a dropping funnel and containing 2 moles of a single hydrocarbon (*o*-xylene or hemimellitene) or, in crosscoupling reactions, one mole of each hydrocarbon (*o*-xylene–*m*-xylene or *o*-xylene–mesitylene) was immersed in an efficient cooling bath. The cooling rate was regulated by the temperature of the coolant, the stirring rate, and the degree of immersion. At −14° ± 2° C, 280 ml of 90% nitric acid (about 6 moles) and 150 ml of concentrated sulfuric acid were added in sequence dropwise, slowly enough to control the exothermic reaction. After the sulfuric acid addition, the flask was gradually lifted from the bath, so that the mixture warmed very slowly to room temperature. Lastly, the mixture was poured onto ethanol-free ether (2 liters) and ice and extracted. The workup procedures for the individual cases are given below.

PRODUCTS FROM *o*-XYLENE. The ether extract was immediately seeded with pure crystals of compound 1. After 15 to 30 minutes, the crystals were filtered and recrystallized from DMF to give pure 2,2′-dinitro-4,4′,5,5′-tetramethylbiphenyl (*1*) (compound 1) (m.p. 250–52°). The ether filtrate was washed with 10% sodium hydroxide and seeded with crystals of compound 2. After 18 hours, the resultant crystals were recrystallized from dimethylformamide or dimethyl sulfoxide to give 2,3′-dinitro-4,4′,5,5′-tetramethylbiphenyl (*1*) (2) (m.p. 173–74°). The ether filtrate at 0° C slowly deposited another crop of crystals, mostly of compound 1. In this way, 1 was isolated in about 2.0% and 2 in about 1.3% yield. Further workup gave crystalline mixtures of isomeric dinitrobixylyls which could not be separated.

PRODUCTS FROM HEMIMELLITENE. A white solid that precipitated in the ether layer was filtered after 1 hour and recrystallized from dimethylformamide to give white crystals of 2,2′-dinitro-3,3′,4,4′,5,5′-hexamethylbiphenyl (*1*) (3) (m.p. 284–86°) in 1.0% yield. The ether filtrate was washed free of acid with 10% sodium hydroxide and with water and then was fractionated up to 170° still-head temperature at 0.8 torr. 4,5-Dinitrohemimellitene and 4,6-dinitrohemimellitene (*1*) were isolated from the higher boiling fractions. The distillation residue, after two recrystallizations from acetic acid and one carbon treatment in ethyl acetate, gave a 2.2% yield of 94% pure crystals of 2,3′-dinitro-3,4,4′,5,5′,6′-hexamethylbiphenyl (4). This was the highest purity obtained. NMR: 2.59 (1), 3.10 (1), 7.60 (3), 7.65 (3), 7.72 (6), 7.77 (3), 7.89 (3). Ultraviolet: $\lambda_{\max}$ 232, $\epsilon_{\max}$ 13.000 with inflection at 275 mμ.

PRODUCTS FROM *o*-XYLENE-*m*-XYLENE CROSSCOUPLING. The ether extract was washed with 10% sodium hydroxide and with water and then vacuum-distilled to remove volatile products up to 170° (1.0 torr). The distillation residue was crystallized from small amounts of acetic acid at 5°. The first crop of crystals was carbon-treated (Darco G-60) in ethyl acetate and recrystallized from acetic acid to give white 3,3′-dinitro- 4,4′,5,6′-tetramethylbiphenyl (5). NMR: 2.15 (1), 2.48 (center of doublet, J = 1.7 cps) (1), 2.69 (center of doublet, J = 1.7 cps) (1), 2.75 (1), 7.38 (3), 7.57 (6), 7.68 (3). Ultraviolet: $\lambda_{\max}$ 241 mμ; $\epsilon_{\max}$ 27.000. Methanol was added to the mother liquors. The separated solids were purified as compound 5 to give pale yellow crystals of 2,3′-dinitro-4,4′,5,6′-tetramethylbiphenyl (6). NMR: 2.13 (1), 2.25 (1), 2.79 (1), 2.95 (1), 7.41 (3), 7.64 (6), 7.91 (3). Ultraviolet: $\lambda_{\max}$ 278 mμ, $\epsilon_{\max}$ 14.000, end absorption with ϵ = 17.000 at 2.40 mμ. Fractional crystallization of the mother liquors produced further crops of 5 and 6, raising the total yields to 0.7 and 1.4%, respectively.

PRODUCTS FROM *o*-XYLENE–MESITYLENE CROSSCOUPLING. The ether layer was washed with 10% sodium hydroxide and with water. Low boiling components were removed by vacuum distillation up to 170° (1.0 torr), and the residue was crystallized from acetic acid. Two recrystallizations from acetic acid–methylene dichloride (9 to 1) gave 23.5 grams (7.5% yield) of 3,3′-dinitro-2′,4,4′,5,6′-pentamethylbiphenyl (7). NMR: 2.60 (1), 2.83 (1), 2.93 (1), 7.55 (6), 7.68 (3), 7.95 (3), 8.08 (3). Ultraviolet showed end absorption only, ϵ = 14.300 at 240 mμ.

LITERATURE CITED

(1) Puskas, I., Fields, E. K., *J. Org. Chem.* **31**, 4204 (1966).
(2) *Ibid.*, **32**, 589 (1967).
(3) *Ibid.*, p. 3924.
(4) *Ibid.*, **33**, 4237 (1937).

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Preparation of 3- and 4-(4-Nitrophenyl)phthalic Acid

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2,3-Dimethyl-4′-nitrobiphenyl and the 3,4-dimethyl isomer were prepared in low yields by modified Gomberg reactions. Oxidation gave the previously unreported 3-(4-nitrophenyl)phthalic acid and the incorrectly described 4-(4-nitrophenyl)phthalic acid.

DURING A STUDY of substituted nitrophthalic acids, a sample of 4-(4-nitrophenyl)phthalic acid was desired. This acid had been prepared (*3*) by nitration of 4-phenylphthalic anhydride, which was prepared from diazotized methyl 4-aminophthalate and benzene. In an attempt to simplify this procedure, diazotized 3,4-dimethylaniline was made to react with nitrobenzene and alkali (*6*) to give a 21.0% yield of distilled dimethylnitrobiphenyls, shown by VPC to contain 62% 3,4,2′-, 8% 3,4,3′-, and 30% 3,4,4′-isomer. This crude mixture was oxidized with potassium permanganate in pyridine to give a low yield of 4-(4-nitrophenyl)phthalic acid (m.p. 195–96°), which was characterized by infrared and NMR spectra. Vacuum sublimation of the acid gave the anhydride (m.p. 195–98°).

Since Butterworth *et al.* (*3*) report melting points of 178–79° and 136–37° for the acid and anhydride, respectively, it was of interest to repeat their nitration. Employing the modified Gomberg procedure of Hellwinkel (*8*), the reaction of 3,4-dimethylaniline and butyl nitrite in refluxing benzene gave a 19.0% yield of distilled 3,4-dimethylbiphenyl. Oxidation with permanganate in pyridine gave a poor yield of 4-phenylphthalic acid, converted by vacuum sublimation to the anhydride. The anhydride was nitrated with 90% nitric acid in acetic acid as described by Butterworth *et al.* to give 4-(4-nitrophenyl)phthalic acid (m.p. 192–93°), giving on vacuum sublimation the anhydride (m.p. 191–93°). The identity of these preparations with those described above was established by infrared spectra and mixed melting points. The lower melting points described previously (*3*) probably resulted from the presence of isomers (this possibility was mentioned by the authors). Mixed acid nitration of 4-phenylphthalic anhydride gave predominantly 4-(2,4-dinitrophenyl)phthalic acid, with a little mononitro acid.

In attempted variations on the above procedures, the reaction of 3,4-dimethylaniline and butyl nitrite in nitrobenzene at 100° gave a 25% yield of distilled dimethylnitrobiphenyls, shown by VPC to contain 65% 3,4,2′-, 11% 3,4,3′-, and 24% 3,4,4′-isomer. After long chilling in benzene, this mixture deposited crystals, purified by chromatography on alumina and crystallization to give pure 3,4-dimethyl-4′-nitrobiphenyl. Treatment of 3,4-dimethylacetanilide in acetic acid–sodium acetate with nitrosyl chloride followed by reaction with nitrobenzene (*2*) gave a crude mixture from which no pure products could be isolated, but which gave a little 4-(4-nitrophenyl)phthalic acid on oxidation. Attempted nitrosation of 3,4-dimethylacetanilide with nitrous fumes (*7*), followed by reaction of the crude product with nitrobenzene, gave no isolable biphenyls. The anilide could not be nitrosated by sodium nitrite in acetic or dilute hydrochloric acid.

In a condensation opposite to those used above, the reaction of *p*-nitroaniline and butyl nitrite in refluxing *o*-xylene gave crude yields (by VPC) of 10.9% 2,3-dimethyl-4′-nitrobiphenyl and 6.8% of the 3,4,4′-isomer. Crystallization gave the pure 2,3,4′-isomer, which was characterized by NMR and infrared. This coupling, like that of dimethylaniline with nitrobenzene, gave a preponderance of *o*-substitution. A 22% yield of nitrobenzene was also obtained, indicating that reduction accompanied coupling.

Permanganate oxidation as above gave a low yield of 3-(4-nitrophenyl)phthalic acid, characterized by NMR and infrared of the methyl ester. Dehydration with acetic anhydride gave the anhydride. Identity was further established by heating the anhydride 5 hours at 150° to 200° in concentrated sulfuric acid (no reaction took place in 10 minutes at 50° to 60°) to give 7-nitro-9-fluorenone-1-carboxylic acid (*4*). 4-(4-Nitrophenyl)phthalic anhydride was recovered unchanged from similar treatment.

The sodium carbonate–catalyzed decomposition of *p*-nitrobenzene-diazonium fluoborate in *o*-xylene (*9*) gave a 45% yield of *p*-nitrofluorobenzene, but no biphenyls. Better results were obtained in the pyridine-catalyzed decomposition of the fluoborate salt in *o*-xylene–sulfolane, as described by Abramovitch and Koleoso (*1*). This gave a 9.9% yield of 2,3-dimethyl-4′-nitrobiphenyl and a 4.2% yield of the 3,4,4′-isomer, as well as 17% nitrobenzene by reduction. Results were thus similar to those obtained from *in situ* diazotization of *p*-nitroaniline in *o*-xylene.

EXPERIMENTAL

Preparation of 3,4-Dimethyl-4′-nitrobiphenyl. Procedure A. From 3,4-Dimethylbenzenediazonium Chloride and Nitrobenzene. Following the procedure of Gomberg and Pernert (*6*), a solution of diazonium salt prepared from 30.2 grams of 3,4-dimethylaniline (Aldrich Chemical Co.), 47 ml of concentrated hydrochloric acid, 100 ml of water, and 18 grams of sodium nitrite was added in portions to a vigorously stirred mixture of 100 grams of 40% sodium hydroxide in 150 ml of nitrobenzene, with addition of ice to maintain a temperature below 10°. The mixture was then stirred 1 hour at less than 10°, 4 hours at ambient temperature, and left overnight. Steam-distillation, extraction and drying of the residue, and distillation gave 11.9 grams (21%) of a mixture of biphenyls [b.p. 154–80° (0.4 mm)], shown by *VPC* to contain 62% 3,4-dimethyl-2′-nitrobiphenyl, 8% 3,4,3′-, and 30% 3,4,4′-isomer.

Procedure B. From 3,4-Dimethylaniline, Butyl Nitrite, and Nitrobenzene. Using the procedure of Hellwinkel (*8*), a solution of 59.2 grams (0.490 mole) of 3,4-dimethylaniline in 300 ml of nitrobenzene was stirred at 100° while 54.1 grams of (0.526 mole) of freshly distilled butyl nitrite (Eastman) in 50 ml of nitrobenzene was added dropwise, giving a strongly exothermic reaction with slight evolution of nitric oxides. The mixture was stirred 2 days at 100°, then steam-distilled. Vacuum distillation of one half of the extracted, dried residue gave 13.9 grams (25%) of dimethylnitrobiphenyls [b.p. 158–74° (1 to 3 mm)], shown by VPC to contain 65, 11, and 24%, respectively, of the 3,4,2′-, 3,4,3′-, and 3,4,4′-isomers. A solution of the crude distillate in benzene after long standing at −5° deposited crystals, separated by chromatography in petroleum ether on alumina to give 3,3′,4,4′-tetramethylazobenzene [m.p. 158–61° (lit. m.p. 158°)] and 3,4-dimethyl-4′-nitrobiphenyl (m.p. 69–70°, molecular weight by mass spectroscopy 227), characterized by infrared (11.6, 12.2 microns) and NMR [δ 8.27 (d, J = 9 Hz), 7.71 (d, J = 9 Hz), $A,A'B,B'$ of $ArNO_2$ ring, 7.34 (m; remaining ArH), 2.33 (s, $ArCH_3$)].

Procedure C. From 3,4-Dimethylacetanilide, Nitrosyl Chloride, and Nitrobenzene. Refluxing 3,4-dimethylaniline with acetic anhydride in acetic acid gave a 65% yield of acetanilide [m.p. 97.8° (lit. m.p. 98–99°)]. Following Bachmann and Hoffman (*2*), a solution of 26.6 grams (0.163 mole) of anilide, 15.7 grams of dry sodium acetate, 1.6 grams of granular phosphorus pentoxide, 118 ml of acetic anhydride, and 235 ml of acetic acid was stirred in an ice bath while an ice-cold solution of 13.1 grams of nitrosyl chloride in 27.7 grams of acetic anhydride was added dropwise so the temperature did not exceed 8°. After 1-hour additional stirring at 0° to 5°, the mixture was poured onto 1 liter of crushed ice, then extracted with three 100-ml portions of nitrobenzene, giving a deep red solution which underwent self-heating to 49° with some gas evolution. The solution was stirred overnight at 35°, then steam-distilled to leave a tarry residue from which only dimethylacetanilide could be recovered by vacuum distillation. However, oxidation of crude, undistilled residue gave a very small amount of 4-(4-nitrophenyl)phthalic acid.

Preparation of 2,3-Dimethyl-4′-nitrobiphenyl. Following Procedure B a mixture of 39.2 grams (0.284 mole) of *p*-nitroaniline (Eastman), 43.0 ml (0.380 mole) of freshly prepared butyl nitrite, and 200 ml of *o*-xylene was heated to reflux, undergoing violent initial reaction. The mixture was refluxed 2 days, then distilled to give xylene, 7.7 grams (22%) of nitrobenzene, and 11.5 grams (17.7%) of dimethylnitrobiphenyls [b.p. 165–210° (1.5 mm)], shown by VPC to contain 62% 2,3,4′- and 38% 3,4,4′-isomer. The distillate, which solidified on standing, was fractionally crystallized from benzene–cyclohexane to give a little *p*-nitroaniline and 2,3-dimethyl-4′-nitrobiphenyl, crystallized from cyclohexane to melting point 96–9°, infrared 12.05, 12.82, 14.10 microns, NMR δ 8.25 (d, J = 9 Hz), 7.45 (d, J = 9 Hz, $AA'BB'$; for $ArNO_2$ ring), 7.26, 7.17, 7.10, 7.02 (m, remaining ArH), 2.35 (s, 3-methyl), 2.13 (s, 2-methyl).

Preparation of 3,4-Dimethylbiphenyl. A solution of 42.7 grams (0.353 mole) of 3,4-dimethylaniline in 200 ml of benzene was stirred and refluxed while 43.0 ml (0.380 mole) of butyl nitrite (Eastman) in 50 ml of benzene was added over 3 hours. Reaction was less vigorous than above, and no nitric oxides were observed. The solution was refluxed 45 hours, then distilled to give 15.5 grams of reddish liquid [b.p. 113–73° (3 mm)], shown by VPC to contain 78.3% (19.0% yield) of 3,4-dimethylbiphenyl, identified by comparison of infrared spectrum with an authentic spectrum, and three minor components. On standing, the distillate deposited a little 3,3′,3,3′-tetramethylazobenzene, crystallized from heptane to melting point 154–55°.

Decomposition of *p*-Nitrobenzenediazonium Fluoborate in *o*-Xylene. Following the procedure of Hodgsen and Marsden (*9*), a slurry of 10.0 grams (0.042 mole) of *p*-nitrobenzenediazonium fluoborate (Eastman practical) in 30 ml of *o*-xylene was stirred at ambient temperature while 3.00 grams of anhydrous sodium carbonate was added in portions. The slurry was stirred 24 hours at ambient temperature and then heated to 80° without giving off gas. At 110° the mixture darkened and gave off acid fumes. After a final heating to 140° the mixture was cooled, washed with water, sodium bicarbonate, and water, and dried. Distillation gave 2.64 grams (45%) of *p*-nitrofluorobenzene [b.p. 79–82° (10 mm)], which on reaction with piperidine in methyl sulfoxide (10) gave *N*-(*p*-nitrophenyl)piperidine [m.p. 103°–04° (lit. m.p. 105°)].

In a modification of the method of Abramovitch (*1*) a mixture of 7.11 grams (0.0300 mole) of *p*-nitrobenzenediazonium fluoborate, 2.42 ml (0.0300 mole) of pyridine, 36 ml (0.30 mole) of *o*-xylene, and 50 ml of distilled sulfolane was stirred at ambient temperature. The salt dissolved rapidly with vigorous evolution of nitrogen, and the temperature rose to 40–45°. After 1 hour the charge was heated 7 hours at 60° to 70°. It was then cooled, stripped of excess *o*-xylene in vacuo, extracted with methylene chloride, and washed with water. GC showed the extract to contain 0.64 gram (17%) of nitrobenzene, 0.67 gram (9.9%) of 2,3-dimethyl-4′-nitrobiphenyl, and 0.29 gram (4.2%) of 3,4,4′-isomer. No other compounds were detected.

Preparation of 4-(4-Nitrophenyl)phthalic Anhydride. PROCEDURE A. FROM 3,4-DIMETHYL-4′-NITROBIPHENYL. A solution of 11.9 grams of crude 3,4-dimethyl-4-nitrobiphenyl (Procedure A) in 120 ml of pyridine and 60 ml of water was stirred and refluxed while 17 grams of potassium permanganate was added over 2 hours. After 2 hours further reflux, the charge was filtered hot and concentrated to dryness in vacuo. The residue was dissolved in 120 ml of 10% sodium hydroxide, and stirred and refluxed while 24 grams of permanganate was added over 2 hours. After 2-hour additional reflux, the solution was filtered hot, and the cooled filtrate was extracted with methylene chloride and then acidified. Crystallization of the resulting precipitate from acetic acid gave 0.13 gram of 4-(4-nitrophenyl)phthalic acid (m.p. 195–96°), characterized by infrared and NMR spectra of the methyl ester (m.p. 113–14°) (C_6H_6/C_7H_{16}), NMR [$(CO_3)_2CO$] δ 8.41 (d, $J = 9$ Hz), 8.04 (d, $J = 9$ Hz, *AA′BB′* of $ArNO_2$ ring), 8.04 (m, remaining ArH), 3.92 (s, OCH_3). Dehydration of the acid by acetic anhydride or vacuum sublimation (160° / 1 mm) gave 4-(4-nitrophenyl)phthalic anhydride, crystallized from benzene-heptane to melting point 192–93°.

PROCEDURE B. FROM 4-PHENYLPHTHALIC ACID. Oxidation of 15.5 grams of 3,4-dimethylbiphenyl by the pyridine-permanganate method described above gave 1.43 grams (9.3%) of 4-phenylphthalic acid {m.p. 192–201° [lit. m.p. 201–02° (*5*)]}. Vacuum sublimation (160° to 190°/0.5 mm) gave the anhydride {m.p. 131–41° [lit. m.p. 140–41° (*5*), 138–39° (*3*)]}.

Following the procedure of Butterworth *et al.* (*3*), a slurry of 0.50 gram of 4-phenylphthalic anhydride in 1.00 ml of acetic acid was stirred at 85° while 0.50 ml of 90% nitric acid was added dropwise. The solution was then stirred 2½ hours at 90° to 100°. Cooling, filtration, and washing gave 0.37 gram of solid, crystallized from acetic acid to give 4-(4-nitrophenyl)phthalic acid (m.p. 192–93°), the infrared spectrum of which was identical to that prepared above. Vacuum sublimation gave the anhydride (m.p. 191–93°), identical by infrared and mixed melting point with that above.

Preparation of 3-(4-Nitrophenyl)phthalic Anhydride. Oxidation of 1.14 grams of 2,3-dimethyl-4′-nitrobiphenyl by the pyridine-permanganate procedure gave an initial precipitate of 0.65 gram of 4-(4-nitrophenyl)phthalic acid. The filtrate deposited 0.33 gram of 3-(4-nitrophenyl)phthalic acid (m.p. 199–201°). Dehydration in acetic anhydride gave 3-(4-nitrophenyl)phthalic anhydride [m.p. 202.5–03.0° (MeCN)], giving with methanolic sulfuric acid the methyl ester (m.p. 145–48°) (heated rapidly; when heated slowly or remelted a melting point of 200–03° was observed), NMR ($CDCl_3$) δ 8.23 (d, $J = 8$ Hz), 7.55 (d, $J = 8$ Hz, *AA′BB* of $ArNO_2$ ring), 8.05, 7.97, 7.55 (m, remaining ArH), 3.92 (s, 3-CO_2Me), 3.72 (s, CO_2Me). Identity was confirmed by heating the acid in 98% sulfuric acid 5 hours at 150° to 200° to give 7-nitro-9-fluorenone-1-carboxylic acid {m.p. 243–45° [lit. m.p. 245–46° (decomposition) (*4*)]}. Similar treatment of the 4-(4-nitrophenyl)isomer gave no reaction.

Preparation of 4-(2,4-Dinitrophenyl)phthalic Acid. A mixture of 0.60 gram of 4-phenylphthalic anhydride and 2.40 ml of 98% sulfuric acid was stirred at ambient temperature while 2.40 ml of 70% nitric acid was added dropwise. The mixture was stirred 8 minutes at 45°, then drowned in ice. Crystallization of the resulting 0.94 gram of solid from acetic acid gave first an unidentified (apparently unnitrated by infrared) solid [m.p. 288–92° (sublimation)]. From the filtrate was obtained 4-(2,4-dinitrophenyl)phthalic acid, (m.p. 149–50°), giving with methanolic sulfuric acid the methyl ester, [m.p. 144–7° (MeOH)] NMR ($CDCl_3$) δ 8.83 (d, $J = 2$ Hz), 8.63 (d, $J = 2$ Hz), 8.47 (d, $J = 2$ Hz, ABC of $ArNO_2$ ring), 7.94, 7.78, 7.60, 7.45 (m, remaining ArH), 3.95 (split, CO_2Me). Dilution of the filtrate gave a little 4-(4-nitrophenyl)phthalic acid.

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LITERATURE CITED

(1) Abramovitch, R.A., Koleoso, O.A., *J. Chem. Soc.* **B 1968**, 1292.
(2) Bachmann, W.E., Hoffman, R.A., *Org. Reactions* **2**, 224 (1944).
(3) Butterworth, E.C., Heilbron, I.M., Hay, D.M., Wilkinson, R., *J. Chem. Soc.* **1938**, 1386.
(4) Garascia, R.J., Fries, E.F., Ching, C., *J. Org. Chem.* **17**, 226 (1952).
(5) Ghigi, E., *Ber.* **71**, 684 (1938).
(6) Gombert, M., Pernert, J.C., *J. Amer. Chem. Soc.* **48**, 1372 (1926).
(7) Haworth, J.W., Hey, D.M., *J. Chem. Soc.* **1940**, 361.
(8) Hellwinkel, D., *Ber.* **99**, 3642 (1966).
(9) Hodgsen, H.H., Marsden, E., *J. Chem. Soc.* **1940**, 208.
(10) Suhr, H., *Ann.* **689**, 109 (1965).

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