

A Simplified Synthesis for *meso*-Tetraphenylporphin¹

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As a result of our mechanistic studies on porphyrin synthesis,² we have developed a modified synthesis which represents an improvement over previous literature methods³⁻¹¹ for *meso*-tetraphenylporphin (TPP). The yield and rate of the condensation of pyrrole and benzaldehyde to TPP have been found to depend on the acidity, the solvent, the temperature, the availability of atmospheric oxygen, and the initial concentration of the reagents.² Hence, while the following procedure does not represent the conditions for the highest yield, it does represent the most convenient method for rapidly and reproducibly obtaining a $20 \pm 3\%$ yield of crystalline TPP of relatively high purity. In addition, the TPP is in such a form as to facilitate further purification.

This same procedure may also be adapted to the ready preparation of several other *meso*-substituted porphyrins (generally the aromatic derivatives); e.g., substitution of *p*-chlorobenzaldehyde gives a 20% yield of the *meso*-tetra-*p*-chlorophenylporphin. Not all condensations are successful. Although 70 different aldehydes have all given porphyrins under these conditions, the increased solubility due to the formation of the porphyrin acid salts for many of the other *meso* derivatives prevents the use of this method as a convenient procedure for the preparation of these types of porphyrins. Isolation of product in these cases is not as simple as above, but still may be achieved. As a general rule, the alkyl derivatives and those aromatic derivatives which bear ionizable functional groups have a greater tendency to form the porphyrin acid salts.

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(2) A. D. Adler, F. R. Longo, and W. Shergalis, *J. Am. Chem. Soc.*, **86**, 3145 (1964). A second paper on further studies is in preparation.

(3) P. Rothemund, *ibid.*, **57**, 2010 (1935).

(4) R. H. Ball, G. D. Dorough, and M. Calvin, *ibid.*, **68**, 2278 (1946).

(5) D. B. Sharp, U. S. Patent 3,076,813 (1963); *Chem. Abstr.*, **59**, 1593 (1963).

(6) P. Rothemund and A. R. Menotti, *J. Am. Chem. Soc.*, **63**, 267 (1941).

(7) S. Aronoff and M. Calvin, *J. Org. Chem.*, **8**, 205 (1943).

(8) G. D. Dorough, J. R. Miller, and F. M. Huennekens, *J. Am. Chem. Soc.*, **73**, 4315 (1951).

(9) G. D. Dorough and F. M. Huennekens, *ibid.*, **74**, 3974 (1952).

(10) D. W. Thomas and A. E. Martell, *ibid.*, **78**, 1335 (1956).

(11) G. M. Badger, R. A. Jones, and R. L. Laslett, *Australian J. Chem.*, **17**, 1028 (1964).

Experimental Section

Freshly distilled pyrrole (56 ml, 0.8 mole) and 80 ml (0.8 mole) of reagent grade benzaldehyde are added to 3 l. of refluxing reagent grade propionic acid. (Note: crystalline material is not directly obtained if acetic acid is used.) After refluxing for 30 min, the solution is cooled to room temperature and filtered, and the filter cake is washed thoroughly with methanol. After a hot water wash, the resulting purple crystals are air dried, and finally dried *in vacuo* to remove adsorbed acid¹² to yield 25 g (20% yield) of TPP. Spectrophotometric analysis shows that only 1% of the TPP yield remains in the filtrate and also that the filtered material is about 3% tetraphenylchlorin (TPC) by weight. (Note that longer reaction times in propionic acid do not appreciably improve the yield, but actually decrease the purity of the products.)

Anal. Calcd for C₄₄H₃₀N₄: C, 85.90; H, 4.92; N, 9.12. Found: C, 85.16; H, 4.99; N, 9.60.

A study¹³ of previous chromatographic purification techniques^{4,7,10,11} shows that the product obtained by the above procedure is easily purified by a simple batchwise technique. TPP (1.0 g) and 100 g of fuller's earth (Florex) are stirred with enough 1,1,1-trichloroethane to make about 1 l. of mixture. This is immediately passed through a 0.25-in. bed of solvent-washed fuller's earth on a 6-in. sintered-glass vacuum funnel. The eluent is passed through a fresh bed of Florex three or four times. This eliminates the TPC contamination as indicated by the optical spectrum. Due to adsorption, there is a loss of approximately 80% of the starting material in this purification procedure.

Another reliable purification method for the crude TPP was found to be entrainment sublimation using purified nitrogen gas as the carrier. A horizontal furnace with one or two hot zones was used with the temperature of the hotter zone adjusted to 325°, while the cooler zone was maintained at 250°. During the sublimation process, nitrogen gas was allowed to flow at a rate of 1 ft³/hr. against atmospheric pressure. In this method, large, single-crystal needles of TPP were obtained. Combustion analysis of the sublimed product gave good agreement with the theoretical values, and the electronic adsorption spectrum of a solution of this product in benzene was in excellent agreement with that reported by other workers.^{10,11,14}

Anal. Calcd for C₄₄H₃₀N₄: C, 85.90; H, 4.92; N, 9.12. Found: C, 86.10; H, 4.91; N, 9.12.

Alternatively, the TPP can also be purified by vacuum sublimation in a horizontal furnace using vacuum ion pumping and a thermal gradient. The material is sublimed through a 12-in. diffusion path (325–350° at position of initial material to 150–200° at the collection region) at a pressure which must be maintained at less than 1×10^{-7} torr. This method yields octahedral or rhombohedral crystals, rather than needles.

(12) A. D. Adler and J. L. Harris, *Anal. Biochem.*, **14**, 472 (1966).

(13) E. A. Miller, M.S. Thesis, Drexel Institute of Technology, 1966.

(14) J. Mullins, A. D. Adler, and R. Hochstrasser, *J. Chem. Phys.*, **43**, 2548 (1965).

Liquid Crystals. I. Fluorinated Anils

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The presence of mesomorphism in 2,2',6,6'-tetrafluoro-4,4'-di(*p*-*n*-alkoxybenzylidenamino)biphenyls has been deemed to be "extremely doubtful."¹ This assumption was based on the fact that the corresponding tetrachloro derivatives were not mesomorphic.

We wish to report that we have prepared dianils of 2,2',3,3',5,5',6,6'-octafluorobenzidine and have found them to be liquid crystals. Specifically, dianisylidene-

(1) G. W. Gray, "Molecular Structure and the Properties of Liquid Crystals," Academic Press Inc., New York, N. Y., 1962, p 290.

TABLE I
 PHYSICAL PROPERTIES OF THE LIQUID CRYSTALLINE ANILS

| Compound | Smectic range, °C | Nematic range, °C | Anal, % | | | | | |
|------------------------------------------------------------------------------|-------------------|----------------------|---------|------|-------|-------|------|-------|
| | | | Calcd | | | Found | | |
| | | | C | H | N | C | H | N |
| Dianisylideneoctafluorobenzidine | | 219-370 | 59.15 | 2.82 | 4.93 | 59.84 | 3.09 | 5.16 |
| Dianisylidenebenzidine | | 252-345 ^a | | | | | | |
| Di- <i>p</i> -propoxybenzylideneoctafluorobenzidine | 205-210 | 210-315 | 61.54 | 3.85 | 4.49 | 61.68 | 3.93 | 4.53 |
| Di- <i>p-n</i> -propoxybenzylidenebenzidine | | 252-390 | 80.67 | 6.72 | 5.88 | 80.60 | 6.58 | 6.01 |
| Anisylidene- <i>p</i> -aminotetrafluorobenzamide | 238-268 | | 55.21 | 3.06 | 8.58 | 55.20 | 3.46 | 8.67 |
| Anisylidene- <i>p</i> -aminobenzamide | 176-195 | | 70.86 | 5.51 | 11.02 | 71.50 | 5.68 | 11.20 |
| Benzylideneoctafluorobenzidine | | 235 ^b | 61.90 | 2.38 | 5.55 | 61.90 | 2.45 | 5.88 |
| O-Propionyl- <i>p</i> -hydroxybenzylidene- <i>p</i> -trifluoromethoxyaniline | 90-136 | | 60.50 | 4.15 | 4.15 | 60.79 | 4.33 | 4.19 |

^a Reference 2. ^b Not mesomorphic.

octafluorobenzidine has a crystal-nematic transition point at 219-220° and a nematic-isotropic transition point at 370° dec. The di-*p-n*-propoxybenzylidene derivative has a crystal-smectic transition at 205°, a smectic-nematic transition at 210°, and a nematic-isotropic transition at 315°. The dibenzylidene derivative is not mesomorphic, as would be expected,¹ owing to a lack of polarizable groups at the terminal positions of the molecule.

Wiegand² reports the crystal-nematic point of dianisylidene benzidine to be 252-253° and the nematic-isotropic point to be above 345°. Our results indicate that the substitution of fluorine atoms has little effect on the ability of a molecule to exhibit mesomorphic behavior. However, substitution of fluorine for hydrogen would be expected to increase the lateral interactions between nearest neighbors and therefore increase the smectic thermal stability. We have found this to be the case. Anisylidene-*p*-aminotetrafluorobenzamide has a crystal-smectic transition at 238° and a smectic-isotropic point at 268°. The corresponding unfluorinated compound has a crystal-smectic point at 176° and a smectic-isotropic point at 195°. An even more striking example of the effect of fluorine on the smectic thermal stability is illustrated by the substitution of fluorine in a molecule which exhibits a pure nematic state. Di-*p-n*-propoxybenzylidenebenzidine is only nematic from 252 to >390°. However, substitution of fluorine for the eight hydrogen atoms on the benzidine portion of the molecule introduces a smectic state at 205° and in turn decreases the nematic thermal stability. Another interesting example of fluorine increasing the smectic thermal stability is shown by O-propionyl-*p'*-hydroxybenzylidene-*p*-trifluoromethoxyaniline. This material is purely smectic from 90 to 136°, while the corresponding unfluorinated compound is purely nematic from 86-118°. The increased ratio of residual lateral to terminal interactions is due to the strongly polar trifluoromethoxy group, which has a dipole operating perpendicular to the molecular axis.

The physical properties of the new liquid crystalline anils are summarized in Table I. These anils were prepared by the condensation of appropriately substituted benzaldehydes with readily available fluoroaromatic amines.

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(2) C. Wiegand, *Z. Naturforsch.*, **6b**, 240 (1951).

(3) The results of our investigations on this family of anils will be the subject of a future publication.

A Cryoscopic Study of Methanediamines in Sulfuric Acid¹

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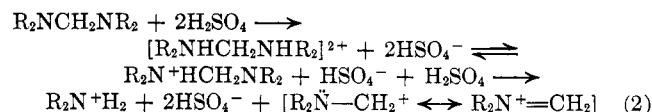
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In connection with studies on the mechanism of the Mannich reaction it became of interest to study the nature of the ionization products of methanediamines in strongly acid media. These compounds as well as hydroxymethylamines have been mentioned as possible intermediates in various proposed mechanisms of the Mannich reaction.^{1,2} We now report the results of cryoscopic studies on four methanediamines of formula $R_2NCH_2NR_2$ in concentrated sulfuric acid.

Previous cryoscopic studies on dibasic compounds, $X(CH_2)_nY$, have been reported where X and Y are ether or amino groups and $n \geq 2$. These compounds generally have van't Hoff *i* factors of about 3 which indicates that they behave as simple difunctional bases³ (eq 1).



In the compounds which we now report, the nitrogen atoms are separated by only one methylene group. These methanediamines exhibit van't Hoff *i* factors near 4 at approximately 0.02 *m* concentrations (Table I). The simplest explanation for these results involves dissociation of the monoprotonated moiety to form the resonance-stabilized aminocarbonium ion (eq 2).



Such aminocarbonium ions have been suggested previously⁴ as intermediates in the Mannich reaction.

(1) A Study of the Mannich Reaction. VIII. For previous papers, see J. E. Fernandez and W. I. Ferree, *Quart. J. Florida Acad. Sci.*, **29**, 13 (1966); J. E. Fernandez and J. M. Calderazzo, *J. Chem. Eng. Data*, **10**, 402 (1965); J. E. Fernandez, J. S. Fowler, and S. J. Glaros, *J. Org. Chem.*, **30**, 2787 (1965).

(2) (a) J. H. Burkhalter, J. N. Wells, and W. J. Mayer, *Tetrahedron Letters*, 1353 (1964); (b) J. E. Fernandez, *ibid.*, 2889 (1964); (c) E. C. Wagner, *J. Org. Chem.*, **19**, 1862 (1954); (e) B. Reichert, "Die Mannich Reaktion," Springer-Verlag, Berlin, 1959.

(3) R. J. Gillespie and J. A. Leisten, *Quart. Rev. (London)*, **8**, 40 (1954).

(4) (a) S. V. Liebermann and E. C. Wagner, *J. Org. Chem.*, **14**, 1001 (1949); (b) E. R. Alexander and E. J. Underhill, *J. Am. Chem. Soc.*, **71**, 4014 (1949); H. Hellmann and G. Opitz, *Chem. Ber.*, **89**, 81 (1956); *Angew. Chem.*, **68**, 265 (1956).