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NEIGHBORING GROUP PARTICIPATION IN PHOTOLYSIS OF *o*-SUBSTITUTED ARYLS[1]

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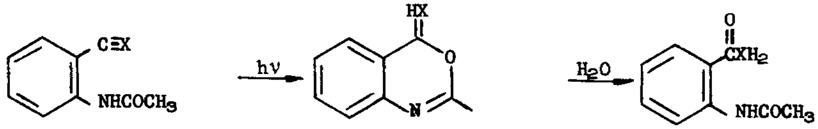
Acetanilides should fragment and rearrange in ultraviolet light.[2] However, if a suitable neighboring group is available in the *ortho* position other reactions may occur. For example, irradiation of *o*-cyanoacetanilide, 1, in aqueous solvents provides not only the expected cleavage and rearrangement of the anilide group, but *o*-acetamidobenzamide, an hydration product (see Equation 1).[3a] Further, photolysis of *o*-(phenylethynyl) acetanilide, 2, followed by aqueous workup yields *only* an hydrate, *o*-acetamidophenyl benzyl ketone.[3b] If the workup is interrupted before water is applied 2-methyl-4-benzylidene-4*H*-3,1-benzoxazine, 3, is isolated (Equation 1). If either cyanoanilide 1 or ethynylanilide 2 is mixed with benzophenone and photolyzed at 366 nm only hydration occurs.[3a,c] Thus, neighboring group participation apparently occurs in a triplet state. In order to amplify the scope of this new cyclization reaction, experiments involving anilides which contain doubly bonded groups in the *ortho* position rather than triple bonds were initiated. Herein is described research on photolysis of N-acetylanthranilic acid, 4.



(1)

1 X = N

3

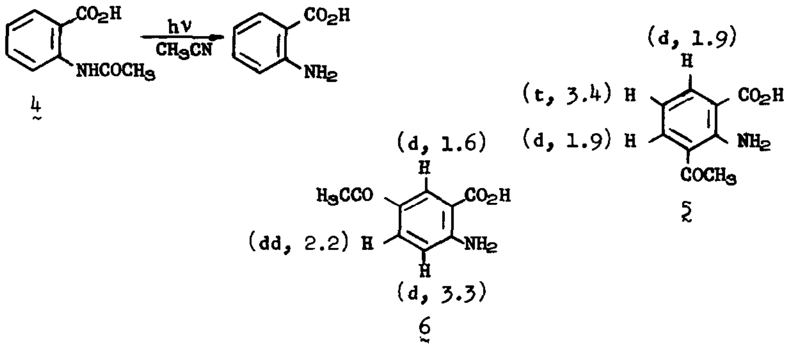
2 X = CPh

Degassed 0.01 M solutions of acidanilide 4 (0.9 g in 500 ml of acetonitrile) were irradiated in quartz at 254 nm for 100 hr. Monitoring was accomplished by removing aliquots and obtaining uv spectra. (The low intensity peak at 309 nm gradually shifts to 292 nm.) Workup of the reaction mixture included both extensive silica gel column chromatography and sublimation *in vacuo*. Along with starting material (50%)[4] three products eluted: anthranilic acid (6%) - physical and spectral properties identical to an authentic sample;[5] 3-aceto-2-aminobenzoic acid, 5, as yellow crystals (18%), mp 203-5°, $\lambda_{max}^{CH_3CN}$ 220 (25,900), 240 (sh, 9,800), 280 (1,510), γ_{max}^{KBr}

3430, 3315, 1680, 760, 705, 635, cm^{-1}, pmr (C_3D_6O) τ 1.92 (d, 2H, J=7), 3.42(t, 1H, J=7), 5.0 (br s, 3H), 7.45 (s, 3H), ms m/e=179 (P, 100), 164 (66) 146 (22), 133 (31), 119 (16); 5-aceto-2-aminobenzoic acid, 6, as a light yellow solid (16%), mp 188-9°, $\lambda_{max}^{CH_3CN}$ 220 (21,600), 240 (sh, 1,300), 295 (19,300), ν_{max}^{KBr} 3490, 3355, 1665, 1620, 1280, 1235, 970, 825, 655 cm^{-1}, pmr (C_3D_6O) τ 1.57 (d, 1H, J=1.5), 2.24 (dd, 1H, J=9, 1.5), 3.25 (d, 1H, J=9), 7.1 (br s, 3H), 7.58 (s, 3H), ms, m/e=179 (P, 41), 164 (25), 146 (23), 137 (52), 119 (100).[6] Reaction does not occur when acidanilide 4 is stored in the dark at 55° for this time period.

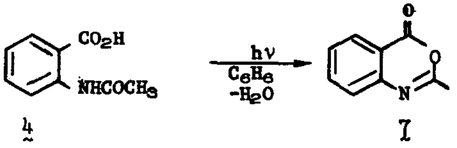
Assignment of structure to the high and low melting solids as isomeric aceto-2-aminobenzoic acids is based on ir and pmr spectral properties (see Equation 2). Since the major C=C-C bending vibration in the infrared spectrum of the high melting isomer, 5, falls at 760 cm^{-1}, aryl substituents are arranged in a 1,2,3-trisubstituted pattern. The fact that the low melting isomer, 6, has weak C=C-H bending absorption at 970 cm^{-1} and strong C=C-H bending absorption at 825 cm^{-1} indicates a 1,2,4-trisubstituted pattern. PMR splitting patterns of the aryl protons confirm these assignments. Isomer 5 exhibits a low field 2H doublet coupled to a higher field 1H triplet. Since the J values suggest ortho substitution, two accidentally equivalent protons are split by a third proton as expected for 1,2,3-trisubstituted aryls (see Equation 2). Isomer 6 exhibits three absorptions. A very low field 1H doublet has such a very low J value that coupling to a meta proton only is suggested. A 1H doublet of doublets is obviously coupled to the low field 1H doublet and a higher field 1H doublet. The J value of the higher field doublet indicates *ortho* coupling. Such fits a 1,2,4-trisubstituted aryl. Of the three possible 1,2,3-trisubstituted isomers of acetoaminobenzoic acid only 3-aceto-2-aminobenzoic acid could exhibit a pmr triplet upfield and a doublet of doublets downfield which results from two virtually equivalent hydrogens. Of the six possible 1,2,4-trisubstituted isomers of acetoaminobenzoic acid only 5-aceto-2-aminobenzoic acid or 3-aceto-4-aminobenzoic acid (a highly unlikely product of this photoreaction) could exhibit a doublet at 1.6τ with a coupling constant of 1.5 Hertz. Because the doublet of doublets absorbs as low as 2.2τ, 5-aceto-2-aminobenzoic acid is assigned as the structure of this solid.

In order to check for the presence of 2-methyl-4*H*-3,1-benzoxin-4-one, 7, in the product of direct irradiation of acidanilide, 4, GLC conditions were established for detection in 1% solutions. Analysis of aliquots removed during the irradiation period were negative. Thus direct irradiation of acidanilide 4 provides mainly anthranilic acid, 3-aceto-2-aminobenzoic acid, 5, and 5-aceto-2-aminobenzoic acid, 6, products of photo-Fries-like cleavage and rearrangement[2] (Equation 2).



(2)

Since photo-Fries and similar reactions have been postulated to occur from singlet excited states,[2] efforts were directed toward experiments which would form the triplet state of acidanilide 4. In acetonitrile acidanilide 4 flouresces at 367 nm and phosphoresces at 428 nm. Although a number of different sensitizers were tried, each left some slight ambiguity as to the source of the phosphorescence. However, a solution of acidanilide 4 (10^{-5}M) and benzene (10^{-1}M) in EPA exhibits an absorption spectrum of benzene and a phosphorescence spectrum of acidanilide 4. The intensity of phosphorescence is *ca*. ten times that of similar solutions of acidanilide 4 in EPA. *Thus initial evidence for energy transfer from the triplet state of benzene to that of* acidanilide 4 was noted. Solutions of acidanilide 4 (0.51 g, 0.001M) in dry benzene containing a few grams of molecular sieve[7] were irradiated in quartz under nitrogen for 200 hr. Solvent was evaporated to give a brown residue whose ir and pmr were identical to those of authentic[5,8] benzoxazinone 7. When this irradiation is interrupted after 40 hrs. and a pmr spectrum obtained of a sample, peaks identical to that of a mixture of acidanilide 4 and benzoxazinone 7 result. If water is added to this sample and the analysis repeated the pmr peaks of benzoxazinone 7 are absent. If sodium methoxide is added, a solid with mp and pmr identical to those of authentic methyl N-acetylanthranilate[9] results. An identical solution stored in the dark for this time period did not give reaction. A solution of benzoxazinone 7 in benzene and EPA stored in the dark does not react.[10] *The only explanation which will fit all of this data is that acidanilide* 4 forms photo-Fries-like cleavage and rearrangement products via a singlet state and cyclizes to benzoxazinone 7 via a triplet state (Equation 3).[11]



(3)

These results confirm previous postulates about the mechanism of both the photo-Fries reaction of anilides[2] and neighboring group participation of ortho groups to form cycles.[3] Although time periods are long for sensitized reaction, yields are high and products are relatively clean.

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References

1. Abstracted in part from the Ph.D. Dissertation of R. Staudenmayer, University of Arkansas, 1973.
2. D. Bellus in "Advances in Photochemistry", Vol. 8, Ed. by J. N. Pitts, Jr., G. S. Hammond, and W. A. Noyes, Jr., Wiley-Interscience, New York, N.Y., 1971, p 109ff; V. I. Stenberg in "Organic Photochemistry", Vol. 1, O. L. Chapmen, Ed., Marcel Dekker, New York, N.Y., 1967 p 127ff.
3. a) L. Munchausen, I. Ookuni, and T. D. Roberts, Tetrahedron Lett., 1917 (1971); b) T. D. Roberts, L. Ardemagni, and H. Shechter, J. Amer. Chem. Soc., **91**, 6185 (1969); c) Unreported observation, this Laboratory.
4. Several other products make up the missing 10% of products. None has an infrared carbonyl absorption which can be assigned to **7**.
5. Purchased from commercial suppliers.
6. This completes the characterization of aceto-2-aminobenzoic acids in that the other two isomers have appeared in the literature: See F. Mayer, O. Stark, and K. Schon, Ber., **65**, 1333 (1932) and B. R. Baker, R. E. Schaub, J. J. Joseph, F. J. McEvoy, and J. H. Williams, J. Org. Chem., **17**, 164 (1952).
7. Molecular sieve was added to ensure an anhydrous environment. Since a similar solution does not react when stored in the dark, the molecular sieve does not cause reaction to occur.
8. A referee has asked why this product was not purified. Since it is extremely hygroscopic recrystallization might cause dehydration of acidanilide **4** to yield benzoxazinone **7**, or vice versa. Both gas-liquid and alumina column chromatography cause **4** to dehydrate to **7**. The chosen method (above) should unambiguously prove the structure of this product.
9. Authentic[5] benzoxazinone **7** yields methyl N-acetylanthranilate when treated with sodium methoxide under these conditions.
10. Although benzoxazinone **7** photolyzes very slowly to yield other products, neither **5** nor **6** are produced.
11. This work does not distinguish between reaction directly from the excited state to products and one in which the excited state is only an intermediate state leading to a reactive state, such as a vibrationally excited ground state.