

PHOTOXYGENATION OF 7,12-DIMETHYLBENZ(a)ANTHRACENE

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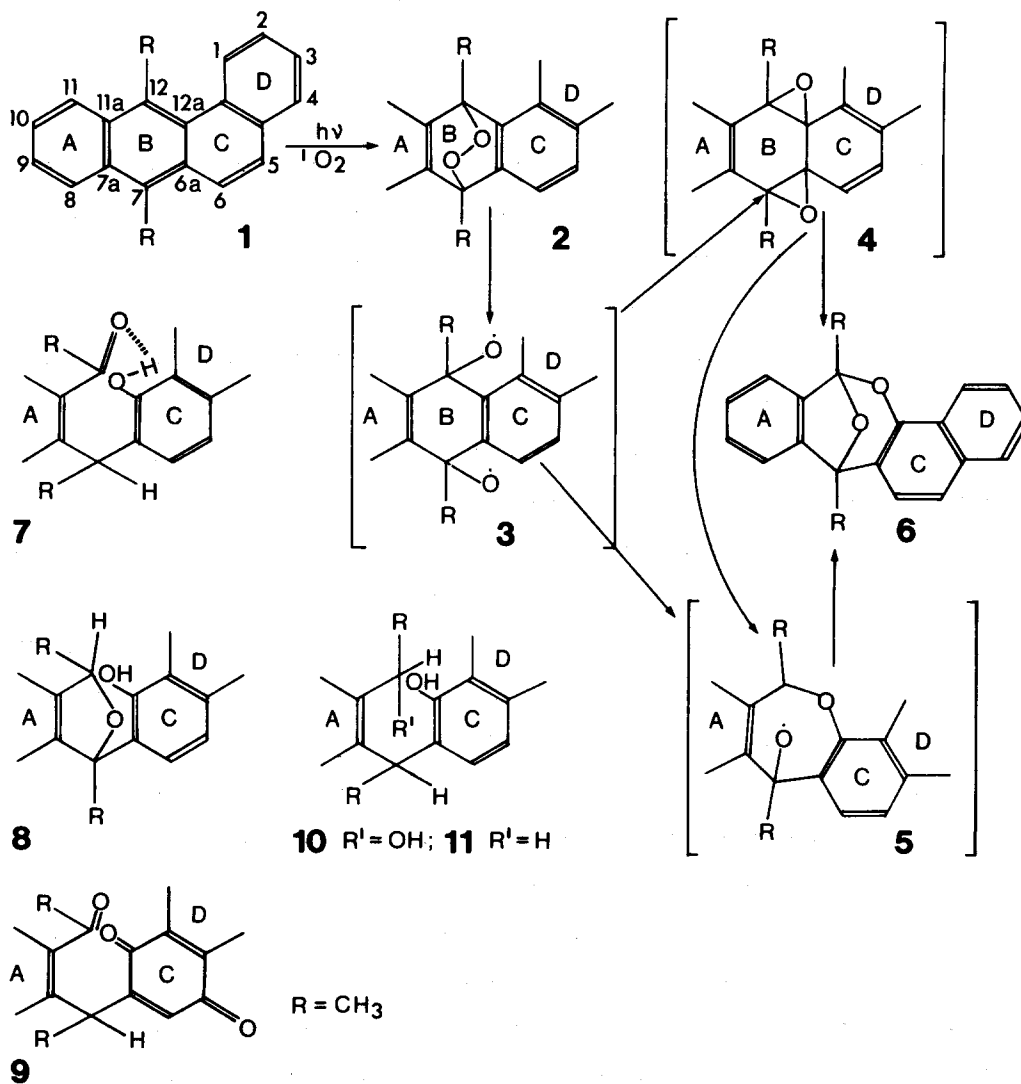
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Many polycyclic hydrocarbon carcinogens are strong photosensitizers. Studies of the effect of *in vivo* irradiation of these compounds on their carcinogenic activity have given conflicting results.<sup>1</sup> In attempting to understand the components of this interaction we have studied the *in vitro* photolysis of 7,12-dimethylbenz(a)anthracene (1). The direct irradiation (filtered xenon arc, 295-400 nm) of 1 in benzene (0.33% solution) in a pyrex container for 1 hr afforded a novel bicyclic acetal (6, m.p. 137-138°, 32%) of this hydrocarbon. It was separated and isolated by TLC (silica gel G, hexane/benzene/methanol 30:70:1, Rf 0.58). The structural elucidation of this compound is presented in this communication.

Mass spectrum<sup>2</sup> of 6 [70eV, m/e (relative intensity): 288 (M,94.9), 270(24.6), 255(26.5), 245(M - COCH<sub>3</sub>, 100)] established its molecular composition as C<sub>20</sub>H<sub>16</sub>O<sub>2</sub> indicating an addition of two oxygen atoms to 1. The IR did not show any absorption for OH or C=O functions and NMR<sup>3</sup> [CS<sub>2</sub>,  $\delta$  1.99 (CH<sub>3</sub>,s), 2.08 (CH<sub>3</sub>,s), 7.03-7.95 (10H, arom.)] displayed significant variations from that of 1<sup>4</sup>. Two methyl singlets appearing at  $\delta$  3 (7-CH<sub>3</sub>) and 3.2 (12-CH<sub>3</sub>) in 1 were strikingly shifted upfield to 1.99 and 2.08 in 6, suggesting carbons 7 and 12 as the sites for oxygen attachment. Absence of proton signals in the region of  $\delta$  3-7 further indicated that oxygen atoms were attached only to tetrasubstituted carbons. The UV [hexane,  $\lambda$  max nm (log  $\epsilon$ ): 328(3.47), 320 (3.38), 314(3.47), 305(3.45), 299(3.49), 244(4.23), 233(4.29) and 215(4.45)] spectrum was suggestive of the presence of naphthalene ring in the molecule.

Reductive opening of 6 with Zn/AcOH at elevated temperature yielded a phenolic ketone 7 [36% UV(hexane),  $\lambda$  max nm (log  $\epsilon$ ): 326(3.35), 290(3.65), 235.5(4.6, 213(4.5)]; IR (KBr): 3237 (OH)

1693 (C=O), Ac: 1758 and 1199  $\text{cm}^{-1}$ ;  $m/e$  290 (M, 100); NMR ( $\text{CS}_2$ ):  $\delta$  1.59 ( $\text{CH}_3\text{CH}$ , d), 2.71 ( $\text{CH}_3\text{CO}$ , s), 5.05 ( $\text{CH}_3\text{CH}$ , q) 7.18-8.08 (10H, arom.), 8.96 (ArOH, s). Sodium borohydride and Wolff Kishner reduction of this compound afforded the expected products 10 and 11<sup>5</sup>, respectively. Jones' oxidation of **7** gave a quinone<sup>6</sup> **9** and its oxidation with dil  $\text{HNO}_3$  at 180° produced two moles of phthalic acid. Formation of **7** suggests that carbon 12 is attached to two different oxygen atoms in **6**. Considering that both methyls are shifted upfield in **6** as compared to **1**, it follows that one oxygen introduced in **1** forms a bridge between position 7 and 12 carbons and the



second one has entered between 12 and 12a positions.

In addition to 7, another phenolic compound cis 8<sup>7</sup> (12%) was obtained upon Zn/AcOH reduction. This compound could be produced in much higher yield (77%) when 6 was reduced with lithium triethylborohydride<sup>8</sup> in THF at 65°, along with the formation of some trans compound (6%)<sup>9</sup>. On the other hand LAH: AlCl<sub>3</sub> (d:1) reduction of 6 in THF, under reflux, produced 37% of the trans isomer of 8. Chemical ionization (isobutane) spectra of cis and trans 8 exhibited a base peak at m/e 147. This peak possibly originates from 2,3-dimethyl-2,3-dihydro-isobenzofuran moiety present in these molecules.

An unequivocal proof of the proposed structure for 6 was obtained by x-ray analysis<sup>10</sup>.

Formation of 6 apparently takes place by rearrangement of 2<sup>11</sup> which is one of the initial products in our irradiation. Irradiation of 2 itself under our experimental conditions gave 6 in similar yield as obtained from 1. Rearrangement of 2 to 6 presumably occurs through intermediates like 3, 4 and 5<sup>12</sup>. A thermal rearrangement of similar type has been reported by Rigaudy et al<sup>13</sup> with 9,10-dimethylanthracene-9,10-epidioxide<sup>14</sup> in chlorobenzene; however to our knowledge rearrangement of 2 to 6 represents the first case of photoisomerisation of a 1,4-epidioxide to a bicyclic acetal.

#### REFERENCES AND FOOTNOTES

1. F. Stenbeck, J. Invest. Dermatol. 64, 253 (1975) and references cited therein.
2. We thank Dr. J. Zarembo for the mass spectra. Some of the mass spectra were obtained by Dr. R. Foltz under Battelle's Columbus Laboratories HRMS program, earlier supported by the NIH.
3. NMR were recorded at 220 MHz, by Dr. G. McDonald, University of Pennsylvania, through a program supported by the NIH.
4. K. K. Bartle, D. W. Jones and R. S. Matthews, Spectrochimica Acta, 25A, 1603 (1969).
5. UV, IR, NMR and mass spectra of the compounds were found to be in complete agreement with the proposed structures.
6. Compound 9: IR (AgCl, film) 1690 and 1667  $\text{cm}^{-1}$ , NMR (CCl<sub>4</sub>):  $\delta$  1.40(CH<sub>3</sub>,d), 2.64(CH<sub>3</sub>,s) 4.81(CH<sub>3</sub>CH, q), 6.70(1H,s), 7.31-8.01(8H, arom.); MS (70eV) m/e 304 (M<sup>+</sup>).
7. Cis 8: IR (KBr): 3226 (OH); Ac: 1764 and 1200  $\text{cm}^{-1}$ ; NMR (CCl<sub>4</sub>):  $\delta$  1.53 (CH<sub>3</sub>, d), 1.88 (CH<sub>3</sub>, s), 5.51 (CH<sub>3</sub>CH, q), 6.91-7.20 (10H, arom.), 9.1 (ArOH, s).

8. S. Krishnamurthy, R. M. Schubert, and H. C. Brown, *J. Amer. Chem. Soc.*, 95, 8486 (1973).
9. Trans 8: IR (KBr): 3235 (OH); Ac: 1771 and 1205  $\text{cm}^{-1}$ ; NMR ( $\text{CCl}_4$ ):  $\delta$  1.22 ( $\text{CH}_3$ , d), 1.9 ( $\text{CH}_3$ , s), 5.18 ( $\text{CH}_2\text{CH}$ , q), 6.01-7.5 (10H, arom.), 9.08 (ArOH, s).
10. All inquiries regarding x-ray analysis should be addressed to Prof. Jon Clardy, Department of Chemistry, Iowa State University, Ames, Iowa 50011.
11. NMR ( $\text{CS}_2$ ):  $\delta$  2.25( $\text{CH}_3$ , s), 2.63( $\text{CH}_3$ , s), 7.36-8.52 (10H, arom.), MS (70eV) m/e 288 (M, 7.02), 256 (M -  $\text{O}_2$ , 100). The sample was found identical with that obtained by the procedure of J. W. Cook and R. H. Martin, *J. Chem. Soc.*, 1125 (1940).
12. 4 can be the most likely intermediate. C-C bond cleavage in oxirane rings to gain resonance stabilisation energy has been observed by several workers in arene oxide-oxepin system. For a review, see D. M. Jerina, H. Yagi and J. W. Daly, *Heterocycles*, 1, 269 (1973).
13. J. Rigaudy, N. Moreau and N. K. Cuong, *C. R. Acad. Sci.*, 274 Series C, 1589 (1972). It was interesting to observe that unlike 2, photolysis of 9,10-dimethylanthracene epidioxide in benzene did not give a bicyclic acetal; anthracene 9,10-dione was obtained as the predominant product.
14. It may be noted that thermolysis of naphthalene-1,4-epidioxide does not yield analogs of 4 or 6. Instead  $^1\text{O}_2$  is released. In contrast, thermolysis of 1,6-imino[10]annulene-2,4-epidioxide results in complete isomerisation to the corresponding diepoxide [E. Vogel et al, *Angew. Chem. Int. Ed. Engl.* 15, 228 (1976); *ibid* 229 (1976)].

#### ACKNOWLEDGEMENT

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