Synthesis of Phenanthrene-9,10-imine Tosylate.¹⁾ A Stable Arene Imine

KOICHI SHUDO and TOSHIHIKO OKAMOTO

Faculty of Pharmaceutical Sciences, University of Tokyo²⁾

(Received August 26, 1975)

Phenanthrene-9,10-imine tosylate was prepared from phenanthrene-9,10-oxide.
The chemical behavior was described.

Norcaradiene-cycloheptatriene (**1a**⇌**2a**) and benzene oxide-oxepine (**1b**⇌**2b**) systems have been the subjects of recent organic chemistry.³⁾ In particular, the epoxides of aromatic systems have been the focus of considerable interest due to the theoretical and biological relevance.⁴⁾ The analog of **1a, b** in which nitrogen replaces the carbon or oxygen atom, the benzene imine system (**1c**), is believed to exist as a transient species in the reaction of aromatic compounds and nitrenes.⁵⁾ In a special case, where the position 1 and 6 are bridged by a trimethylene carbon, the benzene imine (**3**) can be observed.⁶⁾ We wish to report the synthesis of a simple stable arene imine derivative, phenanthrene-9,10-imine tosylate (**4**).

Nucleophilic ring opening of phenanthrene oxide (**5**)⁷⁾ by sodium azide in aqueous acetone yielded *trans*-9-azido-10-hydroxy-9,10-dihydrophenanthrene (**6**). The *trans* configuration was confirmed by nuclear magnetic resonance (NMR). Even mild tosylation of **6** gave 9-azidophenanthrene (**7**). Lithium aluminum hydride reduction of **6** in ether gave an amino alcohol (**8**). Reaction of **8** with excess tosyl chloride gave 9-tosylaminophenanthrene (**9**), which is identical with the tosylate of 9-aminophenanthrene.⁸⁾ When an equimolar tosyl chloride was used, a monotosylate (**10**) could be obtained. Treatment of the tosylate **10** in tetrahydrofuran with excess sodium hydride, followed by excess tosyl chloride produced a mixture of reaction products. Careful separation by preparative thin-layer chromatography (TLC) and recrystallization gave a white crystalline compound (**4**) as the major product.

The NMR of the imino tosylate (**4**) shows no evidence of the existence of the tautomeric isomer (azepine) and 9-tosylaminophenanthrene (**9**). The imino tosylate is stable at 100°,

Chart 1

- 1) Studies on Carcinogenic Functional Groups, Part VI. See the previous papers, T. Okamoto, K. Shudo, and S. Nagata, *Chem. Pharm. Bull.* (Tokyo), **23**, 687 (1975); T. Okamoto, K. Shudo, and T. Ohta, *J. Am. Chem. Soc.*, **97**, 7184 (1975).
- 2) Location: Hongo, Bunkyo-ku, Tokyo.
- 3) E. Vogel and H. Gunther, *Angew. Chem.*, **79**, 429 (1967); L.A. Paquette, *ibid.*, *Internat. Ed.*, **10**, 11 (1971).
- 4) D.M. Jerina and J.W. Daly, *Science*, **185**, 573 (1974), and references cited therein.
- 5) K. Hafner and C. Koenig, *Angew. Chem., Internat. Ed.*, **2**, 96 (1963); W. Lwowsky and T.J. Maricich, *J. Am. Chem. Soc.*, **87**, 3630 (1965).
- 6) L.A. Paquette, D.E. Kuhla, J.H. Barrett, and R.J. Haluska, *J. Org. Chem.*, **34**, 2866 (1969).
- 7) M.S. Newman and S. Blum, *J. Am. Chem. Soc.*, **86**, 5559 (1964).
- 8) *Beil.* **12**, 1338. Library of Infrared Spectra, Aldrich, 558B.

Chart 2

but was converted to 9-tosylaminophenanthrene at 160°. Treatment of 4 in aqueous acetone with 2% trifluoroacetic acid, led to a mixture of 9 and 10. These chemical reactions correspond to the reactivity of phenanthrene oxide.⁷⁾ Photolysis of 4 gave 9 as the only isolable product.⁹⁾ We are trying to identify the minor components.

Experimental

trans-9-Azido-10-hydroxy-9,10-dihydrophenanthrene (6)—A solution of 2 g of phenanthrene oxide (5)⁷⁾ and sodium azide (3 g) in acetone (40 ml) and H₂O (30 ml) was refluxed for 8.5 hr. Evaporation of acetone under a reduced pressure gave crystalline precipitates, 2.3 g. Recrystallization from aqueous acetone gave colorless needles, mp 142–143°. IR $\nu_{\text{max}}^{\text{KBr}}$: 2130 cm⁻¹ (N₃). NMR (CDCl₃, δ); 4.52 and 4.68 ($J=8$ cps). Anal. Calcd. for C₁₄H₁₁ON₃, C, 70.87; H, 4.67; N, 17.71. Found: C, 71.09; H, 4.70; N, 18.00.

9-Azidophenanthrene (7)—To a solution of 254 mg of 6 was added TsCl (300 mg) and the mixture was left at room temperature for 7 hr. Water was added and the mixture was extracted with CHCl₃. CHCl₃ was washed with dil HCl, and H₂O, dried over Na₂SO₄ and evaporated under a reduced pressure. Though a small amount of the starting material (6) was observed on TLC, recrystallization from methanol gave pure straw colored needles, mp 112–113°, 188 mg. IR $\nu_{\text{max}}^{\text{KBr}}$: 2110 cm⁻¹ (N₃). Anal. Calcd. for C₁₄H₉N₃, C, 76.69; H, 4.14; N, 19.17. Found: C, 76.70; H, 4.11; N, 19.31.

trans-9-Amino-10-hydroxy-9,10-dihydrophenanthrene (8)—To an ethereal solution of 6 (450 mg) was added 300 mg of LiAlH₄, and the mixture was stirred for 2 hr at room temperature. Excess hydride was decomposed by wet ether and precipitates were removed by filtration. The ether was evaporated to give 95 mg of almost pure white needles. The precipitates was extracted with hot ethyl acetate to give 150 mg of crude product. Recrystallization from CH₂Cl₂-hexane gave needles, mp 125–126°. Anal. Calcd. for C₁₄H₁₃ON, C, 79.59; H, 6.20, N, 6.63. Found: C, 79.42; H, 6.18; N, 6.68.

9-Tosylaminophenanthrene (9)—To a solution of 30 mg of 8 in 1 ml of pyridine was added 100 mg of TsCl. The mixture was allowed to stand at 10° for 15 hrs. Water was added and the mixture was worked up as the preparation of 7. The crude product, which was almost pure, judged from TLC, was recrystallized from ethanol to afford 18 mg of prisms. Sometimes needles were obtained. They were different crystals, but interconvertible by recrystallization with seeding of the crystals, mp 198–199° (both needles and prisms show the same melting point). Anal. Calcd. for C₂₁H₁₇O₂NS, C, 72.61; H, 4.93; N, 4.03. Found: C, 72.29; H, 4.96; N, 4.08.

trans-9-Hydroxy-10-tosylamino-9,10-dihydrophenanthrene (10)—One hundred milligrams of amino alcohol (8) was dissolved in 5 ml of tetrahydrofuran (THF) and 0.1 ml of pyridine. TsCl (100 mg) was added to the solution and the mixture was left for 24 hr at room temperature. Work up as above, and recrystallization from CH₂Cl₂-ethanol gave prisms, mp 196–197° (80 mg). The analytical sample was dried at 100°. NMR (CDCl₃, δ); 4.45 and 4.63 ($J=7.5$ cps.) (after deuteration of hydroxyl). Anal. Calcd. for C₂₁H₁₉O₃NS, C, 69.03, H, 5.24; N, 3.83. Found: C, 68.63; H, 5.27; N, 3.68.

9,10-Dihydro-9,10-tosyliminophenanthrene (4)—To a solution of tosylate 10, (590 mg, 1.63 mmoles) in anhydrous THF (30 ml) was added sodium hydride (118 mg, 4.8 mmoles). After the completion of evolution of hydrogen gas, solid TsCl (934 mg, 4.8 mmoles) was added to the solution. The mixture was stirred

9) Cf. The photolysis of phenanthrene oxide, N.E. Brightwell and G.W. Griffin, *Chem. Commun.*, 1973, 37; K. Shudo and T. Okamoto, *Chem. Pharm. Bull.* (Tokyo), 21, 2809 (1973).

at 15° for 24 hrs. Though TLC of the reaction mixture showed the presence of unreacted starting material (about 1/3), a small amount of H₂O was added to decompose the excess TsCl (3 hr). After addition of H₂O, the mixture was extracted with CH₂Cl₂, CH₂Cl₂ was washed with aq. K₂CO₃, aq. NaCl and aq. K₂CO₃, and evaporated. The mixture was purified by preparative TLC (Kiesel gel G, PF₂₅₄, Merck) multiply developed by hexane-CH₂Cl₂ (9:1) for 5 times. The major band was extracted with CH₂Cl₂-CH₃OH (2:1) to give 300 mg of crude crystalline product. Recrystallization from CH₂Cl₂-EtOH gave needles, which showed double melting points, mp 95—105° and 170—171°. Analytical sample was recrystallised from AcOEt, prisms, mp 168—171°. IR $\nu_{\text{max}}^{\text{KBr}}$ cm⁻¹: 1595, 1493, 1457, 1392, 1321, 1152, 1090, 1019, 887, 832, 785, 744, 715, 668, (prisms, anhydrous). NMR (CDCl₃, δ): 2.37 (CH₃), 4.44 (2H, 9 and 10). UV_{max} (95% EtOH, log ϵ): 232 (sh. 4.49), 267 (4.16), 275 (sh. 4.19), 276 (4.21), 290 (4.03). *Anal.* Calcd. for, C₂₁H₁₇O₂NS: C, 72.61; H, 4.93; N, 4.03. Found: C, 72.44; H, 4.94; N, 3.85. From a more polar band, the crude starting compound, 110 mg, was recovered.

Thermal Isomerization of 4—The imine (5 mg) was heated in a sealed tube at 165° for 1 hr. Quantitative isomerization was observed on TLC, and the product was recrystallised from EtOH and identified with **9** by mixed mp measurements and infrared (IR) spectral comparison.

Acid Hydrolysis of 4—The imine (**4**, 20 mg) was dissolved in 70% acetone (3 ml), and 60 μ l (2%) of CF₃CO₂H was added. The mixture was allowed to stand for 30 min. The mixture was evaporated at 40°. The residue was dissolved in CH₂Cl₂, and applied to a silica gel column (10 ml, Waco gel C-200). The fastest moving part (6 mg) was recrystallized from EtOH to give pure **9**. The main part (14 mg) was also recrystallized from EtOH to give **10**. These products were fully identified with authentic samples obtained above.

Photolysis of 4—The imine in acetonitrile (7 mg in 4 ml) was irradiated with ultraviolet light (275 nm). The major product isolated by TLC was 9-tosyliminophenanthrene (2.5 mg, **9**), which was identified with a sample obtained above.