Chemistry of Heterocyclic Compounds, Vol. 34, No. 7, 1998

STRUCTURE OF 9-(4-PYRIDYLMETHYLENE)FLUORENE AND 9-(E)-BENZYLIDENE-1-AZAFLUORENE. OXIDATION OF 9-(4-PYRIDYLMETHYLENE)FLUORENE AND ITS CONDENSATION WITH ACETYLENEDICARBOXYLIC ACID DIESTER

N. M. Kolyadina, A. T. Soldatenkov, G. V. Gridunova,
and N. S. Prostakov

It was found by x-ray diffraction analysis that in the fulvenes studied, the aromatic rings of the condensed tricyclic fragment are not in the same plane. The angle between them is approximately 4°. The exocyclic carbon atom is at the same angle relative to the plane of the five-membered ring. Starting from 9-(4-pyridylmethylidene)fluorene, there were obtained 3-(4-pyridyl)spirooxirane[2,9']fluorene and 1,2,3,4-trimethoxycarbonyl-8-(fluorylidene-9-methylene)-9a-H-quinolizine.

9-(4-Pyridylmethylene)fluorene (IIIa), synthesized [1] by condensation of 4-formylpyridine with fluorene I, is used in a study of its reactions at three congugate fragments: pyridyl radical, phenyl rings, and exocyclic double bond.

We attempted to synthesize an analogous compound by condensation in an alkaline medium of fluorenone II with γ-picoline N-oxide, in which the nucleophilicity of the methyl group becomes sufficient for an attack at the $C_{(9)}=O$ bond of polycyclic compound II. The yield of pyridylmethylidenefluorene N-oxide IV in this reaction — 33% based on the unreacted fluorenone — does not permit the method to be considered preparative. The initial hetarylidene IIIa was obtained by use of the method proposed in [1]. The grown single crystals of this compound made it possible to determine its molecular structure by x-ray diffraction analysis. Figures 1 and 2 show the molecules of compound IIIa, as well as the analogous compound 9-(E)-benzylidene-1-azafluorene (IIIb), previously obtained in our laboratory [2] with an indication of the bond lengths and valence angles.* It follows from the results of the x-ray diffraction study of these compounds that in the crystalline state in their molecules, the angle between the planes of the six-membered rings A and B is 3.6° and 4.1°, respectively, i.e., the benzene rings of compound IIIa and the benzene and pyridine rings of compound IIIb are not in the same plane. The exocyclic $C_{(14)}$ carbon atom is 4° above the plane of the five-membered ring in both molecules, and the $C_{(15)}$ atom protrudes from the plane of this ring by an angle of 5° in the molecule of IIIa and 8.5° in the molecule of IIIb. The pyridyl fragment C protrudes from the average plane of the fluorene polycyclic compound IIIa at a 47° angle, and the phenyl fragment protrudes from the plane of compound IIIb at a 65° angle. These data, as well as the values of the bond lengths $C_{(9)}=C_{(14)}$ and $C_{(14)}-C_{(15)}$, indicate a decrease of the degree of conjugation between the fulvene fragment and the (het)arylidene portion in the molecules of IIIa, b.

A study of the transformations of pyridylmethylidenefluorene IIIa established that the latter forms a coordination compound at the nitrogen atom with Cu(II) ion in a 1:1 ligand/$CuCl_2$ ratio. Complex V obtained is the subject of the study of its fungicidal and antibacterial action.

Condensation of pyridylfulvene IIIa with two molecules of acetylenedicarboxylic ester formed tetramethoxycarbonyl-substituted 9-(9a-H-quinolizin-8-yl)methylenefluorene (VI) — a dark-red substance. In its PMR spectrum, the protons of the four CH_3 groups are manifested in the form of two singlet signals at 3.38 ppm and 4.0 ppm with an integrated intensity of 3H

---

*Detailed data of the x-ray structural analysis of these compounds will be published elsewhere.

Russian University of Peoples' Friendship, Moscow 117923. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 7, pp. 962-966, July, 1998. Original article submitted October 31, 1997.

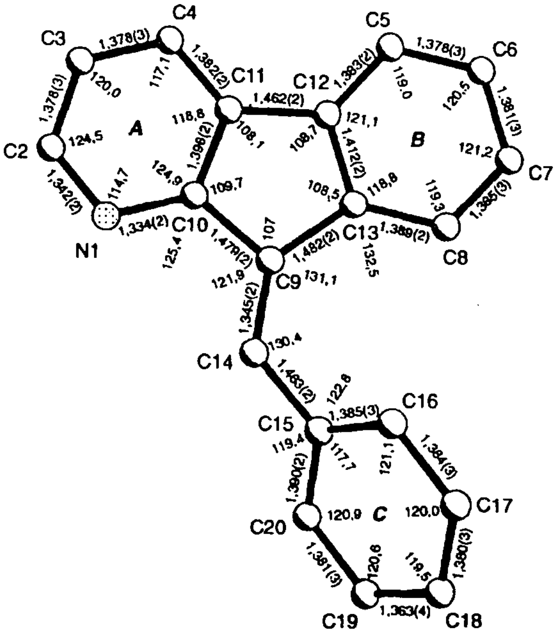


Fig. 1. General form of the 9-(4)-pyridylmethylidene)fluorene IIIa molecule with an indication of the bond lengths (Å) and valence angles (deg).

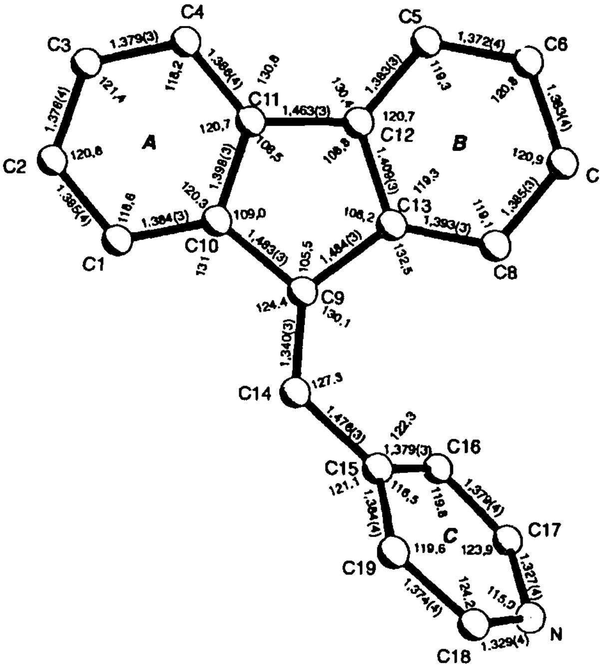
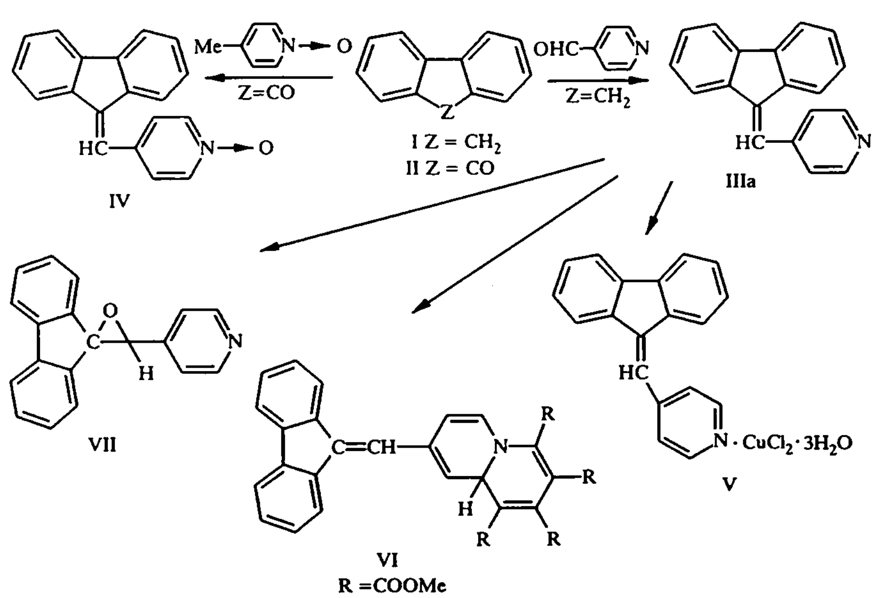


Fig. 2. General form of the E-isomer molecule of 9-benzylidene-1-azafluorene IIIb with an indication of the bond lengths (Å) and valence angles (deg).

and 9H, respectively. The AB system of 6′-H and 7′-H protons of the quinolizine ring resonates at 9.4-7.7 ppm (J = 7.2 Hz), as was confirmed in a double-resonance experiment: The two 9a-H and 9b-H protons produce two broadened singlets at 8.95 ppm and 7.75 ppm.



Oxidation of the exocyclic C=C bond of fulvene IIIa was carried out using the method described in [3], whereby its nitrogen-free analogue underwent oxidation (bubbling air, sodium ethoxide solution in a mixture of HMPT and benzene). It was reported [3] that in the case of 9-benzylidenefluorene, a complex mixture of oxidation products is formed from which phenylspirooxiranefluorene was separated with a 40% yield. We found that its pyridyl-containing analogue IIIa oxidizes under the same conditions more selectively to 3-(4-pyridyl)spirooxirane[2,9']fluorene (VII), which was obtained with a 72% yield. In addition, ketone II was separated (28% yield) from the reaction mixture.

Thus, the introduction of the electron-deficient pyridyl radical (instead of a phenyl radical) promotes the attack by the ethoxy anion on the $C_{(9)}$ atom with the subsequent addition of oxygen to the carbanion formed [3]. Use of the polar HMPT apparently also promotes this reversible nucleophilic attack thanks to the possibility of formation of a π complex with the fulvene fragment of IIIa [4]. Substitution of DMSO for the sterically hindered HMPT results in almost complete oxidation of the initial fulvene to fluorenone II (oxirane VII was isolated with a 10% yield in this case). In the PMR spectrum of oxirane VII, the proton of the three-membered heterocyclic resonates as a singlet at 4.85 ppm. We should mention the substantial screening effect of the cyclic oxygen atom on the $H_{(1)}$ proton of the fulvene portion, the signal from which is observed at 6.50 ppm.

EXPERIMENTAL

The chromatographic separation and purification of the compounds obtained were carried out on columns with L40/100 silica get and with TLC monitoring on Silufol UV-254 plates. The mass spectra were obtained on an MX-1303 spectrometer at an ionizing electron energy of 70 eV. The PMR spectra were recorded on a Bruker WP-80 instrument in $CDCl_3$ with TMS as the internal standard. The x-ray diffraction analysis of compounds IIIa and IIIb was carried out on an automatic Enraf-Nonius CAD-4 diffractometer using MoKα radiation, with a graphite monochromator. A total of 2383 independent reflections were measured. The structure was solved by using the direct method technique and was refined by means of full-matrix least-squares analysis.

9-(4-Pyridylmethylidene)fluorene (IIIa) was obtained by using the method described in [1]; mp 136°C (according to the data of [1], mp 136°C); hydrochloride–mp 217-219°C (dec.) (according to the data of [1], mp 202°C).

9-(4-Pyridylmethylidene)fluorene N-Oxide (IV). To a solution of 1.7 g (9.4 mmole) of fluorenone in 75 ml of absolute THF is added at ~20°C, with stirring in a stream of nitrogen, 0.4 g (0.01 mole) of potassium, then a solution of 1.09 g (10 mmole) of 4-methylpyridine N-oxide in 50 ml of THF is added. The mixture is allowed to stand for 24 h and cooled to 0°C, 30 ml of water is poured in, then the solution is acidified with 18% HCl to pH 3-4 and extracted with ether. From the ether extract, 1.26 g of fluorenone is separated. From the aqueous layer after alkalization extraction with ether, 0.22 g (33%

based on the unreacted fluorenone) of yellow crystals of N-oxide IV are obtained, mp 211-212°C, R_f 0.34 (1:10 hexane–ether). Found, %: C 84.5; H 5.0; N 5.0. M^+ 271. $C_{19}H_{13}NO$. Calculated, %: C 84.2; H 4.8; N 5.2. M 271. PMR spectrum: 8.30 (2H, d.d, J = 4.1 and 0.9 Hz, protons of the pyridine fragment); 7.86 (1H, br.s, 10-H); 7.40-7.80 ppm (10H, m, arom. protons).

Complex IIIa with $CuCl_2$ (V). To a solution of 0.26 g (1 mmole) of fulvene IIIa in 10 ml of acetone is added a solution of 0.67 g (5 mmole) of $CuCl_2$ in 10 ml of acetone, and the mixture is boiled for 1 h and allowed to stand for 24 h at 20°C. The precipitate is separated and washed with 50 ml of acetone. There is obtained 0.26 g (59%) of coordination compound V, green crystals, mp 192°C (dec.). Found, %: C 51.3; H 4.0; N 3.5; Cl 16.2. $C_{19}H_{13}N\cdot CuCl_2\cdot 3H_2O$. Calculated, %: C 51.4; H 4.3; N 3.2; Cl 16.0. IR spectrum: 1610 (C=N), 1450 and 1430 cm^{-1} ($C_{(9)}=C_{(10)}$. UV spectrum, λ_{max}: 327 nm. PMR spectrum: 8.2 (1H, s); 7.7-8.03 (4H, br.m); 7.0-7.55 ppm (8H, br.m).

1,2,3,4-Tetramethoxycarbonyl-8-(fluorylidene-9-methylene)-9a-H-quinolizine (VI). To a solution of 1.23 g (5 mmole) of pyridylmethylidenefluorene IIIa in 15 ml of absolute benzene is added 0.71 g (5 mmole) of acetylenedicarboxylic ester. The mixture is stirred for 24 h at 20°C, then for 4 h at 50-60°C. Benzene is distilled off, and the residue is chromatographed on a column (10:1 hexane–ethyl acetate eluent). Dark-red crystals of compound VI are obtained in an amount of 0.14 g (39% based on the reacted IIIa) mp 194-195°C (dec.). Found, %: C 69.0; H 4.6; N 2.6. M^+ 539. $C_{31}H_{25}NO_8$. Calculated, %: C 69.0; H 4.6; N 2.6. M 539. PMR spectrum: 9.4 (1H, d, J = 7.2 Hz, 6'-H); 8.95 (1H, br.s, $J_{1/2}$ = 4 Hz, 9'a-H); 7.75 (1H, br.s, 9'-H); 7.7 (1H, d, 7'-H); 7.45 (1H, s, 10-H); 4.0 (9H, s, 3 × CH_3); 3.83 ppm (3H, s, 4'-CH_3).

3-(4-Pyridyl)spirooxirane[2,9']fluorene(VII). To a solution of 1.5 g (5 mmole) of pyridylmethylidenefluorene IIIa in 20 ml of a 1:1 mixture of absolute benzene and HMPT is added a previously prepared mixture of 0.06 g (2.61 mmole) of sodium hydride (powder) with 0.5 ml of abs. ethanol and 0.5 ml of abs. benzene. The reaction mass is stirred at room temperature, dry air being bubbled through for 1.5 h. After 20 ml of water is added, extraction with ether is carried out. The ether extract is dried with sodium sulfate. After the ether is driven off, the residue is chromatographed on a column (1:1 hexane–ethyl acetate eluent). Fluorenone II is eluted in an amount of 0.25 g (~28%), followed by 0.97 g (72%) of oxirane VII. Colorless crystals, mp 105-106°C. Found, %: C 84.1; H 5.0; N 5.0. M^+ 271. $C_{19}H_{13}NO$. Calculated, %: C 84.1; H 4.8; N 5.16. M 271. PMR spectrum: 8.68 (2H, d.d, J = 6.0 and 1.6 Hz, 2'-, 6'-H); 7.73 (2H, m, 4-, 5-H); 7.5-7.3 (6H, m, arom. H); 7.28 (1H, d.d, 3-H); 6.93 (1H, t.t, J = 7.2 and 1.2 Hz, 2-H); 6.5 (1H, d.d, J = 7.2; 1.0 and 1.9 Hz, 1-H); 4.85 ppm (1H, s, 10-H). When an analogous experiment is carried out with substitution of DMSO for HMPT, from compound IIIa there is obtained 0.8 g (90%) of fluorenone and 0.14 g (~10%) of oxirane VII.

This work was supported by the Russian Fund for Basic Research in accordance with "Fine Organic Synthesis" (Grant FT-15).

REFERENCES

1. N. P. Buu-Hoi, F. Delbarre, P. Jacquignon, H. Brouilhet, A. Rose, J. F. Sabathier, and M. P. Sinh, Rec. Trav. Chim., **82**, 1047 (1963).
2. N. S. Prostakov, V. O. Fedorov, and A. T. Soldatenkov, Zh. Org. Khim., **16**, 2373 (1980).
3. B. Muckensturm, Bull. Soc. Chim. Fr., No. 5, 1770 (1973).
4. M. I. Zaretskii, Khim. Geterotsikl. Soedin., No. 9, 1163 (1994).
5. G. R. Kotel'nikov, L. V. Strunnikov, V. A. Patanov, and I. G. Arapova, Dehydrogenation Catalysis for Lower Paraffin, Olefin, and Alkylaromatic Hydrocarbons [in Russian], Moscow (1978), p. 44.