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LETTERS TO THE EDITOR

Synthesis of Phosphorylated Nitrovinylindoles

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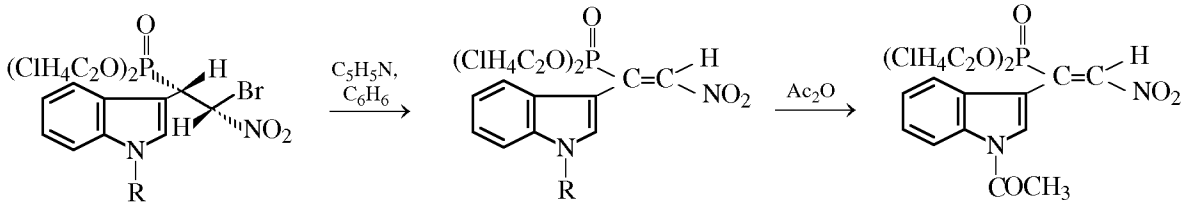
Introduction of the indole ring into the molecules of nitroethenylphosphonates forms a new type of functionalized nitroethenes [1, 2] which can be considered as prospective highly reactive synthons for purposeful synthesis of phosphorylated molecules with the a pharmacotropic indole group [3, 4]. Convenient objects for designing such structures are bis-(2-chloroethyl) 2-bromo-1-(indol-3-yl)-2-nitroethylphosphonate and its 1-alkyl derivatives prepared by reactions of *gem*-bromonitroethenylphosphonate with indole or its *N*-ethyl derivative [5].

It was found that in exceptionally mild conditions, i.e. on treatment with equimolar amount of pyridine in absolute benzene at 16–18°C, compounds **I** and **II** undergo dehydrohalogenation to form nitrovinylindoles **III** and **IV** in yields of up to 70%. The facility of HBr cleavage is apparently associated with the fact that the mobility of the hydrogen atom at the C^1 atom is increased under the effect of the phosphoryl group and the aromatic heteroring.



I, II **III, IV** **V**

R = H (**I, III**), C_2H_5 (**II, IV**).

By acylation of the unsubstituted indole nitrogen atom of nitrovinylindole **III** with acetic anhydride in the presence of sodium acetate we obtained bis(2-chloroethyl) 1-(1-acetylindol-3-yl)-2-nitroethenylphosphonate (**V**).

Indolylnitroethenylphophonates **III**–**V** are brightly colored crystalline substances with well-defined melting points; their structure was proved by ^1H and ^{31}P NMR, electronic, and IR spectroscopy; their geometry in solutions was established by the values of $^3J_{PH}$ (15–18 Hz), corresponding to *cis* orientation of the phosphoryl group and the hydrogen atom at the double bond [6] and implying *E* molecular configuration.

The starting *gem*-halonitroindolylphosphonates **I** and **II** were synthesized by the procedures described in [5].

Bis(2-chloroethyl) 1-(indol-3-yl)-2-nitroethenylphosphonate (III). mp 113–114°C (from ethanol). IR spectrum (CH_2Cl_2), ν, cm^{-1}: 1530, 1330 (NO_2), 1240 (P=O), 1020, 1080 (P–O–C), 1580 (C=C, indolyl), 3460 (NH). UV spectrum (C_2H_5OH), λ_{max}, nm (ε): 242 (4900), 274 (7150), 433 (4800). ^1H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz): 7.70 d (1H, CH, $^3J_{PH}$ 18), 7.15–7.48, 7.80 m (5H, indolyl), 4.30 m (4H, CH_2O), 3.60 t (4H, CH_2Cl), 10.10 s (1H, NH). ^{31}P NMR spectrum ($CDCl_3$), δ_P, ppm: 14.20. Found, %: C 42.79, 42.80; H 3.91, 3.90; N 7.16, 7.13; P 7.96,

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7.93. $C_{14}H_{15}Cl_2N_2O_5P$. Calculated, %: C 42.75; H 3.82; N 7.12; P 7.89.

Bis(2-chloroethyl) 1-(1-ethylindol-3-yl)-2-nitroethenylphosphonate (IV). mp 80–82°C (from ethanol). IR spectrum (CH_2Cl_2), ν, cm^{-1}: 1320, 1510 (NO_2), 1260 (P=O), 1020, 1080 (P–O–C), 1590 (C=C, indolyl). UV spectrum (C_2H_5OH), λ_{max}, nm (ε): 260 (5200), 279 (8600), 443 (5600). ^1H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz): 7.75 d (1H, CH, $^3J_{PH}$ 15), 7.06–7.63, 7.84 m (5H, indolyl), 4.35 m (4H, CH_2O), 4.22 q (2H, CH_2), 3.65 t (4H, CH_2Cl), 1.53 t (3H, CH_3). ^{31}P NMR spectrum ($CDCl_3$), δ_P, ppm: 14.50. Found, %: C 45.64, 45.67; N 4.50, 4.51; N 6.69, 6.68; P 7.46, 7.47. $C_{16}H_{19}Cl_2N_2O_5P$. Calculated, %: C 45.60; H 4.51; N 6.65; P 7.36.

Bis(2-chloroethyl) 1-(1-acetylindol-3-yl)-2-nitroetenylphosphonate (V). mp 85°C (from methanol). ^1H NMR spectrum ($CDCl_3$), δ, ppm (*J*, Hz): 7.71 d (1H, CH, $^3J_{PH}$ 8), 7.19–7.40, 7.76 m (5H, indolyl), 4.25 m (4H, CH_2O), 3.54 t (4H, CH_2Cl), 2.61 s (3H, CH_3). Found, %: C 44.02, 44.10; H 4.23, 4.25; N 6.55, 6.58; P 7.28, 7.20. $C_{16}H_{17}Cl_2N_2O_6P$. Calculated, %: C 44.14; H 3.91; N 6.44; P 7.13.

The IR spectra were obtained on Specord M-80 (in solid phase and in methylene chloride, concentrations 0.1–0.001 M) and InfraLYuM FT-02 spectrometers (in chloroform, concentrations 0.1–0.001 M). The ^1H and ^{31}P NMR spectra were measured on a Bruker AS-200 spectrometer (200 MHz) in chloroform-d_1; the chemical shifts were measured in δ relative to external HMDS to within ±0.5 Hz (^1H) and 85% phosphoric acid (^{31}P) ^{31}P. The electronic absorption spectra were obtained on an SF-121 spectrometer in quartz cells, solvent ethanol.

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