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Organic Chemistry

Hexamethyldimethylenindolino[4,5-e]Indoline Reaction with Nitrous Acid

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ABSTRACT. In order to obtain dinitrozo compound we carried out the reaction of Fisher base analogue - hexamethyldimethylenindolino[4,5-e]indoline with nitrous acid (solution of sodium nitrite in acetic acid). The reaction runs in two steps. At the first step respective dioxime was separated as salt of perchloric acid- diperchlorate. The alcoholic solution of obtained salt was processed with the solution of sodium hydroxide, afterwards instead of expected dinitroso compounds symmetric 1,1,3,8,10,10-hexamethyl-2,9-dioxoindolino[4,5-e]indoline was formed. Thus, unlike ~~of~~indole, in case of indoloindole, with adding strong base, from perchlorate of dioxime with perchloric acid molecule of HCN is eliminated leading to theformation of symmetric 2,9-dioxo-indoloindole. Structure of synthesized compounds is confirmed by the data of IR,UV, 1H-NMR, 13C- NMR and mass spectra. *© 2016 Bull. Georg. Natl. Acad. Sci.*

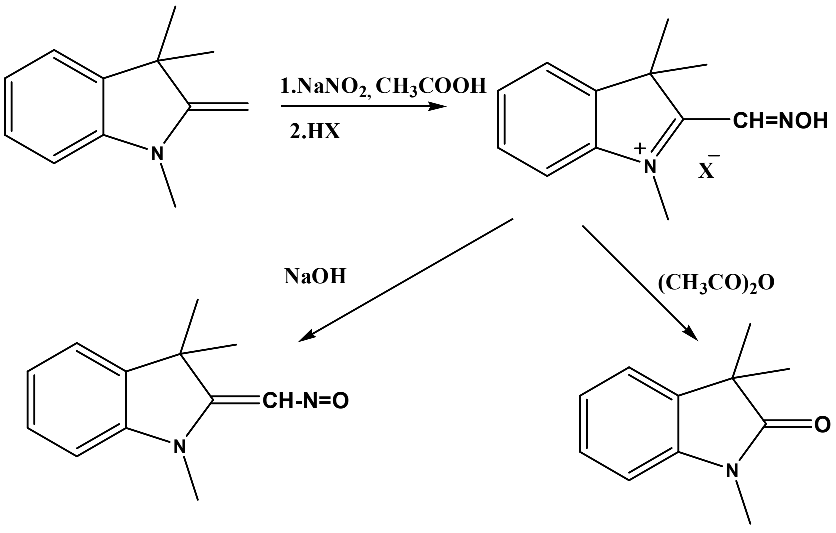
Key words: Fischer base, indolinoindoline, dinitrosoindoloindole, dioxoindoloindole

2-methylenindoline bases, the so-called Fischer bases, are important reactive by-products in synthesis of several different organic compounds [1,2]. We synthesized bis-analogs of the Fischer base on the basis of isomeric indoloindole [3] and benzenepyrrolindole [4]. In order to study their properties some transformations are conducted such as reactions of Vilsmeier, azo-coupling and condensation reaction with salicylaldehydes.

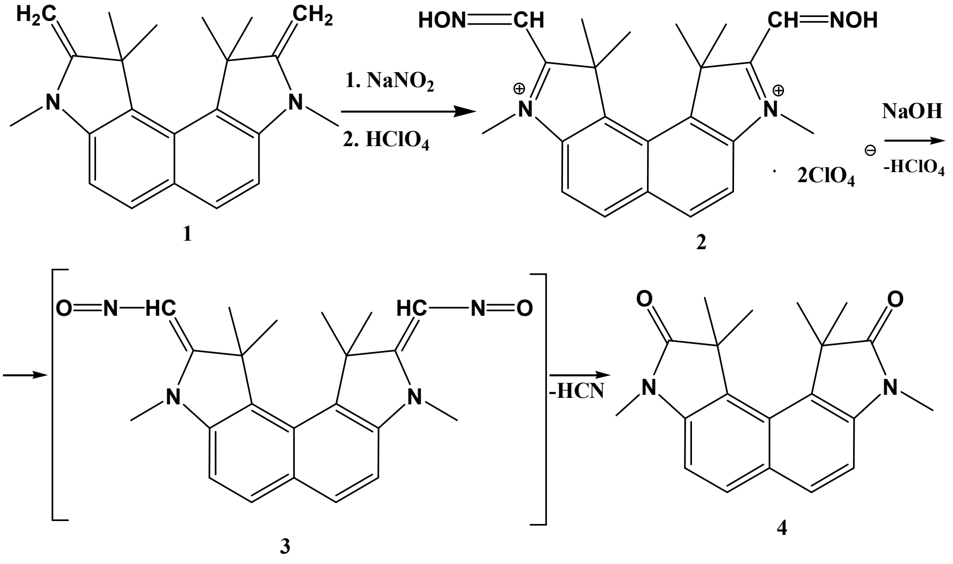
In the present paper, nitrosation reaction is studied for one of the isomeric bis-analogs of Fischer base - hexamethyldimethylenindolo[4,5-e]indole (1) synthesized by us earlier [3]. Nitrosation reaction was conducted for 2-methylenindoline [5] according to the given scheme 1 and method [6,7].

Nitrosation of compound 1 with aqueous solution of sodium nitrite in acetous acid medium under the analogous conditions of Fisher base nitrosation takes place in two steps. At the 1st step dioxime is separated as perchlorate 2. As a result of processing diperchlorate 2 with diazotizing salt in aqueous-alcoholic solution according to the technique formation of the respective dinitroso compound 3 was expected (scheme 2). We reported this at the Second Interna-

Scheme 1



Scheme 2



tional Conference of Young Chemists[8] and the 75th TSU students' conference publishing the data of IR, UI, NMR-1H spectra. The latter proved symmetric structure of compound 3 but there was not found a signal corresponding to methylene –CH=proton. As a result of the study of mass- and NMR-13C spectra it was established that a structure of the product of dioxime 2 corresponds to structure 4 - 1,1,3,8,10,10-hexamethyl-2,9-dioxo–indolino[4,5-e]indoline.

IR spectrum of Compound 2. An absorption band characterizing exocyclic bond $CH=CH_2$ of initial Fischer base vanishes and absorption bands characterizing functional groups in a molecule are revealed in corresponding regions: 1589, 1627, 1681 (C=N); 3294 (-OH); 2029 cm^{-1} (N+ quaternary);

IR spectrum of Compound 4. An absorption band of high intensity is revealed at the 1705 cm^{-1}, which we have previously determined as belonging to the nitroso group of structure 3 although a group >C=O also shows an absorption band in the same region.

UV spectrum of dioxime 2. Absorption maxima are revealed in long-wave region, which reveals low intensity in dilute solution. Existence of those maxima in 655 and 615 nm region indicates formation of

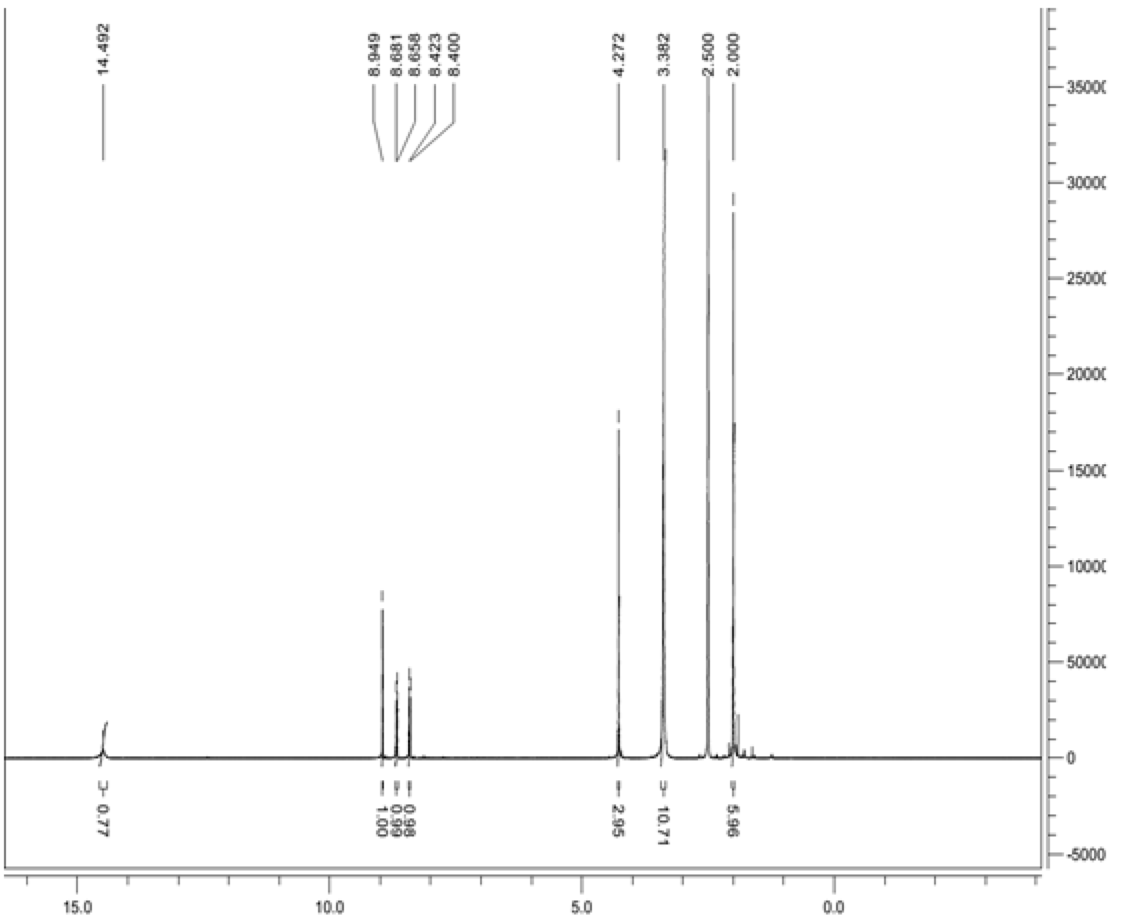


Fig. 1. NMR-^{1}H spectrum of perchlorate of dioxime 2.

diproduct 2, where the chain-length of conjugated π-electrons increases significantly in comparison with the initial Fischer base. An absorption maximum of the most intensity is observed at 391 nm region.

UV spectrum of dioxo compound 4. An absorption peak of low intensity is recorded at long-wave region 581 and 485 nm only in concentrated solution; it is hypsochromically shifted compared to dioxime. This fact indicates weakening of a conjugation chain between oxogroupand aromatic ring in the pyrrole ring. Comparison of the UV spectra of dioxo compound 4 and an initial Fischer base 1 shows that bathochromic shift of the absorption peak (541 nm) of exocyclic C=CH2 group is caused by the effect of >C=O group at the 581 nm region.

In mass-spectrum of Compound 4 a molecular ion M+ is found as a peak of high-intensity (m/z 322), fragment ions were also fixed, which occurred as a result of gradual elimination of methyl radicals.

NMR spectra of dioxime 2 and dioxo compound 4 correspond to symmetric molecules. A series of signals is observed in the spectra for one half of the molecule, which characterizes symmetric derivatives of indoloindole.

NMR-^{1}H spectrum of dioxime 2 (Fig.1). in the weakest region of the field (14.5 ppm) proton signal of hydroxyl group =N-OH is revealed as enlarged singlet. Singlet signal at 8.95 ppm was defined as belonging to methylene CH= protons, which, under the influence of =NOH group, are strongly shifted towards the weak field compared to $=CH_2$ protons analogous to Fischer base (3.79 ppm) [3]. Aromatic protons of naphthalene ring give doublet signals at 8.67 and 8.41 ppm with a spin-spin interaction ortho constant (SSIC) 9.2 Hz. Protons of methyl group are revealed in the strong field as singlets 2.00 ppm

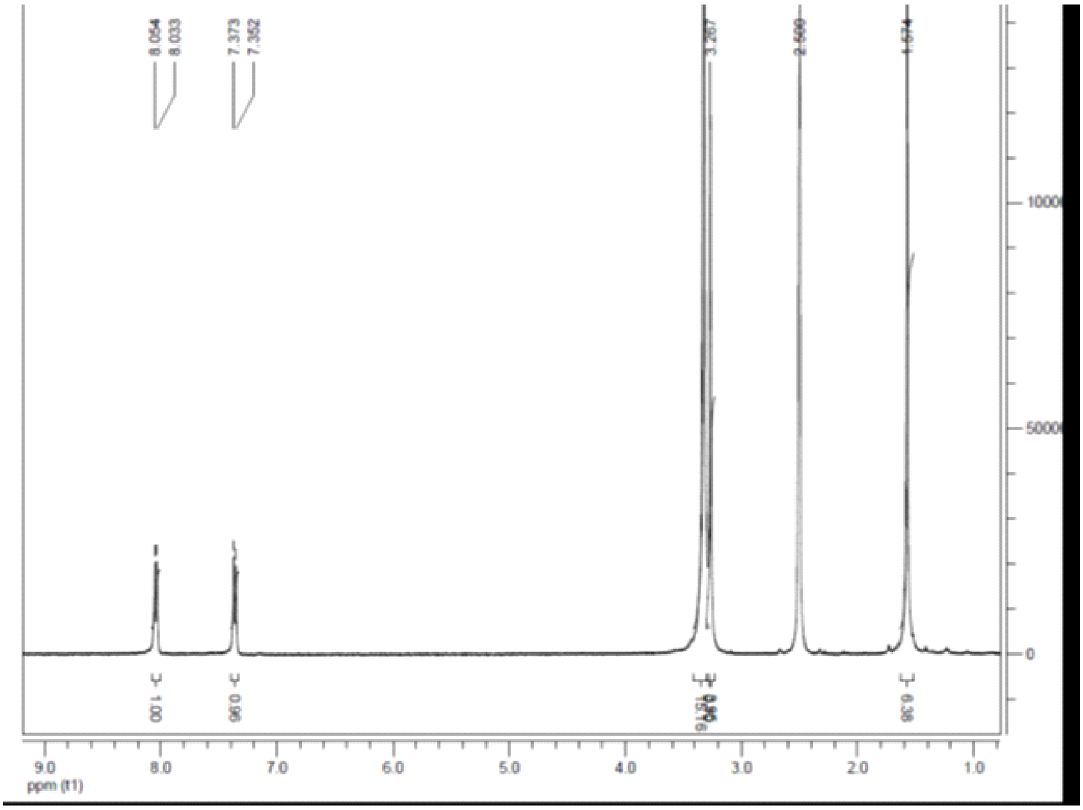


Fig. 2. NMR-^{1}H spectrum of 1,1,3,8,10,10-hexamethyl-2,9-dioxo–indolino[4,5-e]indoline(4).

($C(CH_3)_2$) and 4.27 ppm N+CH_3.

NMR-^{1}H spectrum of dioxo compound 4 (Fig.2). Signal of methlen-CH=protons vanishes and two doublet signals are detected at aromatic regions 8.04 and 7.36 ppm with SSIC jo=8.4 Hz; methyl group protons in the strong part of field give singlets 1.57 ppm ($C(CH_3)_2$) and 3.27 ppm (N-CH_3).

NMR ^{13}C spectra of compounds 2,4 (scheme 3) were analyzed by their comparison with the spectrum of the initial Fischer base 1 [3].

NMR-^{13}C spectrum of dioxo–indolo[4,5-e]indole(Fig.3). Carbon atom signal of C=O group is detected in the weakest region (181.14 ppm), which is shifted to the very weak field compared to the C-2 atom signal (165.98 ppm) of Fisher field under the influence of an oxygen atom.

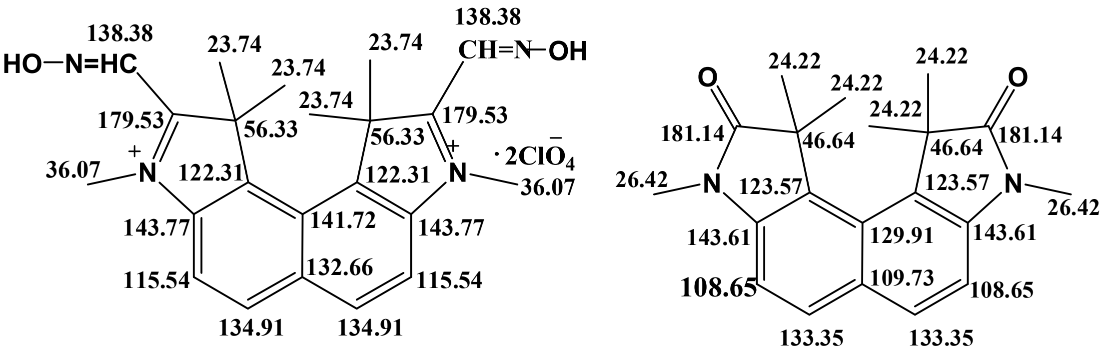
Thus, in case of indolo[4,5-e]indole in difference with indole, HCN molecule is eliminated together with the acid residue ($HClO_4$) by the effect of strong base (alcohol solution of alkali) from dioxime perchlorate. Symmetric 2,9-dioxo-indoloindole 4 is obtained that can be explained by its more energetic stability in comparison with intermediate dinitroso compound.

Experimental

The reaction course, monitoring the purity of the products, and determination of R_f values were carried out on Silufol UV-254 plates. The IR spectra were taken on a Termo Nikolet Avatar-370 spectrometer equipped with FTIR in vaseline mull. The UV spectra were taken on a Agilent 8453 UV-Visible Specrto-sco-py System. UV-Visible Program. Chemstation B. 0402. The ^{1}H NMR spectra were taken on a Bruker DRX-500 spectrometer at 500 MHz with TMS as the internal standard. The error of the chemical shift measurement was $\delta \pm 0.01$ ppm and the error for the coupling constant was ±0.1 Hz.

The mass spectra was done by using of ISQ Single Quadrupol GC-MS (Thermo-Scientific). In the module EI by the technology of "Direct sample probe".

Scheme 3



Compound 2 Compound 4

NMR spectra of signals with full attribution to -^{13}C for every atom of carbon compounds 2 and 4 (chemical shift δ, ppm).

1,1,3,8,10,10-hexamethyl-2,9-di[hydroxyiminomethyl]-indolino[4,5-e]indoline diperchlorate (2). To 0.32g (1 mmol) Fischer's base 1 solution in 20 ml acetic acid was added 0.21 g (3 mmol) $NaNO_2$ solution in 8 ml water dropwisely, at 0-5^{0}C temperature. The color of reaction mixture was changed from violite to brown. Afterwards, it was left for 30 min at room temperature. Then 25 ml of $HClO_4$ was added, heated up to 50^{0}C and left for 24 hours. The precipitate was filtered, washed with cold water to a neutral area and dried. The dark yellow powder was obtained, yield: 0.28 g (48%). $T_{dec.}$ > 300^{0}C. IR

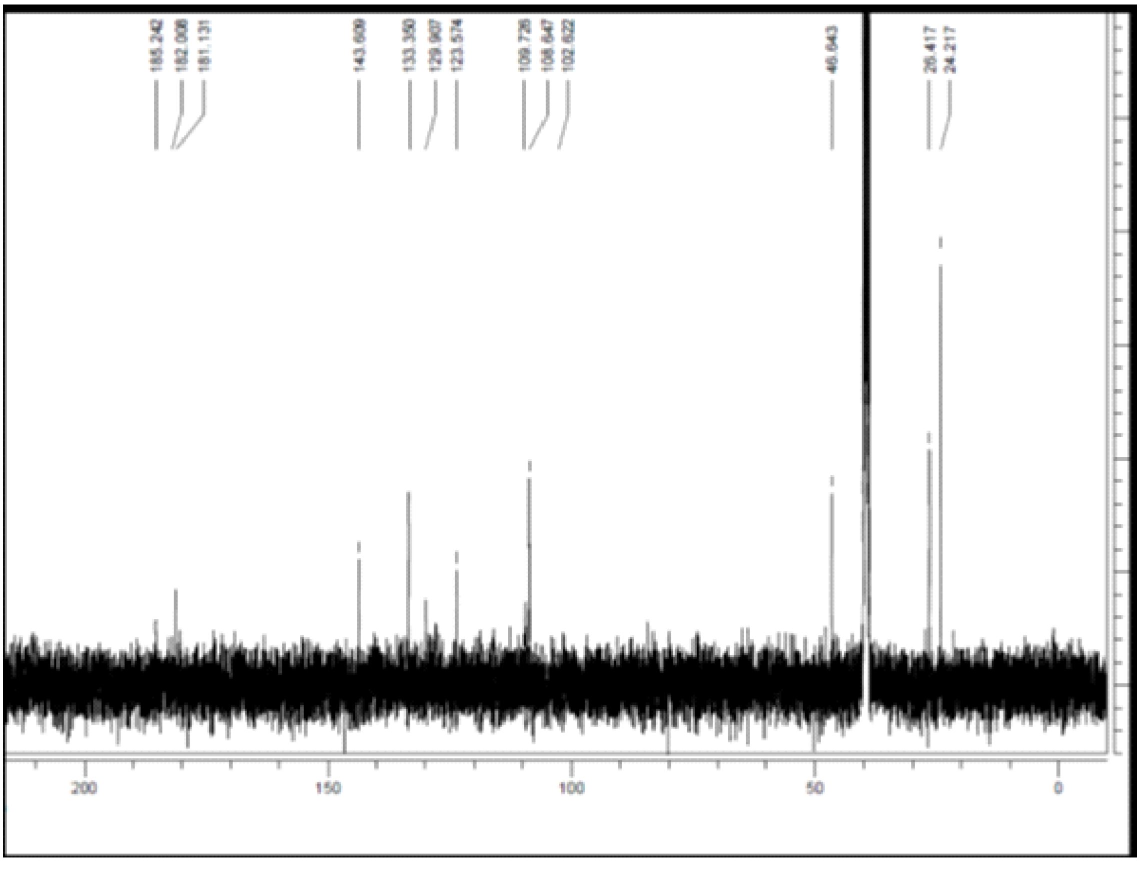


Fig. 3. NMR-^{13}C spectrum of1,1,3,8,10,10-hexamethyl-2,9-dioxo–indolino[4,5-e]indoline(4).

spectrum, μ, cm^{-1}(in vaseline mull): 1589, 1627, 1681 (C=N); 3294 (-OH); 2029 (N^{+}-quaternary); 1304, 1111, 1064, 1026, 926, 841, 794, 725, 625, 486. UV spectrum), λ_{max}, nm (D) (C_2H_5OH): 655.0 (1.9126E-3); 615.0 (2.3646 E-3); 391.0 (1.36670); 337.0 (0.68280); 209.0 (0.67597); 250.0 (0.63722); 232.0 (0.54369); 225.0 (0.54279); 298.0 (0.51714); 267.0 (0.50050);

^{1}H NMR spectrum (data for half of the molecule are given), δ, ppm (*J*, Hz): 2.00 (6H,s, $C(CH_3)_2$); 4.27(3H,s, N–CH_3); 8.41(1H,d, J_o = 9.2,H Ar); 8.67(1H,d, J_o = 9.2,H Ar); 8.95(1H,s,-CH=N), 14.5(1H,s,=N-OH)

^{13}C NMR spectrum (scheme 3).

1,1,3,8,10,10-hexamethyl–2,9–dioxoindolino[4,5-e]indoline (4). 0.1g(0.2 mmol)-dioxime diperchlorate 2 was dissolved in the mixture of water and ethanol (20 ml water + 15 ml ethanol) and heated up to 50°C. The brown-reddish solution was obtained. After cooling, the icy solution of NaOH (10%) was added. Gradually the solution became coulourless, light coulored, and the compound precipitated. The reaction mixture was left for a night, then filtered and washed with water to a neutral area. After evaporation of ethanol from filtrate, the precipitation occurred. The beige powder was obtained, yield: 0.021 g (32%). $T_{dec.}$ > 300^{0}C. IR spectrum, μ, cm^{-1} (in vaseline mull): 1705 (C=O; strong); 1604, 1535, 1234, 1157, 1072, 926, 879, 833, 787, 764, 725, 563, 470. UV spectrum, λ_{max}, nm (D) (C_2H_5OH): 485.0 (1.7099 E-2); 352.0 (0.20514); 336.0 (0.24466); 273.0 (2.67100); 227.0 (1.79970). In concentrated solution: 581.0 (2.2611 E-2); 485.0 (4.6112 E-2); 352.0 (0.87195); 336.0 (1.05050); 308.0 (1.18220).

^{1}H NMR spectrum (data for half of the molecule are given), δ, ppm (*J*, Hz): 1.57 (6H,s, $C(CH_3)_2$); 3.27(3H,s, N–CH_3); 7.36(1H,d, J_o = 8.4,H Ar); 8.04(1H,d, J_o = 8.04,H Ar);

^{13}C NMR spectrum ((scheme 3).

Mass spectrum (EI, 70 eV), found : m/z 322.21 [M]$^+$, 307.20, 292.12, 249.10, 170.09, 127.06. $_{20}H_{22}N_2O_2$. Calculated M = 322.

ორგანული ქიმია

ჰექსამეთილდიმეთილენინდოლინო[4,5-e]ინდოლინის ურთიერთქმედება აზოტოვან მჟავასთან

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ჩატარებულია ფიშერის ფუძის ბის-ანალოგის - ჰექსამეთილდიმეთილენინდოლინო[4,5-e] ინდოლინის ურთიერთქმედების რეაქცია აზოტოვან მჟავასთან ნატრიუმის ნიტრიტის წყალხსნარით ძმარმჟავას არეში დინიტროზონაერთის მიღების მიზნით. რეაქცია მიმდინარეობს ორ საფეხურად. პირველ საფეხურზე გამოყოფილია შესაბამისი დიოქსიმი ქლორის მჟავას მარილის -დიპერქლორატის სახით. მიღებული მარილის სპირტხსნარის დამუშავების შედეგად ნატრიუმის ტუტის წყალხსნარით მოსალოდნელი დინიტროზონაერთის ნაცვლად გამოყოფილ იქნა სიმეტრიული აღნაგობის 1,1,3,8,10,10–ჰექსამეთილ–2,9-დიოქსო–ინდოლინო[4,5-e]ინდოლინი. ამრიგად, ინდოლოინდოლის შემთხვევაში, ინდოლისაგან განსხვავებით,ძლიერი ფუძის მოქმედებით დიოქსიმის პერქლორატიდან ქლორის მჟავასთან ერთად ($HClO_4$) იხლიჩება HCN-ის მოლეკულაც. შესაბამისად მიიღება სიმეტრიული აღნაგობის 2,9-დიოქსო-ინდოლინოინდოლინი. სინთეზირებული ნაერთების სტრუქტურა დადასტურებულია იწ, უი, ბმრ-^{1}H, ბმრ-^{13}C და მას-სპექტრების მონაცემებით.

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