NITROAZINES.

5.* USE OF THE JAPP—KLINGEMANN REACTION FOR THE SYNTHESIS OF NITROTRIAZINES

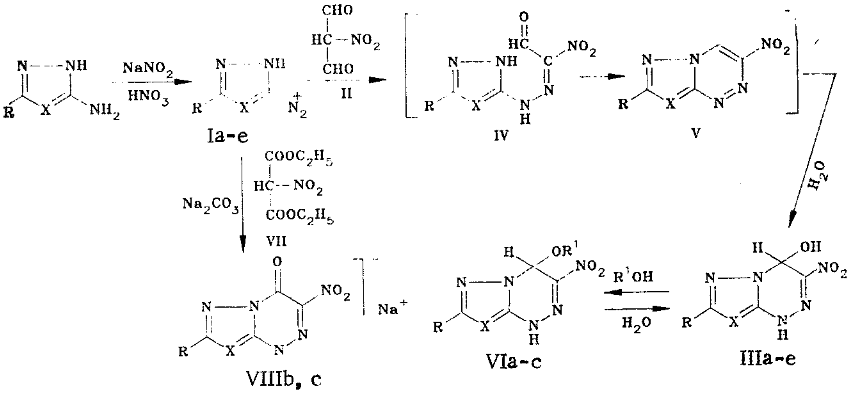
V. L. Rusinov, T. L. Pilicheva,
O. N. Chupakhin, N. A. Klyuev,
and D. T. Allakhverdieva

UDC 547.792.9'873.07:
543.422'51

Condensation of diazoles with β-dicarbonyl nitro compounds (nitromalondialdehyde and nitromalondiester) gives derivatives of azolo[5,1-c][1,2,4]triazine with a nitro group in the triazine ring.

Cyclization of aliphatic nitro compounds is a basis for synthesis of nitrotriazines. It has previously been shown that construction of the 1,2,4-triazine ring (containing a nitro group) can be brought about by condensation of the α-nitrocarbonyl compounds (nitroacetic ester [2] or nitroacetonitrile [3]) with diazoles. The reaction proceeds via formation of azolylhydrazones of nitroglyoxylic ester or nitrile. At the same time it is known that glyoxal arylhydrazones and their derivatives may be readily obtained from β-dicarbonyl compounds by the Japp—Klingemann reaction [4, 5]. This stimulated us to examine the use of the more convenient and more stable β-dicarbonyl nitro products for the synthesis of azolo-annelated nitrotriazines rather than the monocarbonyl analogs.

We have shown that the diazonium salts Ia-e (obtained from 3-carbethoxy-5-aminopyrazole or 3-R-5-amino-1,2,4-triazole) react with nitromalondialdehyde (II) in acid medium to form 6-nitro-7-hydroxy-4,7-dihydroazolo[5,1-c][1,2,4]-triazines IIIa-e (see scheme).



a,b R=H, c R=CH_3, d R=C_6H_5, e R=$COOC_2H_5$; a X=$CCOOC_2H_5$, b—e X=N

In the IR spectra of IIIa-e there are observed bands corresponding to the symmetric (1330-1350 cm^{-1}) and asymmetric (1540-1590 cm^{-1}) absorption modes of the nitro groups together with a broad band (3100-3500 cm^{-1}) which may be assigned to vibrations of the N—H and O—H bonds. The mass spectra of tne nitrotriazines show a molecular ion peak (M^+) and decomposition under electron impact conditions with ejection of OH$^\cdot$ (ion F) and H_2O (ion F_1) (see Experimental section) thus pointing to the presence of a hydroxy group in the molecule. The occurrence of nitro groups is confirmed by the characteristic processes [6] of sequential elimination of NO$^\cdot$ and CO as well as nitro groups from ions F and F_1. For IIIa, loss of the nitro group occurs directly from M^+. Ions with m/z 68 and 67 point to the presence of a tri-

---

*For 4, see [1].

S. M. Kirov Ural Polytechnic Institute, Sverdlovsk. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 5, pp. 662-665, May, 1986. Original article submitted January 30, 1985.

azole fragment in the molecule — the ion composition being supported by high resolution mass spectral data. For IIIa-e the general position is the same but, along with formation of F_1, there are observed the fragments C_2H_4, OC_2H_4, $OC_2H_5{}^{\cdot}$, and $COOC_2H_4{}^{\cdot}$ from M^+ and F_1, which points to a carbethoxy group in the molecule.

In their PMR spectra, compounds IIIa-e gave signals for the substituent protons in the azole ring as well as two doublets for 7-H (7.00-7.90 ppm) and the O—H (8.15-8.30 ppm) with a spin-spin coupling of 8 Hz. The inter-spin correlation of these protons was demonstrated by double resonance and by addition of D_2O which caused the signal near 8 ppm to disappear and the doublet near 7 ppm to collapse to a singlet.

The 1,2,4-triazoles IIIb-e could be formed as the [5,1-c] or the [4,5-c] isomer. Experiments have shown [2, 3, 7] that the position of the triazole ring proton is an indication of the nature of the ring fusion and occurs at 8.55 ppm in 7-oxo-4,7-dihydro-1,2,4-triazolo[5,1-c]-[1,2,4]triazine, at 8.29 ppm in the 6-nitro derivative, and at 9.23 ppm in 7-oxo-4,7-dihydro-1,2,4-triazolo[4,5-c][1,2,4]triazine. The chemical shift of the triazole proton in IIIb (8.04 ppm) thus points to formation of the [5,1-c] isomer. The close similarity in the UV spectra of triazines IIIb-d suggests condensation at the triazole N_1 atom in the reactions of the substituted triazoles Ic-e.

Cyclization to azolo[5,1-c][1,2,4]triazines when Ia-e were treated with nitromalondialdehyde is difficult to envisage without the formation of the Japp—Klingemann nitroglyoxal hydrazone but it was not possible to separate this intermediate even upon carrying out the reaction at −5°C. Evidently, in the course of the reaction, the hydrazones IV very readily cyclize to derivatives of 6-nitroazolo[5,1-c][1,2,4]triazine V. The increased π-deficiency of V leads to addition of water to form the sigma adducts, 6-nitro-7-hydroxy-4,7-dihydroazolo[5,1-c][1,2,4]triazines IIIa-e, which were separated from the reaction mixture.

Heating the adducts III in methanol or ethanol causes substitution of hydroxy by alkoxy groups with formation of VIa-c, boiling of which with water regenerates the adducts (scheme). The spectral data for VIa-c (see Experimental section) is in full agreement with their proposed structures. In the IR, bands are produced corresponding to the nitro and the amino groups. Fragmentation of the alkoxy adducts VIb, c under electron impact occurs with elimination of $OC_2H_5{}^{\cdot}$ (ion F) and HOC_2H_5 (ion F_1) and further decomposition analogous to IIIb, c. The PMR spectra show signals for the azole part of the molecule: a singlet for 7-H (6.80-7.11 ppm) and signals for methoxy (VIa) or ethoxy (VIb, c) groups.

Other β-dicarbonyl nitro compounds react analogously to nitromalondialdehyde, e.g., the nitromalondiester VII condenses with diazo-1,2,4-triazoles (Ib, c) in the presence of sodium carbonate to give the sodium salts of 6-nitro-7-oxo-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]-triazoles (VIIIb, c), identical to products obtained from diazo-1,2,4-triazoles Ib, c and nitroacetate [2].

EXPERIMENTAL

UV Spectra were recorded for aqueous solutions on a Specord UV-vis, IR spectra in paraffin oil on a UR-20, and mass spectra on a Varian MAT-311A under standard working conditions [3]. PMR spectra were measured on a Perkin-Elmer R-12B using DMSO-d_6 solvent and were refered to HMDS as internal standard.

3-Carbethoxy-6-nitro-7-hydroxy-4,7-dihydropyrazolo[5,1-c][1,2,4]triazine (IIIa). A solution of sodium nitrite (0.8 g, 11 mmoles) in water (5 ml) was added over 15 minutes to a solution of 4-carbethoxy-5-aminopyrazole (1.55 g, 10 mmoles) in nitric acid (d 1.4, 1.6 ml) and water (10 ml) which had been cooled to 0°C. After holding at this temperature for 10 min and mixing with a solution of sodium nitromalondialdehyde monohydrate (1.57 g, 10 mmoles) in water (7 ml), the product was stirred at 20°C for 3 h and filtered. The precipitated solid (IIIa) was crystallized from water and dried *in vacuo* at 100°C over P_2O_5 to give 2.3 g, 90%, with mp 204-205°C. UV spectrum, λ_{max}, log ε: 218 (3.49), 238 (3.51), 370 nm (3.43). IR spectrum: 1330, 1590 (NO_2), 1730 (C=O), 3100-3400 cm^{-1} (NH, OH). Mass spectrum (ionization temperature 120°C), m/z (%)*: 46 (10) $[NO_2]^+$, 53 (23), 65 (32) $[C_3H_1N_2]^+$, 66 (10) $[C_3H_2N_2]^+$, 67 (20), 95 (21), 146 (56) $[F_1 - OC_2H_5 - NO_2]^+$, 162 (56) $[F_1 - OC_2H_5 - NO]^+$, 165 (74) $[F_1 -$

---

*Ions reported have intensities >10% of the intensity of the maximum peak in the spectrum.

$COOC_2H_4]^+$, 191 (11) $[F_1 - NO_2]^+$, 192 (100) $[F_1 - OC_2H_5]^+$, 193 (66) $[F_1 - OC_2H_4]^+$, 209 (58) $[M - NO_2]^+$, 210 (18) $[M - OC_2H_5]^+$, 237 (43) $[M - H_2O]^+$ (F_1), 255 (47) M^+. PMR spectrum: 1.30 (3H, t, CH_3), 4.3 (2H, q, CH_2), 6.90 (1H, s, 2-H), 7.98 (1H, d, 7-H), 8.10 (1H, d, OH), 12.7 ppm (1H, s, NH). Found: C 38.0; H 3.6; N 27.2%. $C_8H_9N_5O_5$. Calculated: C 37.7; H 3.5; N 27.5%.

6-Nitro-7-hydroxy-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]triazine (IIIb) was obtained analogously to IIIa in 90% yield with mp >300°C. UV spectrum, λ_{max} (log ε): 202 (3.5), 340 nm (3.84). IR spectrum: 1344, 1543 (NO_2), 3150-3500 cm^{-1} (NH, OH). Mass spectrum (ionization temperature 140°C), m/z (%): 46 (15) $[NO_2]^+$, 53 (90) $[F_3 - HCN]^+$, 67 (10) $[C_2H_1N_3]^+$, 68 (29) $[C_2H_2N_2]^+$, 80 (18) $[F_2 - N_2H]^+$ (F_3), 109 (22) $[F - NO - CO]^+$ (F_2), 120 (60) $[F_1 - NO_2]^+$ 137 (10) $[F - NO]^+$, 166 (100) $[M - H_2O]^+$ (F_1), 167 (31) $[M - OH]^+$ (F), 184 (30) M^+. PMR spectrum: 7.00 (1H, d, 7-H), 8.04 (1H, s, 2-H), 8.15 (1H, d, OH), 12.62 ppm (1H, s, NH). Found: C 25.8; H 2.7; N 45.0%. $C_4H_4N_6O_3$. Calculated: C 26.1; H 2.2; N 45.2%.

2-Methyl-6-nitro-7-hydroxy-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]triazine (IIIc) obtained as for IIIa in 80% yield with mp 280-282°C. UV spectrum, λ_{max} (log ε): 203 (3.34), 341 nm (3.90. IR spectrum: 1350, 1543 (NO_2), 3050-3400 cm^{-1} (NH, OH). Mass spectrum (ionization temperature 130°C), m/z (%): 46 (10) $[NO_2]^+$, 67 (91) $[F_3 - HCN]^+$, $[C_2H_1N_3]^+$, 68 (14) $[C_2H_2N_3]^+$, 94 (12) $[F_2 - NH]^+$ (F_3), 123 (11) $[F - NO - CO]^+$ (F_2), 134 (24) $[F_1 - NO_2]^+$, 150 (10) $[F - NO]^+$, 180 (100) $[M - H_2O]^+$ (F_1), 181 (19) $[M - OH]^+$ (F), 198 (20) M^+. PMR Spectrum: 2.30 (3H, s, CH_3), 7.10 (1H, d, 7-H), 8.30 (1H, d, OH), 12.60 ppm (1H, s, NH). Found: C 30.0; H 2.8; N 42.2%. $C_5H_6N_6O_3$. Calculated: C 30.3; H 3.0; N 42.4%.

2-Phenyl-6-nitro-7-hydroxy-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]triazine (IIId) was obtained as for IIIa in 75% yield with mp 199-200°C. UV spectrum, λ_{max} (log ε): 204 (3.50), 256 (3.00), 340 nm (3.92). IR spectrum: 1340, 1540 (NO_2), 3100-3400 cm^{-1} (NH, OH). PMR spectrum: 7.10 (1H, d, 7-h), 7.50-8.00 (5H, m, C_6H_5), 8.20 (1H, d, OH), 12.65 ppm (1H, s, NH) Found: C 45.7; H 3.3%. $C_{10}H_8N_6O_3$. Calculated: C 46.1; H 3.1%.

2-Carbethoxy-6-nitro-7-hydroxy-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]triazine (IIIe) was obtained analogously to IIIa in 80% yield with mp >300°C. IR spectrum: 1350, 1560 (NO_2), 1730 (C=O), 3100-3400 cm^{-1} (NH, OH). Mass spectrum (ionization temperature 120°C), m/z (%): 46 (11) $[NO_2]^+$, 53 (60), 67 (36) $[C_2H_1N_3]^+$, 68 (29) $[C_2H_2N_3]^+$, 120 (10), 165 (12) $[F_1 - COOC_2H_4 - H_2O]^+$, 167 (52) $[M - C_2H_4 - OH]^+$, 180 (24) $[M - CH_2H_4 - NO - H_2O]^+$, 184 (26) $[M - COOC_2H_4]^+$, 193 (100) $[F_1 - OC_2H_5]^+$, 198 (18) $[M - C_2H_4 - NO]^+$, 211 (17) $[M - OC_2H_5]^+$, 228 (10) $[M - C_2H_4]^+$, 238 (10) $[M - H_2O]^+$ (F_1), 256 (10) M^+. PMR spectrum: 1.30 (3H, t, CH_3), 4.25 (2H, q, CH_2), 7.05 (1H, d, 7-H), 8.30 (1H, d, OH), 12.65 ppm (1H, s, NH). Found: C 33.1; H 3.2; N 32.5%. $C_7H_8N_6O_5$. Calculated: C 32.8; H 3.1; N 32.8%.

3-Carbethoxy-6-nitro-7-methoxy-4,7-dihydropyrazolo[5,1-c][1,2,4]triazine (VIa). The hydroxy adduct IIIa (1.27 g, 5 mmoles) in methanol (20 ml) was refluxed for 5 min and evaporated to dryness *in vacuo* to give VIa in quantitative yield, mp 155-156°C. IR spectrum: 1340, 1550 (NO_2), 1680 (C=O), 3265 cm^{-1} (N-H). PMR spectrum: 1.30 (3H, t, CH_3), 3.48 (3H, s, OCH_3), 4.30 (2H, q, CH_2), 6.80 (1H, s, 7-H), 8.05 (1H, s, 2-H), 12.95 ppm (1H, br. s, NH). Found: C 39.8; H 4.3%. $C_9H_{11}N_5H_5$. Calculated: C 40.1; H 4.1%.

6-Nitro-7-ethoxy-4,7-dihydro-1,2,4-triazolo-[5,1-c][1,2,4]triazine (VIb). Refluxing of IIIb (0.9 g, 5 mmoles) in ethanol (10 ml) for 5 min, cooling, and filtration gave VIb (0.75 g, 70%) with mp 164-165°C. IR spectrum: 1344, 1540 (NO_2), 3122 cm^{-1} (NH). Mass spectrum (ionization temperature 60°C): 46 (15) $[NO_2]^+$, 53 (80) $[F_3 - HCN]^+$, 67 (10) $[C_2H_1N_3]^+$, 68 (40) $[C_2H_2N_3]^+$, 71 (64), 80 (29) $[F - NO - CO - H_2O]^+$ (F_3), 120 (33) $[F_1 - NO_2]^+$, 121 (71) $[F - NO_2]^+$, 166 (88) $[M - HOC_2H]^+$ (F_1), 167 (100) $[M - OC_2H_5]^+$ (F), 212 (13) M^+. PMR spectrum: 1.10 (3H, t, CH_3), 3.85 (2H, q, CH_2), 6.95 (1H, s, 7-H), 8.04 (1H, s, 2-H), 12.60 ppm (1H, s, NH). Found: C 34.0; H 4.0%. $C_6H_8N_6O_3$. Calculated: C 34.0; H 3.8%.

2-Methyl-6-nitro-7-ethoxy-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]triazine (VIc) was obtained analogously to VIb in 75% yield mp 230°C, IR spectrum: 1344, 1556 (NO_2), 3110 cm^{-1} (NH). Mass spectrum (ionization temperature 60°C): 46 (15) $[NO_2]^+$, 67 (70) $[F_3 - HCN]^+$, $[C_2H_1N_3]^+$, 68 (30) $[C_2H_2N_3]^+$, 94 (26) $[F - NO - CO - NH_2]^+$ (F_3), 134 (10) $[F_1 - NO_2]^+$, 135 (73) $[F - NO_2]^+$ 180 (86) $[M - HOC_2H_5]^+$ (F_1), 181 (100) $[M - OC_2H_5]^+$ (F), 226 (15) M^+. spectrum: 1.08 (3H, t, CH_3), 2.31 (3H, s, CH_3), 3.55 (2H, q, CH_2), 7.11 (1H, s, 7-H), 12.60 ppm (1H, s, NH). Found: C 36.9; H 4.5; N 37.7%. $C_7H_{10}N_6O_3$. Calculated: C 37.2; H 4.5; N 37.2%.

6-Nitro-7-oxo-4,7-dihydro-1,2,4-triazolo[5,1-c][1,2,4]triazine, Sodium Salt (VIIIb). A solution of the diazonium salt of 5-amino-1,2,4-triazole (1.7 g, 20 mmoles), nitromalonic diester (4.4 g, 20 mmoles) and Na_2CO_3 (3.2 g) was mixed in ethanol (50%, 20 ml). Stirring for 1 h at 0°C and 2 h at 20°C and filtration gave triazine VIIIb (1.25 g, 60%) with mp >300°C (from [2], mp >300°C).

2-Methyl-6-nitro-7-oxo-4,7-dihydro-1,2,4-triazolo-[5,1-c][1,2,4]triazine, sodium salt (VIIIc) was obtained by the method described above in 55% yield with mp 282-284°C (from [2], mp 282-284°C).

LITERATURE CITED

1. L. Kh. Baumane, R. A. Gavar, Ya. P. Stadyn', O. N. Chupakhin, V. L. Rusinov, and A. Yu. Petrov, Khim. Geterotsikl. Soedin., No. 5, 689 (1985).
2. V. L. Rusinov, A. Yu. Petrov, and I. Ya. Postovskii, Khim. Geterotsikl. Soedin, No. 9, 1283 (1980).
3. V. L. Rusinov, A. Yu. Petrov, O. N. Chupakhin, N. A. Klyuev, and G. G. Aleksandrov, Khim. Geterotsikl. Soedin., No. 5, 682 (1985).
4. F. R. Japp and F. Klingemann, Chem. Ber., 20, 2942 (1887).
5. Yu. V. Maksimov, S. M. Kvitko, and V. V. Perekalin, Zh. Org. Khim., 8, 332 (1982).
6. R. A. Khmel'nitskii and P. B. Terent'ev, Usp. Khim., 48, 854 (1979).
7. J. Dannis and M. Follet, Bull. Soc. Chim. France, No. 7-8, 1178 (1976).

REACTION OF 3,4-DIAMINOFURAZAN WITH CARBONYL COMPOUNDS AND THEIR METAL COMPLEXES

I. S. Vasil'chenko, S. G. Kochin,
V. A. Anisimova, L. I. Khmel'nitskii,
and A. D. Garnovskii

UDC 547.793.2:542.953.2

It is shown that when 3,4-diaminofuranzan reacts with formic acid under various conditions there is, along with the mono- and diformylation, an intermolecular reaction leading to a polymeric compound. The diamine under consideration forms a monoazomethine with salicylaldehyde but a bis(azomethine) complex with the salicylaldehydate of divalent nickel.

It is known that as a consequence of the extremely low basicity of the NH_2 groups in aminofurazans [1, 2], the latter have substantial difficulty in reacting with carbonyl-containing compounds [1].

In the present paper, we report on an attempt to obtain imidazo[d,c]furazan (II) and azomethines from 3,4-diaminofurazan (I) with salicylaldehyde (III). These products are of interest as potentially biologically active substances [1] and as ligands for complex formation [4].

M. A. Suslov Scientific-Research Institute of Physical and Organic Chemistry, Rostov State University, Rostov-on-Don. N. D. Zelinskii Institute of Organic Chemistry, Academy of Sciences of the USSR, Moscow. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 5, pp. 666-669, May, 1986. Original article submitted February 27, 1985.

0009-3122/86/2205-0546$12.50