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SYNTHESIS OF HETERYLPHTHALONITRILES

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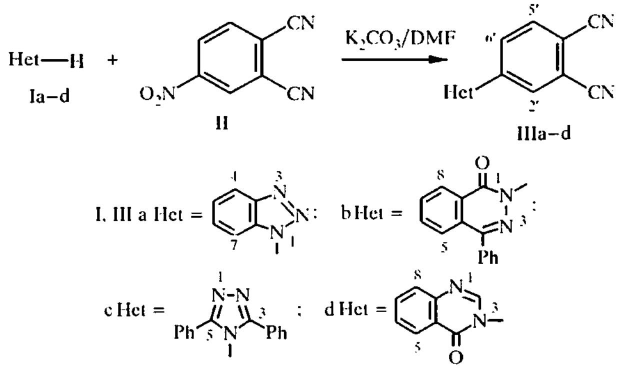
The corresponding heterylphthalonitriles are obtained in the reaction of 4-nitrophthalonitrile with heterocyclic N-nucleophiles in the presence of potassium carbonate.

We have recently studied the kinetics of nucleophilic substitution of the nitro group in 3- and 4-nitrophthalonitriles by arylhydroxy group using the phenol/K_2CO_3 system in aqueous DMF [1, 2] and showed that the dependence of the reaction rate on the water content passes through a maximum. The greatest rate is achieved in 75% DMF for both dinitriles. Similar behavior has been noted when thiophenols were used as the nucleophiles. In continuation of this work, we studied the reaction of N-nucleophiles Ia–d with 4-nitrophthalonitrile (II) under analogous conditions, leading to new heterylphthalonitriles IIIa–d:



In the case of reaction of the compound II with benzotriazole Ia (the initial concentration of the starting reagents being 0.03 mol/l), addition of water up to 25% of the reaction mixture leads to decrease of in the rate of substitution and finally to cessation of this reaction. The introduction of water clearly not only does not accelerate the reaction (as in the case of O- and S-nucleophiles) but, on the contrary, reduces the reaction rate. The inhibiting effect of water was also noted in the reaction of dinitrile II with other N-nucleophiles Ib–d. At such low reagent concentrations, water probably strongly solvates the given nucleophile as a protic solvent. Analysis of the PMR spectrum indicates that the product is 1.4:1 mixture of 1-(3',4'-dicyanophenyl)benzotriazole (IIIa) and its 2-substituted isomer. Pure compound IIIa was isolated upon subsequent crystallization of this mixture.

The [HetH · $KHCO_3$] complex formed *in situ* is probably the reagent in the reaction under study, since in the presence of water, rapid hydrolysis of the nitrile groups was observed in our previous work when previously prepared potassium phenoxide or phenol and potassium hydroxide were used, while no reaction occurs in the absence of a deprotonating agent.

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TABLE 1. Characteristics of the Synthesized Compounds

Compound	Empirical formula	Found, % Calculated, %			mp, °C (Crystallization solvent)	IR spectrum, ν, cm^{-1}	PMR spectrum, δ, ppm, spin-spin coupling constants (*J*), Hz	Yield, %
		C	H	N				
IIIa	$C_{14}H_7N_5$	68.22 68.56	3.06 2.88	28.41 28.56	240 - 242 (DMF - ethanol, 1:1)	2220 (C≡N)	7.55 (2H, m, 5- and 6-H); 7.96 (2H, m, 4-, and 7-H); 8.36 (1H, d, *J* = 9, 5'-H); 8.76 (1H, dd, *J* = 9, *J* = 2, 6'-H); 8.90 (1H, d, *J* = 2, 2'-H)	42
IIIb	$C_{22}H_{12}N_4O$	76.17 75.85	3.48 3.47	16.12 16.08	239 - 241 (DMF)	2230 (C≡N), 1668 (C=O)	7.61-8.49 (3H, m, 5-, 6- and 7-H); 7.61-8.01 (5H, m, Ph); 8.30 (1H, dd, *J* = 9, *J* = 2, 6'-H); 8.38 (1H, d, *J* = 9, 5'-H); 8.49 (1H, m, 8-H); 8.63 (1H, d, *J* = 2, 2'-H)	82
IIIc	$C_{22}H_{13}N_5$	75.55 76.07	3.82 3.77	19.86 20.16	184 - 186 (DMF - ethanol, 1:1)	2240 (C≡N)	7.54 (8H, m, 4 *o*- and *m*-H_{Ph}); 7.95 (1H, dd, *J* = 9, *J* = 2, 6'-H); 8.16 (2H, m, 2 p-HPh); 8.27 (1H, d, *J* = 9, 5'-H); 8.36 (1H, d, *J* = 2, 2'-H)	56
IIId	$C_{16}H_8N_4O$	70.20 70.48	3.06 2.96	20.42 20.55	>300 (DMF)	2230 (C≡N), 1680 (C=O)	7.65-8.25 (4H, m, H_{Het}); 8.22 (1H, dd, *J* = 9, *J* = 9, 6'-H); 8.38 (1H, d, *J* = 9, 5'-H); 8.43 (1H, s, 2-H); 8.48 (1H, d, *J* = 2, 2'-H)	69

When the reaction is carried out in anhydrous DMF, the use of an alkaline agent, KOH, is possible leading to the increase of reaction rate. However, when 3,5-diphenyl-1,2,4-triazole (Ic) is used as the nucleophile the reaction rate is lower than using K_2CO_3.

The synthesized heterylphthalonitriles IIIa-d (see Table 1) are colorless crystalline compounds, whose structures were confirmed by the spectral data. In the IR spectra of these compounds the characteristic C≡N stretching bands at 2220–2240 cm^{-1} are present but there are no absorbtion bands for the NH (3130–3300 cm^{-1}) and NO_2 groups (1345 and 1525 cm^{-1} observed in the compounds Ia-d and II, respectively [3]. The PMR spectra of IIIa-d have aromatic proton signals.

EXPERIMENTAL

Polarographic analysis of the samples for nitro compound concentration was carried out on an LP-7 polarograph. The cell with dropping mercury and saturated calomel electrodes in 50% aqueous ethanol with Et_4NBr as the base electrolyte was maintained at 298±0.5K. The concentration was determined by the addition method [4]. The IR spectra were taken on an IR-75 spectrometer for vaseline mulls. The PMR spectra were taken for DMSO-d_6 solution on a Bruker AC-300 spectrometer at 300.13 MHz using HMDS as the internal standard.

1-(3',4'-Dicyanophenyl)benzotriazole (IIIa). Samples of 1.2 g (0.01 mol) of benzotriazole Ia, 1.38 g (0.01 mol) of anhydrous K_2CO_3, and 1.73 g (0.01 mol) of 4-nitrophthalonitrile II were added consecutively with stirring to 30 ml of DMF. The mixture was stirred rapidly for 1 h at 70-80°C. After cooling to room temperature, the reaction mixture was poured into 100 ml of water. The resultant precipitate was filtered off, washed with water, and crystallized. 2-(3',4'-Dicyanophenyl)phthalazine IIIb, 4-(3',4'-dicyanophenyl)-3,5-diphenyl-1,2,4-triazole IIIc, and 3-(3',4'-dicyanophenyl)-4-quinazolinone IIId were obtained from the compounds Ib-d, respectively. The characteristics of the synthesized compounds IIIa-d are given in Table 1.

REFERENCES

1. P. S. Kaninskii, V. V. Plakhtinskii, I. G. Abramov, O. A. Yasinskii, and G. S. Mironov, *Zh. Org. Khim.*, **28**, No. 6, 1232 (1992).
2. V. V. Plakhtinskii, I. G. Abramov, G. S. Mironov, and O. A. Yasinskii, *Izv. Vyssh. Uchebn. Zaved. Ser. Khim. Khim. Tekhnol.*, **40**, No. 2, 31 (1997).
3. A. Gordon and R. Ford, *Chemist's Handbook* [Russian translation], Mir, Moscow (1976).
4. S. G. Mairanovskii, Ya. P. Stradyn', and V. D. Bezuglyi, *Polarography in Organic Chemistry* [in Russian], Khimiya, Leningrad (1975).