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Dyes and Pigments 53 (2002) 263–266

DYES and PIGMENTS

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The preferential reduction of 4,6 (5,7)-dinitro and 5,6-dinitrobenzimidazoles

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Received 10 August 2001; received in revised form 12 December 2001; accepted 8 February 2002

Abstract

4,6 (5,7)-Dinitro and 5,6-dinitrobenzimidazoles were reduced in aqueous ethyl alcohol by sodium polysulfide to give 4(7)-amino-6(5)-nitrobenzimidazole and 5(6)-amino-6(5)-nitrobenzimidazole. The spectroscopic properties were examined with respect to the effects of the 4- and 5-nitro groups present in the benzimidazole ring. Thus, the preferential reduction could be related to the chelating structure in the studied compounds.

Keywords: Benzimidazole; Dinitrobenzimidazoles; Zinin reduction; Aminobenzimidazoles; Nitroaminobenzimidazoles; Azo dyes

1. Introduction

Dinitrobenzimidazoles and their amino derivatives have been extensively investigated. They possess biological activity and are often employed in drug design and also find application in photography [1–7]. The use of nitroaminobenzimidazole derivatives in the synthesis of azo dyes is not known [8]. However, these compounds may be used as diazo components in the azo dyes synthesis. On the other hand, the nitro group is particularly advantageous in inducing bathochromic shifts in the dyes [9].

According to the literature data, dinitrobenzimidazoles can be obtained by nitration of nitrobenzimidazoles. Nitration of 5-nitrobenzimidazole gives two isomers, 4,6 (5,7)- and 5,6-dinitrobenzimidazoles which may be isolated by fractional crystallization [10].

In the present study, the preferential reduction of dinitrobenzimidazoles was reported. 4,6 (5,7)- and 5,6-dinitrobenzimidazoles were reduced also by the similar procedure. To the extent of the author's best knowledge, these compounds have not been synthesized before by the preferential reduction and furthermore, the information related to 5(6)-amino-6(5)-nitrobenzimidazole is lacking in the literature. The 4,6 (5,7)-dinitro isomer was more easily reduced suggesting an intramolecular influence that makes the 4-nitro group more susceptible to reduction [11–13].

Since one of the advantages of this reduction is that it often stops at the nitro-amino stage to give a particular isomer, 4(7)-amino-6(5)-nitrobenzimidazole was obtained in high yield. The preferential reduction of 4,6 (5,7)-dinitrobenzimidazole (**I**), having a structure permitting chelation, leads to the formation of the 4(7)-amino-6(5)-nitrobenzimidazole (**III**) as the major reduction product. The preferential reduction of 5,6-dinitrobenzimidazole (**II**) gives 5(6)-amino-6(5)-nitrobenzimidazole (**IV**) in good yield also (Fig. 1).

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0143-7208/02/$ - see front matter
PII: S0143-7208(02)00018-9

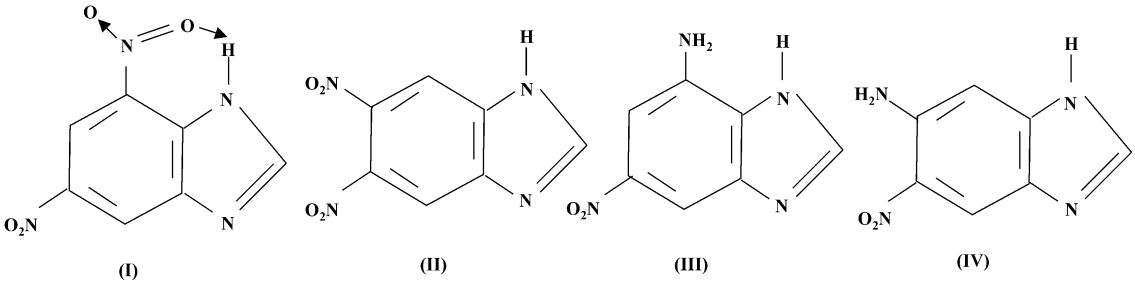


Fig. 1. (**I**) 4,6 (5,7)-dinitrobenzimidazole, (**II**) 5,6-dinitrobenzimidazole, (**III**) 4(7)-amino-6(5)-nitrobenzimidazole, (**IV**) 5(6)-amino-6(5)-nitrobenzimidazole.

The spectral properties of the nitroaminobenzimidazoles are reported. Additionally these compounds are used as diazo components in two azo dyes prepared with 2-hydroxynaphtalene and the some preliminary spectral data of azo dyes are given.

2. Experimental

2.1. General information

Melting points were determined on a Gallonkamp apparatus using a capillary tube. The NMR spectra were obtained with a Bruker DPX. FT–NMR (400 MHz) spectrometer, IR absorption spectra were recorded on a Mattson 1000 FT–IR spectrometer in KBr discs UV–vis spectra were measured in a UNICAM UV2–100 spectrometer. Mass spectra were obtained with a Agilant GC–MSD and micromass platform II spectrophotometer.

2.2. Preparation of nitroaminobenzimidazoles

Two different starting materials based on the 5-nitrobenzimidazole have been prepared by nitration procedure given in the literature. Two isomeric dinitro benzimidazoles were isolated by fractional crystallization and reduced in aqueous ethyl alcohol by sodium polysulfide.

2.2.1. 4(7)-Amino-6(5)-nitrobenzimidazole

4,6 (5,7)-Dinitrobenzimidazole (10.4 g, 5×10^{-2} mol) was dissolved in ethyl alcohol (75 ml). A warm solution of 13.0 g sodium sulfide and 3.5 g sulfur in 50 ml water was added slowly and the mixture was warmed at 60–70 °C for 1 h. After the reaction was completed, the mixture was cooled at room temperature and filtered. The crude product was washed with water and acidified with dilute hydochloric acid and heated until the termination of H_2S and SO_2 formation. The mixture was evaporated to dryness and the residue was extracted with ethyl alcohol. Treatment with dilute ammonium hydroxide and recrystallization from water (Norit) gave free base 4(7)-amino-6(5)-nitrobenzimidazole (5.5 g, 62%); mp 245–247 °C [14]; ^{1}H NMR (DMSO-d_6,); δ 6.2 (2H, *s*, NH_2), 7.4 (1H, *d*, 6(5)-H), 7.8 (1H, *d*, 4(7)-H), 8,4 (1H, *s*, 2-H), 11,3 (1H, *b*, N–H): FT-IR (KBr, cm^{-1}): 3370–3309 ν (NH) for NH_2, 3126 ν (NH), 1655 ν (C=N); 1538 and 1336 ν (NO_2); UV (λ_{max}, EtOH, nm): 406; *m*/*z* (EI), 178, M^+, 132 $[M–NO_2]^+$, 105 $[M–(NO_2+HCN)]^+$.

2.2.2. 5(6) Amino-6(5)-nitrobenzimidazole

This derivative was prepared by the same procedure starting from 10.4 g (0.05 mol) 5,6-dinitrobenzimidazole to give 67% (6.0g) 5(6)-amino-6(5)-nitrobenzimidazole as an orange powder, mp 222–223 °C; ^{1}H NMR (DMSO-d_6): δ 8.3 (2H, *s*, 2-H and 4(7)-H), 8.7 (1H, *s*, 7(4)-H), 13.5 (1H, *b*, N–H); FT–IR (KBr, cm^{-1}): 3590 ν (NH) for NH_2, 3320–3300 ν (NH) for NH_2, 3105 ν (NH), 1653 ν (C=N), 1536 and 1371 ν (NO_2); UV (λ_{max}, EtOH, nm): 370; *m*/*z* (EI), 178, M^+, 132 $[M–NO_2]^+$, 105 $[M–(NO_2+HCN)]^+$.

2.3. Diazotisation and coupling

The nitroaminobenzimidazoles were diazotised and coupled according to standart procedures:

0.360 g (2×10^{-3} mol) of nitroaminobenzimidazole was dissolved in aqueous hydrochloric acid (8 ml, 1:1) and cooled to 0–5 °C prior to addition of a cold solution of sodium nitrite (5%) whilst maintaining the temperature at 0–5 °C and the mixture was then stirred for 15 min at the same temperature. By addition of sodium acetate, the pH of the solution was adjusted to 6.0 and 2-hydroxy naphtalene solution (5% in 2 N NaOH) was added dropwise to the diazonium solution. The crude product precipitate was filtered, washed with water and dried to give azo dye (Fig. 2). The crude yields of the dyes (**V**) and (**VI**) were 71% (0.473 g) and 73% (0.486 g), respectively. For purification of azo dyes, chromatography colums prepared with silica gel (230–400 mesh ASTM) were used ($CHCl_3$:izopropanole; 9:1). Characterisation data are given below.

2.3.1. 4(7)-(2-Hydroxy-1-naphtylazo)-6(5)-nitrobenzimidazole (**V**)

Red-brown powder; mp > 280 °C; pure yield 68% (0.453 g); FT–IR (KBr, cm^{-1}): 3400 ν (OH), 3109 ν (NH), ν 1577 and 1320 ν (NO_2), 1452 ν (N=N) ^{1}H NMR: δ 6.8 (1H, *d*, ArH), 7.1–7.4 and 7.6–7.9 (5H, m, Ar H), 7.5 (1H, *d*, 6(5)-H), 8.5 (1H, *d*, 4(7)-H), 8.3 (1H, s, 2-H), 12,7 (1H, *b*, N–H), 16.4 (1H, *s*, N–H); UV (λ_{max}, EtOH, nm): 532; *m*/*z* (EI), 333, M^+, 316 $[M–OH]^+$, 270 $[M–(OH+NO_2)]^+$, 243 $[M–(OH+NO_2+HCN)]^+$, 178 $[C_7H_6N_4]$, 144 $[C_{1O}H_8O]$.

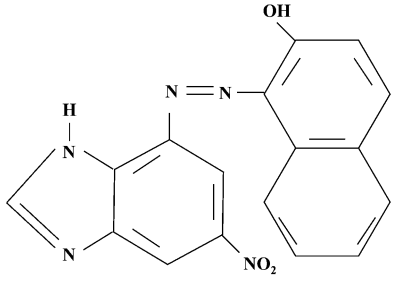
2.4.2. 5(6)-(2-Hydroxy-1-naphtylazo)-6(5)-nitrobenzimidazole (VI)

Red-brown powder, mp > 300 °C; pure yield 65% (0.433 g); FT–IR (KBr, cm^{-1}): 3400 ν (OH), 3100 ν (NH); 1540 and 1350 ν (NO_2), 1450 ν (N=N); ^{1}H-NMR: δ 7.0–7.8 (6H, *m*, ArH), 8.3 (1H, *s*, 2-H), 8.5 (1H, *s*, 4(7)-H), 8.9 (1H, *s*, 7(4)-H), 12.1 (1H, *b*, N–H), 15.8 (1H, *s*, N–H); UV (λ_{max}, EtOH, nm): 503; *m*/*z* (EI), 333, M^+, 316 $[M–OH]^+$, 270 $[M–(OH+NO_2)]^+$, 243 $[M–(OH+NO_2+HCN]^+$, 178 $[C_7H_6N_4]$, 144 $[C_{10}H_8O]$.

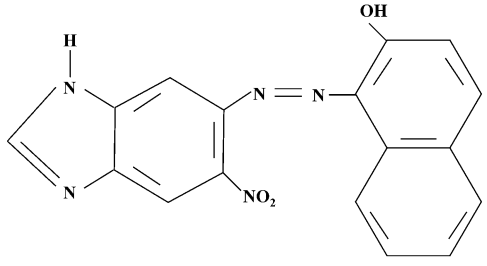
3. Conclusion

Nitroaminobenzimidazoles were prepared by preferential reduction of dinitrobenzimidazoles with Na_2S/S. The reduction of 4,6 (5,7)-dinitrobenzimidazole leads to the formation of 4(7)-amino-6(5)-nitrobenzimidazole as the major product and 5,6-dinitrobenzimidazole is reduced to the mono nitro derivative. The peak at 3590–3595 cm^{-1} observed in the infrared spectra of 4,6 (5,7)-dinitro and 5(6)-amino-6(5)-nitro benzimidazoles prove that $-NO_2$ group forms an intramolecular hydrogen bond with NH_2 group and −NH group in the imidazole ring respectively for 5(6)- amino-6(5)- nitro benzimidazole and 4,6(5,7)-dinitrobenzimidazole. The ^{1}H-NMR spectra of azo dyes of these compounds (in DMSO-d_6) showed a peak at δ 15.0–16.5 ppm suggesting that these compounds exist as hydrazone-keto form in solution.

This investigation has shown that zinin reduction is useful for the reduction of dinitrobenzimidazoles to corresponding nitroaminobenzimidazoles and these compounds can be employed in the synthesis of benzimidazole azo dyes.



(V)



(VI)

Fig. 2. (**V**) 4(7)-(2-Hydroxy-1-naphtylazo)-6(5)-nitrobenzimidazole, (**VI**) 5(6)-(2-hydroxy-1-naphtylazo)-6(5)-nitrobenzimidazole.

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