DIAZOTISATION OF 5,6-DIAMINO-1*H*-BENZİMİDAZOLE

Sebla Dincer

Department of Chemistry, Ankara University, 06100 Ankara, Turkey

Abstract

The synthesis of the bis(diazonium) salt derived from 5,6-diamino-1*H*-benzimidazole and subsequent coupling with β-naphthol are reported. The coupling reaction gives an imidazo-benzotriazole derivative when the diazotization is performed with nitrosyl hydrogen sulfate and a mono-azo compound when coupling is done in the presence of concentrated HCl.

Introduction

Research carried out on the reduction of 5,6-dinitro-1*H*-benzimidazole is limited in literature (1,2) and the diazotization and the coupling reactions of the reduction product 5,6-diamino-1*H*-benzimidazole have not yet been studied.

In the present study, a well-known synthesis of benzotriazoles using o-diamines as starting materials (3,4) was employed for 5,6-diamino-1*H*-benzimidazole. In recent years, many analogues of 2-(2*H*-1,2,3- benzotriazol - 2-yl) naphthol have been intensively studied because of their ultraviolet absorber activity protecting the natural and synthetic materials against light (5-7). As an extension of these investigations, the synthesis a new ring system 1,7-dihydroimidazo[4, 5 -*f*] [1,2,3] benzotriazole which may also form ultraviolet absorber agen is reported. On the other hand, by the hydroxy-dediazoniation reaction, a mono-azo compound was also obtained depending on the experimental conditions.

Experimental

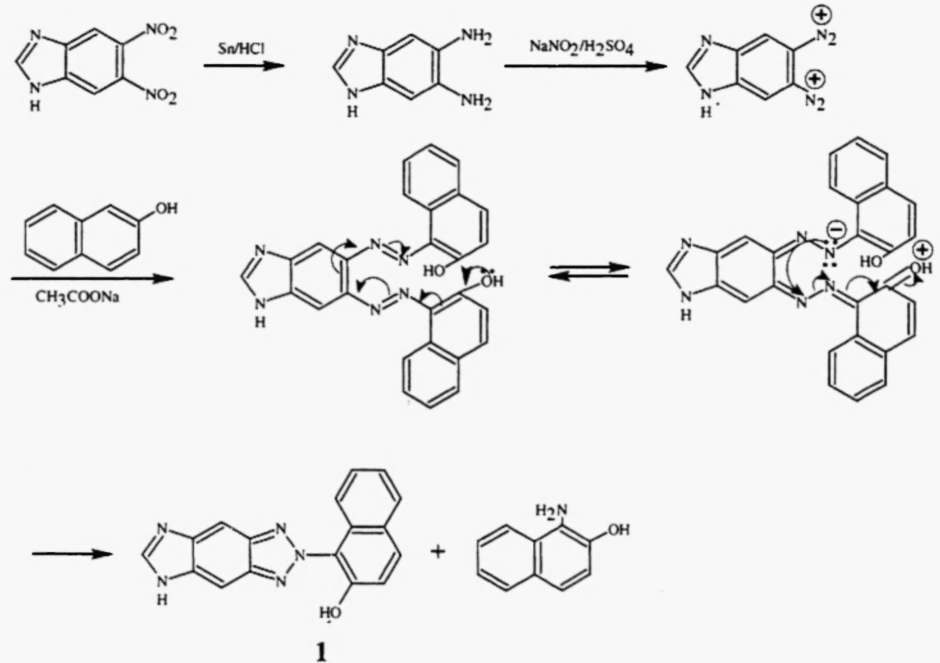
Melting points were obtained on a Gallenkamp apparatus (uncorrected). IR spectra were recorded on a Mattson 1000 FT-IR spectrophotometer in KBr discs. ^{1}H and ^{13}C NMR spectra were obtained with a Brucker DPX-400 spectrometer in hexadeuteriodimethylsulfoxide. Mass spectra were recorded on a Agilant GC-MSD spectrophotometer. Elemental analyses were carried out an a LECO-932 C, H, N analyser.

5,6-Dinitro-1*H*-benzimidazole was obtained employing the method described in literature (8) and used as a starting material to synthesize the desired benzimidazole derivatives.

Synthesis of 1-imidazo[4,5-*f*][1,2,3]benzotriazol-2(5*H*)-yl-2-naphthol <u>1</u>

5,6-Diamino-1*H*-benzimidazole: Reduction of 5,6-dinitro-1*H*-benzimidazole (5.0 g, 2.4×10^{-2} mol) with tin (16.0 g) and concentrated hydrochloric acid (50.0 mL) gave 5,6-diamino-1*H*-benzimidazole dihydrochloride salt. According to literature procedure (1), treatment with ammonia and recrystallisation from water afforded 5,6-diamino-1*H*-benzimidazole as colourless needles, mp 213-214 °C (2.9 g, 84 %).

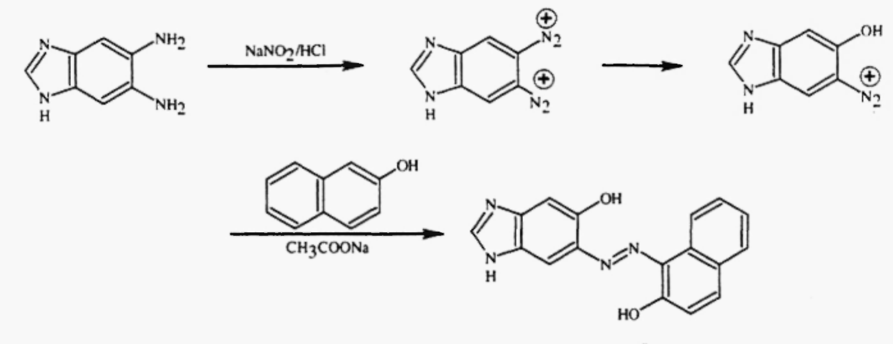
Ring closure of 5,6-diamino-1*H*-benzimidazole: Nitrosylsulfuric acid was prepared by adding sodium nitrite (1.5 g) to sulfuric acid (98 %, 15.0 mL) at 20-30 ^{0}C, heating to 60-65 ^{0}C over 10 minutes with stirring and maintaining this temperature for 5 minutes to ensure complete dissolution. After cooling, a solution of 5,6-diamino-1*H*-benzimidazole (0.3 g, 2 x 10^{-3} mol) in concentrated sulfuric acid was added over for 30 minutes below 5 ^{0}C. When the diazotisation was completed, the bis(diazonium) salt solution was used immediately for the coupling reaction. The solution of β-naphthol in sodium hydroxide (5 % in 2N NaOH) was slowly added at 5-10 ^{0}C maintaining the pH at 5-6 by addition of aqueous solution of sodium acetate (40 %). The obtained precipitate was filtered off, washed with water and air-dried. The crude product (0.43 g, 72 %) was purified by a combination of column chromatography (silicagel, 230-400 mesh ASTM / toluene: ethyl acetate, 95:5) and recrystallisation (aqueous ethanol). The pure product is a light red powder with melting point 263-265 ^{0}C. The yield is 0.41 g (68 %). Found, %: C 67.12; H 3.41; N 23.18. $C_{17}H_{11}N_5O$. Calculated, %: C 67.78; H 3.66; N 23.26. MS; m/z: 301 [M$^+$], 286, 272, 222, 192.



1

Synthesis of 6-[(2-hydroxy-1-naphthyl)diazenyl]-1*H*-benzimidazol-5-ol 2

5,6-Diamino-1*H*-benzimidazole (0.3 g, 2 x 10^{-3} mol) was dissolved in concentrated hydrochloric acid (10.0 mL) and cooled at 0-5 ^{0}C. A solution of sodium nitrite (0.2 g) in ice-water (1.0 mL) was added over for 30 minutes, maintaining the temperature at 0-5 ^{0}C. The mixture was stirred for a further 15 minutes during which time the temperature was allowed to rise at 40-45 ^{0}C. When the evolution of the N_2 gas was completed, the pH was adjusted to 6-7 by addition of aqueous solution of sodium acetate then the solution of β-naphthol in sodium hydroxide was added until the precipitation of the reaction product ceased. Recrystallisation from ethanol gave the pure 2, red powder (0.32 g, 53 %). The melting point is 209-211 ^{0}C. Found, %: C 67.35; H 3.60; N 18.31. $C_{17}H_{12}N_4O_2$. Calculated, %: C 67.11; H 3.95; N 18.42. MS; m/z: 304 [M$^+$], 272, 244, 144.



2

Results and discussion

Ring closure reaction. According to the literature (2), the method of the diazotization in which a solution of the diamine in concentrated sulfuric acid is mixed with nitrosyl sulfuric acid was employed succesfully for the preparation of bis(diazonium) salt derived from 5,6-diamino-1*H*-benzimidazole. The coupling with β-naphthol give 1-imidazo[4,5-*f*][1,2,3]benzotriazol-2(5*H*)-yl-2-naphthol in good yield.

Under diazotization conditions reported in literature, the formation of the unsubstituted triazole ring is prevented and consequently 1,7-dihydroimidazo [4,5-*f*] [1,2,3] benzotriazole was not obtained. However, by raising the pH to 5-6, the coupling reaction with β-naphthol takes place very easily and the ring closure followed. The resulting N-substituted N-azo group forms part of the fused triazole ring of 1,7-dihydroimidazo [4,5-*f*][1,2,3] benzotriazole.

Hydroxy-dediazoniation reaction. 5,6-Diamino-1*H*-benzimidazole was dissolved in concentrated hydrochloric acid and sodium nitrite solution in water was added 0-5 ^{0}C. The whole reaction mixture was maintained at 40-45 ^{0}C with stirring to ensure the evolution of N_2 gas. Adjusting the pH to 6-7 and coupling with β-naphthol , 6-[(2-hydroxy-1-naphthyl)diazenyl]-1*H*-benzimidazol-5-ol was obtained .

According to the literature, it is not possible to diazotise one amino group of the 5,6-diamino-1*H*-benzimidazole on treatment with acid (10). Also a ring closure reaction was not observed under these experimental conditions. Both amino groups were diazotised in acid. However, one of N_2^+ groups was replaced by water in an ordinary substitution reaction. The imidazole ring, which is an electron-supplying group, increases the double bond character of the C-N bond in the diazonium cation and the cleavage of this bond in the latter diazonium group was hindered (11).

Spectroscopic properties

The structures of the compounds 1 and 2 were examined by ^{1}H and ^{13}C NMR and infrared spectroscopies. The elemental analysis results agree with the structures determined.

IR spectroscopy was used to distinguish between two benzimidazole derivatives. The compound 1 displayed an absorption band in the region 3200-2900cm^{-1} having markedly lowered intensity, whereas the compound 2 showed a broad band near 3600-3500cm^{-1}. The compound 1 displayed an absorption band, (O-H stretching vibration) at lower values depending on the intramolecular hydrogen bonding (12). However the compound 2 cannot form an intramolecular hydrogen bond.

For ^{1}H NMR measurements, the samples were dissolved in hexadeuteriodimethylsulfoxide. In all cases, the aromatic regions were characteristic indicating the presence of the 2-hydroxy-1-naphthyl group. Doublets at δ 7.09, 7.89, 8.03, 8.73 ppm and triplets at δ 7.50 and 7.68 ppm were assigned to aromatic protons in the compound 1. These assignments were observed at δ 7.43, 7.96, 8.08, 8.97 and δ 7.69 and 7.88 ppm respectively in the compound 2.

Singlets at δ 8.19 and 8.49 ppm were assigned to 4-H and 7-H in the benzimidazole ring of 2, whereas a singlet at δ 8.31 ppm is due to the same protons in 1. The appearance of a singlet at δ 8.53 ppm, indicating one proton, confirmed the presence of the hydroxyl group in the compound 2. The compounds 1 and 2 displayed one singlet corresponding to 2-H at δ 8.27 and 8.21ppm respectively.

The signal observed at δ 15.47 ppm proved the azo-hydrazone tautomerism in solution for the compound 2 (13).

The ^{13}C NMR spectra in hexadeuteriodimethylsulfoxide showed seventeen aromatic carbon signals in the region 112.18 – 159.59 ppm. The 2-hydroxy-1-naphthyl group provided ten ^{13}C NMR signals. C-2 was observed at δ 159.59 ppm. C-1 was assigned at δ 129.49 ppm. C-3, C-4 , C-7, C-8 and C-8a were assigned at δ 125.78, 144.28, 122.35, 122.25 and 133.34 ppm respectively while C-4a, C-5 and C-6 peaks appeared in the region of 128.72-129.71 ppm. The benzimidazole carbon ring signals were observed at δ 147.73, 144.72, 137.54, 116.27 and 112.18 ppm for C-5, C-2, C-4a, C-7a, C-4(7) and C-6 respectively for the compound 2 whilst for the compound 1 ^{13}C chemical shifts were not significantly distinguishable.

Conclusion

1-Imidazo[4,5-*f*][1,2,3]benzotriazol-2(5*H*)-yl-2-naphthol and 6-[(2-hydroxy-1-naphthyl)diazenyl]-1*H*-benzimidazol-5-ol were prepared in good yields by the diazotisation and the coupling reactions of 5,6- diamino-1*H*-benzimidazole.

References

(1) G. E. Ficken and D. J. Fry, J. Chem. Soc. 736 (1963).

(2) S. Dincer, Dyes and Pigments **53**, 263 (2002).

(3) T. L. Gilchrist and G. E. Gymer, Adv. Heterocycl. Chem. **16**, 33 (1974).

(4) F. R. Benson and W. L. Savell, Chem. Rev. 1 (1950).

(5) A.R. Katritzky, S. Rachwal and B. Rachwal, J. Chem. Soc. Perkin Trans I 799 (1987).

(6) R.J. Greenwood, M.F. Mackay and J.F.K. Wilshire, Aust. J. Chem. **45**, 965 (1992).

(7) J.F.K. Wilshire, Aust. J. Chem. **41**, 617 (1988).

(8) Z. Kazimierczuk and D. Shuger, Nucleosides and Nucleotides **8** (8), 1379 (1989).

(9) H.H. Hodgson and J. Walker, J. Chem. Soc. 530 (1935).

(10) K.H.Saunders and R.L.M. Allen, Aromatic Diazo Compounds, Edward Arnold, London, 1985.

(11) C.G. Swain, J.E. Sheats and K.G. Harbison, J. Amer. Chem. Soc. **97**(4), 783 (1975).

(12) J. Durmis, M. Karvas and Z. Manăsek, Coll. Czechoslov. Chem. Commun. **38**, 243 (1973) .

(13) A. Lyčka, Dyes and Pigments **43**, 27 (1999) .

Received on September 27, 2003.