bp 50–53° (0.04 mm), n^{20}D 1.5322 [lit.[13] bp 130–135° (20 mm)[14]]; cyclopentanone oxime *O*-ethyl ether reported[15] without physical constants, bp 59–61° (15–16 mm), n^{20}D 1.4540, was analyzed for $C_7H_{13}NO$ (Calcd: C, 66.11; H, 10.30; N, 11.01. Found: C, 66.28; H, 10.14; N, 11.11). Previously unreported oxime ethers included *n*-butyraldoxime *O*-ethyl ether, bp 119–121°, n^{14}D 1.4133 (*Anal.* Calcd for $C_6H_{13}NO$: C, 62.57; H, 11.38; N, 12.16. Found: C, 62.63; H, 11.34; N, 12.19); *n*-butyraldoxime *O*-methyl ether, bp 93–97°, n^{25}D 1.4054 (*Anal.* Calcd for $C_5H_{11}NO$: C, 59.37; H, 10.96; N, 13.85. Found: C, 59.52; H, 10.82; N, 13.94); phenyl-2-propanone oxime *O*-ethyl ether, bp 60–66° (0.01–0.1 mm) n^{21}D 1.5070 (*Anal.* Calcd for $C_{11}H_{15}NO$: C, 74.54; H, 8.53; N, 7.90. Found: C, 74.53; H, 8.62; N, 8.02); 2-pentanone oxime *O*-methyl ether, bp 118–120°, n^{24}D 1.4152 (*Anal.* Calcd for $C_6H_{13}NO$: C, 62.57; H, 11.38; N, 12.16. Found: C, 62.68; H, 11.30; N, 12.12).

General Procedure for the NBS Bromination of *O*-Alkyl Oximes.—The procedure for the preparation of 3-bromo-2-butanone oxime *O*-methyl ether is representative. A mixture of 20.2 g (0.2 mol) of 2-butanone oxime *O*-methyl ether and 35.6 g (0.2 mol) of *N*-bromosuccinimide in 80 ml of carbon tetrachloride was heated at reflux with occasional shaking and irradiated with a 275-W G.E. sunlamp (about 10 cm away). In about 15 min, vigorous boiling ensued with the development of an intense red-dish-brown color and, after an additional 10 min, the color suddenly disappeared and the boiling subsided. The reaction mixture was cooled and filtered with suction, and the residue was washed with a small amount of carbon tetrachloride. The filtrate was combined with the washings and then shaken with 50 ml of a saturated solution of sodium bicarbonate. The organic layer was dried (Na_2SO_4) and distilled under diminished pressure to remove the solvent. The residual yellow liquid was then distilled twice under reduced pressure giving 26.2 g (72.8%) of **8**. Physical properties, spectral data, and elemental analysis are shown in Tables I and II.

TABLE II

NMR DATA OF 2-ALKOXYIMINOALKYL BROMIDES

Compd	Solvent	Nmr, δ
1	Neat	1.20 (t, 3, J = 7.0 Hz), 1.88 (s, 3), 3.90 (s, 2), 4.04 (q, 2, J = 7.0 Hz)
2	$CDCl_3$	1.23 (t, 3, J = 7.0 Hz), 1.78 (d, 3, J = 7.0 Hz), 1.92 (s, 3), 4.09 (q, 2, J = 7.0 Hz), 4.70 (q, 1, J = 7.0 Hz)
3	Neat	1.00 (t, 3, J = 7.0 Hz), 1.17 (t, 3, J = 7.0 Hz), 1.72–2.27 (m, 2), 4.03 and 4.09 (two q, 2, J = 7.0 Hz), 4.45 and 5.00 (two q, with ratio of 3 to 1, 1, $J \simeq$ 7.5 Hz, CHBr), 6.70 and 7.35 (two d, with ratio of 1 to 3, J = 8.8 Hz)
4	$CDCl_3$	0.98 (t, 3, J = 7.0 Hz), 1.23 (t, 3, J = 7.0 Hz), 1.90 (s, 3) 1.70–2.35 (m, 2), 4.13 (q, 2, J = 7.0 Hz), 4.52 (t, 1, $J \simeq$ 7.5 Hz)
5	$CDCl_3$	1.36 (t, 3, J = 7.0 Hz), 4.37 (q, 2, J = 7.0 Hz, 4.38 (s, 2), 7.30–7.90 (m, 5)
6	CCl_4	1.22 (t, 3, J = 7.0 Hz), 1.87 (s, 3), 4.12 (q, 2, J = 7.0 Hz), 5.80 (s, 1), 7.18–7.61 (m, 5)
7	$CDCl_3$	1.96 (s, 3), 3.90 (s, 3), 3.99 (s, 2)
8	$CDCl_3$	1.81 (d, 3, J = 7.0 Hz), 1.93 (s, 3), 3.89 (s, 3), 4.77 (q, 1, J = 7.0 Hz)
9	CCl_4	1.83–2.67 (m, 6), 3.86 (s, 3), 4.80–5.00 (m, 1)
10	$CDCl_3$	1.01 (t, 3, J = 7.0 Hz), 1.76–2.20 (m, 2), 1.89 (s, 3), 3.85 (s, 3), 4.47 (t, 1, $J \simeq$ 7.5 Hz)
11	$CDCl_3$	4.04 (s, 3), 4.29 (s, 2), 7.22–7.84 (m, 5)
12	Neat	1.29 (t, 3, J = 7.0 Hz), 1.80–3.00 (m, 6), 4.36 (q, 2), 5.18–5.38 (one broad band, 1)
13	Neat	1.29 (t, 3, J = 7.0 Hz), 1.25–3.60 (m, 8), 4.31 (q, 2), 5.17–5.40 and 5.85–6.10 (two broad bands, 1)
14	CCl_4	1.83–2.67 (m, 6), 3.86 (s, 3), 4.80–5.00 (m, 1)

(13) W. R. Dunstan and E. Goulding, *J. Chem. Soc.*, **79**, 628 (1901).

(14) The refractive index of this compound was not reported, therefore its structure was confirmed by nmr (neat TMS internal standard): δ 1.27 (t, 3 H), 2.10 (s, 3 H), 4.21 (q, 2 H), 7.50–7.79 (m, 2 H), and 7.08–7.37 (m, 3 H).

(15) L. G. Donaruma, *J. Org. Chem.*, **22**, 1024 (1957).

Registry No.—**1**, 31376-82-6; **2**, 31376-83-7; **3**, 31376-84-8; **4**, 31376-85-9; **5**, 31376-86-0; **6**, 31376-87-1; **7**, 31376-88-2; **8**, 31376-89-3; **9**, 31376-90-6; **10**, 31376-91-7; **11**, 31376-92-8; **12**, 31376-93-9; **13**, 31376-94-0; **14**, 31376-95-1; cyclopentanone oxime *O*-ethyl ether, 31376-96-2; *n*-butyraldoxime *O*-ethyl ether, 20135-03-9; *n*-butyraldoxime *O*-methyl ether, 31376-98-4; phenyl-2-propanone oxime *O*-ethyl ether, 31376-99-5; 2-pentanone oxime *O*-methyl ether, 31377-00-1; sodium *S*-(2-ethoxyimino-2-phenylethyl) thiosulfate, 31377-01-2; 2-(2-ethoxyimino-2-phenylethylthio)-2-imidazolinium bromide, 31377-02-3; 2,5-dibromocyclopentanone oxime *O*-methyl ether, 31377-03-4; NBS, 128-08-5.

Methylation of 2-Aminobenzimidazole

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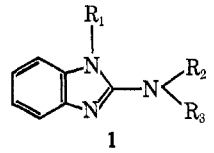
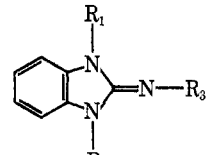
During an investigation of the preparation and properties of 2-aminobenzimidazoles, we wished to determine the nature of the products formed by direct methylation of these compounds. Methylation of 2-aminobenzimidazole can lead to either of two products, **1** and **2** ($R_1 = R_2 = R_3 = CH_3$). Based upon the observed behavior of the 5-aminotetrazoles,[2a] formation of the imine **2** was anticipated.



1



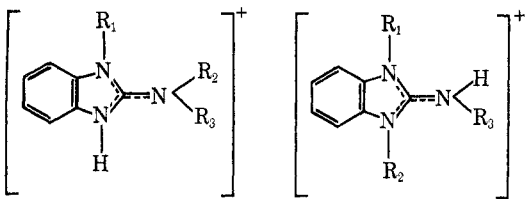
2

Treatment of 2-aminobenzimidazole with dimethyl sulfate afforded a trimethylated product whose physical properties differed substantially from those of an authentic sample of 1-methyl-2-dimethylaminobenzimidazole[2b] and which was apparently the expected 1,3-dimethyl-2-methyliminobenzimidazole. The ultraviolet spectrum of this compound shows only a single strong absorption at 284 nm rather than the two distinct maxima characteristic of both 2-aminobenzimid-

(1) To whom correspondence should be addressed: Herbert H. Lehman College of the City University of New York, Bronx, N. Y. 10468.

(2) (a) R. A. Henry, W. G. Finnegan, and E. Lieber, *J. Amer. Chem. Soc.*, **76**, 2894 (1954); D. B. Murphy and J. P. Picard, *J. Org. Chem.*, **19**, 1807 (1954). (b) A. Hunger, J. Kebrle, A. Rossi, and K. Hoffmann, *Helv. Chim. Acta*, **44**, 1273 (1961).

azole (244 and 283 nm) and 1-methyl-2-dimethylaminobenzimidazole (255 and 287 nm). The similarity in the spectra of the latter two compounds strongly suggests that 2-aminobenzimidazole exists principally in the form of the primary amine **1** rather than as the tautomeric imine **2** ($R_1 = R_2 = R_3 = H$).[3] When protonated, all three compound should exhibit guanidinium-type resonance (**3** and **4**) and, as expected, they show similar absorption in acid solution.

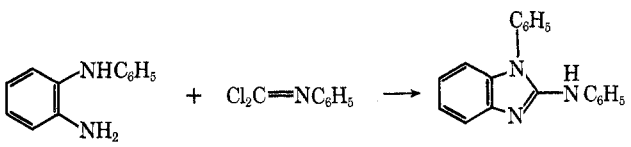


3

4

2-Anilinobenzimidazole also undergoes methylation of both ring nitrogens, yielding 1,3-dimethyl-2-phenyliminobenzimidazole, as evidenced by the higher melting point, more complex uv spectrum, and completely different ir spectrum, compared with those of authentic 1-methyl-2-(*N*-methylanilino)benzimidazole.[2b] Again, the differences in the uv spectrum largely disappear in acid solution.

In the course of this work, the previously unreported compound 1-phenyl-2-anilinobenzimidazole was prepared by the reaction of *N*-phenyl-*o*-phenylenediamine with phenyl carbonimidoyl dichloride.



Experimental Section[4]

2-Aminobenzimidazole.—A mixture of 0.24 g of benzimidazole-2-sulfonic acid[5] and 1 ml of 28% aqueous NH_3 was heated in a sealed tube at 160° for 6 hr. After recrystallization from alcohol and water, the product melted at 222° (lit.[6] 222°): λ_{max}^{EtOH} 244 nm (ε 6300), 283 (7950); $\lambda_{max}^{0.1\ N\ HCl}$ 276 nm (ε 9200).

1-Methyl-2-dimethylaminobenzimidazole.—A mixture of 0.2 g of 1-methyl-2-chlorobenzimidazole[2b] and 1.6 ml of 3.7 *N* dimethylamine in ethanol was heated 4 hr in a sealed tube at 150°. The mixture was evaporated, treated with Na_2CO_3 solution, and extracted with $CHCl_3$. The extract was dried ($MgSO_4$) and treated with a solution of dry HCl in $CHCl_3$. Chilling afforded crystals of the hydrochloride: mp 236–238° (lit.[2b] 238–239); $\lambda_{max}^{0.1\ N\ NaOH}$ 250 nm (ε 7500), 255 (7550), 287 (9800); $\lambda_{max}^{0.1\ N\ HCl}$ 281 nm (ε 9250), 288 (9400); ir (Nujol) 6.08, 12.2, 12.95, 13.1 μ.

1-Methyl-2-(*N*-methylanilino)benzimidazole was prepared in 43% yield by heating 0.214 g of redistilled *N*-methylaniline, 0.64 g of 22% BuLi in hexane, and 0.200 g of 1-methyl-2-chlorobenzimidazole under reflux in benzene for 2.5 hr. The solution was evaporated *in vacuo*, and the residue was taken up in ether. The ether solution was washed once with H_2O, dried ($MgSO_4$), and evaporated, leaving an oil which soon solidified. The crystals were sublimed *in vacuo* and then recrystallized from petroleum ether (bp 60–70°): mp 131–131.5° (lit.[2b] mp 128–129°); λ_{max}^{EtOH} 258 nm (ε 10,700), 294 (18,700); $\lambda_{max}^{0.1\ N\ HCl}$ 244 nm (ε 11,200), 288 (19,950); ir (Nujol) 6.22, 6.31, 6.58, 7.82, 8.06, 12.62, 13.22, 13.48, 13.78, 14.42 μ.

Methylation of 2-Aminobenzimidazoles.—Methylation was carried out according to the method described by Herbst, *et al.*, for the methylation of 1-ethyl-5-aminotetrazole.[7] From 0.133 g (0.001 mol) of 2-aminobenzimidazole and 0.441 g (0.0035 mol) of $(CH_3)_2SO_4$ was obtained 0.08 g of white, waxy crystals of 1,3-dimethyl-2-methyliminobenzimidazole, mp 62–64°, after purification by sublimation: λ_{max}^{EtOH} 250 nm (sh) (ε 10,700), 284 (22,800); $\lambda_{max}^{0.1\ N\ HCl}$ 277 nm (22,450), 283 (22,400).

Anal. Calcd for $C_{10}H_{13}N_3$: C, 68.57; H, 7.43. Found: C, 68.50, H, 7.40.

The hydrochloride melted at 253–255°: ir of hydrochloride (Nujol) 5.8, 5.9, 6.0, 13.4, 13.7 μ.

Treatment of 0.209 g (0.001 mol) of 2-anilinobenzimidazole[8] with 0.441 g (0.0035 mol) of $(CH_3)_2SO_4$ gave 0.18 g of 1,3-dimethyl-2-phenyliminobenzimidazole, which was recrystallized five times from EtOH–H_2O: mp 197–198°; λ_{max}^{EtOH} 247 nm (ε 16,600), 257 (20,000), 263 (21,000), 294 (28,700), 302 (30,500); $\lambda_{max}^{0.1\ N\ HCl}$ 246 nm (ε 17,200), 286 (25,000).

Anal. Calcd for $C_{15}H_{15}N_3$: C, 75.95; H, 6.33; N, 17.72. Found: C, 75.64; H, 6.05; N, 17.67.

The hydrochloride melted at 235–237°: ir (Nujol) 6.25, 6.6 6.7, 8.1, 11.7 w, 13.0 w, 13.4 sh, 1.5 s, 14.4 μ.

1-Phenyl-2-anilinobenzimidazole.—To a solution of 2.76 g (0.015 mol) of *N*-phenyl-*o*-phenylenediamine in 25 ml of 1,2-dichloroethane was added 2.61 g (0.015 mol) of phenyl carbonimidoyl dichloride.[8] Crystals appeared after a short time, and after several days a total of 2.91 g (60%) of purple, matted crystals separated, mp 218°. After several recrystallizations from H_2O, the hydrochloride was obtained as white crystals, mp 236–240°.

Anal. Calcd for $C_{19}H_{16}N_3Cl$: C, 70.91; H, 5.02; N, 13.06. Found: C, 70.70; H, 5.13; N, 13.20.

Addition of dilute NaOH to a solution of the hydrochloride precipitated 1-phenyl-2-anilinobenzimidazole: mp 160–165°; λ_{max}^{EtOH} 302 nm (ε 22,600), 296 (22,950), 256 (20,225), 245 sh (18,600); $\lambda_{max}^{0.1\ N\ HCl}$ 285 (ε 21,250), 280 (20,875); ir (Nujol) 6.13, 6.22, 6.35, 13.5, 14.4 μ.

Registry No.—**1** ($R_1 = R_2 = R_3 = H$), 934-32-7; **1** ($R_1 = R_2 = R_3 = Me$), 6595-23-9; **1** ($R_1 = Me$; $R_2 = Ph$; $R_3 = Me$), 31413-78-2; **1** ($R_1 = Ph$; $R_2 = Ph$; $R_3 = H$) HCl, 31413-79-3; **1** ($R_1 = R_2 = Ph$; $R_3 = H$), 31413-80-6; **2** ($R_1 = R_2 = Me$; $R_3 = Ph$), 29290-31-1; **2** ($R_1 = R_2 = Me$; $R_3 = Ph$) HCl, 31413-82-8; **2** ($R_1 = R_2 = R_3 = Me$), 19363-66-7; **2** ($R_1 = R_2 = R_3 = Me$)·HCl, 31413-84-0.

(3) A. R. Katritzky and J. M. Lagowski in *Advan. Heterocycl. Chem.*, **2**, 71 (1963).

(4) Melting points were determined on a calibrated Thomas-Hoover apparatus. Ultraviolet spectra were obtained using a Bausch and Lomb Spectronic 505. The infrared spectra were determined as Nujol mulls, using a Perkin-Elmer 137 spectrophotometer. Microanalyses by Schwartzkopf Microanalytical Laboratory, Woodside, N. Y.

(5) J. G. Everett, *J. Chem. Soc.*, 2406 (1930).

(6) I. G. Farbenindustrie, German Patent 612,544 (1935); *Chem. Abstr.*, **30**, 733 (1936).

(7) R. M. Herbst, C. W. Roberts, and E. J. Harvill, *J. Org. Chem.*, **16**, 139 (1951).

(8) D. B. Murphy, *ibid.*, **29**, 1613 (1964).

Isomeric Steroidal Isoxazolines by 1,3 Dipolar Cycloaddition

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Dipolar addition of nitrile oxides to unsaturated systems affords a simple method of preparing isoxazoline derivatives and has been used extensively to prepare 4,5-dihydro-1,2-oxazoles.[1] It was long believed that such cycloaddition to an asymmetric ene system resulted in only one of the two possible isomers, namely that in which the oxygen of the nitrile oxide is bonded to the

(1) C. Grundmann and P. Grünanger, "Nitrile Oxides," Springer Verlag, New York, N. Y., and Heidelberg, 1971.