yellow solid, m.p. 145–148°. Two recrystallizations from ethanol afforded pale yellow needles, m.p. 144–145°.

Anal. Calcd. for $C_{11}H_{11}N_3O_2$: C, 60.82; H, 5.10; N, 19.35. Found: C, 60.34; H, 5.14; N, 19.20.

Attempted acidic or basic hydrolysis to the known dihydroxydiacid was unsuccessful because of the great degree of stability shown by the nitrile groups.

STAMFORD, CONN.

[CONTRIBUTION FROM THE CHEMISTRY DEPARTMENT, ASSIUT UNIVERSITY]

2-Arylnaphthoxazoles and Some Other Condensed Oxazoles

ABDEL-MEGUID OSMAN AND ISMAIL BASSIOUNI

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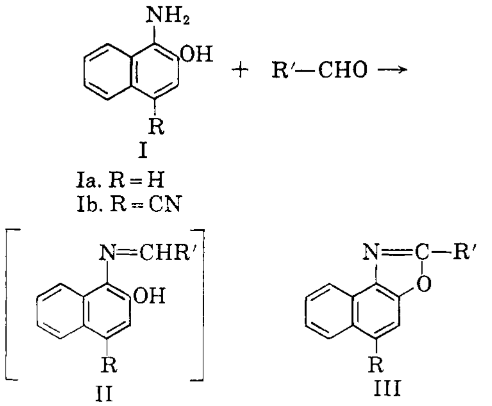
2-Arylnaphth(1,2-*d*)oxazoles (III. R = H) and their 5-cyano derivatives (III. R = CN) were synthesized by interaction of 1-amino-2-naphthol and 1-amino-2-hydroxy-4-cyanonaphthalene (1b) with aromatic aldehydes. The products exhibited strong violet or bluish-violet fluorescence in solutions. 2-Mercapto-5-cyanonaphth(1,2-*d*)oxazole (IV) was obtained by the action of potassium methyl xanthate on 1b. Interaction of 1-nitroso-2-naphthol with benzylamine gave a naphthoxazole, considered to be 2-phenyl-5-benzylaminonaphth(1,2-*d*)oxazole (VIII). Other condensed oxazoles—namely, benzoxazoles (X), benzdioxazoles (XI. R = H), 4,8-dichlorobenzdioxazoles (XI. R = Cl), phenanthroxazoles (XII), and chrysenoxazoles (XIII)—were obtained in good yields by direct fusion of aromatic aldehydes with suitable amino or imino compounds.

Continuing our work on the synthesis of condensed oxazoles[1] for their use as bacteriostatic agents and as intermediates for azo dyes, the preparation of naphthoxazoles and other condensed oxazoles was undertaken.

The chemistry of naphthoxazoles has received little attention before,[2,3] and in the following investigation, 2-arylnaphth(1,2-*d*)oxazoles[4] (III. R-H) and their 5-cyano derivatives (III. R = CN) were synthesised by the action of aromatic aldehydes on 1-amino-2-naphthol hydrochloride and 1-amino-2-hydroxy-4-cyanonaphthalene (Ib),[5] in the absence of solvents and basic catalysts. The reaction was negative with aliphatic aldehydes.

The resulting naphthoxazoles and cyanonaphthoxazoles possessed similar properties and they were characterized as follows: Their color ranged from white to pale yellow; they showed violet to bluish violet fluorescence in the organic solvents; they were remarkably stable toward acids and bases, and they sublimed unchanged in vacuum. These properties when combined with the analytical results, confirmed the oxazole structure (III. R = H or CN) assigned to these products.

Formation of these oxazoles is expected to take place through an intermediate Schiff's base (II), which is likely to undergo oxidation and instantaneous cyclization forming 2-arylnaphth(1,2-*d*)oxazoles. The reaction can be illustrated as follows:



I

Ia. R = H

Ib. R = CN

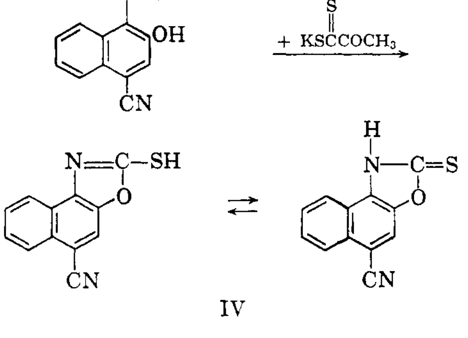
II

III

IIIa. R = H; R′ = C_6H_5; o-OHC_6H_4; p-$CH_3OC_6H_4$

IIIb. R = CN; R′ = C_6H_5; p-$CH_3OC_6H_4$; $C_6H_5CH{=}CH$; $CH_2O_2C_6H_3$

The aminonaphthols (Ia and Ib) were utilized for the preparation of mercaptonaphthoxazoles by interaction with potassium methyl xanthate. The reaction proceeded only with the cyanoaminonaphthol (Ib) giving a highly stable light yellow product which sublimed unchanged in vacuum, dissolved readily in alkalies, and precipitated unchanged on acidification. The substance showed no fluorescence in solutions. The analytical results were in full agreement with the mercaptocyanonaphthoxazole (IV).



IV

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(1) A.-M. Osman *et al.*, *J. Am. Chem. Soc.*, **79**, 966 (1957); **82**, 1607 (1960).

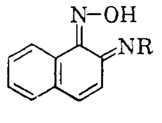
(2) N. I. Fisher *et al.*, *J. Chem. Soc.*, 962 (1934).

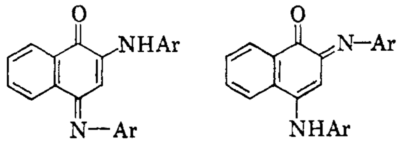
(3) O. Fischer, *J. Prakt. Chim.* (ii), **73**, 419 (1906); Fries *et al.*, *J. Soc. Chem. Ind.*, **55**, 199 (1936).

(4) These are also known as B-naphthoxazoles; *cf.* N. I. Fisher *et al.*, *J. Chem. Soc.*, 962 (1934).

(5) W. Bradely *et al.*, *J. Chem. Soc.*, 1484 (1934).

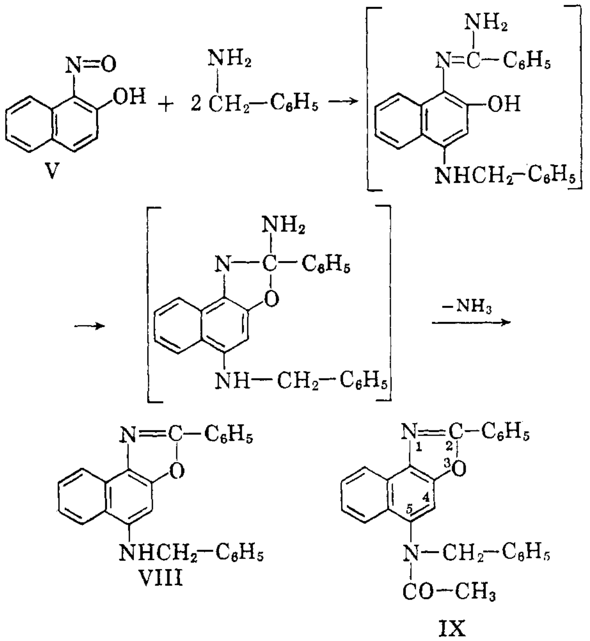
Further, a new naphthoxazole molecule was obtained by interaction of 1-nitroso-2-naphthol(V) with benzylamine. The properties of this oxazole are very similar to those of cyanonaphthoxazoles (IIIb). The reaction of nitrosonaphthol with primary amines was reported before and claimed to give products of the type (VI) in case of aliphatic amines and (VII) in case of aromatic amines.[6]


VI

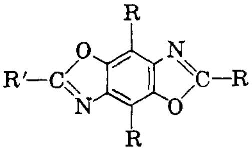

VII

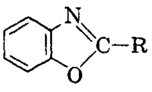
According to our preliminary studies, reinvestigation of the whole problem is necessary; however, at present we shall concentrate on the reaction of benzylamine with the nitrosonaphthol. The reaction was carried out under a variety of conditions and in all cases a yellowish product was produced which exhibited intense violet fluorescence in the organic solvents and in concentrated sulfuric acid. The product was insoluble in alkalies but soluble in concentrated acids from which it was precipitated unchanged on dilution. The substance was not reduced when heated with zinc dust-acetic acid and did not form a 2,4-dinitrophenylhydrazone derivative. These properties are characteristic of an oxazole molecule. On the other hand, the analytical results indicated the presence of two nitrogen atoms, a state which implied that two benzylamine molecules must have reacted with the nitrosonaphthol, apparently one forming the oxazole nucleus and the other entering the naphthalene nucleus probably in the form of a benzylamino group. This view was substantiated by acetylation of the product when a monoacetyl derivative was obtained which retained all the properties of the parent oxazole. Further confirmation was obtained by determination of the infrared spectra of the oxazole and its acetyl derivative. The oxazole showed a medium band at 3533 cm.$^{-1}$ indicating a secondary amino group, while that of the acetyl derivative showed the absence of this band and the presence of a very strong band at 1661 cm.$^{-1}$ which is characteristic of an amide group.[7] On this basis, a structure like (VIII) was suggested for the oxazole and (IX) for its acetyl derivative. The benzylamino group was placed at position 5 in accord with the well known reactivity of the nitroso-naphthol in this position.[5,6] However, the evidence presented is by no means conclusive and the proposed structure (VIII) is a tentative one.

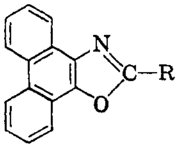
The reaction of benzylamine with the nitrosonaphthol is exceptional in this direction, a state which may be attributed to the reactivity of the methylene group of benzylamine. The reaction was accompanied by the liberation of ammonia which was proved by different methods (see Experimental). Considering these facts, the reaction can be suggested to proceed as follows:

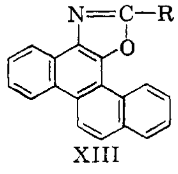


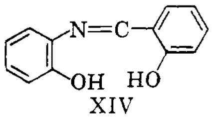
The work on oxazoles was extended to the general synthesis of condensed oxazoles by the fusion method—*i.e.*, heating the reactants in absence of solvents and basic catalysts. The method was applied satisfactorily to a variety of condensed oxazoles such as benzoxazoles (X), benzdioxazoles (XI. R = H), 4,8-dichlorobenzdioxazoles (XI. R = Cl), phenanthroxazoles (XII), and chrysenoxazoles (XIII). The reaction was smooth and the yields were high, except for one case, namely that of *o*-aminophenol with salicylaldehyde, whereby the Schiff base (XIV) was obtained instead of the corresponding oxazole. This could be attributed to the high resistance of the Schiff base (XIV) toward oxidation under the reaction conditions, thus pre-


XI
R=H or Cl


X


XII


XIII


XIV

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(6) O. Fischer and D. Weris, *J. Prakt. Chim.* [2], **100**, 168 (1922); Bromme, *Ber.*, **22**, 390 (1888).

(7) L. I. Bellamy, *The Infrared Spectra of Complex Molecules*, Methuen, London, 1954, p. 212; H. Gilman, *Org. Chem.* (Book), Vol. III, p. 140 (1953).

TABLE I

Naphth(1,2-*d*)-oxazoles	Solvent of Crystn.	M.P.	Yield, %	Formula	Carbon, %		Hydrogen, %		Nitrogen, %	
					Calcd.	Found	Calcd.	Found	Calcd.	Found
2-Phenyl-[b]	A[a]	130–131	50	$C_{17}H_{11}ON$	83.24	83.22	4.52	4.56	5.71	5.95
2-(*o*-Hydroxyphenyl)-[c]	B	215–220	45	$C_{17}H_{11}O_2N$	78.15	77.81	4.24	4.5	5.36	5.30
2-(3,4-Oxymethylenephenyl)[b]	C	198	60	$C_{17}H_{11}O_3N$	74.73	74.87	3.83	3.94	4.84	4.86
2-Phenyl-5-cyano-[c]	D	191–193	90	$C_{19}H_{12}ON_2$	79.98	80.32	3.73	3.90	10.37	10.60
2-Anisyl-[c]	E	196	92	$C_{19}H_{12}O_2N_2$	75.99	75.85	4.03	4.45	9.33	9.32
2-(3,4-Oxymethylenephenyl)[c]	E	228	94	$C_{19}H_{10}O_3N_2$	72.61	72.51	3.15	3.42	8.90	8.88
2-Cinnamyl-[c]	E	115	60	$C_{20}H_{12}ON_2$	81.06	81.35	4.08	4.27	9.46	9.89

[a] A, aqueous methanol; B, alcohol or toluene; C, benzene–petroleum ether (b.p. 60–80°); D, petroleum ether (100–120°); E, petroleum ether (80–100°). [b] Colorless needles. [c] Pale yellow needles.

venting cyclization and transformation to the oxazole (X. R = C_6H_4OH).[8]

EXPERIMENTAL

2-Arylnaphth(1,2-d)oxazoles (III. R = H). A pure sample of 1-amino-2-naphthol hydrochloride (one mole) was covered with the aromatic aldehyde (4 moles) and heated in the direct flame for about three minutes, whereby the aminonaphthol hydrochloride dissolved completely. The reaction mixture was cooled. If a solid deposited, it was collected and dried; otherwise, the reaction mixture was extracted with petroleum ether (b.p. 100–120°), the extracts were evaporated and the residue was titrated with a small amount of methanol to remove any resins, then cooled, and the solid material was collected. Crystallization was effected from a suitable solvent. The results are summarized in table 1. The products showed an intense violet fluorescence in benzene and a bluish-violet fluorescence in concentrated sulphuric acid.

1-Amino-2-hydroxy-4-cyanonaphthalene (Ib).[5] A suspension of 60 g. of 1-nitroso-2-naphthol in 500 ml. water was treated with a solution of 150 g. of potassium cyanide in 400 ml. water and the mixture maintained at 80–90° during one and one-half hour. The nitrosonaphthol passed into a clear brownish yellow solution from which ammonia was evolved. The cooled filtered liquid was acidified with 150 ml. concentrated hydrochloric acid. The light brown precipitate was collected and crystallized from hot water (boiling should be avoided as resinification would take place) into cream needles, m.p. 198–200°.

Anal. Calcd. for $C_{11}H_8ON_2$: C, 71.72; H, 4.38; N, 15.21. Found: C, 72.01; H, 4.56; N, 15.03.

2-Aryl-5-cyanonaph(1,2-d) oxazoles (III. R = CN). A mixture of 1-amino-2-hydroxy-4-cyanonaphthalene (2 g.) and the aromatic aldehyde (10 g.) was heated in the direct flame for three to five minutes. The excess aldehyde was removed and the reaction mixture was cooled and then treated with a small amount of alcohol. The precipitated solid was collected and crystallized from a suitable solvent forming cream or pale yellow crystals which showed intense violet fluorescence in benzene and bluish-violet fluorescence in concentrated sulphuric acid. Yields were almost quantitative. The results are included in Table I.

Attempted reaction of Ia *and* Ib *with aliphatic aldehydes.* A pure sample of Ia or Ib was covered with the aliphatic aldehyde and refluxed for about one hour. The excess aldehyde was removed and the reaction mixture was cooled and the deposited material was collected. It proved to be unchanged material by acetylation and determination of melting points and mixed melting points with authentic acetyl derivatives.

Action of hydrochloric acid on 2-arylnaphthoxazoles. A sample of (III. R = H or CN) was refluxed in excess concentrated hydrochloric acid for about thirty minutes then cooled and the solid substance was collected. After crystallization it was found to be unchanged oxazole by melting point and mixed melting point determinations.

Action of sodium hydroxide on 2-arylnaphthoxazoles. A sample of III was heated in excess of alkali (10%) for more than half an hour. After cooling, the solid material was collected, washed thoroughly, and recrystallized from a suitable solvent. It proved to be unchanged material by melting point and mixed melting point determinations.

2-Mercapto-5-cyanonaphth(1,2-d) oxazole (IV). A solution of potassium methyl xanthate was prepared by dissolving 0.9 g. of potassium hydroxide in a mixture of 15 ml. of methyl alcohol and of 2.5 ml. of water. To this mixture one g. of carbon disulfide was added and the solution was refluxed for about 15 hours with 3 g. of 1-amino-2-hydroxy-4-cyanonaphthalene, after which the reaction mixture was boiled with charcoal, cooled, and filtered. The clear filtrate was heated whereby 2.5 ml. of glacial acetic acid was added and the precipitated cream substance was filtered, washed with water followed by alcohol, and then dried. It was crystallized from nitrobenzene into pale cream clusters of very fine long needles, m.p. 280–300°.

Anal. Calcd. for $C_{12}H_6ON_2S$: C, 62.21, H, 2.65, N, 12.03, S, 14.1. Found. C, 62.55; H, 2.55; N, 12.42; S, 13.69.

Reaction of 1-nitroso-2-naphthol with benzylamine. A solution of 3.5 g. (one mole) of pure 1-nitroso-2-naphthol (crystallized from petroleum ether, b.p. 60–80°) in 60 ml. of alcohol was refluxed with 4.2 g. (2 moles) of benzylamine for about one hour. The reaction mixture was concentrated, cooled, and the precipitated violet product was collected and washed with few drops of methanol when the violet color was removed and the substance acquired a yellow color (13. g.). It was crystallized from alcohol or benzene (charcoal) giving light yellow needles considered to be 5-benzylamino-2-phenylnaphth(1,2-*d*)oxazole (VIII), m.p. 218°. The oxazole exhibited intense violet fluorescence in the organic solvents and in concentrated sulfuric acid. The substance was moderately soluble in the usual solvents and was very stable in acids and alkalies. It also sublimed unchanged in vacuum.

The oxazole was also obtained when the above reaction was carried out in benzene, acetic acid, or aqueous methanol.

Anal. Calcd. for $C_{24}H_{18}ON_2$: C, 82.26; H, 5.18; N, 8.00. Found: C, 82.17; H, 5.10; N, 7.94, 7.98.

The ammonia evolved during the reaction was detected as follows: The forgoing experiment was repeated using very pure 1-nitroso-2-naphthol, benzylamine which has been distilled over solid potassium hydroxide, and freshly distilled absolute alcohol. After refluxing for half an hour, about one third of the alcohol was distilled and received in an ice-salt cooled receiver. The ammonia was detected in this distillate as follows: (i) by its smell and by litmus paper test; (ii) on adding a few milliliters of the alcoholic solution to a freshly prepared Nessler's solution, a brown precipitate characteristic of ammonia was obtained; and (iii) on addition of a small volume of the distillate to a very dilute alcoholic solution of

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[8] *Cf.* F. Stephens *et al.*, *J. Chem. Soc.*, 1722 (1950).

TABLE II

Type of Oxazole	Solvent of Crystn.	M.P.	Yield, %	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen % Calcd.	Hydrogen % Found	Nitrogen, % Calcd.	Nitrogen, % Found
				Benzoxazoles						
2-Phenyl-	A	102	80	$C_{13}H_9ON$	80.0	79.68	4.65	4.43	7.18	6.84
2-Anisyl-	B	99	83	$C_{14}H_{11}O_2N$	74.66	74.34	4.88	4.52	6.22	5.97
				Benzdioxazoles						
2,6-Diphenyl-	A	325	Quant.	$C_{20}H_{12}N_2O_2$	76.91	76.90	3.87	3.64	8.97	8.55
2,6-Dianisyl-	C	317	Quant.	$C_{22}H_{16}O_4N_2$	70.96	70.79	4.33	4.08	7.52	7.77
2,6-Di(3,4-oxymethyl-enephenyl)-[b]	D	330	Quant.	$C_{22}H_{12}O_6N_2$	66.00	66.54	3.02	3.22	7.00	6.85
2,6-Dianisyl-4,8-dichloro-	D	330	85	$C_{22}H_{14}O_4N_2Cl_2$	59.86	59.53	3.19	2.87	6.34	6.36
2,6-Di(3,4-oxymethyl-enephenyl)-4,8-dichloro	D	Very high	Quant.	$C_{22}H_{10}O_6N_2Cl_2$	56.28	55.76	2.13	2.42	5.97	6.03
2,6-Di(*o*-hydroxyphenyl)-4,8-dichloro-[b]	A	242–244	Quant.	$C_{20}H_{10}O_4N_2Cl_2$	58.11	57.74	2.41	2.17	6.75	6.93
				Chrysenoxazole						
2-(*o*-Hydroxyphenyl)-	A	275	80	$C_{25}H_{15}O_2N$	83.08	83.01	4.18	3.94	3.88	3.81
2-Cinnamyl	E	245	70	$C_{27}H_{17}ON$	87.3	87.12	4.6	4.31	3.8	3.46
				Phenanthroxazole						
2-Anisyl-	A	232	60	$C_{22}H_{15}O_2N$	81.1	80.81	4.65	4.40	4.31	4.12

[a] A, benzene; B, dilute ethanol; C, acetic acid; D, nitrobenzene; E, benzene–petroleum ether (b.p. 40–60°). [b] Not prepared before.

p-benzoquinone and ethyl malonate an intense blue color indicative of ammonia was produced.[9]

Acetyl derivative of VIII.—Five-tenths gram of VIII was mixed with 1.5 g. of fused sodium acetate and 7 ml. of acetic anhydride and the mixture was refluxed for fifteen minutes and then poured onto ice-cold water and left to stand for few hours. The deposited yellow solid was collected, dried and crystallized from methyl alcohol as lemon yellow clusters of needles, m.p. 166.° Yield, quantitative. The acetyl derivative exhibited very strong violet fluorescence in benzene and in concentrated sulfuric acid.

Anal. Calcd. for $C_{26}H_{20}O_2N_2$; C, 79.57; H, 5.14; N, 7.14. Found: C, 78.86, 78.88; H, 4.93, 5.01; N, 7.40, 7.15.

Benzoxazoles (X). A pure sample of *o*-aminophenol was just covered with the aromatic aldehyde and heated for two minutes in the direct flame. The reaction mixture was cooled, filtered, washed with a small amount of alcohol, and crystallized (Table II). In case of salicylaldehyde, the resulting product was orange in color and it was identified as the Schiff's base 2-salicylalaminophenol (XIV), m.p. and mixed melting point with an authentic sample[8] was 183°.

Anal. Calcd. for $C_{13}H_{11}O_2N$: C, 73.22; H, 5.16; N, 6.58. Fonnd: C, 72.99; H, 4.94; N, 6.73.

The Schiff's base was decomposed readily into salicylaldehyde and *o*-aminophenol by warming with concentrated hydrochloric acid.

Benzdioxazoles (XI. R = H) *and dichlorobenzdioxazoles* (XI. R = Cl). A pure sample of 2,5-diaminobenzoquinone or its 3,6-dichloroderivative (one mole) was mixed with the aromatic aldehyde (4 moles) and refluxed for twenty minutes (oil bath) at a temperature 10° higher than the boiling point of the aldehyde. In case of piperonal, the reaction was carried out by heating the reactants in the direct flame (2–3 minutes). The reaction mixture was cooled and then treated with a small amount of alcohol. The precipitated product was collected and crystallized from a proper solvent (Table II).

The benzdioxazoles and the 4,8-dichloro derivatives gave intense violet fluorescence in different solvents; they were insoluble in aqueous sodium hydroxide but readily soluble in concentrated hydrochloric acid from which they percipitated unchanged on dilution.

Phenanthroxazoles (XII) *and chrysenoxazoles* (XIII). A pure sample of the corresponding quinoneimine was covered with the aromatic aldehyde and refluxed for twenty minutes and then cooled. The formed oxazole was filtered and then crystallized (Table II). These oxazoles were stable in acids and bases.

ASSIUT, U. A. R. EGYPT

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(9) A. M. Osman, *Bull. Sc. Tech., Assiut Univers.*, 1, 41 (1958); R. Craven, *J. Chem. Soc.*, 1665 (1931).