TABLE I

ION-EXCHANGE CHROMATOGRAPHY OF SYNTHETIC LYSINE-VASOPRESSIN

Tube no.	Act. before lyophil.	Wt. after lyophil., mg.	Pressor act. after lyophil., units/mg.	Total pressor act. in fract., units
41, 42	2,200	9.5	245	2,300
43–46	20,500	68.0	275	18,500
47–50	14,500	50.0	280–300	14,500
51–60	11,500	43.5	290	12,500
61–70	2,500	11.5	250	2,900
Recovery		182.5		50,700

Lysine-vasopressin.—The recrystallized protected nonapeptide VI (500 mg.) was dissolved in liquid ammonia (500 ml.) which had been distilled from sodium. Sodium was added in small quantities over a period of 20 to 40 minutes until a permanent blue color remained for 3 minutes, approximately 50 mg. of sodium being necessary. Glacial acetic acid (0.25 ml.) was added and the ammonia was then evaporated to a small volume (20–30 ml.). The rest of the ammonia was evaporated from the frozen state on a water pump with a KOH drying jar between pump and flask. This left the solid material in a loose and porous form. In order to remove last traces of ammonia the flask was kept under reduced pressure for another 1–2 hr. and then dry nitrogen was admitted. To remove most of the thiocresol the residue was washed twice with ethyl acetate (250 ml.) which had been freshly distilled from calcium chloride. The residue was then quickly dissolved in 1 l. of oxygen-free, redistilled water at 0°. The *p*H of the solution (4.5–5.0) was adjusted to 6.5–6.8 with dilute ammonia and air was then passed through the solution for 4 hr. The solution contained approximately 100,000 pressor units.[8] The *p*H was adjusted to 4.0 with acetic acid and the solution was passed through an IRC-50 (XE-64) column (1.9 × 23.5 cm.) in the H^+ form for desalting.[10] The column was washed with 0.25% acetic acid (400 ml.) until the *p*H of the effluent reached approximately 3.0 and then with water (25 ml.). The hormone was eluted with a 30% pyridine–4% acetic acid solution. The eluate (about 20 ml.) was lyophilized to a product (401 mg.) with a pressor activity of approximately 250 units per mg., or a total of about 100,000 pressor units.

Purification of Lysine-vasopressin by Ion-exchange Chromatography.—The above material (250 mg., containing approximately 62,500 pressor units) was dissolved in 1 ml. of 0.5 *M* ammonium acetate buffer, *p*H 6.38 (20°) and placed on an IRC-50 (XE-64) column (1.9 × 43.5 cm.) which had been equilibrated with the buffer. The chromatogram was developed with the same buffer at room temperature with a flow rate of 4 ml. per hour. The volume per fraction was 3.2 ml. The eluates were analyzed by determination of ultraviolet absorption (275 mμ), Folin–Lowry color reaction (700 mμ) and pressor activity. One single sharp peak was obtained in each case. The curves for the three determinations coincided closely, indicating that the material was a single compound. The contents of the peak tubes Nos. 41 + 42, 43–46, 47–50, 51–60, and 61–70 were pooled and lyophilized three times to remove the ammonium acetate. The pressor activities of the fractions are summarized in Table I. The recovery of activity in these fractions was 81 % and the recovery in terms of weight, 73%.

Tests of Purity of Synthetic Lysine-vasopressin.—The material was subjected to paper electrophoresis[18] on Whatman No. 3 MM paper with 0.1 *M* pyridine–acetate buffer of *p*H 4.0 at 400 volts and was found to travel as a single spot (15.5 cm. in 13 hr). Paper chromatography with the system butanol–acetic acid–water (4:1:5) showed the chromatographically purified material to travel as a single spot (R_F 0.12–0.16), whereas the material before chromatography contained a small amount of slow-moving impurities (R_F 0.02).[19] Amino acid analysis, on the starch column,[20] of hydrolysates of the synthetic product before and after ion-exchange chromatography showed the following amino acid content, expressed in molar ratios (with the ratio for glycine arbitrarily taken as 1 and the ratios for the product before chromatography given in parentheses): phenylalanine 1.0 (0.9), tyrosine 1.0 (0.9), proline 1.0 (0.8), glutamic acid 1.1 (0.9), aspartic acid 1.2 (1.0), glycine 1.0, lysine 1.0 (1.0), cystine 0.9 (0.9) and ammonia 3.4 (2.8).

The specific rotation of the synthetic material in 1 *N* acetic acid was $[\alpha]^{21.5}D$ −23.0° (*c* 0.5). It was found that 1 *N* acetic acid was a more satisfactory solvent than water, which had hitherto been used,[2] for determining the rotation of lysine-vasopressin.

A sample of the purified material was dried at 100° over P_2O_5 for 8 hr. for analysis.

Anal. Calcd. for $C_{46}H_{65}N_{13}O_{12}S_2 \cdot C_2H_4O_2$: C, 51.7; H, 6.23; N, 16.4. Found: C, 51.5; H, 6.35; N, 16.5.

(18) S. P. Taylor, Jr., V. du Vigneaud and H. G. Kunkel, *J. Biol. Chem.*, **205**, 45 (1953).

(19) Sometimes material remains at the origin. This is due to secondary reactions during the drying of the vasopressin solution on the paper. The difficulty can be overcome by using buffered paper and applying the hormone solution just before the solvent front moves over the starting line.

(20) S. Moore and W. H. Stein, *J. Biol. Chem.*, **178**, 53 (1949).

NEW YORK, N. Y.

[CONTRIBUTION FROM THE LABORATORY OF ORGANIC CHEMISTRY, THE UNIVERSITY OF NEW MEXICO, AND THE BIOMEDICAL RESEARCH GROUP,[3] LOS ALAMOS SCIENTIFIC LABORATORY, UNIVERSITY OF CALIFORNIA]

Liquid Scintillators. XI. 2-(2-Fluorenyl)-5-aryl-substituted Oxazoles and 2-(2-Fluorenyl)-5-phenyl-1,3,4-oxadiazole[1]

BY MARTIN D. BARNETT,[2] GUIDO H. DAUB, F. NEWTON HAYES AND DONALD G. OTT

RECEIVED AUGUST 21, 1959

Fluorene-2-carboxylic acid (I) has been prepared, either by treatment of 2-acetylfluorene with one equivalent of iodine in excess pyridine followed by basic cleavage of the intermediate pyridinium salt (II), or by direct carboxylation of fluorene with oxalyl chloride. The reaction of fluorene-2-carbonyl chloride (III) with the appropriate α-aminoketone salt (IV) gave 1-(2-fluorenyl)-4-aryl-2-aza-1,4-butanediones (V) which were cyclized to the respective oxazoles (VI) with phosphorus oxychloride. 2-(2-Fluorenyl)-5-phenyl-1,3,4-oxadiazole (X) was prepared by cyclization of 1-benzoyl-2-(fluorene-2-carbonyl)-hydrazine (IX), obtained by the reaction of III with benzoylhydrazine. The oxazoles and oxadiazole were evaluated as primary liquid scintillation solutes. In addition, 5-(4-biphenylyl)-2-(2-fluorenyl)-oxazole (VIb), 2-(2-fluorenyl)-5-(1-naphthyl)-oxazole (VIc) and 2-(2-fluorenyl)-5-(2-naphthyl)-oxazole (VId) were screened as potential secondary solutes. The compounds exhibited excellent scintillation characteristics.

The 2,5-diaryl-substituted oxazole nucleus (VI) has received much attention[4–8] in the study of organic compounds as solutes in scintillation detector systems. Comparison of a 2,5-diaryloxazole with a similarly electronically constituted

(1) From the dissertation presented by Martin D. Barnett to the graduate faculty of The University of New Mexico in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

(2) Graduate Research Assistant under Los Alamos Contract SC-5 with The University of New Mexico.

(3) Work done in part under the auspices of the U. S. Atomic Energy Commission.

TABLE I

1-(2-FLUORENYL)-4-ARYL-2-AZA-1,4-BUTANEDIONES (V), Ar-$\overset{O}{\overset{\|}{C}}CH_2NH\overset{O}{\overset{\|}{C}}$-2-FLUORENYL

Compound	Ar	M.p.,[a] °C.	Yield, %	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Recrystn. solvent
Va	Phenyl	206–208	54	80.71	81.02	5.24	5.41	Ethyl acetate
Vb	4-Biphenylyl	270–272	34	83.35	83.32	5.25	5.12	Pyridine
Vc	1-Naphthyl	[b]	..	...	...	..	..	.....
Vd	2-Naphthyl	231–233	48	82.74	82.91	5.07	5.01	Pyridine
Ve	Mesityl	196–200	61	81.27	81.07	6.27	6.41	Toluene

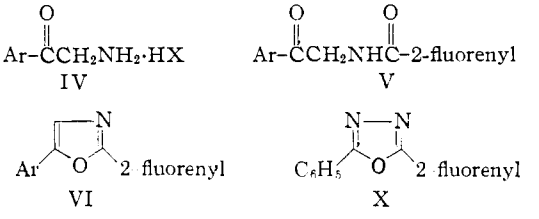
[a] Uncorrected. [b] Crude product was converted directly to the oxazole.

p-diarylbenzene shows both a greater solubility and a longer wavelength fluorescence spectrum for the oxazole. A better match results between the fluorescence spectrum of the solution and the response curve of the photomultiplier in a typical liquid scintillation detector. Also, the increase in mean-free-path of the longer wave length photons increases the probability of the photon reaching the photomultiplier before being absorbed by the solution. Because of the relative insolubility of the various 2- and 2,7-aryl-substituted fluorenes reported in a previous communication,[9] the synthesis of some 2-(2-fluorenyl)-5-aryl-substituted oxazoles was undertaken.

The literature does not record a convenient synthesis of fluorene-2-carboxylic acid (I), a required starting reagent, although several preparations have been reported. Schiessler and Eldred[10] have reduced fluorenone-2-carboxylic acid, available from the potassium dichromate[11] or potassium hypochlorite[10] oxidation of 2-acetylfluorene,[12] to I in 43% yield by a modified Wolff–Kishner reduction. Ray and Rieveschl[13] reduced the keto-acid to 9-hydroxyfluorene-2-carboxylic acid with a mixture of zinc dust and alcoholic potassium hydroxide, followed by phosphorus and iodine reduction of the hydroxy-acid to I in an over-all 64% yield. Recently, Morrison[14] has reported the preparation of I by the reduction of ethyl fluorenone-2-carboxylate with phosphorus and hydriodic acid. Morrison[15] has also obtained I in 20% yield by carbonation of 2-fluorenylmagnesium bromide. Gray and Ibbotson[16] have carried out the controlled oxidation of 2-acetylfluorene to I in good yield using cold potassium hypobromite. The latter two methods, however, appear to be applicable only on a small scale.

In this work, compound I was prepared by two different methods, both of which gave the acid in good yield from readily available starting materials. 2-Acetylfluorene[12] was allowed to react with one equivalent of iodine in excess pyridine[17] and the crude [2-(2-fluorenyl)-2-oxoethyl]-pyridinium iodide (II) thus obtained was warmed with aqueous potassium hydroxide to give, after acidification, a 75% over-all yield of I. The reaction of fluorene with oxalyl chloride in the presence of anhydrous aluminum chloride[18] afforded I in 73% yield. This latter method represents the most direct preparation of I and gives a crude product which is superior, both in quality and yield, to any reported thus far.

The preparation of the 2-(2-fluorenyl)-substituted oxazoles was carried out according to published procedures.[4,8] Fluorene-2- carbonyl chloride (III), prepared from I and thionyl chloride, was allowed to react with various α-aminoketone salts (IV) in refluxing anhydrous pyridine and the resulting 1-(2-fluorenyl)-4-aryl-2-aza-1,4-butanediones (V) (Table I) cyclized to the desired 2-(2-fluorenyl)-5-aryl-substituted oxazoles (VI) (Table II) by heating with phosphorus oxychloride. In this manner, the following oxazoles were prepared: 2-(2-fluorenyl)-5-phenyloxazole (VIa), 5-(4-biphenylyl)-2 (2-fluorenyl)-oxazole (VIb), 2-(2-fluorenyl)-5-(1-naphthyl)-oxazole (VIc), 2-(2-fluorenyl)-5-(2-naphthyl)-oxazole (VId) and 2-(2-fluorenyl)-5-mesityl-oxazole (VIe).

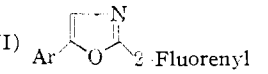


Three of the five required α-aminoketone salts phenacylammonium chloride (IVa), 1-naphthacylammonium bromide (IVc) and 2-naphthacylammonium bromide (IVd), were commercially available. 4-Phenylphenacylammonium bromide (IVb) was prepared in 62% yield by allowing 4-phenylphenacyl bromide to react with hexamethylenetetramine and hydrolyzing the hexamine salt thus obtained with 48% hydrobromic acid. The synthesis of N-(2-mesityl-2-oxoethyl)-ammonium bromide (IVe) was accomplished in 76% yield by the basic cleavage[19] of N-(2-mesityl-2-oxoethyl)-

(4) F. N. Hayes, B. S. Rogers and D. G. Ott, THIS JOURNAL, **77**, 1850 (1955).
(5) F. N. Hayes, D. G. Ott, V. N. Kerr and B. S. Rogers, *Nucleonics*, **13**, No. 12, 38 (1955).
(6) F. N. Hayes, D. G. Ott and V. N. Kerr, *ibid.*, **14**, No. 1, 42 (1956).
(7) D. G. Ott, F. N. Hayes and V. N. Kerr, THIS JOURNAL, **78**, 1941 (1956).
(8) D. G. Ott, F. N. Hayes, E. Hansbury and V. N. Kerr, *ibid.*, **79**, 5448 (1957).
(9) M. D. Barnett, G. H. Daub, F. N. Hayes and D. G. Ott, *ibid.*, **81**, 4583 (1959).
(10) R. W. Schiessler and N. R. Eldred, *ibid.*, **70**, 3958 (1948).
(11) G. Rieveschl, Jr., and F. E. Ray, "Organic Syntheses," Coll. Vol. III, John Wiley and Sons, Inc., New York, N. Y., 1955, p. 420.
(12) G. Rieveschl, Jr., and F. E. Ray, "Organic Syntheses," Coll. Vol. III, John Wiley and Sons, Inc.,,New York, N. Y. 1955, p. 23.
(13) G. Rieveschl, Jr., and F. E. Ray, THIS JOURNAL, **65**, 836 (1943).
(14) D. C. Morrison, *J. Org. Chem.*, **23**, 1772 (1958).
(15) D. C. Morrison, THIS JOURNAL, **74**, 3430 (1952).
(16) G. W. Gray and A. Ibbotson, *J. Chem. Soc.*, 3228 (1957).
(17) L. C. King, THIS JOURNAL, **66**, 894 (1944).
(18) C. Liebermann, *Ber.*, **45**, 1204 (1912).
(19) G. Drefal and F. Fischer, *Ann.*, **610**, 166 (1957).

TABLE II

2-(2-FLUORENYL)-5-ARYLOXAZOLES (VI)



Compound[a]	Ar	M.p.,[b] °C.	Yield,[c] %	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
VIa	Phenyl	185–186	53	85.41	85.37	4.89	4.91
VIb	4-Biphenylyl	236–238	54	87.25	87.43	4.97	5.10
VIc	1-Naphthyl	162–164	62[d]	86.88	87.04	4.77	4.95
VId	2-Naphthyl	187–190	46	86.88	86.74	4.77	4.72
VIe	Mesityl	146–147	39	85.44	85.32	6.02	6.08

[a] Maxima and (log ϵ) values for the ultraviolet absorption spectra are: VIa, 222 (4.16), 228 (4.15), 237(s) (3.86), 244 (3.45), 272 (3.91), 318(s) (4.46), 333(s) (4.61), 344 (4.66), 361 mμ (4.37); VIb, 224 (4.26), 283 (4.08), 342(s) (4.81), 350 (4.84), 368 mμ(s) (4.53); VIc, 228(s) (4.51), 258(s) (3.78), 298 (4.25), 322 mμ (4.61); VId, 227 (4.72), 246 (4.05), 264 (4.24), 273(s) (4.15), 284 (4.33), 295 (4.41), 345(s) (4.75), 355 (4.80), 374(s) mμ (4.49); VIe, 220 (4.35), 310(s) (4.56), 320 (4.66), 332 mμ (4.62). [b] Uncorrected. [c] From the corresponding 1-(2-fluorenyl)-4-aryl-2-aza-1,4-butanedione (V). All oxazoles were recrystallized from isopropyl alcohol except VIb, which was recrystallized from toluene. [d] From crude 1-(2-fluorenyl)-4-(1-naphthyl)-2-aza-1,4-butanedione (Vc).

phthalimide (VII)[20] to N-(2-mesityl-2-oxoethyl)-phthalamic acid (VIII), followed by hydrolysis of VIII with 48% hydrobromic acid.

In addition to the above oxazoles, 2-(2-fluorenyl)-5-phenyl-1,3,4-oxadiazole (X) was prepared from III and benzoylhydrazine in 21% over-all yield *via* the hydrazine IX.

Experimental[21]

Fluorene-2-carboxylic Acid (I). (a) From 2-Acetylfluorene.—A mixture of 15.7 g. (0.0755 mole) of 2-acetylfluorene,[12] 19.2 g. (0.0755 g.-atom) of iodine and 50 ml. of dry C.P. pyridine was warmed on a steam-bath for 0.5 hr., then allowed to stand overnight, and evaporated to near-dryness under reduced pressure.[17] A small portion of the residual brown solid was recrystallized three times from aqueous *n*-propyl alcohol to give an analytical sample of **[2-(2-fluorenyl)-2-oxoethyl]-pyridinium iodide (II)** as faint orange needles, m.p. 264–267°.

Anal. Calcd. for $C_{20}H_{16}ONI$: C, 58.12; H, 3.90; N, 3.39. Found: C, 57.91; H, 3.71; N, 3.33.

The remaining solid was warmed on a steam-bath with 31.0 g. of 85% C.P. potassium hydroxide in 300 ml. of water for 1.0 hr., treated with Norit, filtered, cooled, and acidified. The light tan fluorene-2-carboxylic acid (I), m.p. 270–275° (reported[10] m.p. 271–275°), weighed 12.4 g. (75%).

(b) From Fluorene.—Seventeen and three-tenths grams (0.13 mole) of anhydrous technical aluminum chloride was added portionwise to a stirred solution of 20.8 g. (0.125 mole) of fluorene (m.p. 112–114°) and 31.7 g. (0.25 mole) of oxalyl chloride (Eastman Kodak Co. 1436) in 400 ml. of dry carbon disulfide maintained at 1–3°.[18] After addition was complete, the mixture was stirred at 1–3° for an additional 0.5 hr., then at room temperature for 24 hr., and decomposed by pouring over a slurry of ice and dilute hydrochloric acid. The solvent was removed by steam distillation and the tan residue extracted with several portions of warm 10% potassium hydroxide. The extracts were filtered, and the filtrate was acidified with concentrated hydrochloric acid to give, after drying overnight at 120°, 19.2 g. (73%) of nearly colorless fluorene-2-carboxylic acid (I), m.p. 277–279°.

Fluorene-2-carbonyl Chloride (III).—A solution of 10.1 g. (0.048 mole) of I, m.p. 270–275°, 150 ml. of purified thionyl chloride and 1 ml. of dry pyridine was refluxed for 7.0 hr. After removal of the unreacted thionyl chloride under reduced pressure, the brown residue was extracted with several portions of boiling petroleum ether (b.p. 90–120°), the hot extracts filtered, and the filtrate concentrated to yield 7.75 g. of **fluorene-2-carbonyl chloride (III)** as faint yellow needles, m.p. 126–129°. From the filtrate there was obtained a second crop (1.80 g.) which, after recrystallization from petroleum ether (b.p. 90–120°), afforded an additional 1.20 g., m.p. 126–128°, for an over-all yield of 81%. The analytical sample, recrystallized twice from petroleum ether (b.p. 90–120°), melted at 128–129°. Ray and Rieveschl[13] report a m.p. of 182° for this compound but do not give an analysis.

Anal. Calcd. for $C_{14}H_9OCl$: C, 73.53; H, 3.97. Found: C, 73.35; H, 4.03.

4-Phenylphenacylammonium Bromide (IVb).—To a stirred solution of 55.0 g. (0.20 mole) of 4-phenylphenacyl bromide (Eastman Kodak Co. 3297) in 500 ml. of dry chloroform was added 28.0 g. (0.20 mole) of U.S.P. hexamethylenetetramine. Within 15 min., the salt began precipitating from the solution which was stirred at room temperature for 5.0 hr. After filtering and washing with cold chloroform, the air-dried colorless salt weighed 78.0 g. The salt was stirred at 60° for 38 hr. with 350 ml. of 48% hydrobromic acid, after which the suspension was poured into ice-water, filtered, and dried. Crystallization from 50% aqueous *n*-propyl alcohol gave 36.0 g. (62%) of 4-phenylphenacylammonium bromide (IVb) as a light tan powder. The component appeared to char at about 240° and was not completely melted at 300°.

N-(2-Mesityl-2-oxoethyl)-phthalamic Acid (VIII).—Thirty and seven-tenths grams (0.10 mole) of N-(2-mesityl-2-oxoethyl)-phthalimide (VII),[20] m.p. 179–181°, was refluxed with 7.9 g. (0.12 mole) of 85% C.P. potassium hydroxide in 500 ml. of water for 15.0 hr. during which time the solid had dissolved.[19] The bright yellow solution was cooled in ice, filtered, and the filtrate acidified with dilute hydrochloric acid. The granular, light yellow solid was filtered, washed with water, and air-dried to yield 32.5 g. (100%) of **N-(2-mesityl-2-oxoethyl)-phthalamic acid (VIII)**, m.p. 137–141°. An analytical sample, m.p. 137–141°, was prepared by reprecipitation several times from sodium hydroxide solution with dilute hydrochloric acid.

Anal. Calcd. for $C_{19}H_{19}O_4N$: C, 70.14; H, 5.89; N, 4.32. Found: C, 69.28; H, 5.98; N, 4.29.

N-(2-Mesityl-2-oxoethyl)-ammonium Bromide (IVe).—A mixture of 21.5 g. (0.066 mole) of VIII and 300 ml. of 48% hydrobromic acid was refluxed for 17 hr., after which the colorless solution was evaporated to dryness under reduced pressure. The residual solid was dissolved in about 150 ml. of hot water, filtered, and the filtrate allowed to cool to room temperature. Removal of the crystallized phthalic acid and evaporation of the filtrate to dryness gave a nearly colorless residue which was subjected to Soxhlet extraction with ether for 12 hr. The undissolved solid was recrystallized from isopropyl alcohol to yield a total of 13.1 g. (76%) of **N-(2-mesityl-2-oxoethyl)-ammonium bromide (IVe)** as colorless plates, m.p. 200–220°.

The benzamide of IVe, prepared by refluxing the salt with an equimolar quantity of benzoyl chloride in dry C.P. pyridine, was recrystallized from petroleum ether (b.p. 60–90°) to give an analytical sample, m.p. 95–97°.

Anal. Calcd. for $C_{18}H_{19}O_2N$: C, 76.84; H, 6.81. Found: C, 77.36; H, 6.98.

General Procedure for Preparation of Oxazoles.—One-hundredth of a mole each of III and the appropriate α-aminoketone salt (IV) were refluxed for 0.5 hr. in 20 ml. of

(20) Kindly supplied by Mr. Vernon Kerr, Biomedical Research Group, Los Alamos Scientific Laboratory.

(21) Melting points are uncorrected. Ultraviolet absorption spectra were determined in cyclohexane at concentrations of *ca.* 3×10^{-5} *M* in 1-cm. silica cells using a Beckman DK-1 recording spectrophotometer.

dry C.P. pyridine, allowed to cool, and the mixture poured into water. The precipitated solid was collected, washed with water, and dried. Recrystallization provided the desired 2-aza-1,4-butanedione (V), which was cyclized to the corresponding oxazole (VI) by refluxing with 25 ml. of redistilled phosphorus oxychloride for 1.5 hr. The solution was cautiously poured into 300 ml. of water with vigorous stirring. The crude oxazole was dissolved in benzene, chromatographed through a short alumina column and, after removal of the solvent under reduced pressure, the residue recrystallized to provide analytically pure oxazole.

1-Benzoyl-2-(fluorene-2-carbonyl)-hydrazine (IX).—A mixture of 1.15 g. (0.0084 mole) of benzoylhydrazine (Eastman Kodak Co. 7536), 1.92 g. (0.0084 mole) of III and 25 ml. of dry C.P. pyridine was refluxed for 0.5 hr., cooled, and poured into water. The precipitated solid, after being washed with water and air-dried, was recrystallized three times from toluene to provide 1.60 g. (58%) of **1-benzoyl-2-(fluorene-2-carbonyl)-hydrazine (IX)** as tiny, faint yellow needles, m.p. 223–225°.

Anal. Calcd. for $C_{21}H_{16}O_2N_2$: C, 76.81; H, 4.91. Found: C, 77.24; H, 5.14.

5-(2-Fluorenyl)-2-phenyl-1,3,4-oxadiazole (X).—One and two-tenths grams (0.0037 mole) of IX was refluxed for 2.0 hr. with 25 ml. of redistilled phosphorus oxychloride and the warm reaction mixture poured slowly into 500 ml. of water. The solid, after being washed with water and air-dried, was dissolved in benzene and chromatographed on a short alumina column. Evaporation of the eluates to dryness and two recrystallizations of the residue from isopropyl alcohol gave 0.40 g. of **5-(2-fluorenyl)-2-phenyl-1,3,4-oxadiazole (X)** as nearly colorless tufts, m.p. 163–163.5°. Maxima and (log ϵ) values for the ultraviolet absorption spectrum are: 221 (4.22), 224 (4.20), 241 (3.50), 265 (3.78), 308 (4.55), 323 (4.68) and 340 mμ (4.41).

Anal. Calcd. for $C_{21}H_{14}ON_2$: C, 81.27; H, 4.55. Found: C, 81.27; H, 4.68.

Discussion

Conventional scintillation performance tests were run on the oxazoles and the oxadiazole. The results are given in Table III and include both peak relative pulse heights as primary solutes and single determinations of pulse height as secondary solutes. The latter test was applied only to the three solutes (VIb, c and d), with the longest wave lengths of fluorescence. The fluorescence measurements are reported as wave lengths of both the maximum (most probable) and the mean (most representative) for the corrected spectrum of each solute in toluene at *ca.* 1 g./l. excited by the 315 mμ Hg line.

The oxazoles and oxadiazole prepared in this study had solubility characteristics which permitted determination of their maximum relative pulse-heights (I_m) before their solubility limits were reached. The compounds proved to be excellent scintillation solutes, although their I_m values were somewhat lower than those previously reported[5] in which the 2-(2-fluorenyl)–group has been replaced by a 2-(4-biphenylyl)–moiety. Thus, 2-(2-fluorenyl)-5-phenyloxazole (VIa) exhibited an I_m of 0.97 at 2.8 g./l., while 2-(4-biphenylyl)-5-phenyloxazole had a peak value of 1.18 at 8.0 g./l. Similarly, 5-(2-fluorenyl)-2-phenyl-1,3,4-oxadiazole (X) had an I_m of 0.96 at 3.2 g./l., as compared with 1.28 at 10.0 g./l. for 5-(4-biphenylyl)-2-phenyl-1,3,4-oxadiazole. It would appear, therefore, that replacement of a 4-biphenylyl group by the 2-fluorenyl group at the 2-position of the oxazole nucleus results in a scintillator which is more susceptible to concentration quenching.

TABLE III

SCINTILLATION AND FLUORESCENCE SPECTRAL DATA

Compound	I_m[a]	c_m[b]	I[a,c]	λ_{max}, mμ	$\bar{\lambda}$, mμ	TiO_2/Al,[d] (g./l.)
VIa	0.97	2.8	..	396, 413	418	1.18 (3)
VIb	1.12	4.1	1.18	413, 433	432	1.19 (3)
VIc	1.10	6.9	1.21	420, 436(s)	436	1.24 (3.6)
VId	1.07	5.0	1.20	410, 430	427	1.22 (3.6)
VIe	1.00	7.4	..	400, 416(s)	410	1.19 (3.6)
X	0.96	3.2	..	370, 386	388	1.05 (3.6)

[a] Relative to 3 g./l. of 2,5-diphenyloxazole (PPO) in toluene. [b] Concentration in g./l. at I_m. [c] Evaluation at 0.1 g./l. in toluene containing 4 g./l. *p*-terphenyl. [d] Ratio of relative pulse height using titanium dioxide reflector to relative pulse height using aluminum reflector[5] (at specified concentrations).

It is of interest to note that 5-(4-biphenylyl)-2-(2-fluorenyl)-oxazole (VIb) (I_m = 1.12 at 4.1 g./l.) was actually a better scintillation solute than the related 2,5-di-(4-biphenylyl)-oxazole (I_m = 0.88 at 1.4 g./l.). However, the I_m value for the latter compound was obtained at saturation and would most likely exceed 1.12 if the relative pulse-height curve could be extrapolated to a higher concentration. The three oxazoles evaluated as secondary solutes (Table III) displayed excellent characteristics in this capacity.

Acknowledgments.—The authors are indebted to Dr. Wright H. Langham of the Los Alamos Scientific Laboratory for making laboratory facilities available to them, and to Miss Elizabeth Hansbury and Mr. Vernon N. Kerr, also of the Los Alamos Scientific Laboratory, for technical assistance. Financial support from the Industrial Hygiene Laboratory of Sandia Corporation, as well as encouragement from Mr. William H. Kingsley of that laboratory, was also greatly appreciated.

ALBUQUERQUE, N. MEX.
LOS ALAMOS, N. MEX.