Infrared (ir) spectra were taken using a Perkin-Elmer Model 337 spectrophotometer in Nujol mulls, unless otherwise stated. The nmr spectra were recorded on a Varian A-60A spectrometer using tetramethylsilane as an internal reference. Thin layer chromatography (tlc) was carried out on microscopic slides employing Kieselgel G (Merck) as absorbent. The spots could be detected on the chromatogram from the color of the compounds.

Tetrahydrofuran was refluxed over lithium aluminum hydride and distilled before use. *t*-Butylamine was refluxed over potassium hydroxide and distilled. Dimethyl sulfoxide-d_6 (99.5% deuterated) was obtained from Stohler Isotope Chemicals and used directly.

Trinitroanisole was prepared by nitration of 2,4-dinitroanisole and recrystallized from methanol, mp 67–67.5° (lit.[10] mp 67–68°). Phenyl picryl ether was obtained in 85% yield from picryl chloride and alcoholic sodium phenoxide: mp 157–158° (lit.[11] mp 153°); nmr (DMSO-d_6, 10%) δ 9.26 (s, 2), 7.26 (m, 5).

Picryl Mesityl Ether.—Picryl mesityl ether was prepared by the method just mentioned in 80% yield: mp 154–155°; nmr (DMSO-d_6, 10%) δ 9.13 (s, 2), 6.93 (s, 2), 2.23 (s, 3), 2.06 (s, 6).

Anal. Calcd for $C_{12}H_{13}N_3O_7$: C, 51.87; H, 3.74; N, 12.10. Found: C, 52.12; H, 3.62; N, 12.01.

Neutral Meisenheimer Complex Ia.—Picryl phenyl ether (1 g, 0.0032 mol) in 2.75 ml of tetrahydrofuran (1 *M* sol) at −60° was treated with 0.233 g of *t*-butylamine in 3.18 ml of tetrahydrofuran (1 *M* sol) also at −60°. The nmr spectrum of the mixture was recorded at −57°: δ 11.9 (br, 1, NO_2H), 8.40 (s, 2 at C-3, C-5), 6.96 (m, 5), 6.06 (br, 1, NH), 1.16 (s, 9).

When a second portion of amine solution was added to the picryl phenyl ether solution, the signals δ 11.9 and 6.06 were replaced by 4.06 (br, 3), but the other peaks remained at the same places.

Other Meisenheimer complexes (Ib–d) were formed in like manner at Dry Ice temperatures.

N-β-Hydroxy-*t*-butyl-2,4,6-trinitroaniline (IIb).—A methanol (100 ml) solution of trinitroanisole (5.0 g, 0.021 mol) and 2-amino-2-methyl-1-propanol (1.83 g, 0.021 mol) was kept at room temperature for 30 min. Removal of the methanol gave 6.15 g (90%) of the substituted picramide IIb, mp 95–100°. Two recrystallizations from absolute ethanol gave a yellow compound, mp 106–108.5°, pure by tlc (R_f 0.38 on Kieselgel G; solvent, benzene with 5% methanol). The impure picramide has been made before from picryl chloride and the same amino alcohol[12] but has not been characterized.

Anal. Calcd for $C_{10}H_{12}N_4O_7$: C, 40.00; H, 4.03; N, 18.66. Found: C, 40.59, H, 4.38; N, 17.61, 17.58.

It is not unusual to find low nitrogen content by analysis in compounds that are explosive, and the purity of the picramide IIb was confirmed by the absence of stray peaks in the nmr spectrum: nmr ($CDCl_3$, 5.4%) δ 1.30 (s, 6), 2.11 (unresolved triplet, 1, OH), 3.48 (diffuse doublet, 2, CH_2), 8.41 (br, 1, NH), 8.97 (s, 2). The NH proton moved downfield 5 cps by the addition of a trace of pyridine, whereas the OH signal spread into a broad band between δ 2.83 and 1.97. The methylene doublet changed into a sharp singlet indicating that the coupling between OH and CH_2 protons ceased after pyridine addition.

The ir spectrum of IId showed a broad OH and NH band at 3600–3100 cm^{-1} and the primary alcohol band at 1042 cm^{-1}.

When excess amino alcohol was used in the reaction with trinitroanisole the reaction did not stop at the picramide stage but formed 5,7-dinitro-3,3-dimethylbenzomorpholine by cyclic elimination of the elements of nitrous acid. Stronger bases give higher yields of dinitrobenzomorpholines.[12] The structure of 5,7-dinitro-3,3-dimethylbenzomorpholine has been previously proved[12] but is here substantiated by an nmr spectrum (deuterioacetone, 3.5%): δ 1.52 (s, 6), 3.72 (s, 1, NH), 4.10 (s, 2), 7.77 (d, J = 3 Hz, C-8), 8.63 (d, J = 3 Hz, C-6). The NH proton was unaffected by the addition of pyridine.

The picramide IIa[13] was made in a similar manner: mp 94–95°; 95%; nmr ($CDCl_3$) δ 1.56 (s, 9), 3.33 (br, 1, NH), 8.53 (s, 2).

Trimethyl-β-hydroxy-*t*-butylammonium Picrate (IIIa) and Hydrochloride (IIIb).—Trinitroanisole (5 g, 0.021 mol) in 16 ml of dry toluene was brought to reflux, and 1.4 g (0.015 mol) of 2-amino-2-methyl-1-propanol in 10 ml of toluene was added dropwise in 20 min and then refluxed 0.5 hr more. Removal of the solvent gave a brown viscous oil. The oil was dissolved in a minimum of methanol and triturated with ether to give 1.1 g (19%) of crude trimethyl-β-hydroxy-*t*-butylammonium picrate, mp 225–228° dec. Recrystallization from methanol–ether and then methanol gave a pure sample, mp 245–246° dec. The picrate is slightly soluble in water. Tlc (R_f 0.43 on Kieselgel G; solvent, 1-propanol–chloroform–water 2:1:0.2) gave a single spot.

With an excess of trinitroanisole and slow addition of the amino alcohol, the yield of the picrate was raised to 36%: nmr (deuterioacetone, 5%) δ 1.53 (t, 6, $J_{^{14}NH\beta}$ = 2 Hz), 3.33 [s, 9, $N(CH_3)_3$], 3.93 (t, 2, $J_{^{14}NH\beta}$ = 2 Hz), 8.63 (s, 2 aromatic). At δ 2.95 a broad peak, possibly due to the OH signal, became sharp after addition of pyridine.

The picrate was converted into trimethyl-β-hydroxy-*t*-butylammonium chloride by treatment with hydrochloric acid. Two recrystallizations from methanol–ethyl acetate and one from ethanol gave a white product: mp 242–245° dec; nmr (methanol-d_4) δ 1.45 (t, 6, $J_{^{14}NH\beta}$ = 2 Hz), 3.20 (s, 9) 3.81 (t, 2, $J_{^{14}NH\beta}$ = 2 Hz).

Anal. Calcd for $C_7H_{18}NOCl$: C, 50.14; H, 10.82; N, 8.35. Found: C, 50.21; H, 10.78; N, 8.16.

Methyl-β-hydroxy-*t*-butylammonium Picrate (IIIc).—The mother liquor from the preparation of the trimethylated derivative of 2-methyl-2-amino-1-propanol (previous paragraph) was concentrated and triturated with chloroform. On standing (with refrigeration) 1.1 g (21%) of the monoalkylated derivative was obtained as the picrate. Repeated recrystallization gave the analytical sample: mp 174–176°; nmr (deuterioacetone, 10%) δ 1.47 (s, 6), 2.86 (s, 3, N–CH_3), 3.76 (s, 2, CH_2), 8.71 (s, 2, aromatic). The remaining three protons appeared in two broad diffuse curves at 7.26–8.6 (1 H) and 4.0–5.2 (1 < H < 2) but were brought together in a nicely rounded peak of the correct integrated area centered at δ 6.06 by the addition of pyridine. The R_f value of 0.46 was observed for the compound when the previously mentioned tlc system was used.

Anal. Calcd for $C_{11}H_{16}N_4O_8$: C, 39.74; H, 4.86; N, 16.87. Found: C, 39.56; H, 5.04; N, 17.02.

N,N-Dimethyl-*t*-butylammonium Picrate (IIId).—In the manner just described 4.08 g (0.02 mol) of trinitroanisole and 0.73 g (0.01 mol) of *t*-butylamine gave 2.27 g (50%) (after recrystallization from methanol) of N,N-dimethyl-*t*-butylammonium picrate, mp 278–280° dec. The analytical sample was sublimed at 150° (0.06 mm): nmr (DMSO-d_6, 10%) δ 1.33 (s, 9), 2.76 (s, 6, NCH_3), 3.03 (s, 1, NH), 8.60 (s, 2).

Anal. Calcd for $C_{12}H_{18}N_4O_7$: C, 43.63; H, 5.45; N, 16.96. Found: C, 44.11; H, 5.33; N, 17.17.

From the toluene solution, a 21% yield of N-*t*-butyl-2,4,6-trinitroanisole (IIa) was recovered. The yield of IIId was not changed when 0.05 mol of trinitroanisole was used in a similar experiment.

Registry No.—Picryl mesityl ether, 17691-66-6; 5,7-dinitro-3,3-dimethylbenzomorpholine, 17691-69-9; Ia, 17691-67-7; IIb, 17691-68-8; IIIa, 17691-70-2; IIIb, 17691-71-3; IIIc, 17691-72-4; IIId, 17691-73-5.

Acknowledgment.—We had the benefit of valuable conversations with Dr. Ronald G. Lawler concerning the spectra reported in this paper.

(10) E. Chapman, A. G. Perkins, and R. Robinson, *J. Chem. Soc.*, 3030 (1927).

(11) C. Willgerodt, *Ber.*, **12**, 1277 (1879); C. L. Jackson and R. B. Earle, *Am. Chem. J.*, **29**, 212 (1903).

(12) H. R. Jurgens, A. L. Burton, A. Eichenbaum, and L. B. Clapp, *J. Org. Chem.*, **25**, 1710 (1960).

(13) I. D. Rae, *Aust. J. Chem.*, **18**, 1807 (1965).

1-Methyl-4-phenyl-2(1H)-quinazolinone

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In the course of investigations in the quinazoline field we discovered an interesting series of reactions leading to 1-methyl-4-phenyl-2(1H)-quinazolinone (**4**),

a compound which to our knowledge has not been described previously in the literature.

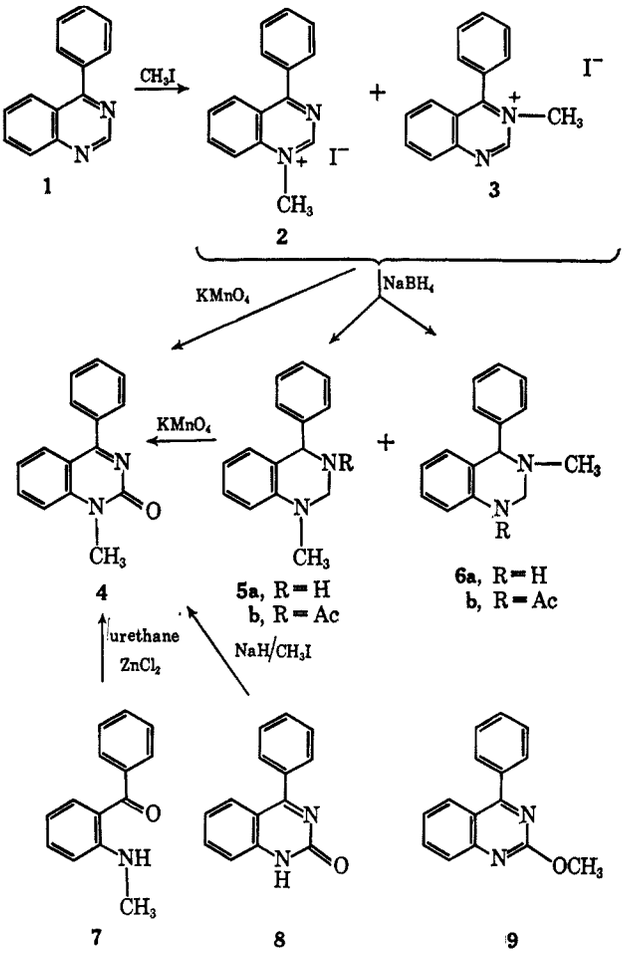
Refluxing 4-phenylquinazoline (1) with methyl iodide resulted in a highly crystalline product which, according to nmr evidence (two distinct methyl singlets in an integration ratio of approximately 7:1), consisted of a mixture of the two methiodides **2** and **3**. Our tentative assignment of structure **2** to the major component is (a) based on the limited number of quaternization experiments of 4-substituted quinazolines reported in the literature,[1,2] which invariably resulted in quaternization of N-1 and (b) substantiated by the lower magnetic field position of the stronger methyl signal.

This is the first time to our knowledge that a 4-substituted quinazoline is shown to give a mixture of the N-1 and the N-3 methiodide. It must be pointed out, however, that the experimental evidence in previous quaternizations of this type[1,2] does not prove exclusive reaction at N-1, since the salts obtained were characterized only by melting point and elemental analysis. In particular no nmr spectra are mentioned in those investigations. Based on our finding it seems quite probable that those quaternary salts also contained some of the N-3 isomer. Unfortunately we have not been able to separate our mixture of methiodides by fractional crystallization or by chromatography owing to their very similar physical properties.

Unambiguous proof of structure **2** for the major product of quaternization was obtained through further chemical transformations. Reduction to the 1,2,3,4-tetrahydroquinazoline stage was achieved with sodium borohydride under mild conditions and in essentially quantitative yield.[3] It was obvious from the nmr spectrum that the expected 7:1 mixture (oil) of 1-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (**5a**) and 3-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (**6a**) has resulted (Scheme I). Again the lower field position of the stronger methyl signal points to 1-methyl 4-phenyl-1,2,3,4-tetrahydroquinazoline (**5a**) as the major product. The individual components **5a** and **6a** were obtained as colorless oils by column chromatography of this mixture on silica gel and were characterized by conversion into the crystalline acetyl derivatives **5b** and **6b**, respectively. The nmr spectra of the free bases (**5a**, **6a**) and their N-acetyl derivatives (**5b**, **6b**) conclusively confirmed our originally tentative assignment of structures **2** and **5a** as the major products. It is interesting to note that the C-2 methylene group appears in the 1-methyl compounds (**5a**, **5b**) as a singlet while in the 3-methyl compounds (**6a**, **6b**) it occurs as an AB pattern (J_{AB} = 11 cps).

We now intended to reintroduce the 3,4 double bond in **5a** by oxidation with potassium permanganate. This oxidation led, however, in good yield to a compound $C_{15}H_{12}N_2O$, the infrared spectrum of which showed an amide carbonyl absorption at 1665 cm^{-1} and a C=N

SCHEME I



absorption at 1610 cm^{-1}. Microanalysis and ir and nmr spectra are consistent with the structure of 1-methyl-4-phenyl-2(1H)-quinazolinone (**4**). The closest analogy to this type of oxidation might be considered the conversion of 3-phenyl-1,2,3,4-tetrahydroquinazoline into 3-phenyl-4(3H)-quinazolinone[4] with potassium permanganate. The 2(1H)-quinazolinone **4** was also isolated on direct oxidation of the quaternary salt **2** with permanganate, although in lower yield. We assume that the latter oxidation is initiated by covalent hydration across the 1,2 double bond in analogy to the proposed mechanism[5] of mild oxidation of a number of quinazolines, not substituted in position 4, to 4(3H)-quinazolinones. Characteristically, the permanganate oxidation of either 4-phenyl-3,4-dihydroquinazoline or 4-phenyl-1,2,3,4-tetrahydroquinazoline, under both acidic or alkaline conditions, gave exclusively 4-phenylquinazoline (**1**); *i.e.*, the oxidation did not proceed beyond the quinazoline stage. This strongly indicates that covalent hydration at C-2 plays a significant role only when N-1 is quaternized.

Two other independent synthetic pathways, namely (a) condensation of 2-methylaminobenzophenone (**7**) with urethan and (b) N-methylation of 4-phenyl-2(1H)-quinazolinone (**8**) through its sodium salt, provided 1-methyl-4-phenyl-2(1H)-quinazolinone (**4**), which was in every respect identical with the product of potassium permanganate oxidation of **2** or **5a**. The

(1) W. L. F. Armarego, "Heterocyclic Compounds," Vol. XXIV, Interscience Publishers, New York, N. Y., 1967, p 56.

(2) G. F. Duffin, *Advan. Heterocycl. Chem.*, **3**, 29 (1964).

(3) In our hands, sodium borohydride has proved very satisfactory for the reduction of a number of other quinazolines, *e.g.*, 3,4-dihydroquinazoline, 4-phenylquinazoline (**1**), and 4-phenyl-3,4-dihydroquinazoline, to the corresponding 1,2,3,4-tetrahydroquinazolines. We are aware of only one publication on metal hydride reductions of quinazolines by R. F. Smith, P. C. Briggs, R. A. Kent, J. A. Albright, and E. J. Walsh, *ibid.*, **2**, 157 (1965), the results of which do not appear to be very conclusive.

(4) C. Paal and M. Busch, *Ber.*, **22**, 2683 (1889).

(5) See ref 1, p 54.

methylation of 4-phenyl-2(1H)-quinazolinone (**8**) also gave a less polar by-product (approximately 5% yield) which was isolated from the mother liquor by chromatography on aluminium oxide and identified by ir and nmr spectral analysis as 2-methoxy-4-phenylquinazoline (**9**). Both O- and N-alkylation of quinazolinones have been reported previously[6] and reflect the lactam–lactim tautomerism of these systems. Steric factors seem to influence the ratio of N- to O-alkylation drastically. When we treated, *e.g.*, the sodium salt of **8** with isopropyl iodide, 2-isopropoxy-4-phenylquinazoline became the major reaction product while 1-isopropyl-4-phenyl-2(1H)-quinazolinone was obtained in only 1–2% yield.

We have applied the methods mentioned above to the preparation of numerous variously substituted 2(1H)-quinazolinones with excellent results. These will be published elsewhere[7] in connection with a discussion of their biological activities.

Experimental Section

Melting points were determined on a Thomas–Hoover capillary melting point apparatus and are not corrected. Ultraviolet spectra were measured on a Model 14 Cary spectrophotometer in alcoholic solution; infrared spectra, on a Model 237 Perkin-Elmer spectrophotometer in methylene chloride; nmr spectra, in deuteriochloroform solution, (unless otherwise stated) with tetramethylsilane as an internal standard, on a Varian A-60 instrument. Microanalyses were carried out in our analytical unit.

4-Phenylquinazoline (1).—A solution of 2.3 g (14.6 mmol, 10% excess) of potassium permanganate in 44 ml of water was added within 5 min at room temperature to 4.16 g (20 mmol) of 4-phenyl-3,4-dihydroquinazoline,[8] dissolved in 200 ml of pure dioxane. After standing for 1 hr the slight excess of $KMnO_4$ was destroyed with a few drops of formic acid; the dioxane solution was filtered from the inorganic precipitate; and this filtrate was evaporated to dryness *in vacuo*. The obtained residue was dissolved in 50 ml of methylene chloride and extracted twice with sodium bicarbonate solution. The organic phase was dried over anhydrous sodium sulfate, filtered, and evaporated. From ether, 3.65 g (89%) of 4-phenylquinazoline resulted as coarse white crystals, mp 99–100°.[9] In the ir (CH_2Cl_2) typical quinazoline bands[10] at ν_{max} 1485, 1565, and 1615 cm^{-1} were observed.

Anal. Calcd for $C_{14}H_{10}N_2$: C, 81.5; H, 4.9; N, 13.6. Found: C, 81.4; H, 5.2; N, 13.5.

1-Methyl-4-phenylquinazolinium Iodide (2).—A solution of 7.30 g (35 mmol) of 4-phenylquinazoline in 50 ml of methyl iodide was refluxed for 6 hr. The crystalline reaction product was filtered off and washed with diethyl ether (7.73 g), mp 183–184° dec. From the filtrate an additional amount (2.80 g) of the same product was obtained (85% total). On recrystallization from methylene chloride–ethyl acetate yellow prisms, mp 180° dec, resulted. In the nmr spectrum ($CDCl_3/CD_3SOCD_3$) the methyl group appeared as two singlets at δ 4.77 and 4.35 in a ratio of *ca.* 7:1. By the same token the proton on C-2 showed up as two singlets at δ 10.41 and 9.90 in the same ratio. The product obtained represented therefore a mixture of 1-methyl-4-phenylquinazolinium iodide (**2**) and 3-methyl-4-phenylquinazolinium iodide (**3**) in a ratio of 7:1.

Anal. Calcd for $C_{15}H_{13}IN_2$: C, 51.7; H, 3.8; N, 8.0. Found: C, 51.4; H, 3.7; N, 7.8.

1-Methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (**5a**).—To a solution of 7.73 g (22 mmol) of 4-phenylquinazoline methiodide (mixture as described in previous experiment) in 100 ml of ethanol and 50 ml of methylene chloride were added 2.5 g of sodium borohydride in several portions at room temperature. After stirring for an additional 45 min at room temperature the excess sodium borohydride was carefully decomposed by addition of acetic acid. The solution was then concentrated to a small volume *in vacuo* and distributed between methylene chloride and 0.5 *N* sodium hydroxide. The organic phase was washed with water, dried over anhydrous sodium sulfate, and evaporated to dryness *in vacuo* to obtain 5.0 g (theoretical amount) of a mixture of 1-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline and 3-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline as a colorless oil which resisted all attempt of crystallization: ir (CH_2Cl_2) ν_{max} 3350, 1610, and 1500 cm^{-1}; nmr spectrum singlets at δ 2.78 and 2.35 (CH_3), 3.95 and 3.73 (2 H), 5.10 and 4.50 (1 H), of all these pairs of singlets appearing in a ratio of *ca.* 7:1. This mixture was used without further purification in the following permanganate oxidation.

In an other experiment the crude reduction mixture (3.0 g) was separated on a column of 150 g of silica gel, using chloroform as an eluent. The efficiency of the separation was followed by tlc.

From the first fractions 1.8 g of fairly pure 1-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (**5a**) were obtained as a colorless oil, which resisted all attempts of crystallization. In nmr ($CDCl_3$) singlets appeared at δ 2.80 (N_1–CH_3) and 4.0 (methine H). Acetylation with acetic anhydride–pyridine at room temperature gave 3-acetyl-1-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (**5b**): mp 89–91° (from ether); ir (CH_2Cl_2) ν_{max} 1605 cm^{-1} (amide); nmr ($CDCl_3$) singlets at δ 2.20 (acetyl) and 2.92 (N–CH_3).

Anal. Calcd for $C_{17}H_{18}N_2O$: C, 76.7; H, 6.8; N, 10.5. Found: C, 76.3; H, 6.7; N, 10.4.

Later fractions yielded 0.42 g of practically pure 3-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (**6a**) as an oil: nmr ($CDCl_3$) singlets at δ 2.38 (N_3–CH_3) and 4.55 (C-4 methine) and AB pattern (J_{AB} = 11 cps) centered at δ 3.90 (C-2 methylene). On acetylation 1-acetyl-3-methyl-4-phenyl-1,2,3,4-tetrahydroquinazolone (**6b**) was obtained in white prisms (ether): mp 117–118°; ir (CH_2Cl_2) ν_{max} 1655 cm^{-1} (amide); nmr ($CDCl_3$) singlets at δ 2.32, 2.35 ($COCH_3$ and N–CH_3), and 2.55 (C-4 methine), AB pattern (J_{AB} = 11 cps) centered at 4.50 (C-2 methylene).

Anal. Calcd for $C_{17}H_{18}N_2O$: C, 76.7; H, 6.8; N, 10.5. Found: C, 76.5; H, 7.0; N, 10.3.

1-Methyl-4-phenyl-2(1H)-quinazolinone (4). **A. Oxidation of 1-Methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline** (**5a**) **with $KMnO_4$.**—To a solution of 4.48 g (20 mmol) of crude 1-methyl-4-phenyl-1,2,3,4-tetrahydroquinazoline (described in the previous experiment) in 180 ml of pure dioxane was added dropwise under stirring at room temperature a solution of 5.0 g of potassium permanganate in 90 ml of water. The slight excess of $KMnO_4$ (purple color persisted for 10 min after the addition) was destroyed with a few drops of formic acid. After filtration of the precipitated manganese dioxide the filtrate was concentrated *in vacuo;* methylene chloride was added; and the obtained solution was extracted with dilute sodium bicarbonate. The organic phase was dried over sodium sulfate and evaporated to dryness. The crystalline residue (3.91 g) was recrystallized from ethyl acetate to obtain 2.50 g of pure 1-methyl-4-phenyl-2(1H)-quinazolinone as pale yellow prisms, mp 142–143°. From the mother liquor 0.46 g of the same product resulted (63%): uv (ethanol) λ_{max} 230 mμ (ϵ 38,800), 270 (10,500), and 357 (5380); ir (CH_2Cl_2) 1665, and 1600 cm^{-1} (shoulder); nmr singlet at δ 3.73 (CH_3).

Anal. Calcd for $C_{15}H_{12}N_2O$: C, 76.2; H, 5.1; N, 11.9; O, 6.8. Found: C, 76.5; H, 5.3; N, 11.7; O, 7.1.

B.—Condensation of 2-Methylaminobenzophenone (**7**) **with Ethyl Carbamate.**—A mixture of 2.11 g (10 mmol) of 2-methylaminobenzophenone, 4.0 g of ethyl carbamate, and 50 mg of zinc chloride was heated for 1.5 hr to 180–190° (oil-bath temperature). The reaction mixture was distributed between methylene chloride and water; the organic phase was dried over sodium sulfate and evaporated to a crystalline residue *in vacuo*. On recrystallization from ethyl acetate 1.96 g (82%) of 1-methyl-4-phenyl-2(1H)-quinazolinone resulted, mp 141–143°. This product was identical in melting point, mixture melting point, thin layer chromatography, and infrared spectrum with the compound obtained under A.

C. Methylation of 4-Phenyl-2(1H)-quinazolinone (**8**).—The sodium salt of 4-phenyl-2(1H)-quinazolinone was prepared by heating a mixture of 222 mg (1 mmol) of 4-phenyl-2(1H)-quinazolinone and 80 mg of sodium hydride (50% suspension in

(6) See ref 1, p 235.

(7) H. Ott and E. I. Takesve, paper in preparation.

(8) T. Higashino, Yakugaku Zasshi, **80**, 245 (1960); *Chem. Abstr.*, **54**, 13125e (1960).

(9) The melting point reported for 4-phenylquinazoline by K. Schofield, *J. Chem. Soc.*, 1927 (1952), is identical with ours, but the analytical values given are incorrect.

(10) H. Culbertson, J. C. Decius, and B. E. Christensen, *J. Amer. Chem. Soc.*, **74**, 4834 (1952).

mineral oil) in 3 ml of dimethylacetamide for 15 min to 40–50°. Then 0.4 ml of methyl iodide was added, and the above temperature was maintained until this reaction mixture showed a pH of 7 (after approximately 15 min). Water was added and the aqueous phase was extracted three times with methylene chloride. The combined organic phases were dried over sodium sulfate and evaporated to dryness, and the thoroughly dried residue (240 mg) crystallized from ethyl acetate to give 120 mg (68%) of 1-methyl-4-phenyl-2(1H)-quinazolinone, mp 143°. This product was again identical in melting point, mixture melting point, thin layer chromatography, and infrared spectrum with the compound obtained under A.

Since a small amount of a less polar by-product was observed in this reaction it was repeated on a larger scale (5.2 g of **8**); most of the starting material (**8**) and the N-methyl compound (**4**) were removed from the crude mixture by crystallization, and the mother liquor (1.25 g) was chromatographed on 80 g of aluminum oxide with methylene chloride as an eluent. From the first fractions (340 mg), 2-methoxy-4-phenylquinazoline (**9**) crystallized from petroleum ether: 115 mg; mp 87–89°; typical quinazoline bands[10] in ir (CH_2Cl_2) at ν_{max} 1470, 1570, and 1615 cm^{-1}; nmr ($CDCl_3$) singlet at δ 4.20 (O-methyl).

Anal. Calcd for $C_{15}H_{12}N_2O$: C, 76.3; H, 5.1; N, 11.9. Found: C, 75.9; H, 5.2; N, 11.6.

Registry No.—**1**, 17629-01-5; **2**, 17629-02-6; **3**, 17629-03-7; **4**, 17629-04-8; **5a**, 17629-05-9; **5b**, 17629-06-0; **6a**, 17629-07-1; **6b**, 17629-08-2; **9**, 17629-09-3.

Chemiluminescence from the Reaction of Phthalimido Oxalate with Hydrogen Peroxide and Fluorescent Compounds

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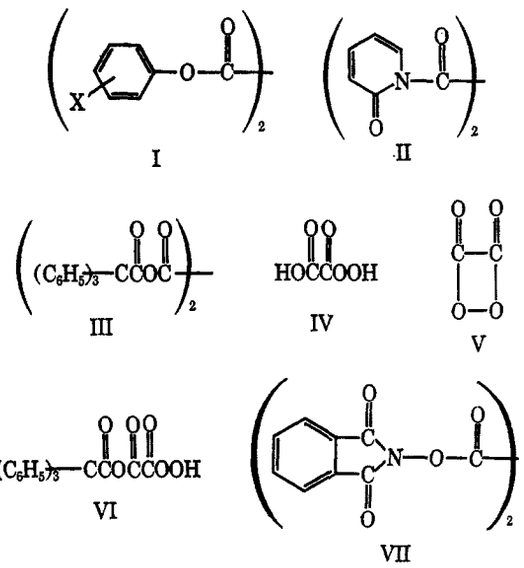
Chemiluminescence has been reported from a wide variety of organic reactions.[1] However, most reactions produce light with low efficiency. The quantum yields obtained from these classical reactions are below 0.01 einstein mol^{-1} the efficiency of the well known luminol reaction.[2] Unusually high emission efficiencies have been obtained from the reaction of several oxalic acid derivatives with hydrogen peroxide and fluorescent compounds. Electronegatively substituted aryl oxalates[3] (I), pyridonylglyoxals[4] (II), and certain oxalic anhydrides[5] (III) produced 0.24 0.16, and 0.14 einstein mol^{-1}, respectively, whereas oxalyl chloride[6] gave up to 0.05 einstein mol^{-1} and



X is an electron-withdrawing group such as $-NO_2$, $-Cl$

oxamides[7] 0.01 einstein mol^{-1}. Three peroxyoxalic acid derivatives IV, V, and VI have been suggested as intermediates depending on the oxalic acid derivative and reaction conditions.[3,5,6] The concerted multiple bond cleavage decomposition of these intermediates could release sufficient energy to excite a fluorescent compound.[8]

The primary requirement for peroxyoxalate chemiluminescence appears to be an oxalic acid derivative which reacts rapidly with hydrogen peroxide. However, not all reactive oxalates produce equal emission efficiency probably due to the different competing dark side reactions and possible quenching by-products. Therefore, to further examine these points and to broaden the scope of peroxalate chemiluminescence we prepared diphthalimido oxalate VII.

Esters of N-hydroxyphthalimide react rapidly with amino acid esters and are useful intermediates of peptide synthesis.[9] Thus, diphthalimido oxalate might be expected to react readily with hydrogen peroxide and could conceivably give chemiluminescence in the presence of a fluorescer.

Preliminary qualitative experiments indicated that VII indeed produced chemiluminescent light on reaction with hydrogen peroxide and 9,10-diphenylanthracene in dimethyl phthalate solution. The light intensity was increased by bases and quenched by strong acids. A similar base–acid effect was observed in connection with the oxalic ester reaction.[3] A good agreement of the chemiluminescence and fluorescence spectra indicates that the light-emitting species is the first singlet excited state of the fluorescer.

Absolute quantum yield measurements were carried out in dimethyl phthalate and the results are collected in Table I. A quantum yield of 0.087 einstein mol^{-1} was obtained at 1×10^{-3} *M* phthalimido oxalate in the presence of the usually inefficient fluorescer 9,10-diphenylanthracene[3-5] [bis(2,4-dinitrophenyl)oxalate

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