ammonium hydroxide to the hydrochloride brought about the formation of the free base (IIIa), m.p. 180–190°. Recrystallization from 200 ml. of ethanol gave clusters of yellow-orange prisms, wt. 2.6 g. (13.1% yield based on benzaldehyde), m.p. 196–198°.

1-Acetyl-2-benzoyl-4-phenylimidazole (IV).—A mixture of 4.10 g. (0.016 mole) of 2-benzoyl-4 (or 5)-phenylimidazole (IIIa), 20 ml. of isopropenyl acetate[19] and five drops of concentrated sulfuric acid was refluxed for one hour. Acetone and excess isopropenyl acetate were removed by distillation. Recrystallization of the acetyl derivative (IV), obtained as a solid residue from the distillation, was most successful from isopropenyl acetate from which it separated as light yellow prisms, m.p. 153–155° (softening at 150°), wt. 3.98 g. (83% yield). The compound is very easily hydrolyzed; after four recrystallizations from moist benzene complete conversion to 2-benzoyl-4(or 5)-phenylimidazole occurred.

Anal. Calcd. for $C_{18}H_{14}O_2N_2$: C, 74.47; H, 4.86; N, 9.65. Found: C, 74.34; H, 4.52; N, 9.80.

Oxidation of 2-Benzoyl-4(or 5)-phenylimidazole (IIIa).—A solution of 0.16 g. (0.0006 mole) of the imidazole in 40 ml. of 9% sodium hydroxide was warmed on a steam-cone. To this solution a 6% solution of potassium permanganate was added by a dropping funnel until a purple color persisted after one hour of heating at 70° (about 35 ml. was required). The solution was cooled and the excess permanganate was discharged by the addition of 1 ml. of formalin. The precipitated manganese dioxide was removed by filtration and the filtrate acidified. After a few minutes a copious precipitate of white needles, m.p. 120–122°, was obtained. Ether extraction of the mother liquor followed by evaporation of the ether gave an additional portion of this solid. The total yield was 0.070 g. (49% yield). There was no depression in the melting point when this product was mixed with a known sample of benzoic acid.

Reduction of 2-Benzoyl-4(or 5)-phenylimidazole (IIIa).—To a solution of 1.24 g. (0.005 mole) of the imidazole in 100 ml. of refluxing isoamyl alcohol was added 8 g. of sodium in small pieces over a period of 30 minutes. The solution was kept at reflux temperature an additional half-hour to allow complete dissolution of the sodium. After about 40 minutes the solution had completely lost the yellow-orange color of the benzoyl imidazole. Acidification of the cold reaction mixture with dilute hydrochloric acid was followed by separation of the layers and distillation of isoamyl alcohol from the organic layer. The gummy residue was recrystallized from aqueous ethanol from which the colorless solid, **2-benzyl-4(or 5)-phenylimidazole** precipitated in long, colorless, felt-like needles, m.p. 158–160°, wt. 0.30 g. (26% yield). After several recrystallizations from aqueous ethanol the m.p. became constant at 161–162° with softening at 158°.

Anal. Calcd. for $C_{16}H_{14}N_2$: C, 82.02; H, 6.02; N, 11.96. Found: C, 81.97; H, 5.89; N, 11.20.

Pyrolysis of Triazoacetone and 1-Azido-3,3-dimethylbutanone-2.—Nitrogen evolution was observed when one per cent. solutions of each of these α-azidoketones in trichlorobenzene were heated between 180 and 200°. Cooling the solutions brought about the separation of a high melting (>250°) amorphous solid from the experiments on triazoacetone but only a dark viscous unidentified oil was obtained from the azidobutanone. In neither case could imidazoles be detected.

ANN ARBOR, MICHIGAN

(19) A sample of this compound was obtained from Tennessee Eastman Corporation, Kingsport, Tennessee.

CONTRIBUTION FROM THE RESEARCH LABORATORIES OF DOJINDO AND CO., LTD., AND FROM THE LABORATORY OF ORGANIC SYNTHESIS, DEPARTMENT OF APPLIED CHEMISTRY, KYUSHU UNIVERSITY]

Synthesis and Ultraviolet Absorption Spectra of Polyazobenzenes

BY KEIHEI UENO

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The ultraviolet absorption spectra of *p*-, *m*- and *o*-polyazobenzenes have been determined. Both a bathochromic effect and an increase of the extinction coefficient has been observed in the series of *p*-polyazobenzenes. There was observed only an increase of the extinction coefficient without a shift of the absorption peak in the case of *m*-polyazobenzenes. In the case of mixed *p*- and *m*-polyazobenzenes, the para effect is predominant. The results are discussed qualitatively.

Little has been reported about the relation between the structure of polyazobenzenes and their ultraviolet light absorption. A number of polyazobenzenes were synthesized by Ruggli and his co-workers[1] but a comprehensive spectroscopic study was not carried out. Since the discovery of stereoisomerism of azobenzene by Hartley,[2] Cook[3,4] has isolated the stereoisomers of azobenzene and its derivatives and determined their ultraviolet light absorption. Although he also studied the three stereoisomers of 1,4-bis-(phenylazo)-benzene, he did not examine higher members of the polyazobenzene series because of the expected complexity of the stereoisomerism, and his major interest was to study the relationships within his set of stereoisomers.

Since our purpose was to study the relationship between structure and ultraviolet light absorption of polyazobenzenes, our attention was first directed to the *trans* isomers, which are believed to be the more stable and the predominant constituent of the usual preparations. Thus the present paper reports a study of the ultraviolet light absorption of a series of *trans* isomers of *p*-, *m*- and *o*-polyazobenzenes.

In addition to Ruggli's preparations in this series, we synthesized and studied several new members. These new members were prepared by the condensation of nitronitrosobenzene with an amino compound, followed by reduction of the nitro group and condensation with nitrosobenzene. The syntheses of the compounds are illustrated on the chart, and all the compounds investigated in our absorption study are shown in Table I. The substances were purified by recrystallization to constant melting point and by chromatography on activated alumina, and samples obtained in this way were used for the spectrophotometry.

The features of the ultraviolet spectra of *p*-polyazobenzenes are given in Table I. A regular bathochromic shift as well as a regular increase of the extinction coefficient occurs as the number of *p*-phenylazo groups increases, similar to the behavior

(1) Ruggli and co-workers, *Helv. Chim. Acta*, **17**, 992 (1934); **21**, 711 (1938); **25**, 1533 (1942); **28**, 781 (1945); **30**, 739 (1947).

(2) G. S. Hartley, *J. Chem. Soc.*, 633 (1938).

(3) A. H. Cook, *ibid.*, 876 (1938).

(4) A. H. Cook and D. G. Jones, *ibid.*, 1309 (1939).

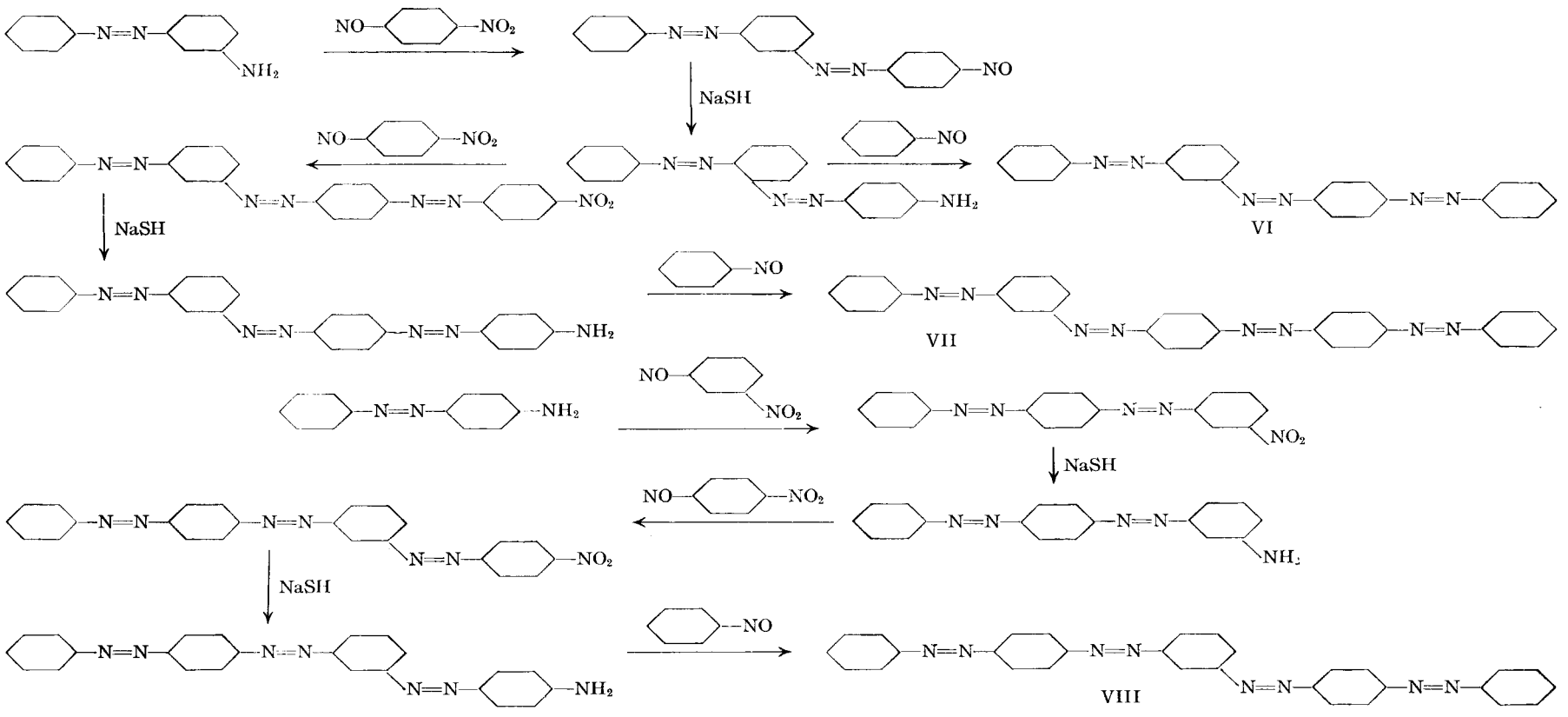

TABLE I: ULTRAVIOLET ABSORPTION OF POLYAZOBENZENES

	Material	Chromatograph Solvent[a]	Chromatograph Develop.	Sample[b]	M.p., °C.	Color	Absorption First band λ_{max}, mμ	First band $\epsilon \times 10^{-3}$	Second band λ_{max}, mμ	Second band $\epsilon \times 10^{-3}$
I	Azobenzene	P	P	E	67.5–68.0	Orange	319	20.5	440	0.5
II	4-Phenylazoazobenzene	P–B (1:1)	P–B (1:1)	E	168.5–169.0	Yellow-red	363	39.5	...	...
III	4,4′-Bis-(phenylazo)-azobenzene	B–C (1:1)	B–C (1:1)	E	236–236.5	Dark red	388	60.2	...	...
IV	3-Phenylazoazobenzene	B	B	E	80–80.5	Orange	325	41.4	445	1.0
V	3,3′-Bis-(phenylazo)-azobenzene	B–C (1:1)	B–C (1:1)	E	163.5–164.0	Yellow-brown	325	60.7	448	1.9
VI	3,4′-Bis-(phenylazo)-azobenzene	P	P	B	166–166.5	Orange-yellow	362	43.0	...	...
VII	3-Phenylazo-4′-(*p*-phenylazo)-phenylazoazobenzene	B–C (1:1)	B–C (1:1)	B	213.0–214.0	Brown-red	390	66.0	...	...
VIII	1,3-Bis-(*p*-phenylazophenylazo)-benzene	B–C (1:1)	B–C (1:1)	B	169.0–169.5	Dark red	370	50.0	...	...
IX	1,2-Bis-(phenylazo)-benzene	P–B (1:1)	P–B (1:1)	E	106.5–107.0	Red	305	35.0	...	...

[a] P, petroleum ether; B, benzene; C, chloroform. [b] E, sample was prepared from the effluent; B, sample was prepared by elution of an adsorbed band.

of other linear-conjugated systems. The absorption curve of *trans*-azobenzene has two absorption bands in the ultraviolet region,[4] a strong band at 319 mμ (K band) and a weak band at 470 mμ (R band). The former is believed to be due to conjugation between the azo group and the benzene nucleus, the latter to the azo group alone. On increasing the number of azo groups, the weak R band is overcome by the strong absorption of the more powerful chromophore which is thought of as a resonance hybrid involving the entire molecule. This results in the formation of a single, strong absorption band for the higher homologs of the *p*-polyazobenzene series.

In case of *m*-polyazobenzenes one observes no shift of the wave length of the absorption maxima, but only a regular increase of the maximum extinction coefficient as the number of *m*-phenylazo groups goes up. As in the case of the *p*-polyazobenzenes, the extinction coefficient increases linearly with the number of azo groups; also the weak band at 470 mμ shows a regular increase which, however, is not observed in the para-series. In the case of *m*-polyazobenzenes no resonance structures involving the whole molecule can be written, and each azo group can be in conjugation only with the two benzene nuclei adjacent to it. Thus the absorption curves of *m*-polyazobenzenes can be represented by arithmetical addition of the contributions of each azobenzene system, and no shift of the λ_{max}-value occurs.

In the case of mixed *p*- and *m*-polyazobenzenes (VI, VII and VIII), the wave length at maximum absorption is determined by the number of azo groups in para position, and is almost the same as that of a *p*-polyazobenzene having the same number of azo groups. The intensity of absorption is related to, and roughly proportional to, the total number of azo groups in the molecule. These results are qualitatively explained by the resonance theory according to which only *p*-linked azo groups, as stated before, contribute to the length of the chromophoric system.

The absorption of 1,2-bis-(phenylazo)-benzene is quite different from the other compounds, exhibiting a hypsochromic effect. Since this is the only example observed in the *o*-series, we do not wish to offer any interpretation of the phenomenon until more data have been obtained.

Experimental[5]

Preparation of Materials.—Substances I, II, III, IV, V and IX were synthesized according to Ruggli and his coworkers.[1]

3,4'-Bis-(phenylazo)-azobenzene (VI).—A solution of 5.3 g. of 3-aminoazobenzene in 70 ml. of ethanol and a solution of 6.0 g. of *p*-nitronitrosobenzene in 60 ml. of ethanol and 60 ml. of glacial acetic acid were mixed. The mixture became nearly solid in a few minutes, depositing 3-(*p*-nitrophenylazo)-azobenzene. The product was filtered and washed with dilute ethanol. The yellowish-brown crystals, melting at 168–170°, weighed 8.5 g. (95.5%), and were used without purification for the next step.

The nitro compound (8.5 g.) was suspended in 85 ml. of ethanol and the liquid was warmed to boiling on the water-bath. At this point, a mixture of 40 ml. of 50% sodium hydrosulfide and 40 ml. of water was added gradually during 30 minutes and the whole was refluxed for an additional hour.

(5) Melting points are uncorrected.

After the reaction, the mixture was allowed to cool and an equal volume of water was added. 3-(*p*-Aminophenylazo)-azobenzene separated and was washed with dilute ethanol. The crude crystals weighed 6.1 g. (79.0%) and melted at 124.5–125.5°, after recrystallization from ethanol.

The amino compound (5.0 g.) and 5.0 g. of nitrosobenzene was dissolved in 100 ml. of warm glacial acetic acid and allowed to stand overnight. 3,4'-Bis-(phenylazo)-azobenzene (VI) crystallized, was separated and recrystallized from glacial acetic acid. The light brown product, melting at 164.5–165.0°, weighed 4.5 g. (69%).

Anal. Calcd. for $C_{24}H_{18}N_6$: N, 31.1. Found: N, 30.7.

3-Phenylazo-4'-(*p*-phenylazo)-phenylazoazobenzene (VII).—A solution of 1.1 g. of 3-(*p*-aminophenylazo)-azobenzene in 10 ml. of glacial acetic acid and a solution of 0.7 g. of *p*-nitronitrosobenzene in 7 ml. of glacial acetic acid were mixed and allowed to stand overnight. The mixture became nearly solid, and the crystals were separated by suction, washed with acetic acid and then with ethanol. The light brown 3-phenylazo-4'-(*p*-nitrophenylazo)-azobenzene weighed 1.5 g. (95%) and melted at 210–210.5°.

A suspension of 1.0 g. of the nitro compound in 10 ml. of ethanol was reduced with 1 ml. of 40% sodium hydrosulfide as described above. After the reaction, 1 ml. of water was added and the solution allowed to stand for several hours. The crystalline mass was filtered by suction and crystallized from ethanol. The resulting 3-phenylazo-4'-(*p*-aminophenylazo)-azobenzene weighed 0.6 g. (64.5%) and melted at 180–182°.

A solution of 0.5 g. of the amino compound and 0.3 g. of nitrosobenzene in 20 ml. of glacial acetic acid was heated on the water-bath for 2 hr. After cooling, the product was filtered and washed with hot ethanol. The crude product was dissolved in benzene and an insoluble solid was removed. The benzene was evaporated from the clear reddish-brown solution, until crystals separated. Light brown crystals of 3-phenylazo-4'-(*p*-phenylazo)-phenylazoazobenzene resulted melting at 212.0–212.5° weighing 0.5 g. (82%).

Anal. Calcd. for $C_{30}H_{22}N_8$: N, 22.7. Found: N, 22.5.

1,3-Bis-(*p*-phenylazo)-phenylazobenzene (VIII).—4-Aminoazobenzene (2.5 g.) and 2.2 g. of *m*-nitronitrosobenzene was dissolved in 20 ml. of glacial acetic acid and allowed to stand overnight. The crystalline product was separated by suction, washed with acetic acid, then with dilute ethanol. The crude product, melting at 180–181°, weighed 3.5 g. (83%).

A suspension of 2.0 g. of 3-nitro-4'-phenylazoazobenzene in 20 ml. of ethanol was treated with 2 ml. of 50% sodium hydrosulfide. After cooling, an equal volume of water was added, and the crystalline mass was separated and washed with dilute ethanol. The amino compound, melting at 161–162°, weighed 1.1 g. (60%).

One gram of the amino compound and 0.8 g. of *p*-nitronitrosobenzene were dissolved in 10 ml. of glacial acetic acid and allowed to stand overnight. The crystalline 3-(*p*-nitrophenylazo)-4'-phenylazoazobenzene was filtered, washed with glacial acetic acid and then with dilute alcohol. The brown crystalline powder, melting at 204–205°, weighed 0.7 g. (48%).

A suspension of 0.7 g. of the nitro compound in 10 ml. of ethanol was treated with 1 ml. of 50% sodium hydrosulfide. After cooling an equal volume of water was added and the solid material was separated and washed with dilute ethanol. The crude product was recrystallized from pyridine. The reddish-brown crystals, melting at 118–120°, weighed 0.3 g. (46%).

The amino compound (0.3 g.) and 0.15 g. of nitrosobenzene was mixed in 7 ml. of glacial acetic acid and heated on the water-bath for 5 hours. After cooling, the crude product was separated and purified as described, using benzene as the solvent. 1,3-Bis-(*p*-phenylazo)-phenylazobenzene resulted, melting at 167.0–168.0°, weighing 0.3 g. (82%).

Anal. Calcd. for $C_{30}H_{22}N_8$: N, 22.7. Found: N, 22.1.

Chromatographic Purification.—Each azo compound was dissolved in the proper solvent as indicated in Table II, and passed through activated alumina. The developing solvents are also indicated in the same table. In each run the effluent or the lowest band was collected. In the latter case, the band was separated and eluted with chloroform containing 2% ethanol. Then, the effluent (or the eluting solvent) was removed under reduced pressure until crystals

separated, and the pure product was separated from the mother liquor. Melting points of the pure compounds are also indicated in the table.

Ultraviolet Absorption Spectrophotometry.—The sample was dissolved in chloroform, and the ultraviolet absorption was measured using a "Spekker" type spectrophotometric device and a medium sized quartz spectrograph. The cell length was 2 cm.

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KUMAMOTOSHI, JAPAN

[CONTRIBUTION FROM THE STERLING-WINTHROP RESEARCH INSTITUTE]

Quinolines. VIII.[1] 8-(3-Dimethylamino-1-methylpropylamino)-6-quinolinol and 8-(4-Diethylamino-1-methylbutylamino)-6-quinolinol

BY EDGAR A. STECK AND WERNER BOEHME[2]

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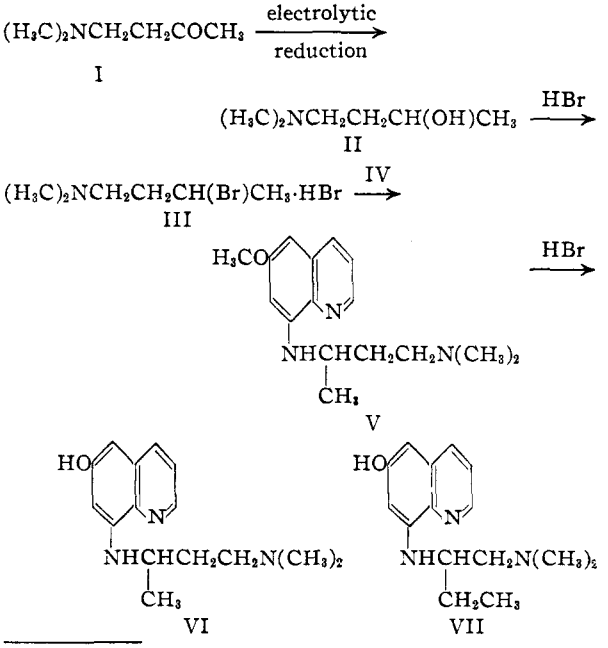
The above-named 6-quinolinols were prepared for study as potential antimalarials.

8-Amino-6-quinolinols have been studied less well than the related 8-amino-6-methoxyquinoline types. Only one compound of the 6-quinolinol type has received much attention, *viz.*, 8-(3-dimethylamino-1-methylpropylamino)-6-quinolinol (VI)[3-20] which has also been known as Oprochin, Cilional, Certuna and SN-191.[21] The lack of information on the activity of 8-(4-diethylamino-1-methylbutylamino)-6-quinolinol, the 6-quinolinol relative of Pamaquine, led us to prepare and characterize the compound and two of its salts. Absorption spectra of the two 6-quinolinols have been determined.[21a] Our work on the compounds as potential gametocides was commenced late in 1942 when only a portion of the cited literature was available. Intervening circumstances have hindered assembly of our data on the preparation of these 8-amino-6-quinolinols.

The preparation of the 3-bromo-N,N-dimethylbutylamine hydrobromide (III) from 4-dimethylamino-2-butanone (I) was accomplished by electrolytic reduction to the alcohol (II) and subsequent reaction with hydrobromic acid. Interaction of (III) with 8-amino-6-methoxyquinoline (IV) produced 8-(3-dimethylamino-1-methylpropylamino)-6-methoxyquinoline (V), which has been called Ceprochin.[17c] The latter was converted to the 6-quinolinol (VI), Certuna. The sulfate of (VI), obtained as a trihydrate, was shown by Dr. L. C. Craig to contain (11 ± 4)% inhomogeneity. Subsequent investigations[22,23] lead one to presume that the contaminant present was (VII), by analogy to



(1) Previous contribution: E. A. Steck and L. L. Hallock, THIS JOURNAL, **71**, 890 (1949).

(2) National Drug Co., Phila., Penna.

(3) W. Kikuth, U. S. Patent 2,291,235; Canadian Patent 465,435.

(4) W. Kikuth, *Klin. Wochenschr.*, **17**, 524 (1938).

(5) F. Sioli, *ibid.*, **17**, 527 (1938).

(6) P. Bohrisch, *Süddeut. Apotheker Ztg.*, **78**, 675 (1938).

(7) P. Mühlens, *Deutsche med. Wochenschr.*, **64**, 295 (1938).

(8) R. N. Chopra, B. M. Das Gupta and B. Sen, *Indian Med. Gazz.*, **73**, 667 (1938).

(9) A. Missiroli and E. Mosna, *Riv. Parassitol.*, **2**, 55 (1938).

(10) J. A. Sinton, E. L. Hutton and P. G. Shute, *Trans. Roy. Soc. Trop. Med., Hyg.*, **32**, 419 (1938).

(11) A. D'Ambrosio, *Chim. e industria*, **23**, 41 (1941).

(12) F. Schönhöfer, *Z. physiol. Chem.*, **274**, 1 (1942).

(13) R. Aguilar Meza, E. González A., and A. R. Medrano, *Boll. Oficina San. Panamericana*, **21**, 549 (1940), abstract, *J. Amer. Med. Assn.*, **120**, 320 (1942).

(14) F. M. Peter, *Hippokrates*, **12**, 505 (1942), abstract, *Chem. Zentr.*, **113**, I, 3018 (1942).

(15) E. Ghigi, *Ann. chim. applicata*, **32**, 3 (1942).

(16) C. Toffoli, *Gazz. chim. ital.*, **74**, 219 (1944).

(17) Office of Publication Board (OPB), Dept. of Commerce, Washington, D. C., 1945. (a) F. J. Curtis, F. C. Davis, J. E. Smadel, H. Southworth and E. H. Volwiler, Report 237, p. 25; (b) K. C. Blanchard, Report 246, pp. 9, 16; (c) E. C. Kleiderer, J. B. Rice and V. Conquest, Report 248, p. 32.

(18) A. S. Alving, T. N. Pullman, B. Craige, Jr., R. Jones, Jr., C. M. Whorton and L. Eichelberger, *J. Clin. Invest.*, **27**, No. 3, Pt. 2, 34 (1948).

(19) F. Eicholtz, editor, "Pharmakologie u. Toxikologie," Teil III (Naturforschung u. Medizin in Deutschland, 1939-1946. Bd. 63), Dieterich'sche Verlagsbuchhandlung, Wiesbaden, 1948, p. 59.

(20) F. C. Goble, *J. Parasitol.*, **35**, 375 (1949).

(21) All drugs identified by Survey Numbers (SN) in the files of the Antimalarial Survey have been tabulated systematically, with antimalarial activities, in the work "Antimalarial Drugs, 1941-1945" (F. Y. Wiselogle, Editor), Edwards Bros., Ann Arbor, Mich., 1946.

(21a) E. A. Steck and F. C. Nachod, THIS JOURNAL, to be published.

(22) R. C. Elderfield, L. C. Craig, W. M. Lauer, R. T. Arnold, W. J. Gensler, J. D. Head, T. H. Bembry, H. R. Mighton, J. Tinker, J. Galbreath, A. D. Holley, L. Goldman, J. T. Maynard and N. Pincus, *ibid.*, **68**, 1516 (1946).

(23) A. C. Cope, H. R. Nace, W. R. Hatchard, W. H. Jones, M. A. Stahmann and R. B. Turner, *ibid.*, **71**, 554 (1949).