TABLE I

4-AMINOQUINOLINE DERIVATIVES

Quinoline nucleus	Side chain in position 4[a]	Yield, %	Appearance	Solvent[b]	M. p., °C.	Analyses, % Calcd. C or Cl	Calcd. H	Calcd. N	Found C or Cl	Found H	Found N
Unsubstituted[c]	I	78	White needles	Sa	76–77	75.74	9.58	14.72	75.70	9.49	14.80
7-Chloro	II	86	White needles	Sc	102.5–103	12.15		14.40	11.98		14.25
7-Chloro	III	71	White needles	Ac	146–146.4	11.52		13.65	11.44		13.51
7-Chloro	IV	80	Creamy microcryst.	Ac	161–161.8	12.07		14.30	12.09		14.39
7-Chloro[d]	V	74	White needles	Ea	139–139.5	58.75	6.07	15.81	59.04	5.91	15.75
3-Methyl-7-chloro[e]	V	82	Pale yell. needles	E	222.5–223	20.68[f]		15.02	20.49[f]		15.29
6-Methyl-7-chloro	I	76	Creamy needles	Sb	129–129.6	68.40	8.40	12.62	68.29	8.22	12.47

[a] Same designations as in text. [b] Legend: Ac = acetone; E = ethanol; Ea = ethyl acetate; Sa, Sb, and Sc = Skellysolve A, B and C. [c] Cf. refs. 7 and 8. Tested as the methane bis-1,1′(2-hydroxy-3-naphthoate); yellow powder, m. p. >300°. *Anal.* Calcd. for $C_{18}H_{27}N_3 \cdot C_{23}H_{16}O_6$: base, 42.36; acid, 57.64. Found: base, 41.6; acid, 57.1; H_2O, 0.98. Given the designation SN-6732.[2] [d] Tested as the dihydrochloride monohydrate: white needles from ethanol, m. p. 239.5–240°. *Anal.* Calcd. for $C_{13}H_{16}ClN_3O \cdot 2HCl \cdot H_2O$: Cl^-, 20.45; H_2O, 5.05. Found: Cl^-, 20.58; H_2O, 4.93. Designated as SN-12,309.[2] [e] The base was oily; data given are the dihydrochloride, which was prepared from the crude base in alcohol–ether. [f] Ionic chlorine only.

Skellysolve B. The yield of 3-benzylisopropylamino-2-hydroxypropylamine was 60.8 g. (59%); m. p. 59–60°.

Anal. Calcd. for $C_{13}H_{22}N_2O$: neut. equiv., 111.2. Found: neut. equiv., 112.7.

One hundred grams (0.45 mole) of benzylamino compound was dissolved in warm alcohol and acidified with concd. hydrochloric acid. To the diamine hydrochloride there was added a slurry of 10% palladium–charcoal catalyst, prepared from 1.0 g. of palladium chloride, in alcohol. The mixture was diluted with alcohol to a volume of 500 cc. and reduced at 75° under a hydrogen pressure of 500 lb./sq. in. (*cf.* ref. 27). Upon completion of the reduction in two hours, the solvent was removed and the residue dissolved in water. The 2-hydroxy-3-isopropylaminopropylamine (IV) was liberated by basification, extracted with ether and dried over potassium carbonate. The base was obtained as a colorless, viscous liquid which boiled at 78–80° (2 mm.), $n^{25}D$ 1.4680. The yield was 49.1 g. (82.6%).

Anal. Calcd. for $C_8H_{16}N_2O$: N, 21.19; neut. equiv., 66.1. Found: N, 20.86; neut. equiv., 66.3.

C. 4-Aminoquinoline Derivatives

The reaction of the 4-chloroquinoline types with the requisite amino compound was carried out in phenol,[28] using sodium iodide as a catalyst. It was found to be most expedient to remove excess side chain by distillation with steam. The 4-aminoquinolines prepared are listed with pertinent data in Table I.

Acknowledgment.—The authors are indebted to Mr. M. E. Auerbach and his staff for the analyses recorded. To Mr. E. V. Ryan, Mrs. C. E. Dzembo and Mrs. M. S. Hawn we express appreciation for technical assistance.

Summary

Several aliphatic diamines were prepared for use in the synthesis of possible antimalarials of the 4-aminoquinoline type. The presence of a terminal secondary amino or an hydroxyl group was not a therapeutically satisfactory modification for the basic side chain in position 4 of the 7-chloroquinoline nucleus. Alkylation of the benzenoid or pyridine ring in that type was not desirable.

(27) Baltzly and Buck, THIS JOURNAL, **65**, 1984 (1943).

(28) Steck, Hallock and Holland, *ibid.*, **68**, 129 (1946).

RENSSELAER, N. Y. RECEIVED JUNE 25, 1948

[CONTRIBUTION FROM STERLING-WINTHROP RESEARCH INSTITUTE]

The Preparation of Some Amides of 4,6-Diaminoquinaldine[1]

BY MARGARET G. PRATT AND S. ARCHER

Over ten years ago several patents[2] appeared which indicated that derivatives of 4,6-diaminoquinaldine were useful as chemotherapeutic agents. In a short review which summarized his work up to that time, Jensch[3] pointed out that certain diamides were particularly useful in combating some tropical diseases which have hitherto resisted conquest. Since very few chemical or pharmacological data have appeared in the literature, it seemed of interest to prepare some malonamides and related compounds for chemotherapeutic study.

The 4,6-diaminoquinaldine, V, needed for this work was prepared according to the scheme shown.

Substance V had previously been reported by Jensch[2] and, after most of this work had been completed, in a Department of Commerce report.[4] Jacini,[5] Kermack[6] and Rubtsov[7] have carried out the ring closure of the anilinocrotonate, I.

(1) A part of this paper was presented before the Medicinal Division of the American Chemical Society at the Chicago meeting in September, 1946.

(2) Jensch, U. S. Patents 2,034,983, 2,050,971, 2,066,730, 2,092,352, 2,118,244.

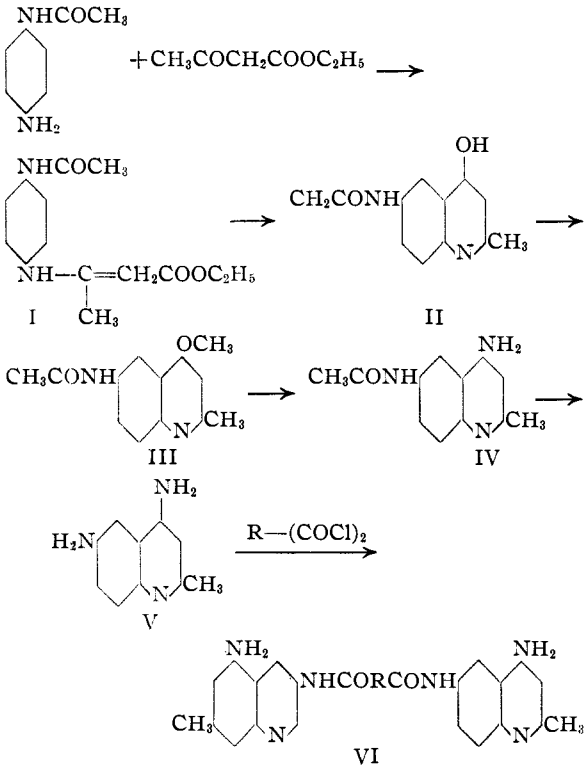
(3) Jensch, *Angew. Chem.*, **50**, B91 (1937).

(4) Report No. PB-981, Office of the Publication Board, Department of Commerce, Washington, D. C.

(5) Jacini, *Gazz. Chim. Ital.*, **71**, 53 (1941).

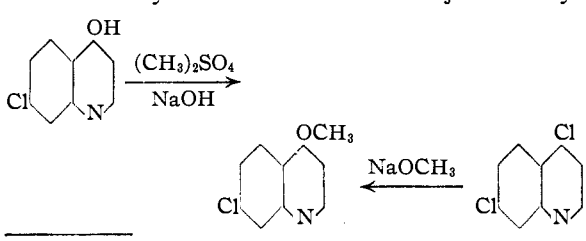
(6) Kermack, *J. Chem. Soc.*, 563 (1939).

(7) Rubtsov and Bunina, *C. A.*, **40**, 7194 (1946).

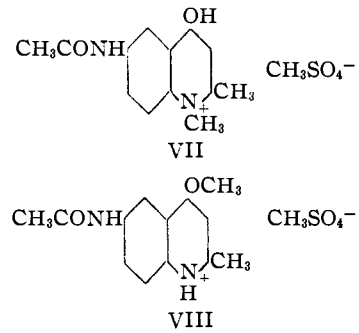


When pure *p*-aminoacetanilide was used in the condensation with ethyl acetoacetate it was possible to obtain the anil, I, in 87–95% yield. After several preliminary trials at effecting the ring closure in chloronaphthalene[4] or mineral oil, it was found that Dowtherm[8] was the most satisfactory medium for this reaction. When the methine base was heated to 240° in this solvent a rapid evolution of ethanol took place with the concomitant precipitation of the hydroxyquinoline II. The substance was obtained as a brownish-tan solid in about 65% yield. It was subsequently found that the yield could be raised to 98% and the quality improved considerably by adding the anil portionwise to pre-heated Dowtherm.[9]

Maurin[10] claimed to have prepared 4-methoxyquinolines from the corresponding hydroxyquinolines by treatment with methyl sulfate and followed by the addition of alkali to an aqueous solution of the resulting salt. To assure ourselves that O-methylation did occur we subjected 4-hydroxy-7-chloroquinoline[11] to this reaction and found the methylated product to be identical with the compound prepared from 4,7-dichloroquinoline and sodium methoxide.



It is implied in the Department of Commerce report[4] that the salt formed from the quinaldine, II, and methyl sulfate is represented by VII. Presumably on treatment with alkali the methyl group rearranges from the nitrogen to the oxygen.[12] Evidence that a substantial part of the product obtained by treating II with methyl sulfate is the salt VIII was obtained from Zeisel determinations. In one experiment the methoxyl content of the crude dry salt was determined before treatment with alkali. Compound VII should show only one methoxy group (8.4%) whereas VIII should yield two (17%). The analysis indicated 13% methoxyl or about 50% of the O-methyl derivative. The yield of III in this case was 54%, a value which agrees with the result of the Zeisel determination. In other runs the yield of methoxyquinaldine was 60–65%.



When the ether, III, was heated under pressure at 110° in alcoholic ammonia, compound IV was formed. This was converted without purification to the diaminoquinaldine, V.[2,13] The replacement was effected at atmospheric pressure and in better yield when the ether was heated with excess ammonium acetate at 135° for several hours. When the reaction mixture was poured onto water and the solution made alkaline, compound IV separated. Its isolation was avoided by adding excess hydrochloric acid to the quenched reaction mixture and then heating at 90° to effect the deacetylation. The 4,6-diaminoquinaldine, V, was obtained as a stable hydrate which lost water of hydration at 100° in vacuum.

The alkylated malonic esters were prepared in the usual manner and then saponified with concentrated potassium hydroxide to the dibasic acids. With the possible exception of allylthenylmalonic acid the others have been reported previously. On treatment with thionyl chloride the acids were converted to the corresponding malonyl chlorides.

(8) Price and Roberts, THIS JOURNAL, **68**, 1204 (1946).

(9) This experiment was carried out by Mr. William Wetterau of this Laboratory.

(10) Maurin, *Ann. chim.*, [II] **4**, 301 (1935).

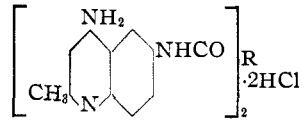
(11) Surrey and Hammer, THIS JOURNAL, **68**, 113 (1946).

(12) In the Report No. PB-981, p. 63, the salt is called "4-oxy-6-acetylamino-N-methylquinaldine methosulfate" and the product obtained from it "4-methoxy-6-acetaminoquinaldine."

(13) Jensch, German patent 708,416; *Chem. Zentr.*, **113**, II, 2088 (1942).

TABLE I

PROPERTIES OF THE DIAMIDES OF 4,6-DIAMINOQUINALDINE



R =	M. p.,[a] °C.	Formula	Analyses,[c] % Calcd. N	Calcd. Cl	Found N	Found Cl	Purification procedure[b]	Activity against *T. cruzi*	Activity against *T. Bruce*,
CH_2	253	$C_{22}H_{22}N_6O_2\cdot 2HCl\cdot 5H_2O$	17.24	14.55	17.12	14.63	A	−	+
$(CH_2)_3$	225	$C_{25}H_{26}N_6O_2\cdot 2HCl\cdot 4H_2O$	16.31	13.56	15.97	13.78	B	−	+
$(CH_2)_4$	>300	$C_{26}H_{28}N_6O_2\cdot 2HCl$	15.87	13.70	15.59	13.39	C	−	++++
$(CH_2)_5$	292	$C_{27}H_{30}N_6O_2\cdot 2H_2O$[d]	16.59		16.23		D	−	+
$(CH_2)_7$	227	$C_{29}H_{34}N_6O_2\cdot 2HCl\cdot H_2O$	14.71	12.41	14.45	11.80	C	−	+
$(CH_2)_8$	301	$C_{30}H_{36}N_6O_2\cdot 2HCl$	14.35	12.11	13.80	11.95	C	−	+
$(CH_3)_2C$	>300	$C_{25}H_{26}N_8O_5\cdot 2HCl\cdot 3H_2O$	16.31	13.76	15.78	13.79	C	+	+
$(CH_3)(C_2H_5)C$	>300	$C_{26}H_{28}N_6O_2\cdot 2HCl\cdot 2H_2O$	15.87	13.70	15.50	13.32	C	±	+
$(CH_3)(C_3H_7)C$	292	$C_{27}H_{30}N_6O_2\cdot 2HCl\cdot 3H_2O$	15.47	13.05	14.98	12.79	C		
$(C_2H_5)_2C$	>300	$C_{27}H_{30}N_6O_2\cdot 2HCl\cdot H_2O$	15.47	13.05	15.21	13.21	C	+++	+
$(C_2H_5)(C_3H_7)C$	293	$C_{28}H_{32}N_6O_2\cdot 2HCl\cdot 3H_2O$	15.08	12.72	14.89	12.69	C	+++	+
$(C_2H_5)(C_3H_5)C$	280	$C_{28}H_{30}N_6O_2\cdot 2HCl\cdot 5H_2O$	15.13	12.77	14.91	12.53	C	+++	+
$(C_3H_7)_2C$	238	$C_{29}H_{34}N_6O_2\cdot 2HCl$	14.71	12.41	14.41	12.16	G	+++	+
$(C_3H_7)(C_3H_5)C$	251	$C_{29}H_{32}N_6O_2\cdot 2HCl\cdot H_2O$	14.76	12.45	14.37	12.19	E	+++	−
$(C_3H_5)_2C$	284	$C_{28}H_{30}N_6O_2\cdot 2HCl$	14.81	12.49	14.39	12.29	C	++++	−
$(C_4H_9)_2C$	>300	$C_{31}H_{38}N_6O_2\cdot 2HCl\cdot 5H_2O$	14.02	11.83	13.87	11.56	F	−	−
$(C_3H_5)(C_4H_3SCH_2)C$	285	$C_{31}H_{30}N_6O_2S$[f]	15.26	5.82[e]	14.92	5.80	D	+++	−
$(C_3H_5)(C_6H_5CH_2)C$	285	$C_{33}H_{32}N_6O_2\cdot 2HCl\cdot 2H_2O$	13.61	11.46	13.43	11.02	A	++	−

[a] Actually decomposition ranges. The temperature at which all the compound disappears is given. [b] A = Precipitation by saturated salt solution. B = Crystallization from dilute hydrochloric acid. C = Crystallization from dilute ethanol–hydrochloric acid. D = Crystallization from dilute ethanol. E = Precipitation from acetic acid with ether. F = Crystallization from acetic acid–acetone. G = Trituration with boiling alcohol. [c] Analyses calculated and reported on the dry basis. [d] Free base. *Anal.* Calcd. for dihydrate: C, 64.01; H, 6.76; H_2O, 7.11. Found: C, 64.00; H, 6.69; H_2O, 7.42. [e] Sulfur analysis. [f] Free base.

No attempt was made to obtain these compounds in pure form; rather, they were used directly after simple distillation from the reaction mixture. It was noted that all the dialkylmalonyl chlorides were more stable than malonyl chloride itself.

We experienced considerable difficulty in duplicating our initial preparation of allylthenylmalonyl chloride. As part of our usual procedure the ethereal solutions of the malonic acids were dried over Drierite before concentration. It was noted that when indicating Drierite was used a small amount of the colored substance contaminated the acid. The chloride prepared from the colored material invariably decomposed on distillation. No trouble was encountered when we reverted to the white desiccant.

The mildly exothermic condensations between the acid chlorides and 4,6-diaminoquinaldine were carried out in acetic acid solution. Most of the crude hydrochlorides were soluble in large volumes of hot dilute alcohol but on cooling separated as thick unfilterable gels. To obtain crystalline salts it was necessary to add hydrochloric acid carefully to the hot solutions and allow the cooling to take place slowly. In a few instances reprecipitation was the only feasible method of purification. In two instances we were unable to avoid gelation of the hydrochlorides. However, it was possible to recrystallize the corresponding bases from dilute ethanol.

Jensch had represented the structure of the diamides by formula VI. Recent work,[14a] however, has shown that 4-aminoquinoline is more basic than the isomeric 6-aminoquinoline. It thus seemed possible that acylation of 4,6-diaminoquinaldine occurred at the four rather than the six position. To test this hypothesis the base, V, was treated with acetyl chloride in acetic acid. The product obtained was identical with the substance prepared by amination of 4-methoxy-6-acetamidoquinaldine. The ultraviolet absorption spectra of the specimens prepared by the different methods were indistinguishable (Fig. 1) and resembled the spectrum of 4-aminoquinoline more closely than that of 6-aminoquinoline.[14b]

The hydrochlorides, particularly those obtained from the malonyl chlorides, tended to hold moisture tenaciously. Only in a very few cases was it possible to obtain the salts in an anhydrous state. In several instances it was possible to remove most of the water of hydration by prolonged drying in vacuum at elevated temperatures, but as soon as they were exposed to atmospheric moisture the salts reverted to the hydrated state.

Chemotherapeutic Results.—The compounds were tested *in vivo* against five trypanosomes.[15]

(14) (a) Albert and Goldacre, *Nature*, **153**, 467 (1947). Irvin and Irvin, THIS JOURNAL, **69**, 1091 (1947). (b) Steck and Ewing, *ibid.*, **70**, 3397 (1948).

(15) We are indebted to Dr. Frans Goble of this Laboratory for the data given here.

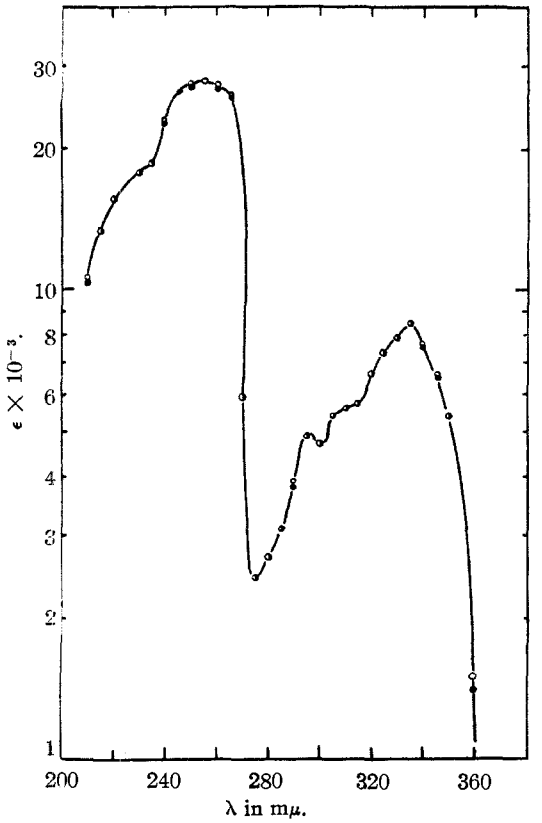


Fig. 1.—Ultraviolet absorption spectrum of 6-acetamido-4-aminoquinaldine in 0.01 *N* hydrochloric acid: ●, sample prepared by amination of III; ○, sample prepared by acetylation of 4,6-diaminoquinaldine; ◑, points common to each.

As a group they were inactive against *T. congolense*. Only the adipamide showed more than weak activity against *T. hippicum* and *T. equiperdum*.

A striking correlation between structure and activity was noted when *T. brucei* and *T. cruzi* were the test organisms. Against the former practically all the straight chain amides exhibited some activity (the adipamide was strongly active), whereas the disubstituted malonamides were either slightly or completely ineffective. On the other hand, against *T. cruzi* the malonamides exhibited pronounced activity and the straight chain amides were ineffective.

Acknowledgment.—We wish to express our thanks to Professor William S. Johnson for some helpful discussions, particularly in connection with the structure of the acylated quinaldines.

Experimental[16]

Ethyl β-(*p*-Acetamidophenylamino)-crotonate (I).—A solution of 400 g. of *pure* *p*-aminoacetanilide and 400 ml. of ethyl acetoacetate in 1200 ml. of methanol was refluxed for five hours. After thorough cooling the mixture was filtered, washed with methanol and dried. The product weighed 608 g. (87%) and melted at 180–182°. In other experiments yields as high as 94% were obtained.

6-Acetamido-4-hydroxyquinaldine[9] (II).—In a three-liter three-necked flask equipped with a mercury-seal stirrer, downward condenser and an addition tube 20 mm. wide and 20 inches long, there was placed 1 liter of Dowtherm. The liquid was stirred and heated to boiling. The anil (250 g.) was added portionwise through the long tube over a period of thirty minutes. The mixture was heated a few minutes more after the addition and then allowed to cool. The granular hydroxyquinaldine was filtered, thoroughly washed with methanol and dried. The light yellow solid weighed 198.4 g. (96.7%). In a duplicate run, over three times as large, the yield was 97.5%.

6-Acetamido-4-methoxyquinaldine (III).—As a mixture of 100 g. of 4-hydroxy-6-acetamidoquinaldine was heated with stirring for two and one-half hours with 75 ml. of dimethyl sulfate in 490 ml. of dry toluene a change in color from orange to light yellow was noted. The salt was filtered, pressed dry and dissolved in 1350 ml. of water and heated to 70°. The solution was clarified by filtration (Filter-cel) and treated with 100 ml. of 35% sodium hydroxide. The solid that separated was collected on a filter and washed with a large quantity of water, m. p. 217–219°; yield, 102 g. (60%). Jacini[5] reported the m. p. as 190°. In a series of runs the yield varied between 59–65% and occasionally dropped to as low as 50%.

4,6-Diaminoquinaldine (V).—From 150 g. of IV, 450 ml. of 6.8% alcoholic ammonia and 36 g. of ammonium chloride at 115° there was obtained, after hydrolysis, 58 g. (51%) of the quinaldine. A more convenient preparation is the following.

A mixture of 127.4 g. of 6-acetamido-4-methoxyquinaldine was heated at 135 ± 5° for three hours with 637 g. of ammonium acetate. The reaction mixture was then added to a solution of 640 ml. of water and 1030 ml. of hydrochloric acid and the whole heated at 90° with stirring for five hours. On cooling the dihydrochloride separated. It was dissolved in 660 ml. of boiling water, treated with charcoal and filtered. The cooled filtrate was made basic with 370 ml. of 35% sodium hydroxide. The base was collected on a filter, washed with water and dried at 100° *in vacuo;* 72 g. (79%), m. p. 194°.

6-Acetamido-4-aminoquinaldine (IV). **From Amination of III.**—A mixture of 20 g. of 6-acetamido-4-methoxyquinaldine and 100 g. of ammonium acetate was heated at 135° for three hours and then poured onto water. The resulting solution was made basic and the solid that separated was filtered. After recrystallization from water with the aid of charcoal the substance was obtained as white feathery needles. A sample was recrystallized again for analysis; m. p. 284–287° dec. (uncor.).

Anal. Calcd. for $C_{12}H_{13}N_3O$: N, 19.52. Found: N, 19.50.

From 4,6-Diaminoquinaldine and Acetyl Chloride.—A solution of 17.3 g. of 4,6-diaminoquinaldine in 100 ml. of acetic acid was treated dropwise with 7.8 g. of acetyl chloride over a period of ten minutes. The temperature rose to 60° and on cooling the hydrochloride separated as a gum. It was covered with ether and allowed to stand for one hour. The solid salt was collected, dissolved in water and filtered. On treatment of the filtrate with dilute sodium hydroxide a voluminous precipitate formed. After several recrystallizations from water, white feathery needles of IV were formed which did not depress the decomposition point of the specimen prepared above.

7-Chloro-4-methoxyquinoline.—The gummy suspension resulting from heating a mixture of 35.9 g. of 4-hydroxy-7-chloroquinoline and 20.3 ml. of dimethyl sulfate in 130 ml. of dry toluene for one hour was thoroughly extracted with water. After treatment of the aqueous solution with sodium hydroxide a crystalline solid was obtained which melted at 141–143° after crystallization from dilute ethanol.

A solution of 1.98 g. of 4,7-dichloroquinoline, 0.25 g. of sodium in 25 ml. of methanol was refluxed for two hours and then poured onto water. The solid was filtered and

(16) The analyses were carried out under the direction of Mr. M. E. Auerbach of these Laboratories.

recrystallized from dilute ethanol, m. p. 142–144°, undepressed when mixed with a sample prepared by the other procedure.

Ethyl Allylthenylmalonate.—The alkylation was carried out in the usual way.[17] From 131 g. of ethyl allylmalonate and 85 g. of chloromethylthiophene there was obtained 130 g. (68%) of the dialkylated ester, b. p. 122–124° at 0.6 mm.

Anal. Calcd. for $C_{15}H_{20}O_4S$: S, 10.82. Found: S, 11.11.

Allylthenylmalonic Acid.—The method given below was used for all the dialkylmalonic acids. To a stirred boiling solution of 101 g. of potassium hydroxide in 101 ml. of water there was added dropwise 127 g. of the ester. If the addition was rapid, after an induction period an exothermic reaction resulted. After six hours the mixture was poured into cold water. The solution was extracted with ether, cooled to 5° and carefully acidified with hydrochloric acid. The acid separated as an oil which was gathered in ether and dried over *white* Drierite. After removal of the ether, the acid solidified. It was recrystallized from benzene–ligroin; 86 g. (84%), m. p. 125–127°.

Anal. Calcd. for $C_{11}H_{12}O_4S$; neutral equivalent, 120. Found: neutral equivalent, 122.

The acid chloride prepared from this acid was 95% pure on the basis of the chlorine analysis.

(17) "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, N. Y., p. 250.

Allylbenzylmalonyl Chloride.—The following is a typical preparation of a dialkylmalonyl chloride. A mixture of 78 g. of allylbenzylmalonic acid and 150 ml. of thionyl chloride was gently refluxed for four hours. The chloride was then distilled to give 56.3 g. of the acid chloride. Since the chloride was reddish-yellow it was redistilled, b. p. 106–108° (0.75 mm.); 44.6 g. (50%).

Anal. Calcd. for $C_{13}H_{12}Cl_2O_2$: Cl, 26.15. Found: Cl, 26.16.

In the other cases the chlorides were not redistilled.

Preparation of the Diamides (VI).—To a solution of 17.7 g. (0.102 mole) of 4,6-diaminoquinaldine in 100 ml. of glacial acetic acid there was added slowly 0.051 mole of the acid chloride. The temperature generally rose about 20–30°. After cooling to room temperature, the acetic acid was decanted from either the resultant gum or solid. Trituration with ether converted the gummy hydrochlorides to more tractable solids. The yields at this point were quantitative. In most cases it was possible to recrystallize the salts. Otherwise the procedures indicated in Table I were followed.

Summary

Eighteen amides prepared from 4,6-diaminoquinaldine and dibasic acid chlorides are described. Preliminary data on their effectiveness against six species of trypanosomes was given.

RENSSELAER, N. Y. RECEIVED MAY 4, 1948

[CONTRIBUTION NO. 82 FROM THE GENERAL LABORATORIES OF THE UNITED STATES RUBBER COMPANY]

The Preparation, Structure and Properties of the Dimer of Methallyl Chloride

BY K. E. WILZBACH,[1a] F. R. MAYO AND R. VAN METER[1b]

By refluxing methallyl chloride with 1% benzoyl peroxide for eight days, Bauer and Götz[2] polymerized the chloride in 33% yield to a dimer of unspecified structure. In this Laboratory the dimer has been obtained in yields as high as 79% by irradiating a solution of 0.5% tetraethyllead in methallyl chloride at 80° for five days. Since the action of light alone under the same conditions produces only 7.5% polymerization, the high yield of dimer per molecule of tetraethyllead indicates that the dimerization proceeds by a chain transfer reaction.[3a,b]

The dimer has been identified as 2-methyl-4,4-bis-(chloromethyl)-1-pentene. Its reactions, shown in Fig. 1, have been studied and found to include the easy formation of cyclopropane derivatives. The structure of the dimer shows that the transfer mechanism is unique, so far, in that it apparently involves transfer of an atom from a polymeric radical to a monomer, instead of in the reverse direction.

Structure of the Dimer.—In the formation of the dimer a chlorine or a hydrogen atom can be transferred either to the dimer radical or to the monomer. With the additional assumption that a radical would add to the terminal carbon atom of a double bond, several structures for the dimer can be proposed. These structures, in which the four carbon atom group on the left side of each formula is presumed to add to the group on the right, are shown in Fig. 2.

The absence of any chloride ion after heating the dimer with piperidine, alcoholic silver nitrate or alcoholic sodium hydroxide at 100° indicated that the halogens were attached by vinyl or neopentyl linkages. This result left for consideration only structures IV and VI, Fig. 2, which could be distinguished by oxidation at the double bond.

Oxidation by aqueous permanganate at room temperature produced one chloride ion per dimer molecule, a misleading result which suggested that one halogen was attached by a vinyl linkage, as in structure VI, Fig. 2. The organic residue polymerized upon distillation, even at reduced pressure, and attempts to prepare carbonyl derivatives were unsuccessful. However, when the dimer was ozonized in formic acid at 0° no chloride ion was found, in contrast to permanganate oxidation, and a nearly quantitative yield of a compound analyzing for $C_7H_{12}Cl_2O$ was obtained. The formation of carbonyl derivatives and a positive iodoform

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(2) Bauer and Götz, U. S. Patent 2,338,893.

(3) (a) Flory, THIS JOURNAL, **59**, 241 (1937); (b) Mayo, *ibid.*, **65**, 2324 (1943).