was developed with hexane + 5% acetone (45 × 8 cm.). The top-to-bottom sequence was (besides minor zones): all-*trans*-*retro*-bisdehydrocarotene and *cis* forms (54.5 mg., photometrically estimated); all-*trans*-3,4,3',4'-bisdehydro-β-carotene and *cis* forms (4.5 mg.); combined yield, 60%; m.p. 204–207° (III) and 195–197° (II).

Anal. (III). Calcd. for $C_{40}H_{52}$: C, 90.16; H, 9.84. Found: C, 90.54; H, 9.81 (after correction for 0.8% ash).

Mixed chromatogram tests showed identity, respectively, with authentic samples of III and II.

PASADENA, CALIF.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, ILLINOIS INSTITUTE OF TECHNOLOGY]

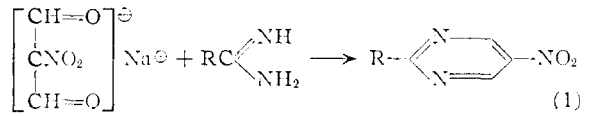
2-Substituted-5-nitropyrimidines by the Condensation of Sodium Nitromalonaldehyde with Amidines[1]

BY PAUL E. FANTA AND EDWARD A. HEDMAN[2]

RECEIVED JUNE 30, 1955

In an aqueous solution of Triton B, sodium nitromalonaldehyde condenses with a wide variety of aryl and aryl-alkyl amidines to form the corresponding 2-substituted-5-nitropyrimidines. With alkyl and hydroxyalkyl amidines, no pyrimidines are formed. The reduction of some 5-nitropyrimidines was studied and the diazotization of 5-amino-2-phenylpyrimidine was attempted.

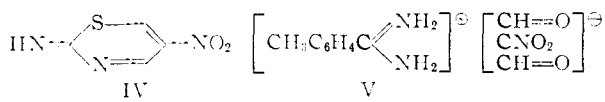
As part of a program[3] concerned with the investigation of new applications of sodium nitromalonaldehyde (I) to the synthesis of nitro-substituted heterocyclic compounds, we have studied the scope of the reaction of I with amidines. Previously reported reactions of I with compounds containing



I II III (1)

the guanyl group as illustrated in equation 1 led to the formation of 2-hydroxy-5-nitropyrimidine from urea (R = OH),[4] 2-amino-5-nitropyrimidine in "almost quantitative yield" from guanidine (R = NH_2),[4-6] 5-nitro-2-phenylpyrimidine from benzamidine (R = C_6H_5)[4] and 2-methylthio-5-nitropyrimidine from S-methylthiourea (R = SCH_3).[7]

Compounds containing a guanyl group which were reported not to react with sodium nitromalonaldehyde to form a pyrimidine according to equation 1 are thiourea, which formed 2-imino-5-nitrometathiazine (IV)[4,7] and formamidine,[6] which gave no isolable condensation product.



IV V

Although it has previously been inferred[4,8] that the precipitate obtained immediately on mixing aqueous solutions of benzamidine hydrochloride and sodium nitromalonaldehyde is a nitropyrimidine, isolation of the product demonstrated that it is a simple salt, which is unstable at room temperature and decomposes on standing to form a black resin. The crystalline precipitate obtained immediately on mixing aqueous solutions of *p*-toluamidine hydrochloride and sodium nitromalonaldehyde is a more stable salt which gives an elemental analysis corresponding to formula V. Heating aqueous solutions of either of these salts with a small amount of Triton B results in the formation of the expected pyrimidines.

The effect of various reaction media on the condensation of sodium nitromalonaldehyde with benzamidine was studied in order to establish a procedure resulting in an optimum yield of the pyrimidine. In aqueous solution, heating at 70° with Triton B for four hours was significantly superior to the other conditions tried, and was adopted as the standard conditions for a study of the condensation of other amidines. Of the various non-aqueous media studied, acetic anhydride-pyridine at 90° gave an exceptionally high yield of clean product in a short reaction time.

In order to determine the effect of variations in group R on the formation of pyrimidines according to equation 1, a variety of amidine hydrochlorides in aqueous solution were treated with sodium nitromalonaldehyde in the presence of Triton B. Triton B is a 40% aqueous solution of benzyl trimethylammonium hydroxide technical grade. The results of this study are summarized in Table 1.

From these data it is evident that reaction conditions successful for the condensation of various aryl and aryl-alkyl amidines with sodium nitromalonaldehyde cannot be extended to alkyl and hydroxyalkyl amidines. A wide variety of media and temperatures were tried for the condensation of acetamidine hydrochloride and sodium nitromalonaldehyde, and a very poor yield of 2-methyl-5-nitropyrimidine was obtained when the reaction was run with sodium hydroxide in ethanol at 25° or with piperidine in the absence of solvent at 90°. Under other conditions either an intractable tar was formed or unreacted sodium nitromalonaldehyde was recovered

(1) This work was aided by grants from the Office of Ordnance Research and the United States Public Health Service and was presented in part at the National Meeting of the A.C.S., Chicago, Ill., September, 1953. This paper was abstracted from the Ph.D. thesis of E. A. Hedman, June, 1955.

(2) Armour Research Foundation Industrial Research Fellow, 1952–1955.

(3) For the preceding paper in this series, see P. E. Fanta and R. A. Stein, THIS JOURNAL, **77**, 1045 (1955).

(4) W. J. Hale and H. C. Brill, *ibid.*, **34**, 82, 295 (1912).

(5) P. E. Fanta, *Org. Syntheses*, **32**, 95 (1952).

(6) R. O. Roblin, P. S. Winnek and J. P. English, THIS JOURNAL, **64**, 567 (1942).

(7) M. P. V. Boarland and J. F. W. McOmie, *J. Chem. Soc.*, 1218 (1951).

(8) C. A. C. Haley and P. Maitland, *ibid.*, 3155 (1951).

TABLE I

2-SUBSTITUTED-5-NITROPYRIMIDINES OBTAINED BY THE CONDENSATION OF SODIUM NITROMALONALDEHYDE WITH AMIDINES IN AQUEOUS TRITON B

Group R of II and III	Hydrochloride of amidine, II M.p., °C. Obsd.	Lit.	Ref.	Nitropyrimidine, III Yield, %	M.p., °C.	Analyses, % Calcd. C	H	N	Found C	H	N
Aryl											
C_6H_5	70–73	72	[a]	79	222–223.5[b]						
p-$CH_3C_6H_4$	215–216	213	[c]	87	249–250	61.40	4.22	19.53	62.05	4.33	19.11
p-$CH_3OC_6H_4$	216–218		[d]	30	216–218	57.14	3.92	18.18	57.52	3.87	18.40
p-BrC_6H_4	261–263	264–265	[e]	89	225–227	42.88	2.16	15.00	43.35	2.30	14.75
p-ClC_6H_4	240–244	241–242	[f]	81	170–171.5	50.95	2.57	17.84	51.23	2.86	17.62
p-FC_6H_4	209–211		[g]	71	154–155	54.80	2.76		55.07	2.89	
p-$NO_2C_6H_4$	294–295	294–296	[h]	48	235–237	48.78	2.46		49.17	2.53	
p-$NH_2SO_2C_6H_4$	207–209	203	[i]	41	268–270	42.86	2.88	19.99	43.04	3.26	19.58
p-$C_6H_5C_6H_4$	245–249	238–239	[j]	85	253–254	69.30	4.00	15.15	69.47	4.05	15.06
m-$NO_2C_6H_4$	238–242	240	[k]	79	133–134	48.78	2.46	22.75	48.83	2.39	22.73
3,4-$(CH_3O)_2C_6H_3$	234	237	[h]	67	182–183	55.19	4.25	16.09	55.09	4.20	16.00
3-C_5H_4N	190–194	189–190	[e]	36	202–203	53.46	2.99	27.70	53.67	3.14	27.53
Aryl-alkyl											
$C_6H_5CH_2$	151–153		[l]	77	170	61.37	4.22	19.53	61.87	4.28	19.39
3,4-$(CH_3O)_2C_6H_3CH_2$	153–155		[g]	38	235	56.72	4.76	15.27	56.21	4.78	15.50
$C_6H_5CH{=}CH$	68–70		[g]	81	219–220	63.43	3.99	18.50	63.22	4.08	18.08
$C_6H_5COCH_2$			[m]	77	210–211	59.25	3.73		59.43	3.98	
Alkyl											
CH_3	164–166		[n]	0							
n-C_4H_9	Oil		[o]	0							
n-$C_{11}H_{23}$	125–127	128–129	[p]	0							
CH_3CHOH	162–166	171	[q]	0							
$HOCH_2CH_2$	81–82	84–85.5	[r]	0							

[a] A. R. Ronzio and J. B. Ekeley, "Organic Syntheses," Coll. Vol. I, 2nd Ed., John Wiley and Sons, Inc., New York, N. Y., 1941, p. 6. [b] Reference 4 reports m.p. 219°. [c] G. Glock, *Ber.*, **21**, 2650 (1888). [d] The amidine was characterized as the picrate, observed m.p. 210–212°; reported 213° by P. Oxley and W. F. Short, *J. Chem. Soc.*, 147 (1946). [e] C. H. Andrews, H. King and J. Walker, *Proc. Roy. Soc. (London)*, **133B**, 20 (1946); *C. A.*, **41**, 727 (1947); see also reference 15. [f] J. B. Ekeley, D. V. Tieszen and A. Ronzio, THIS JOURNAL, **57**, 381 (1935). [g] No literature value reported. [h] A. P. T. Easson and F. L. Pyman, *J. Chem. Soc.*, 2991 (1931). [i] Obtained and used in the form of the free base, observed m.p. 207–209° reported 203° by R. C. Iris, R. D. Leyva and C. R. Ramirez, *C. A.*, **41**, 4117 (1947) and 228° in footnote *e* of this table. [j] L. Bauer and J. Cymerman, *J. Chem. Soc.*, 2078 (1950). [k] J. Tafel and C. Enoch, *Ber.*, **23**, 1550 (1890). [l] No literature value reported for the hydrochloride. The amidine was characterized as the picrate, observed m.p. 228–230°, reported 227–228° by W. F. Short and M. W. Partridge, U. S. Patent 2,450,386 in *C. A.*, **43**, 3456 (1949). [m] Obtained and used in the form of the free base, observed m.p. 185–187°, reported 188–189° by B. Roth and J. M. Smith, THIS JOURNAL, **71**, 616 (1949). [n] A. W. Dox, footnote *a* of this table, p. 5. [o] Characterized as the picrate, observed m.p. 193–195°, reported 195–196° in footnote *h* of this table. [p] P. Eitner and H. Wetz, *Ber.*, **26**, 2840 (1893). [q] A. Pinner, *ibid.*, **23**, 2942 (1890). [r] C. C. Price and J. Zomlefer, *J. Org. Chem.*, **14**, 210 (1949).

In order to rationalize this observed difference in the behavior of benzamidine and acetamidine, other properties of amidines were examined. The base strengths of the amidines cannot be correlated with the yield of pyrimidine, since two amidines which give excellent yields of pyrimidine are guanidine, pK_a 13.71,[9] and benzamidine, pK_a 11.6,[9] 11.23,[10] whereas intermediate values, pK_a 12.41,[11] 12.52,[9] have been reported for acetamidine. In a further search of the literature, a number of qualitative observations suggested[12] that amidines differ considerably in rates of hydrolysis. A rapid hydrolysis under conditions utilized for the condensation with sodium nitromalonaldehyde would diminish the yield of pyrimidine both by destruction of amidine and by the formation of ammonia, which reacts with nitromalonaldehyde to give a dark, amorphous product. A quantitative determination of the rate of ammonia evolution from benzamidine and acetamidine in aqueous sodium hydroxide at 70° showed that the difference in rates of hydrolysis, *per se*, is also insufficient to account for the failure to obtain the desired pyrimidine from acetamidine. It must be concluded that the relative rates of the competing condensation and hydrolysis reactions favors pyrimidine formation from the aryl and aryl-alkyl amidines but not from the alkyl and hydroxyalkyl amidines.

The reduction of the nitropyrimidines to the corresponding aminopyrimidines was also investigated. As previously reported,[13] hydrogenation with a palladium catalyst gave an excellent yield of the 5-amino-2-phenylpyrimidine. The same conditions also were applicable to the reduction of 5-nitro-2-p-tolylpyrimidine, but were unsuccessful for several other nitropyrimidines. A number of other reductive techniques were tried, but no generally useful method was found.

A variety of conditions were tried for the diazotization of 5-amino-2-phenylpyrimidine but, in agreement with recent reports,[6,13] no products

(9) A. Albert, R. Goldacre and J. Phillips, *J. Chem. Soc.*, 2240 (1948).

(10) J. N. Baxter and J. Cymerman-Craig, *ibid.*, 1490 (1953).

(11) G. Schwarzenbach and K. Lutz, *Helv. Chim. Acta*, **23**, 1162 (1940).

(12) R. L. Shriner and F. W. Neumann, *Chem. Revs.*, **35**, 351 (1944).

(13) B. Lythgoe and L. S. Rayner, *J. Chem. Soc.*, 2323 (1951), reported the use of palladium-on-barium sulfate catalyst for this reduction.

could be isolated which corresponded to the formation of a diazonium compound.

Experimental[14]

Materials.—Nitriles required for the preparation of the amidines listed in Table I were obtained from commercial sources except for the following which were prepared by methods described in the literature: *p*-sulfonamidobenzonitrile from sulfanilamide,[15] *p*-chlorobenzonitrile from *p*-chloroaniline,[16] *p*-nitrobenzonitrile from *p*-nitroaniline,[16] nicotinonitrile from nicotinamide,[17] veratronitrile from veratraldehyde,[18] *p*-anisonitrile from *p*-anisidine,[16] *m*-nitrobenzonitrile from *m*-nitrobenzaldehyde[18] and benzoylacetonitrile from methyl benzoate and acetonitrile.[19] Lactonitrile and ethylene cyanohydrin were gifts of American Cyanamid Co. and lauronitrile was obtained from Armour and Co.

All of the amidines listed in Table I were prepared from the corresponding nitriles by a slight modification of the well-known Pinner synthesis.[20] Treatment of 0.5 mole each of the nitrile and absolute methanol with a slight excess of dry hydrogen chloride was carried out in 25 ml. of absolute ether to facilitate handling the solid methyl iminoester hydrochloride. A 10% solution of ammonia in absolute methanol was used for the decomposition of the iminoester. Except as noted in Table I, the amidines were isolated, characterized and used in the form of the hydrochlorides.

Sodium nitromalonaldehyde monohydrate[5] was prepared from mucobromic acid,[21] which in turn was prepared from furoic acid obtained from the Quaker Oats Co.

Triton B was a 40% aqueous solution of benzyltrimethylammonium hydroxide, technical grade.

Salt of *p*-Toluamidine and Nitromalonaldehyde.—A pale yellow crystalline substance was formed immediately when 1.86 g. (0.01 mole) of *p*-toluamidine and 1.57 g. (0.01 mole) of sodium nitromalonaldehyde were mixed in 25 ml. of water at room temperature. Recrystallization from water gave fine, white needles which melted at 148–150°.

Anal. Calcd. for $C_8H_{11}N_2 \cdot C_3H_2NO_4$: C, 52.60; H, 5.22. Found: C, 52.84; H, 5.34.

5-Nitro-2-*p*-tolylpyrimidine, m.p. 247°, was formed when this salt was heated in aqueous Triton B for two hours at 70°. The salt obtained on mixing benzamidine hydrochloride and sodium nitromalonaldehyde in water at room temperature darkened and resinified on standing and was characterized only by conversion to 5-nitro-2-phenylpyrimidine on heating in aqueous Triton B.

Reaction Conditions.—In order to establish optimum conditions for pyrimidine formation, a mixture of benzamidine hydrochloride and sodium nitromalonaldehyde was treated with various reagents at different temperatures. The results are summarized in Table II. Since the best yield in aqueous solution was obtained with Triton B, this medium was used for all of the amidines listed in Table I, and will be described in detail for a typical amidine. The yield data reported in Table I are for the unrecrystallized products, although the melting points and analytical data are for samples prepared by recrystallization or vacuum sublimation. All of the nitropyrimidines listed in Table I are stable at room temperature.

Aqueous Triton B.—In a 50-ml. erlenmeyer flask containing 25 ml. of distilled water was placed 1.94 g. (0.01 mole) of benzamidine hydrochloride dihydrate and 1.57 g. (0.01 mole) of sodium nitromalonaldehyde monohydrate. The salts dissolved rapidly and in about 20 seconds a creamy, flocculent mass was precipitated. One ml. of Triton B was added, and the reaction mixture was heated in a steam-chest at 65–70°. The initial precipitate dissolved on warming, and a heavy, yellow-orange microcrystalline mass slowly was deposited. After four hours, the reaction mixture was placed in an ice-chest and chilled overnight. The product was collected on a hirsch funnel, washed with cold water and with cold alcohol, and air-dried. The yield was 1.50 g. (75%) of pale tan microcrystals of 5-nitro-2-phenylpyrimidine which melted at 222–223.5° (literature value[4] 219°).

TABLE II

EFFECT OF REACTION CONDITIONS ON THE FORMATION OF 5-NITRO-2-PHENYLPYRIMIDINE

Medium	Time, hr.	Temp., °C.	Yield, %	Notes
Water + Triton B	4	70	79	
Water + K_2CO_3	4	70	66	
Water + NaOH	4	70	42	[a]
Water + NaOH	4	Reflux	0	[a,b]
Acetic anhydride–pyridine	0.25	90	85	
Acetic anhydride	0.25	90	40	
Ethanol + $NaOC_2H_5$	2	Reflux	0	[a]
Ethanol + HCl	12	0	0	[c]

[a] NH_3 evolved during the reaction. [b] Benzoic acid isolated. [c] 1,3,5-Trinitrobenzene isolated.

Acetic Anhydride–Pyridine.—A slightly better yield of particularly clean 5-nitro-2-phenylpyrimidine was obtained by heating 0.01 mole each of benzamidine hydrochloride and sodium nitromalonaldehyde in a mixture of 10 ml. of acetic anhydride and 6 ml. of anhydrous pyridine on a steam-bath for 15 min. The reaction mixture was worked up by pouring it into 150 ml. of water, heating and stirring for 15 minutes and then proceeding as described in the Triton B procedure. The acetic anhydride–pyridine reagent was tried with several other amidines and appeared to offer a consistent advantage of shorter reaction time and cleaner product than aqueous Triton B, although it did not always result in a higher yield.

Reaction of Acetamidine with Sodium Nitromalonaldehyde.—During the course of this research 2-methyl-5-nitropyrimidine was mentioned in the literature[22] without a description of the method of preparation. By private communication with the authors, a procedure was obtained[23] which was used for the preparation of an authentic sample of 2-methyl-5-nitropyrimidine. The same product was obtained when the reaction was run with sodium hydroxide in absolute ethanol. Using either procedure, the yield was less than 1% and repeated sublimation or recrystallization was necessary to obtain a pure product. Many other reaction conditions which were tried gave only unreacted starting material or dark tar.

Alkaline Hydrolysis of Amidines.—The procedure was similar to that described in a recent publication.[24] In 25 ml. of *N* aqueous sodium hydroxide solution at 70° at intervals of one-half, one and three hours, 1.05 mmoles of benzamidine evolved 14, 31 and 81% of the nitrogen as ammonia, while 1.22 millimoles of acetamidine evolved 63, 83 and 91% of the nitrogen as ammonia.

Reaction of Nitromalonaldehyde with Ammonia.—In many of the unsuccessful reactions of sodium nitromalonaldehyde with amidines a brown or black resin was formed. A similar product was obtained when sodium nitromalon-

(14) Melting points were determined on a Fisher–Johns block and are corrected. *Microanalyses by Micro-Tech Laboratories, Skokie, Ill.*

(15) E. D. Bergmann, H. Bendas and U. d'Avilla, *J. Org. Chem.*, **18**, 64 (1953).

(16) Using the Sandmeyer procedure as described by H. T. Clarke and R. R. Read, "Organic Syntheses," Coll. Vol. I, 2nd Ed., John Wiley and Sons, Inc., New York, N. Y., 1941, p. 514.

(17) F. B. LaForge, THIS JOURNAL, **50**, 2177 (1928).

(18) Via the oxime as described by J. S. Buck and W. S. Ide, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 622.

(19) R. S. Long, THIS JOURNAL, **69**, 990 (1947); J. B. Dorsch and S. M. McElvain, *ibid.*, **54**, 2960 (1932).

(20) A. Pinner, "Die Imidoaether und ihre Derivate," Robert Oppenheim, Berlin, 1892, see also footnote *a*, of Table I.

(21) C. F. H. Allen and F. W. Spangler, *Org. Syntheses*, **27**, 60 (1947).

(22) R. Andrisano and G. Modena, *C. A.*, **47**, 4737 (1953).

(23) We wish to thank Drs. R. Andrisano and G. Modena of the Istituto di Chimica Industriale, Bologna, for the following description of their procedure: "An intimate mixture of 2.8 g. of sodium nitromalonaldehyde with 1.8 g. of acetamidine hydrochloride is placed in a flask and a few drops of piperidine added. The reaction mixture is heated one hour on a steam-bath, then one g. of sodium carbonate is added, and heating continued for another half-hour. The reaction mass is taken up in a small amount of water, and, after cooling, is filtered. When the residue is extracted with ligroin the product is isolated and melts at 186–187° (ligroin). More product can be recovered from the aqueous solution."

(24) H. Rapoport, A. R. Williams, O. G. Lowe and W. W. Spooncer, THIS JOURNAL, **75**, 1125 (1953). Some additional details were furnished in a private communication from Dr. Rapoport.

aldehyde was treated with concentrated aqueous ammonia, or with ammonium chloride, ammonium acetate or acetamide in the presence of Triton B. The elemental analysis of the resin did not correspond to the condensation of nitromalonaldehyde with ammonia in a simple ratio. No significant characteristics were obtained in the infrared, visible or ultraviolet absorption spectra of the resin.

Unsuccessful Procedures for the Reduction of 2-Nitro-5-phenylpyrimidine.[25]—The following procedures gave either no reaction or intractable products: tin and hydrochloric acid,[26] hydrazine hydrate and Raney nickel,[27] stannous chloride and hydrochloric acid[28] or platinum oxide catalyst and hydrogen at several atmospheres pressure.

Reduction with Sodium Hydrosulfite.—A suspension of 0.20 g. of 2-nitro-5-phenylpyrimidine in a solution of 0.40 g. of sodium hydroxide in 10 ml. of water was warmed and stirred while 1.05 g. of sodium hydrosulfite was added. The solution was centrifuged to remove a small amount of brown solid, then cooled to 5° and treated with 2 ml. of acetic anhydride. White crystals of **5-acetylamino-2-phenylpyrimidine** were formed which were recrystallized from 20% alcohol–water to give shiny, white platelets, m.p. 208–209°.

Anal. Calcd. for $C_{12}H_{11}N_3O$: N, 19.71. Found: N, 19.60.

Hydrogenation with Palladium Catalyst.—A suspension of 2.00 g. (0.01 mole) of 5-nitro-2-phenylpyrimidine in 200 ml. of absolute ethanol was shaken with 0.6 g. of 5% palladium-on-charcoal catalyst at room temperature for one-half hour under a hydrogen pressure of three atmospheres. The suspension was evaporated to dryness *in vacuo* on the steam-bath and the residue was extracted with boiling benzene. Filtration and cooling gave feathery, white clusters and a second crop was obtained by concentration of the liquor. The yield was 1.50 g. (88%) of **5-amino-2-phenyl-pyrimidine** melting at 90.5–92°; previously reported[13] 90–91°.

5-Amino-2-*p*-tolylpyrimidine, m.p. 183.5–184° (sealed capillary), was obtained in 95% yield by the use of the same reduction procedure on the corresponding nitro compound.

Anal. Calcd. for $C_{11}H_{11}N_3$: C, 71.35; H, 5.95. Found: C, 70.98; H, 6.18.

Attempted reductions of 2-(4-chlorophenyl)-, 2-(4-bromophenyl)- and 2-(4-methoxyphenyl)-pyrimidines under the same conditions were not successful. At high pressure or at elevated temperatures oily or tarry products were obtained.

Attempted Diazotization of 5-Amino-2-phenylpyrimidine.—The following reaction conditions were tried: sodium nitrite in aqueous hydrochloric acid, nitrosylsulfuric acid in sulfuric acid,[29] bromine and sodium nitrite in hydrobromic acid,[30] isoamyl nitrite and hydrogen chloride in absolute ethanol, and sodium nitrite in aqueous trifluoroacetic acid.[31] Each reaction mixture was tested for the presence of aromatic diazonium salt by adding it to an alkaline solution of β-naphthol. In no case was a color observed which could be attributed to the formation of a coupling product.

Biological Testing.—Some of the compounds described in this publication were submitted to a microbiological screening program with emphasis on pyrimidine antimetabolite activity under the supervision of Dr. Irving Slotnick, Roswell Park Memorial Institute, Buffalo 3, N. Y.

(25) Raney nickel at low hydrogen pressure in dioxane has previously been reported to result in the formation of 2,2′-diphenyl-5,5′-azoxypyrimidine, P. E. Fanta and T. R. Hughes, THIS JOURNAL, **72**, 5343 (1950).

(26) R. L. Shriner and R. C. Fuson, "The Systematic Identification of Organic Compounds," 3rd Ed., John Wiley and Sons, Inc., New York N. Y., 1948, p. 144.

(27) D. Balcom and A. Furst, THIS JOURNAL, **75**, 4334 (1953).

(28) L. A. Perez-Medina, R. P. Mariella and S. M. McElvain, *ibid.*, **69**, 2574 (1947).

(29) H. A. J. Schoutissen, *ibid.*, **55**, 4531 (1933).

(30) L. C. Craig, *ibid.*, **56**, 231 (1934).

(31) M. R. Pettit, M. Stacey and J. C. Tatlow, *J. Chem. Soc.*, 3081 (1953).

CHICAGO 16, ILLINOIS

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY OF THE UNIVERSITY OF MINNESOTA]

The Formation of Naphthalenes from Indenes. II[1,2]

BY WILLIAM E. PARHAM, HARRY E. REIFF[3] AND PAUL SWARTZENTRUBER

RECEIVED AUGUST 22, 1955

The yield of 2-chloronaphthalene from indene and chloroform has been increased to 65% by utilization of potassium *t*-butoxide as the base for generation of dichlorocarbene from chloroform. The proposed intermediate, 1,1-dichloro-1a,6a-dihydrocycloprop[a]indene (I), has been isolated. The status of this intermediate in the ring expansion reaction has been confirmed by its quantitative conversion into 2-chloronaphthalene, a reaction which appears to follow first-order kinetics in neutral or basic media. The reaction of indene, potassium *t*-butoxide and bromoform affords a 51% yield of 2-bromonaphthalene. A similar reaction, using iodoform, does not lead to the formation of iodonaphthalene; the iodoform is reduced to methylene iodide. The reaction of 1-(or 3)-methylindene with potassium *t*-butoxide and bromoform leads to the formation of 1-methyl-2-bromonaphthalene in 44% yield. No evidence for the formation of the 3-bromoisomer was obtained.

A new synthesis of 2-chloronaphthalene was recently described[1] which involves the reaction of indenylsodium with chloroform in excess indene. This paper describes additional studies of this, and related, reactions.

2-Chloronaphthalene and an azulene were the only isolable compounds[1] when the crude reaction mixture obtained from indenylsodium, chloroform and indene was distilled with steam. It has been found in this study, however, that 2-chloronaphthalene is not present when only non-polar solvents are employed in processing the crude reaction mixture. In this case the principal product (2–4% yield) is a neutral compound which has been assigned the structure 1,1-dichloro-1a,6a-dihydrocycloprop[a]indene (I). Analysis and molecular weight determinations establish the empirical formula $C_{10}H_8Cl_2$ for the neutral compound. The substance gives no immediate reaction with bromine in carbon tetrachloride or with neutral potassium permanganate solution, indicating the absence of an olefinic bond. The ultraviolet spectrum of the material is quite similar to that of indane, and, specifically, absorption in the region of 250 mμ, typical of a double bond conjugated with an aromatic system,[4] is absent. These data, together with the report of Doering and Hoffmann[5] that olefins such as cyclo-

(1) Preceding paper: W. E. Parham and H. E. Reiff, THIS JOURNAL, **77**, 1177 (1955).

(2) Presented in part at the 127th Meeting of the American Chemical Society, Cincinnati, Ohio, March, 1955.

(3) National Science Foundation Pre-doctoral Fellow, 1954–1955.

(4) T. W. Campbell, S. Linden, S. Godshalk and W. G. Young, THIS JOURNAL, **69**, 880 (1947).

(5) W. von E. Doering and A. K. Hoffmann, *ibid.*, **76**, 6162 (1954).