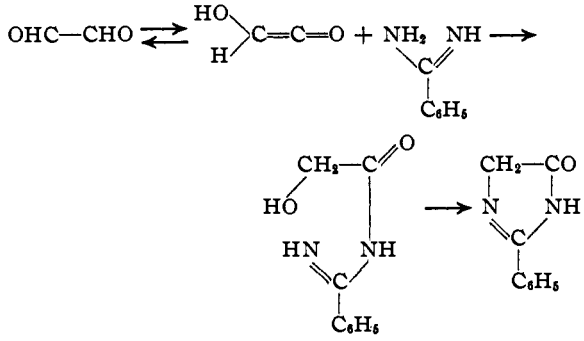
This is in fair agreement with the electron diffraction measurements of LuValle and Schomaker,[18] who found a value of 1.47 Å.

The following equation is a suggested mechanism for the reaction of benzamidine and glyoxal.



Experimental

The compound obtained from benzamidine, glyoxal and benzaldehyde was prepared by the method described by Ekeley and Ronzio.[9] The product, recrystallized several times from *s*-amyl alcohol, melted at 284° (capillary tube melting point).

One gram of the finely powdered product was suspended in 100 ml. of alcohol in a two-necked flask fitted with a reflux condenser and mechanical stirrer. The solvent was heated to boiling and 2% sodium amalgam was added, in small portions, through the reflux condenser. Glacial acetic acid was then added periodically in quantities sufficient to keep the mixture acidic throughout the reaction. After about one hour the yellow color disappeared and the solution became clear. The solution was separated from the mercury and evaporated to dryness in a vacuum. The solid residue was washed first with water, then with a little ether. The yield of crude product was 85%. Recrystallized twice from xylene (using carbon), and washed with petroleum ether and dried, the colorless crystals melted at 150–151°.

Anal. Calcd. for $C_{16}H_{16}N_2O$: C, 76.16; H, 6.39; N, 11.10. Found: C, 76.10, 76.28; H, 6.46, 6.65; N, 10.88, 10.92.

The compound easily formed a picrate melting at 238°.

A like amount of compound prepared from benzaldehyde, hippuric acid, and ammonia (m. p. 280°), according to the directions of Erlenmeyer,[15] was reduced in exactly the same manner. The colorless crystals melted at 150–151°.[19]

Anal. Calcd. for $C_{16}H_{16}N_2O$: C, 76.16; H, 6.39; N, 11.10. Found: C, 76.29, 76.28; H, 6.40, 6.20; N, 11.03, 10.92.

A picrate of the compound melted at 238°.

A melting point determination of a mixture of the two reduction products showed no change in melting point.

Summary

The series of products prepared by Erlenmeyer from aromatic aldehydes, hippuric acid, and ammonia and by Ekeley and Ronzio from aromatic aldehydes, benzamidine, and glyoxal have been shown to be identical—namely, 2-phenyl-4-arylidine-5-glyoxalidones.

Thermodynamic calculations indicate the existence of the tautomer of glyoxal, hydroxyketene, to the extent of about 28%.

(18) LuValle and Schomaker, THIS JOURNAL, **61**, 3520 (1939).

(19) Granacher and Gulbas (*Helv. Chim. Acta*, **10**, 819 (1927)) obtained 145–146° for the melting point of this reduction product after recrystallization from methanol.

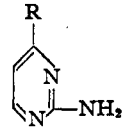
APPLETON, WISCONSIN RECEIVED SEPTEMBER 25, 1944

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY AND PHYSICS OF THE PENNSYLVANIA STATE COLLEGE]

Heterocyclic Basic Compounds. V. 2-Amino-4-basically-substituted-pyrimidines[1]

BY ROBERT R. ADAMS[2] AND FRANK C. WHITMORE

As an extension of our previous investigations on pyrimidine compounds,[3] we have prepared a number of basically-substituted pyrimidines which correspond to the formula



where R is an aminoalkylamino or a di-(ω-aminoalkyl)-amino group of three to eight carbon atoms which may be interrupted by an oxygen atom or an amino group and in addition may have either a straight or branched carbon chain. The ω-amino group may be either diethylamino, di-*n*-propylamino, di-*n*-amylamino, piperidino or morpholino. The properties of these compounds and their derivatives are shown in Table I.

These compounds were prepared by treatment of 2-amino-4-chloropyrimidine[4] with two moles of the basically-substituted aliphatic amine[5] or with about one and two-tenths moles of the amine in pyridine. When triethylamine was used as solvent instead of pyridine in the reaction of 2-amino-4-chloropyrimidine with δ-diethylaminobutylamine, the yield dropped from 79 to 27%. This is perhaps because the chloropyrimidine is soluble in the excess diamine or in pyridine but

(1) This paper is taken from a portion of the doctoral dissertation of Robert R. Adams, the Pennsylvania State College, 1944.

(2) Parke, Davis and Company, Research fellow, 1942–1944; present address, Parke, Davis and Company.

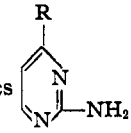
(3) Adams and Whitmore, THIS JOURNAL, **67**, 745 (1945).

(4) Kindly furnished by the Calco Chemical Division of American Cyanamid Company.

(5) Whitmore, Mosher, Adams, Taylor, Chapin, Weisel and Yanko, THIS JOURNAL, **66**, 725 (1944).

TABLE I

2-AMINO-4-BASICALLY-SUBSTITUTED PYRIMIDINES



R	Moles of 2-amino-4-chloro-pyrimidine	Moles of aliphatic diamine	Ml. of pyridine	Yield %	B. p. at 3 mm., °C.	M. p., °C.	M. p. of picrate, °C.	M. p. of hydrochloride, °C.
—NH—$CH_2CH_2NC_4H_8O$[d]	0.0775	0.155	15	81.5	190–195	87	205	.....
—NH—$(CH_2)_3NH_2$	.34	1.35	0	47	198–200	108–110	204.5	.....
—NH—$(CH_2)_3NEt_2$	.0775	0.1147	25	64.3	183–183	.....	176	128–130
—NH—$(CH_2)_3N(n\text{-}Pr)_2$	.0581	.0641	25	51.5	150–180	.....	138–140	.....
—NH—$(CH_2)_3N(n\text{-}C_5H_{11})_2$	.0565	.0933	25	67.4	203–205	Oily solid	148–149	.....
—NH—$(CH_2)_3NC_5H_{10}$[c]	.0775	.115	25	65.5	178–180	105–109	185	170–172
—NH—$(CH_2)_3NC_4H_8O$[d]	.0845	.139	25	76.0	195–210	130–131	218–219	208–209
—NH—$(CH_2)_4NEt_2$	.058	.132	0	79.0	195	.....	174–175	105[e]
	.0775	.0855	[a]	27.5				
—NH—$CH(CH_3)(CH_2)_3NEt_2$	.0775	.129	25	54.0	184–187	.....	177	.....
—NH—$(CH_2)_4NC_5H_{10}$[c]	.0775	.104	25	53.4	204–207	Oily solid	174–176	.....
—NH—$(CH_2)_4NC_4H_8O$[d]	.058	.076	25	28.6	150–210	208–209	211.5	165–168
—NH—$(CH_2)_5NH_2$	.102	.306	25	55.1	198–203	.....	193–195	.....
—NH—$(CH_2)_6NH_2$	.31	1.09	0	66.3	218–221	93	208–209	.....
—NH—$(CH_2)_2NH—(CH_2)_2NH_2$	.0775	.583	0	76.0	215–216	Oily solid	230–231	.....
—NH—$(CH_2)_3NH—(CH_2)_3NEt_2$	.0581	.160	20	51.2	210–215	.....	187.5	209–211
—NH—$(CH_2)_3O(CH_2)_2NEt_2$	.058	.116	10	76.8	185–190	.....	171–173	.....
—NH—$(CH_2)_3OCH(CH_3)(CH_2)_3NEt_2$	.0465	.093	10	72.2	210	.....	133–133.5	.....
—N=$[(CH_2)_3NEt_2]_2$	.0526	.070	25	54.7	183–187	Oily solid	139–142	206–207
—N=$[(CH_2)_3NC_5H_{10}]_2$[c]	.0504	.0663	25	36.3	243–245	.....	186–188	176–178
—N=$[(CH_2)_3NC_4H_8O]_2$[d]	13.1	40	0	46.5	250–260	97–98	205–205.5	....
—N=$[(CH_2)_4NC_5H_{10}]_2$[c]	0.0502	0.0688	25	48.1	240–250	Oily solid	190–192	.....
—N=$[(CH_2)_4NC_4H_8O]_2$[d]	.0254	.0333	25	31.9	254	.....	242	115 dec. softens 98–100
—N=$[(CH_2)_3O(CH_2)_2NEt_2]_2$	.0388	.042	25	43.0	225–230	Oily solid[f]	115–116.5	.....
—N=$[(CH_2)_3OCH(CH_3)(CH_2)_3NEt_2]_2$	.031	.0388	15	50.6	245–255	.....	[b]	.....

[a] Run using 25 cc. of triethylamine instead of pyridine. [b] Picrate not obtained in crystalline form. [c] —NC_5H_{10} represents the piperidino group (1-piperidyl radical). [d] —NC_4H_8O represents the morpholino group (4-morpholinyl radical). [e] *Anal.* Calcd. for $C_{12}H_{23}N_5 \cdot 2HCl$; C, 45.30; H, 8.13. Found: C, 45.65; H, 8.38. [f] *Anal.* Calcd. for the base $C_{22}H_{44}O_2N_6$: N, 19.78. Found: N, 19.30.

not in triethylamine. The alkylation was usually carried out by heating the reactants in a sealed tube at 150–165° for four to six hours. The yields of 30 to 80% seemed to be dependent on the excess aliphatic amine used.

Some of the reaction mixtures of 2-amino-4-chloropyrimidine and various basically-substituted aliphatic amines gave 2,4-diaminopyrimidine in small amounts. This was identified by Dumas nitrogen analysis, physical properties[6] and mixed melting points with an authentic sample.

Acknowledgment.—The authors wish to thank Dr. Harry S. Mosher for his interest and help and Parke, Davis and Company whose support made this work possible.

Experimental

Of the twenty-four compounds in Table I only three typical examples are given in detail.

2-Amino-4-(δ-diethylaminobutylamino)-pyrimidine.—A mixture consisting of 7.5 g. (0.058 mole) of 2-amino-4-chloropyrimidine and 19.0 g. (0.132 mole) of δ-diethylaminobutylamine[5] was placed in a bomb-tube and heated at 150° for five hours. The tube was opened and the contents placed over approximately 20 g. of flake sodium hydroxide and allowed to stand overnight. The sodium hydroxide–sodium chloride was removed by filtration, the residue washed with a little pyridine, and the filtrate and washings distilled from a modified Claisen flask. After removal of the pyridine, the fraction boiling at 180–203° (mainly 195°) at 3 mm. was collected; yield 10.8 g. (79%). The product was a very light yellowish viscous oil. The picrate was prepared in ethanol and after recrystallization melted at 174–175°.

2-Amino-4[γ-(γ′-diethylaminopropyl)-aminopropylamino]-pyrimidine.—A paste consisting of 7.5 g. (0.058 mole) of 2-amino-4-chloropyrimidine, 30 g. (0.16 mole) of γ-(γ′-diethylaminopropyl)-aminopropylamine[5] and 20 ml. of pyridine was refluxed in an oil-bath at 130° for four and one-half hours. The solution was cooled, 20 g. of flake sodium hydroxide added and the mixture heated on the steam-bath overnight. The sodium hydroxide–sodium chloride was removed by filtration and the pyridine by distillation. Distillation of the residue yielded 8.3 g., 51.2%, of the product which boiled at 210–215° at 3 mm. The picrate was prepared in ethanol and after recrystallization melted at 187–187.5°. The hydrochloride was prepared by adding a saturated solution of dry hydrogen chloride in *n*-amyl alcohol to an *n*-amyl alco-

(6) Buttner, *Ber.*, **36**, 2233 (1903).

Formula	Analyses, % Calcd.	Found
$C_{10}H_{17}ON_5$	N 31.35	31.32
$C_7H_{13}N_5$	N 41.87	41.96
$C_{11}H_{21}N_5 \cdot 3HCl$	Cl 32.14	32.10
$C_{13}H_{26}N_6 \cdot 2C_6H_3O_7N_3$	N 21.70	21.68
$C_{17}H_{33}N_5 \cdot 3C_6H_3O_7N_3$	N 19.72	19.99
$C_{12}H_{21}N_5 \cdot 3HCl$	Cl 30.91	30.83
$C_{11}H_{19}ON_5 \cdot 3HCl$	Cl 30.73	30.67
$C_{12}H_{23}N_5 \cdot 2C_6H_3O_7N_3$	N 22.14	22.14
$C_{13}H_{25}N_5 \cdot 2C_6H_3O_7N_3$	N 21.70	21.42
$C_{13}H_{23}N_5 \cdot 2C_6H_3O_7N_3$	N 21.79	21.75
$C_{12}H_{21}ON_5 \cdot 3HCl$	Cl 29.53	29.51
$C_9H_{17}N_5 \cdot 2C_6H_3O_7N_3$	N 23.56	23.19
$C_{10}H_{19}N_5 \cdot 2C_6H_3O_7N_3$	N 23.17	23.06
$C_8H_{16}N_6 \cdot 4C_6H_3O_7N_3$	N 22.65	22.83
$C_{14}H_{28}N_6 \cdot 3HCl$	Cl 27.34	27.37
$C_{13}H_{25}ON_5 \cdot 3C_6H_3O_7N_3$	N 20.53	20.43
$C_{15}H_{29}ON_5 \cdot 3C_6H_3O_7N_3$	N 19.67	19.75
$C_{18}H_{36}N_6 \cdot 4HCl$	Cl 29.46	29.46
$C_{19}H_{36}N_6 \cdot 4HCl$	Cl 28.06	28.00
$C_{19}H_{34}O_2N_6 \cdot 4C_6H_3O_7N_3$	N 19.68	19.20
$C_{22}H_{40}N_6 \cdot 4C_6H_3O_7N_3$	N 19.46	19.32
$C_{21}H_{36}O_2N_6 \cdot 4C_6H_3O_7N_3$	N 19.40	19.48
$C_{22}H_{44}O_2N_6 \cdot 3C_6H_3O_7N_3$	N 18.88	18.81
$C_{26}H_{52}O_2N_6$	N 16.49	16.93

hol solution of the base. The salt after recrystallization from *n*-butanol–ether mixture melted at 209–211°.

2-Amino-4-(ω-aminohexylamino)-pyrimidine.—A paste consisting of 40 g. (0.31 mole) of 2-amino-4-chloropyrimidine and 126 g. (1.09 moles) of hexamethylenediamine[7] was placed in a flask equipped with a reflux condenser. The mixture was heated in an oil-bath at 155° for five hours, cooled and 65 g. of flake sodium hydroxide added. The mixture was warmed overnight by steam, the liquid was decanted, and the residue washed with a little pyridine. After distillation of the pyridine, the residue was distilled from a modified Claisen flask and the fraction boiling at 218–221° (3 mm.) was collected; yield 43 g. (66.3%). The product was a light yellow, viscous oil which crystallized on cooling and after recrystallization from petroleum ether melted at 93°. The picrate was prepared in ethanol and after recrystallization melted at 208–209°.

Summary

2-Amino-4-chloropyrimidine reacts with primary or secondary basically-substituted aliphatic amines to yield the corresponding 2-amino-4-basically-substituted pyrimidines. Twenty-four compounds of this type have been prepared.

(7) Furnished by the courtesy of E. I. du Pont de Nemours & Co., Inc.

STATE COLLEGE, PENNSYLVANIA

RECEIVED APRIL 12, 1945

[CONTRIBUTION FROM STARCH AND DEXTROSE DIVISION, NORTHERN REGIONAL RESEARCH LABORATORY,[1] PEORIA, ILLINOIS]

Separation of Amylose and Amylopectin by Certain Nitroparaffins[2]

BY ROY L. WHISTLER AND G. E. HILBERT

Schoch's[3] fundamental discovery that butanol (or isoamyl alcohol) separates starch into two fractions—amylose and amylopectin[4]—having widely different properties and molecular configurations[5] is of importance from two standpoints:

1. A preparative method for the fractions, which appears to be applicable to starches in general, has been provided.

2. The procedure used for effecting the fractionation is an unusual one involving the formation of a complex between amylose and butanol which is insoluble in the system water–butanol while amylopectin is soluble under the same conditions. Practically nothing is known regarding the mechanism of formation of the butanol–amylose complex. Schoch,[3b] for example, states: "The reason for the selective precipitating action of normal butyl and isoamyl alcohols is obscure, possibly depending on some undefined optimum of molecular volume or 'hydrophil balance'." Information on the mechanism of formation or on the nature of the butanol–amylose complex obviously would be of value as a guide in developing new procedures for separating the components of starch and possibly other mixtures of high polymers.

Very few data are available on the composition or structure of the butanol–amylose complex. From Schoch's[3a] work, it is apparent that the complex contains butanol, but the ratio of butanol to amylose is not known. Rundle and Edwards,[6] on the basis of X-ray diffraction data, have concluded that the complex is composed of helically shaped amylose molecules[7] with butanol occupying the core of the helix.

The wide occurrence of hydrogen bonding[8] suggests that the association of butanol and starch

(1) This is one of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Article not copyrighted.

(2) Original manuscript received August 14, 1944.

(3) (a) Schoch, *Cereal Chem.*, **18**, 121 (1941); (b) Schoch, THIS JOURNAL, **64**, 2957 (1942); (c) Wilson, Schoch and Hudson, *ibid.*, **65**, 1380 (1943); see also Wiegel, *Koll. Zeit.*, **102**, 145 (1943).

(4) Schoch did not name the two different fractions separated by means of butanol. The conventional terms now in use for designating the starch fractions are amylose and amylopectin. The amylose fraction, consisting essentially of linear molecules, is prepared by butanol precipitation or elution from swollen granules. Amylopectin is the fraction remaining after the removal of the amylose, and is composed mainly of branched or tangled molecules.

(5) Meyer, "Advances in Colloid Sciences," Interscience Publishers, Inc., New York, N. Y., 1942, pp. 143–165.

(6) Rundle and Edwards, THIS JOURNAL, **65**, 2200 (1943).

(7) Freudenberg, *Naturwissenschaften*, **27**, 841 (1939).

(8) Hilbert, Wulf, Hendricks and Liddel, THIS JOURNAL, **58**, 548 (1936); Gordy and Sanford, *J. Chem. Phys.*, **8**, 170 (1940).