will have different effects upon the enzyme, the mechanism indicated by I, III, IV and V must be further enlarged. This leads to an expression for V which cannot be arranged in the form of 7. Thus a plot of V *vs.* pH may be asymmetrical if the pK of a buffer such as phosphate is in the same region as the activity curve. However, if the buffer concentration is high and one form has a sufficiently great affinity to displace the other, the V–pH curve may be symmetrical and the pK values would correspond to the enzyme saturated with the more strongly bound form of the buffer. Buffers of the uncharged-acid or uncharged-base types have the advantage over phosphate that the concentration of the ionized form of the buffer may be held constant over a wide range of pH.

Since enzymes are proteins it is to be expected, in general, that their properties will depend on the concentration and nature of salts in the solution and upon the pH. Although these effects may be too complicated to express by such simple mechanisms as those used here, the fact that the present equations are in good agreement with the results for fumarase is encouraging.

Acknowledgment.—The author is indebted to Dr. Vincent Massey, Dr. Robert Bock and Carl Frieden for many helpful discussions. The research was aided by grants from the National Science Foundation and the Research Committee of the Graduate School of the University of Wisconsin from funds supplied by the Wisconsin Alumni Research Foundation.

MADISON, WISCONSIN

NOTES

A Synthesis of 1-C^{14}-Labeled Diethyl Ether

BY JEROME G. BURTLE AND WILLIAM N. TUREK

RECEIVED DECEMBER 14, 1953

In the course of other work in this Laboratory, need arose for a sample of C^{14}-labeled diethyl ether. A search of the literature revealed that, although many preparations of ethyl ether are described,[1] no synthesis of the C^{14}-labeled compound could be found. Furthermore, no high yield procedure for small amounts (10–12 g. of product) which could be used directly for this purpose, came to light. It became imperative, therefore, for us to develop a satisfactory process for our own use.

Since it was necessary to label only one ethyl radical, it was decided to use the Williamson synthesis[2] as the basic reaction because it offered maximum economy of radioactive starting material. The procedure ultimately adopted as satisfactory for small batches was based on the experiments of Hunt[3] and of Beilstein[4] on ethyl iodide preparation, and those of Bishop[5] on the reaction of ethyl iodide with sodium ethoxide.[6]

From 11–12 g. of 95% ethanol-1-C^{14} (100 microcuries) 32.4 g. (87.6%) of ethyl-1-C^{14}-iodide boiling at 70–73° was obtained. Treatment of 26.4 g. of this material with sodium ethoxide gave 11.5 g. (92%) of 1-C^{14}-ethyl ether boiling at 33.5–34°.

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DEPARTMENT OF CHEMISTRY
COLLEGE OF ST. THOMAS
SAINT PAUL 1, MINNESOTA

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(1) T. Saussune, *Ann. chim.*, [1] **89**, 273 (1814); J. L. Gay-Lussac, *ibid.*, [1] **95**, 311 (1815); Dumas and Boullay, *ibid.*, [2] **36**, 294 (1827); A. W. Williamson, *ibid.*, [3] **40**, 98 (1854); *Ann.*, **77**, 37 (1851); *ibid.*, **81**, 73 (1852); E. Erlenmeyer, *ibid.*, **162**, 380 (1872); A. W. Titherley, *J. Chem. Soc.*, **79**, 392 (1901).

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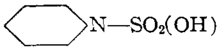
(6) The complete experimental details of this preparation have been deposited as Document number 4193 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. A copy may be secured by citing the Document number and by remitting $1.25 for photoprints, or $1.25 for 35 mm. microfilm. Advance payment is required. Make checks or money orders payable to: Chief, Photoduplication Service, Library of Congress.

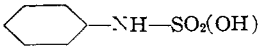
N-Cycloalkyl- and N,N-Polymethylenesulfamic Acids

BY F. F. BLICKE, HENRY E. MILLSON, JR., AND N. J. DOORENBOS

RECEIVED JANUARY 21, 1954

Since considerable quantities of hexa-, hepta- and octamethylenimine were available, it seemed desirable to prepare a few N,N-polymethylenesulfamic acids. These compounds are of interest since they are related to cycloalkylsulfamic acids. The sodium and calcium salt of N-cyclohexylsulfamic acid (Sucaryl or Cyclamate sodium or calcium) are important sweetening agents.[1] It is obvious that N,N-pentamethylenesulfamic acid (I) represents N-cyclohexylsulfamic acid (II) in which the nitrogen atom has been made a part of the ring structure.


I


II

The N,N-polymethylenesulfamic acids were obtained by interaction of chlorosulfonic acid with pyrrolidine, hexamethylen-,[2] heptamethylen-[2] or octamethylenimine[2] by the general method used by Audrieth and Sveda[3] for the synthesis of N-cyclohexylsulfamic acid.

No sweet taste could be detected when the solid sodium salts of the N,N-polymethylenesulfamic acids were tested. Furthermore, no sweet taste

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TABLE I

SULFAMIC ACIDS AND SALTS, B–SO_2(OX)

Compounds 1, 3, 6, 9, 12 and 15 were recrystallized from 95% ethanol, and 4, 7 and 10 from water.

	B	X	M.p., °C. (dec.)	Yield, %	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Sulfur, % Calcd.	Sulfur, % Found
1	N<$(CH_2)_4$	Na		52	$C_4H_8O_3NSNa$	8.09	8.11	18.51	18.75
2	N<$(CH_2)_4$	H	173–175		$C_4H_9O_3NS$	9.27	9.25	21.21	21.02
3	N<$(CH_2)_6$	Na		56	$C_6H_{12}O_3NSNa$	6.96	6.95	15.93	15.82
4	N<$(CH_2)_6$	Ba/2		32	$C_{12}H_{24}O_6N_2S_2Ba$	5.67	5.53	12.98	12.68
5	N<$(CH_2)_6$	H	173–174		$C_6H_{13}O_3NS$	7.82	7.70	17.88	17.65
6	N<$(CH_2)_7$	Na		68	$C_7H_{14}O_3NSNa$	6.51	6.28	14.89	15.33
7	N<$(CH_2)_7$	Ba/2		34	$C_{14}H_{28}O_6N_2S_2Ba$	5.37	5.35	12.29	12.26
8	N<$(CH_2)_7$	H	172–173		$C_7H_{15}O_2NS$	7.25	7.22	16.59	16.71
9	N<$(CH_2)_8$	Na		69	$C_8H_{18}O_3NSNa$	6.11	6.00	13.98	14.54
10	N<$(CH_2)_8$	Ba/2		40	$C_{16}H_{32}O_6N_2S_2Ba$	5.09	5.16	11.66	11.32
11	N<$(CH_2)_8$	H	172–174		$C_8H_{17}O_3NS$	6.76	6.59	15.47	15.34
12	NC_7H_{14}[a]	Na		86	$C_7H_{14}O_3NSNa$	6.51	6.49	14.90	15.04
13	NC_7H_{14}	Ba/2		30–40	$C_{14}H_{28}O_6N_2S_2Ba$	5.37	5.34	12.29	12.38
14	NC_7H_{14}	H	178–179		$C_7H_{15}O_3NS$	7.25	7.24	16.59	16.66
15	NC_8H_{16}[b]	Na		81	$C_8H_{16}O_3NSNa$	6.11	6.14	13.98	14.21
16	NC_8H_{16}	Ba/2		30–40	$C_{16}H_{32}O_6N_2SBa$	5.09	5.07	11.66	11.85
17	NC_8H_{16}	H	183–184		$C_8H_{17}O_3NS$	6.76	6.77	15.47	15.70

[a] NC_7H_{14} = cycloheptylamino. [b] NC_8H_{18} = cyclooötylamino.

was noticed when these salts were tested in dilutions of 1:1,000–1:10,000.

Since it was also of interest to determine the influence of ring size in N-cycloalkylsulfamic acids on sweet taste, we prepared N-cycloheptyl- (III) and N-cyclooöctylsulfamic (IV) acid. These compounds were obtained from cycloheptyl-[4] and cyclooöctylamine[5] by the method mentioned above.[3]

The sweet taste of Sucaryl sodium was easily perceptible in a dilution of 1:10,000. The sweet taste of sodium salt of III could be detected easily in a dilution of 1:4000, and that of the sodium salt of IV in a dilution of 1:1000.

Experimental

The sodium and barium salts of the sulfamic acids were obtained from the reaction mixture by the method which has been mentioned.[3] In order to isolate the sulfamic acid from the sodium salt, an analytically-pure sample of the latter substance was treated with an exactly equivalent amount of standardized sulfuric acid. The mixture was evaporated to dryness and the acid was extracted with absolute ethanol. After evaporation of the solvent, the pure acid was obtained in practically quantitative yield.

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(5) N. J. Doorenbos, Dissertation, University of Michigan, 1953.

COLLEGE OF PHARMACY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

Organosilicon Compounds Containing the Thiocyanomethyl Group Attached to Silicon

BY GLENN D. COOPER

RECEIVED DECEMBER 28, 1953

In connection with an investigation of the properties of organosilicon compounds having various functional groups attached to carbon, a number of silanes and siloxanes having a thiocyanomethyl group attached to silicon were prepared by the reaction of the corresponding chloro compound with sodium thiocyanate in ethanol.

Trimethylsilylmethyl thiocyanate underwent silicon–carbon cleavage to give a 93% yield of hexamethyldisiloxane on refluxing for 20 hours with 5% sodium hydroxide solution. It was not affected by refluxing for 20 hours with 5% hydrochloric acid solution.

Equilibration of heptamethylcyclotetrasiloxanylmethyl thiocyanate with a small amount of chain-stopper (hexamethyldisiloxane) according to the procedure of Patnode and Wilcock[1] yielded a silicone oil containing approximately one –CH_2SCN group for each four silicon atoms. The viscosity-temperature coefficient of the oil was 0.69, as compared with 0.60 for methyl silicone oils[2]; the activation energy of viscous flow was 4.5 kcal. as compared with 3.8 kcal. for high molecular weight methyl silicone oils.[3] This probably indicates greater interchain forces due to dipole interactions of the polar CN group.

Experimental[4]

Trimethylsilylmethyl Thiocyanate.—Chloromethyltrimethylsilane (48.8 g., 0.4 mole) and 32.4 g. (0.4 mole) of sodium thiocyanate were heated under reflux with 100 ml. of 95% ethanol for three hours. The precipitate of sodium chloride was filtered off and 200 ml. of water was added to the filtrate. The organic layer was drawn off, dried over anhydrous calcium chloride and distilled at atmospheric pressure; there was obtained 35.2 g. (61%) of trimethylsilylmethyl thiocyanate, b.p. 196–197°, n^{20}_D 1.4676, d^{20}_4 0.9426. *Anal.* Calcd. for $C_5H_{11}NSSi$: C, 41.4; H, 7.6; N, 9.7; MR_D 42.64.[5] Found: C, 41.4; H, 7.6; N, 9.7; MR_D 42.82.

Pentamethyldisiloxanylmethyl Thiocyanate.—From 78.4 g. (0.4 mole) of chloromethylpentamethyldisiloxane and 32.4 g. of sodium thiocyanate there was obtained 35.2 g. (40%) of pentamethyldisiloxanylmethyl thiocyanate, b.p. 135° (42 mm.), n^{20}_D 1.4443, d^{20}_4 0.9518. *Anal.* Calcd. for $C_7H_{17}ONSSi_2$: C, 38.4; H, 7.8; S, 14.6; MR_D 61.28. Found: C, 38.8; H, 7.8; S, 15.0; MR_D 61.28.

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(2) E. G. Rochow, "Introduction to the Chemistry of the Silicones," 2nd edition, John Wiley and Sons, Inc., New York, N. Y., 1951, p. 87.

(3) D. F. Wilcock, THIS JOURNAL, **68**, 691 (1946).

(4) Microanalyses and infrared spectra were determined by the members of the Analytical Section of this Laboratory. Fractional distillations of the thiocyanates were performed by E. M. Hadsell and Mrs. J. R. Ladd. The chloro compounds were prepared by Dr. J. R. Ladd.

(5) Calculated from the bond refraction values of E. L. Warrick, THIS JOURNAL, **68**, 2455 (1946).