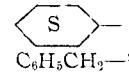
NOTES

Esters of 2-Furanacrylic Acid

By Paul D. Bartlett and Sidney D. Ross

In connection with the insect repellent program of the O.S.R.D., it became necessary to prepare a series of esters of 2-furanacrylic acid. Although esters of 2-furanacrylic acid are known, there is no satisfactory general preparative method available. Fischer esterification almost invariably gives low yields and impure products. The most commonly employed methods are the Claisen condensation of furfuraldehyde with the appropriate ester of acetic acid,[1] the alkylation of an alkali metal salt of 2-furanacrylic acid,[2] and treatment of 2-furanacrylyl chloride with an alcohol in benzene.[2] We have found that good yields of esters can be obtained from a variety of alcohols if 2-furanacrylyl chloride is treated with the alcohol in benzene in the presence of excess pyridine. Table I lists the esters prepared, their physical constants, the yields obtained, and the analyses. In cases where the ester is reported in the literature a reference is given.

Table I

R	B. p. °C.	Mm.	M. p., °C.	n_D	Yield, %	Analyses, % Calcd. C	Calcd. H	Found C	Found H
$CH_3CH_2CH_2$—[2]	91–94	3		1.5392/24	86				
CH_2=$CHCH_2$—[3]	131–133	16		1.5573/25	100				
$CH_3OCH_2CH_2$—	118–120	3	33–34		97				
$(CH_3)_2CHCH_2$—	94–95	2		1.5277/24	75	68.03	7.27	68.16	7.47
CH_2=$C(CH_3)CH_2$—	93.5–94	3		1.5500/25	90	68.73	6.30	68.12	6.43
$CH_3CH_2OCH_2CH_2$—	124–126	3		1.5398/25	91	62.84	6.77	62.44	6.71
$CH_3CH_2CH_2CH_2CH_2$—[2]	116.5–118	2		1.5289/24	88	69.22	7.75	68.67	7.93
$(CH_3)_2CHCH_2CH_2$—[1]	123–124	5		1.5253/25	92				
$(CH_3CH_2)_2CHCH_2$—	119–120	3		1.5239/25	54	70.25	8.16	70.45	8.18
	121–124	3	52–53		80	70.90	7.33	71.55	7.58
$C_6H_5CH_2$—[2]	131–132	3	42–43		86				
$C_6H_5CH_2CH_2$—	155–156	3		1.5872/25	72	74.36	5.82	74.01	6.03

Experimental

2-Furanacrylic acid was prepared by the method of Dutt.[4] A more satisfactory procedure has since been reported by Rajagopalan and Raman.[5]

2-Furanacrylyl chloride was prepared by the method of Sasahi.[6] The product boils at 126° at 30 mm. Yields as high as 87% can be obtained by avoiding local superheating during the distillation.

The preparation of the esters can be illustrated by the procedure used to prepare the allyl ester. 2-Furanacrylyl chloride (403 g., 2.33 moles) was dissolved in 600 cc. of benzene in a three-necked flask, fitted with a mercury sealed stirrer, a condenser, and a dropping funnel. Pyridine (395 g., 5 moles) was added with stirring. Allyl alcohol (232 g., 4 moles) in 600 cc. of benzene was then added dropwise. After the addition the reaction mixture was heated for two hours on the steam-bath with stirring. The reaction mixture was cooled and poured into a large volume of water. The benzene layer was separated, washed with saturated sodium chloride solution, and dried over anhydrous sodium sulfate. The benzene was removed *in vacuo* and the product was distilled. The yield was 415 g. (100%), b. p. 131–133 (16); $n^{25}D$ 1.5573.

Gibbs Chemical Laboratory
Harvard University
Cambridge, Massachusetts

Received August 19, 1946

(1) Posner, *J. prakt. Chem.*, **82**, 425 (1910). Schimmel and Co. Reports 225 (1929).
(2) Gilman and Wright, *Iowa State College J. Sci.*, **3**, 109 (1929).
(3) Bliche, *Ber.*, **47**, 1353 (1914).
(4) Dutt, *J. Indian Chem. Soc.*, **1**, 297 (1925).
(5) Rajagopalan and Raman, *Org. Syn.*, **25**, 51 (1945).
(6) Sasahi, *Biochem. Z.*, **25**, 272 (1910).

Urea Alkyl Sulfates

By C. L. Carter and P. A. Ongley

In an attempt to prepare alkyl isoureas by the alkylation of urea using the reaction products of alcohols and either sulfuryl chloride or chlorosulfonic acid, it was found that the main product of the reaction in either case was not alkyl isourea but urea alkyl sulfate, $[CO(NH)_2H]^+RSO_4^-$. As these salts apparently are not recorded in the literature, a number of them have been prepared and their properties studied.

Experimental

The urea alkyl sulfates were prepared by adding dropwise to one mole of sulfuryl chloride in a beaker cooled with ice slightly more than two moles of the required alcohol. One mole of urea was then stirred in with continued

Table I

Urea Alkyl Sulfates

Alkyl	Formula	Neutralization equivalent Calcd.	Found
Methyl	$C_2H_8O_5N_2S$	172	175
Ethyl[a]	$C_3H_{10}O_5N_2S$	186	186
i-Propyl	$C_4H_{12}O_5N_2S$	200	196
n-Butyl	$C_5H_{14}O_5N_2S$	214	213
s-Butyl	$C_5H_{14}O_5N_2S$	214	210

[a] This salt recrystallized gave a constant m. p. of 126°. It yielded a picrate m. p. 252–255° (with charring) and a nitrate m. p. 158°.

cooling. The salt which formed in 80–90% yield consisted of colorless, deliquescent crystals which could be recrystallized from absolute alcohol. However, only the urea ethyl sulfate could be thus recrystallized to a constant melting point. Their neutralization equivalents were as given in Table I.

Anal. Calculated for $C_3H_{10}O_5N_2S$: C, 19.3; H, 5.59; N, 14.8. Found: C, 19.4; H, 5.38; N, 15.0.

When the urea ethyl sulfate was prepared from chlorosulfonic acid, using the same procedure as for sulfuryl chloride except that equal moles of alcohol and chlorosulfonic acid were employed, almost the theoretical yield of sulfate was obtained m. p. 126.5°, which gave no depression of the melting point when mixed with some of the same salt prepared from the sulfuryl chloride.

These alkyl urea sulfates form urea nitrate (slowly) and urea picrate, and give the biuret and furfuryl alcohol tests for urea. In aqueous solution they are strongly acid and their neutralization equivalents correspond to the expected formulas. When treated with barium chloride they give no appreciable precipitate unless they have been previously boiled with concentrated mineral acid, such as hydrochloric or nitric acids. Their property of deliquescence tends to give indefinite melting points.

Summary.—(1) The hitherto unknown urea alkyl sulfates are described. (2) It has been shown that the main reaction products of alcohols with sulfuryl chloride are alkyl hydrogen sulfates. (3) The isolation of ethyl hydrogen sulfate as the urea salt is far superior to its isolation as a metallic salt.

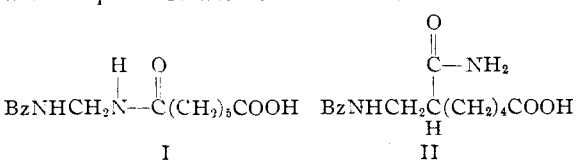
DUNEDIN, N 1, NEW ZEALAND

RECEIVED DECEMBER 31, 1945

The Preparation of N-(Benzamidomethyl)-pimelamic Acid: A Correction

BY JACKSON P. ENGLISH AND RICHARD C. CLAPP

We have previously reported the synthesis of a compound which was assumed to be 7-benzoylamino-6-carbamylheptylic acid.[1] This compound was thought to result as the product of a synthesis which began with the condensation of N-methylolbenzamide and a substituted cyanoacetic ester. We are indebted to Dr. S. R. Buc, who permitted us to see his manuscript before publication, for pointing out that the initial reaction has taken another and isomeric course. The work which led him to this conclusion is published concurrently.[2] With his demonstration of the course of the reaction we have now been enabled to show that the product of the series of reactions described in the previous note is N-(benzamidomethyl)-pimelamic acid, I, and not the heptylic acid derivative, II (compound IV of the earlier publication). This was shown by its conversion into formaldehyde, benzoic acid, and pimelic acid by acid hydrolysis. These products are not possible with the earlier formulation.



(1) J. P. English and R. C. Clapp, THIS JOURNAL, **67**, 2262 (1945).

(2) S. R. Buc, *ibid.*, **69**, 254 (1947).

Experimental

Hydrolysis of N-(benzamidomethyl)-pimelamic Acid (I).—A solution of 302 mg. of N-(benzamidomethyl)-pimelamic acid in 10 cc. of water and 5 cc. of concentrated hydrochloric acid was refluxed for six hours. The flask was swept out with nitrogen throughout the period of refluxing, and the emergent gas was bubbled through alcoholic dimedone solution. A total of 123 mg. of a crude precipitate melting from 170 to 180° was obtained. This product melted at 188 to 190° after recrystallization and did not depress the melting point of a sample of the dimedone derivative of formaldehyde.[3] Considerable solid collected in the condenser during the refluxing, and removal by washing with ether yielded 78 mg. of a product melting from 116 to 120° that was proved to be benzoic acid (62%) by a mixed melting point.

Approximately 20 cc. of water was added to the solution from the hydrolysis, and it was concentrated to a small volume. Treatment of the distillate with dimedone solution gave an additional 27 mg. of the dimedone derivative of formaldehyde (total of 50% of theoretical yield). Steam distillation of the remaining solution yielded no additional benzoic acid, and concentration to dryness gave 112 mg. of a solid melting from 95 to 100°. This product melted at 103–105° on recrystallization and was identical with an authentic sample of pimelic acid (68% of theoretical quantity).

(3) "Organic Reagents for Organic Analysis," Chemical Publishing Co., Inc., Brooklyn, N. Y., 1946, p. 44.

STAMFORD RESEARCH LABORATORIES
AMERICAN CYANAMID COMPANY
STAMFORD, CONNECTICUT RECEIVED SEPTEMBER 28, 1946

Tryptophan as a Competitive Growth Inhibiting Analog of Phenylalanine

BY ERNEST BEERSTECHER, JR., AND WILLIAM SHIVE

Burrows and Neymann[1] pointed out nearly thirty years ago that pure α-amino acids inhibit the growth of living cells. Wyon and McLeod[2] shortly thereafter showed that tryptophan in concentrations of 30 millimoles per liter was toxic to the growth of certain bacteria. Gordon and McLeod[3] later showed that serum reversed this tryptophan toxicity. More recently Sullivan, *et al.*,[4] have pointed out that high tryptophan diets are injurious to rats. Most early workers attributed the toxicity of tryptophan to the formation of decomposition products in the medium. Modern studies have considered the toxicity of some other amino acids from the stand-point of competition with another metabolite for some enzyme system essential to the growth of the organism.[5] In the light of our present understanding of analog inhibition, it therefore seems strange that some of the β-substituted alanines, particularly those substituted with aromatic groups, have not been demonstrated to be mutual antagonists.

We have recently had occasion to study the effect of *dl*-phenylalanine on bacterial growth in the presence of large concentrations of trypto-

(1) M. T. Burrows and C. A. Neymann, *J. Exp. Med.*, **25**, 93 (1917).

(2) G. A. Wyon and J. W. McLeod, *J. Hyg.*, **21**, 376 (1923).

(3) J. Gordon and J. W. McLeod, *J. Path. Bact.*, **29**, 13 (1926).

(4) M. X. Sullivan, W. C. Hess and W. H. Sebrell, *U. S. Pub. Health Repts.*, **47**, 75 (1932).

(5) R. O. Roblin, Jr., *Chem. Rev.*, **38**, 255 (1946).