from benzene, melted at 194.5–195°. *Anal.* Calcd. for $C_{18}H_{14}O_2$: C, 82.44; H, 5.34. Found: C, 82.40; H, 5.55.

Salicylacetone.—Prepared from salicylaldehyde and acetone in 10% sodium hydroxide essentially as described,[22] yield 65%, m. p. 140.5–141.5°, literature 139°.

_p_-Hydroxybenzalacetone.—To 25 g. of *p*-hydroxybenzaldehyde dissolved in 70 cc. of 10% sodium hydroxide, there was added at 25° 50 g. of acetone, followed by 100 cc. of 10% sodium hydroxide. The resulting mixture was diluted to 2000 cc. and allowed to stand at room temperature for seventy-two hours. The deep red solution was then acidified and the crude *p*-hydroxybenzalacetone recrystallized from benzene, yield 22 g., m. p. 107–108°, literature[23] 102–103°.

3-Bromo-2-hydroxybenzalacetone: Procedure was as described for *p*-hydroxybenzalacetone using 3-bromo-2-hydroxybenzaldehyde. The substituted benzalacetone was obtained in a yield of 56%, and, after recrystallization from ethyl alcohol, melted at 155–156°. *Anal.* Calcd. for $C_{10}H_9O_2Br$: C, 49.81; H, 3.76. Found: C, 49.87; H, 3.88.

3,5-Dibromo-4-hydroxybenzalacetone was secured from 3,5-dibromo-4-hydroxybenzaldehyde as described for the 2-isomer, yield 48%, m. p. 150.5–151° after recrystallization from acetone–water. *Anal.* Calcd. for $C_{10}H_8O_2Br_2$: C, 37.52; H, 2.52. Found: C, 37.75; H, 2.94.

The following substituted pyruvic acids were prepared essentially as described in the literature: benzalpyruvic acid, yield 80%, m. p. 60–61°, literature[24] 61–62°; *p*-methoxybenzalpyruvic acid yield 60%, m. p. 130.5–131°, literature[25] 131°; furfural pyruvic acid, yield 68%, m. p. 112–113°, literature[26] 112°; and piperonylidene-acetic acid, yield 82%, m. p. 163–164°, literature[27] 162–163°.

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Summary

1. β-Aroylacrylic acids have been obtained by the Friedel–Crafts reaction using maleic anhydride and/or the corresponding ester-acid chloride with the appropriate aromatic compound.

2. Two higher unsaturated acids were prepared, but their antibacterial activity was not comparable to the β-aroylacrylic acids.

3. Several benzalpyruvic acids and benzalacetones are described. However, these compounds show poor antibacterial action.

4. It will be reported elsewhere that β-aroylacrylic acids have *in vitro* bacteriostatic activity against a variety of gram negative organisms as well as against several strains of *Staphylococcus aureus*. Several of the compounds also show fungistatic activity.

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(22) Harries, *Ber.*, **24**, 3180 (1891).

(23) Zincke and Muhlhausen, *Ber.*, **36**, 134 (1903).

(24) Reimer, THIS JOURNAL, **53**, 3148 (1931).

(25) Reimer, *ibid.*, **48**, 2458 (1926).

(26) Friedmann, *Helv. Chim. Acta*, **14**, 790 (1931).

(27) *C. A.*, **35**, 5875 (1941); R. Nath Sen and B. Kumar Sen, *J. Indian Chem. Soc.*, **11**, 411 (1934).

BLOOMFIELD, NEW JERSEY RECEIVED MAY 28, 1948

[CONTRIBUTION NO. 672 FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF PITTSBURGH]

The Synthesis of Acyl-2-thenoylmethanes by the Alkali Amides[1]

BY SAMUEL R. HARRIS[2] AND ROBERT LEVINE

A convenient method for preparing β-diketones of the type $RCOCH_2COR'$ is to condense a methyl ketone with an ester in the presence of a basic condensing agent such as sodium,[3] sodium ethoxide,[3] sodium triphenylmethide,[4] sodium amide[4,5] or lithium amide.[6] The following equation indicates the reaction which takes place.

$$CH_3COR + R'CO_2C_2H_5 \xrightarrow[\text{agent}]{\text{basic condensing}} RCOCH_2COR' + C_2H_5OH$$

Apparently no β-diketones containing the thiophene nucleus have been prepared previously. In the present investigation a series of such β-diketones has been synthesized by condensing 2-acetylthiophene with appropriate esters in the presence of sodium amide or lithium amide. Two methods of synthesis have been used. Either two equivalents of the alkali amide are allowed to react with one of the ketone and two of the ester (Method A)[4,5] or two equivalents each of base and ketone are allowed to react with one of the ester (Method B).[4,5]

The results are summarized in Table I. It will be observed that when sodium amide or lithium amide is used in Method A the yield of product using the former is much higher. This may be due to the fact that the lithio derivative of the ketone is probably less soluble in ether than the corresponding sodio derivative and hence does not react as completely with the acylating ester. It may also be seen that when Method B is employed using sodium amide as the base, the yields of the β-diketones are much lower than those obtained with the same base employing Method A. It may also be observed that when benzoyl-2-thenoylmethane is prepared using sodium amide in Method B, the yield of product is 16% when the

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(1) Paper II in a series on condensations effected by the alkali amides. For Paper I see Zellars and Levine, *J. Org. Chem.*, **13**, 160 (1948).

(2) This work is based on a thesis submitted by Samuel R. Harris in partial fulfillment of the requirements for the degree of Master of Science at the University of Pittsburgh.

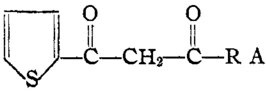
(3) Sprague, Beckham and Adkins, THIS JOURNAL, **56**, 2665 (1934).

(4) Levine, Conroy, Adams and Hauser, *ibid.*, **67**, 1510 (1945).

(5) Adams and Hauser, *ibid.*, **66**, 1220 (1944).

(6) Zellars and Levine, *J. Org. Chem.*, **13**, 160 (1948).

TABLE I

β-DIKETONES OF THE TYPE  ACYL-2-THENOYLMETHANES

R	2-Thenoylmethane	B. p. °C.	B. p. Mm.	Yield, % LiNH$_2$	Yield, % NaNH$_2$[a]	S Analyses[b] Calcd.	S Analyses[b] Found	Cu salt m. p., °C.
Methyl	Acetyl	129–131	8	57.4	80.7	19.06	18.85	228–230
Ethyl	Propionyl	124–126.5	4	49.2	62.2	17.58	17.58	192–194
n-Propyl	*n*-Butyryl	135–139.5	4	37.2	62.1 (18.7)	16.34	16.14	140–142
Isopropyl	Isobutyryl	133–136	5	30.1	49 (6.3)	16.34	16.38	159–161
n-Amyl	Caproyl	163–166	4	42.1	69.3 (24.4)	14.29	14.34	108–109
Phenyl	Benzoyl	198–201 78–78.5 (m. p.)	4	45.2	58.1 (16.1) [(61.1)][c]	13.92	13.80	276–278
2-Thienyl	2-Thenoyl	99–100 (m. p.)		..	63.8	27.14	27.10	259–263

[a] The values in parentheses are from experiments carried out by Method B. All other experiments were carried out by Method A. [b] These analyses were performed by Mr. George Stragand of the University of Pittsburgh Microanalytical Laboratory. [c] Refluxed eight hours. In this experiment, since a crystalline copper salt could not be obtained, the product was isolated by distillation. In addition to the β-diketone, there was obtained 2.2 g. (8.5%) of benzamide, m. p. 130°, and a considerable non-distillable boiler residue which may have consisted of self-condensed 2-acetylthiophene.

reaction mixture is refluxed two hours. However, when the reflux time is increased to eight hours, the yield is increased to 61%.

Experimental

The Use of Sodium Amide as the Condensing Agent.—The apparatus used in these reactions consisted of a 1000-ml., three-necked, round-bottomed flask equipped with ground-glass joints, a mercury-sealed stirrer, a reflux condenser, and an addition funnel (protected from atmospheric moisture by a drying tube filled with Drierite). The reactions were carried out in a well-ventilated hood. Using a method previously described,[4] 0.4 mole (9.2 g.) of sodium metal was converted to sodium amide and the amide was then suspended in 300 ml. of absolute ether. To the rapidly stirred suspension of the sodium amide, 0.2 mole (Method A) or 0.4 mole (Method B) of 2-acetylthiophene, dissolved in 50 ml. of absolute ether, was added. Four tenths of a mole (Method A) or 0.2 mole (Method B) of the appropriate ester dissolved in 50 ml. of absolute ether was then added and the reaction mixture was then stirred and refluxed for two hours on a water-bath. The reaction mixture was poured onto a mixture of ice and 125 ml. of concentrated hydrochloric acid, and then was extracted several times with ether. The combined ethereal solutions were dried over Drierite and the ether distilled. The β-diketones were isolated by the copper salt method which has been described previously.[4,5,6] A sample of each β-diketone was analyzed. The yields of the β-diketones are given in Table I.

The Use of Lithium Amide as the Condensing Agent.—Four-tenths of a mole (9.2 g.) of commercially available lithium amide was used in each of these experiments and the reactions were carried out as described above with sodium amide.

Summary

The acylation of 2-acetylthiophene with a series of esters has been studied in the presence of sodium amide and lithium amide.

Two methods for synthesizing these β-diketones are described.

Sodium amide is superior to lithium amide for the acylation of 2-acetylthiophene with the esters used in the present investigation.

PITTSBURGH, PA. RECEIVED APRIL 16, 1948

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

The Dehydration of Isopropyl-*t*-butylcarbinol[1]

BY J. A. DIXON, N. C. COOK AND F. C. WHITMORE

As a portion of the research on the dehydration of aliphatic alcohols being conducted at The Pennsylvania State College, a group of carbinols containing the neopentyl system has been investigated.[2] Isopropyl-*t*-butylcarbinol contains such a structure and in 1932 Whitmore and Houk[3] published a preliminary report on its dehydration. Although they reported only the isolation and identification of 2,4,4-trimethyl-1-pentene, they suggested that 2,4,4-trimethyl-2-pentene, 2,3,4-trimethyl-1-pentene, 2,3,4-trimethyl-2-pentene and 3-methyl-2-isopropyl-1-butene might be present in the complex mixture of dehydration product. Houk[4] later reported that upon ozonolysis of the distillation fractions, he obtained fragments whose precursors should have been the two 2,4,4-trimethylpentenes and the two 2,3,4-trimethylpentenes.

In the present study the alcohol was dehydrated over alumina at 340–375°. The olefins found and their amounts are shown in Table I.

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(1) Paper XX on dehydration of alcohols. For paper XIX see Whitmore, Rowland, Wrenn and Kilmer, THIS JOURNAL, **64**, 2970 (1942).

(2) Whitmore, *et al.*, *ibid.*, **54**, 4011 (1932); **55**, 1119 (1933); **55**, 1528 (1933); **55**, 3721 (1933); **55**, 3732 (1933); **55**, 4153 (1933).

(3) Whitmore and Houk, *ibid.*, **54**, 3714 (1932).

(4) A. L. Houk, Ph.D. Thesis, The Pennsylvania State College, 1933.