TABLE II (*Concluded*)

Amines	Formula	B. p. or m. p., °C.	n^{25}_D	d^{25}_4	N Calcd.	N Found	Hydrochloride M. p.	Hydrochloride Calcd.	Hydrochloride Found
Di-*n*-duodecyl	$C_{24}H_{51}N$	M 55–56	....	....	3.96	4.05	207–208	9.11	9.06
n-Heptylethyl	$C_9H_{21}N$	81–83 (16 mm.)	1.4265	0.7831	9.79	9.68	188–190	19.76	19.70
n-Duodecylphenylethyl	$C_{20}H_{35}N$	182–184 (2 mm.)	1.4995	.9052	4.84	4.99	232–233	10.89	10.87
n-Duodecylcyclohexyl	$C_{18}H_{37}N$	158–159 (2 mm.)	1.4588	.8420	5.24	5.40	204–205	11.67	11.61
n-Duodecylphenyl	$C_{18}H_{31}N$	160–161 (2 mm.)	1.4638	.8470	5.36	5.48	206	11.92	11.96
n-Duodecylethyl	$C_{14}H_{31}N$	124–129 (2 mm.)	1.4408	.9244	6.57	6.43	205–207	14.21	14.16
n-Duodecyl *n*-amyl	$C_{17}H_{37}N$	175–177 (10 mm.)	1.4425	.9248	5.49	5.55	240–241	12.16	12.14
n-Heptyl-β-phenylethyl	$C_{15}H_{25}N$	153–156 (9 mm.)	1.4815	.8711	6.39	6.27	254–255	13.88	13.88
n-Heptyldiethyl	$C_{11}H_{25}N$	86–87 (16 mm.)	....	....	..	..	105–106	17.09	17.23
n-Duodecyldi-*n*-amyl	$C_{22}H_{47}N$	174–175 (3 mm.)	1.4460	.8094	4.31	4.26	.....	...	...
Urethans									
Phenyl-N-pentamethylene[3]	$C_{12}H_{15}O_2N$	101–102 (3 mm.)	1.5160	1.046	6.83	6.73	.....	...	...
Phenyl-N-amyl	$C_{12}H_{17}O_2N$	108–111 (5 mm.)	1.4680	0.9368	6.76	6.90	.....	...	...
Butyl-N-pentamethylene	$C_{10}H_{19}O_2N$	98–99 (13 mm.)	1.4820	1.028	7.57	7.87	.....	...	...

Summary

The reactions of representative amides with hydrogen over copper–chromium oxide have been outlined and some of the relationships of structure to the course of the reactions indicated. The practicality of the preparation of amines by the catalytic hydrogenation of amides has been demonstrated.

The direct formation of urethans through the reaction of an alcohol or phenol, an amine and carbon dioxide has been shown to be feasible.

MADISON, WISCONSIN RECEIVED JULY 5, 1934

[A COMMUNICATION FROM THE LABORATORY OF ORGANIC CHEMISTRY OF THE UNIVERSITY OF WISCONSIN]

Alkylation of Acetoacetic, Malonic and Succinic Esters

BY BRUNO WOJCIK AND HOMER ADKINS

A combination of the Knoevenagel[1] or Stobbe[2] reactions and catalytic hydrogenation over Raney nickel[3] renders available an excellent method for the alkylation of malonic, acetoacetic and succinic esters. For this purpose an aldehyde is allowed to react with malonic or acetoacetic ester in the presence of piperidine, or a ketone with succinic ester and sodium ethoxide, the resulting unsaturated ester being then hydrogenated at room temperatures over Raney nickel. The fact that the hydrogenation may be carried out at room temperature, by virtue of the high activity of Raney nickel, is particularly important in the case of the acetoacetates since at higher temperatures the ketone group of these esters would suffer reduction. The substituted malonates and succinates may be hydrogenated in a shorter time at higher temperatures without any disadvantageous side reaction.

The methods for the preparation of the unsaturated esters may be illustrated by the following.

Diethyl Heptylidenemalonate.[1]—Piperidine (1.5 cc.) was added to a mixture (0°) of acid free heptaldehyde (38 g.) and malonic ester (54 g.). The reaction mixture was allowed to stand for twelve to fifteen hours at 0° and six hours at room temperatures and then fractionated through a Widmer column. The yield (53 g., b. p. 143–145° (5 mm.)) was 68% of the theoretical.

Anal. Calcd. for $C_{14}H_{24}O_4$: C, 65.62; H, 9.37. Found: C, 65.7; H, 9.33; n^{25}_D 1.446, d^{25}_{25} 0.962.

Diethyl Isopropylidenesuccinate.[2]—Sodium ethoxide (68 g.) was suspended in dry ether (500 cc.) contained in a flask surrounded by an ice–salt mixture and provided with a mechanical stirrer, a separatory funnel and a reflux condenser protected from moisture. A mixture of diethyl succinate (87 g.) and dry acetone (58 g.) was added dropwise while the reaction mixture was stirred and kept at approximately 0°. The mixture was allowed to stand in the cold for several hours and then at room temperature for a few days. A liter of water was added to the mixture, and the aqueous layer extracted three times with 200-cc. portions of ether. The sodium salt in the aqueous layer was acidified with five 50-cc. portions of dilute (1:1) sulfuric acid. After the addition of each portion of acid the solution was extracted with ether. The combined ether extracts were evaporated and the residual oil (68 g.) refluxed with ethanol (200 cc.) and sulfuric acid (6 cc.) for ten hours. Ether (200 cc.) and water (500 cc.) were added

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[1] Knoevenagel, *Ber.*, **31**, 734 (1898).

[2] Stobbe, *Ann.*, 281, 282 (1890).

[3] Adkins and Covert, THIS JOURNAL, **54**, 4116 (1932).

TABLE I

HYDROGENATION OF UNSATURATED ESTERS AT ROOM TEMPERATURES OVER RANEY NICKEL

(M is malonate, S succinate and A acetoacetate)

Ethyl ester of	G.	Time, hrs.	Yield of ethyl ester of	B. p. of ester, °C.	M. p. of acid, °C.
Methyliden M[5]	43	3	95% Me M	196–199	124–125[9]
Ethyliden M[6]	46	5	93% Et M	205–208	110–111[10]
Butyliden M[7]	21	3	95% Bu M	128–130 (17)	101–102[11]
Heptyliden M[1]	43	4	97% Heptyl M	136–138 (3)	95–96
Benzyliden M[7]	61	5	97% Benzyl M	158 (8)	117–118[12]
Furfuryliden M[7]	79		94% Furfuryl M	138–140 (6)	124–125[13]
Methyliden S[8] (itaconate)	100	4	98% Me S	108–110 (16)	
Isopropylidene S[2]	35	3	97% *i*-Pr S	110–112 (8)	
Me-Ph carbinylidene S[2]	28	8	95% (Me-Ph-carbinyl) S	165–167 (8)	
α-Heptyliden A[1]	75	6	97% α-Heptyl A	130–132 (7)[14]	
α-Cinnamyliden A[1]	50	9	78% α-Acetyl Δ Ph valerate	163–170 (8)[15]	

and the ether layer separated. The aqueous layer was extracted with 100 cc. of ether. The ether solution of the ester was washed with 100 cc. of 5% solution of sodium bicarbonate, then with water, dried over anhydrous sodium sulfate and fractionated through a Widmer column. The yield (44 g., b. p. 115–122°, 7 mm.) was 41% of the theoretical.

The hydrogenations summarized in Table I were, with one exception, carried out under a pressure of 100–130 atm. with an amount of Raney nickel[3] corresponding to 10 to 15% of the weight of ester. This proportion of catalyst to ester was unnecessarily high as 2 g. of nickel was found sufficient for 100 g. of diethyl itaconate. In a larger preparation in which 12 g. of nickel was used with 282 g. of that ester, the hydrogenation went to completion within three minutes, the heat of reaction being sufficient to raise the temperature from 23 to 123°. An amount of ether equal to the volume of the ester was ordinarily used as the reaction medium. Ethanol was also used for this purpose and with diethyl itaconate no solvent was used. The malonic esters were characterized by converting them to the free acids whose melting points are given in Table I. The keto esters were hydrolyzed by the method recently described[4] and the ketones, decanone-2 and 6-phenylhexanone-2, obtained and characterized.

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(4) Connor and Adkins, THIS JOURNAL, **54**, 3424 (1932).

(5) Welch, *J. Chem. Soc.*, **553**, 673 (1931).

(6) Komnenos, *Ann.*, **218**, 156 (1883).

(7) Knoevenagel, *Ber.*, **31**, 2585, 2895 (1898).

(8) Anschütz, *ibid.*, **14**, 1638 (1881).

(9) Lucas and Young, THIS JOURNAL, **51**, 2537 (1929).

(10) Conrad, *Ann.*, **214**, 134 (1880).

(11) Hell and Lumpp, *Ber.*, **17**, 2219 (1884).

(12) Claisen and Crismer, *Ann.*, **218**, 139 (1883).

(13) Marckwald, *Ber.*, **21**, 1083 (1888).

(14) Jourdan, *Ann.*, **200**, 105 (1880).

(15) Borsche and Peitzsch, *Ber.*, **62**, 372 (1929).

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Hydrogenation of Derivatives of Pyridine

BY HOMER ADKINS, LEO F. KUICK, MARK FARLOW AND BRUNO WOJCIK

The pyridinoid ring may be saturated with hydrogen over catalytic nickel at temperatures and pressures of hydrogen which are a function of the substituents in the ring, the nature of the solvent and the type of nickel catalyst. There is a very wide variation with respect to the effect of these factors upon the temperature required for hydrogenation. The control of the temperature of hydrogenation is particularly important in the hydrogenation of pyridine derivatives because of the side reactions that occur. These reactions are apparently of three types, cleavage of a nitrogen to carbon linkage, alkylation of the secondary amine formed by hydrogenation, and condensation of various intermediate products. Since Raney nickel[1] is characterized by its activity at relatively low temperatures, it is particularly suited for use with pyridine compounds. For example, 2-benzylpyridine which required 160° with a nickel-on-kieselguhr catalyst was hydrogenated completely at 100° with Raney nickel in less than one-half the time required at 160° with the supported catalyst. Quinolinic ester (2,3-dicarbethoxypyridine) was hydrogenated over Raney nickel at a temperature 50° lower than was feasible with the supported catalyst.

Incidental to the study of another problem Folkers prepared ethyl nipecotate (3-carbethoxy-

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(1) Adkins and Covert, THIS JOURNAL, **54**, 4116 (1932).