

APPLICATION OF A PROTIC SOLVENT FOR THE REACTION  
OF CARBONYL COMPOUNDS WITH DIALKYL ESTERS  
OF SUBSTITUTED ALKYLPHOSPHONIC ACIDS

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A number of esters and amides of  $\alpha,\beta$ -unsaturated acids have been prepared by reaction of ketones with esters of substituted alkylphosphonic acids in ethanol solution in the presence of sodium ethoxide.

Esters and amides of  $\alpha,\beta$ -unsaturated acids are conveniently prepared according to a modification<sup>1</sup> of the Wittig reaction (A)



$\text{R}^1, \text{R}^2, \text{R}^3 = \text{alkyl}$

in which an aprotic solvent is used, especially 1,2-dimethoxyethane and sodium hydride<sup>1</sup> as the base for the formation of the corresponding ylide, or tetrahydrofuran and sodium amide<sup>2</sup>, dioxane and sodium hydride<sup>3</sup>, or dimethylformamide and ethanolic sodium ethoxide<sup>4</sup>. However, these procedures are not suitable when carrying out the preparation on a larger scale.

We have now found that the reaction may be performed in the protic solvent ethanol. Into the ethanolic solution of the carbonyl compound and the diester of the substituted alkylphosphonic acid ethanolic sodium ethoxide is added dropwise at 20–30°C. The reaction time ranges from 5 to 20 hours and the temperature from 20 to 80°C, according to the reactivity of the carbonyl compound and the substituted alkylphosphonic acid. The dialkyl esters of the alkylaminocarbonyl-alkylphosphonic acid and dialkylaminocarbonylalkylphosphonic acid, respectively, react generally slower, and therefore it is necessary to perform the reaction at elevated temperature.

This procedure affords good yields and is gentle, for in this way it is possible to accomplish the reaction also with compounds which polymerise when applied to the previously used procedures, as for example with pseudoionone<sup>4</sup>. Thus, from

TABLE I  
Survey of the  $\alpha,\beta$ -Unsaturated Acid Esters and Amides Prepared

Compound	Ketone g	Phospho- nate <sup>a</sup> g	A, ml	Na, g (B ml)	<i>t</i> , min <i>T</i> , h	B.p., C Torr	Yield, g (%)
<i>II</i>	<i>I</i>	M	80	1.21	75	98—99.5	11.82 <sup>b</sup>
	9.72	11.77		(32)	23	0.008	(94.3)
<i>IV</i>	<i>III</i>	M	80	1.23	75	95—99	10.42
	10.0	11.99		(33)	23	0.007	(76.8)
<i>VI</i>	<i>V</i>	M	350	9.66	90	89—102	78.5 <sup>c</sup>
	56.88	94.16		(240)	21	0.006	(92.45)
<i>VIII</i>	<i>VII</i>	M	25	0.60	90	105—112	5.98
	4.95	6.30		(20)	21	0.009	(89)
<i>X</i>	<i>IX</i>	M	15	0.34	300	115—120 <sup>e</sup>	0.5
	2.7	3.7		(10)	3 <sup>d</sup>	0.009	(13.5)
<i>XII</i>	<i>XI</i>	N	12	0.30	60 <sup>f</sup>	145—150 <sup>e</sup>	2.56 <sup>g</sup>
	2.4	3.6		(10)		0.05	(71.5)
<i>XIV</i>	<i>XIII</i>	O	5	0.13	60 <sup>f</sup>	155—160 <sup>e</sup>	0.84 <sup>g,h</sup>
	1.0	1.3		(4)		0.01	(62.2)

<sup>a</sup> M Diethyl ethoxycarbonylmethanephosphonate, N diethyl N,N-diethylaminocarbonylmethanephosphonate, O diethyl N-ethylaminocarbonylmethanephosphonate. <sup>b</sup> By distillation was recovered 0.51 g of ketone *I*. <sup>c</sup> For C<sub>12</sub>H<sub>20</sub>O<sub>3</sub> (212.3) calculated: 67.89% C, 9.50% H; found: 67.78% C, 9.54% H. <sup>d</sup> The reaction mixture was warmed at 40°C for 5 h. <sup>e</sup> Bath temperature. <sup>f</sup> The reaction mixture was heated at 80°C for 8 h. By chromatography was recovered 0.2 g of the starting ketone. <sup>g</sup> For C<sub>17</sub>H<sub>33</sub>NO (267.4) calculated: 76.34% C, 12.44% H, 5.24% N; found: 76.30% C, 12.45% H, 5.18% N.

6,10-dimethyl-5,9-undecadien-2-one (*I*) was prepared ethyl 3,7,11-trimethyl-2,6,10-dodecatrienoate (*II*), 6,10-dimethyl-9-undecen-2-one (*III*) afforded ethyl 3,7,11-trimethyl-2,10-dodecadienoate (*IV*), and 4-(2-tetrahydrofuryl)-2-butanone (*V*) was the starting compound for the preparation of ethyl 3-methyl-5-(2-tetrahydrofuryl)-2-pentenoate (*VI*). From 6,10-dimethyl-2-undecanone (*VII*) was prepared ethyl 3,7,11-trimethyl-3-dodecenoate (*VIII*), 6,10-dimethyl-3,5,9-undecatrien-2-one (*IX*) was the starting compound for the preparation of ethyl 3,7,11-trimethyl-2,4,6,10-dodecatetraenoate (*X*), and 6,10-dimethyl-9-undecen-2-one (*XI*) afforded 3,7,11-trimethyl-2,10-dodecadienoic acid N,N-diethylamide (*XII*), and from 6,10-dimethyl-2-undecanone (*XIII*) was prepared 3,7,11-trimethyl-2-dodecenoic acid N-ethylamide (*XIV*).

## EXPERIMENTAL

### General Procedure

To a stirred solution of the carbonyl compound and the dialkyl ester of the substituted alkyl-phosphonic acid in absolute ethanol (A ml) a solution of sodium in ethanol (B ml) is added dropwise during  $t$  minutes under nitrogen at 20–30°C. The reaction mixture is then stirred at room temperature during the time  $T$ , respectively heated at 40–80°C for 5–8 h. The reaction course is followed by thin-layer chromatography. As soon as the carbonyl compound disappears from the reaction mixture, or when the composition of the reaction mixture does not change any more, ethanol is removed under reduced pressure, the residue poured into water acidified with acetic acid, and the product extracted with light petroleum. The combined extracts are washed successively with water, sodium hydrogen carbonate solution, and water until neutral and, after drying, the solvent is removed by distillation. The crude product is fractionally distilled *in vacuo* or purified by chromatography on silica gel. Detailed data are given in Table I.

Substances *II*, *IV*, *VIII*, *X*, and *XII* were characterised by their gas chromatographic comparison with authentic samples. The prepared substances *VIII*, *X*, *XII*, and *XIV* were purified by chromatography on silica gel. Elution of substances *VIII* and *X* was performed with a 20 : 1 mixture of light petroleum and ether and that of substances *XII* and *XIV* with a 10 : 1.5 mixture of the same solvents.

### REFERENCES

1. Wadsworth W. S., Emmons W. D.: J. Am. Chem. Soc. *83*, 1733 (1961).
2. Takahashi H., Fujiwara K., Ohta M.: Bull. Chem. Soc. Japan *35*, 1498 (1962).
3. Azerad R., Cyrot M. O.: Bull. Soc. Chim. France *1965*, 1740.
4. Kovalev B. G., Janovskaja L. A., Kučerov V. F.: Izv. Akad. Nauk SSSR, Otd. Chim. Nauk *1962*, 1876.

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