## β-Aroylpropionic Acids. Part XI.\* The Action of Grignard 205. Reagents on Phenylsuccinic Anhydride.

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Arylmagnesium halides with phenylsuccinic anhydride give  $\beta$ -aroyl- $\alpha$ phenylpropionic acid (I),  $\gamma\gamma$ -diaryl- $\gamma$ -hydroxy- $\alpha$ -phenylbutyric acid (II), isolated as its lactone (IV), and a neutral product from which a tetrahydrofuran (V) has been isolated. The same products are obtained when the anhydride is replaced by the  $\beta$ -aroyl- $\alpha$ -phenylpropionic acid corresponding to the Grignard reagent. However, ary lmagnesium halides with  $\beta$ -aroyl- $\alpha$ phenylpropionic esters or with diethyl phenylsuccinate give 3:3-diaryl-1-phenylprop-2-ene-1-carboxylic acids.

Propene-acids isomerise irreversibly to the lactones.

PREVIOUS work on methylsuccinic anhydride<sup>1</sup> has been extended to phenylsuccinic anhydride. Contrary to Weizmann et al.,2 phenylmagnesium bromide with phenylsuccinic anhydride gave the lactone (IVa) and the furan (Va), but naphthylmagnesium bromide gave the keto-acid (Ih) and the lactone (IVh).

Similarly, when one or two mols. of o- or p-methoxyphenyl-, o- or p-tolyl-, or o- or p-chlorophenyl-magnesium bromide reacted with phenylsuccinic anhydride they gave the  $\beta$ -aroyl- $\alpha$ -phenylpropionic acid (I), the  $\gamma\gamma$ -diaryl- $\gamma$ -hydroxy- $\alpha$ -phenylbutyric acid (II) [isolated as its lactone (IV)], and a neutral product, from which a 2:2:5:5-tetra-aryltetrahydro-3-phenylfuran (V) was isolated (see Table 1).



However, although the neutral product isolated in the former case, gave analytical figures corresponding to 1:1:4:4-tetra-p-methoxyphenyl-2-phenylbuta-1:3-diene (VIb), its absorption spectrum ( $\lambda_{max}$  291 m $\mu$ ,  $\varepsilon$  51,990) was different from that of 1:1:4:4:4tetra-p-methoxyphenyl-buta-1: 3-diene,<sup>3</sup> and this threw some doubt on its structure which needs further investigation.

The structure of the  $\beta$ -aroyl- $\alpha$ -phenylpropionic acids was confirmed by the fact that they gave pyrylium salts,<sup>4</sup> and the  $\beta$ -benzoyl-,  $\beta$ -p-toluoyl-, and  $\beta$ -p-methoxybenzoyl-acids were identical with authentic specimens. The structure of the lactones and furans was established by identity with the products obtained when phenylsuccinic anhydride was replaced by  $\beta$ -aroyl- $\alpha$ -phenylpropionic acids (I). The lactones (IVa, d, and f) with arylmagnesium halides gave the 2:2:5:5-tetra-aryltetrahydro-3-phenylfurans (Va, d, and f, respectively).

When  $\beta$ -aroyl- $\alpha$ -phenylpropionic esters (VIIa, b, and c) were used instead of the

\* Part X, J., preceding paper.

<sup>1</sup> Baddar, El-Assal, and Habashi, J., 1957, 1690. <sup>2</sup> Weizmann, Blum-Bergmann, and Bergmann, J., 1935, 1370.

<sup>3</sup> Baddar and Sawires, J., 1955, 4469.
<sup>4</sup> Wali, Khalil, Bhatia, and Ahmad, Proc. Indian Acad. Sci., 1941, 14, A, 139; Desai and Wali, *ibid.*, 1937, **6**, A, 135.

[1959]

corresponding acids, 3: 3-diaryl-1-phenylprop-2-ene-1-carboxylic acids (VIIIa, b, and c, respectively) were obtained according to the following scheme:

The same propene-acids were obtained when the  $\beta$ -aroyl- $\alpha$ -phenylpropionic esters were replaced by diethyl phenylsuccinate.

The structure of the lactones, furans, and propene-acids was further confirmed by the identity of their absorption spectra with those previously reported.<sup>3,5</sup>

Attempts to isomerise the lactones (IVa, b, and f) to the corresponding propene-acids (VIII) by boiling with hydrochloric-acetic acid<sup>6</sup> were not successful. However, when the propene-acids were treated in the same manner, they were converted into the lactones in almost quantitative yield.

				I ABLE	L.			
Ar in ArMgX		Yields *	(%) of		Ar in ArMgX	Yields * (%) of		
(1 mol.)	ĩ	IV	v	vī	(1 mol.)	ĩ	IV	v
Ph	12	22	3.5		o-Me·C <sub>6</sub> H <sub>4</sub>	22	4.7	1.6 †
<i>p</i> -MeO·C <sub>6</sub> H <sub>4</sub>	<b>21</b>	6		1.4?	p-Cl·C <sub>6</sub> H <sub>4</sub>	40	13	0.7
o-MeO·C <sub>6</sub> H <sub>4</sub>	18	9	1.4		o-Cl·C <sub>6</sub> H <sub>4</sub>	15	6	<b>3</b> ∙5 †
<i>p</i> -Me·C <sub>6</sub> H <sub>4</sub>	47	6	$1 \cdot 2$		1-C <sub>10</sub> H <sub>7</sub>	41	8	$1 \cdot 2 \dagger$

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\* Calc. on crude product. † The neutral portion was an oil. ? structure not rigidly established.

## EXPERIMENTAL

The procedure described in the first experiment was adopted with slight modification in the others.

Action of Phenylmagnesium Bromide on Phenylsuccinic Anhydride.—An ethereal solution (40 ml.) of phenylmagnesium bromide [from bromobenzene (7.85 g., 1 mol.)] was added dropwise (20 min.) to a boiling solution of phenylsuccinic anhydride (8.8 g., 1 mol.) in dry, thiophen-free benzene (100 ml.). The mixture was refluxed for a further 3 hr., left overnight at room temperature, then treated with ammonium chloride solution. The ether-benzene layer was extracted with sodium hydroxide solution, and the alkaline solution (charcoal) was cooled and acidified. The precipitated acids were refluxed with benzene for 1.5 - 2 hr., solvent was removed. and the semi-solid residue was extracted with cold sodium carbonate solution. The insoluble viscous oil solidified on trituration with cold alcohol. On crystallisation from benzene-light petroleum (b. p. 40–60°)  $\alpha\gamma\gamma$ -triphenylbutyrolactone (IVa) was obtained (ca. 3.5 g.), m. p. 162°, undepressed on admixture with an authentic specimen prepared by the method of Weizman et al.<sup>2</sup>

The sodium carbonate solution gave on acidification an acid (ca. 1.6 g.), which on crystallisation from benzene-light petroleum (b. p.  $40-60^{\circ}$ ) gave  $\gamma$ -oxo- $\alpha\gamma$ -diphenylbutyric acid (Ia), m. p. 153°, undepressed on admixture with a specimen prepared according to Hann and Lapworth.<sup>7</sup> The neutral product in the ether-benzene layer was refluxed for 1-2 hr. with 20%sodium hydroxide solution to remove any lactone, and the insoluble oil (ca. 0.8 g.) was reextracted with benzene. It was refluxed with acetic acid for 1 hr., then allowed to crystallise, giving tetrahydro-2:2:3:5:5-pentaphenylfuran (Va), m. p. 180° (Found: C, 89.7; H, 6.4.  $C_{34}H_{28}O$  requires C, 90.2; H, 6.2%). The experiment was repeated with other aryl-magnesium bromide, with results given in Table 2.

Action of Grignard Reagents on  $\beta$ -Aroyl- $\alpha$ -phenylpropionic Acids.—The above experiment was repeated with  $\beta$ -aroyl- $\alpha$ -phenylpropionic acids instead of phenylsuccinic anhydride in the usual manner; the results are in Table 3.

- $^{\rm 5}$  Baddar, Habashi, and Sawires, J., 1957, 1699.
- <sup>6</sup> Baddar and El-Assal, J., 1951, 431. <sup>7</sup> Hann and Lapworth, J., 1904, 1355.

When in this reaction phenylmagnesium bromide was treated with  $\beta$ -benzoyl- $\beta$ -phenylpropionic acid even under more drastic conditions, the keto-acid was recovered unchanged. Action of Grignard Reagents on  $\gamma\gamma$ -Diaryl- $\alpha$ -phenylbutyrolactones.—The experiment was

TABLE 2.

Solv. for			Found (%)			Required (%)			
Compd.	М. р.	cryst.*	Formula	c	H	cì	C	H	Cì
Ib	149° ª	A	C <sub>17</sub> H <sub>18</sub> O <sub>4</sub>						
IVb	132	Α	C,H,O	76.4	5.8		77.0	5.9	
VIb?	262	в	$C_{33}H_{34}O_{4}$	82.6	$6 \cdot 1$		82·3	$6 \cdot 2$	
Ic	152	Α	$C_{17}H_{16}O_{4}$	71.6	5.7		<b>71·8</b>	5.7	
IVc	172	Α	$C_{24}H_{22}O_{4}$	<b>76</b> ·9	$5 \cdot 9$		<b>77</b> ·0	5.9	
Vc	208	в	$C_{38}H_{36}O_5$	<b>78</b> ·9	<b>6</b> ∙ <b>3</b>		<b>78</b> .7	$6 \cdot 3$	
Id	151 0	Α	$C_{17}H_{16}O_{3}$						
IVd	142	Α	$C_{24}H_{22}O_{2}$	83·8	<b>6</b> ∙3		$84 \cdot 2$	6.5	—
Vd	2 <b>28</b>	в	$C_{38}H_{36}O$	<b>89</b> ·9	$7 \cdot 2$		<b>89</b> ·7	$7 \cdot 1$	—
Ie	116	Α	$C_{17}H_{16}O_{3}$	75.6	6.0		$76 \cdot 1$	6.0	—
IVe	125	Α	$C_{24}H_{22}O_2$	84·1	6.5		$84 \cdot 2$	6.5	
Ve	Oil								
If	160	Α	C16H13O3Cl	67.1	<b>4</b> · <b>4</b>	12.1	66.5	4.5	12.3
IVf	181	Α	$C_{22}H_{16}O_2Cl_2$	<b>69</b> ·0	<b>4</b> ∙3	18.0	68·9	$4 \cdot 2$	18.5
Vf	202	в	$C_{34}H_{24}OCl_4$	69·0	4.1	$23 \cdot 8$	69.1	<b>4</b> ·1	$24 \cdot 1$
$\mathbf{Ig}$	112	Α	$C_{16}H_{13}O_{3}Cl$	66·3	<b>4</b> ·4	12.6	66.5	4.5	12.3
IVg	172	Α	$C_{22}H_{16}O_2Cl_2$	68·8	4.1	18.0	68·9	$4 \cdot 2$	18.5
Vg	Oil								
Iĥ	142	Α	$C_{20}H_{16}O_{3}$	78.7	$5 \cdot 2$		<b>78</b> ·9	$5 \cdot 3$	
IVh	211	Α	$C_{30}H_{22}O_2$	<b>86</b> ·9	5.4		86.9	$5 \cdot 4$	
$\mathbf{V}\mathbf{h}$	Oil				—				

\* A, Benzene-light petroleum (b. p. 40--60°). B, Acetic acid. ? Structure not rigidly established.
<sup>a</sup> Identical with an authentic specimen (Allen and Frame, *Canad. J. Res.*, 1932, 6, 605. <sup>b</sup> Identical with an authentic specimen (Desai *et al.*<sup>4</sup>).

TABLE 3.

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	Reactants			Products	
Ar in ArMgX	(g. = 1 mol.)	Keto-acid $(g. = 1 \text{ mol.})$	Unchanged keto-acid (g.)	Lactone (g.)	Neutral (g.)
Ph	7.5	Ia 10.5	2.0	IVa $2.5$	Va 1.1
<i>p</i> -MeO·C <sub>6</sub> H <sub>4</sub>	9.3	Ib 12·4	$1 \cdot 2$	IVb 3·1	VIb(?) 2.5
o-MeO·C <sub>6</sub> H <sub>4</sub>	9.3	Ic 12·4	2.6	IVc 3.8	Vc 2.2
<i>p</i> -C <sub>6</sub> H₄Me	9.7	Id 13·4	3.8	IVd 4·1	Vd 1.9
o-C <sub>6</sub> H <sub>4</sub> Me	9.7	Ie 13·4	$3 \cdot 2$	IVe 3.6	Ve 2·1
$p-C_{a}H_{a}C1$	9.5	If 12.7	2.4	IVf 3.7	Vf 2·8
o-C,H_Cl	9.5	Ig $12.7$	2.8	IVg $2 \cdot 9$	Vg 3·1
1-C1.H,	11.6	$I \tilde{h} 15 \cdot 2$	4.1	IVň 3.8	Vh 3.6

repeated in the usual manner with  $\gamma\gamma$ -diaryl- $\alpha$ -phenylbutyrolactones (1 mol.) instead of phenylsuccinic anhydride. The alkaline extract gave no precipitate on acidification, indicating the absence of acid. Only the neutral product was obtained, as in Table 4.

TABLE 4.

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ç.	Lactone (g.	= 1  mol.	Neutral p	oroduct, g.
$22 \cdot 5$	IVa	13.0	Va	10.2
29.0	IVd	16.5	Vd	8.1
28.6	IVf	17.0	Vf	7.8
	22·5 29·0 28·6	Lactone (g. 22.5 IVa 29.0 IVd 28.6 IVf	Lactone (g. = 1 mol.) $22 \cdot 5$ IVa 13 \cdot 0 $29 \cdot 0$ IVd 16 \cdot 5 $28 \cdot 6$ IVf 17 \cdot 0	Lactone (g. = 1 mol.)         Neutral p $22 \cdot 5$ IVa 13 \cdot 0         Va $29 \cdot 0$ IVd 16 \cdot 5         Vd $28 \cdot 6$ IVf 17 \cdot 0         Vf

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Action of Grignard Reagents on Ethyl  $\beta$ -Aroyl- $\alpha$ -phenylpropionate.—(i) Action of phenylmagnesium bromide on ethyl  $\gamma$ -oxo- $\alpha\gamma$ -diphenylbutyrate. The Grignard reagent [from bromobenzene (7.8 g., 1 mol.)] was added to a benzene solution (60 ml.) of ethyl  $\gamma$ -oxo- $\alpha\gamma$ -diphenylbutyrate (14·1 g., 1 mol.), and the mixture worked up as usual. The acid (ca. 2·4 g.), precipitated from the sodium hydroxide extract, crystallised from benzene-light petroleum (b. p. 40—60°) to give 1:3:3-triphenylprop-2-ene-1-carboxylic acid (VIIIa), m. p. 166° (Found: C, 83·9; H, 5·9. C<sub>22</sub>H<sub>18</sub>O<sub>2</sub> requires C, 84·0; H, 5·8%). It discharged the colour of alkaline potassium permanganate.

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The neutral fraction (ca. 1.6 g.) was boiled with sodium hydroxide solution, then refluxed with glacial acetic acid for 1 hr., and left to crystallise, giving tetrahydro-2: 2: 3: 5: 5-pentaphenylfuran (Va), m. p. and mixed m. p.  $180^{\circ}$ .

(ii) A similar experiment with *p*-methoxyphenylmagnesium bromide and ethyl  $\gamma$ -*p*-methoxyphenyl- $\gamma$ -oxo- $\alpha$ -phenylbutyrate gave, as acid fraction (*ca.* 2·6 g.), 3: 3-*di*-p-*methoxyphenyl*-1-*phenylprop*-2-*ene*-1-*carboxylic acid* (VIIIb), m. p. 141° [from benzene-light petroleum (b. p. 40-60°)] (Found: C, 77·3; H, 6·0. C<sub>24</sub>H<sub>22</sub>O<sub>4</sub> requires C, 77·0; H, 5·9%). It discharged the colour of alkaline potassium permanganate.

The neutral fraction (ca.  $2 \cdot 0$  g.) gave the same product, m. p. and mixed m. p.  $262^{\circ}$ , as in the case of phenylsuccinic anhydride.

(iii) A similar experiment with p-chlorophenylmagnesium bromide and ethyl  $\gamma$ -p-chlorophenyl- $\gamma$ -oxo- $\alpha$ -phenylbutyrate gave 3: 3-di-p-chlorophenyl-1-phenylprop-2-ene-1-carboxylic acid (ca. 1.6 g.) (VIIIc), m. p. 200° [from benzene-light petroleum (b. p. 40-60°)] (Found: C, 68.8; H, 4.4; Cl, 18.3. C<sub>22</sub>H<sub>16</sub>O<sub>2</sub>Cl<sub>2</sub> requires C, 68.9; H, 4.2; Cl, 18.5%) (discharged the colour of alkaline potassium permanganate), and tetrahydro-2:2:5:5-tetra-p-chlorophenyl-3-phenyl-furan (Vf) (ca. 2.1 g.), m. p. and mixed m. p. 202°.

Action of Grignard Reagents on Diethyl Phenylsuccinate.—Similar experiments with 2 mols. of the Grignard reagent and diethyl phenylsuccinate (1 mol.) gave the same propene-acids (cf. Table 5).

## TABLE 5.

	Reactant	S		
Ar in ArMgX		Et. phenvl-	Produ	ucts
g. = 2  mols.		succinate (g.)	Propene acid, g.	Neutral, g.
Ph	15.7	12.5	VIIIa 1.5	Va 2.5
<i>p</i> -MeO·C <sub>6</sub> H₄	18.6	12.5	VIIIb $1.2$	VIb 0.9?
<i>p</i> -C <sub>6</sub> H <sub>4</sub> Cl	19.0	12.5	VIIIc 0.8	Vf 1.0

Isomerisation of the Propene-acids to the Lactones.—When 1:3:3-triphenyl-, 3:3-di-pmethoxyphenyl-1-phenyl-, and 3:3-di-p-chlorophenyl-1-phenyl-prop-2-ene-1-carboxylic acid were dissolved in the least amount of boiling concentrated hydrochloric acid-acetic acid (1:1v/v) and refluxed for 6 hr., they were converted almost quantitatively into the lactones, identified by their m. p.s and mixed m. p.s.

 $\alpha\gamma\gamma$ -Triphenyl-,  $\gamma\gamma$ -di-p-methoxy-phenyl- $\alpha$ -phenyl-, and  $\gamma\gamma$ -di-p-chlorophenyl- $\alpha$ -phenyl-butyrolactone were unaffected when similarly treated.

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