

α -Aryloxyesters. II. Further Studies on Certain Self-Condensations

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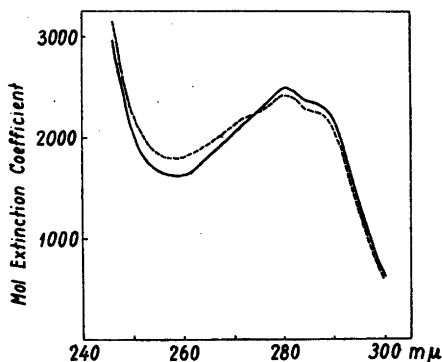
In a previous paper¹ the self-condensations of ethyl and *t*-butyl 2,4,6-trichlorophenoxyacetates* to the corresponding α , γ -di-TCPO-acetoacetates were described, and it was reported that the yield was considerably lower with the ethyl ester than with the *t*-butyl ester. Furthermore, the condensation product of the ethyl ester had a surprisingly lower melting point (78°) than both that of the *t*-butyl ester (131°) and that of ethyl 2,4-dichlorophenoxyacetate (98°). The purpose of the present investigation has been to elucidate, firstly, whether ortho-substituents in the phenyl groups have any significant influence on the yield of self-condensation products; and, secondly, whether any connection could be found between the melting

Table 1.

Substituents in benzene ring of aryloxyacetic ester	Alkyl in ester group	Yield of α, γ -diaryloxy acetoacetic ester %	m.p. °C	Analyses: % Halogen			
				Formula	Mol. weight calc.	Calc. Found	
2-Chloro	Ethyl	68	72-74	C ₁₅ H ₁₆ O ₅ Cl ₂	383.22	Cl 18.50	18.54
2,4-Dichloro	Ethyl ¹	60	96-98				
2,4,6-Trichloro	Ethyl	50	77-78 ¹				
2,4,6-Trichloro	Methyl	55	136-37	C ₁₇ H ₁₀ O ₅ Cl ₆	506.99	Cl 41.96	42.31
2,4,6-Trichloro	<i>i</i> -Propyl	70	88-89	C ₁₉ H ₁₄ O ₅ Cl ₆	535.04	Cl 39.76	39.77
2,4,6-Trichloro	<i>t</i> -Butyl ¹	51	129-31				
2,4-Dibromo	Ethyl	62	119-20	C ₁₈ H ₁₄ O ₅ Br ₄	629.95	Br 50.74	51.09
2,6-Dibromo-4-methyl	Ethyl	59	100-02	C ₂₀ H ₁₈ O ₅ Br ₄	658.00	Br 48.58	48.73
2,4-Dichloro	Methyl ¹⁴	65	102-04				

* Throughout this paper the 2,4,6-trichlorophenoxy group is abbreviated to TCPO.

Fig. 1. Ultraviolet absorption spectra of solutions in absolute ethanol of ethyl (---) and *t*-butyl (—) α,γ -di-TCPO-acetoacetate. Concentrations 0.0002 M, cell-thickness 1.000 cm.



point of the acetoacetic ester and the size of the esterifying alcoholic group. To this end, a number of new self-condensations were carried out with suitable aryloxy esters as represented in Table 1. Attempts also have been made to search for structural differences between ethyl and *t*-butyl α,γ -di-TCPO-acetoacetates. The ultraviolet and infrared absorption spectra were determined; in the infrared, a number of structurally related compounds were investigated as well.

Apparently the size of ortho-substituents in the phenoxy groups has no important influence on the yield of self-condensation products. The low yield previously reported for ethyl TCPO-acetate must have been due to the procedure used in working up the reaction mixture. This procedure has been improved and now ethyl TCPO-acetate gives satisfactory yield. Even ethyl 2,6-dibromo-4-methylphenoxyacetate gives more than 50 % yield. Nor do the melting points show any systematic variation: although both ethyl and *i*-propyl α,γ -di-TCPO-acetoacetate have low melting points, the melting point of the methyl ester appears to be "normal". The absorption curves in ultraviolet (2400–3000 Å) for ethyl and *t*-butyl α,γ -di-TCPO-acetoacetate in absolute ethanol (Fig. 1) and in *n*-heptane do not give much information about the structures of the compounds. They are very similar and show a maximum at 2800 Å, probably due to the TCPO-group*.

* The values of the extinction coefficients ($\epsilon = 2415$ and 2490) are much too high for a carbonyl group ($\epsilon = 15-20^2$). Ethyl acetoacetate shows a maximum at 2430 Å ($\epsilon = 1900$), which has been ascribed to its enol content³. Any appreciable enolization of the di-TCPO-acetoacetates would be expected to effect a shift to lower wave-lengths. The ultraviolet spectra of ethyl TCPO-acetate, TCPO-acetone, and 2,4,6-trichloroanisole are almost identical and show likewise a band at 2800 Å ($\epsilon = 800$); in addition they show another band at 2880 Å ($\epsilon = 800$), while the di-TCPO-acetoacetates show only a shoulder at that wave-length.

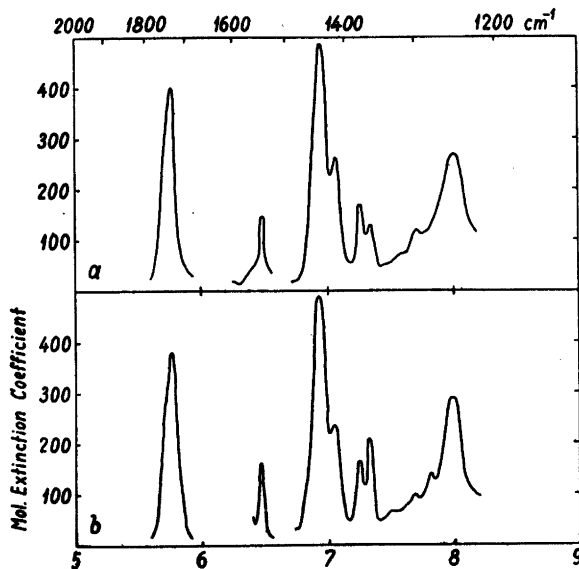


Fig. 2. Infrared absorption spectra of solutions in carbon tetrachloride of (a) ethyl and (b) *t*-butyl α,γ -di-TCPO-acetoacetate. Concentrations (a) 0.1093 M and (b) 0.0641 M; cell-thickness 0.1 mm.

The infrared absorption curves of the same two substances in carbon tetrachloride solution (Fig. 2) are practically coincident in the 5–7 μ region, showing a single strong absorption at 5.76 μ (1735 cm^{-1}) presumably due to the carbonyl group. On the other hand, the infrared spectra of both compounds as solids suspended in nujol (Fig. 3 b and d) showed two peaks, at about 5.70 μ (1755 cm^{-1}) and 5.82 μ (1720 cm^{-1}). While the latter band was of about the same strength in the two spectra, the first band was considerably weaker in the spectrum of the ethyl ester. The methyl (Fig. 3 a) and the *i*-propyl (c) esters show the same two bands, the 5.70 μ band being of intermediate strengths*. No band was observed either in the 3 μ or the 6 μ region (corresponding to hydroxyl groups and carbon-carbon double-bonds respectively).

* In an attempt to interpret these bands, the spectra of certain related compounds as solids in nujol were measured: while 2,4,6-trichloroanisole (Fig. 3 k) shows no absorption at all in this region, and TCPO-acetone (i), TCPO-acetic acid (g), and TCPO-acetamide (h) all show one broad band, ethyl TCPO-acetate (f) (and ethyl phenoxyacetate), surprisingly, show two bands, at 5.65 μ (1770 cm^{-1}) and 5.75 μ (1740 cm^{-1}). Ethyl TCPO-acetate shows these bands also in solution (Fig. 4). α,γ -Diphenoxyacetoacetamide (Fig. 3 e), however, show two bands at 5.74 μ (1742 cm^{-1}) and 5.88 μ (1702 cm^{-1}), very near those of the acetoacetic esters investigated.

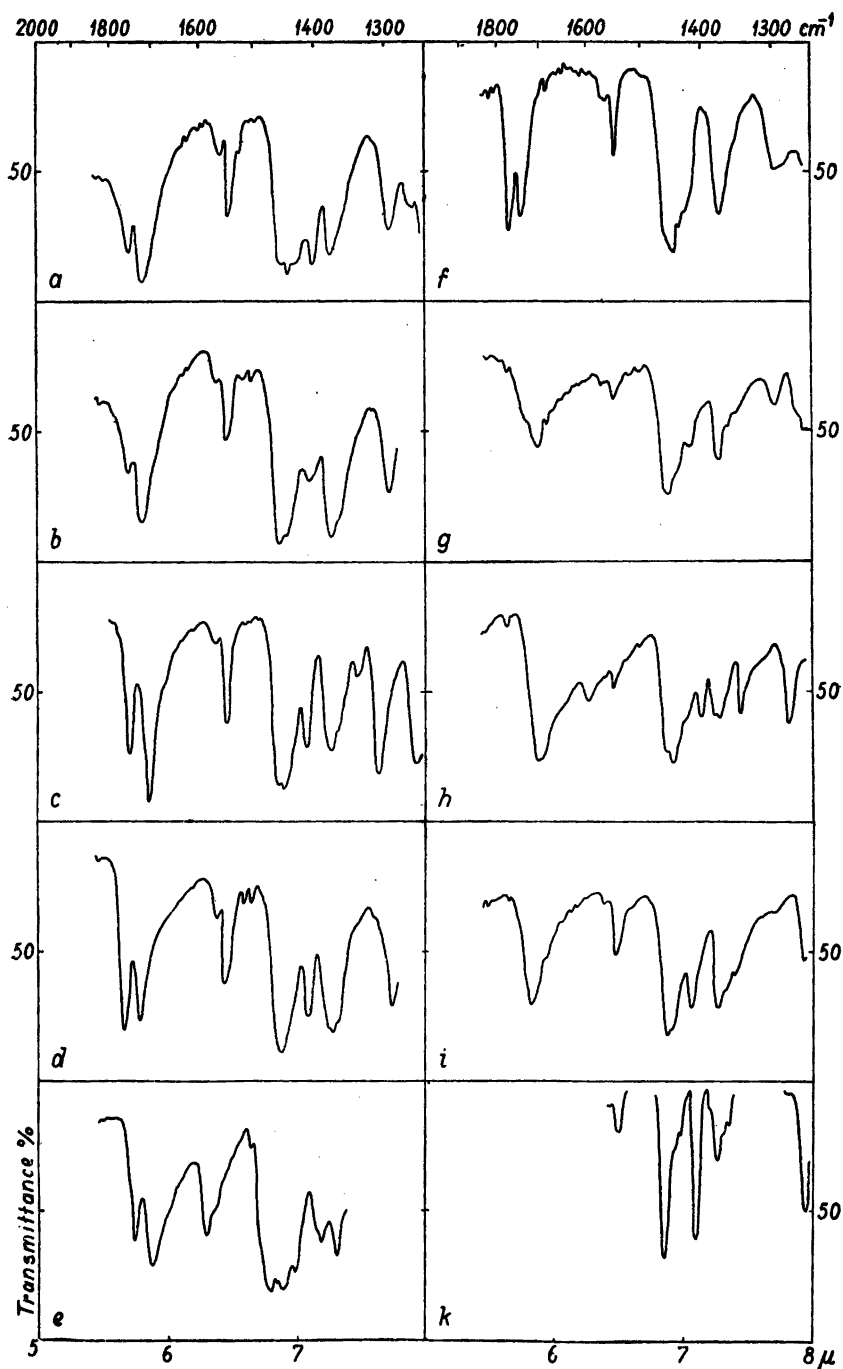


Fig. 3. Infrared absorption spectra of suspensions in nujol of: (a) methyl, (b) ethyl, (c) *i*-propyl, (d) *t*-butyl α,γ -di-TCPO-acetoacetate; (e) α,γ -diphenoxyacetoacetamide; (f) ethyl TCPO-acetate; (g) TCPO-acetic acid; (h) TCPO-acetamide; (i) TCPO-acetone; (k) 2,4,6-trichloroanisole. Approximate concentrations 1.3×10^{-4} mole in 0.2 ml nujol; cell-thickness approximately 0.01 mm.

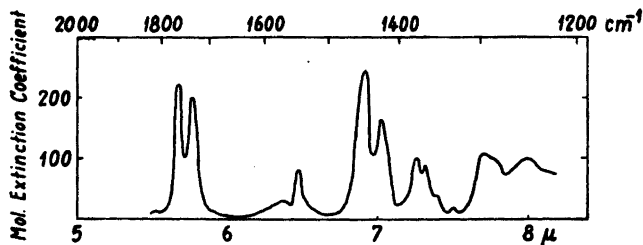


Fig. 4. Infrared absorption spectrum of ethyl TCPO-acetate in carbon tetrachloride solution. Concentration 0.247 M, cell-thickness 0.1 mm.

Thus, no indication of enolization has been obtained, and the compounds appear to be essentially ketonic in structure. According to their spectra in solution, they seem to be chemically almost identical, and the difference between them appears to be connected with the crystalline state. The solubilities (Table 2) show good correspondence with the melting points, as the two low-melting compounds are almost ten times as soluble as the two high-melting ones. A reasonable possibility, therefore, is that the differences observed are due to the degree of intermolecular association caused by steric effects of the alkyl of the ester group and the large TCPO group.

Table 2. Solubilities of α,γ -di-TCPO-acetoacetic esters at 20° C in moles per liter of absolute ethanol.

		m.p. °C
Methyl	0.032	137
Ethyl	0.282	78
<i>i</i> -Propyl	0.252	89
<i>t</i> -Butyl	0.030	131

EXPERIMENTAL

All melting and boiling points are uncorrected.

Starting materials. The following two esters were prepared from the corresponding phenol and ethyl chloroacetate, as previously described¹: *Ethyl o-chlorophenoxyacetate*, b.p. 151–153° at 15 mm (m.p. 32°⁴), yield 70%. Alkaline hydrolysis: C₁₀H₁₁O₃Cl (214.65) Equiv.wt. found 214.2. *Ethyl 2,4-dibromophenoxyacetate*, b.p. 162–166° at 1 mm (m.p. 39.5–40.5°), yield 52%. Alkaline hydrolysis: C₁₀H₁₀O₃Br₂ (338.01) Equiv.wt. found 335.0. 2,4-Dibromophenoxyacetic acid isolated: m.p. 150–152° (reported 151.8–153.3°⁵).

i-Propyl TCPO-acetate, b.p. 152–154° at 1 mm, was obtained by esterification of the acid¹, yield 65%. This ester solidifies partially at room temperature. Alkaline hydrolysis: C₁₁H₁₁O₃Cl₃ (297.57) Equiv.wt. found 296.2.

The following two (solid) esters were obtained as previously¹ described for ethyl TCPO-acetate: *Methyl TCPO-acetate*, m.p. 62–63°; alkaline hydrolysis: $C_9H_7O_3Cl_3$ (269.52) Equiv.wt. found 268.3. *Ethyl 2,6-dibromo-4-methylphenoxyacetate*, m.p. 83–85°, yield 72 %; alkaline hydrolysis: $C_{11}H_{12}O_3Br_2$ (352.05) Equiv.wt. found 352.0. 2,6-Dibromo-4-methylphenoxyacetic acid isolated: m. p. 175° (reported 200°⁶); titration with 0.1 N sodium hydroxide: $C_9H_8O_3Br_2$ (323.98) Neutr.equiv. found 324.7. The required 2,6-dibromo-4-methylphenol, b.p. 153–156° at 20 mm (reported 139–40° at 11 mm⁷) was obtained in 48 % yield, by a procedure analogous to that given for 2-bromo-4-methylphenol⁸, from 3,5-dibromo-4-aminotoluene, m.p. 73°, which was prepared by the bromination of *p*-toluidine in methanol.

2,4,6-Trichloroanisole, m.p. 60°⁹, was prepared by shaking the phenol in potassium hydroxide solution with dimethyl sulfate¹⁰.

TCPO-acetone, m.p. 78–79° (reported 75°¹¹) was obtained from bromoacetone¹², the phenol, and potassium carbonate in dry acetone¹³, yield 72 %. Found Cl 42.10; Calc. for $C_9H_7O_2Cl_3$ (253.52) Cl 41.96.

TCPO-acetic acid, *TCPO-acetamide*, *ethyl TCPO-acetate*, *ethyl α , γ -di-TCPO-acetoacetate*, *t-butyl α , γ -di-TCPO-acetoacetate*, and *α , γ -diphenoxyacetoacetamide* were the products previously described¹.

Self-condensations. The procedure previously described^{14,1} was modified. To the ether suspension of di-*i*-propylaminomagnesium bromide * (generally 0.1 or 0.2 moles) was added, during $\frac{1}{2}$ –1 hour, one equivalent of the ester in ether solution. An oily precipitate usually formed **. After stirring at room temperature for about $\frac{1}{2}$ hour the mixture was refluxed for two hours. The flask was cooled in an ice-salt bath and crushed ice and concentrated hydrochloric acid added until acidic reaction. Stirring was continued at room temperature until two clear layers were obtained. The ether layer was separated and the water layer extracted with ether. The combined ether solutions were washed with saturated sodium bicarbonate solution and water, dried by shaking with anhydrous sodium sulfate for 10–15 minutes, filtered, and concentrated to a small volume (50–100 ml). After standing over-night in the ice-box, generally most of the acetoacetic ester had crystallized. The products were recrystallized from the corresponding alcohols. The yields, data, and analyses are given in Table 1.

The ultraviolet absorption spectra (Fig. 1) were obtained by means of a Beckman model DU spectrophotometer, using quartz cells and a hydrogen discharge lamp.

The infrared absorption spectra (Figs. 2–4) were measured by using a Beckman model IR 2 spectrophotometer with a rock-salt prism. The slit was automatically adjusted by means of a mechanical slit drive coupled to the wave-length drive; the slit being 0.140 mm at 5.4 μ (1 850 cm^{-1}) and 0.285 mm at 8.5 μ (1 177 cm^{-1}). The substances were examined between rock-salt plates as dilute solutions in carbon tetrachloride (Figs. 2 and 4), or as suspensions in nujol (Fig. 3).

The solubilities in ethanol were determined by recrystallization of the pure compounds from that solvent. After standing over-night at 20°, the mother liquors were regarded as

* The author is indebted to A/S [Dansk Shell, Copenhagen, and to Shell Chemical Corporation, New York, for generous samples of di-*i*-propylamine.

** In the case of 2,6-dibromo-4-methylphenoxyacetic ester the precipitate formed lumps which made stirring difficult and probably decreased the yield. In the case of *i*-propyl TCPO-acetate the reaction mixture remained a clear solution.

saturated solutions. Chlorine was determined on aliquote samples, according to Stepanow's sodium reduction procedure followed by Volhard titration*, and from the chlorine content the concentration of acetoacetic ester was calculated.

SUMMARY

A number of halogen substituted aryloxyacetic esters have been satisfactorily self-condensed, apparently independently of the size and the position of the substituents in the phenyl ring.

Attempts have been made to explain some irregularities concerning the melting points of the self-condensation products of different 2,4,6-trichlorophenoxyacetic esters. The suggestion is made that the irregularities are due to differences in the crystalline, rather than in the chemical structures.

The ultraviolet and infrared spectra of some of the self-condensation products and certain related compounds are given.

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* All halogen analyses were carried out using this method.