

THE WESSELY ACETOXYLATION

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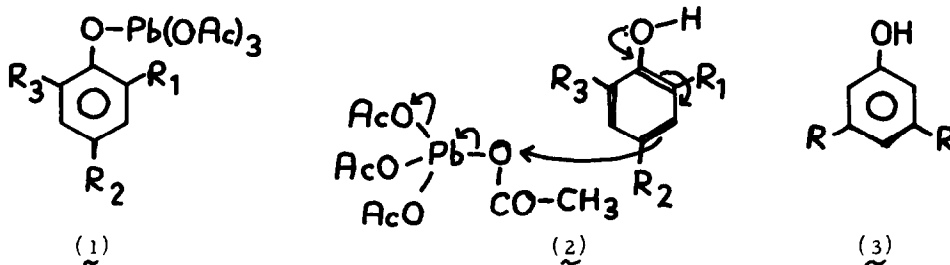
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We have carried out reactions of a number of substituted phenols with saturated solutions of lead tetraacetate¹ in glacial acetic acid at ambient temperatures and obtained absolute yields of all major products by an NMR method utilising internal standards². The conditions used in working up the reaction mixtures were found not to lead to detectable isomerisation of cyclohexadienones³ and thus we believe that the results summarised in Table 1 reflect the initial distribution of the products better than most published data, which refer to isolated yields.

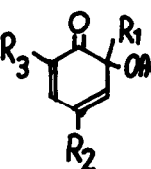
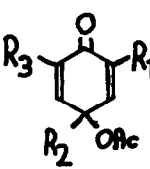
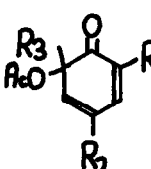
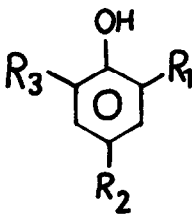
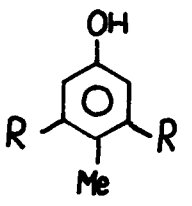
It can be seen that the yields of the typical acetoxylation products are considerably higher than is generally believed⁴ and experiments 1, 3, 5, 9, 10 and 11 (Table 1) indicate that reaction at the ortho positions is not necessarily predominant⁴.

Wessely⁵ proposed a mechanism involving a one electron oxidation of the phenol to the corresponding aryloxy radical but Criegee⁶, Waring⁴ and Norman⁷ have mustered extensive evidence against free radical mechanisms and proposed variants of a heterolytic mechanism which essentially amounts to nucleophilic displacement by acetate ions on a postulated intermediate aryloxy lead triacetate, e.g. (1). We would like to propose



that the results quoted in Table 1, as well as data found in the literature, can be better rationalised in terms of an electrophilic substitution, e.g. (2). In particular, this

TABLE 1 : Product Distribution

No.	Substrate			Products (%)			Reaction time(min)
	R1	R2	R3				
							
1	Me	Me	H	55	27	12 (R ₃ =OAc)	5
2	Me	CMe ₃	H	61	12	20 (R ₃ =OAc)	10
3	Me	Ph	H	29	58	≤10 (R ₃ =OAc)	8
4	Me	Cl	H	71	≤5	22 (R ₃ =OAc)	5
	"	"	"	70	≤5	21 (R ₃ =OAc)	20
5	Me	OAc	H	22	28 (+ TQ ^a 15)	≤10 (R ₃ =OAc)	5
	"	"	"	21	36 (+ TQ 14)	≤10 (R ₃ =OAc)	5
	"	"	"	19	7 (+ TQ 47)	≤10 (R ₃ =OAc)	25
6 ^b	Me	CMe ₃	Ph	60	14	26	30
7 ^c	CMe ₃	H	H	ca. 10	13 (R ₂ =OAc) (+BQ ^d 7)	49 (R ₃ =OAc)	19 hr
8	Me	Me	Me	76	19	-	5
9	CMe ₃	CMe ₃	CMe ₃	63	27	-	24 hr
	"	"	"	62	25	-	25 hr
							
10	R = H			33 (R ₁ =OAc)	34	-	5
				28 (R ₁ =OAc)	37	-	15
				36 (R ₁ =OAc)	35	-	60
11	R = Me			17 (R ₁ =OAc)	58	-	6

^aTQ = *p*-Toluquinone^bRelative yields only^cBy GLC^d*p*-*t*-Butylquinone

mechanism rationalises the catalytic effect⁸ of BF_3 as conferring better electrophilic properties to lead tetraacetate, is consistent with variations of reactivity with substitution in the phenolic ring and is analogous to some of the mechanisms proposed for the reaction of lead tetraacetate with methoxy benzenes^{8,9}.

To obtain supporting evidence for our proposal, we have examined the relative reactivity of a number of 3,5-disubstituted phenols (3) and found the order of reactivity, under the conditions described above, to be $\text{R} = \text{OMe} \gg \text{Me} \gg \text{Cl} \gg \text{NO}_2$. In fact the reaction of phloroglucinol dimethyl ether was essentially instantaneous while 3,5-dinitrophenol did not react after two months. Since in the transition state resulting from a movement of electrons depicted in (2) the positive charge can be placed at C-3 and C-5, as well as on the oxygen, we conclude that the order of reactivity shown in the series (3) is in accord with the Wessely acetoxylation falling into the category of electrophilic substitutions in aromatic systems. Experiments (10) and (11) in Table 1 can also be interpreted in the same fashion.

Two lines of evidence which appear to favour mechanisms involving nucleophilic displacement need to be considered. Cavill *et al.*¹⁰ have observed that reactions of phenols with lead tetraacetate in propionic acid yield propionoxy derivatives which suggests that the acyloxy groups are introduced as a result of an attack by the acyloxy ions or the acids. We have found, however, that lead tetraacetate in propionic acid equilibrates rapidly with lead tetrapropionate, a process whose possibility had already been considered¹⁰. More recently, Norman⁷ observed that acetoxylation of 2,4,6-tri-*t*-butylphenol in the presence of methanol resulted in methoxylated products, as well as the expected compounds (see experiment 9, Table 1), which suggests the interception of an intermediate of the type (1) by a competing nucleophile, here methanol. However, it had been shown by Criegee¹¹ that lead tetraacetate and methanol rapidly yield dimethoxy lead diacetate which is a better methoxylating than acetoxyating agent.

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