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THE EFFECT OF ORTHO SUBSTITUENTS IN $S_{RN}1$ REACTIONS. SOME SYNTHETIC APPLICATIONS.

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Abstract. Several ortho-substituted iodobenzenes were allowed to react, via the $S_{RN}1$ mechanism, with mixtures of diethyl phosphite ion and pinacolone enolate ion. From product composition data, the relative reactivities of the two nucleophiles were reckoned. They represent relative reactivities in attachment to aryl radical intermediates. Most of the ortho effects are slight, but there is evidence that large ortho substituents hinder attachment of the phosphite more than the enolate nucleophile. The methoxy and diethoxyphosphoryl substituents, when para to the site of substitution, respectively favour and disfavour the phosphite with respect to the enolate ion. $S_{RN}1$ reactions of ortho-substituted halobenzenes are, for some substituents, followed by other reactions which afford products of synthetic interest.

Since 1970,[1] it has been recognized that nucleophilic substitution at aromatic sites can occur by the radical chain, $S_{RN}1$ mechanism.[2,3] The propagation cycle of this mechanism is presented in Scheme 1.

$$ArX^{\cdot -} \longrightarrow Ar\cdot + X^- \qquad (M1)$$

$$Ar\cdot + Y^- \longrightarrow ArY^{\cdot -} \qquad (M2)$$

$$ArY^{\cdot -} + ArX \longrightarrow ArY + ArX^{\cdot -} \qquad (M3)$$

Scheme 1

The mechanism involves radical (Ar·) and radical anion ($ArX^{\cdot -}$ and $ArY^{\cdot -}$) reactive intermediates. The overall result of the processes sketched in Scheme 1 is an aromatic nucleophilic substitution ($ArX + Y^- \longrightarrow ArY + X^-$).

Whereas reactions by the familiar S_NAr mechanism of aromatic nucleophilic substitution[4] are greatly accelerated by electron-attracting substituents such as nitro groups, and impeded by substituents that release electrons, $S_{RN}1$ reactions generally fail when nitro groups are present[5] and are immune to deactivation by substituents such as methoxy and amino[6] groups.

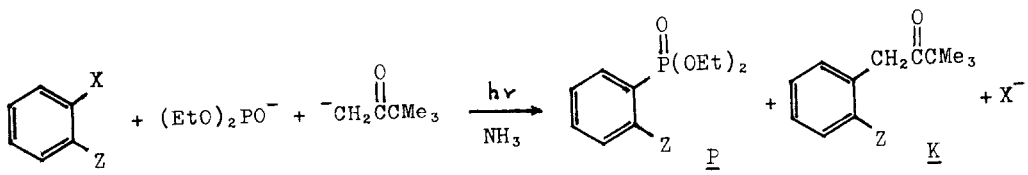
$S_{RN}1$ reactions have sometimes been observed to give lower than usual yields of products when

ortho substituents are present,[7] but heretofore there has been no systematic attention to the effects of ortho substituents on reactivity. We now report a study of the effects of ortho substituents on the relative reactivities of two prominent nucleophiles. Besides their intrinsic interest, our results may serve to guide preparative utilization of aromatic $S_{RN}1$ reactions.

Certain special effects have been recognized in $S_{RN}1$ reactions of ortho-substituted halobenzenes. When the ortho substituent has capability to stabilize an aryl anion, a nucleophile may effect nucleophilic capture of positive halogen with resultant reductive dehalogenation or other consequences.[5,8] In some cases the product of nucleophilic replacement of halogen may undergo a ring closure reaction with the ortho substituent, in preparatively useful fashion.[6,9-13] When two replaceable substituents are ortho to each other, the product of replacement of both may experience some further reaction leading to a ring closure product.[14] Other special effects have also been identified.[15]

RESULTS AND DISCUSSION

To study the effect exerted by an ortho substituent, we chose to explore further a competition system we had earlier investigated.[16] The system involves competition between two nucleophiles, diethyl phosphite ion and pinacolone enolate ion, reacting with a single substrate. In the present study, the substrates are mostly ortho-substituted iodobenzenes, and the system is represented as follows:



These nucleophiles were chosen in part because they generally give clean and quantitative $S_{RN}1$ reactions with aryl iodides.[16,17] Second, they present rather different steric features, the enolate ion being planar at the nucleophilic carbon site while the phosphite is pyramidal at phosphorus.[18]

Reactions of ortho-substituted iodobenzenes and other substrates with mixtures of the two nucleophiles, both at known concentrations, were submitted to photostimulated reaction for short time such that neither nucleophile was fully consumed. From the product compositions, as determined by GLC, and with use of a standard expression for reckoning of relative rate constants,[19] we determined the relative reactivities of the two nucleophiles. Our principal rate data are presented in Table 1. In planning what substrate to use, we avoided those ortho substituents that are known to engage in other than simple $S_{RN}1$ behaviour. A few para substituents were also examined. Substituent effects on relative nucleophile reactivities are summarized in Table 2.

Experiments listed in Table 1 concern three o-halotoluenes, three 1-halonaphthalenes, and two o-haloanisoles. For all three sets of substrates, k_P/k_K is within experimental error independent of the identity of the halogen. The observation of independence of k_P/k_K from identity of the leaving group in the case of plain phenyl substrates[16] provided significant additional support for the $S_{RN}1$ mechanism hypothesis.

Table 1. Competitive Reactions with Substituted Halobenzenes of Diethyl Phosphite Ion versus Pinacolone Enolate Ion.[a]

Expt. no.	Halogen	Subst.	Isomer	[ArX], M	[P^-],[b] M	[K^-],[c] M	k_P/k_K	$t_{\frac{1}{2}}$, s (approx.)
1	I	H[d]	-	0.015	0.065	0.071[e]	1.49±.06	20
2	I	Me	ortho	0.030	0.087	0.098	1.93±.23	20
3	Br	Me	ortho	0.029	0.086	0.103	2.27±.08	150
4	Br	Me	ortho	0.030	0.085	0.102	1.49±.22	170
5	Br	Me	ortho	0.030	0.086	0.101	2.03±.20	190
6	Br	Me	ortho	0.021	0.075	0.072	1.90±.09	90
7	Cl	Me	ortho	0.030	0.086	0.101	2.07±.34	280
8	I	Ph	ortho	0.022	0.072	0.086	1.15±.11	60
9	I	NMe_2	ortho	0.015	0.069	0.081	1.16±.03	120
10	I	$(Me)_2$	2,6	0.015	0.068	0.071[e]	1.17±.01	30
11	I	α-Np[f]	-	0.027	0.081	0.093	1.05±.07	140
12	I	α-Np[f]	-	0.025	0.075	0.088	1.01±.14	80
13	Br	α-Np[f]	-	0.023	0.075	0.086	1.07±.13	170
14	Br	α-Np[f]	-	0.023	0.076	0.085	1.29±.31	50
15	Cl	α-Np[f]	-	0.021	0.076	0.089	0.94±.03	200
16	I	OMe	ortho	0.029	0.086	0.098	0.89±.03	23
17	Br	OMe	ortho	0.030	0.085	0.101	0.83±.01	200
18	Br	OMe	ortho	0.019	0.067	0.075	0.84±.06	100
19	I	$PO(OEt)_2$	ortho	0.014	0.066	0.064	0.022±.002	300
20	Br	Me	para	0.021	0.073	0.076	1.46±.05	60
21	I	OMe	para	0.020	0.070	0.071	1.78±.05	10
22	I	$PO(OEt)_2$	para	0.012	0.071	0.064	0.25±.02	250
23	I	F	para	0.017	0.074	0.072	0.82±.02	5

[a] In ammonia at reflux (-33 °C), in Pyrex flasks under irradiation in a Rayonet RPR-100 photochemical reactor equipped with 16 lamps.

[b] "P^-" stands for diethyl phosphite ion.

[c] "K^-" stands for pinacolone enolate ion, unless otherwise noted.

[d] Substrate was PhI.

[e] Acetone enolate ion.

[f] Substrate was an α-naphthyl halide.

In Table 1, the approximate half-life (for substrate consumption) for each experiment is listed. There are a few striking differences between half-lives observed in replicate experiments. These are not considered to be unusual, for adventitious impurities with inhibitor properties might be present in larger amount in one experiment than in another. Indeed, in several experiments the apparent half-lives reckoned from product concentrations in aliquots withdrawn late in the run were shorter than in aliquots withdrawn early. Nevertheless certain trends in overall reactivity may be discerned. For one, the reactivity order, ArI>ArBr>ArCl, generally manifest in aromatic $S_{RN}1$ reactions, is expressed. Reactions of iodine derivatives of diethyl phenylphosphonate are notably slow, while the electron-releasing methoxy group has no adverse effect and even the *o*-dimethylamino group has a modest effect. Because reactivity in several steps, including termination steps, contributes to overall reactivity in a radical chain process, it is difficult to judge, for example, in which step the apparent deactivating effect of the diethoxyphosphoryl group is exerted.

Table 2. Summary of Relative Reactivities. Competitive Reactions with Substituted Halobenzenes of Diethyl Phosphite Ion *versus* Pinacolone Enolate Ion.[a]

Substituent	$(k_P/k_K)_{ortho}$	$(k_P/k_K)_{para}$
H	1.4[b]	1.4[b]
Me	1.9	1.5
Ph	1.2	
NMe_2	1.2	
α-Naphthyl	1.1	
OMe	0.9	1.8
$PO(OEt)_2$	0.02	0.25
F		0.82
$2,6\text{-}Me_2$	1.2	

[a] Based on experiments of Table 1.

[b] From ref. 16.

Our data show that an *o*-methyl group slightly favours diethyl phosphite ion over the enolate ion nucleophile. The observed k_P/k_K of 1.9±0.2 for *o*-iodotoluene is only a little higher than 1.4±0.1 for iodobenzene.[16] Two *o*-methyl groups, in 2-iodo-*m*-xylene, depress the reactivity ratio to 1.2±0.1, a figure not significantly lower than that for iodobenzene. The *o*-phenyl and *o*-dimethylamino groups likewise give reactivity ratios of 1.2±0.1. 1-Iodonaphthalene can be regarded as an *o*-substituted iodobenzene. Its reactivity ratio, 1.1±0.1, again indicates very little influence of the *peri* C-H on selectivity between the two nucleophiles. The *o*-methoxy group, in *o*-iodoanisole, exerts a more

pronounced effect, favouring the enolate over the phosphite nucleophile. A much stronger influence in the same direction is expressed by the diethoxyphosphoryl group in diethyl o-iodophenylphosphonate; the enolate ion is here about 50 times more reactive than the phosphite reagent.

Some attention was also given to the effect of para substituents. In contrast to o-methoxy, p-methoxy somewhat favoured the phosphite over the enolate reagent. p-Fluorine, on the other hand, enhanced the reactivity of the enolate as compared to the phosphite reagent. As for the p-diethoxyphosphoryl group, it behaved qualitatively the same as when ortho to the reaction site, but more weakly. From these facts, it seems that the effect of the ortho-diethoxyphosphoryl group is partly steric and partly electronic.

a) Discussion of Nucleophile Reactivities

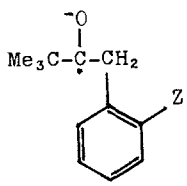
We judge that the nucleophile relative reactivities listed in Table 1 reflect behaviour in step M2 of the propagation cycle (Scheme 1), in which the aryl radical bonds to the nucleophile. We know of no evidence that the radical anion so formed can, in the cases of present interest, dissociate to regenerate the aryl radical and an enolate or dialkyl phosphite ion. The nucleophiles doubtless are involved also in initiation steps,[2,3] but once initiation has occurred, and if the chain is a long one, the aryl radical intermediates should react objectively with the two nucleophiles without reference to which was involved in its "ancestry".

There is an indication that large ortho substituents favour pinacolone enolate ion over diethyl phosphite ion as a nucleophile in the very low k_P/k_K ratio for diethyl o-iodophenylphosphonate. The steric demands of the pyramidal phosphite nucleophile are evidently larger than those of the planar enolate ion, even though the latter has a t-butyl group near its nucleophilic site. We suggest that the somewhat depressed k_P/k_K ratio for o-iodoanisole also represents a steric effect. A priori, the steric effect of an o-methoxy group in a phenyl radical should depend on its conformation. When coplanar and with the methyl group anti to the radical site, it should provide minimal interference with attack on the radical centre. But when coplanar and syn with respect to the radical site, it should greatly interfere. Observations of Kasai and McLeod[20] indicate that the o-anisyl radical is at least occasionally in the syn-coplanar conformation. Inasmuch as these nucleophiles react with the phenyl radical nearly at encounter-controlled rate,[16,21] encounters with the o-anisyl radical in the syn-coplanar conformation are likely to be much less productive for the phosphite than for the enolate nucleophile. In this way the modest depression of k_P/k_K for o-iodoanisole may be understood.

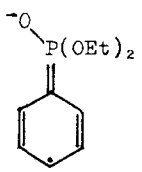
Interpretation of the somewhat depressed k_P/k_K (1.2) for 2-iodo-m-xylene is complicated by the fact that the enolate ion was derived from acetone and therefore is presumed to have lesser steric requirements than pinacolone enolate ion. Expt. 1, involving iodobenzene, also concerns acetone enolate ion; the measured k_P/k_K of 1.5 is not different within experimental error from that (1.4) observed when the enolate competitor is derived from pinacolone.[16] Apart from steric characteristics, the two enolate ions behave much the same.

The effects of the methoxy and diethoxyphosphoryl groups as para substituents cannot be steric. Respectively, they raise and lower k_P/k_K. We believe that understanding of them must take account of where the "extra" electron of the radical ion formed in step M2 (Scheme 1) is located in the transition state for attachment of aryl radical to nucleophile. We advance a tentative hypothesis of interpretation.

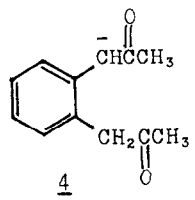
In the case of attachment to a ketone enolate ion, the latter may be considered to be a substituted alkene and the reaction visualized as analogous to additions of radicals to olefins.[22] Accordingly the product should be a ketyl (of structure A), with the "extra" electron in the side-chain carbonyl group, and the transition state an approach to that structure. Consideration of the process in terms of MO theory leads to a similar conclusion.[23] When an aryl radical attaches to a dialkyl phosphite ion, the "extra" electron presumably begins to occupy the σ^* MO of the new C-P bond but smoothly migrates into the dp π orbital that develops, as that bond forms, from overlap between the 2p orbital of C-1 and a d orbital of phosphorus. As a result of that bonding, the diethyl phenylphosphonate radical anion formed has structure B as a significant canonical form, and the transition state has some of the character of structure B. Inasmuch as an α-methoxy group stabilizes



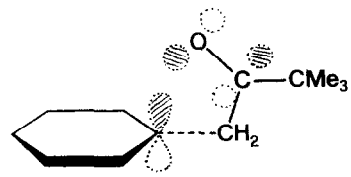
A



B



4



C

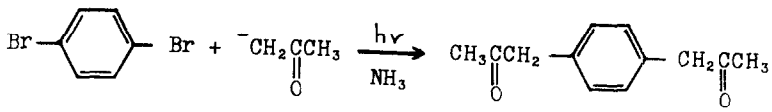
a radical,[24] the transition state for attachment of the p-anisyl radical to diethyl phosphite ion is favoured by the methoxy group while that for attachment to the enolate ion is not. In these terms the high value of k_p/k_K for p-iodoanisole can be rationalized.

As mentioned, a ketyl type of structure is formed as an aryl radical attaches to a ketone enolate ion. The radical doubtless approaches the enolate ion more or less perpendicular to its "alkene" plane. In the transition state, represented as structure C, the π^* MO of the carbonyl group, in which the "extra" electron begins to appear, is geometrically disposed so as to interact (in regard to orbital symmetry) with the π^* LUMO of the benzene ring and thereby the negative charge of the "extra" electron can be in part in the aromatic ring at the transition state for attachment. Attachment of the enolate ion is therefore strongly favoured by an electron-withdrawing diethoxyphosphoryl group[25] in the para position (or also by a para fluorine). As for the transition state of attachment of an aryl radical to diethyl phosphite ion, there is as discussed above (structure B) an opportunity for the "extra" electron to appear in the aromatic ring, while the diethoxyphosphoryl group being installed can in part accommodate the negative charge. In such a case, assistance by another diethoxyphosphoryl group in the para position is marginal. Thus we may rationalize the low value (0.25) of k_p/k_K for diethyl p-iodophenylphosphonate or the slightly higher one (0.82) for p-fluoroiodobenzene.

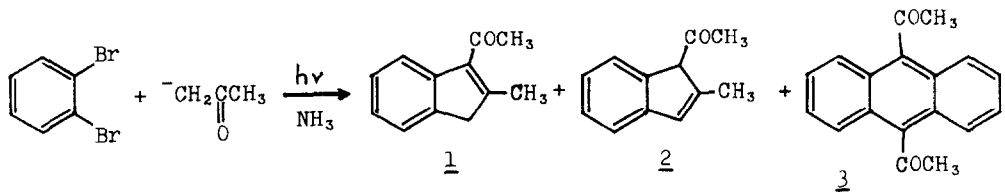
b) Synthetic Applications

We now describe several cases of peculiar behaviour by ortho substituents in $S_{RN}1$ reactions that, although making them unsuitable for the quantitative study summarized in Table 2, nevertheless provide intriguing hints as to synthetic application. We shall see that reactions utilizing enolate ion nucleophiles are of foremost interest for use in synthesis.

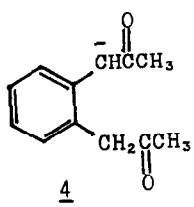
Ortho halogen group. While interaction of an enolate ion with m- or p-dihalobenzenes leads to the bis-substituted product,[2,26] Bunnett and Singh have reported[14] that reaction of acetone enolate



ion with o-dibromobenzene affords 64% yield of a mixture of two isomeric indene derivatives, along with 5% yield of 9,10-diacetylanthracene:



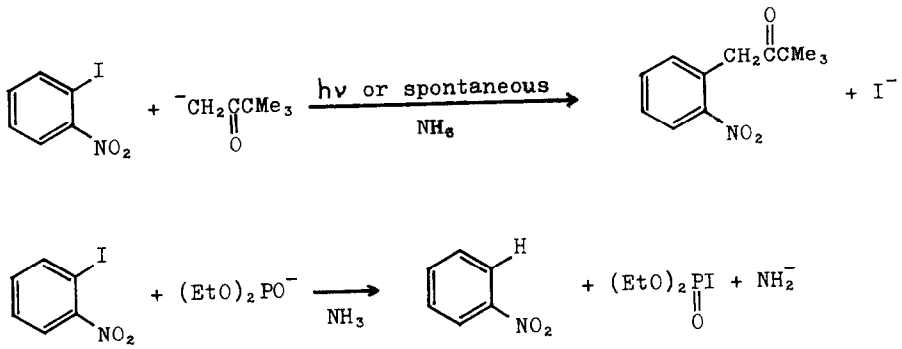
Deprotonation of the straightforward disubstitution product, that occurs easily in the basic reaction conditions, gives 4, which brings about an intramolecular aldol condensation and gives products 1 and



2. Product 3 results instead from further $S_{RN}1$ reaction of 4 with another molecule of substrate. Incidentally, the enolate of pinacolone affords only the expected bis-substituted product, being withheld from the subsequent intramolecular condensation by the steric hindrance of its t-butyl group. However, the $S_{RN}1$ substitution is unusually sluggish in this case, 35% of unreacted substrate being recovered after a span of time (2 h) generally quite sufficient for quantitative conversion.

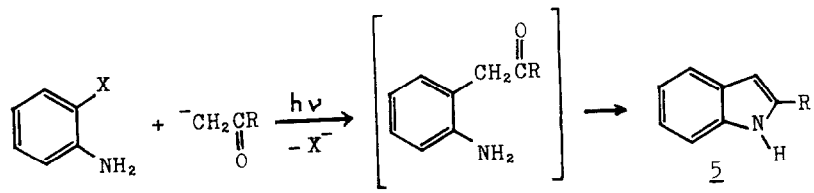
Ortho nitro group. One of us stated in his 1978 Account,[2] that "$S_{RN}1$ reaction with a nitroaryl halide has yet to be recognized". The reason for it is simple. Stabilization of the π^* MO in the radical anion of a nitroaryl halide by its electron-withdrawing nitro group is so strong that i) intramolecular transfer of the odd electron to the σ^* MO of the C-halogen bond and ii) concomitant fragmentation of the latter[27,28] (step M1 in Scheme 1) are retarded. When a key step in the chain propagation sequence is inefficient, termination steps have a much better chance to reduce the overall rate nearly to zero.

We have recently obtained experimental evidence of a $S_{RN}1$ substitution occurring on o-iodonitrobenzene.[5] Steric inhibition of coplanarity of the nitro group by the bulky adjacent iodine atom reduces stabilization of the π^* MO, so as to allow population of the σ^* MO of the C-iodine bond and the concomitant fragmentation of that bond. As a matter of fact, replacement of iodine with smaller halogen atoms causes a dramatic decrease of efficiency of the substitution process. The ketoalkyl-de-halogenation occurs only with enolates; abstraction of X^+ takes place instead[8] with $(EtO)_2PO^-$



Ortho cyano group. Koppang, Woolsey and Bartak have reported the electrochemical generation of the radical anion of o-cyanoanisole.[29] The radical anion enjoys a stabilization which is different from that experienced by the meta and para isomers, due to the close proximity of the electronegative oxygen of the MeO-group. Further data by Behar and Neta indicate that stabilization of a radical anion by a cyano group is however less strong than that due to a nitro group.[30] Accordingly, $S_{RN}1$ substitution in halogen derivatives of benzonitrile should occur more readily than in halonitrobenzenes. A few $S_{RN}1$ reactions with p-halobenzonitriles have been reported,[31] but so far none to our knowledge with ortho-halogen derivatives.

Ortho amino group. This is probably the most interesting substituent from a synthetic point of view and several examples are reported in the literature concerning its use.[6,9,10] $S_{RN}1$ replacement of halogen from an o-haloaniline by a ketone enolate ion and subsequent cyclization affords easily a large number of indole derivatives 5 in good to excellent yields (Table 3):



The process is even suitable for the use of α-dicarbonyl compounds,[10] provided that one carbonyl has been protected:

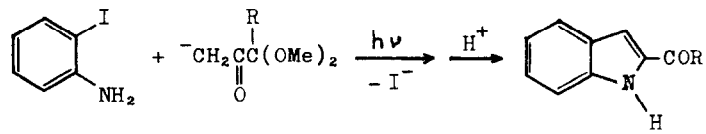
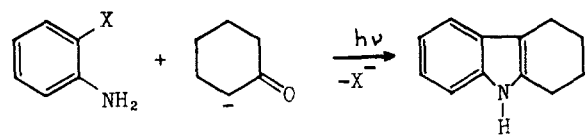


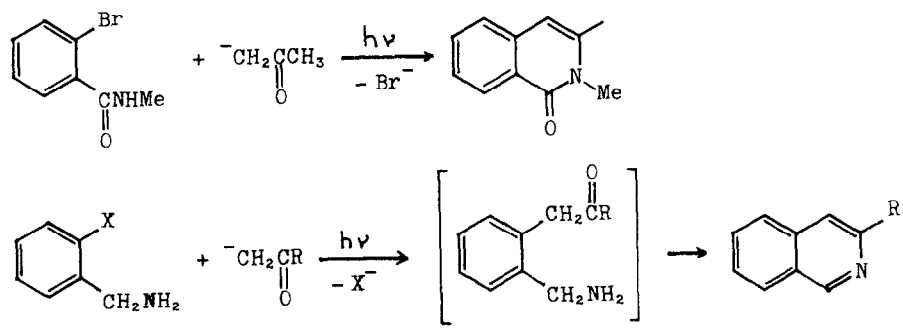
Table 3. Indole Syntheses by Photostimulated Reactions of o-Haloanilines with Enolate Ions.

aniline deriv.	enolate from	irradn. time, h	indole derivative(% yield)	ref.
2-Br-	acetone	2	2-methyl- (93)	6
2-Br-3-Me-	acetone	4	2,4-dimethyl- (80)	6
2-Br-5-Me-	acetone	2	2,6-dimethyl- (82)	6
2-Br-5-Ph-	acetone	12	2-methyl-6-phenyl- (88)	6
2-Br-N-Me-	acetone	3	1,2-dimethyl- (79)	6
2-I-	CH_3CHO	0.3	indole (50)	10
2-Br-	CH_3COCMe_3	3	2-t-butyl- (94)	6
2-Cl-3-aza	acetone	10.5	4-aza-2-methyl- (45)	6
2-Cl-3-aza	CH_3COCMe_3	2.5	4-aza-2-t-butyl- (100)	9b
2-I-	$CH_3COC(OMe)_2CH_3$	0.3	2-acetyl- (35)	10
2-Br-	cyclohexanone	4	1,2,3,4-tetrahydrocarbazole (14)	6

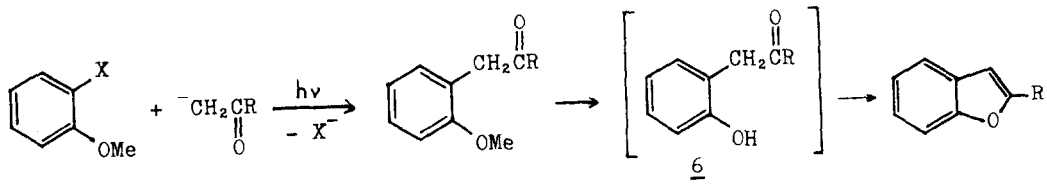
Yields are instead lower with the enolates of cyclic ketones:[6]



Interesting products from intramolecular steps of similar nature can be obtained when the substituent ortho to halogen is either a -CONHR[11] or a $-CH_2NHR$[12] group:

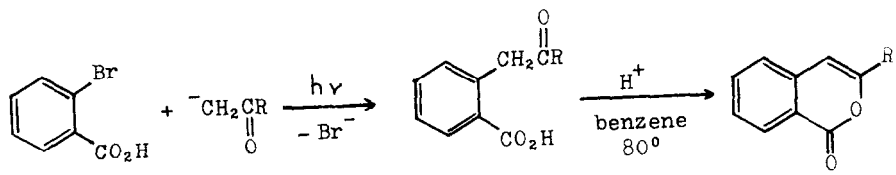


Ortho hydroxy group. This has been reported[13] as another useful functionality, when properly masked as a methoxy group for the purpose of the $S_{RN}1$ process:



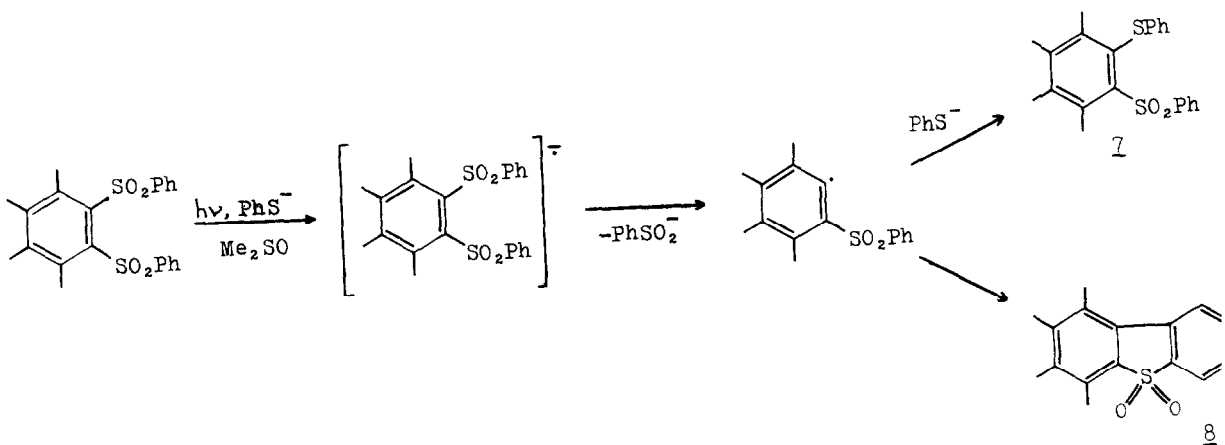
As we have seen (Table 1), an ortho methoxy group favours the enolate attack, and then it may be deblocked to free phenolic group 6 for the cyclization step. Yields range from good to excellent, depending on the R moiety of the enolate.

Ortho carboxylic group. Some use has been done of this substituent to obtain lactone derivatives:[11]



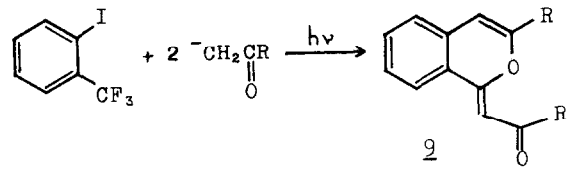
Better results are obtained in the $S_{RN}1$ step when the carboxylic group is transformed into an ester group and subsequently deprotected for the cyclization step.

Ortho phenylsulphonyl group. It has been reported[32] that photostimulation of an o-bis(phenylsulphonyl)arene with PhS^- gives only a small amount of the straightforward substitution product 7 along with good yields of a cyclization product 8:

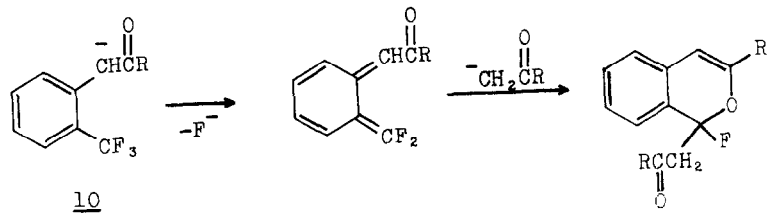


The process is also susceptible of initiation by reduction at a cathode in a cyclic voltammetric experiment, and the yield of the cyclization route becomes nearly quantitative.[33]

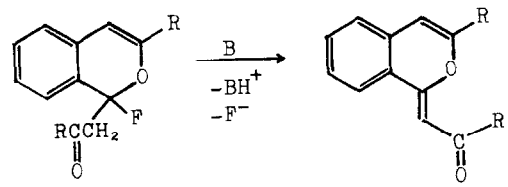
Ortho trifluoromethyl group. Reaction of an enolate ion with m-I-benzotrifluoride affords the straightforward substitution product, although in moderate yield.[34] When we carried out the same reaction on the ortho isomer, we obtained instead a more complex molecule 9, along with traces of the expected $S_{RN}1$ substitution product:[15]



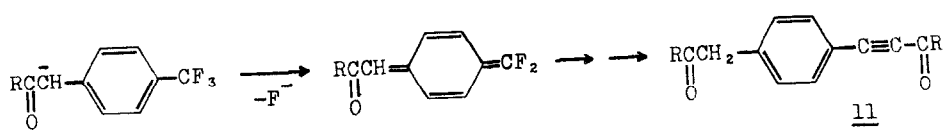
We have suggested a mechanism for such a rearrangement, whereby an intramolecular elimination of fluoride occurs in a concerted process from the anion 10, which is formed in the basic environment from the "intermediate" $S_{RN}1$ substitution product:



Subsequent nucleophilic substitutions lead to complete removal of fluorine atoms and to product 9:



The singularity of the behaviour obtained with the trifluoromethyl-substituent is not only confined to the ortho position. The concerted intramolecular elimination of fluoride can occur also from the "intermediate" substitution product of the para isomer, triggering again the complete removal of fluorine and leading to product 11:



In conclusion, it is our hope that the examples of participation of ortho substituents we have here collected can show the potentialities of the $S_{RN}1$ process for synthetic use and stimulate other applications of the reaction.

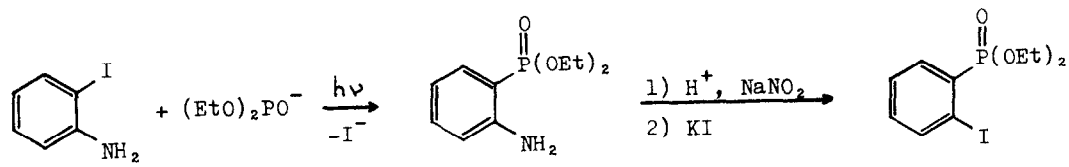
EXPERIMENTAL

Reaction conditions for the competitive reactions were described in detail previously.[16] In most experiments samples of the reaction solution were withdrawn, to be analyzed for P and K, at two to four times, and often replicate determinations were made on the samples withdrawn. From each determination, k_P/k_K was reckoned[19] and from all the determinations in any experiment the mean value of this ratio and the standard deviation with (N-1) weighting were calculated.[35] GLC analyses were performed on a Hewlett-Packard 5840A flame ionization instrument fitted with a 10 m quartz capillary column supporting methyl silicone fluid or with a 183cmx3.2mm glass column of 10% silicon rubber (UC-W98) on 80-100 mesh Chromosorb WAW DMCS. Molar response factors were determined for all the products with respect to an internal standard (biphenyl).

Most of the starting reagents were commercially available. Some of the reaction products had been previously synthesized in the laboratory. A brief description of the preparation of all the other new compounds is now given (see Table 4 for physical data).

3,3-Dimethyl-1-(2-biphenyl)-2-butanone. The following general procedure was adopted for the preparation of all the aryl-pinacolones and aryl-phosphonates employed in the study. A solution of 8 mmol of o-iodobiphenyl and 24 mmol of potassium pinacolone enolate in 200 ml of refluxing ammonia (-33 °C) was subjected to 35 minutes photostimulation in a Rayonet RPR-100 reactor. Treatment of the reaction crude as previously reported[16,36] yielded 83% of the title compound; bp 128 °C (2 Torr).

Diethyl 2-iodophenylphosphonate. It was synthesized according to the following Scheme:



Scheme 2

Diethyl 2-aminophenylphosphonate was obtained in quantitative yield from the previous general procedure; ^{1}H-NMR as expected. A standard iododediazoniation reaction gave the title compound, bp 130-134 °C (0.3 Torr). MS: 340(M^+),312,284,185,157,141,125,77. ^{1}H-NMR (CCl_4) δ 7.5-6.5(m,4H, aromatic protons),3.8(q,4H,OCH_2Me),1.1(t,6H,CH_3).

Diethyl 4-iodophenylphosphonate. It was obtained from p-iodo-aniline as in Scheme 2; bp 130-131 °C (0.2 Torr). MS: 340(M^+). ^{1}H-NMR (CCl_4) δ 7.0-6.4(m,4H,aromatic protons),3.6(q,4H, OCH_2Me),1.1(t,6H,CH_3).

N,N-dimethyl-2-iodoaniline. Ortho-iodoaniline (8.6 g; 0.039 mol) was dissolved in 65 ml CH_3CN and kept for 12 h at reflux under vigorous stirring in the presence of 30 g CH_3I (0.21 mol) and 15 g K_2CO_3. Water-ice was added and the mixture worked-up with benzene. Removal of the solvent left 10.5 g of liquid, bp 117-118 °C (at 11 Torr; lit.[38] 116 °C at 11 Torr).

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Table 4. Synthesis and Physical Properties of the New Reaction Products.

Substrate	irrad. time (min)	I^- (%)	Product				
			formula[a]	mp or bp (Torr), °C	^{1}H-NMR (CCl_4) δ (ppm)	MS	Anal. Calcd. (Found) C H
o-CH_3-C_6H_4I	35	87	o-CH_3-C_6H_4-K	32.5-34.0 113(3)	7.4-7.0(m,4H),3.8(s,2H), 2.2(s,3H),1.2(s,9H)		82.06; 9.54 (82.03; 9.60)
o-CH_3O-C_6H_4I	35	86	o-CH_3O-C_6H_4-K	39.0-40.5 74-75(0.05)	7.2-6.8(m,4H),3.8(s,2H), 3.7(s,3H),1.2(s,9H)		75.69; 8.80 (75.60; 8.75)
p-CH_3O-C_6H_4I	40	97	p-CH_3O-C_6H_4-K	105-107(0.4)	6.8-6.3(m,4H),3.6(s,3H), 3.4(s,2H),1.1(s,9H)	206(M^+),121, 91,85,57	
o-Ph-C_6H_4I	35	95	o-Ph-C_6H_4-K	128(2)	7.6-7.2(m,9H),3.9(s,2H), 1.2(s,9H)	252(M^+),195, 167,85,57	85.67; 7.99 (85.75; 8.03)
o-Ph-C_6H_4I	35	97	o-Ph-C_6H_4-P	155(1)		290(M^+)	66.20; 6.60 (66.19; 6.56)
1-I-naphth.	35	94	1-K-Naphth.	67-69	7.6-7.2(m,7H),4.1(s,2H), 1.2(s,9H)	226(M^+),85,57	84.91; 8.02 (85.04; 8.07)
o-Me_2N-C_6H_4I	40	99	o-Me_2N-C_6H_4-K	117-119(3)	7.0-6.7(m,4H),3.6(s,2H), 2.4(s,6H),1.1(s,9H)	219(M^+),134, 118,57	
o-Me_2N-C_6H_4I	60	53	o-Me_2N-C_6H_4-P	145-146(3)	7.6-6.8(m,4H),3.9(q,4H), 2.6(s,6H),1.3(t,6H)	257(M^+),242, 228,169,120	
o-P-C_6H_4I	25	97	o-P-C_6H_4-K	b	7.7-6.8(m,4H),4.0(s,2H), 3.7(q,4H),1.2(bt,15H)	312(M^+),256,228, 213,200,85,57	
p-P-C_6H_4I	40	93	p-P-C_6H_4-K	157-158(1.6) c	7.5-6.8(m,4H),3.8(q,4H), 3.5(s,2H),1.2(bt,15H)	312(M^+),228, 200,172,85,57	

[a] Where K stands for $-CH_2COCMe_3$ and P for $-PO(OEt)_2$. [b] Distilled bulb-to-bulb. [c] Purified also by prep.-GC.

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