353. *Elimination of Sulphinate from Sulphonic Esters.*

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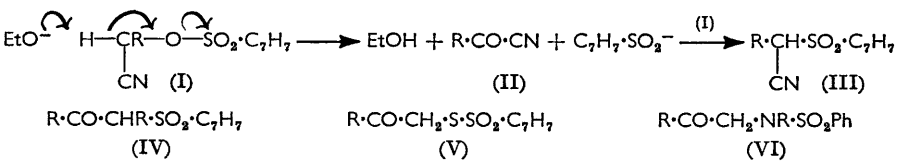
Arenesulphonates of mandelonitriles are prepared by the action of potassium cyanide on the appropriate benzaldehyde and sulphonyl chloride. In contrast to the replacement of the sulphonate group, which characterises their reactions with most nucleophilic reagents, the esters eliminate the arenesulphinate ion when treated with sodium ethoxide in ethanol.

The sulphone (III; R = *o*-$NO_2 \cdot C_6H_4$) was an unexpected product of an attempted condensation between sodiomalonic ester and the toluene-*p*-sulphonate (I; R = *o*-$NO_2 \cdot C_6H_4$) of *o*-nitromandelonitrile. Investigation showed that this was the result of a two-stage process in which the toluene-*p*-sulphonate first furnished and then reacted with toluene-*p*-sulphinate anions. So far as we are aware the elimination of sulphinate from a sulphonic ester has not been observed previously although, among others, a close analogy is provided by the hydrolytic elimination of nitrite from nitric esters.[1]



α-Cyanobenzyl sulphonates have not been studied extensively. Those derived from mandelonitrile are prepared by the interaction of benzaldehyde, potassium cyanide, and a sulphonyl chloride.[2,3] Although the method is said [4] to fail with other arylaldehydes as reagents, a satisfactory extension may be achieved in many cases (see Experimental section). As non-lachrymatory substitutes for α-cyanobenzyl halides the sulphonates react with thiourea,[3] substituted thioureas, dithiocarbamates, or thioamides,[5] forming appropriate derivatives of thiazole. With sulphonyl chlorides in presence of thiourea they yield alkyl- or aryl-sulphonylacetonitriles,[6] and under Friedel–Crafts conditions condense with aromatic compounds affording diarylacetonitriles.[4] The nucleophilic displacement of the sulphonate group, implicit in these reactions, is supplemented by our own observations which, while not systematic, provide examples of sulphonate replacement under attack by bromide, mercaptide, *p*-nitrophenoxide and toluene-*p*-sulphinate ions. It may also be noted that hydrogenation of 2-chloro-α-cyanobenzyl toluene-*p*-sulphonate with palladised charcoal as catalyst affords 2-chlorophenethylamine, recalling the similar hydrogenation of *O*-acylmandelonitriles.[7]

In sharp contrast to the foregoing reactions α-cyanobenzyl toluene-*p*-sulphonates react with sodium ethoxide in cold anhydrous ethanol, affording sodium toluene-*p*-sulphinate in high yield (*ca.* 90%). In each case the other immediate product is undoubtedly the benzoyl cyanide (II), but this undergoes further reaction so that the isolated product is the ethyl ester (or sodium salt) of the corresponding benzoic acid. It is interesting that under these conditions elimination of sulphinate is virtually complete and outstrips formation of the sulphone (III). The sulphone was formed when 2-chloro-α-cyanobenzyl toluene-*p*-sulphonate was heated with triethylamine, whereas the same ester with pyridine gave a pyridinium salt from which a betaine type of product, $C_5H_5\overset{+}{N}-\overset{-}{C}(CN) \cdot C_6H_4Cl$, was obtained by treatment with alkali.

[1] Baker and Easty, *J.*, 1952, 1193.
[2] Francis and Davis, *J.*, 1909, **95**, 1403.
[3] Dodson and Turner, *J. Amer. Chem. Soc.*, 1951, **73**, 4517.
[4] Sisido, Nozaki, Nozaki, and Okano, *J. Org. Chem.*, 1954, **19**, 1699.
[5] Taylor, Wolinsky, and Lee, *J. Amer. Chem. Soc.*, 1954, **76**, 1866, 1870; Taylor, Anderson, and Berchtold, *ibid.*, 1955, **77**, 5444.
[6] Dodson, U.S.P. 2,748,164; cf. *Chem. Abs.*, 1957, **51**, 2860.
[7] Kindler, *Arch. Pharm.*, 1931, **269**, 70.

It seems reasonable to expect that sulphinate elimination should also be observable from sulphonic esters of type (IV), from thiolsulphonic esters of type (V), and from sulphonamides of type (VI). The benzenesulphonate of benzoin [8] and the toluene-*p*-sulphonate of 2-oxo-3-phenylpropan-1-ol were accordingly prepared and examined, but elimination of sulphinate was not detected. Attempts to prepare phenacyl toluene-*p*-thiolsulphonates (V; R = Ar) from phenacyl bromides led chiefly to phenacyl *p*-tolyl sulphones presumably *via* sodium toluene-*p*-sulphinate formed by decomposition of the sodium toluene-*p*-thiolsulphonate used as a reagent. On the other hand, Takata [9] has shown that compounds allied to type (VI) yield sulphinates when heated with potassium ethoxide in non-hydroxylic solvents. This we have confirmed for the particular case (VI; R = R = Ph) and have shown that the oil (phenylglyoxal or its anil) simultaneously formed affords 2-phenylquinoxaline in reaction with *o*-phenylenediamine.

Experimental

α-Cyanobenzyl Arenesulphonates (I).—In a typical preparation potassium cyanide (0·66 g.) was added with stirring to a solution of *o*-chlorobenzaldehyde (1·4 g.) and toluene-*p*-sulphonyl chloride (1·9 g.) in dioxan (2 c.c.) and water (4 c.c.), the temperature being kept below 5° and stirring continued for 1 hr. The solid was collected, dissolved in a mixture of acetone, ethanol, and water (5 c.c.; 2 : 2 : 1), filtered if necessary, and treated with ice (3 g.), affording the crude product.

α-Cyano(substituted)benzyl toluene-p-*sulphonates* (I)

				Found (%)			Required (%)		
Subst.	M. p.	Yield (%)	Formula	C	H	N	C	H	N
H	60° [2]	72							
2-Br	104	75	$C_{15}H_{12}O_3NBrS$	49·4	3·2	3·9	49·2	3·3	3·8
2-Cl	86	78	$C_{15}H_{12}O_3NClS$	55·9	3·6	4·6	56·0	3·7	4·4
3-MeO	52	55	$C_{16}H_{15}O_4NS$	60·5	4·7	4·4	60·6	4·8	4·4
2-NO_2	111	72	$C_{15}H_{12}O_5N_2S$	54·1	3·9	8·3	54·2	3·6	8·4
2 : 4-Cl_2	78	72	$C_{15}H_{11}O_3NCl_2S$	50·6	3·4	4·0	50·5	3·2	3·9
2-Cl-5-NO_2	118 *	70	$C_{15}H_{11}O_5N_2ClS$	49·3	3·4	7·7	49·2	3·1	7·6

* From benzene–light petroleum (b. p. 60—80°): the others from ethanol.

From 2 : 5-dichlorobenzenesulphonyl chloride there were prepared in the same way *α-cyanobenzyl*, m. p. 102° (from ether) (Found: C, 49·0; H, 2·6; N, 4·5. $C_{14}H_9O_3NCl_2S$ requires C, 49·1; H, 2·6; N, 4·1%), and *4-chloro-α-cyanobenzyl* 2 : 5-*dichlorobenzenesulphonate*, m. p. 86° [from benzene–light petroleum (b. p. 60—80°)] (Found: C, 44·8; H, 2·2; N, 4·3. $C_{14}H_8O_3NCl_3S$ requires C, 44·8; H, 2·1; N, 3·7%).

Elimination of Sulphinate.—(i) A solution of sodium ethoxide (from 0·12 g. of sodium in 2 c.c. of ethanol) was added to a solution of α-cyano-2-nitrobenzyl toluene-*p*-sulphonate (1·66 g.) in ethanol (10 c.c.). After 15 min. the solvent was removed *in vacuo* and the residue was extracted with benzene, leaving sodium toluene-*p*-sulphinate (0·77 g.) which was identified as the sulphinic acid (m. p. and mixed m. p. 84°) and as the derived 2 : 4-dinitrophenyl sulphone (m. p. and mixed m. p. 187°). Chromatography of the benzene solution on alumina afforded ethyl *o*-nitrobenzoate (0·68 g.), m. p. 30° (Found: N, 7·3. Calc. for $C_9H_9O_4N$: N, 7·2%), which was hydrolysed to *o*-nitrobenzoic acid (m. p. and mixed m. p. 147°).

(ii) High yields of the appropriate sulphinic acid were likewise obtained from the other sulphonates described above. 2 : 5-Dichlorobenzenesulphinic acid had m. p. and mixed m. p. 122°.

(iii) When the sodium ethoxide of (i) was replaced by diethyl sodiomalonate the solid precipitated in the reaction contained (water-soluble) sodium toluene-*p*-sulphinate and α-cyano-2-nitrobenzyl *p*-tolyl sulphone, m. p. and mixed m. p. 167° (cf. below). An oil, recovered from the reaction mother-liquor, was hydrolysed by 5N-sodium hydroxide, affording *o*-nitrobenzoic acid.

[8] Zoldi, *Ber.*, 1927, **60**, 656.
[9] Takata, *J. Pharm. Soc., Japan*, 1951, **71**, 1474.

(iv) 2-Chloro-α-cyanobenzyl toluene-*p*-sulphonate (1·5 g.) was heated for 30 min. with triethylamine (5 c.c.) at 100°. The oil obtained by concentration *in vacuo* was rubbed with benzene–light petroleum (b. p. 60—80°; 1 : 1) affording 2-chloro-α-cyanobenzyl *p*-tolyl sulphone, m. p. and mixed m. p. 112° (cf. below), and an oily extract which, after hydrolysis, yielded *o*-chlorobenzoic acid, m. p. and mixed m. p. 142°.

(v) *From* N-*phenacylbenzenesulphonanilide.* Ethanolic solutions of the anilide [9] (0·73 g. in 10 c.c.) and sodium ethoxide (from 0·046 g. of sodium in 3 c.c.) were mixed and after 30 min. the precipitated sodium toluene-*p*-sulphinate was collected and identified as in (i). An ethereal extract of the evaporated filtrate afforded an oil which, with *o*-phenylenediamine in warm ethanol, yielded 2-phenylquinoxaline,[10] m. p. 78° (Found: C, 81·6; H, 4·7; N, 13·2. Calc. for $C_{14}H_{10}N_2$: C, 81·5; H, 4·9; N, 13·6%).

Replacement of Sulphonate.—α-Cyanobenzyl bromide, b. p. 137—139°/15 mm., m. p. 29°, was recovered in ether (yield 70%) after a solution of α-cyanobenzyl toluene-*p*-sulphonate (2·87 g.) in methanol (20 c.c.) had been heated with sodium bromide (1·53 g.) under reflux for 1 hr., and the resultant mixture concentrated.

2-*Chloro-α-cyanobenzyl* p-*tolyl sulphide*, m. p. 62° (from methanol), was obtained (yield 85%) when a solution of 2-chloro-α-cyanobenzyl toluene-*p*-sulphonate (0·32 g.), thio-*p*-cresol (0·13 g.), and sodium hydroxide (0·04 g.) in ethanol–water (8 c.c.; 4 : 1) was heated under reflux for 30 min. (Found: C, 65·7; H, 4·1; N, 5·3. $C_{15}H_{12}NClS$ requires C, 65·8; H, 4·3; N, 5·1%).

2-*Chloro-α-cyanobenzyl* p-*tolyl sulphone*, m. p. 112° (from ethanol), crystallised from a refluxing solution of 2-chloro-α-cyanobenzyl toluene-*p*-sulphonate (0·32 g.) and sodium toluene-*p*-sulphinate (0·27 g.) in ethanol (5 c.c.) (Found: C, 59·0; H, 4·1; N, 4·8. $C_{15}H_{12}O_2NClS$ requires C, 59·0; H, 4·0; N, 4·6%). α-*Cyano*-2-*nitrobenzyl* p-*tolyl sulphone*, m. p. 167° (from ethanol) (Found: C, 56·8; H, 3·8; N, 8·8. $C_{15}H_{12}O_4N_2S$ requires C, 57·0; H, 3·8; N, 8·9%), and α-*cyanobenzyl* p-*tolyl sulphone*, m. p. 152° (Found: C, 66·3; , 4·8; N, 5·4. $C_{15}H_{13}O_2NS$ requires C, 66·4; H, 4·8; N, 5·2%), were similarly prepared from the appropriate toluene-*p*-sulphonates.

α-*Cyano*-2-*nitrobenzyl* p-*nitrophenyl ether*, m. p. 157° (from ethanol), was recovered in ether after concentration of the mixture formed by heating sodium *p*-nitrophenoxide and α-cyano-2-nitrobenzyl toluene-*p*-sulphonate in ethanol for 48 hr. (Found: C, 56·2; H, 2·8; N, 13·9. $C_{14}H_9O_5N_3$ requires C, 56·2; H, 3·0; N, 14·0%).

1-(2-*Chloro-α-cyanobenzyl*)*pyridinium toluene*-p-*sulphonate* slowly crystallised at 0° from a solution of 2-chloro-α-cyanobenzyl toluene-*p*-sulphonate (1·6 g.) in anhydrous pyridine (2 c.c.). It formed colourless crystals, m. p. 101° [from benzene–light petroleum (b. p. 60—80°) containing a trace of ethanol] (Found: C, 60·5; H, 4·2; N, 6·8. $C_{20}H_{17}O_3N_2ClS$ requires C, 60·0; H, 4·2; N, 7·0%), and when treated with 5N-sodium hydroxide afforded a *betaine* as dark red crystals, m. p. 138° (from ethanol) (Found: C, 68·5; H, 4·2; N, 12·1. $C_5H_5\overset{+}{N}-\overset{-}{C}(CN)\cdot C_6H_4Cl$ requires C, 68·3; H, 3·9; N, 12·3%).

2-*Chlorophenethylamine*.—2-Chloro-α-cyanobenzyl toluene-*p*-sulphonate (0·32 g.) was hydrogenated in acetic acid (3 c.c.) containing concentrated sulphuric acid (0·05 c.c.) and in presence of 10% palladium–charcoal (0·15 g.). Absorption of hydrogen (3 mol.) was complete after 3 hr. The filtered solution was basified and the amine, recovered in ether, was precipitated as the picrate,[11] m. p. 186° (from benzene; yield 60%) (Found: C, 44·2; H, 3·3; N, 14·5. Calc. for $C_{14}H_{12}O_7N_4Cl$: C, 43·7; H, 3·4; N, 14·6%).

[With G. Tennant.] 2-*Oxo*-3-*phenylpropyl Toluene*-p-*sulphonate*.—To a stirred solution of diazomethane (~10 g.) in anhydrous ether (500 c.c.) was added phenacetyl chloride (15·5 g.) in ether (50 c.c.) and, after several hours, powdered toluene-*p*-sulphonic acid (17 g.). After 12 hr. at 20° the solvent was removed and the gummy solid afforded the *ester*, m. p. 63° (from ethanol) (Found: C, 63·0; H, 5·4. $C_{16}H_{16}O_4S$ requires C, 63·15; H, 5·3%).

The authors thank the Department of Scientific and Industrial Research for an award to one of them (I. W.), and Mr. J. M. L. Cameron and his staff for microanalyses.

The University, Glasgow, W.2. [*Received, January 28th*, 1959.]

[10] Hinsberg, *Annalen*, 1896, **292**, 246.
[11] Goodson, *et al.*, *Brit. J. Pharmacol.*, 1948, **3**, 49.