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NOVEL REACTIONS OF CYANIDE ANION WITH SULFONIMIDES

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Treatment of N-benzyl-N,N-di(trifluoromethane)sulfonimide, **1a**, with sodium cyanide in

$PhCH_2NRR^1$

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a, $R=R^1 = CF_3SO_2$
b, $R=CF_3SO_2$, R^1 = mesitylenesulfonyl
c, $R=R^1$ = *p*-toluenesulfonyl
d, $R=R^1$ = mesitylenesulfonyl
e, $R=R^1$ = 2,4,6,-triisopropylbenzenesulfonyl
f, R=H, R^1 = *p*-toluenesulfonyl
g, R=H, R^1 = mesitylenesulfonyl
h, R=H, R^1 = 2,4,6-triisopropylbenzenesulfonyl

hexamethylphosphoric triamide (HMPT) affords phenylacetonitrile in 80% yield.[1] However, other sulfonimides on reaction with cyanide ion suffer S-N bond cleavage in preference to nucleophilic displacement at carbon.[2] Since nucleophilic displacement at sulfur may compete with attack at carbon, sulfonimides in which attack at sulfur might be disfavored by steric hindrance[3] were investigated.

Reaction of sulfonimide **1b** with cyanide ion in HMPT produced mesitylthiocyanate and N,N-dibenzyltrifluoromethanesulfonamide. However, sulfonimides **1c**-**e** on treatment with sodium cyanide in HMPT at room temperature for four days afforded benzonitrile in 38,22 and 80% yield respectively and the corresponding sulfonamides **1f**-**h** in 44,67 and 10% yield, respectively. The formation of benzonitrile, which involves the overall conversion of an amine into a nitrile, was unexpected and its mechanism investigated.

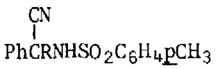
Simple double elimination, as illustrated below, of sulfonimides **1c-e** effected by cyanide

$$PhCH_2N(SO_2Ar)_2 \rightarrow PhCH{=}NSO_2Ar \rightarrow PhCN$$

2a, Ar=*p*-tolyl

ion acting as a base is rendered unlikely by the finding that potassium *tert*-butoxide in HMPT produces no benzonitrile from **1c**. However, potassium *tert*-butoxide in HMPT at room temperature does effect the first elimination of **1c**, to **2a** within 1 hr. Thus the first elimination induced by base is tenable.[4] Indeed **2a** may be trapped by sodium borohydride in the reaction of **1c** with sodium cyanide in HMPT. Treatment of **1c** with sodium cyanide in the presence of sodium borodeuteride in HMPT resulted in a lowered yield of benzonitrile (12%) and an increased yield of N-benzyl-*p*-toluenesulfonamide (67%). Furthermore, deuterium analysis (by nmr and ms) of the sulfonamide produced in this reaction revealed approximately 30% deuterium incorporation in the benzyl methylene group.

To determine the pathway by which **2a** is converted into benzonitrile by cyanide ion, **2a** was prepared and its reaction with cyanide ion studied. Benzaldehyde and *p*-toluenesulfonamide in the presence of *p*-toluenesulfonic acid form **2a**.[5] Treatment of **2a** with sodium cyanide in HMPT gives benzonitrile in 89% yield. This two step conversion of an aromatic aldehyde into an aryl nitrile is synthetically attractive and extensions of this reaction are reported in the following paper. Exposure of **2a** to sodium cyanide in HMPT for short periods of time led to the isolation of **3a**[6] in yields of up to 48%. This suggested that the formation of benzonitrile from **2a** and

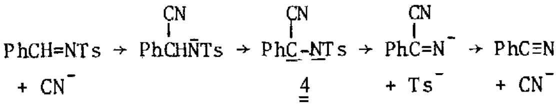


$$Ph\overset{\overset{CN}{|}}{C}RNHSO_2C_6H_4\underline{p}CH_3$$

3a, R=H

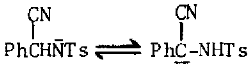
b, R=CH_3

cyanide ion can be accounted for as shown below.[7] Alternatively, dianion **4** need not be formed



$$\begin{array}{ccccccccc} PhCH{=}NTs & \rightarrow & Ph\overset{\overset{CN}{|}}{C}H\bar{N}Ts & \rightarrow & Ph\overset{\overset{CN}{|}}{\underline{C}}\text{-}\underline{N}Ts & \rightarrow & Ph\overset{\overset{CN}{|}}{C}{=}N^- & \rightarrow & PhC{\equiv}N \\ +\ CN^- & & & & \mathbf{4} & & +\ Ts^- & & +\ CN^- \end{array}$$

but rather an equilibrium exist between the nitrogen anion and the carbanion **5** as shown below. Elimination of *p*-toluenesulfinate ion from this carbanion followed by loss of hydrogen cyanide would also account for the formation of benzonitrile.



$$\mathrm{Ph\overset{CN}{CH}\bar{N}Ts \rightleftharpoons Ph\overset{CN}{\underline{C}}\text{-}NHTs}$$

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To investigate these possibilities for the transformation of **2a** into benzonitrile the following experiment was carried out. Treatment of **3a** with lithium 2,2,6,6-tetramethylpiperidide[8] (1:2 molar ratio) in tetrahydrofuran at -78°C followed by warming to room temperature afforded, after one day at room temperature, benzonitrile in 66% yield. If methyl iodide was added prior to warming then the C-methylated product **3b**[9] was produced in 85% yield. Even an equimolar amount of lithium 2,2,6,6-tetramethylpiperidide produced benzonitrile from **3a** in 52% yield. Similarly, treatment of **3a** with an equimolar amount of sodium hydride in HMPT gave, after 17 hr, at room temperature, benzonitrile in 88% yield.

Finally, it should be noted that the proposed mechanisms for the formation of benzonitrile from sulfonimide **1c** require the production of *p*-toluenesulfinate anion. This material was not isolated but was trapped with methyl iodide in HMPT as methyl *p*-tolyl sulfone. Quantitative determination of the methyl *p*-tolyl sulfone so formed suggested the production of *p*-toluenesulfinate in 73% yield in the reaction of **1c** with sodium cyanide.

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