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THE REACTION OF ANIONS OF DIARYLKETIMINES WITH *p*-TOLUENESULFONYL AZIDE

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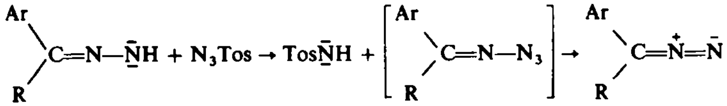
Abstract—The reaction of the chloromagnesium salt of benzophenone imine with tosyl azide gives a mixture of diphenyldiazomethane and of N-tosyl benzophenone imine. Similarly, diazofluorene was formed from the chloromagnesium salt of fluorenone imine and tosyl azide. The lithium salt of benzophenone imine underwent dimerization in solvents such as ether and tetrahydrofuran. The reaction of this dimeric dianion with tosyl azide and with methyl iodide is discussed. Evidence for the structure of the azide formed from dimeric anion and tosyl azide is presented.

INTRODUCTION

THE *diazo transfer* reaction[1] of *p*-toluenesulfonyl azide (tosyl azide) to anions of primary amines and hydrazones has previously been reported to give the corresponding azides[2] and diazoalkanes.[3]

$R{-}\bar{N}H + N_3Tos \rightarrow Tos\bar{N}H + R{-}N_3$

(R = alkyl, aryl)



$$\mathrm{Ar(R)C{=}N{-}\bar{N}H + N_3Tos \rightarrow Tos\bar{N}H + \left[Ar(R)C{=}N{-}N_3\right] \rightarrow Ar(R)C{=}\overset{+}{N}{=}\overset{-}{N}}$$

(R = aryl, methyl, benzoyl)

Since *p*-toluenesulfinate anion is an excellent leaving group, tosyl azide can in theory transfer all three of its nitrogen atoms as well and, indeed, this reaction has been reported by Smith and Bruner[4] and more recently by Ito.[5]

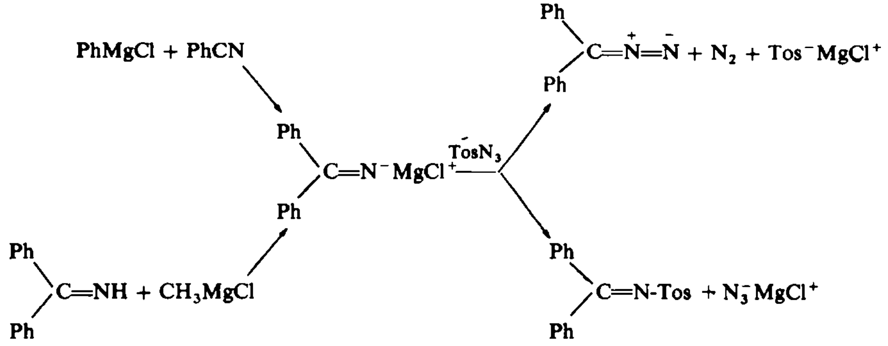
We have investigated the reaction of imine anions with tosyl azide and the results of this study are the subject of the present paper.

RESULTS AND DISCUSSION

In contrast to anions of primary amines, the imine group does not have α-hydrogens available for the completion of the *diazo transfer* reaction. Thus, it was anticipated that tosyl azide would transfer all three of its nitrogens to the imine anions (*azido transfer*) to give the N-azidimines. These azidimines were expected to be unstable and to lose nitrogen with the formation of the corresponding diazoalkanes.[3]

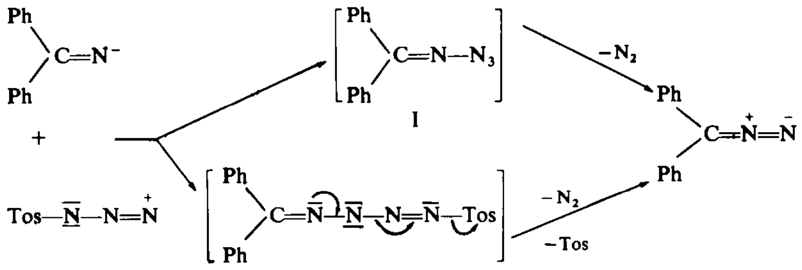
Because of the sensitivity of imines to hydrolysis, the anions of the imines were generated by the reaction of Grignard reagents with nitriles. Thus, the chloromagnesium salt of benzophenone imine, prepared by the addition of phenylmagnesium chloride to benzonitrile, was dissolved in dry tetrahydrofuran. The addition of tosyl azide to this solution resulted in a vigorous evolution of nitrogen and the appearance of a deep red color. Work-up of the reaction mixture gave a red oil identified as diphenyldiazomethane. It was isolated as benzhydryl 3,5-dinitrobenzoate in 12Π yield. In addition, N-tosyl benzophenone imine was obtained.[6] When benzophenone imine was treated with methylmagnesium chloride and tosyl azide was added after the formation of the anion, a 13% yield of diphenyldiazomethane (as benzhydryl 3,5-dinitrobenzoate) was obtained. N-Tosyl benzophenone imine was isolated in 64% yield. In a similar fashion, the chloromagnesium salt of fluorenone imine anion reacted with tosyl azide to give diazofluorene. Its triphenylphosphine adduct was isolated in 6–7% yield. These reactions can be summarized in the following scheme:

SCHEME I



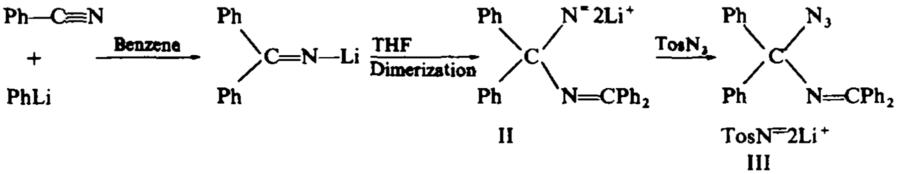
Presumably as in the reaction of hydrazone anions with tosyl azide,[3] the participation of N-azidimines even as fleeting intermediates could not be ruled out although a concerted mechanism could account for the formation of the diazoalkanes. The formation of N-tosyl benzophenone imine was the result of the attack of the anion at the sulfonyl group with elimination of azide ion.

SCHEME II

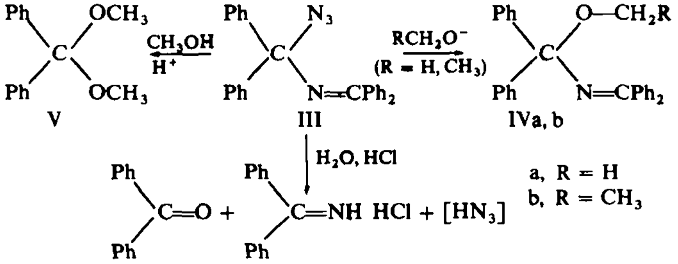


When phenyllithium was added to benzonitrile in benzene solution, a yellow precipitate, presumably the lithium salt of benzophenone imine was formed. Addition of tetrahydrofuran to this solid, resulted in the formation of an orange-red solution. Slow addition of a solution of tosyl azide in tetrahydrofuran to this solution gave a brownish precipitate. Work-up of the reaction mixture gave a 46% yield of colorless solid, m.p. 87–88°. Structure III, N-benzhydrylidene azidobenzhydrylamine, was assigned to this compound on the basis of its infrared spectrum and its reactions. The formation of III may be viewed as arising by the dimerization of the imine anion to give II which then underwent a *diazo transfer* reaction with tosyl azide. This type of addition of anions to imine anions is not without precedent, for example, Allen and Henze[7] and Rabe and Pasternack[8] have reported the addition of organolithium and Grignard reagents to imine anions.

Scheme III



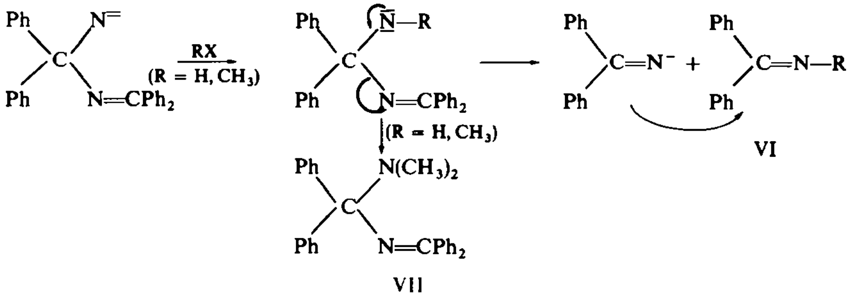
The infrared spectrum of III exhibited a strong azide absorption at 2050 cm^{-1}, a $>$C=N—band at 1630 cm^{-1} and monosubstituted phenyl absorption at the usual positions. The acid-catalyzed reaction of III with methanol gave the dimethyl ketal of benzophenone (V). The reaction of III with hydrochloric acid in ether gave a precipitate which dissolved in water. Benzophenone imine and benzophenone were identified as products of this reaction. With sodium methoxide, III was converted to a white solid, m.p. 88–89°. Its infrared spectrum was very similar to that of III except for the absence of the azide band, and the appearance of aliphatic protons absorptions at 2900 cm^{-1} and a C—O at 1080 cm^{-1} which indicated the incorporation of the methoxy group. The assignment of structure IVa to this compound was consistent with the results of combustion analysis. A white solid, m.p. 114–115° was obtained with sodium ethoxide. The infrared spectrum of the compound was very similar to that of IVa and again combustion analysis was in agreement with structure IVb, the ethoxy analogue of IVa.



Benzophenone imine with methyllithium in ether gave an orange-red solution with concomitant evolution of the theoretical amount of methane. Addition of tosyl azide to this orange-red solution gave a yellow precipitate. An 81% yield of III, identical in all respects with the sample prepared from benzonitrile and phenyllithium was isolated. In addition, a small amount of a high-melting solid, m.p. 226–227° was isolated. This product is *not* s-triphenyl triazine, m.p. 229–230°.

The reaction of the orange-red solution of (II) with methyl iodide gave N-methylbenzophenone imine (VI) as the main product.[9] However, a high boiling compound was isolated in a very low yield. Its infrared spectrum was very similar to that of VI. This would not be unexpected since the N,N-dimethyl derivative of II (VII) incorporates all the structural features of VI (R = CH_3). The fact that VI is the main product of the alkylation is not surprising. Indeed, benzophenone imine can be prepared from the lithium salt of benzophenone imine (which is actually the dimer II). These results may be rationalized as follows:

SCHEME V



EXPERIMENTAL

All m.p. and b.p. are uncorrected. IR spectra were obtained on a Perkin Elmer Infracord. The analyses were performed by MHW Laboratories, Garden City, Michigan. The organometallic compounds were used as received from Alpha Inorganics, Beverly, Massachusetts.

Reaction of the chloromagnesium salt of benzophenone imine with Tosyl Azide

(a) *Salt generated from phenylmagnesium chloride and benzonitrile.* To a soln of 9·27 g (90 mmoles) benzonitrile in 100 ml ether was added 30 ml 3M PhMgCl in ether. The reaction mixture was heated under reflux for 3 hr. The precipitated salt was separated from the solvent by decantation and washed with 50 ml ether. The salt was dissolved in 150 ml THF and 15·80 g (80 mmoles) tosyl azide was added. A vigorous reaction ensued with copious evolution of N_2. The reaction mixture, which had turned to a deep red color, was stirred for 1 hr and, after this time, 100 ml ether was added and the organic phase extracted with 50 ml 10% NaOH aq. The ether layer, after being dried over Na_2SO_4, was evaporated and the resulting oil extracted with heptane. The heptane insoluble oil was dissolved in hot MeOH and upon cooling a colorless solid precipitated, identical in all respects with an authentic sample of N-tosyl benzophenone imine.[6] Recrystallization from MeOH gave 3·7 g (14%) colorless crystals, m.p. 102–103°. The acidified aqueous layer gave a positive ferric ion test for sulfinic acid.

The red heptane extract gave, upon removal of the solvent, a red oil, whose spectrum exhibited a strong band at 2025 cm^{-1} ($>C=\overset{+}{N}=\overset{-}{N}$). Addition of an excess of a soln of 3,5-dinitrobenzoic acid in THF to an ethereal soln of diphenyldiazomethan slowly discharged the red color. The excess acid was extracted with 5% Na_2CO_3 aq. The ethereal soln was then washed with water and dried. Removal of the solvent left an oil which dissolved in hot EtOH. Upon cooling, 3·6 g (12%) benzhydryl 3,5-dinitrobenzoate, m.p. 142°, identical to an authentic sample, was obtained.

(b) *Salt generated from benzophenone imine and methylmagnesium chloride.* To a soln of 4·4 g (24 mmoles) benzophenone imine in 150 ml THF was added 8 ml 3·0M MeMgCl in THF. When the gas evolution had ceased the soln was cooled to −30° and a soln of 4·7 g (24 mmoles) tosyl azide in 20 ml THF was added. The pale yellow colloidal suspension obtained was stirred and allowed to warm up to room temp. A red color developed at 10°. The deep red reaction mixture was poured onto 50 ml ice water and extracted with three 50 ml portions ether. The dried ($MgSO_4$) ethereal extract was evaporated and the residual oil extracted with three 70 ml portions heptane. During the extraction, the bulk of the oil crystallized and 5·1 g (64%) N-tosyl benzophenone imine, m.p. 101–102°, was obtained. Evaporation of the red heptane extract gave a red oil ($>C=\overset{+}{N}=\overset{-}{N}$ at ~2030 cm^{-1}), which was dissolved in ether. Addition of an ethereal soln of 3,5-dinitrobenzoic acid (equimolar) gave 1·3 g (16%) benzhydryl 3,5-dinitrobenzoate.

Reaction of the chloromagnesium salt of fluorenone imine

The chloromagnesium salt of fluorenone imine was generated as described above from 5·4 g (30 mmoles) fluorenone imine and 10 ml 3M MeMgCl. The reaction mixture was worked up in the same fashion. Extraction of the organic residue gave a red soln which was concentrated to an oil. The IR spectrum of this oil indicated the presence of tosyl azide and diazofluorene. Addition of an ethereal soln of 4·0 g (15 mmoles) triphenylphosphine to an ice-cold soln of the oil in ether gave the triphenylphosphine adduct of tosyl azide.[10a] The ppt was filtered off immediately and the red filtrate was allowed to stand overnight. After this time, the red color had changed to yellow and the yellow biphenylenemethylenetriphenylphosphine had crystallized (0·91 g, 7% yield), m.p. 204°.[11]

N-Benzhydrylidene azidobenzhydrylamine (III)

(a) *From Benzonitrile and Phenyllithium.* To a soln of 8·24 g (80 mmoles) benzonitrile in 100 ml 30/70 ether–benzene was added 40 ml 2·0M PhLi in the same solvent mixture at room temp. Heat was evolved and the mixture was stirred until it had reached the room temp. The solvent was decanted from the yellow solid and 100 ml THF added. A deep red soln was obtained. Upon slow addition of a soln of 7·90 g (40 mmoles) tosyl azide in 50 ml THF, a brownish ppt was formed. The reaction mixture was stirred for 1 hr, decomposed by the addition of 10% NaOHaq, and extracted with 100 ml ether. The dried ethereal soln was evaporated and the residual oil was dissolved in a minimum amount of hot isopropanol. Upon cooling, 7·2 g (46%) of a colorless solid, m.p. 87–88°, was obtained. Recrystallization from *n*-heptane gave a pure sample of N-benzhydrylidene azidobenzhydrylamine, m.p. 87–88°. Its IR spectrum exhibited absorption at 2005 cm^{-1} (N_3), 1630 cm^{-1} (C═N) and at 3000, 1600, 1595, 750 and 690 cm^{-1} (aromatic). (Found: C, 80·31; H, 5·48; N, 14·12 MW, 430; Calc for $C_{26}H_{20}N_4$: C, 80·38; H, 5·18; N, 14·42%, MW, 388).

(b) *From benzophenone imine and methyllithium.* To a stirred soln of 4·26 g (23·5 mmoles) benzophenone imine in 50 ml ether was added 10 ml 2·35M MeLi. A reaction occurred almost immediately and the theoretical amount of CH_4 was evolved. An orange-red color developed in the clear soln. Then a soln of 4·65 g (23·5 mmoles) tosyl azide in 20 ml ether was added. A yellow solid began to form as soon as the addition of the azide had begun. The reaction mixture was stirred for an additional hr and poured into ice-water. The organic layer was separated and aqueous layer extracted with 50 ml ether. The combined ethereal soln was dried over $MgSO_4$ and the solvent removed *in vacuo*. Hot isopropanol was added to the resulting orange oil (7·3 g) and upon cooling the soln in an ice bath, 0·5 g silky colorless crystals m.p. 225–226°, precipitated. This solid was collected and the filtrate was cooled further in the refrigerator overnight to give 3·7 g (81%) of a pale yellow cubic crystals, m.p. 85–87°, identical in all respect with an authentic sample (prepared in (a) above).

Recrystallization of the azide from isopropanol *above its m.p.* (boiling water bath), leads to another crystalline modification (flakes) of III, m.p. 100–102°. The spectra of both samples in CS_2 were superimposable. In m.p. capillary, the azide apparently did not decompose below 200°.

Reaction of III *with hydrochloric acid*

To a soln of 1·0 g (2·5 mmoles) of III in 30 ml ether was added 5 ml conc HCl and the mixture was shaken for a few min. The colorless ppt was dissolved by the addition of 10 ml water. The organic layer was separated from the aqueous phase and dried. Evaporation of the solvent left 0·53 g of an oil whose IR spectrum was superimposable on that of an authentic sample of benzophenone. The aqueous phase was made basic immediately with conc NaOHaq and extracted with ether. The ethereal extract, on evaporation, gave an 0·38 g oil which was identified as benzophenone imine by its IR spectrum (which also indicated the presence of a small amount of benzophenone).

Acid-catalyzed reaction of III *with methanol*

Formation of V. A soln of 1·0 g (2·5 mmoles) of III in 50 ml MeOH containing a few drops of conc H_2SO_4 was heated under reflux for 2 hr. Evaporation of the soln to near dryness gave a 0·84 g colorless solid, m.p. 107°, lit.[11] m.p. 106–107°.

Reaction of III *with sodium methoxide*

Formation of IVa. A soln of 0·2 g (9 mg-atoms) Na metal in 50 ml MeOH was heated under reflux with 1 g (2·5 mmoles) of III for 1 hr. The reaction mixture was concentrated to ½ its volume and cooled in an ice bath; 0·80 g of colorless IVa was obtained, m.p. 88–89°. Recrystallization from MeOH gave an analytical sample, m.p. 88–89°. Its IR spectrum exhibited bands at 2900 (aliphatic) and 1080 cm^{-1} (C—O). (Found: C, 85·70; H, 6·37; N, 3·82. Calc. for $C_{27}H_{23}NO$: C, 85·91; H, 6·14; N, 3·70%).

Similarly, 0·87 g of IVb was obtained, colourless colid, m.p. 114–115°, bands at 2900 and 1060 cm^{-1}. (Found: C, 85·56; H, 6·46; N, 3·67. Calc. for $C_{28}H_{25}NO$: C, 85·89; H, 6·43; N, 3·57%).

Reaction of II *with methyl iodide*

To a soln of 4·26 g (23·5 mmoles) benzophenone imine in 24 ml benzene, was added dropwise 10 ml

2·35M MeLi in ether. After the evolution of CH_4 had subsided, a soln of 3·30 g (23·5 mmoles) MeI in 10 ml ether was added to the orange red soln. The reaction mixture was stirred for 3 hr at room temp and a white solid was formed. The reaction mixture was poured into 100 ml ice water and the organic layer was separated. The aqueous layer was extracted with 50 ml ether. The combined ethereal soln was dried over $MgSO_4$, and the solvent evaporated. The residue upon distillation gave 2 fractions. The first was compound VI obtained as a pale yellow oil (3·8 g, 83%), b.p. 100–102°/0·2 mm, $n_D^{29°}$ 1·6200. Its IR spectrum had aliphatic absorption at the usual positions and a strong C=N at 1630 cm^{-1}, lit.[9] b.p. 93°/0·4 mm, n_D^{25} 1·5985.

Comparison with the IR spectrum of an authentic sample prepared from dichlorodiphenylmethane and methylamine, b.p. 98–99°/0·5 mm, n_D^{21} 1·6005, indicated the presence of benzophenone imine.

The second fraction, b.p. 180°/0·2 mm, consisted of an orangy oil (VII). Its IR spectrum was very similar to that of N-methyl benzophenone imine.

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