

## Preparation of the Reagent *o*-Nitrobenzenesulfonylhydrazide

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*o*-Nitrobenzenesulfonylhydrazide (NBSH) has been shown to be a valuable reagent for the synthesis of allenes from propargylic alcohols,<sup>1</sup> for the reductive transposition of allylic alcohols,<sup>2</sup> and, most recently, for the deoxygenation of unhindered alcohols.<sup>3</sup> Each of these transformations proceeds by Mitsunobu displacement<sup>4</sup> of an alcohol with NBSH followed by in situ elimination of *o*-nitrobenzenesulfinic acid to form a monoalkyl diazene intermediate. The mild reaction conditions (neutral pH, reaction temperatures  $\leq 23$  °C) are especially attractive for substrates containing sensitive functional groups. The success of this methodology relies critically upon the purity of the NBSH reagent employed in the reaction. A simple and practical procedure for the preparation of NBSH of high purity and guidelines for the handling and storage of the reagent are provided in this note.

The preparation of NBSH from *o*-nitrobenzenesulfonyl chloride and hydrazine in benzene was described in 1929 by Dann and Davies. Although detailed isolation and purification procedures were not provided, the authors did describe the reagent to be unstable and identified the primary decomposition product as the corresponding arenosulfinic acid.<sup>5</sup> Hünig et al. have noted that the decomposition of NBSH in solution at 25 °C is a viable means of generating diimide.<sup>6</sup> We find that the rate of decomposition of NBSH is dramatically accelerated in solution versus the solid state and is especially rapid in polar solvents such as methanol and water (NBSH exhibits appreciable water solubility). Simply dissolving pure NBSH in water or methanol at ambient temperature proceeds with gas evolution and yellowing of the solution, characteristic features of the decomposition. Decomposition is much slower in nonpolar organic solvents such as tetrahydrofuran (THF) and ethyl acetate and at temperatures below 0 °C. For this reason, the recommended procedure for the preparation of NBSH employs THF as solvent and ethyl acetate for the workup, and both the reaction and product isolation are conducted at subambient temperatures (−30 and 0 °C, respectively). Hydrazine hydrate is recommended over anhydrous hydrazine because the reaction of the latter reagent with the sulfonyl chloride is quite exothermic and is therefore difficult to control. Of paramount importance is an isolation process involving repeated extraction of the

product solution with 10% aqueous sodium chloride solution. This serves to remove hydrazine hydrochloride and any contaminating *o*-nitrobenzenesulfinic acid while minimizing the loss of NBSH due to aqueous solubility.<sup>7</sup> Removal of the sulfinic acid is of particular importance for the applications cited above, for this impurity is an excellent nucleophile in the Mitsunobu displacement reaction. Final purification of NBSH is conducted by precipitation with hexanes, affording the product as an off-white solid (mp 100–101 °C, dec; lit.<sup>5</sup> mp 101 °C, dec).

NBSH can be stored in the solid state at 23 °C for several days without appreciable decomposition, but storage at this temperature for longer than 2 weeks is not recommended. For longer term storage refrigeration is necessary. We have successfully used the solid reagent when stored at −20 °C under nitrogen for 2 months. Pure NBSH affords clear and nearly colorless solutions when initially dissolved in THF. The formation of distinctly yellow solutions upon dissolution in THF<sup>8</sup> indicates that the reagent is of poor quality and is not suitable for the applications cited. The experimental procedure detailed below has been performed several times over to provide 20-g batches of analytically pure NBSH with yields in excess of 80%.

### Experimental Section

Reagents were commercial materials and were used without further purification with the exception of tetrahydrofuran, which was distilled from sodium benzophenone ketyl.

***o*-Nitrobenzenesulfonylhydrazide (NBSH).** Hydrazine monohydrate (12.1 mL, 0.25 mol, 2.5 equiv) was added dropwise to a solution of *o*-nitrobenzenesulfonyl chloride (22.2 g, 0.10 mol, 1 equiv) in THF (100 mL) at −30 °C under an argon atmosphere. During the addition the reaction mixture became brown and a white precipitate of hydrazine hydrochloride was deposited. After stirring at −30 °C for 30 min, thin-layer chromatographic (TLC) analysis indicated that the sulfonyl chloride had been consumed (2:1 ethyl acetate:hexanes eluent). Ethyl acetate (200 mL, 23 °C) was added to the cold reaction solution and the mixture was washed repeatedly with ice-cold 10% aqueous sodium chloride solution (5 × 150 mL).<sup>7b</sup> The organic layer was dried over sodium sulfate at 0 °C and then was added slowly to a stirring solution of hexanes (1.2 L) at 23 °C over 5 min. *o*-Nitrobenzenesulfonylhydrazide precipitated within 10 min as an off-white solid and was collected by vacuum filtration. The filter cake was washed with hexanes (2 × 50 mL, 23 °C) and then was dried in vacuo (<1.5 mm) at 23 °C for 14 h to afford pure NBSH as an off-white powder (17.61 g, 81%); mp 100–101 °C; IR (EtOAc, cm<sup>−1</sup>) 3100–3400, 1547, 1352, 1165; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>CN)  $\delta$  8.17–8.03 (1H, m), 7.91–7.78 (3H, m), 5.97 (1H, bs), 3.90 (2H, bs); <sup>13</sup>C NMR (75 MHz, CD<sub>3</sub>CN)  $\delta$  149.4, 135.5, 133.4, 133.2, 130.8, 125.8; *R*<sub>f</sub> 0.19 (2:1 ethyl acetate:hexanes). Anal. Calcd for C<sub>6</sub>H<sub>7</sub>N<sub>3</sub>O<sub>4</sub>S: C, 33.18; H, 3.25; N, 19.35. Found: C, 33.41; H, 3.27; N, 19.20.

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(7) (a) When pure water was used in the extraction, less than 40% yield of NBSH was obtained. When 15% aqueous sodium chloride solution was used, NBSH was obtained in slightly higher yield (84%) but exhibited a depressed melting point (97 °C). (b) The contact time for each wash with 10% aqueous sodium chloride solution was  $\leq 1$  min.

(8) This color test is not valid for the solvent *N*-methylmorpholine (an alternative medium for Mitsunobu displacement),<sup>2</sup> which produces yellow solutions even with pure NBSH. Solutions of NBSH in THF that are pale yellow are generally suitable for the applications of refs 1–3.

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