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# Approximate Rate Constants for Intermolecular Additions of Alkyl Radicals to Phenylsulfonyl Oxime Ethers

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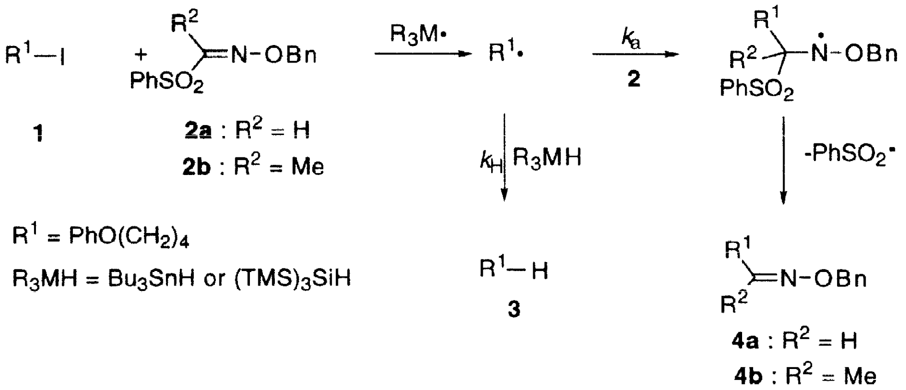
*Abstract: Approximate rate constants for intermolecular additions of alkyl radicals to phenylsulfonyl oxime ethers (**2a** and **2b**) have been determined to be* $k_a$*=9.6x10*$^5$ $M^{-1}s^{-1}$ *at 25* $^0C$ *for* ***2a*** *and* $k_a$ *=7.3x10*$^4$ $M^{-1}s^{-1}$ at 60 $^0C$ *for* ***2b****, indicating that the additions are fast and highly efficient processes. The kinetic data have been confirmed by two competition experiments.* © 1998 Elsevier Science Ltd. All rights reserved.

Recently we reported that phenylsulfonyl oxime ethers were highly effective for free radical mediated acylation approach.[1] As shown in Scheme 1, the present approach relies on additions of alkyl radicals to C=N bonds and subsequent fast and irreversible β-exclusion of phenylsulfonyl radicals to afford oxime ethers which can be readily converted into aldehydes and ketones by the well-known procedures.[2] The rate constants for intramolecular additions of alkyl radicals to C=N bonds such as hydrazones,[3] imines,[4] and oxime ethers[5] have been recently determined and the kinetic data indicate that alkyl radical additions to C=N bonds are considerably faster than those to C=C bonds. The intermolecular additions of alkyl radicals to C=O[6] and C=N bonds[7] are relatively rare, as compared to C=C bonds. As far as we are aware, no reports on the rate constants for intermolecular additions of alkyl radicals to C=N bonds are presently available. Thus, we performed kinetic studies to determine approximate rate constants for intermolecular additions of primary alkyl radicals to phenylsulfonyl oxime ethers.

**Scheme 1**



Under pseudo-first order conditions, the ratio of the reduction product to the oxime ether ([**3**]/[**4**]) can be described by eq 1. The rate constant ratio $k_H/k_a$ can be obtained by plotting [**3**]/[**4**] vs [$R_3MH$]/[**2**]. Since $k_H$ is known,[8,9] one can calculate a value for $k_a$ from its slope.

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$$[3]/[4]=k_H[R_3MH]/k_a[2] \qquad (1)$$

Since phenylsulfonyl oxime ether **2a** was decomposed to some extent upon heating with $Bu_3SnH$/AIBN in benzene at 80 °C within 30 min, kinetic studies were carried out with 4-phenoxybutyl iodide and phenylsulfonyl oxime ether **2a** (3-6 equiv) in the presence of a large excess amount of $Bu_3SnH$ (12 equiv) in benzene at 350 nm at 25 °C for 15 min. The ratio of **3** and **4a** were obtained by HPLC analysis after chromatographic removal of an excess amount of $Bu_3SnH$. As shown in Figure 1, a plot of [**3**]/[**4a**] vs [$Bu_3SnH$]/[**2a**] gave a straight line with a slope of $k_H/k_a$=2.50, in which the slope indicates the rate of hydrogen atom abstraction relative to an alkyl radical addition to **2a**. Since the rate constant for hydrogen atom abstraction from $Bu_3SnH$ by primary alkyl radical was known to be $2.4\times10^6$ $M^{-1}s^{-1}$ at 25 °C,[8] the approximate rate constant $k_a$ can be calculated to be $9.6\times10^5$ $M^{-1}s^{-1}$, indicating that an alkyl radical addition to **2a** is very fast and highly efficient.

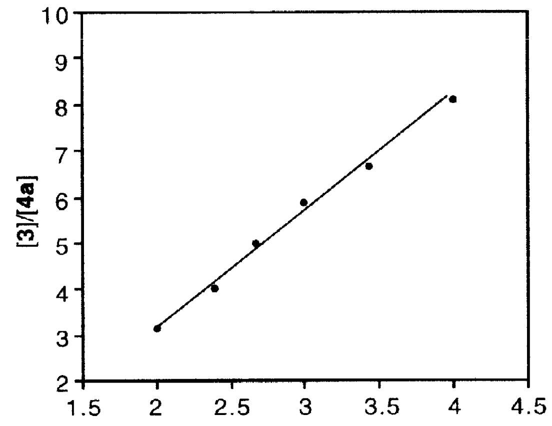


Figure 1

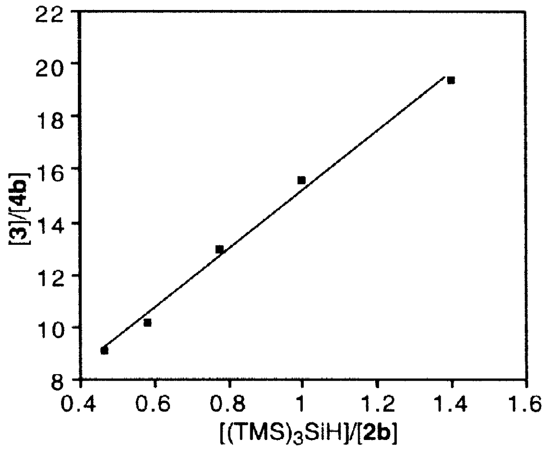
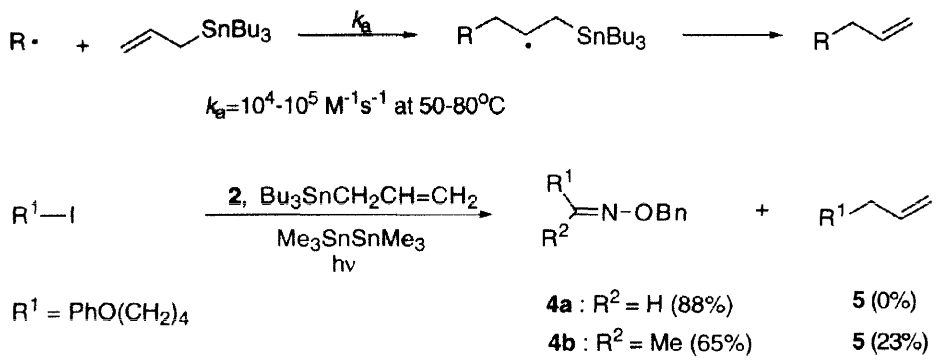


Figure 2

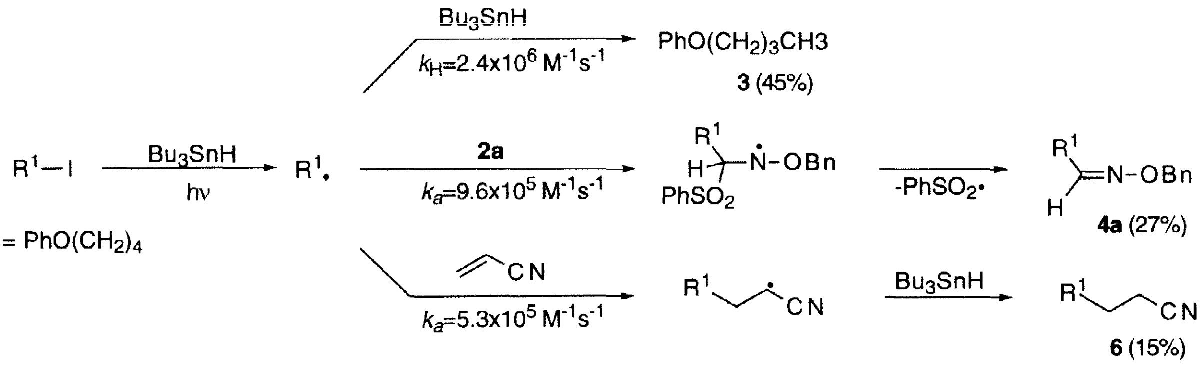
Kinetic studies using **2b** were initially carried out with $Bu_3SnH$/AIBN under the similar conditions. However, the reaction afforded direct reduction product **3** almost exclusively without yielding an observable amount of oxime ether **4b**. Evidently, the alkyl radical addition to **2b** should be much slower than the direct reduction of an alkyl radical by $Bu_3SnH$. Thus, $(TMS)_3SiH$ was employed as a hydrogen atom donor ($k_H$=$8.2\times10^5$ $M^{-1}s^{-1}$ at 60 °C).[9] When the reaction was carried out with **1**, **2b** (5-15 equiv), $(TMS)_3SiH$ (7 equiv), and AIBN (0.1 equiv) in benzene at 60 °C for 2 h, a mixture of **3** and **4b** was obtained and the experimental results are shown in Figure 2. From a slope of $k_H/k_a$=11.25, the approximate rate constant for an alkyl radical addition to **2b** is determined to be $7.3\times10^4$ $M^{-1}s^{-1}$. As predicted from the previous study, [1a] an alkyl radical addition to **2b** is much slower than that to **2a**.

Scheme 2



In order to confirm the kinetic data, we examined standard competition studies involving (i) attack of an alkyl radical to allyltributylstannane relative to its addition to **2** (Scheme 2) and (ii) attack of an alkyl radical to acrylonitrile relative to its addition to **2** (Scheme 3). The approximate rate constants for alkyl radical additions to allyltributylstannane were known to be $10^4$-$10^5$ $M^{-1}s^{-1}$.[10a] As predicted from this data, when a mixture of an alkyl iodide, allyltributylstannane, and **2a** was treated with hexamethylditin at 300 nm for 8 h, only oxime ether **4a** was isolated in 88% yield. When a similar experiment was carried out with **2b** under the similar conditions, a mixture of **4b** (65%) and **6** (23%) was isolated along with a small amount of 1-phenoxybutane (7%), indicating that the rate for an alkyl radical addition to **2b** is approximately three times faster than its addition to allyltributylstannane.[10b]

Scheme 3



An additional competition study was conducted with **2a** and acrylonitrile using $Bu_3SnH$/AIBN. When an equimolar mixture of **2a** and acrylonitrile in benzene was treated with $Bu_3SnH$ (1.5 equiv)/AIBN at 350 nm at room temperature for 1 h, as predicted, a mixture of **4a** (27%), nitrile **6** (15%), and direct reduction product **3** (45%) was obtained, indicating that $k_a$ would be roughly twice larger than the rate constant for alkyl radical addition to acrylonitrile ($k_a$=5.3x$10^5$ $M^{-1}s^{-1}$).[11]

In conclusion, kinetic studies indicate that intermolecular additions of alkyl radicals to phenylsulfonyl substituted oxime ethers (**2a** and **2b**) are very fast and highly efficient processes ($k_a$=9.6x10$^5$ M$^{-1}$s$^{-1}$ at 25 ℃ for **2a**, 7.3x10$^4$ M$^{-1}$s$^{-1}$ at 60 ℃ for **2b**), and kinetic data have been confirmed by two competition experiments involving a radical allylation and an alkyl radical addition to acrylonitrile.

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