Pergamon

Tetrahedron Letters 39 (1998) 1587–1590

TETRAHEDRON
LETTERS

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

Sunggak Kim * and Ill Young Lee

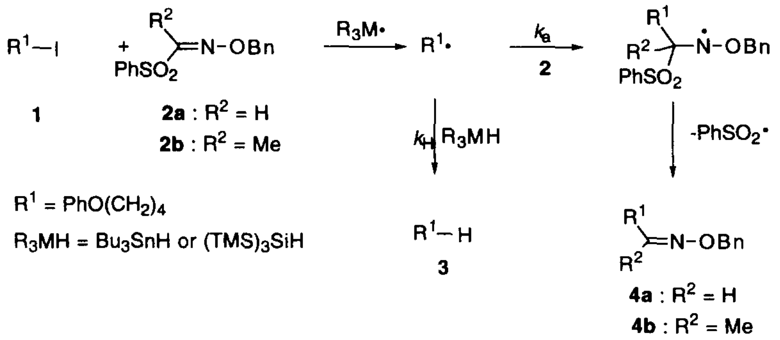
Department of Chemistry, Korea Advanced Institute of Science and Technology, Taejon 305-701, Korea

Received 10 November 1997; revised 15 December 1997; accepted 19 December 1997

*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* ^{0}*C for **2a** and* k_a *=7.3x10*^{4} $M^{-1}s^{-1}$ at 60 ^{0}C *for **2b**, indicating that the additions are fast and highly efficient processes. The kinetic data have been confirmed by two competition experiments.*

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.

0040-4039/98/$19.00 © 1998 Elsevier Science Ltd. All rights reserved.
PII: S0040-4039(98)00035-5

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

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 2.4×10^6 $M^{-1}s^{-1}$ at 25 °C,[8] the approximate rate constant k_a can be calculated to be 9.6×10^5 $M^{-1}s^{-1}$, indicating that an alkyl radical addition to **2a** is very fast and highly efficient.

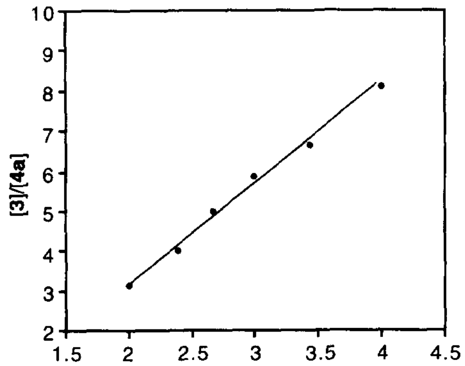


Figure 1

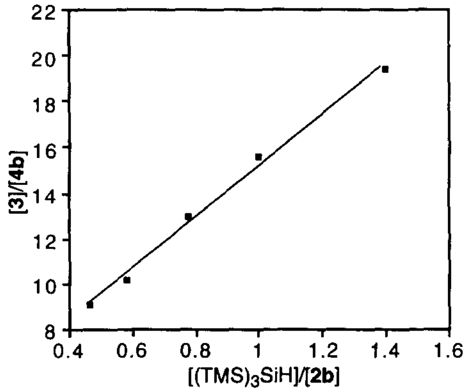
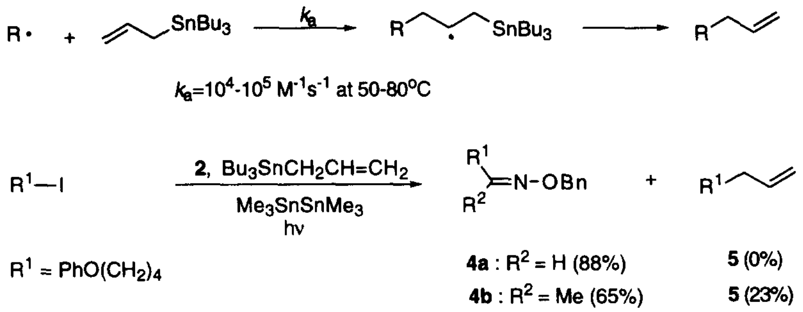


Figure 2

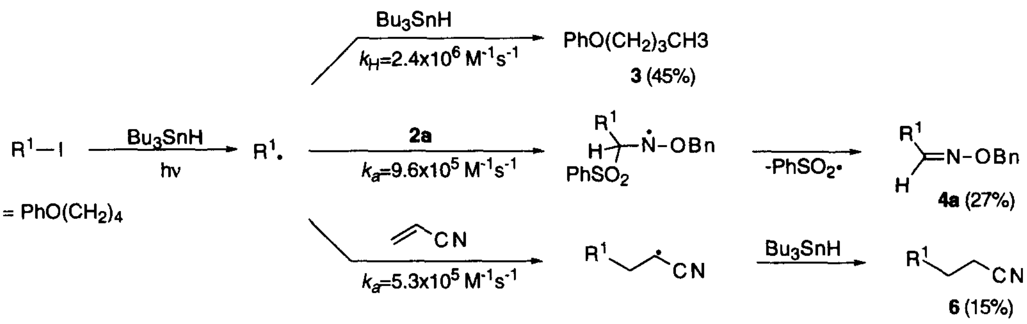
Kinetic studies using **2b** were initially carried out with Bu_3SnH/AIBN under the similar conditions. However, the reaction afforded direct reduction product **3** almost exclusively without yielding an observable amount of oxime ether **4b**. Evidently, the alkyl radical addition to **2b** should 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=8.2×10^5 $M^{-1}s^{-1}$ 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 7.3×10^4 $M^{-1}s^{-1}$. 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=5.3x10^5 $M^{-1}s^{-1}$).[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.

Acknowledgments. We thank the Organic Chemistry Research Center (KOSEF) and NON DIRECTED RESEARCH FUND (01D0374), Korea Research Foundation, 1997 for financial support.

References and Notes

1. (a) Kim, S.; Lee, I. Y.; Yoon, J.; Oh, D. H. *J. Am. Chem. Soc.* **1996**, *118*, 5138. (b) Kim, S.; Yoon, J.; Lee, I. Y. *Synlett.* **1997**, 475. (c) Kim, S.; Yoon, J. *J. Am. Chem. Soc.* **1997**, *119*, 5982.
2. (a) Greene, T. W.; Wuts, P. G. *Protective Groups in Organic Synthesis*; John Wiely & Sons, Inc.: New York, 1991; P214. (b) Donaldson, R. E.; Saddler, J. C.; Byrn, S.; McKenzie, A. T.; Fuchs, P. L. *J. Org. Chem.* **1983**, *48*, 167. (c) Haley, M. F.; Yates, K. *J. Org. Chem.* **1987**, *52*, 1817.
3. (a) Sturino, C. F.; Fallis, A. G. *J. Org. Chem.* **1994**, *59*, 6514. (b) Kim, S.; Cheong, J. H.; Yoon, K. S. *Tetrahedron Lett.* **1995**, *36*, 6069.
4. (a) Tomaszewski, M. J.; Warkentin, J. *J. Chem. Soc., Chem. Commun.* **1993**, 966. (b) Tomaszewski, M. J.; Warkentin, J. *Tetrahedron Lett.* **1992**, *33*, 2123. (c) Kim, S.; Yoon, K. S.; Kim, Y. S. *Tetrahedron* **1997**, *53*, 73.
5. Kim, S.; Kim, Y. J.; Yoon, K. S. *Tetrahedron Lett.* **1997**, *38*, 2487.
6. (a) Kharasch, M. S.; Brown, H. C. *J. Am. Chem. Soc.* **1942**, *64*, 329. (b) Bentrude, W. G.; Darnall, K. R. *J. Am. Chem. Soc.* **1968**, *90*, 3588. (c) Oyama, M. *J. Org. Chem.* **1965**, *30*, 2429. (d) Minisci, F.; Galli, R.; Cecere, M.; Malatesta, V.; Caronna, T. *Tetrahedron Lett.* **1968**, 5609.
7. (a) Citterio, A.; Filippini, L. *Synthesis* **1986**, 473. (b) Hart, D. J.; Seely, F. L. *J. Am. Chem. Soc.* **1988**, *110*, 1631.
8. (a) Chatgiliaglu, C.; Ingold, K. U.; Scaiano, J. C. *J. Am. Chem. Soc.* **1981**, *103*, 7739. (b) Newcomb, M. *Tetrahedron* **1993**, *49*, 1151. (c) Avila, D. V.; Ingold, K. U.; Lusztyk, J. ; Dolbier, W. R., Jr.; Pan, H. -Q.; Muir, M. *J. Am. Chem. Soc.* **1994**, *116*, 99.
9. Chatgilialogu, C.; Dickhaut, J.; Giese, B. *J. Org. Chem.* **1991**, *56*, 6399.
10. (a) Curran, D. P.; van Elburg, P. A.; Giese, B.; Gilges, S. *Tetrahedron Lett.* **1990**, *31*, 2861. (b) According to the competition experiment, the rate constant for primary alkyl radical addition to allyltributylstannane would be approximately 2x10^4 $M^{-1}s^{-1}$.
11. (a) Citterio, A. Arnoldi, A. Minisci, F. *J. Org. Chem.* **1979**, *44*, 2674. (b) Giese, B.; Kretzschmar, G.; Meixner J. *Angew. Chem. Int. Ed. Engl.* **1983**, *22*, 753.