

The First Example of Cation Radical Induced Ether Cleavage of Benzyl Phenyl Ether

Seong Yi Nam, Dong Sul Han,[†] and Wang Keun Lee*

Department of Chemistry Education, Chonnam National University, Gwang-Ju 500-757, Korea

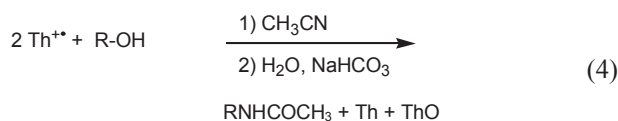
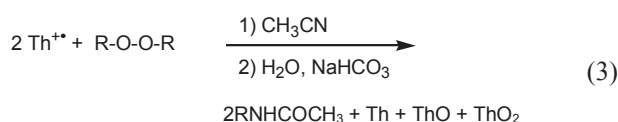
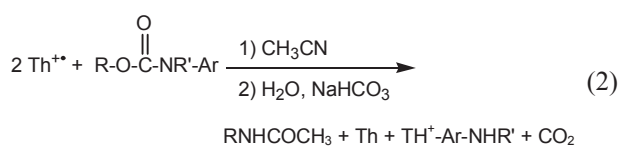
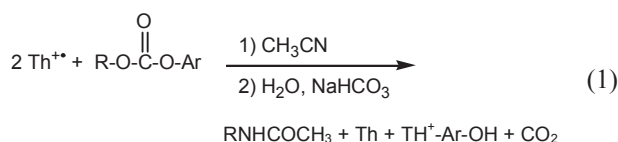
*E-mail: wklee@chonnam.ac.kr

[†]Department of Chemistry, Mokpo National University, Mu-an, Chonnam 534-729, Korea

Received March 16, 2010, Accepted April 15, 2010

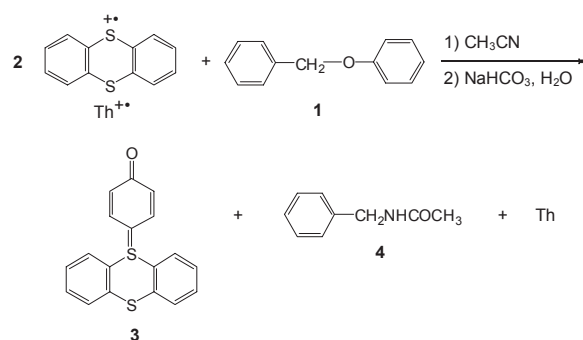
Key Words: Ether cleavage, Benzyl phenyl ether, Thianthrene cation radical

Over the last several years, our lab has discovered cation radical-induced oxidative C-O bond cleavages such as carbonates (eq 1),^{1,2} carbamates (eq 2),³ peroxides (eq 3),⁴ and alcohols (eq 4),⁵ where R is either *tert*-butyl or benzyl. It was recognized from those reactions that carbocationic chemistry with C-O bond cleavages was predominant, with a 2:1 stoichiometry of Th^{•+}:oxidized molecules.



In a continuation of our work with benzyl phenyl ether (**1**), in acetonitrile at room temperature, it was found to undergo oxidative C-O bond cleavage by the thianthrene cation radical (Th^{•+}ClO₄⁻). As far as the authors are aware, reactions of ether with cation radicals have not been reported, and as such, they offer the first examples of cation radical-induced ether cleavage. Generally, ethers react only reluctantly with bases, reducing agents and oxidizing agents. The C-O cleavage of benzyl phenyl ether typically occurs by heating with one equivalent of acid,⁶ through a S_N1 pathway given the relative stability of the benzyl cation being formed; this is followed by C-O cleavage.

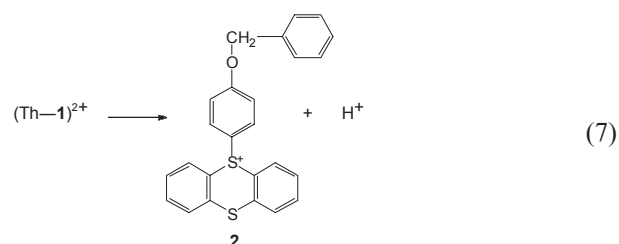
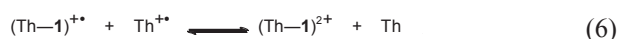
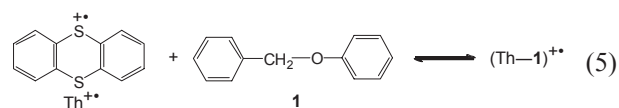
It has been found that **1** reacts quantitatively with Th^{•+} at a 1:2 (**1**:Th^{•+}) stoichiometry to give quinonoids (**3**),⁷ *N*-benzylacetamide (**4**),⁸ and thianthrene (Th). The simplest representation of the reaction is given in Scheme 1. The products yielded

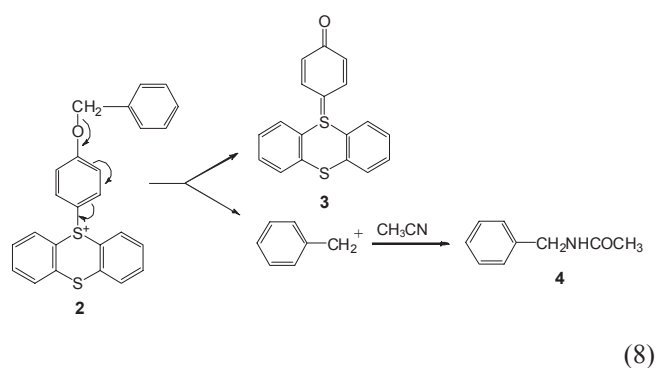


Scheme 1

were determined by quantitative GC and GC/MS analyses. *N*-Benzylacetamide (**4**) was isolated in a yield of 87.4%, **3** (100%), Th (96.4%), phenol (1.01%), and trace amounts of ThO.

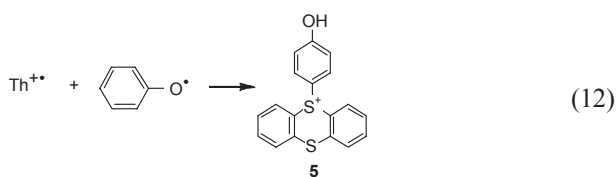
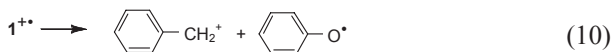
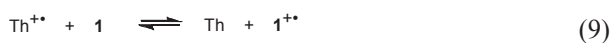
A mechanism that fits the formation of such products involves the initial complexation of Th^{•+} with **1** (eq 5) to produce a species more easily oxidized than Th^{•+}, where electron transfer (eq 6) produces a thianthrene dication-benzyl phenyl ether complex (Th-1)²⁺ that undergoes a rate-determining bond formation with expulsion of a proton (eq 7) to product **2**.⁹ Benzyl cations are subsequently formed by S_N1 loss of **3** from **2**. Benzyl cations then react with the acetonitrile solvent, to give a Ritter-type intermediate (C₆H₅CH₂N⁺CMe), which then reacts with water during work-up to give **4**.





Although the major products are rationalized by Scheme 1, the origin of the 1.01% of phenol remains uncertain. Formation of the phenoxonium ion by oxidation of Th^{2+} can be excluded as free phenoxonium ion could not be formed from the mono- and unsubstituted phenols.¹⁰ ThO was obtained as a side product from hydrolysis of **1** by water, either adventitiously in the solvent or added during work-up.¹¹ In order to exclude all doubts of autocatalytic effects by the trace acid generated from the cation radical-induced oxidative reaction, a control reaction of 70% perchloric acid and **1** in acetonitrile was conducted. Quantitative amounts of starting ether (**1**) were recovered. These observations indicate that the oxidative C-O cleavage of **1** was not catalyzed by the acid but is proceeded by the electron transfer (ET) follows the complexation mechanism exclusively.

The ether cleavage of **1** by Th^{2+} may take place by the simplest representation as in eq 9-13. However, the interconversion of **5** to **3** in basic solution was not monitored with UV spectroscopy. The fact that **3** were not interconverted from **5** in basic solution and were formed in quantitative yield in the absence of base provides evidence for the Parker's complexation mechanism as in eq 5-8.



In conclusion, a thermally stable benzyl phenyl ether has been shown to cleavage under mild conditions. The new reaction described herein further expands the chemistry of the ether cleavage by cation radicals.

Acknowledgments. The authors wish to thank the Korea Basic Science Institute, Gwang-Ju center, for GC/MS, ¹H-NMR support.

References and Notes

- Park, Y. S.; Lee, W. K. *Bull. Korean Chem. Soc.* **1997**, *18*, 360.
- Choi, J. M.; Ma, E.-K.; Sohn, C. K.; Lee, W. K. *Bull. Korean Chem. Soc.* **2000**, *21*, 1254.
- Park, Y. S.; Han, D. S.; Lee, W. K. *Bull. Korean Chem. Soc.* **1998**, *19*, 615.
- Park, B. K.; Sohn, C. K.; Lee, W. K. *Bull. Korean Chem. Soc.* **2002**, *23*, 103.
- Moon, H. M.; Lee, W. K. *Bull. Korean Chem. Soc.* **2009**, *30*, 729.
- Bhatt, M. V.; Kulkarni, S. U. *Synthesis* **1983**, 249-282.
- ¹H NMR (CDCl_3) δ 8.50 (m, 2H), 8.00 (m, 4H), 7.40 (m, 2H), 7.22 (d, $J = 9.08$, 2H), 7.01 (d, $J = 9.18$, 2H). GC-MS, m/e (relative intensity): 310 ($M^+ + 2$, 10, 1), 309 ($M^+ + 1$, 20.1), 308 (M^+ , 100). IR (cm^{-1}) C=O, 1661.
- ¹H NMR (CDCl_3) δ 7.45 (m, 5H), 6.4 (s, 1H), 4.35 (d, 2H), 1.95 (s, 3H). GC-MS, m/e (relative intensity): 149 (M^+ , 100), 106 (20.3).
- Svanholm, U.; Hammerich, O.; Parker, V. D. *J. Am. Chem. Soc.* **1975**, *97*, 101.
- Shin, S.-R.; Shine, H. J. *J. Org. Chem.* **1992**, *57*, 2706.
- Shine, H. J.; Murata, Y. *J. Org. Chem.* **1969**, *34*, 3368.