A Convenient, Mild Method for Oxidative Cleavage of Alkenes with Jones Reagent/ Osmium Tetraoxide

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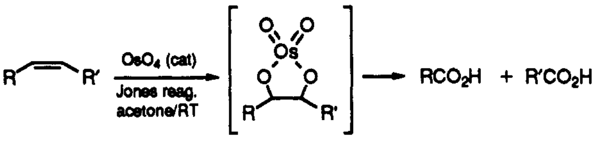
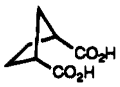
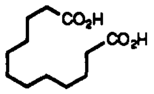
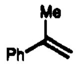
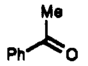
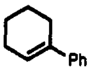
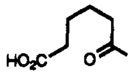
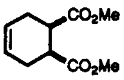
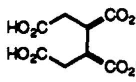
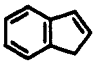
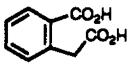
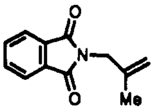
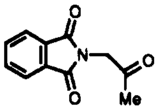
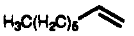
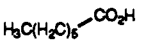
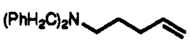
Oxidative scission of alkenes is a widely used method for preparation of carboxylic acids and ketones.[1] The most common reagents for this transformation include ozone, potassium permanganate, and ruthenium tetraoxide. In addition, several methods exist involving initial oxidation of an alkene to a 1,2-diol[2,3] or epoxide,[4] followed by C–C bond cleavage to the acid and/or ketone. During the course of a project in alkaloid total synthesis, we required a method for cleavage of a terminal olefin to a carboxylic acid which could be run conveniently on both milligram and gram scales and one which could be conducted under mildly acidic conditions to allow for protection of a basic nitrogen as its ammonium salt. Since it is known that chromic acid oxidizes 1,2-diols,[2b,5,6] we reasoned that in the presence of a catalytic amount of osmium tetraoxide chromate should convert an olefin via a diol to an acid and/or ketone in one operation.[7]

In fact, we have found that a combination of a catalytic amount of OsO_4 and stoichiometric Jones reagent in acetone at room temperature oxidizes various types of alkenes into acids and/or ketones (eq 1). We believe that the process involves initial formation of an osmate ester, and the osmium is then reoxidized by the chromate, which also cleaves the 1,2-diol.



(1)

Table I

entry	alkene	oxidation product	isolated yield (%)
1			89
2			50
3			65
4			98
5			75
6			75
7			89
8			85
9			85
10			65

We have tested this procedure on a number of alkenes listed in Table I. In general, good yields of cleavage products were obtained with a structural variety of olefins. Moreover, the presence of a basic nitrogen (entry 10) does not seem to interfere with the reaction. Due to its mildness and simplicity, we anticipate this procedure should prove widely applicable.

Experimental Section

General Procedure. To a solution of the alkene (2 mmol) dissolved in 10 mL of acetone was added 0.25 mL (2 mol %) of a 4 wt % solution of OsO_4 in water and 2.6 mL (6.9 mmol of Cr^{VI}) of Jones reagent.[8] After the mixture was stirred for 20 h at rt, 1 mL of 2-propanol was added followed by 0.3 g of $NaHSO_3$. The mixture was diluted with 10 mL of water and stirred until a dark green, homogeneous solution was produced. This solution was diluted with 20 mL of water and extracted with six 10-mL portions of ethyl acetate. The organic extracts were combined, dried with $MgSO_4$, and concentrated in vacuo. The products were purified by Kugelrohr distillation or recrystallization. Isolated yields of products are given in Table I.

The above procedure was followed in the case of trisubstituted alkenes except that 1.9 mL (5 mmol of Cr^{VI}) of Jones reagent was used.

Acknowledgment. We thank the National Institutes of Health (GM-32299) for financial support.

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(1) For recent reviews and leading citations, see: (a) Hudlicky, M. *Oxidations in Organic Chemistry*; ACS Monograph 186; American Chemical Society: Washington, DC, 1990; p 77. (b) Lee, D. G.; Chen, T. Cleavage Reactions. In *Comprehensive Organic Synthesis*; Trost, B. M., Ed.; Pergamon, Oxford, 1991; Vol. 7, p 541. See also: Marshall, J. A.; Garofalo, A. W.; Sedrani, R. C. *Synlett* 1992, 643.

(2) For example, see: (a) Perold, G. W.; Pachler, K. G. R. *J. Chem. Soc. C* **1966**, 1918. (b) Kwart, H.; Ford, J. A., Jr.; Corey, G. C. *J. Am. Chem. Soc.* **1962**, *84*, 1252 and references cited therein.

(3) For a review, see: Shing, T. K. M. Glycol Cleavage Reactions. In *Comprehensive Organic Synthesis*; Trost, B. M., Ed.; Pergamon: Oxford, 1991; Vol. 7, p 703.

(4) Khatri, N.; Schmitthenner, H. F.; Shringarpure, J.; Weinreb, S. M. *J. Am. Chem. Soc.* **1981**, *103*, 6387. Zevaco, T.; Dunach, E.; Postel, M. *Tetrahedron Lett.* **1993**, *34*, 2601.

(5) CrO_3/HOAc has been used on occasion to oxidize olefins to acids; see: Riegel, B.; Moffett, R. B.; McIntosh, A. V. *Organic Syntheses;* Wiley: New York, 1955; Collect. Vol. III, p 234.

(6) For oxidation of a hydroxyolefin to a γ or δ-lactone with CrO_3/HOAc, see: Schlecht, M. F.; Kim, H. *Tetrahedron Lett.* **1985**, *26*, 127.

(7) For a review of osmium tetraoxide oxidations, see: Schroder, M. *Chem. Rev.* **1980**, *80*, 187.

(8) Prepared as described in ref 1a, p 273.

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