## A Convenient, One-Pot Conversion of Secondary Alcohols to Esters Via A Tandem Oxidation-Baeyer-Villiger Sequence

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Abstract: A one-pot reaction sequence has been developed which converts secondary alcohols to esters via oxidation to the carbonyl compound and concomitant Baeyer-Villiger reaction. This procedure employs metachloroperoxybenzoic acid (mCPBA) as the primary oxidant in both steps and a catalytic amount of a cyclic Cr(VI) ester as a co-oxidant in the initial step. Isolated yields are typically very high and chromatographic purification of the crude product is often unnecessary for routine operations.

In the course of a total synthesis, it was necessary to produce both enantiomers of the lactone 2 from Land D-menthol (1 and *ent*-1, respectively). Although 2 has been synthesized from L-menthol previously,<sup>2</sup> this has traditionally been accomplished in a two-step procedure involving oxidation with, e.g., PCC followed by isolation of the intermediate L-methone (3) and subsequent Baeyer-Villiger reaction. Since both steps involve



oxidation, it appeared possible in theory to carry them out in a single operation. In practice, it was necessary to find conditions in which the reagents needed to oxidize the alcohol would not interfere with the peroxy acid in the next step. A logical choice for such a system is a reagent which catalyzes the oxidation of alcohols by peracids. Such a reagent has been developed and reported by Corey.<sup>3</sup> Secondary alcohols, when treated with 2 equivalents of peroxyacetic acid in the presence of 5 mol % of the cyclic chromate ester 4, are converted to ketones in high yield.<sup>3</sup>



When the more reactive peracid *meta*-chloroperoxybenzoic acid<sup>4</sup> (*m*CPBA) is substituted for peroxyacetic acid and the number of equivalents increased to 4, the ketone initially produced is converted to the corresponding lactone by Baeyer-Villiger reaction. One equivalent of sodium hydrogen carbonate is added after an hour to accelerate the Baeyer-Villiger reaction.<sup>5</sup> Typically, the starting alcohol has been consumed within an hour and the reaction is complete within 12 hours. When applied to the oxidation of D-menthol, this procedure leads to the desired lactone *ent*-2 in 95% isolated yield. The crystalline product obtained from the extractive workup is of sufficient purity to be used directly in subsequent reactions. A number of other alcohols were oxidized under the same reaction conditions (Table 1), resulting in uniformly high yields of the Baeyer-Villiger product, often exceeding the yields reported for the Baeyer-Villiger reaction alone (*vide infra*.).



<sup>a</sup> All products were characterized by <sup>1</sup>H-NMR, <sup>13</sup>C-NMR and correlation with reported data. <sup>b</sup> Yield after chromatography <sup>c</sup> Yields reported for Baeyer-Villiger reaction of corresponding ketones with *m*CPBA.

<u>Typical procedure:</u> A solution of chromate ester 4 (100  $\mu$ L, 0.2<u>M</u> in CCl<sub>4</sub>, 0.02 mmol) was added to freshly distilled CH<sub>2</sub>Cl<sub>2</sub> (5 mL) in a dry flask under a nitrogen atmosphere and cooled to 0°. To this solution *meta*-chloroperoxybenzoic acid<sup>4</sup> (690 mg, 4.0 mmol) was added with stirring, followed by the alcohol (1.0 mmol). After one hour, solid sodium hydrogen carbonate (1.0 mmol) was added and the reaction allowed to stir at room temperature for another 6-24 hours. When the reaction was judged complete by TLC, the contents of the reaction were poured into diethyl ether (15 mL) and washed with saturated sodium bisulfite followed by saturated sodium hydrogen carbonate (three times) and water. The organic layer was dried over magnesium sulfate and evaporated to afford the crude lactone.<sup>9</sup>

## **References** and Notes

- 1. American Chemical Society Petroleum Research Fund Fellow
- 2. Miller, D.;Bilodeau, F.; Burnell, R.H. Can. J. Chem. 1991, 69, 1100-1106.
- 3. Corey, E. J.; Barrette, E.-P.; Magriotis, P. Tet. Lett. 1985, 26, 5855-5858.
- 4. "Practical" grade mCPBA (98% purity, EK 135 5759) from Fisher Scientific was used.
- 5. Whitesell, J. K.; Matthews, R.S.; Helbing, A.M. J. Org. Chem. 1978, 43, 784-786.
- 6. Toda, F.; Yagi, M.; Kiyoshige, K. J. Chem. Soc. Chem. Comm. 1988, 958-959.
- 7. Stracher, P.S.; Phillips, B. J. Am. Chem. Soc. 1958, 80, 4079-4082.
- 8. Krow, G.R. Tetrahedron 1981, 37, 2697-2724.
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