

Benzylic Oxidation by Sodium Bismuthate in Acetic Acid: A Simple Method for the Synthesis of Polycyclic Aromatic Ketones

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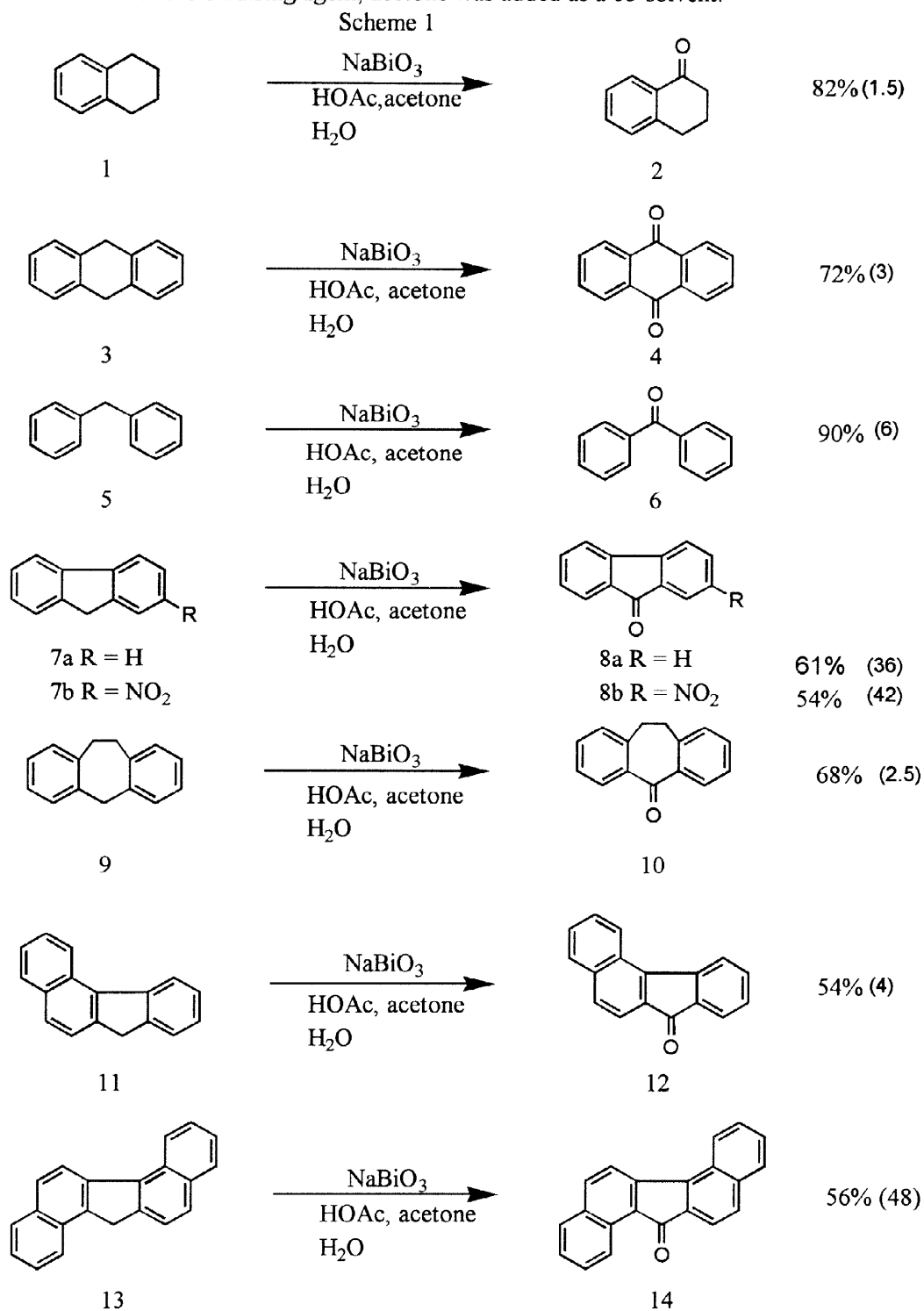
Abstract: Oxidation of benzylic methylenes in polycyclic systems to the benzylic ketones was carried out with sodium bismuthate in the presence of acetic acid. © 1998 Elsevier Science Ltd. All rights reserved.

The oxidizing power of sodium bismuthate in acid media is proved by the facile conversion of bivalent manganese salts to heptavalent manganese.¹ In comparison to common oxidizing agents, the use of this reagent in synthetic organic chemistry has not been extensively explored. Rigby² demonstrated the cleavage of vicinal diols and the conversion of acyloins to α -diketones by sodium bismuthate. This reagent was also used for the oxidation of phenols³, olefins⁴ and α -ketols.⁵ Recently, a few other bismuth derivatives were developed for the oxidation of various functional groups.⁶

We have been engaged in the synthesis and biological evaluation of polycyclic aromatic compounds which required several polycyclic aromatic ketones in good yield. Oxidation of benzylic methylenes to the ketones by DDQ⁷, PCC⁸, CrO₃⁹, tBuOOH¹⁰, tetrapyridinesilver peroxydisulfate¹¹ is known in the literature. Recently, Harvey et al¹² reported a new oxidation method with n-BuLi in the presence of molecular oxygen. Although this method is attractive, it has several limitations. For examples, oxidation of some structurally similar benzylic compounds could not be achieved by this method. Dimer formation in strong basic media was observed and mixtures of products were formed in some cases. Most importantly, extreme precaution has to be taken to get successful results as the method requires absolutely dry and inert media. Thus, development of new, operationally simple and relatively safe synthetic methods are challenging and a subject of interest. We wish to report here for the first time that sodium bismuthate in acetic acid can oxidize benzylic methylenes to ketones under reflux conditions.

Commercially available tetralin (**1**), diphenylmethane (**5**), 9-10 dihydroanthracene (**3**), dibenzosuberane (**9**) fluorene (**7a**) and 2-nitrofluorene (**7b**) were readily converted to the respective ketones **2**, **6**, **4**, **8a**, **8b** and **10** by sodium bismuthate in acetic acid. We selected two synthetic compounds, 2,3-benzo fluorene (**11**) and 13H-dibenzo[a,g]fluorene (**13**) reported by Harvey et al.⁷ for the oxidation study and produced the ketones **12** and **14** in good yield (Scheme 1). The presence of acetic acid is required for the completion of the

reaction. We found that the progress of the reaction became very slow when carried out without acetic acid. However, use of sulfuric acid-acetic acid mixture (10:90) did not change the reaction time. In order to keep the reactants in contact with the oxidizing agent, acetone was added as a co-solvent.



The values in parentheses indicate reaction times in hours.

Oxidation of **1**, **5**, **7**, **9**, **11** and **13** produced monoketones **2**, **6**, **8**, **10**, **12**, and **14** in 50-90% yield. The presence of the diketone was not observed in the crude product while compound **3** produced a diketone **4** in 72% yield. No side products such as hydroxy, acetates, quinones, or dicarboxylic acid were observed during this oxidation.

The mechanism of the sodium bismuthate induced oxidation is not firmly established. Oxidation of phenols by sodium bismuthate in neutral aromatic solvent has been shown to proceed by one-electron^{3c} (through a radical intermediate) oxidation. Similar reaction in the presence of acetic acid as the solvent is believed to occur through a two-electron^{3f} (carbonium ion) oxidation process. The suggested mechanism has a close similarity to the chromic acid¹³ mediated benzylic oxidation. Thus, we hypothesize that our acid-catalyzed sodium bismuthate induced oxidation of benzylic methylenes may follow one of the processes mentioned above.

A representative procedure is as follows:

To the starting hydrocarbon (20 mmol) in aqueous acetic acid (4 mL, 50%, v/v) and acetone (2 mL), was added sodium bismuthate (80 mmol) and the mixture was heated to reflux. At the end of reactions as indicated by TLC, the mixture was filtered through a pad of Celite and diluted with water (10 mL). The mixture was extracted with methylene chloride (3 x 20 mL). The combined organic layer was washed with sodium bicarbonate solution (3 x 10 mL, 10%), brine (10 mL), dried over anhydrous sodium sulfate, and concentrated under reduced pressure. The resultant crude product was purified by column chromatography over silica gel using ethyl acetate-hexanes¹⁴.

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14. All products have been characterized through a comparison of mp, TLC and NMR with authentic compounds.