Sodium Bromate: An Eco-Friendly Brominating and Oxidizing Reagent

Compiled by Jie Lu

Jie Lu was born in Shijiazhuang, P. R. of China. She received her B.Sc. in 2008 from the Hebei Normal University of Science and Technology, P. R. of China. Currently she is working towards her M.Sc. degree under the supervision of Professor Zhan-Hui Zhang at Hebei Normal University. Her research interest is focused on the development of new reagents and catalysts in organic synthesis.

The College of Chemistry & Material Science, Hebei Normal University, Shijiazhuang 050016, P. R. of China
E-mail: lujiechem@gmail.com

Introduction

Sodium bromate is commercially available as an inexpensive stable white crystal, and has been extensively used in organic synthesis as an eco-friendly brominating and oxidizing reagent. It decomposes at 381 °C with liberation of oxygen. It can oxidize primary alcohols to aldehydes, secondary alcohols to ketones, sulfides to sulfoxides, hydroquinones and polyaromatics to quinones, thiols to disulfides, iodonobenzenes to iodoxybenzenes, and ortho-diols to dicarboxylic acids or lactones. Under different sets of conditions, the oxidation can result in the formation of esters and carboxylic acids.1 It has been used for oxidative cleavages of alkyl, trimethylsilyl, t-butyldimethylsilyl, tetrahydropyranyl ethers, and ethylene acetals to the corresponding carbonyl compounds.2,3 The transformations of benzylidene acetals to hydroxy esters with NaBrO3·Na2S2O4 in EtOAc–H2O biphasic medium are readily accomplished.4,5 Even more interesting is the finding that the reaction of cyclic ethers with sodium bromate in the presence of catalytic amounts of hydrobromic acid gave lactones.6 Sodium bromate can also serve as an effective bromohydroxylation reagent for alkenes, alkynes, and allylic alcohols.7 It has also been reported to be a powerful brominating agent for aromatic compounds including phenols, anilines, aromatic ethers, and benzenes.8,9

Abstracts

(A) Regio- and Stereoselective Bromination of Alkenes, Alkynes, Toluences, and Ketones:
An efficient NaBr/NaBrO3 system for the bromination of alkenes, alkynes, toluenes, and ketones has been developed by Adimurthy and co-workers.10 Treatment of several structurally diverse alkenes and alkynes with NaBr/NaBrO3 (5:1, BR-A) lead to the corresponding dibromides. On the other hand, the regioselective bromine substitution at the α-carbon of ketones and at the benzylic position of toluene derivatives can be accomplished with treatment with NaBr/NaBrO3 (2:1, BR-S) in aqueous acidic methanol or dichloromethane.

(B) Oxidation of Alkyl Arenes and Alcohols to the Corresponding Carbonyl Compounds:
The oxidation of primary and secondary alcohols with NaBrO3 and tungstophosphoric acid lead to aldehydes and ketones, respectively. In a similar manner, alkyl benzenes are regioselectively oxidized at the α-position to afford the corresponding ketones.11 The oxidation of alcohols and alkyl benzenes to carbonyl compounds can also be performed by treatment with NaBrO3 in ionic liquids.12
(C) Oxidation of Sulfides to Sulfoxides:
The oxidation of sulfides with NaBrO₃ in the presence of a catalytic amount of ceric ammonium nitrate (CAN) supported on silica lead to excellent yields of the corresponding sulfoxides with no overoxidation to sulfones.¹³ The oxidations of sulfides to sulfoxides can also be accomplished using an immobilized vanadyl, cobalt or nickel alkyl phosphonates.¹⁴

(D) Synthesis of Disulfides:
Khan and co-workers have reported that various aliphatic and functionalized aromatic thials can be converted into the corresponding disulfides using NaBrO₃, in a two-phase system of carbon tetrachloride and water in the presence of NaHSO₃.¹⁵ Furthermore, amino group, aliphatic alcohols and phenols were not affected under the same oxidative conditions.

(E) One-Pot Synthesis of α-Bromo Ketones:
Patil et al. reported that NaBr/NaBrO₃ can serve as an efficient and green brominating agent for the synthesis of α-bromo ketones by direct oxybromination of olefins.¹⁶

(F) Carbon–Hydrogen oxyfunctionalization of Cyclic Steroidal Ethers:
Lee and co-workers reported a new, mild protocol for site-specific carbon–hydrogen oxyfunctionalization of cyclic steroidal ethers using NaBrO₃ or NaIO₄ as terminal oxidants in biphasic EtOAc/MeCN–H₂O at 80 °C to furnish exclusively the 1,3-diaryl succinimides in high yields.

(G) Synthesis of N-Phenylsuccinimides:
A convenient and practical method for the synthesis of N-phenylsuccinimides by decarboxylative oxidation of α-carboxylic acids with NaBrO₃ in combination with ceric ammonium nitrate (CAN) has been developed.¹⁹ The reactions were performed in MeCN–H₂O at 80 °C to furnish exclusively the 1,3-diaryl succinimides in high yields.

References