

MODELING DISSOLVED OZONE AND BROMATE ION FORMATION IN OZONE CONTACTORS

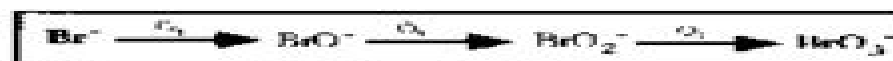
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Abstract. Many drinking water utilities that use source waters with significant bromide ion levels are currently seeking disinfection regimes that will minimize the formation of brominated disinfection byproducts while providing adequate disinfection. While ozonation appears to be a promising option for achieving these goals, the uncertainty of future drinking water regulations has developed a need for predicting actual disinfection byproduct formation prior to the costly investment for upgrading existing treatment facilities. The models developed in this paper provide comparisons of ozonation application methods, providing a basis for minimizing bromate and aiding in future design considerations. Theoretical and empirical models for the determination of ozone transferred, dissolved ozone concentrations, and bromate formation have been derived and compared with pilot-scale and full-scale data; a good agreement has been observed between the actual data and the predicted data, showing the validity of these models. True-batch bromate formation more closely simulated pilot-scale and full-scale data. Bromate formation in one stage vs two stage ozone contactors and different reactor configurations have been compared. Ozone gas phase concentration appears to have an effect on bromate formation as well.

1. Introduction

Ozone is a strong oxidant and it oxidizes bromide ion Br^- in water to bromate ion BrO_3^- through two different pathways. BrO_3^- can form through both a molecular ozone (O_3) pathway and a hydroxyl radical ($\text{OH}\cdot$)^{*} pathway, depending on the dissolved organic carbon (DOC), br^- content, and pH of the source waters (Richardson *et al.*, 1981 and Yates and Strenstrom, 1993). By the molecular ozone pathway, Br^- is first oxidized by dissolved ozone to hypobromite ion (OBr^-) which is then further oxidized to BrO_3^- as shown below.



This reaction is pH-dependent since BrO_3^- is in equilibrium with hypobromous acid (HOBr). The molecular ozone theory suggests that BrO_3^- formation is directly driven by dissolved ozone (DO_3) and the OH radical theory indicates that dissolved ozone plays only an indirect role by decomposing O_3 to produce radicals which further react with bromine species to produce BrO_3^- :

* OH radicals are produced as a result of the decomposition of molecular ozone (O_3) at pH>8.0. O_3 is highly selective as an oxidant whereas OH radicals are non-selective. The reaction rates of OH radicals with bromine species are many orders of magnitude faster than with O_3 .

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