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Influence of Ultraviolet Light Coupled with Hydrogen Peroxide Treatment on Organic Nitrogen and Carbon Precursors and Disinfection By-Product Formation

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Abstract

This study examined the relationships between organic matter composition and disinfection by-product formation potential (DBPFP) following water chlorination. Laboratory synthetic water with various compositions of organic carbon and nitrogen were treated with ultraviolet light, coupled with hydrogen peroxide (UV/H_2O_2), to assess the effects of UV/H_2O_2 on their DBPFPs. Biologically treated wastewater effluent and histamine dihydrochloride were spiked in the tested solutions to represent complex organic matter compositions and nitrogenated aromatic structure. It was found that carbon-containing precursors were relatively easier to mineralize by UV/H_2O_2 treatment than the nitrogen-containing compounds. UV/H_2O_2 processes successfully reduced the precursors of trihalomethanes and haloacetic acids (HAAs); however, the treatment efficiency was lower for *N*-nitrosodimethylamine (NDMA) precursors. It was also observed that the degree of precursor removal was reduced when raw water was contaminated by domestic wastewater effluents. In comparison to untreated water, UV/H_2O_2-treated water produced a higher ratio of HAAs than trihalomethanes after chlorination. This suggests that a higher fraction of hydrophilic compounds was obtained after UV/H_2O_2 treatment. Raw water impaired by wastewater effluent also altered the formation and species distribution of DBPs, because higher ratio of HAAs and brominated DBPs were observed.

Key words: UV/H_2O_2; dissolved organic nitrogen; nitrosodimethylamine; DBPFP; photodegradation

Introduction

Disinfection is used to provide sufficient control over bioactivities in potable water treatments. However, during the process, organic matters that are already present in water may react with chlorine and/or chloramines to form various carcinogenic disinfection by-products (DBPs). Thus, the application of chlorine to water containing high levels of natural organic matters (NOMs) would elevate DBP formation and may pose potential health concerns. In addition to conventional DBPs, new generations of DBPs such as nitrosamines and iodinated trihalomethanes (THMs) were found with substantial toxicity at low concentrations in drinking water treated with distinct disinfectants (Richardson, 2003; Krasner *et al.*, 2006). Consequently, the need to control DBP precursors became a crucial issue in ensuring the safety of drinking water.

The structure and functional groups of NOM may affect DBP formation. As a result, the prediction of DBP formation based on dissolved organic carbon (DOC) removal may not be sufficient. The sources of NOM in water can be categorized into fractions, allochthonous and autochthonous (Westerhoff and Mash, 2002). In areas where raw water was contaminated by wastewater effluent discharge, because of anthropogenic activities, higher levels of nitrogenous organics were present in the water. The elemental composition of wastewater effluent is similar to that of autochthonous substances, with considerable higher concentrations of pesticides, detergents, pharmaceuticals, and personal care products. Wastewater effluents that impair allochthonous NOMs pose a great threat to drinking water quality because of their high chlorine demands and formation of emerging DBPs such as *N*-nitrosodimethylamine (NDMA).

NDMA is a potent carcinogen. In some water systems, where wastewater-contaminated raw water is used and monochloramine was applied as the disinfectant, higher concentrations of NDMA were observed in the treated water. Choi and Valentine (2002) reported that dimethylamine (DMA) with the presence of dissolved oxygen and ammonia in water produced NDMA and various by-products after chlorination through the formation of unsymmetrical dimethyl hydrazine. Further studies have revealed that strong oxidants such as ozone, chlorine dioxide, and hydrogen peroxide (H_2O_2) react with DMA to form NDMA (Andrzejewski

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