Iodinated trihalomethanes in waters: a new class of toxic disinfection by-products

Disinfection of water supplies started in the early 1900s to reduce risks to public health from pathogenic microorganisms. Chlorination is the most common disinfection practice, achieving effective primary disinfection and sufficient disinfection residual in drinking water distribution. In the negative results, the potential formation of chlorination by-products has been widely recorded. Disinfection byproducts (DBPs) are formed when dissolved organic matter reacts with a chemical disinfectant (chlorine, chloramine, chlorine dioxide, ozone) in the presence of inorganic precursors, such as bromide or iodide. World Health Organization proposed guideline values for 15 DBPs in drinking water that exhibited sufficient toxicological evidence of carcinogenicity, genotoxicity or adverse reproductive incidences. Besides the regulated DBPs, currently there is also concern on emerging DBPs, such as iodinated DBPs. Iodinated DBPs (I-DBPs) were found to be more cytotoxic, mutagenic and genotoxic than their chlorinated and brominated analogues. The presence of I-DBPs in drinking water could be responsible for taste and odor issues. I-DBPs are formed during disinfection of iodide-containing water/wastewater with chlorine reagents. Currently there is interest on iodine-containing pharmaceuticals and their behavior under disinfection processes. Iodinated X-ray contrast media (ICM) is a class of pharmaceuticals commonly used for medical imaging of soft tissues. Wastewater treatment only partially remove ICM and these compounds are found in wastewater treatment plants effluents and receiving surface waters.

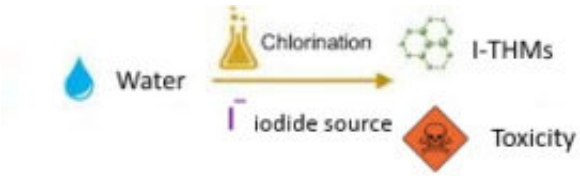

Fig. 1. Formation of I-THMs in water during chlorination.

Iodinated trihalomethanes (I-THMs) are a major group of I-DBPs, ubiquitous in wastewater effluents and surface water. Due to increase interest on I-THMs and possible negative health effects, various studies are currently investigating the formation of these compounds under disinfection practices. For our better understanding, our lab recently published a manuscript about the formation potential of I-THMs during chlorination of river water and wastewater in the presence of various iodide sources, such as potassium iodide (KI) and two iodinated X-ray contrast media, iopamidol and diatrizoate, usually occurring in waters. It is observed that the formation rates of I-THMs depend on the reactivity of organic precursors, chlorine agents, iodide sources and reaction time.

Among iodide sources, iopamidol significantly favors the formation of higher yields of I-THMs,

whereas inorganic iodide and diatrizoate are less reactive. Bromochloroiodomethane (CHBrClI) is the most abundant I-THM specie in all matrices, following by dibromoiodomethane ($CHBr_2I$) and dichloroiodomethane ($CHCl_2I$). These compounds are considered as emerging DBPs with moderate to elevated occurrence and relevant toxicity. Chlorination contact times affect significantly the formation of I-THMs depended with reactivity of precursor organic matter. At the begging of chlorination of river water, I-THMs species are rapidly increased up and after 24 h whereas a decreasing trend is usually observed with extended time. Chlorination of wastewater leads to rapid formation of I-THMs within the first 6 h, following by lower formation rate with extended time. In addition, varying concentrations of iodide agents in waters/wastewaters, as inorganic or organic form, play an important role on the formation of I-THMs. The formation and speciation of I-THMs is also affected by the molar ratio Br/I. This ratio may vary in water due to the seawater intrusion and salt deposits, as well as in wastewater due to discharges from chemical wastewaters, impact from municipal waste incinerators and seawater toilet flushing. Generally, increase of Br/I ratio enhances the formation of I-THMs, resulting in a change of speciation of I-THMs, with a shift to brominated-species (CHBrClI and $CHBr_2I$) and relevant decline of chlorinated ones.

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