Heterogeneous Fenton's reaction: a promising way for drinking water biofilm disinfection

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Summary
One of the most promising methods emerging from SecurEau for drinking water distribution system disinfection is based on Fenton's reaction. It was applied for the pesticide Paraquat decomposition in water (Santos *et al*. 2011. Chemical Engineering Journal 175, 279-290). Moreover Oliveira et al. (2012; 7th International Conference on Environmental Catalysis, Lyon, F, Sept 2-6, 2012) tested successfully the use of drinking water pipes deposits as catalyst in Fenton-like oxidation of organics. Fenton's reaction appears as a non-expensive and friendly environmental method. The process is known to generate powerful oxidative species as hydroxyl radicals $HO^{\cdot}$ through a succession of reactions involving iron and hydrogen peroxide at acidic pH. This powerful reaction could generate oxidants *in situ*, directly in the biofilm taking profit of the presence of species of interest as iron, and cupper in this attached biomass.

Preliminary assays were carried out with magnetite particles, which represent one of the abundant iron oxides in many corroded drinking water distribution systems. This crystallised Fe_3O_4 iron oxide (bearing one Fe II and two Fe III atoms organised in a spinel structure) is made of small particles of 0.1 µm or less in diameter. As pointed out by Matta et al. (2007; Sci Total Environ. 385, 242-251) it represents one interesting iron oxide for driving effective heterogeneous Fenton-like reactions and degrading organics. The assays were carried out at 23°C, in batch conditions, in drinking water acidified at pH 3 (sulphuric acid), spiked with H_2O_2 (1.5×10^{-2} M or 510 mg/L) and three concentrations of iron as magnetite (10^{-2}, 5×10^{-2}, and 10^{-1} M). We measured both the number of cultivable bacteria on R2A agar media at 20°C after 3, 7 and 14 days (expressed as CFU), and the total number of cells counted with a microscope after staining with the fluorochrome Sybr-II (expressed as cells).

First, the total number of cells decreased slightly after Fenton's treatment as the result from both slight sorption of bacteria onto magnetite particles, slight damage generated by H_2O_2, and intracellular damage caused by the $HO^{\cdot}$ generated in the assay, which limit the efficient staining of the cells as reported with many other oxidants.

Second, the number of culturable bacteria was dramatically affected by the treatment as a result of the slight sorption on magnetite particles, the acidification of the water to pH 3, and the generation of free radicals by the heterogeneous Fenton's reaction. Indeed this very rapid effect was iron concentration-dependant (the highest concentration of magnetite, the best disinfection).

This potential treatment is planned to be tested *in situ* on drinking water distribution pilots.

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