OH-radical formation in the Fenton process at high pH

Introduction

The Fenton process can be an effective way of treating water, to remove micropollutants without bromate formation and with respect to the costs. The Fenton process is an advanced oxidation process (AOP). Advanced oxidation processes use •OH, hydroxyl radicals to oxidize (in)organic compounds. This technology can be applied to the drinking water treatment practice. The principle of the Fenton process is the catalytic cycle of the reaction between iron (catalyst) and hydrogen peroxide (oxidant) to produce hydroxyl radicals. The system has its maximum catalytic effect at pH 3. At higher pH, competition between the reduction of ferric to ferrous iron, precipitation of ferric iron as ferric hydroxide and the formation of other (unknown) less reactive intermediates than OH-radicals might occur and reduce the process efficiency. Nevertheless, relevant organic pollutant degradation can be achieved by the ferrous iron concentration present in the groundwater and at ambient pH.

Importance

Groundwater used for drinking water production generally does not contain organic micropollutants, however, some sites have to cope with low concentrations of micropollutants such as pesticides. The Fenton process could be a suitable and cost-effective in degrading these components.

Approach

The Fenton process efficiency was investigated with two different types of anaerobic groundwater from two water treatment sites: Kamerik (Oasen) and Waalwijk (Brabant Water). The water at Kamerik was tested both with pilot scale and batch experiments. The other water type was only tested in a batch experiment. pCBA was used for the evaluation of the production of OH radicals. This component has a high reactivity with OH radicals. Experiments were carried out at different pH values (3.5 – 7), hydrogen peroxide concentrations (2 – 15 mg/l) and contact times (2 and 10 min).

Result

The results prove that the water quality parameters influence the OH radical production. The used waters contained iron in a concentration between 7 and 10 mg Fe (total)/l. These concentrations fit the Fenton process requirement, nevertheless the pCBA conversion, and thus the formation of OH radicals was different for the two waters: Both the pilot scale experiments and the batch experiments with the water from Kamerik showed low conversion (<15%) of pCBA at high pH values. Even after decreasing the NOM concentration by ion exchange, no significant pCBA conversion was observed. For the batch experiment with water from Waalwijk, depending on the experimental

conditions the pCBA conversion increased from 18% (pH 6.6; [H_2O_2] = 2 mg/l; 2 min) to 99% (pH 3.5; [H_2O_2] = 8 mg/l; 10 min). The high pCBA conversion level indicates OH radical formation and low scavenging rate at low pH values.
The Fenton process can work; even at ambient pH, but the water matrix and mainly the concentration of alkalinity, the type and concentration of DOC and the presence of different ligands play a prominent role in the formation and scavenging of oxidizing intermediates, which in turn determine the efficiency of the method towards micropollutant oxidation.

More information

Report: "Fenton process for Contaminant Control - Investigation of OH radical formation with two water types" (D. 2.4.1.2) by Julien Ogier, Danny Harmsen, Wolter Siegers and Anneke Abrahamse – Kiwa Water Research.
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