

# Removal of chromium (VI) from water by micro-alloyed aluminium composite (MAIC) under flow conditions

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## Abstract

This paper deals with Cr(VI) ion removal from water, by micro-alloyed aluminium composite (MAIC), under flow conditions. In a water environment the MAIC acts as a strong reducing agent. Dissolving it in water is accompanied by the generation of Al(III) ions and reduction of water to H<sub>2</sub>, with OH<sup>-</sup> ions. The final product is insoluble Al(OH)<sub>3</sub>. A series of Cr(VI) model solutions, with initial pH ranging between 1 and 5, were treated in the original semi-flow system (SFS), which simulated flow conditions well. The results demonstrate a high MAIC efficacy, considering that at the end of the treatment, concentrations of Cr(VI) were below the maximal allowed concentrations for drinking water, in all model solutions. The MAIC mechanism of action is based mainly on processes of reduction and co-precipitation by Al(OH)<sub>3</sub>, because Cr(VI) is removed from the water phase as metal chromium and insoluble Cr(OH)<sub>3</sub>. Behaviour of the composite in water is under significant influence of pH, which affects its efficacy and mechanism of action. Therefore, the rate of Cr(VI) removal is greater at the beginning, decreasing towards the end of the treatment. Additionally, the ratio of [metal chromium]/[Cr(OH)<sub>3</sub>] in precipitate, at the end of the treatment, decreases with increasing initial pH of the model solution. Application of the SFS significantly enlarges efficacy of the MAIC, compared to work under stationary conditions.

**Keywords:** chromium (VI) removal, wastewater, micro-alloyed aluminium, reduction, co-precipitation, flow conditions

## Introduction

Chromium is present in the environment in both trivalent and hexavalent oxidation states. Cr(III) occurs naturally and is an essential micronutrient (requirement is 50 to 200 µg per day) that assists the body in metabolising sugar, protein and fat. Cr(VI) is usually of anthropogenic origin and rarely occurs naturally (Barceloux, 1999; Barnhart, 1997). Chromium-plating processes are the main source of Cr(VI) pollution. Cr(VI) is a skin and mucous membrane irritant and some of these hexavalent compounds produce an allergic contact dermatitis characterised by eczema (Hassmanova et al., 2000; Kanerva et al., 2000); it is also recognised as a pulmonary carcinogen (Barceloux, 1999; Hassmanova et al., 2000). Because of these potential health hazards the maximum level of Cr(VI) allowed in drinking water is 0.05 mgCr·ℓ<sup>-1</sup> (*Standard Methods*, 1995). The remediation of Cr(VI)-contaminated industrial effluents is gaining great interest due to limitations in potable water supplies. The main strategies for Cr(VI) removal from wastewaters are precipitation as Cr(OH)<sub>3</sub> (Paterson, 1975; Cooney et al., 1992) and ion exchange (Tenorio and Espinosa, 2001). In addition, there are other options such as sorption onto various materials (Mesuere and Fish, 1992; Leinonen and Lehto, 2001; Selvi, 2001) and membrane filtration (Bohdziewicz, 2000; Alliane et al., 2001).

This study investigated a new treatment process for the removal of Cr(VI) from aqueous solutions by applying MAIC, under flow conditions. The composite consists of micro-alloyed aluminium

(MAI), coated over a thin iron wire. In aqueous solutions, it behaves like a strong reducing agent, which may affect various pollutants in water. Additionally, as a final product of the MAI, dissolution, water-insoluble Al(OH)<sub>3</sub> is produced, which may co-precipitate pollutants and their degradation products from the water phase (Bojic, 1997; Purenovic et al., 1998; Novakovic et al., 1998).

Previous studies (Bojic, 1997; Purenovic et al., 1998; Novakovic et al., 1998), which deal with purification of different wastewaters, show great MAIC efficacy. After water treatments, concentrations of pollutants were reduced for several logs in a relatively short period, and in many cases, they were below the maximum allowed concentrations. The major factors significant for MAIC efficacy are treatment time, the total area of applied composite wires and water convection. The influence of convection is obvious from previous studies which showed that composites have greater efficacy under flow conditions than under stationary conditions (Bojic et al., 2001; Bojic, 2002). Flow systems, applied in some experiments, were massive and impractical for laboratory work and therefore in this study an original semi-flow system was designed, which simulates flow conditions in small spaces (Bojic et al., 2001; Bojic, 2002). Mechanisms of MAIC action on various inorganic and organic compounds (Bojic, 1997; Purenovic et al., 1998; Novakovic et al., 1998), as well as micro-organisms in water (Bojic et al., 2001; Bojic, 2002), were also investigated. It is mainly based on reduction and hydrolysis. It is important to emphasise that in all prior studies no undesirable by-products were found in the water phase after treatment.

The results obtained in this work show that the MAIC treatment of Cr(VI) wastewaters is very efficient, simple and does not acquire any pretreatment, such as pH correction.

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Received 16 January 2004; accepted in revised form 5 March 2004.