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Activated carbon as a redox mediator on azo dye reduction: influence of surface chemistry and pH

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Abstract

Azo dyes account for about 60-70% of all dyes in textile, food, pharmaceutical, leather, cosmetics and paper industries and are the most common synthetic colorants released into the environment, causing undesirable colouring of surface waters, as well as toxicity and mutagenicity problems. Their removal is a major concern when treating dyeing-processing wastewaters. Under anaerobic conditions, azo dyes are non-specifically reduced, a fortuitous but often slow process. Acceleration can be achieved by using electron-shuttling compounds that speed up the reaction by acting as redox mediators. Activated carbon (AC) has been shown a feasible redox mediator. [1] Moreover, it was shown that the surface chemistry of AC plays a key role in dye adsorption performance. [2] In this study, the effect of modified AC on anaerobic chemical dye reduction was assayed. The surface chemistry of AC was selectively modified, without changing significantly its textural properties, by means of chemical oxidation using 6 M HNO_3 (AC with acidic surface properties) and thermal treatments (900 ºC) under a flow of H_2 or N_2 (AC with basic surface properties). Oxidation with 5% O_2 (in N_2) was also performed leading not only to surface chemistry changes (acidic properties), but also in the textural properties. Characterization of AC samples was also done. Four azo dyes from different classes, Acid Orange 7, Reactive Red 2, Mordant Yellow 10 and Direct Blue 71, were tested and at different pH values, 5, 7 and 9.

Batch experiments in the presence of low amounts of AC, demonstrated an increase of the first-order reduction rate constants for all the studied azo dyes as compared with assays without AC. The reduction of AO7 and MY10 with all the treated AC was highly dependent on the pH, with optimum rates at pH 5 and 7, respectively. Higher rates of RR2 and DB71 reduction were obtained at pH 5. The best decolourisation results were obtained with basic AC samples (AC_N_2 and AC_H_2). Comparing the rates of single dyes, MY10 was the faster reduced (12 ± 2.3 d^{-1}) and RR2 the slowest (1.3 ± 0.1 d^{-1}). In fact, MY10 was almost completely decolourised in 1 day. Colour removal of 80% was obtained for DB71 at a rate of 5.6 ± 0.3 d^{-1}. AO7 and RR2 were the most resistant to degradation (~ 60 %).

[1] van der Zee et al., 2003. Environ. Sci. Technol.: 37, 402-408.
[2] Pereira et al., 2003. Carbon 41: 811-821.
[3] Faria et al., 2005. Water research: 39, 1461-1470.