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Activated Carbon as a redox mediator: Effect of AC surface chemistry and solution pH on dye reduction

Luciana Pereira^{*1}, Raquel Pereira¹, Fernando Pereira², Frank van der Zee¹, Madalena Alves¹
¹University of Minho, Portugal, ²Faculdade Engenharia da Universidade do Porto, Portugal

Azo dyes have a wide application in food, pharmaceutical, textile, leather, cosmetics and paper industries. These are the largest and most versatile classes of dyes used, but are recalcitrant to biodegradation and many are carcinogenic or cytotoxic. Their removal is a major concern when treating dye-containing wastewaters. Under anaerobic conditions, they are non-specifically reduced, a fortuitous but often slow process. Acceleration can be achieved by using electron-shuttling compounds that speed up the reaction, acting as redox mediators. Activated carbon (AC) has been shown as a feasible redox mediator and adsorbent material. In this study, the surface chemistry of a commercial AC (AC₀) was selectively modified, without changing significantly its textural properties, by means of chemical oxidation with HNO₃ (AC_{HNO3}) (mild acidic surface properties) and thermal treatments under H₂ (AC_{H2}) or N₂ (AC_{N2}) flow (basic surface properties). Oxidation with 5% O₂ (AC_{O2}) ends not only in surface chemistry changes (acidic properties), but also in the textural properties. The effect of modified AC on anaerobic chemical dye reduction was assayed with sulphide as a reducing agent at different pH values: 5, 7 and 9. Four dyes from different classes were tested: Acid Orange 7, Reactive Red 2, Mordant Yellow 10 and Direct Blue 71. Batch experiments with low amounts of AC (0.1 g.L⁻¹) demonstrated an increase of the first-order reduction rate constants (~ 9-fold) for all the dyes tested as compared with assays without AC. The reduction of AO7 and MY10 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. In general, an increase of the rates with increasing the pH_{pzc} was observed, following the trend AC_{HNO3} < AC_{O2} < AC₀ < AC_{N2} < AC_{H2}. Comparing the rates of single dyes, MY10 was reduced at the highest rate (12 ± 1 d⁻¹) and RR2 at the lowest (1.3 ± 0.1 d⁻¹).

Keywords: Azo dye , Activated carbon, redox mediator, dye reduction