

Treatment of ink-containing wastewater by coagulation/flocculation using biopolymers

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Abstract

A coagulation/flocculation process using a selection of biopolymers (chitosan and tannin) was used to treat an ink-containing effluent generated in the processing of packaging. The efficiency of the process was investigated in terms of the influence of pH, coagulant and flocculant concentrations, as well as chitosan characteristics (especially the molecular weight). The process was particularly efficient under acidic solutions: the amount of coagulant and flocculant to be used were significantly reduced by limiting the pH to 5. Optimum conditions for colour abatement (measured at 528 nm) were obtained at pH 5 using the most viscous chitosan (highest molecular weight) at a concentration close to 20 mg·ℓ⁻¹ and a concentration of tannin close to 70-100 mg·ℓ⁻¹.

Keywords: chitosan, polymer concentration, molecular weight, poly-tannin, ink, coagulation, flocculation

Introduction

The packaging industry frequently uses dyes, pigments and inks for the conditioning of cardboard boxes and the printing of advertisements. The process generates highly coloured effluents that cannot be discharged without treatment due to the:

- Direct toxicity of these effluents
- Colour they impart is very undesirable to the water user (Chua and Loh, 2004).

Adsorption is the process which is most frequently employed for the treatment of coloured effluents, using for example activated carbon (McKay, 1983; Walker and Weatherley, 1999; Wu et al., 2001a; Yang and Al-Duri, 2001), resins (Karcher et al., 2002), agricultural wastes (Annadurai et al., 2002; Morais et al., 2000; Robinson et al., 2002), micro-organisms (Fu and Viraraghavan, 2003) and biopolymers (Chiou and Li, 2002; McCarrick et al., 2003; Wu et al., 2001b). However, this process usually comprises a simple transfer of pollutant from a dispersed phase to a concentrated phase. The use of expensive materials and the necessity to control the discharge of these loaded materials sometimes makes the process non-cost-effective. Biological processes are commonly cited for the treatment of coloured effluents alone (Bell and Buckley, 2003; Fu et al., 2001), or in combination with sorption processes (Walker and Weatherley, 1999). Some other processes such as photochemical (Arslan and Balcioglu, 2001; Genç, 2004) and catalytic degradation processes also exist. These oxidation processes may cause pollution hazards since in some cases the products generated during the oxidation are more hazardous for the environment than original contaminants. Membrane processes using nanofiltration techniques have recently received great attention

(Chabot et al., 1999; Diaper et al., 1996; Koyuncu et al., 2004). However, processes such as coagulation and flocculation are shown to be simpler and more cost-effective (Choi et al., 2001; Chu, 2001; Kacha et al., 2003; Kim et al., 2004; Metes et al., 2000; Zemaitaitiene et al., 2003). The use of some conventional materials for coagulation/flocculation is frequently discussed due to changes in environmental regulations (Divakaran and Pillai, 2001; Özacar and Sengil, 2003). For example, the use of inorganic salts (frequently used as coagulants) such as aluminium chloride or sulphate is now controversial due to the possible impact of aluminium on Alzheimer disease. Polyacrylamide is the basis of many flocculants and its discharge in the environment is now considered hazardous due to the possible release of monomers that could enter in the food chain, with potential impact on health (carcinogenic effect). For these reasons, the research recently focused on the use of bio-coagulants and bio-flocculants (Chen et al., 2003; Strand et al., 2003; Tripathy et al., 2001). Among these natural products, chitosan has received a great deal of attention for the past 20 years for many applications in wastewater treatment, including sorption of metal ions (Guibal, 2004), dyes (Gibbs et al., 2003; McCarrick et al., 2003), but also coagulation/flocculation (Ashmore and Hearn, 2000; Bratskaya et al., 2002; Divakaran and Pillai, 2002; Huang et al., 2000; Roussy et al., 2004; Strand et al., 2002). Chitosan is a polymer constituted of glucosamine and acetylglucosamine units. The presence of amine groups confers to this polymer interesting cationic properties in acidic solutions. The protonation of amine groups is also responsible for polymer dissolving. Tannins (polyphenolic products of plant origin) have also recently received attention for their potential application in coagulation and flocculation due to their anionic behaviour in solution (Özacar and Sengil, 2000; 2003). These polymers are divided into two groups, namely, the condensed tannins which are derivatives of flavanols, and the hydrolysable tannins, which are esters of a sugar, usually glucose (Özacar and Sengil, 2003). They carry carboxyl and hydroxyl groups.

The objective of the present study was to investigate the use of both chitosan and tannins (in combination) for the coagula-

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