

Advanced treatment of textile wastewater for reuse using electrochemical oxidation and membrane filtration

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Abstract

The treatment of textile wastewater for reuse using an electrochemical oxidation step combined with a membrane filtration step is reported in this paper. The electrolytical process is a traditional one, which is easy to scale up and to apply in practice. This paper proposes a modification of the transfer-flow membrane (TFM) module with fibres welded in an arc-shape to enhance the mechanical properties of the fibres and to increase the specific membrane surface of TFM modules. The goal of this research was to study the performance of the arc-shaped TFM module to demonstrate these sequences of electrochemical oxidation coupled with membrane filtration processes and to develop a potential dyehouse wastewater treatment system for reuse. Two testing sequences of electrochemical oxidation and membrane filtration were studied in a sequential batch order. The results show clearly that fibres welded in an arc-shape can enhance the mechanical properties of the fibres effectively and that electrochemical oxidation and membrane filtration as sequential processes are feasible. Electrochemical oxidation has a high removal (89.8% efficiency) of the chemical oxygen demand (COD) of the wastewater while the membrane filter can almost totally remove the total suspended solids (TSS) (nearly 100% reduction) and turbidity (98.3% elimination) in it. Coincidentally, their advantages make up for their disadvantages. After these two steps, all the wastewater indices decrease to low levels; in particular, COD levels are reduced to 18.2 mg·L⁻¹. The treated water can be reused in many production areas of the textile dyehouse factory. To take best advantage of this disposal system, the two processes should run in a rational sequence, with membrane filtration following the electrochemical oxidation process. With widely studied electrodes, this research offers a promising way for recycling textile wastewater.

Keywords: electrolysis, oxidation, membrane, dye, wastewater treatment

Introduction

Increasingly stringent effluent discharge permit limitations have been put into effect (Defazio and Lemley, 1999). The textile industry generally has difficulty in meeting wastewater discharge limits, particularly with regard to dissolved solids, ionic salts, pH, COD, colour, and sometimes, heavy metals (Author: This is a consulting firm and the name has to be written out in full: Steffen, Robertson and Kirsten, 1993; Lin and Peng, 1996; Vlyssides et al., 1999)

The problem of colour in textile dyehouse effluent and the possible problems associated with the discharge of dyes and dye degradation products are of concern. Traditional methods for dealing with this kind of wastewater are usually the biological, physical and chemical techniques as well as the various combinations of these. It has been widely reported that many dye chemicals are difficult to degrade using conventional biological treatment processes. It is more important to reuse this kind of wastewater than to discharge it after treatment in that the costs of chemicals, energy and water continually increase.

Many advanced treatments have been studied and electrochemical oxidation has been applied to many kinds of wastewater (Naumczyk et al., 1996; Simonsson, 1997). It is presented as an effective, selective, economical, and clean alternative for dealing with

wastewaters bearing high loads of organic compounds, especially some bio-refractory organic pollutants. Such treatment produces total degradation of compounds to CO₂ and H₂O or at least a considerable decrease in toxicity. A direct anodic process or an indirect anodic oxidation via the production of oxidants such as hydroxyl radicals, ozone, etc. usually destroys the organic and toxic pollutants present in wastewater such as dyes and phenols. Titanium electrodes covered with very thin layers of electrodeposited noble metals have recently been used for electro-oxidation. Electrodes can also be coated with ruthenium, rhodium, lead and stannum oxide (Vlyssides and Israilides, 1998; Chen et al., 2003; Taghizadeh et al., 2000). By means of electrochemical oxidation, pollutants in wastewater can be completely mineralised by electrolysis using high oxygen over-voltage anodes such as PbO₂ and boron-doped diamond. (Nicola and Badea, 1996; Tezuka and Jwasaki, 1996; Casado and Brillas, 1996). Naohide et al. (1998) treated dyestuff using PbO₂ anode. In their study, Orange II was decolourised completely by a 120 min electrolysis procedure using a PbO₂ anode at current density of 0.2 A cm⁻². Polcaro et al. (1999) studied the performance of the Ti/PbO₂ anode during electrolysis of 2-chlorophenol in terms of faradic yield and fraction of toxic intermediates removed. Ti/PbO₂ anode was used as the anode in this experiment, since it has been widely studied and used in some electrolysis industries, such as chlorine producing factories.

Membrane systems have also been reported in dyehouse wastewater treatment (Jadwiga et al., 1998; Wu et al., 1998 and Grimm et al., 1998). Membrane systems can successfully remove the large amount of suspended solids (SS) in wastewater. The aim of introducing membrane filtration is not only to reduce water

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