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The study of lead removal from aqueous solution using an electrochemical method with a stainless steel net electrode coated with single wall carbon nanotubes

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HIGHLIGHTS

- ▶ A new electrode was used to remove lead form solution on this study.
- ▶ The mechanism of lead removal on electrode surface was studied.
- ▶ The effects of experimental parameters on lead removal were investigated.
- ▶ High lead removal was obtained in both synthetically and real wastewaters.
- ▶ The exhausted electrode can be easily regenerated using acid rinsed.

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ABSTRACT

The present work focused on the removal of lead from aqueous solution on a laboratory scale in a lab-made Plexiglas cell using an electrochemical technique. Electrodes of stainless steel net coated with single wall carbon nanotubes (SWCNTs@SSN) were used as both the anode and cathode. The mechanism of lead removal involved that lead ions were reduced and deposited on the surface of the cathode. The effects of various parameters on the percentage of lead removal were investigated, including electrochemical treatment time, solution pH, applied voltage, electrolyte concentration, and the initial lead concentration. Under optimal conditions with 90 min treatment, the lead removal efficiencies ranged from 97.2% to 99.6% when the initial lead concentrations varied from 20 mg dm^{-3} to 150 mg dm^{-3}. The SWCNTs@SSN electrodes could be easily regenerated. The removal results for lead, iron and aluminum in a factory wastewater using the proposed method showed that the method could be regarded as a potential technique for the treatment of industrial wastewater containing heavy metal ions.

1. Introduction

Pollution caused by heavy metal ions has attracted great concern because of their high toxicity and non-degradable characteristics. As one of the heavy metals, lead has special industrial significance, being employed in the battery, paint, pigments, ammunition, petrol, cable, alloy, steel, plastics and glass industries. Lead ranks first in the list of prioritized hazardous substances issued by the Agency for Toxic Substances and Disease Registry (ATSDR) of the United States [1]. Once lead is taken into the human body, it causes severe damage to the kidney, nervous system, reproductive system, liver and brain. Long time exposure to lead can induce sterility, abortion, stillbirths and neo-natal deaths [2]. In drinking water, a lead concentration lower than 50 μg dm^{-3} is considered safe by the World Health Organization (WHO) [3], whereas 15 μg dm^{-3} is the allowable limit regulated by the United States Environmental Protection Agency (USEPA) [4,5]. It is important to remove lead from wastewaters before they are discharged to the environment.

Numerous methods have been studied to remove lead from water and wastewaters, including chemical precipitation [6], adsorption [7], bioadsorption [8], ion exchange [9], membrane separations [10] and solvent extraction [11]. However, all these methods have certain disadvantages, among which are that chemical precipitation leads to the production of toxic sludge; solvent extraction is not suitable for effluents containing less than 1 g dm^{-3} of targeted heavy metals; and the ion exchange process is too expensive due to the high cost of synthetic resins and resin regeneration. To exploit new high efficient methods for lead removal is thus necessary.

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