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Treatment of mixed chemical wastewater and the agglomeration mechanism via an internal electrolysis filter

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HIGHLIGHTS

▸ Internal electrolysis improved biodegradability and reduced biotoxicity of wastewater.
▸ Various techniques was used and determined the granular matters were $Fe(OH)_3$.
▸ The deposition of $Fe(OH)_3$ and its adsorption of organic species caused agglomeration.

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ABSTRACT

An actual mixed chemical wastewater was treated using internal electrolysis. A significant effect was observed, with an average chemical oxygen demand removal efficiency of 20%, a BOD_5/COD enhancement efficiency of 80%, and an acute biotoxicity removal efficiency of 60%. These results show that the technology can be efficiently applied to refractory wastewater. The fillings were agglomerated after 50 days of operation. The pressure drop of the reaction sharply increased from 70 cm H_2O to more than 100 cm H_2O indicating that the fillings were agglomerated, and the performances of the process were simultaneously reduced. Various techniques were used for characterization to determine the mechanism of agglomeration. Scanning electron microscopy (SEM) shows granular matters on the surface of the fillings, which induced agglomeration. X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) results indicate that the granular matters were ferric hydroxide [$Fe(OH)_3$] particles, which exhibited the amorphous crystal structure. XPS and Fourier transform infrared spectroscopy (FTIR) results indicate that the adsorption during the internal electrolysis process was via chemical adsorption, and $Fe(OH)_3$ could easily adsorb organic molecules containing electron-donating groups such as $-CONH_2$, $-COOH$, and $-CH_3$. The deposition of $Fe(OH)_3$ on the surface of the fillings and its subsequent adsorption of organic species were the primary cause of agglomeration in the internal electrolysis technology.

1. Introduction

Wastewaters from pharmaceutical factories and chemical plants are significant sources of environmental contamination. This kind of wastewater shows remarkable antibiotic effects to the microorganisms in traditional biological treatment processes [1,2]. Therefore, technologies that improve the biodegradability of these wastewaters should be developed [3].

Some efforts have been proposed to address this challenge. Physical–chemical technologies were used to modify the chemical characteristics of wastewater to render them treatable in biological systems without any adverse effects. Torres et al. [4] inoculated the coagulation and flocculation pretreatment of high-load wastewater from a chemical pharmaceutical industry to improve its biodegradability. Emad and Malay [5] used a combined photo-Fenton sequencing batch reactor process for antibiotic wastewater treatment. Microwave [6], ultrasonication [7], and other physical–chemical pretreatments [8,9] were also used to enhance the biodegradation of wastewater. However, these technologies are often expensive and difficult to apply directly in engineering.

The internal electrolysis technology, composed of mixture of iron (Fe) scraps and inert carbon (C) particles, has been extensively studied because the filling materials are cheap and easily available [3,7]. Previous papers have investigated the reduction of nitro-aromatic compounds [10,11], decolorization of dyes [12], and dechlorination of chlorinated organic compounds [13,14] via internal electrolysis. During this process, numerous electric cells are formed between Fe, which has low potential, and C, which has high potential, with wastewater acting as the electrolyte. The electrode reactions and their consequent electrochemical redox, electrophoretic deposition, and electrochemical coagulation reactions occur,

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