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Design of a novel sequencing batch internal micro-electrolysis reactor for treating mature landfill leachate

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ABSTRACT

A novel sequencing batch internal micro-electrolysis reactor (SIME) was specifically designed to treat mature landfill leachate. The idea of simulating the biological process of a sequencing batch activated sludge reactor (SBR) was employed in the design of the new reactor. The innovative concepts behind this design are the combination of the processes of reductive internal micro-electrolysis (IME) without aeration and oxidative IME with aeration, and the integration of electro-aggregation and electro-coagulation. The automated operating system in this reactor is centralized automation which rewards for safe control, convenient operation and the possibility of commercial application. The SIME reactor exhibited a COD removal efficiency of 86.1% for mature landfill leachate in this study, which is much higher than that of conventional treatments, such as electrolysis, coagulation–sedimentation, and the Fenton process. A pilot-scale experiment showed that the reactor was also particularly efficient in the removal of color, humic acids, and metal ions. The BOD_5/COD ratio of the leachate was significantly improved after the treatment. All of these results show that the SIME reactor is a promising new technology because it is efficient and automated, and has the potential to be applied to the practical treatment of mature landfill leachate.

Keywords: Advanced oxidation processes; Electrolysis; Fenton; Sequencing batch reactor; Zero valent iron

1. Introduction

Landfill leachates produced from sanitary landfills ought to be properly managed or treated. Otherwise, they can permeate ground water or mix with surface water and cause pollution of the soil, ground water, and surface water (Deng and Englehardt, 2006). However, mature leachate, which is characterized by a low biochemical oxygen demand after 5 days (BOD_5)/chemical oxygen demand (COD) ratio (<0.3) and a large proportion of high molecular-weight organics, is particularly challenging, especially for biological methods, due to its low biodegradable fraction of organics and constituent toxicity (Cortez et al., 2011; Yang, 2007). Mature landfill leachate is extremely stable after pretreatments (Lopez et al., 2004). Its composition varies substantially depending on the type of waste, site hydrology, waste compaction, amount of precipitation, cover design, landfill age, and pretreatment of the leachate (Christensen et al., 1998; Kurniawan et al., 2006; Renou et al., 2008; Wang et al., 2003). Hence, physicochemical processes may be required for full treatment of such leachate.

Among the potential physicochemical technologies for treating mature leachate, the internal micro-electrolysis (IME) method has been extensively studied in recent years (Ju and Hu, 2011; Ruan et al., 2010; Wang et al., 2003). It operates on a principle very similar to that of electrolysis, except that the electrons are supplied from galvanic corrosion of many micro-scale sacrificial anodes instead of external power (Cheng et al., 2007; Liu et al., 2010; Scherer et al., 1998). Most studies have been conducted under anoxic conditions (Aziz et al., 2010; Chang et al., 2009a,b), and IME is generally believed to be reductive under these conditions (Chang et al., 2009a,b; Hardy and Gillham, 1996; Shi et al., 2011). Recent studies have reported the use of aeration to modify the reductive IME process to be oxidative (Deng and Englehardt, 2009; Ju and Hu, 2011). Under aerating conditions in the IME reactor, oxygen competes as the electron acceptor and H_2O_2 is

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