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An alternative treatment process for upgrade of petroleum refinery wastewater using electrocoagulation

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Abstract: An electrocoagulation treatment process was developed for treatment and upgrade of petroleum refinery effluent (wastewater), instead of the conventional methods, which can consume higher amounts of chemicals and produce larger amounts of sludge. The effect of the operation parameters, such as current density, initial pH, anode material, anode dissolution, energy consumption and electrolysis time, on treatment efficiency was investigated. The experimental results showed that the effluent can be effectively treated under optimal conditions. Fourier transform infrared (FTIR) analysis of the effluent, and scanning electron microscopy (SEM) coupled with energy dispersive analysis of X-rays (EDAX) of the sludge produced, revealed that the unwanted pollutants can be eliminated. The electrocoagulation treatment process was assessed by using the removal efficiency of chemical oxygen demand (COD), total suspended solids (TSS), and the general physicochemical characteristics of wastewater, and the results showed that the electrocoagulation is an efficient process for recycling of petroleum wastewater; it is faster and provides better quality of treated water than the conventional methods.

Key words: COD/TSS reduction, electrocoagulation, petroleum refinery effluent, recycle, sludge analysis.

1 Introduction

Petroleum refining is an essential step in converting crude oil into useful products through a series of processes (Diya'uddeen et al, 2011; Yavuz et al, 2010). Usuallyabout 240-340 L of water is consumed when processing of a barrel of crude oil (Diya'uddeen et al, 2012) and huge amounts of wastewater are generated during these processes (about 70-90 percent of the water supplied to the petroleum refinery comes out as wastewater). Wastewater generated by petroleum refineries is characterized by high concentrations of aliphatic and aromatic petroleum hydrocarbons, which usually have detrimental and harmful effects on plant and aquatic life, as well as ground water sources (Wake, 2005). Fortunately, a high proportion of wastewater generated by the petroleum refinery can be recycled/reused. The remaining wastewater after a combination of treatment stepswould be reduced to the allowable limit, in accordance with the international regulations, before the wastewater can be discharged (Prather, 1970). Fig. 1 shows the water balance in a typical petroleum refinery.

A number of criteria have been suggested for evaluating a particular technology for upgrading refinery wastewater, including (IPIECA, 2010):

• The ability to achieve the required product water specification;
• Simple equipment, ease of operation, and flexibility;
• Minimum processing time;
• Reduced capital and operating cost; and
• Lesser space requirement.

In recent years, there has been an increasing interest in the application of electrochemical coagulation in the treatment and purification of industrial wastewater. The treatment of petroleum refinery effluents by electrochemical coagulation has been reported by a number of researchers, supporting the technical feasibility of the process (Abdelwahab et al, 2009; El-Naas, 2010; El-Naas et al, 2009; Martínez-Delgadillo et al, 2010; Yang, 2007). It consumes less chemicals with low sludge production. In addition, the electrochemical coagulationprocess required less time to reach the standard limit for recycling water than other conventional methods (Mohan et al, 2007). Electrocoagulation is an electrochemical technique, which generates the coagulant in situ by anodic dissolution, and subsequently produce metal hydroxides having a considerable sorption capacity. Simultaneously a cathodic reaction allows for pollutant removal either by

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