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Treatment of petroleum refinery wastewater by electro-Fenton process using porous graphite electrodes

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Abstract

The present paper deals with the treatment of wastewaters generated from Al-Dewaniya petroleum refinery plant by Electro-Fenton process in a batch electrochemical reactor using porous graphite as anode and cathode materials. Effects of operating factors such as current density (5-25mA/cm^2), $FeSO_4$ concentration (0.1-0.7mM), NaCl addition (0-2g/l), and time (15–45min) on the efficiency of the chemical oxygen demand (COD) removal were studied. The results revealed that $FeSO_4$ concentration has the main effect on the efficiency of COD removal confirming that the Electro-Fenton process was governed by reaction conditions in the bulk of solution between ferrous ions and H_2O_2 not upon the electrochemical reactions on the surface of electrodes. Parametric optimization was carried out using response surface methodology (RSM) combined with Box–Behnken Design (BBD) to maximize the removal of COD. Under optimized operating conditions: $FeSO_4$ concentration (0.7mM), current density (25 A/cm^2), and time (45 min) with no addition of NaCl, the removal efficiency of COD was found to be 95.9% with an energy consumption of 8.921kWh/kg COD.

Keywords: petroleum refinery wastewater; Electro-Fenton process; porous graphite; Response surface methodology; COD removal**.**

1. Introduction

In Petroleum refinery process, crude oil converts into its main fractions using physical, thermal, and chemical separation stages then these fractions are further handled via a series of other conversion and separation steps into final products like gasoline, liquefied petroleum gas (LPG), , diesel fuels, kerosene, lubrication oils and many others. For the purpose of getting these products, large quantity of fresh water is utilized for refinery processes, mainly for hydro-treating, distillation, desalting and cooling systems [1]. Nearby 80-90 % of fresh water used in petroleum refinery process convert into wastewaters. During the production stage in the oil refinery processing, the amount of water utilized in this stage was found to be in the range from 0.4 to 1.6 times the amount (volume) of processed oil as reported by Coelho et al. [2]. In this case, the wastewater generated from the oil refinery processing, if not treated, may lead to severe damage to the environment.

The type and concentration of the components involved in the generated wastewaters are based on the type of oils, mode of manufacturing, and process configuration. The polluted wastewater generated by refineries contain COD concentration of nearly 300–600 mg/L; phenol concentration of 20–200 mg/L; benzene concentration of 1–100 mg/L; heavy metals with concentrations as chrome (0.1–100 mg/L), as lead (0.2–10 mg/L), and other contaminants [3]. Direct discharge of these wastewaters could lead to essential pollution problems for the environment due to the high content of polycyclic aromatic compounds that have very toxic effects on the environment since they have the ability to be existed in the environment for a long time. Therefore, it should be treated these effluents before discharging [4].

The traditional methods used for treating of these wastewaters are physical, mechanical, and chemical, usually accompanying with biological treatment. The traditional treatments involve gravitational or centrifugation separations, adsorption with activated carbon, application of coagulants, filtration, flotation, and among others [5,6]. These traditional methods be able to remove solids and emulsified oil as well as free oil in suspension from the wastewater, besides to decreasing

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