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Review

# Emerging usage of electrocoagulation technology for oil removal from wastewater: A review

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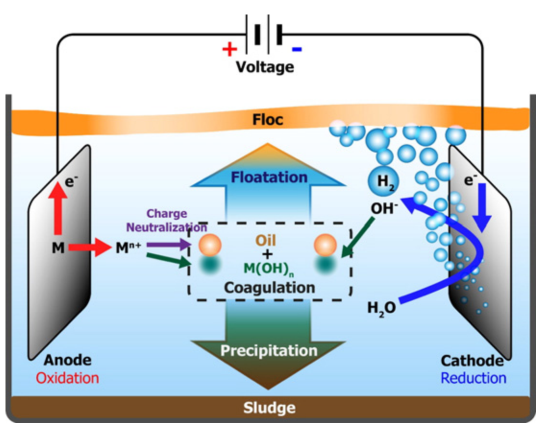
## HIGHLIGHTS

- Oil is one of the most important hydrocarbon products in the modern world.
- There is a significant increase in the amount of oil-containing wastewater.
- This review provides a deep insight into the electrocoagulation for oil removal.
- It presents a full-scale review on the most recent efforts in this emerging field.

## GRAPHICAL ABSTRACT

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## ABSTRACT

Electrocoagulation is a simple and efficient treatment method involving the electrodissolution of sacrificial anodes and formation of hydroxo-metal products as coagulants, while the simultaneous production of hydrogen at the cathode facilitates the pollutant removal by flotation. Oil is one of the most important hydrocarbon products in the modern world. It can cause environmental pollution during various stages of production, transportation, refining and use. Electrocoagulation treatment is particularly effective for destabilization of oil-in-water emulsions by neutralizing charges and bonding oil pollutants to generated flocs and hydrogen bubbles. The development of electrocoagulation technologies provided a promising alternative for oil removal from wastewater. This paper presents a review of emerging electrochemical technologies used for treating oil-containing wastewater. It includes a brief description of the oily wastewater origin and characteristics. The treatment processes developed so far for oily wastewater and the electrocoagulation mechanisms are also introduced. This paper summarizes the current applications of electrocoagulation for oil removal from wastewater. The factors that influence the electrocoagulation treatment efficiencies as well as the process optimization and modeling studies are discussed. The state-of-the-art and development trends of electrocoagulation process for oil removal are further introduced.



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**Contents**



## 1. Introduction

Oil is one of the most important hydrocarbon products in the modern world (Hildenbrand et al., 2016; Rengasamy et al., 2011). Oils may be released into the environment at various stages of production, transportation, refining and use. Major industrial sources of oily wastewater include oil refineries, petrochemical, metal manufacture, machining and finishing, food processing, textile and leather (Kajitvichyanukul et al., 2011). Oily wastewater can also come from municipal sources such as kitchen and human wastes (Hussein et al., 2008). Oils found in contaminated water can be fats, lubricants, cutting liquids, tars, grease, crude oils, diesel oil, kerosene, jet fuel, gasoline, etc. (Srinivasan and Viraraghavan, 2010). Oil concentrations in effluent also vary quite widely in different sources, from 1 to as high as 40,000 mg/L (Zouboulis and Avranas, 2000). With the rapid industrial and urbanization development during the past decades, a large amount of oily wastewater is generated from various sources (Suzuki and Maruyama, 2005). The global amount of oily wastewater was 9–14 billion $m^3$ in 2012 (Gitis and Rothenberg, 2016). When discharged to the environment, oily wastewater causes the formation of surface films and shoreline deposits, which impact ecological resources and functions (Barrera-Díaz et al., 2006; Noh et al., 2015). It can affect surface and groundwater resources, endangering aquatic system and human health (Fox et al., 2016; Phillips et al., 2015). The biodegradability of oil in natural ecosystem is low and oily components can hinder biological functions in the environment for a long time. Therefore, it is essential to remove oil from wastewater before discharge.

Oil removal from wastewater is regarded to be a main challenge in treatment practices. Dispersed oil droplets usually have high surface charges, resulting in the stability of oil-in-water system. This is especially true when emulsified oil exists. Emulsion generation and stabilization are usually achieved by mechanical agitation and addition of emulsifying agents. Although qualitative and quantitative compositions of oily wastes are different in many effluent sources, significant part of oil is always present in the emulsified form (Bratskaya et al., 2006). Some available technologies such as gravity separation, cyclone separation, chemical precipitation, sorption, membrane filtration and chemical oxidation have been used for oil removal (Adebajo et al., 2003; Andreozzi et al., 2000; Ezzati et al., 2005; Husveg et al., 2007; Wilkinson et al., 2000). Although many advantages of these technologies have been reported, some specific disadvantages associated with these approaches (i.e. low efficiency, long processing time, secondary pollution and high