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Study on removal of COD from some industrial liquid waste by electrocoagulation technique

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ABSRTRACT

In this study, the removal of vegetable oil from wastewater by electrocoagulation (EC) using aluminium electrodes in a batch reactor was investigated. The effect of operating parameters such as current density, electrolyte (NaCl) concentration, pH and initial oil concentration were studied, while chemical oxygen demand (COD) was calculated as an indication. The results illustrated that by increasing the current density the percentage removal of COD increased. The increase in the NaCl concentration increased the COD removal efficiency. The optimum pH for EC was found to be 7. And finally, the COD removal efficiency decreased as the initial oil concentration was increased from 10 – 80 ppm.

Keywords: Vegetable oil; sodium chloride; liquid waste; Aluminium electrodes; COD

INTRODUCTION

Control of water pollution has reached primary importance in developed and a number of developing countries. The prevention of pollution at source, the precautionary principle and the prior licensing of wastewater discharges by competent authorities have become key elements of successful policies for preventing, controlling and reducing inputs of hazardous substances, nutrients and other water pollutants from point sources into aquatic ecosystems [1].

There is a growth in demand for new water treatment technologies as the world's population increases and fresh water sources are polluted. Waterborne diseases are still common in developing countries due to the lack of funding or appropriate know-how for water purification. Industry also uses these limited water sources and has to acquiesce to lower quality raw water as a higher proportion of fresh water is required for human consumption. Wastewater treatment technologies used in both municipal and industrial applications have to be further developed in order to reduce the pollution of receiving water bodies [2]. Thus, more attention needs to be directed towards developing various means to provide people with improved water supply.

In view of the increasingly stringent environmental policy adopted by industrialized countries, a growing attention has been directed to the problem of water pollution by oil–water emulsion generated by several industrial activities such as refineries, machining shops, off-shore platforms, automotive repair shops and oil transportation, distribution and storage facilities. Oil–water emulsions not only represent an environmental hazard to aquatic life by virtue of the increase in biological oxygen demand (BOD) but also threaten human life. Methods of demulsification oil–water emulsion include chemical, mechanical and electrochemical techniques. Chemical coagulation is carried out by adding salts such as ferric sulphate or aluminium sulphate to the emulsion followed by a precipitation reaction. This method generates a high water-content sludge with attendant dewatering and disposal problems beside the high cost of the coagulating chemicals. Mechanical methods such as ultrafiltration are limited in use because of the rapid fouling of the membranes used in ultrafiltration[3]. Electrocoagulation is receiving an increasing acceptance by industry in view of its advantages compared to other methods [4-9]. Electrocoagulation is a simple and efficient method where the flocculating agent is generated in situ by electro-oxidation of a sacrificial anode [10]. In addition, EC has been applied to treat water containing oil wastes [11-12], textile wastewaters [13], foodstuff wastes [14], dyes [15], heavy metal-containing solution [16] and fluoride [17]. The electrocoagulation/floatation process provides an alternative technique for removing pollutants from water and waste water. This process involves applying an electric current to sacrificial electrodes inside a reactor tank. The electrodes generate the positive and negative ions which combine to form metal hydroxides flocs. These metal hydroxide flocs combine with the destabilized contaminants creating metal oxides and hydroxides which precipitate. Along with ions generation, hydrogen gas bubbles are also generated from the cathode. These gas bubbles stick to the pollutant particles and float them to surface of the water. The EC treatment technology offers an alternative to the use of metal salts or polymers and polyelectrolyte addition for breaking stable emulsions and suspensions and allow for easier removal of pollutants by sedimentation and flotation [18].

It was stated that coagulation occurs with the current being applied, capable of removing small particles since direct current applied, setting them into motion. Also electrocoagulation could reduce residue for waste production [19].

Electrocoagulation consists of pairs of metal sheets called electrodes, that are arranged in pairs of two—anodes and cathodes. Using the principles of electrochemistry, the cathode is oxidized (loses electrons), while the water is reduced (gains electrons), thereby making the wastewater better treated. When the cathode electrode makes contact with the wastewater, the metal is emitted into the apparatus. When this happens, the particulates are neutralized by the formation of hydroxide complexes for the purpose of forming agglomerates. These agglomerates begin to form at the bottom of the tank and can be removed through filtration [20].

MATERIALS AND METHODS

The electrocoagulation set-up is schematically shown in Fig.(1). The cell used consisted of a cylindrical vessel with a 10 cm diameter and holds up to 1.5 liters. Aluminium electrodes are used; a cylindrical anode was fixed and mounted vertically in the cell and an aluminium disk cathode was fixed in the bottom of the cell. The distance between the anode and cathode was about 0.5 cm. the volume of liquid treated is 1 L. A direct current source was used to supply the system with a constant current density; the effect of the electrocoagulation treatment was determined by analysis of the chemical oxygen demand (COD) at different time intervals. Synthetic emulsions of initial oil concentration of (10, 40, 80 ppm) were prepared by mixing vegetable oil with distilled water with the aid of 1 ml/L Tween 80 and using an electric stirrer at speed of 1000 rpm and the suitable concentration of NaCl.

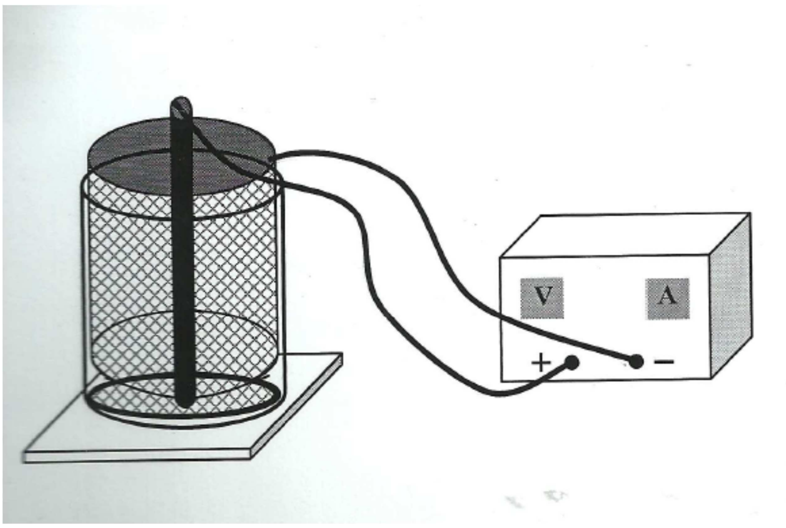

Figure 1. A schematic diagram for the electrocoagulation cell

RESULTS AND DISCUSSION

3.1 Effect of current density

Current density is described as the amount of current applied per surface area of the anode. Figure (2) shows that at constant initial oil concentration, pH, temperature and NaCl concentration it is found that the percentage COD removal increased with increasing the current density.

In former studies it was shown that current density strongly affects the performance of electrocoagulation [11].

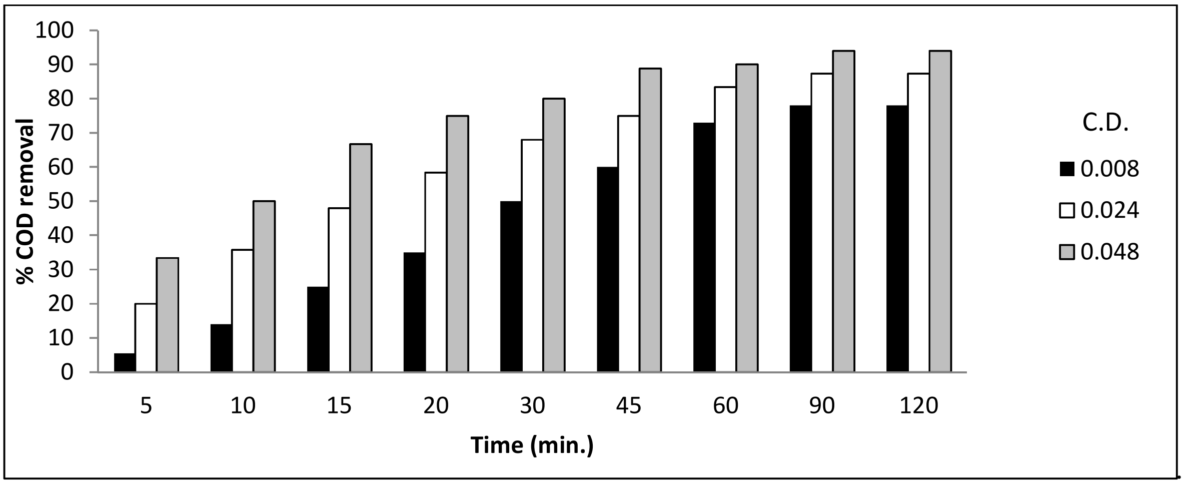

Figure 2. Effect of current density on % removal of vegetable oil
(Operating conditions: C_o=30 ppm, pH= 7 , NaCl concentration= 1 g/L , Temperature= 25˚C)

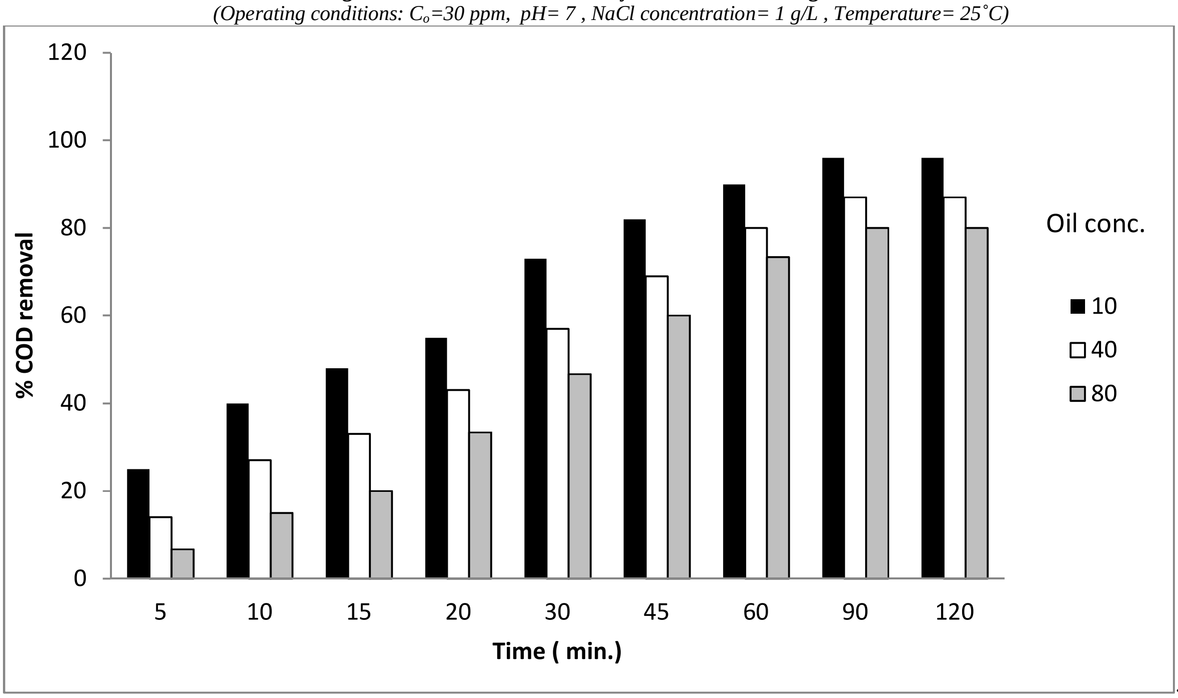

Figure 3. Effect of initial oil concentration on % removal of vegetable oil
(Operating conditions: pH= 7 , Current density= 0.016 mA/cm^2 , NaCl concentration=1 g/L , Temperature= 25˚C)

3.2 Effect of initial oil concentration

Figure (3) illustrates the effect of the initial oil concentration at 10, 40 and 80 ppm. It shows that the increase in concentration at constant electrocoagulation time results in decrease in the removal efficiency. The highest removal efficiency was achieved at 10 ppm. These results are in accordance with previous studies which reached the same results [21].

3.3 Effect of initial pH of the solution.

The pH is one of the important factors affecting the performance of electrochemical process. Figure (4) shows the effect of the initial pH of the solution on the percentage removal of oil at 40 ppm. In the acidic range (pH <7), the removal efficiency increased till it reached the neutral range (pH=7) and then it decreased back as the pH was increased to the basic range (pH>7).

So the best results were achieved at pH=7.

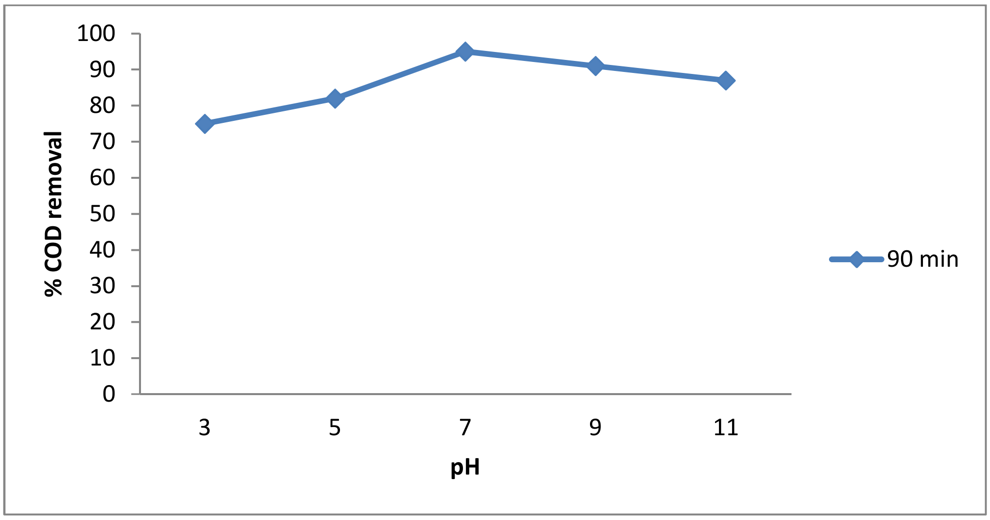

Figure 4. Effect of pH on % removal of vegetable oil
(Operating conditions: C_o= 40 ppm, Current density=0.016 mA/cm^2 , NaCl concentration=1 mg/L, Temperature=25˚C)

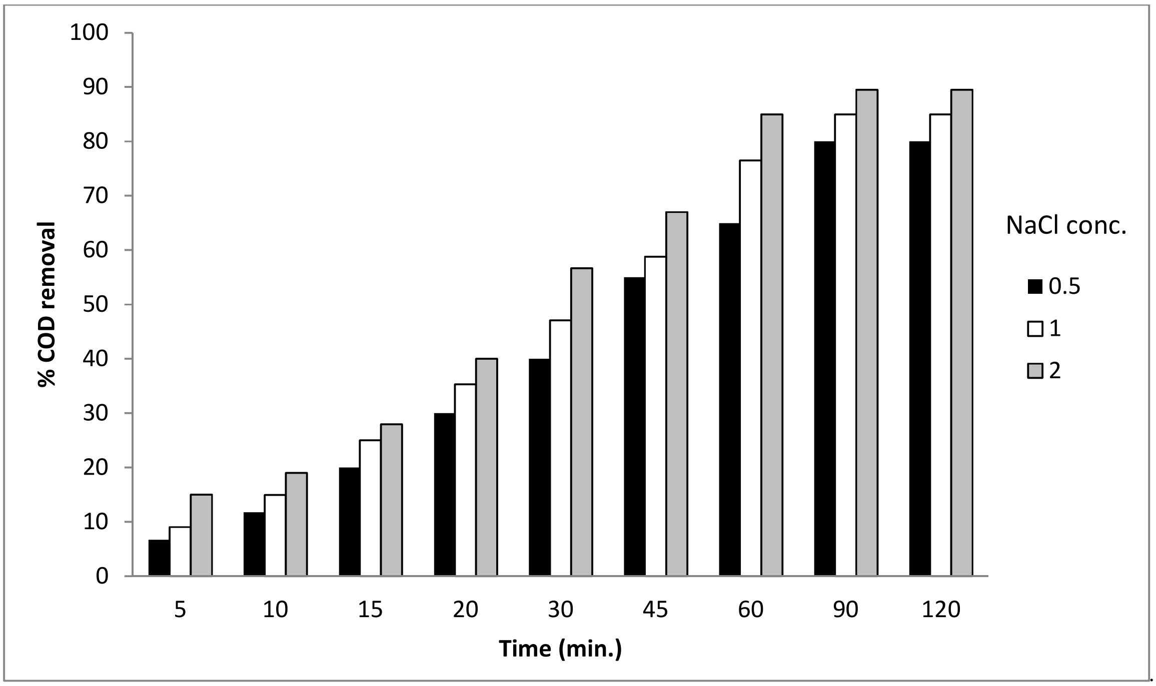

Figure 5. Effect of NaCl concentration on % removal of vegetable oil
(Operating conditions: C_o=30 ppm, pH=7 , Current density=0.016 mA/cm^2 , Temperature=25˚C)

3.4 Effect of electrolyte concentration

NaCl is usually employed to increase the conductivity of the water or the wastes to be treated, rather than sulphates and nitrates. The presence of the chloride ion in solution has been reported to decrease passivation of the Al surface and thereby increase the efficiency of electrocoagulation processes [22].

Figure (5) shows the influence of NaCl concentration, ranging from (0.5 to 2 g/L), on the percentage removal of oil at 30 ppm. The results show that the increasing concentration of NaCl has improved the percentage of oil removal, the optimum condition of this study was NaCl= 1 g/L taking into consideration the slight increase in the removal percentage beyond 1g/L. Previous studies have also showed the same behavior [23].

CONCLUSION

- The use of chemicals in electrocoagulation technique is very limited.
- Electrocoagulation efficiency depends on various parameters.
- Electrocoagulation can be used for effective removal of oil from wastewater.
- Removal efficiency increases with increasing the current density.
- The increase in electrolyte concentration (NaCl) increases the removal efficiency.
- The best removal efficiency was reached in the neutral range (pH=7).
- The removal efficiency decreases as the initial oil concentration increases.
- Removal efficiency increases by increasing the electrocoagulation time.

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