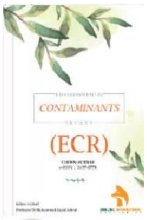
Environmental Contaminants Reviews (ECR)

DOI: http://doi.org/10.26480/ecr.02.2024.36.38

ISSN: 2637-0778 (Online)
CODEN: ECRNAE



RESEARCH ARTICLE

ELECTRO-FENTON PROCESS FOR THE TREATMENT OF WASTEWATER OF ERBIL CITY KURDISTAN REGION, IRAQ

Tablo Abdulrahim Ahmed

University of Salahaddin-Erbil/College of Science, Department Environmental Science and health. KRI, Iraq.
Corresponding Author Email: tablo.ahmed@su.edu.krd

ARTICLE DETAILS

Article History:

Received 15 February 2024
Revised 18 March 2024
Accepted 22 April 2024
Available online 30 April 2024

ABSTRACT

An emerging method of treating water and wastewater is the electro-Fenton process. Electro-Fenton is particularly helpful in treating stubborn compounds that are difficult for traditional water and wastewater treatment plants to break down. It works by using hydroxyl radicals to oxidize hazardous contaminants. This study examines the principles and most recent advancements in the electro-Fenton process, wastewater treatment through the application of EFP, and the benefits of EFP for wastewater remediation from different pollutants. It also focuses on the effects of different operating parameters and the most recent advancements in the electro-Fenton process, observing their optimal ranges for maximum pollutant removal through this process. The obtained results indicated that the authenticated response to the chemical oxygen demand (COD) removal was 89.82%, at optimum values of pH, FeSO4.7H2O dose, H2O2 dose, reaction time and current density of 3, 1 g/L, 8.38 g/L, 50 min, and 4.23 mA/cm2, respectively.

KEYWORDS

Electro-Fenton, hydroxyl radical, water treatment, wastewater treatment

1. INTRODUCTION

Since several industries have produced large amounts of wastewater and water in recent years, the water has become contaminated with organic matter. Considerable risks to the environment and public health are posed by these organic compounds found in water. The advanced oxidation process (AOPs) is one of the newer techniques for treating wastewater. EFPs, or the Electro-Fenton Process, are among the best methods for treating wastewater in AOPs. Significant deterioration in water quality has occurred in the last few decades, mostly due to increased industrialization, urbanization, population growth, and unsustainable use of natural water resources. The variety and quantity of pollutants entering water streams are increasing. Among the contaminants that are already there but are becoming more of a concern are emerging pollutants like pesticides, solvents, surfactants, pharmaceuticals, and personal care items. As stated there are currently over 700 newly discovered contaminants in aquatic environments, along with their metabolites and transformation byproducts by (Geissen et al., 2015).

Due to their affordability, biological treatments are currently the most widely used procedures in wastewater treatment facilities (Ganzenko et al., 2014). However, biorefractory pollutants and their metabolites—which also happen to find their way into waterways through sewage effluents—were not intended for these conventional plants to handle (Luo et al., 2014). This has led to increased public awareness of environmental issues and the passage of environmental protection laws as well as other initiatives aimed at reducing the harmful effects of pollution. Directive 2013/39/UE and the Watch List in Decision 2015/495/UE, two pieces of European Union legislation that specifically address this issue, require the monitoring of 41 organic priority substances and 17 contaminants of emerging concern in surface water, respectively. Moreover, in order to eliminate those compounds, the Directive 2013/39/UE highlights the need for developing innovative water treatment techniques (Sousa et al., 2018). As a result, there has been a lot of interest in research into the development of these alternative water treatments. Wastewater containing hazardous organic compounds that are either non-biodegradable or poorly biodegradable can be treated using advanced oxidation processes (AOPs), a promising class of new water treatment technologies. The hydroxyl radical (HO⅄), which is capable of removing a variety of pollutants from water streams, is one of the powerful oxidizing agents that form the basis of AOPs. A prerequisite for ensuring the efficiency of AOPs is HO● generation (Dewil et al., 2017). There are several proposed mechanisms to explain the production of these radicals. The techniques are classified based on whether light irradiation, ultrasound, electric fields, or both are utilized, and if the reaction occurs in a homogeneous or heterogeneous system. With many significant advantages, such as high pollutants mineralization and relatively low operating costs, electrochemical advanced oxidation processes (EAOPs) are considered to be one of the most promising technologies among all of these approaches (Sirés et al., 2014).

For the treatment of wastewater containing organic compounds, such as aromatics, electro-ferton is one of the most effective and environmentally friendly new technologies. This technology has been developed and applied extensively by numerous research groups, including the Brillas and Oturan groups (Brillas et al., 2009; Oturan and Aaron, 2014). The following steps make up the mechanism of this process: One method of producing H2O2 in situ is by oxygen cathodic reduction (Eq. (1)), which relies on the concentration of dissolved oxygen and the strength of the applied current. When materials like boron doped diamond (BDD) are used as anode, ii) encouraging the formation of HO• physisorbed (anode(HO•)) on the electrode surface, following the reactions shown in Eqs. (3) and (4); iii) producing HO● (Eq. (2)) via Fenton's reaction between ferrous ion and electrogenerated H2O2. (Barhoumi et al., 2017); iv) regeneration of Fe3+/Fe2+ by direct reduction on the cathode (Eq. (5)

$$O2 + 2H+ + 2e- \rightarrow H_2O_2 \qquad (1)$$

Quick Response Code	Access this article online	
	Website: www.contaminantsreviews.com	**DOI:** 10.26480/ecr.02.2024.36.38

Cite The Article: Tablo Abdulrahim Ahmed (2024). Electro-Fenton Process for The Treatment of Wastewater of Erbil City Kurdistan Region, Iraq. *Environmental Contaminants Reviews, 7(1): 36-38.*

$Fe^{2+} + H_2O_2 + H^+ \rightarrow Fe^{3+} + OH^- + HO\bullet$ (2)

$BDD + H_2O \rightarrow BDD(\bullet OH) + H^+ + e^-$ (3)

Organic compounds + $BDD(\bullet OH)$ yields BDD + oxidized products. (4)

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ (5)

Furthermore, the electro-Fenton process could be used as a first treatment step in combination with biological treatment methods. This bioelectro-Fenton process combines the high oxidation power of the electro-Fenton with the commercial viability of biological techniques. (Roshini et al., 2017).

The processes of all the aforementioned EAOPs typically take place in homogeneous systems, requiring the presence of free Fe^{2+} and an ideal pH of 3 for the precipitation of unwanted iron sludge upon disposal. Pilot or full-scale applications have not yet been finished; most EAOP research has been carried out in small laboratories. (Roshini et al., 2017) identified that environmental, technological, and economic factors are frequently responsible for the gap between laboratory research and real-world applications. These factors can be addressed by implementing the following changes:

producing effective catalysts; improving mass transfer inside electrochemical cells and reactors; developing new electrodes (high-performance anodes and cathodes with enhanced electrocatalytic properties);

improving the operating parameters (temperature, pH, catalyst dosage, electric potential or current intensity)

2. MATERIALS AND METHODS

2.1 Chemicals

Ferrous sulfate heptahydrate ($FeSO_4.7H_2O$) and hydrogen peroxide (H_2O_2) were used to conduct the Fenton reactions, while sulfuric acid (H_2SO_4) and sodium hydroxide (NaOH) were used for pH adjustment.

2.2 Wastewater Collection and Characterization

The polluted wastewater was extracted from the municipal wastewater of Erbil. When the wastewater samples were needed for the experiments, they were combined in a big container and stored at 4 °C. In this case, the wastewater samples were sent to the lab for water quality analysis after the experimental work was finished. The salient features of the contaminated wastewater samples that were collected are listed in Table 1.

2.3. Analytical Methods

The Hanna Combo pH/EC/TDS/Temp tester (model HI98129) was used to measure the pH. The Dichromate Reflux Method was used to measure COD. Every analysis was performed in compliance with the 23rd edition of the Standard Procedures for Examination of Water and Wastewater, which was created and released by the Water Environment Federation (WEF), the American Public Health Association (APHA), and the American Water Works Association (AWWA) (Catarino et al., 2017).

2.4 Experimental Procedure

As illustrated in Figure 1, plate 1, Fenton oxidation was carried out on a bench scale in a 1,000 mL pyrex-glass beaker with 600 mL of wastewater contaminated with oil as a batch reactor at a temperature of 25 °C. The pH of the effluent was brought to the necessary levels by adding sodium hydroxide at the conclusion of the Fenton reaction and sulfuric acid at the beginning. To initiate the Fenton reaction, the catalyst $FeSO_4.7H_2O$ and H_2O_2 were added in the doses indicated in Table 2. Examine the impact of different factors on the Fenton reaction, such as pH, H_2O_2 dose, $FeSO_4.7H_2O$ dose, and reaction time (Zhao et al., 2020). To maintain a constant current density, a digital (DC) power supply (0–30 V, 0–5 A) of the UNI-T, UTP3315PE type was used. The pH of the solution was adjusted to 3, and samples were taken out and filtered through 0.45µ filter paper prior to each analysis. Figure 1 depicts a schematic drawing of the Electro-Fenton system. The efficiency of pollutant elimination was ascertained using Eq. 4:

$Re\% = C0 - Cf / C0 \times 100$

Where C0 denotes the initial wastewater (mg/l), Cf denotes the final wastewater (mg/l), and Re% denotes the removal effectiveness.

Parameter	Value
pH	8.47
COD (mg/L)	1,032
TSS (mg/L)	241
TDS (mg/L)	612

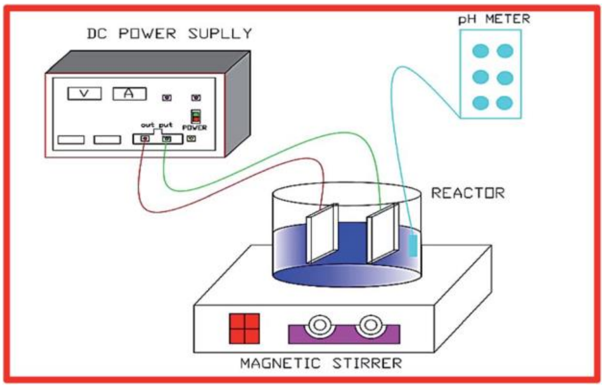


Figure 1: Fenton reactor on bench scale.

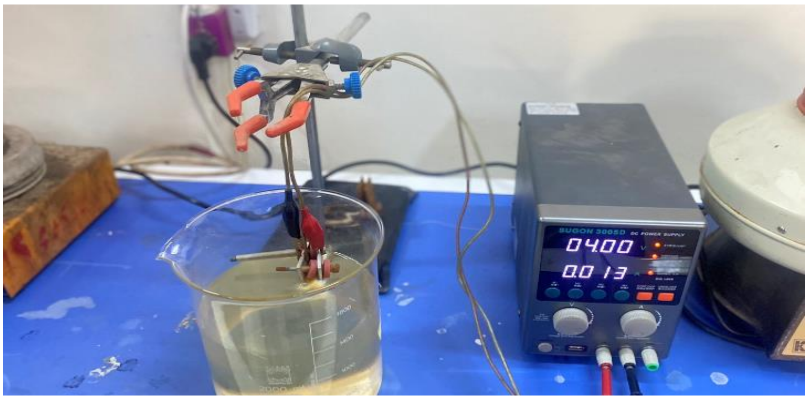


Plate1 Fenton reactor on bench scale in the lab.

Parameter	Value
pH	3
$FeSO_4$.7H2O (g/L)	1.0
H_2O_2 (g/L)	8.38
Reaction time – t (min)	50

3. RESULTS AND DISCUSSION

Table 4 presents the COD removal percentage results for different operating parameters. The COD levels were 1032 mg/L before remediation and 105 mg/L after remediation, respectively.

pH has a significant impact on the production of OH• radicals and, as a result, the oxidation efficiency in the Fenton reaction. The pH was adjusted to three in order to see how it affected the percentages of COD removal. The experiment's findings indicate that a pH of 3 is ideal for removing the most COD (89.82%). These outcomes show some degree of agreement with (Tony et al., 2009; Elmolla, 2015; Ayoub, 2022; Suyatna et al., 2019; Adetunji and Olaniran, 2021).

The reaction time (t) was set to 50 minutes in order to track its effects on the COD removal percentages. It is clear that as reaction time increases, so do the COD removal percentages. percentages of COD elimination that match a maximum reaction time of fifty minutes. Fe2+, in the form of FeSO4.7H2O, was intended to be used in the Fenton reaction at a dose of 1 g/L. Higher doses of FeSO4.7H2O are generally found to result in higher COD removal efficiencies. These outcomes are comparable to those attained by (Steiner and Gec, 1992).

To investigate its impact on the percentages of COD removal, the H2O2 dose in the Fenton oxidation was 8.38 g/L. An ideal H2O2 dose of 8.38 g/L was met by 89.82% of the maximum percentages of COD removal. This suggests that H2O2 doses higher than 8 g/L had a detrimental effect on COD removal rates. This is explained by the fact that OH• radicals react with H2O2 quickly to form OOH•, a phenomenon that is illustrated in equations 1–5. Because OOH• radicals are less reactive than OH• radicals, lower COD removals may be accomplished. Being an OH• scavenger, H2O2 can reduce the efficiency of COD removal when present in excess. Treatment effectiveness will be reduced if H2O2 dosages are low because less OH• will be produced. Thus, it's important to keep high and low H2O2 levels in check. These outcomes are largely in line with(Mustafa and Shihab, 2012).

pH	**$FeSO_4$.7H_2O (g/L)**	**H_2O_2 (g/L)**	**Reaction time (t) (min)**	**(COD removal %)**
3	**1**	**8.38**	**50**	**89.82%**

4. CONCLUSIONS

EF has been used to remove pollutants from wastewater and water over the last ten years. Numerous influencing factors were noted by us, including the type of electrode, pH, current density, Fe2+ and H2O2 concentrations, O2 flow rate, electrode gap, temperature, and electrolyte. the significant volume of polluted wastewater created by rapid industrialization. Recent research has examined different methods for treating wastewater. Many studies have demonstrated that EFp is a viable method for treating wastewater that is more economical, effective, and ecologically friendly than other advanced oxidation processes (AOPs) for eliminating organic matter. This review paper also concluded that EFP is good for removal of COD, Color and it is alternative method for treatment of wastewater containing synthetic dyes due to this efficient and low operating cost and environmental friendly method.

REFERENCES

Adetunji, A.I., and Olaniran, A.O., 2021. Treatment of industrial oily wastewater by advanced technologies: a review. Applied Water Science 11(6): Pp. 98.

Ayoub, M., 2022. Fenton process for the treatment of wastewater effluent from the edible oil industry. Water Science and Technology 86(6): Pp. 1388-1401.

Barhoumi, N., Olvera-Vargas, H., Oturan, N., et al., 2017. Kinetics of oxidative degradation/mineralization pathways of the antibiotic tetracycline by the novel heterogeneous electro-Fenton process with solid catalyst chalcopyrite. Applied Catalysis B: Environmental 209: Pp. 637-647.

Brillas, E., Sirés, I., and Oturan, M.A., 2009. Electro-Fenton process and related electrochemical technologies based on Fenton's reaction chemistry. Chemical reviews 109(12): Pp. 6570-6631.

Catarino, A.I., Thompson, R., Sanderson, W., et al., 2017. Development and optimization of a standard method for extraction of microplastics in mussels by enzyme digestion of soft tissues. Environmental toxicology and chemistry 36(4): Pp. 947-951.

Dewil, R., Mantzavinos, D., Poulios, I., et al., 2017. New perspectives for advanced oxidation processes. Journal of environmental management 195: Pp. 93-99.

Elmolla, E., 2015. DAF-treated lube oil wastewater (DTLOWW) treatment: performance of bench scale and pilot scale Fenton process. Journal of Civil & Environmental Engineering 5(2): Pp. 1.

Ganzenko, O., Huguenot, D., Van Hullebusch, E.D., et al., 2014. Electrochemical advanced oxidation and biological processes for wastewater treatment: a review of the combined approaches. Environmental Science and Pollution Research 21: Pp. 8493-8524.

Geissen, V., Mol, H., Klumpp, E., et al., 2015. Emerging pollutants in the environment: a challenge for water resource management. International soil and water conservation research 3(1): Pp. 57-65.

Luo, Y., Guo, W., Ngo, H.H., et al., 2014. A review on the occurrence of micropollutants in the aquatic environment and their fate and removal during wastewater treatment. Science of the total environment 473: Pp. 619-641.

Mustafa, Y.A., and Shihab, A.H., 2012. Removal of 4-Chlorophenoles from simulated wastewater by advanced oxidation processes. Journal of Engineering 18(10): Pp. 1115-1127.

Oturan, M.A., and Aaron, J-J., 2014. Advanced oxidation processes in water/wastewater treatment: principles and applications. A review. Critical reviews in environmental science and technology 44(23): Pp. 2577-2641.

Roshini, P., Gandhimathi, R., Ramesh, S, et al., 2017. Combined electro-Fenton and biological processes for the treatment of industrial textile effluent: mineralization and toxicity analysis. Journal of Hazardous, Toxic, and Radioactive Waste 21(4): 04017016.

Sirés, I., Brillas, E., Oturan, M.A., et al., 2014. Electrochemical advanced oxidation processes: today and tomorrow. A review. Environmental Science and Pollution Research 21: Pp. 8336-8367.

Sousa, J.C., Ribeiro, A.R., Barbosa, M.O., et al., 2018. A review on environmental monitoring of water organic pollutants identified by EU guidelines. Journal of hazardous materials 344: Pp. 146-162.

Steiner, N., and Gec, R., 1992. Plant experience using hydrogen peroxide for enhanced fat flotation and BOD removal. Environmental progress 11(4): Pp. 261-264.

Suyatna, I., Riadi, R., Feriyanto, I., et al., 2019. Determination of water quality condition from water samples around location of ship to ship transfer of coal in Balikpapan, East Kalimantan, Indonesia. IOP Conference Series: Earth and Environmental Science. IOP Publishing, 012067.

Tony, M.A., Purcell, P.J., Zhao, Y., et al., 2009. Photo-catalytic degradation of an oil-water emulsion using the photo-fenton treatment process: Effects and statistical optimization. Journal of Environmental Science and Health Part A 44(2): Pp. 179-187.

Zhao, D., Zhuang, Z., Cao, X., et al., 2020. Atomic site electrocatalysts for water splitting, oxygen reduction and selective oxidation. Chemical Society Reviews 49(7): Pp. 2215-2264.

Cite The Article: Tablo Abdulrahim Ahmed (2024). Electro-Fenton Process for The Treatment of Wastewater of Erbil City Kurdistan Region, Iraq. *Environmental Contaminants Reviews, 7(1): 36-38.*