CORN OIL REMOVAL BY ADVANCED OXIDATION PROCESSES IN COMPARISON WITH CASTOR AND COCONUT OILS

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Abstract The AOPs advanced oxidation process has been studied in three ways: (UV/H₂O₂), Fenton, and Photo-Fenton in artificial water treating from vegetable oils. The corn, castor, and coconut oils emulsion were prepared and treated by AOPs. Several variables were studied: time, pH, mixing speed, temperature, the dose of chemicals (H₂O₂ & Fe₂SO₄.7H₂O), and finally the oil concentration. The best conditions were obtained in several experiments where the Fenton and Photo-Fenton process operates in an acidic medium (pH = 3.5), while the UV/H₂O₂ process operates with the neutral medium (pH = 7). The optimum temperature for the Photo-Fenton and UV/H₂O₂ processes is 40°C, and for the Fenton process is 20°C. While there was an effect of mixing speed, higher efficiency was achieved at (1000 rpm) for the Photo-Fenton process and (500 rpm) for the Fenton and UV/H₂O₂ processes. Also, the H₂O₂ concentration was at (500 mg/L) for all processes, when the Fe₂SO₄.7H₂O concentration for the photo-Fenton process = (50 mg/L), and for the Fenton process = (250 mg/L). Oil concentration = (1750 mg/L). Optimum conditions were applied to treat vegetable oils, the Fenton process gave a maximum removal efficiency of 95.2% for corn oil (COD 12800 to 610 mg/L), 94.5% for castor oil, while 57.5% for coconut oil after the total reaction time (180 minutes). The Photo-Fenton process gave removal efficiencies: 93% for corn oil (COD 12500 to 870 mg/L), 83.8% for castor oil, and 61.6% for coconut oil. The UV/H₂O₂ process gave removal efficiencies: 69.8% for corn oil, 32% for castor oil, and 23.4% for coconut oil after the total irradiation time. As real wastewater, the treatment was acceptable and achieved an efficiency of 44.7%, 89.2%, and 83.8% for the UV/H₂O₂, Fenton, and Photo-Fenton processes, respectively.

Keywords: Corn Oil, Advanced Oxidation Process, UV/H₂O₂, Fenton, Photo-Fenton, Castor oil, Coconut oil

1. Introduction

The development of the world with agriculture, industries, and urban development leads to an increase in the pollutants generated from them that are disposed of in natural waters, giving increasing attention to methods of effective treatment and protection of surface and groundwater. A good strategy involves treating sewage before dumping it into the river with a technically and economically efficient technique, in which the mechanism is studied on relatively small amounts of toxic and persistent organic matter, to be applied in decontamination of large quantities of natural water and its complex pollutants. In this paper, AOPs are demonstrated to be highly effective technologies for treating industrial water and wastewater. As evidence of this, over the past two decades, there has been a growing interest in studies on the mechanisms and applications of AOPs in wastewater treatment [1].

(AOPs) were precisely identified in 1987 by Glaze et al. that would occur under normal conditions [2]. With increasing research and applied for work as successful and environmentally friendly ways to remove pollutants. AOPs have become an extensive tree

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of processes that depend on the formation of hydroxyl radicals through chemical, photochemical, or electrochemical reactions [3,4]. One of the oldest and most widely used Fenton methods is the one that relies on soluble iron(II) salt and H₂O₂, commonly known as Fenton reagent, to decompose and destroy POPs, irradiation can be added to the Fenton method to simultaneously treat the water sample by UV To be the so-called Photo-Fenton [5].

2. Materials and Methods

2.1. Materials

Commercial corn oil was used as a contaminated sample of edible vegetable oil. Other types of vegetable oils were used in health or cosmetics, namely castor and coconut oils.

The materials used required for this study are:

1. Sodium Dodecyl Sulfate, SDS (C₁₂H₂₅Na₄S) (Beltric, Spain)
2. Ferrous Sulfate (FeSO₄·7H₂O) from Hopkin and Williams (England),
3. Hydrogen Peroxide (H₂O₂) (50%, w/w) from Solvochem
4. Sodium Thiosulfate (Na₂S₂O₃) from Central Drug House (India)
5. NaOH and H₂SO₄ to achieve the desired pH Central Drug House (P) Ltd. (India).

2.2. Methods

The advanced oxidation process (AOPs) were used three methods: UV/H₂O₂, Fenton, and Photo-Fenton. All the reagents used in the experiments for the above methods were hydrogen peroxide, H₂O₂, ferrous sulfate, FeSO₄·7H₂O.

The experiments were performed in the Health Laboratory in batch form, (Fig. 1), the reactor consisted of a 2 L glass beaker placed on a magnetic stirrer with a heater (HTS-1003/HTP-1002/MGS-1001, BOECO, Germany).

Ultraviolet radiation (254 nm) was generated from UV lamps (TUV 11W 4P-SE, Philips, England), which were installed vertically at the top of the reactor. The distance between the lamp and the reactor was 5 cm to ensure more absorption as mentioned [7]. The lamp is completely submerged in the reactor and then encased by a quartz sleeve for protection.

2.3. Experimental

An emulsion (oil-water) was prepared as a sample of artificial water from the used oils using an SDS emulsifying agent by taking (2.5 ml) of (100 mg/L) sodium dodecyl sulfate per liter of distilled water and gradually adding (100 ml) oil. With rapid mixing at (2000 rpm.) for 48 hours [6].

The required volume of the prepared and stored emulsion, which corresponds to the specified oil concentration in each experiment, is taken within the range (1000-2500) mg/l through dilution with distilled water represented in equation (1):

$$V_1 \times C_1 = V_2 \times C_2 \quad (1)$$

Where:

V₁ = Stock Volume (L)

V₂ = Required Volume (L)

C₁ = Stock Concentration (mg/l)

C₂ = Required Concentration (mg/l)

2.4. Analysis

The chemical oxygen order is approved to check the removal percentage of the samples and the assay is using two devices: The first is a 120-minute COD thermal reactor at 150 ° C commercially available digestion solution (COD test kit) in three ranges; Heart rate range (0-15000) mg/L, MR range: (0-1500) mg/L, LR range: (0-150) mg/L. The second device is Lovibond Checkit (Germany) direct COD photometer. The COD concentration reading is colorimetrically measured at 605 nm. , And then assessing the removal efficiency:

$$\text{COD Removal efficiency\%} = \frac{\text{COD}_i - \text{COD}_f}{\text{COD}_i} * 100 \quad (2)$$

Where:

COD_i = Initial COD concentration prior to treatment (mg/L)

COD_f = Final COD concentration after treatment (mg/L)

3. Results and Discussion

3.1. The Effect of Reaction Time

The effect of the time required for 4 hours of treatment was studied to obtain the best clearance for all operations, the initial amount of H₂O₂, Fe₂SO₄.7H₂O, pH, Mixing Speed, and the temperature was determined. The concentration of primary corn oil was (1750 mg/L). As in Fig. (2), with increasing time, the dissociation of the pollutant increases and the reaction reaches beyond carbon dioxide, and thus the efficiency increases. Results are approximate [8].

3.2. The Effect of pH

Many pH values (3.5, 7, and 10.5) were examined with the other parameters being kept constant for 180 min. In Fig. 4, for the UV/H₂O₂ process, the value of removal efficiency was (40.3%) at pH = 7, and the efficiency was also acceptable at pH = 3.5, equal to (39.4%). While the efficiency values for Photo-Fenton and Fenton are (89.5%) and (16.9%), respectively, at pH = 3.5. Note that the Fenton-Fenton reaction occurs in a similar acidic medium (Sohrabi and Khavaran, 2014). The UV / H₂O₂ reaction is in a neutral or acidic medium, similar [9].

3.3. The effect of Mixing Speed

Mixing speed (1500, 1000, 500) rpm. was checked by magnetic motor control. Fig. 4 shows that the removal efficiency is affected by different speeds, as the two processes UV / H₂O₂ and Fenton were at a mixing speed of 500 rpm. , Close to the study [10]. In UV / H₂O₂ the value

of removal efficiency is (55.4%) because it achieves a stoichiometric absorption of UV rays per particle. The Fenton process has an efficiency (49.3%) that the slow mixing determines the time required for the reaction compared to the high speed that helps generate the hydroxyl radicals, which in turn accelerates the advanced oxidation process. For the same reason, for the Photo Fenton process, the removal efficiency was approximate and acceptable for medium and slow mixing because it combines the two processes mentioned above, and thus the efficiency was (84.6%) at 500 rpm., (96.7%) at (1000 rpm.).

3.4. The Effect of H₂O₂ Concentration

The effect of concentration of H₂O₂ is studied with multiple choice of concentrations. The relationship between removal efficiency and H₂O₂ concentrations is fluctuating, because peroxide is the basis of the advanced oxidation process and is the generator of the hydroxyl radical. It was observed through this experiment that the optimum peroxide concentration is 500 mg / l similar [11]. Fig. 5 shows at 500 mg/L the maximum removal efficiency of (69%), (77.2%), and (91.7%) reduction of COD by UV/H₂O₂, Fenton, and Photo-Fenton, respectively. It causes a greater amount of hydroxyl radicals to be generated and they quickly combine to form stable atoms again, which reduces its presence as a free radical and thus reduces oxidation. . At higher H₂O₂ concentrations, lower light intensity is available for oil degradation, since H₂O₂ is also slightly absorbed into the system [12].

3.5. The effect of Fe₂SO₄.7H₂O Concentration

The effect of (Fe₂SO₄.7H₂O) on Fenton and Photo-Fenton processes was tested by running experiments with different concentrations. . Fig. 6 shows the efficiency increases with increasing amounts of iron salt (Fe⁺⁺). For the Fenton process, when the sulfate concentration (250

mg/L), the removal efficiency was (84.9%). In the Photo-Fenton process, the efficiency reaches its maximum value (86.9%) at the concentration of sulfate (50 mg/L) as in a study [13].

3.6. The Effect of Oil Concentration

In Fig. 7, it can be seen that the removal efficiency increases with higher oil concentrations, which range between (1000-2500) mg/l. The optimum efficiency was obtained at a concentration of 1750 mg/l. In the UV/H₂O₂ process, the efficiency is 31.4% and 30.9% at oil concentrations (1750) and (2500) mg/L respectively. In the Fenton process, the efficiency is highest at 96.8% (1750 mg/L). In the Photo-Fenton process, the efficiency is 83.4% at the same concentration, so the higher COD reduction is when the oil is concentrated to 1750 mg/l, and it decreases when the concentrations increase because the turbidity in the solution results from the increase in concentrations of Hinder curing and absorption of UV rays.

3.7. Type of Vegetable Oils

The optimum conditions obtained from the above experiments are applied to other types of vegetable oils instead of corn oil, such as castor oil and coconut oil. Table (1) shows the results for treating three types of oils with advanced oxidation, For UV/H₂O₂ removal efficiency of corn oil was 69.8%, castor oil was 32%, and coconut oil 23.3% had a lower removal efficiency than other oils. As for the Fenton process, the efficiency was 95.2%, 94.5%, and 57.5% for corn oil, castor oil, and coconut oil respectively. Whereas for the Photo-Fenton were 93.04%, 83.85%, and 61.67%, respectively.

Table 1. The COD Removal Efficiency of Types of Oil in Artificial Water by Photo-Fenton, Fenton Processes

Type of Oil	COD Removal Efficiency (%)		
	UV/H ₂ O ₂	Photo- Fenton	Fenton
Corn Oil	69.8	93.04	95.2
Castor Oil	32	83.9	94.5
Coconut Oil	23.3	61.7	57.5

The treatment was also applied to a real sample of wastewater of Al-Rasheed Factory, where a dilute volume was taken to obtain a concentration (1750 mg/L) and a treatment for 180 minutes, and the removal efficiency was obtained 44.7%, 89.2%, 45.5% in UV/H₂O₂. And Fenton and Photo-Fenton, respectively.

Figure 1. (A) Scale batch reactor (B) Laboratory unit scale batch reactor

Figure 2. Effect of reaction time on the COD reduction of corn oil in artificial wastewater by Photo-Fenton, Fenton, and UV/H₂O₂ processes

Figure 3. Effect of pH value on the COD reduction of corn oil in artificial wastewater by Photo-Fenton, Fenton, and UV/H₂O₂ processes

Figure 6. Effect of Fe₂SO₄.7H₂O concentration on the COD reduction of corn oil in artificial wastewater by Fenton and Photo-Fenton processes

Figure 4. Effect of mixing speed on the COD reduction of corn oil in artificial wastewater by Photo-Fenton, Fenton, and UV/H₂O₂ processes

Figure 7. Effect of oil concentration on the COD reduction of corn oil in artificial wastewater by Fenton and Photo-Fenton processes

Figure 5. Effect of H₂O₂ concentration on the COD reduction of corn oil in artificial wastewater by Photo-Fenton, Fenton, and UV/H₂O₂ processes

4. Conclusions

Some of an important conclusions discovered of this study are as follows:

- Advanced oxidation breaks down vegetable oils such as corn oil, castor oil, and coconut oil with processes (Fenton, Photo-Fenton, and UV / H₂O₂).
- The best conditions for UV/H₂O₂ system are: time = 180 minutes, pH = 7, mixing speed = (500 rpm.), Temperature = 40 ° C, [H₂O₂] = 500 mg / L and [oil] = 1750 mg / L.

- The best conditions for Fenton oxidation of wastewater are performed under specified operating conditions: time = 180 minutes, pH = 3.5, mixing speed = (500 rpm.), Temperature = 20 °C, [H₂O₂] = 500 mg/L, [Fe₂SO₄.7H₂O] = 250 mg/L, [oil] = 1750 mg/L.
- The best conditions for Photo-Fenton processes of artificial wastewater are performed under specified operating conditions: time = 180 minutes, pH = 3.5, mixing speed = (1000 rpm.), Temperature = 40 °C, H₂O₂ = 500 mg/L, Fe₂SO₄.7H₂O = 50 mg/L, oil concentration = 1750 mg/L.
- The maximum oil degradation efficiency of artificial wastewater with corn oil for UV/H₂O₂, Fenton, and Photo-Fenton is found 69.8%, 95.2%, and 93.04%.
- The maximum oil degradation efficiency of artificial wastewater with castor oil for UV/H₂O₂, Fenton, and Photo-Fenton is found at 32%, 94.5%, and 83.8%.
- The maximum oil degradation efficiency of artificial wastewater with coconut oil for UV/H₂O₂, Fenton, and Photo-Fenton is found at 23.25%, 57.5%, and 61.7%.
- The maximum oil degradation efficiency of real wastewater obtained from Al- Rasheed Vegetable Oil Factory for UV/H₂O₂, Fenton, and Photo-Fenton is found 44.7%, 89.2%, and 45.5%.

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Conflict of Interest

There is no offense or conflict of interest in the event of publishing this research and study except for the benefit from the study.

Abbreviations

AOPs	Advanced oxidation processes
COD	chemical oxygen demand

5. References

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Appendix – A

$$V_1 \times C_1 = V_2 \times C_2 \quad (\text{A-1})$$

$$\% \text{Efficiency} = \frac{\text{COD}_{\text{initial}} - \text{COD}_{\text{final}}}{\text{COD}_{\text{initial}}} * 100 \quad (\text{A-2})$$