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# Treatment of Pharmaceutical Wastewater by Electrocoagulation Process

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***Abstract:*** **This paper presents the results of research in removal of TKN, COD, color, TDS, TSS, from pharmaceutical wastewater by electrocoagulation (EC) process using aluminum as a sacrificial electrode which is currently used for the purification of many types of water and wastewater. The effecting parameters such as applied voltage, conductivity and initial pH were studied to achieve higher removal. The performance of EC process was carried out in batch reactor. In this process, samples of 25mL were taken out from the batch at 30, 60, 90 and 120 minutes of contact time. Results obtained show that the most effective removal efficiency could be achieved at 1 A of applied current. Moreover, the experimental results also show that the COD removal was strongly influenced by the initial pH. EC was found to be very efficient when the range of initial pH is between 4 and 8. The highest COD removal efficiency of 82% occurred at a current of 1A, initial pH of 4 and contact time of 120 min. In this study, the EC process was proved effective and was capable in degrading COD, TKN, Color, TDS, TSS from pharmaceutical wastewater.**

***Keywords:*** **Pharmaceutical compounds; Electrocoagulation process (EC); Aluminium and Iron electrodes; industrial wastewater; COD.**

## I. INTRODUCTION

Water is one of the most valuable resources on planet earth. Without water life is not possible. Although this fact is widely recognized, pollution of water resources is a common occurrence. The increase in world population as well as industrial revolution has caused severe environmental pollution.

India is one of the largest producer of pharmaceutical chemicals after the USA and Europe Production and use of large quantities of pharmaceuticals for human and veterinary applications could lead to the release of more pharmaceuticals substances into the environment. (CCI 2012)

The first reports of human drugs in the environment appeared in the late 1970s although it is not unreasonable to suppose that aquatic pollution from medicinal compounds dates back much further. The growing importance worldwide of reducing potential impacts on water supplies has ensured that this issue has been steadily gaining attention in recent years both within the academic community and among the general public, although it is only with the comparatively recent advent of more reliable and sensitive analytical techniques that detailed research in this area has become possible.

The need for high quality drinking water is one of the most challenging problems of our times, but still only little knowledge exists on the impact of these compounds on ecosystems, animals and man. Reliable access to clean and affordable water is considered one of the most basic humanitarian goals, and remains a major global challenge for the 21$^{st}$ century. Worldwide, some 780 million people still lack access to improved drinking water sources. (WHO 2012)

**Pharmaceutical industry:**

Pharmaceutical manufacturing industries generally employ batch operations for manufacture of most basic drugs and their derivatives. Formulation units mainly employ physical operations for preparation of tablets, capsules, syrups, injections, liquid preparations, ointments etc. However, the industry is so large and the products are so diversified that it is beyond the scope of this report to describe manufacturing processes for individual drugs. The manufacturing processes are broadly classified and described in the following sections.

**Formulation:**

Formulation products are prepared by physical methods such as mixing, grinding, sieving, filtration, washing, drying, milling, encapsulation, packing etc. Different types of capsules, tablets, injectables, liquid tonics, syrups, ointments etc. are prepared by these methods.

**Extraction:**

Extraction is also a physical method and it is involved in the separation of a. useful constituent from crude or partially refined basic drugs. Suitable solvents like water, alcohol, ether, acetone or steam are used in the separation process

**Fermentation:**

Fermentation is a bio-chemical reaction within a reactor in the presence of selected active microbes or enzymes. Reactions are carried out under mild chemical and physical conditions. Various drugs like antibiotics, enzymes, hormone, vaccines etc. are manufactured by the process of fermentation.

Pharmaceutically active ingredients are generally produced by batch processes in bulk form and must be converted to dosage form for consumer use. Common dosage forms for the consumer market are tablets, capsules, liquids and ointments.

**Electrocoagulation:**

Electrocoagulation involves the generation of coagulants in situ by dissolving electrically either aluminum or iron ions from respectively aluminum or iron electrodes. The metal ions generation takes place at the anode, hydrogen gas is released from the cathode. The hydrogen gas would also help to float the flocculated particles out of the water. The electrodes can be arranged in a mono-polar or bi-polar mode. The materials can be aluminum or iron in plate form or packed form of scraps such as steel turnings, millings, etc. The chemical reactions taking place at the anode are given as follows.

For aluminum anode:

$Al - 3e \rightarrow Al^{3+}$

at alkaline conditions

$Al^{3+} + 3OH^- \rightarrow Al(OH)_3$

at acidic conditions

$Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+$

For iron anode:

$Fe - 2e \rightarrow Fe^{2+}$

at alkaline conditions

$Fe^{2+} + 3OH^- \rightarrow Fe(OH)_2$

at acidic conditions

$4Fe^{2+} + O_2 + 2H_2O \rightarrow 4Fe^{3+} + 4OH^-$

In addition, there is oxygen evolution reaction

$2H_2O - 4e \rightarrow O_2 + 4H^+$

The reaction at the cathode is

$2H_2O + 2e \rightarrow H_2 + 2OH$

The nascent $Al^{3+}$ or $Fe^{2+}$ ions are very efficient coagulants for particulates flocculating. The hydrolyzed aluminum ions can form large networks of Al–O–Al–OH that can chemically adsorb pollutants such as F. Aluminum is usually used for water treatment and iron for wastewater treatment. The advantages of electrocoagulation include high particulate removal efficiency, compact treatment facility, relatively low cost and possibility of complete automation.[2]

**Wastewater sampling:**

The wastewater samples were collected after the first centrifuges of Pharmaceutical intermediate products manufacturing industry located at Vapi, (Gujarat) India. The sampling bottle was cleaned and rinsed carefully with distilled water, filled and seal air tightly. The sample was stored at 4°C within one to two hours of sample collection.

**Characterization of wastewater:**

**Sample Collection Site: -** Aeration Unit.

**Table 1 Physical and chemical characteristic of wastewater**

| Para. | Results | Test method |
|---|---|---|
| pH | 4.91 | IS 3025(PART 11) 1983, (APHA 22nd Ed.,2012,4500-H+B) |
| COD | 23187.37 | IS 3025(PART 58) 2006, (APHA 22nd Ed.,2012,5220-B) |
| TDS | 18639.12 | IS 3025(PART 16) 1984, (APHA 22nd Ed.,2012,2540-C) |
| TSS | 11471.59 | IS 3025(PART 17) 1984, (APHA 22nd Ed.,2012,2540-D) |

## II. MATERIALS AND METHODS

Various methods and devices were used to both characterize and monitor the EC process. Some of these methods and devices are briefly described here. The electrodes used were Aluminium and Iron of size 5 cm x 5 cm x 1 mm. various devices were used like pH meter, magnetic stirrer, DC power supply. NaCl was added for increasing the conductivity.

## III. EXPERIMENTAL SETUP

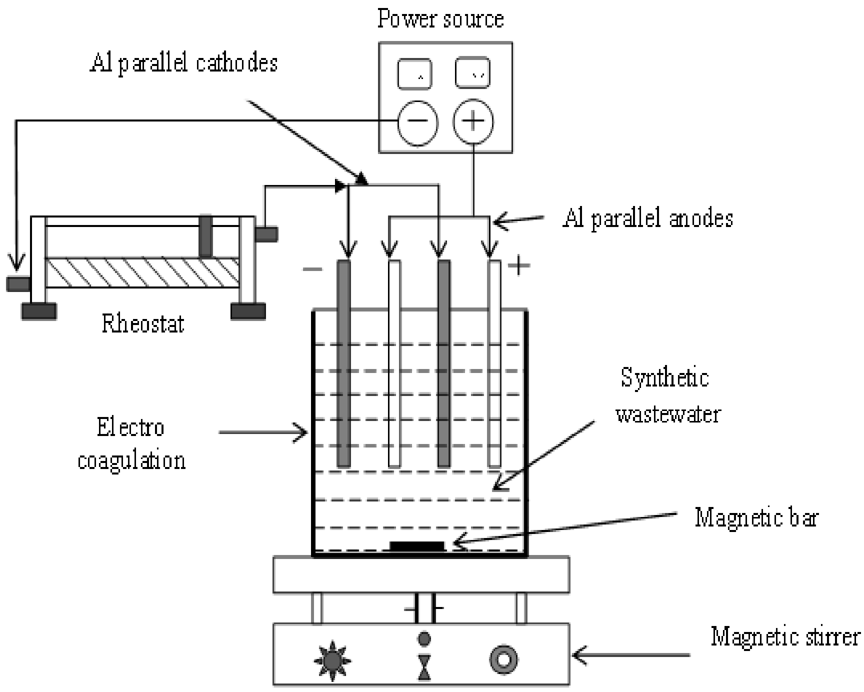
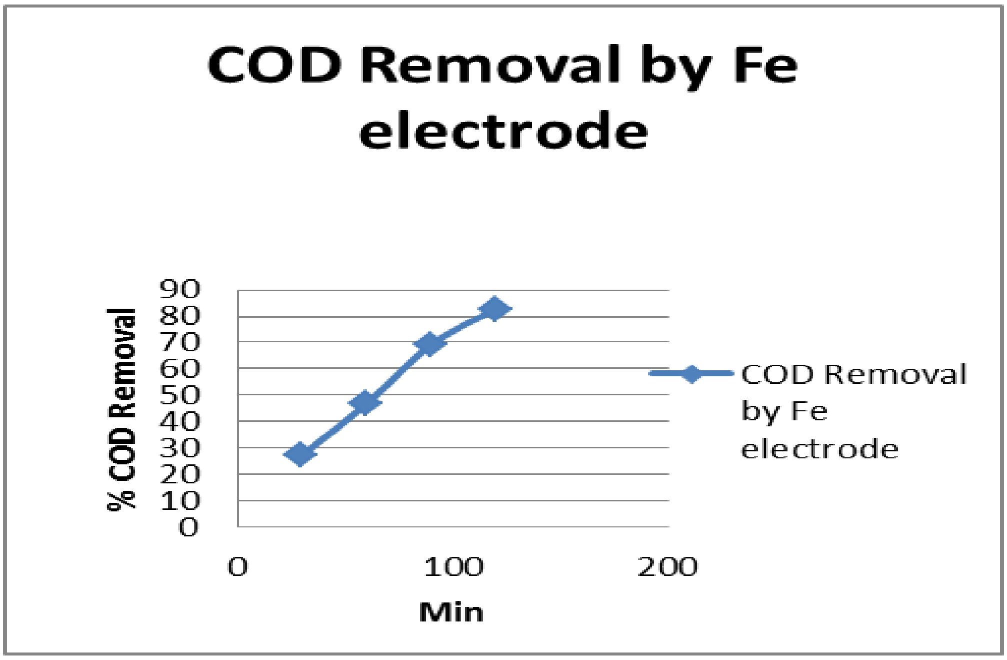



**Figure 1. Experimental set-up**

The electrodes were arranged as shown in the figure above in a batch reactor of size 9cm x 9cm x 15cm. Uniform regulated current was passed through the electrode with the help DC power supply. Constant stirring of the sample is achieved by the magnetic stirrer. Samples were taken at 30, 60, 90, 120 min respectively. Samples were taken from 5 cm height from bottom.

## IV. RESULTS AND DISCUSSION

| Time(min) | Fe electrode | | Al electrode | |
|---|---|---|---|---|
| | COD(%) reduction | TKN(%) reduction | COD(%) reduction | TKN(%) reduction |
| 30 | 27.18 | | 15.96 | |
| 60 | 46.73 | | 29.48 | |
| 90 | 69.17 | | 41.09 | |
| 120 | 82.79 | 63.29 | 57.63 | 51.89 |




## V. CONCLUSION

The results of the study can be summarized as follows:

1. COD is reduced upto 82% with Fe electrodes.
2. TKN is reduced to 63% by Fe electrodes
3. In Electrocoagulation surface area is to kept more and space between the electrodes must be as less as possible for better results.
4. Electrocoagulation process is a promising technique for the abatement of COD, TKN, TDS.
5. Sludge is generated in a large amount.

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