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Treatment Of Textile Wastewater by Electrochemical Oxidation

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A B S T R A C T

In this investigation, The efficiency of electrochemical oxidation technique depending on many factors such as material of electrode used, composition of electrolyte, electrical energy density, mass transfer and electrolysis time. This technique has many advantages such as safety, effectiveness of current density, selectivity, less operational cost and environmental safety. the degradation operation by electrochemical oxidation was performed using stainless steel as anode and cathode to treating textile dye wastewater contain of (**procion red mx5b**) dye. the electrochemical oxidation experiment was conducted for the treatment of textile wastewater . A number of batch experiments were run in a laboratory-scale that was analyzed at every 15 min regular intervals, for a total period of 60 min.The effects of operational parameters such as current density(5 ,10 ,15 ,20 and 25 v), effect of dye concentration (2, 5, 7, 9 and 11 ppm) and effect of pH (2, 4, 6, 8 and 10) on the treatment (decolourization) of (procion red mx5b dye) was studied at optimistic condition.

It was observed that highest treatment (decolourization) (99%) was achieved for 2 ppm concentration of (procion red mx5b) dye and current density at 25 V. The pH did not show any considerable effect on this experiment.We concluded from our results that electrochemical oxidation can used as pretreatment and we finding that SS used in this technique as anode can be effective in treating this electrolyte.

Keywords: Electrochemical Oxidation, Textile wastewater, Dye, Stainless Steel Electrodes

معالجة المياه الملوثة بأصباغ المنسوجات باستخدام الأكسدة الكهروكيميائية

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الملخص

في هذه الدراسة، تعتمد كفاءة تقنية الأكسدة الكهروكيميائية على العديد من العوامل مثل مادة القطب المستخدم، وتركيب المحلول المنحل بالكهرباء، وكثافة الطاقة الكهربائية، وانتقال الكتلة وزمن التحليل

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الكهربائي. تتميز هذه التقنية بالعديد من المزايا مثل السلامة، وفعالية كثافة التيار، والانتقائية، وتكلفة التشغيل المنخفضة، والسلامة البيئية. تم إجراء عملية التحلل بالأكسدة الكهروكيميائية باستخدام الفولاذ المقاوم للصدأ كقطب موجب كاثود لمعالجة المياه الملوثة بأصباغ المنسوجات المحتوية على صبغة حمراء. أجريت تجربة الأكسدة الكهروكيميائية لتنقية المياه الملوثة بأصباغ المنسوجات حيث تم إجراء حزمه من التجارب المعملية المقاسة حيث تم تحليلها كل 15 دقيقة على فترات منتظمة، لمدة 60 دقيقة. تمت دراسة تأثير العوامل التشغيلية مثل كثافة التيار، وتأثير تركيز الصبغة، وتأثير الرقم الهيدروجيني على هذه العملية في ظروف نموذجة. خلصنا من نتائجنا إلى أن أعلي نسبة معالجة (إزالة اللون) تحققت كانت (99%) عند تركيز (2ppm) وكثافة تيار (25v) كما أن تأثير الرقم الهيدروجيني غير جدير بالاعتبار في هذه التجربة. نستنتج من النتائج المتحصل عليها أن التحلل الكهروكيميائية يمكن استخدامه كمعالجة ابتدائية، وأن أقطاب المعدن المقاوم للصدأ المستخدمة في هذه التقنية فعالة في معالجة المياه الملوثة بالأصباغ الناتجة من صناعة المنسوجات.

الكلمات المفتاحية: الأكسدة الكهروكيميائية، الأقطاب من الفولاذ المقاوم للصدأ، المياه الملوثة بالأصباغ.

1. Introduction

Textile industry plays a vital role in the economy of many countries. Textile industry considers oldest and largest industry existing around the word. The gross domestic product of some countries like Sri Lanka, Vietnam and Mauritius increasing by textile industry growing where this industry play important role to provide functions for people whom didn't have special skills. The textile industry is the only industry that has generated huge employments after agriculture in India. This industry in India offers direct employment to over 35 million in the country. Moreover, another 54.85 million people are involved in its allied activities [1]. The chemicals and water will be consumed with large amount in wet process of textile industry where to produce 1 kg of textile we consume about 200 L of water. The usage of water in textile industry is mainly in two operations which are chemicals employment onto the fibers and final products rinsing [2]. Textile dye included the major unit operations which are as follows: Desizing, Scouring, Mercerising, Bleaching, Dyeing, Printing, Finishing. Many methods can be used to treat the textile effluents such as physical, chemical and biological methods. The simple and cheap method can be applied to remove colour and organic pollutants from textile wastewater is Biological method. Some pollutants producing from textiles industry cannot remove by biological operation and cannot treat by traditional methods such as refractory pollutants, this pollutant will remain in waste water. The other disadvantage of conventional biological process to treating textile wastewater is most commercial dyes are toxic to the

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organisms which are used in this technique. So, other methods must be used such as physical and chemical methods. [3]

In electrochemical oxidation the many factors are important such as electrolysis time, pH and concentration of electrolyte and anode material which is important factor. The temperature does not have effect on output of direct oxidation. The electrochemical model consists of anode and cathode, where those electrodes must be immersed in the electrolyte (synthetic solution) which is connected to electrical loop. Electrical circuit contains source of current and control device, where the electrical energy used to impact a chemical change. In this technique, the oxidation and reduction processes occurring at the electrolyte interface and at electrodes. [4]

The reduction processes occurs at the cathode electrode and the oxidation processes occurs at the anode electrode. The maintaining of the current flow continuous is by the electrons flow which producing from electrical source. The solution must be an electrolyte to permit the current to flow by the motion of its ionic charged species. Different factors are important to get high efficiency of electro chemical oxidation process and the important impact on the process is type of electrolyte which play main role in the formation of oxidizing species during the process. [5]

Dyes: environmental impact and remediation

Introduction of Dyes: A natural or synthetic substances used to add a color to change the color of something. Such substances with considerable coloring capacity are widely employed in the production of consumer products, including paints, textile, printing inks, pharmaceutical, food, cosmetics, plastics, photographic and paper industries.

Types of Dyes

1-Natural dyes 2-Synthetic dyes **3**-Food dyes 4-Organic dyes **5**-Other dyes like leather, laser. And also based on chemical classification with respect to the number and production volumes, Azo dyes are the largest group of colorants, constituting 60-70% of all organic dyes produced in the world.

Environmental Impacts

- Air pollution

Most processes performed in textile mills produce atmospheric emissions. Gaseous emission has been identified as the second greatest pollution problem (after effluent quality) for the textile industry.

Air pollution is the most difficult type of pollution to sample, test, and quantify in an adult.

- Water pollution

The waste water from textiles plants is classified as the most polluting of all the industrial sectors, considering the volume generated as well as the effluent composition.

Dyes can remain in the environment for an extended period of time, because of high thermal and photo stability to resist bio-degradation.

Harmful Effects Of Dyes

- Dyes absorb and reflect sunlight in water. This diminishes photosynthetic activity of algae and seriously influences the food chain.
- Many dyes and their breakdown products are carcinogenic, mutagenic and toxic to life.

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- Triple primary cancers involving skin, kidney, urinary bladder and liver of dye workers have been reported. And can cause allergies such as contact dermatitis and respiratory diseases etc.

Remediation Measures

- Enhance the existing effluent disposal treatment plants through Reverse Osmosis (RO) and the resultant water can be used as fresh water for the region.
- Installed Cleaner Production Technologies (CPT).
- Use of activated carbon.
- Dye fed silk worms take silk farming to next level.
- Air dyeing Technology.
- Ultrawund-assisted textile dyeing.[6]

Literature Review

The electrochemical oxidation of acid yellow and acid violet dye assisted by transition metal modified kaolin graphite used as electrodes modified kaolin catalyst was added to the reactor 40 mA/cm2 was the optimized current density. The COD removal was 100% [7].

The electrochemical oxidation of methyl green dye was studied using the Ti/pbo2 as an anode and Ti mesh used as cathode. They found 90% decolourization achieved [8].

The electrodegradation of four azo dyes C.I. Direct Red 254, C.I. acid orange 7,C.I. Direct Red 80, Yellow goldsandolan. They used pervskite as an anode and platinum foil as a cathode electrodegradation of C.I. acid orange 7, C.I. Direct red 254, C.I. Direct 80 dyes was higher than 95% but degradation of yellow gold sandolan was not succeeded well with these electrodes [9].

The electrochemical oxidation of the methylene blue by using the lead acid battery as an electrode was studied. 2V was optimized voltage. They used NaCl as supporting electrolyte. They observed that the COD removal efficiency was 62% achieved [10].

2. Material and Method

- Electrochemical Oxidation Reaction For the electrochemical oxidation reaction reactor system contain the stainless steel (18 cm × 2.4 cm × 0.1 cm) as an anode and (18 cm × 2.4 cm × 0.2 cm) as a cathode were placed 6 cm apart which were attached to DC supply. The steps of supplied energy to a electrode during the process are as following**:**

1) The electro active particle is transported from the solution to the surface of electrode.
2) The electro active particle is adsorbed on the electrode surface.
3) The electron transfer occurs between the electrode and the bulk solution.
4) The reacted particle is either deposited at the surface of electrode or transported to the Solution (desorption).

The **DC** power supply was used to provide the electric energy required during the electrolysis. The magnetic stirrer was used in electrical cell to keep the solution well mixed.

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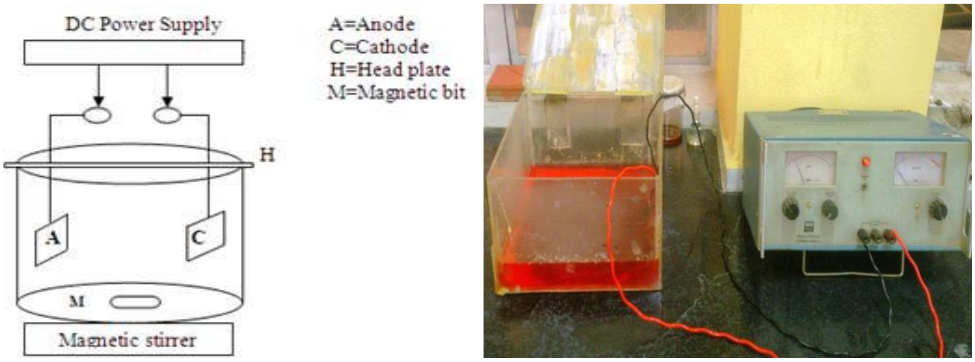

Figure 1: The schematic diagram of the experimental setup Set up of Electrochemical Oxidation

Method:

In this study, we studied the effect of voltage, initial dye concentration and pH on the degradation of **procion red mx5b** dye. Different densities of current were used to study the performance of the electrochemical Cell. The electrochemical cell has a volume of 1000 ml. For each experiment 1 liter of aqueous dye solution was prepared. The duration of each experiment was 60 minutes and every experiment was batch process. The removal of colour was calculated by drawn of samples every 15 minutes. We have to remove the sediments from the surface of electrode, therefore prior each experiment electrodes were dipped into dilute HCl for few minutes and after that washed with distilled water. 1 gm of common salt was added as a supporting electrolyte. The electrical energy used to heating the water must be calculated to prevent any wasting of energy .The current effect on process efficiency depending on current density supplied.

3.Analysis

The efficiency of dye decolourization was evaluated by monitoring at maximum absorption wavelength (530 nm) with UV Spectrophotometer (LABINDIA UV 3000+ UV/ VIS spectrophotometer).

Determining the Percentage of Decolourization (Color Removal Ratio)

Color Removal Ratio Calculated as Follows**:** Absorption (%) = [(Initial absorbance of the raw sample - Absorbance of the treated samples) / Initial absorbance of the raw sample)*100]

$$abs(\%) = \frac{abs(i) - abs(t)}{abs(i)} x100$$

Where, **abs (%)** = Absorbance in percentage, **abs (i)** = Initial absorbance of the raw sample, **Abs (t)** = Absorbance of the treated samples at regular time intervals.

4.Result and Discussion

4.1 Effect of Voltage

The experiment was carried out at five different voltages 5, 10,15,20,25 at 5 ppm dye concentration. It is clear that the degradation is increases as the voltage increases. The 25v was the optimized voltage.

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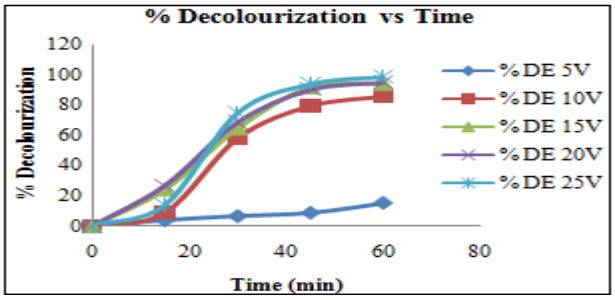

Figure 2: Concentration Vs Time (Effect of Voltage)

4.2 Effect of initial Dye Concentration

Effect of initial dye concentration shows the significant effect on degradation. Effect of initial dye concentration was carried out at optimized voltage i.e. 25 v. the dye concentration varied from 2 to 11 ppm.

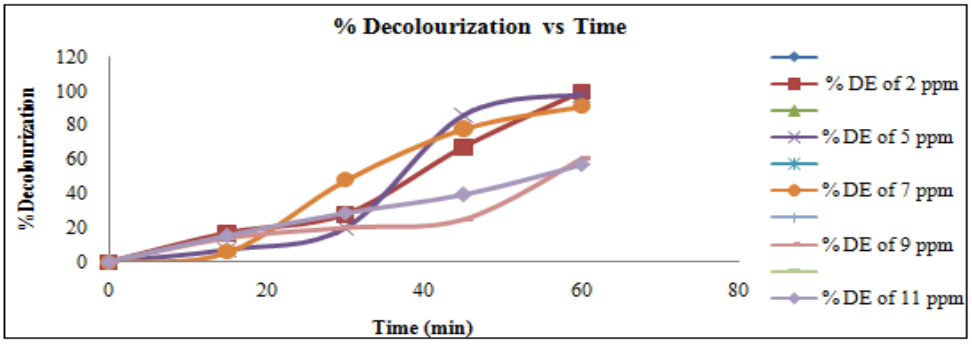

Figure 3: Concentration vs time (effect of initial dye concentration)

4.3 Effect of pH

In this study the solution pH varied from 2 to 12 at 5 ppm dye concentration. In this study pH did not show any considerable effect on degradation of dye

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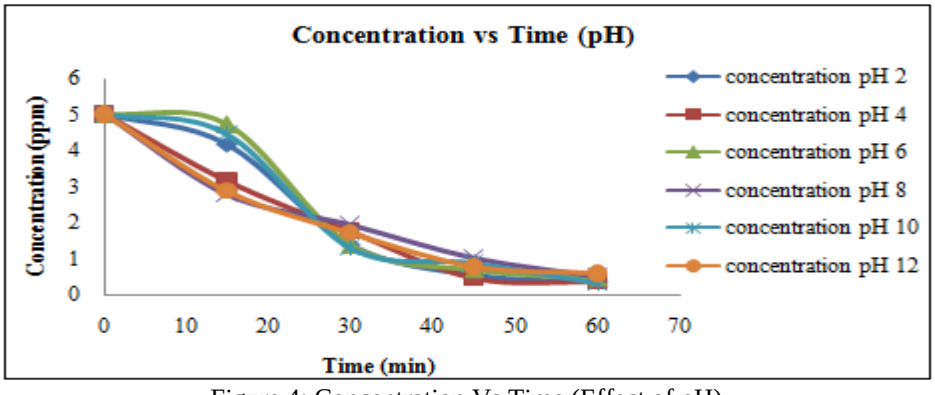

Figure 4: Concentration Vs Time (Effect of pH)

Conclusion:

A study for purification of textile dye wastewater was investigated using electrochemical oxidation. This technology of treatment was used for 60 minutes to remove the colour of

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procion red mx5b dye from synthetic effluent and the electrodes used as anode and cathode were from stainless steel material. The results of the present studied showed the electrochemical oxidation could be the effective treatment for the decolourization of procion red mx5b dye. From the study we proposed that the electrochemical degradation could be the best solution for the effective treatment of textile wastewater.

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