

Advanced Oxidation Process of Methyldiethanolamine in wastewater

by

DOI THI THU HA

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

JANUARY 2009

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Advanced Oxidation Process of Methyldiethanolamine in wastewater

by

DOI THI THU HA

A project dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CHEMICAL ENGINEERING)

Approved by,



AP DR SAIKAT MAITRA

Assoc. Prof Dr Saikat Maitra
Associate Professor
Chemical Engineering Department
Universiti Teknologi PETRONAS

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2009

ACKNOWLEDGEMENT

I would like to express my sincere thanks and profound gratitude to my supervisors, professor Binay kinta Dutta and AP DR Saikat Maitra for their support, encouragement, supervision and useful helping and suggestions throughout my final year research work. With their timely guidance, I am able to complete my project successfully.

I truly appreciate the kindness of Mr Idzahn, a Master student in UTP with his valuable time and assistance to me on doing my project. Thanks to him who trained me the skills in doing laboratory work and gave me the confidence to get over all the difficulties facing earlier.

My great thanks to all my lecturers in UTP who have always there with support and have provided me the necessary knowledge in order to complete my work.

Last but not least, I have to thank to the love and invaluable support from my beloved family and friends who always beside me and encourage me the whole time.

ABSTRACT

Advanced oxidation processes (AOP) are characterised by a common chemical feature : the capacity of exploiting the high reactivity of HO radicals in driving oxidation processes which are suitable for achieving the complete abatement and through mineralization of even less reactive pollutants. The different AOP are considered accordingly to their real applications for water pollutions abatement. Methyldiethanolamine (MDEA) is an alkanolamine used in tail gas treating and hydrogen sulfide enrichment units for selectively removing hydrogen sulfide from gas streams containing carbon dioxide. Methyldiethanolamine is also used in natural gas plants for the bulk removal of carbon dioxide. During recycling process, an amount of MDEA is rejected and become waste water. The purpose of this research is to study a suitable AOP that can apply for waste water contained MDEA treatment. This type of method is called an AOP using UV light.

TABLE OF CONTENTS

CHAPTER I: INTRODUCTION	
1.1 BACKGROUND OF STUDY	1
1.2 PROBLEM STATEMENT	1
1.3 OBJECTIVES and SCOPE OF STUDY	1
CHAPTER II: LITERATURE REVIEW	
2.1 FENTON PROCESS.....	5
2.2 OZONE WATER SYSTEM.....	6
CHAPTER III: METHODOLOGY	7
CHAPTER IV: FINDINGS OF THE STUDY.....	10
CHAPTER V: RESULT AND DISCUSSION.....	17
CHAPTER VI: CONCLUSION AND RECOMMENDATION	
4.1 CONCLUSION.....	30
4.2 RECOMMENDATION	30
REFERENCES.....	31

LIST OF FIGURES

Figure 1	Typical UV/Oxidation ground water Treatment system	9
Figure 2	The reactor with UV light	14
Figure 3	COD vials heating up	15
Figure 4	KMnO ₄ titration	16

LIST OF TABLES

Table 1	COD reading for MEA	17
Table 2	KMnO ₄ titration(MEA)	18
Table 3	COD reading for MDEA	21
Table 4	KMnO ₄ titration(MDEA)	22
Table 5	COD reading for MDEA((Run 2)	26
Table 6	KMnO ₄ titration(MDEA,run 2)	28

INTRODUCTION

1.BACKGROUND OF STUDY

As the rapid development of technology and in the industrial stage, we have to pay our attention to protect our environment. The incessant growing of technology, industry, economy gradually damage to the environment. Therefore, preventing pollution and protecting environment become more and more important in this modern stage. In the past 10 years, a rather fast evolution of the research activities devoted to environment protection has been recorded as the consequence of the special attention paid to the environment by social, political and legislative international authorities leading in some cases to the delivery of very severe regulations. There are some toxic substances can not be undergone the biological degradation processes. Therefore, it must be demanded to other technique, non biological technologies. Those techniques mainly include the separation technique and methods that destroy the pollutants. Chemical oxidation process aims to disintegrate the contaminants to carbon dioxide, water and inorganics or at least to harmless product. It can be seen obviously that the pollutant destruction method give the better solution to the problem of pollution abatement compared to those which only a phase separation is happened and the consequence problem still stay.

2.PROBLEM STATEMENT

MDEA is used widely in gas processing and then be rejected as a waste. This waste water contained rejected MDEA need to be treated. In the past, there was several ways of treating waste water, however some of them were not able to be applied for this case. Therefore, we have to find out another method which can degrade the MDEA in waste water. Thus, we look into the AOP to see whether it can be adopted for carrying out waste water treatment.

3.OBJECTIVES AND SCOPE OF STUDY

The purpose of this project is to find out the suitable AOP method for MDEA degradation in waste water. Then, we can combine this technique with biological

technique to get the better waste water treatment 's result. There are 3 common types of AOP such as Fenton, UV light and Ozone. In this research, I am doing the AOP using UV light to see how much degradation we can get for the waste water contained MDEA.

LITERATURE REVIEW

Advanced oxidation processes although making use of different reacting systems, they are all characterized by the same chemical feature : production of OH radicals. OH radicals are very reactive species, they attack the most part of organic molecules. A suitable application AOP to waste water treatment should not replace totally the more economic treatments as the biological degradation and it has to make use of expensive reactants as H_2O_2 . The potentialities offered by AOP can be exploited to integrate biological treatments by an oxidative degradation of toxic or refractory substances entering or leaving the biological stage. An other requirement for AOP is that only the waste with small chemical oxygen demand (COD) ($< = 5.0$ g/l) is suitable treated by these technique since higher COD contents would require the consumption of large amounts of expensive H_2O_2 . It is the cost that we want to minimize. Waste with more massive pollutants contents can be more conveniently treated by means of wet oxidation or incineration. Wet oxidation makes use of oxygen or air to achieve pollutant oxidation at high temperatures ($130-300^{\circ}$ C) and pressure (0.5- 10 Mpa). Since oxidation is an exothermic process, simple thermal balance shows that wastes with COD contents higher than approximately 20g/l undergo autothermic wet oxidation, whereas fuel consumption should be taken into account to achieve combustion temperatures for leaner waste water. For these waste, the cost evaluation of fuel consumption will give the selection criteria for the application of AOP or wet oxidation treatment.

Hydrogen peroxide (H_2O_2) is a strong oxidant and its application in the treatment of various inorganic and organic pollutants is well established. Numerous applications of H_2O_2 in the remover of pollutants from wastewater, such as sulphites, hypochlorites, nitrites, cyanides, and chlorine, are known.

H_2O_2 is also useful in the treatment of the gaseous sulphur oxides and nitrogen oxides being converted to the corresponding acids. Other related uses include the bleaching of pulp and paper and organic synthesis. H_2O_2 has applications in the surface treatment industry involving cleaning, decorating, protecting and etching of metals.

By dissociation into oxygen and water H₂O₂ can also supply oxygen to microorganisms in biological treatment facilities and in the bioremediation of contaminated sites. It can be used as a disinfecting agent in the control of undesirable biofilm growth. Since the oxygen concentration is generally rate limiting during the in situ biodegradation of organic contaminants, several applications using injection of H₂O₂ into the subsurface have been successfully attempted to enhance the biodegradation activity. H₂O₂ can be decomposed into water and oxygen by enzymatic and nonenzymatic routes.

Still H₂O₂ alone is not effective for high concentrations of certain refractory contaminants because of low rates of reaction at reasonable H₂O₂ concentrations. Improvements can be achieved using transition metal salts (ion salt), or ozone and UV-light can activate H₂O₂ to form hydroxyl radicals, which are strong oxidants.

There are 3 common types of AOP :

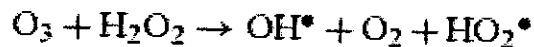
- Fenton:



- H₂O₂ / UV light



- H₂O₂ / O₃



1.FENTON PROCESS :

a) Introduction

Oxidation processes utilising activation of H₂O₂ by iron salts, classically referred to as Fenton's reagent is known to be very effective in the destruction of many hazardous organic pollutant in water.

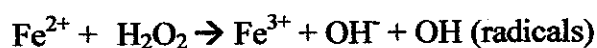
It has been demonstrate that Fenton's reagent is able to destroy toxic compounds in waste waters such as phenols and herbicides.

The main advantage is the complete destruction of contaminants to harmless compounds, e.g. CO₂, water and inorganic salts. The Fenton reaction causes the

dissociation of the oxidant and the formation of highly reactive hydroxyl radicals that attack and destroy the organic pollutants.

b) Kinetic scheme

Production of OH radicals by Fenton reagent occurs by means of addition of H₂O₂ to Fe²⁺ salts:



This is a simple way of producing OH radicals neither special reactants nor special apparatus being required.

pH is an important key in AOP. It indicates the need for an acid environment to produce the maximum amount of hydroxyl radicals. Previous Fenton studies have shown that acidic pH levels near 3 are usually optimum for Fenton oxidations.

c) Stoichiometric relationships

The key features of the Fenton system are believed to be its reagent conditions, (i.e. [Fe²⁺], [Fe³⁺], [H₂O₂] and the reaction characteristics (pH, temperature and the quantity organic and inorganic constituents). Because these parameters determine the overall reaction efficiency, it is important to understand the mutual relationships between these parameters in terms of hydroxyl radical production and consumption.

These relationships can be classified into 3 categories according to the quality of the $[\text{Fe}^{2+}]_0/[\text{H}_2\text{O}_2]_0$ ratio (initial concentration of Fe²⁺ versus initial concentration of H₂O₂). 3 types of ratio is ≥ 2 (high ratio), $= 1$ (medium ratio) and < 1 (low ratio).

d) Conclusion

This reactant is an attractive oxidative system for waste water treatment due to the fact that iron is very abundant and non toxic element and H_2O_2 is easy to handle and environmentally safe.

2. OZONE WATER SYSTEM:

It is shown that the ozone decomposition in aqueous solution develops through the formation of OH radicals. It is cleared that the addition of H_2O_2 to the ozone aqueous solution will enhance the ozone decomposition with formation of OH radicals. The increase of pH and the addition of H_2O_2 to the aqueous ozone solution will thus result into higher rate of OH radical's production.

It must be remarked that the adoption of the H_2O_2 / ozone process does not involve significant changes to the apparatus adopted when only ozone is used because it is only necessary to add H_2O_2 dosing system.

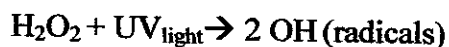
When O_3 is used in the oxidation process, there is the need of an ozone generator and its cooling system and of additional equipments such as pre-treatment section to dry the oxygen (air) fed to the ozonator and post-treatment reactor for the abatement of residual ozone in the off-gas .Moreover, the powerful oxidative capability of ozone requires the choice of construction materials that can resist to its action.

O_3/H_2O_2 , O_3/UV systems require that ozone molecules transfer from the gas stream to the liquid bulk in which they attack the organics. The over- all process of absorption with reaction can develop according to different regimes

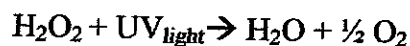
It has been reported that mainly in the case of O_3/UV the rate of ozone consumption per unit volume can be so high that mass transfer limited regime for ozone absorption is established thus resulting in a decrease of quantum efficiencies and an increase of operating costs.

METHODOLOGY

The method im studying is the H_2O_2 with UV light. This process is effected by irradiating the pollutant solution containing H_2O_2 with UV light having wavelengths smaller than 280 nm. This causes the cleavage of H_2O_2



The UV light will make the H_2O_2 decomposition into OH radicals. The rate of photolysis of aqueous H_2O_2 has been found to be dependent on pH and to increase when more alkanline conditions are used. If the pH is too high will lead to the reaction :



Meaning that we lose the valuable OH radical. Then the suitable pH is perfectly < 4 .

UV oxidation is a destruction process that oxidizes organic and explosive constituents in wastewater by the addition of strong oxidizers and irradiation with UV light. Oxidation of target contaminants is caused by direct reaction with the oxidizers, UV photolysis, and through the synergistic action of UV light, in combination with ozone (O_3) and/or hydrogen peroxide (H_2O_2). If complete mineralization is achieved, the final products of oxidation are carbon dioxide, water, and salts. The main advantage of UV oxidation is that it is a destruction process, as opposed to air stripping or carbon adsorption, for which contaminants are extracted and concentrated in a separate phase. UV oxidation processes can be configured in batch or continuous flow modes, depending on the throughput under consideration.

The UV oxidation process is general done with low pressure lamps operating at 65 watts of electricity for ozone systems and lamps operating at 15kW to 60kW for hydrogen peroxide systems.

The duration of operation and maintenance of UV oxidation depends on influent water turbidity, contaminant and metal concentrations, existence of free radical

scavengers, and the required maintenance intervals on UV reactors and quartz sleeves.

a) Applicability

Practically any organic contaminant that is reactive with the hydroxyl radical can potentially be treated. A wide variety of organic and explosive contaminants are susceptible to destruction by UV/oxidation, including petroleum hydrocarbons; chlorinated hydrocarbons used as industrial solvents and cleaners; and ordnance compounds such as TNT, RDX, and HMX. In many cases, chlorinated hydrocarbons that are resistant to biodegradation may be effectively treated by UV/oxidation. Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/oxidation processes.

b) Limitation

Limitations of UV/oxidation include:

- The aqueous stream being treated must provide for good transmission of UV light (high turbidity causes interference). This factor can be more critical for UV/H₂O₂ than UV/O₃ (Turbidity does not affect direct chemical oxidation of the contaminant by H₂O₂ or O₃).
- Free radical scavengers can inhibit contaminant destruction efficiency. Excessive dosages of chemical oxidizers may act as a scavenger.
- The aqueous stream to be treated by UV/oxidation should be relatively free of heavy metal ions (less than 10 mg/L) and insoluble oil or grease to minimize the potential for fouling of the quartz sleeves.
- When UV/O₃ is used on volatile organics such as TCA, the contaminants may be volatilized (e.g., "stripped") rather than destroyed. They would then have to be removed from the off-gas by activated carbon adsorption or catalytic oxidation.
- Costs may be higher than competing technologies because of energy requirements.

- Pretreatment of the aqueous stream may be required to minimize ongoing cleaning and maintenance of UV reactor and quartz sleeves.
- Handling and storage of oxidizers require special safety precautions.

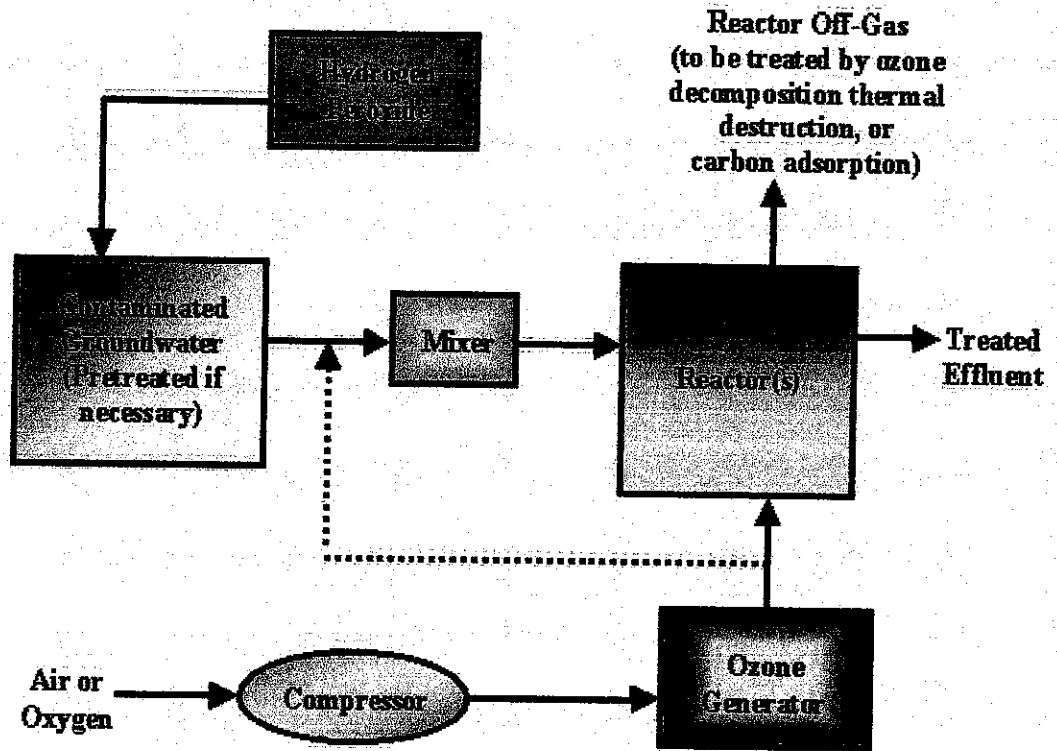


Figure 1: typical UV/Oxidation ground water Treatment system

FINDINGS OF THE STUDY

The purpose of the study is to determine the effect of the combination of UV and hydrogen peroxide on the degradation of MDEA presented in wastewater.

1.MDEA:

Methyldiethanolamine ($C_5H_{13}NO_2$) is a clear, water white, hygroscopic liquid with an ammoniac odor. It is miscible with water, alcohol and benzene. Methyl Diethanolamine is also known as a MDEA or N-Methyl Diethanolamine. Methyl Diethanolamine is widely used as a decarbonizer and Sweating agent in chemical, oil refinery, Gas synthesis, Natural gas & gas. MDEA is more efficient absorber then MEA & DEA for sulphur contains impurity and acid gases found in natural gas processing.

The alkanolamines and their aqueous solutions will absorb CO_2 and H_2S at lower temperatures and release the acid gases at higher temperatures. This forms the basis for processes which separate CO_2 and H_2S from gas streams.

MDEA is an alkanolamines used in tail gas treating and hydrogen sulfide enrichment units for selectively removing hydrogen sulfide from gas streams containing CO_2 . These units will in most cases, permit 60 to 80 % of the CO_2 to remains in the treated gas streams. MDEA is also used in natural gas plants for the bulk removal of CO_2 while producing a gas stream containing 0.25 grains $H_2S/100$ scf. Bulk CO_2 removal can be realized with MDEA when the $CO_2 : H_2S$ ratio ranges from 100 to 1000.

a) Application

Textiles : Used in manufacturing of softener, soap emulsifying agent, Lubricants, Paraffin Emulsion and dyes.

Pharmaceuticals: In synthesis of analgesics and the intermediate product for some products.

Gas absorbent : Purifies the gases particularly natural gas for the bulk removable of Carbon Dioxide and also used as a scrubbing and extracting agent in Gas treatment.

Catalyst : Effective catalyst for urethane and epoxy resin coating system.

Formulators : Used in lubricating oil, hydraulic fluids, corrosion inhibitor, refractory binder, surface active agent, solvent in water paint formula, Herbicides, Pesticides formulation and for P^H control.

MDEA is versatile bifunctional molecules compound that combines the characteristic of Amine and hydroxyl group. So, during the reaction it behaves like Alcohol and Amine Group but Amine group usually exhibits the greater activities. MDEA can be modified with the help of some additives, the product is known as an activated Methyl Diethanolamine.

b) Toxicity and safety:

On the basis of acute studies with laboratory animals, methyldiethanolamine is considered slightly toxic by single oral dose and practically nontoxic by single dermal application. The oral LD50 value in the rat is 4.78 g/kg and the dermal LD50 value in the albino rabbit is 6.24 g/kg.

Methyldiethanolamine is considered moderately irritating to the eyes, but only slightly irritating to the skin. The product is not corrosive under the conditions of the DOT corrosivity test and is not regulated as a hazardous material for transportation purposes. Because of the low vapor pressure of methyldiethanolamine, exposure to vapors is not expected to present a significant hazard under normal workplace conditions.

When handling methyldiethanolamine, chemical-type goggles must be worn. In addition, exposed employees should exercise reasonable personal cleanliness, including washing exposed skin areas several times daily with soap and water and laundering soiled work clothing at least weekly.

Should accidental contact with the eyes occur, flush them thoroughly with water for at least 15 minutes and get medical attention. Wash exposed skin areas with soap and water.

c) HANDLING AND STORAGE

The handling and storage of methyldiethanolamine presents no unusual problems. See the section on toxicity and safety for related additional information.

The solvent properties and alkaline nature of methyldiethanolamine should be considered when installing handling and storage facilities. Methyldiethanolamine will react with copper to form complex salts, so the use of copper and alloys containing copper should be avoided. Carbon steel storage tanks, constructed according to a recognized code, are generally satisfactory. Carbon steel transfer lines, at least 2 inches in diameter and joined by welds or flanges, are suitable. Screw joints are subject to failure unless back-welded because methyldiethanolamine will leach conventional pipe dopes. U.S. Rubber 899 gasket material or its equivalent is satisfactory for use with flange connections. Centrifugal pumps are preferred with methyldiethanolamine, although carbon steel rotary pumps can be used. Rotary pumps should be equipped with externally lubricated bearings. A Dura metallic Type RO-TT mechanical seal is suitable. Garlock 234, 239, or equivalent can be utilized as pump packing.

2. EXPERIMENT WITH MDEA :

In the 4th week, I did the experiment of AOP using H₂O₂ and UV light to degrade MDEA. Unfortunately, the results went bad. It is thought that it due to human errors. Therefore, we decided to do the experiment with MEA to compare the results with the data got from the same previous experiment. From that, I can gain more experience and confidence to do the real one on MDEA.

EXPERIMENT WITH MEA

1.PROCEDURE:

Condition: $T= 28^{\circ}\text{C}$, $\text{pH}=2$

- Prepare 0.5 ml MEA in 500 ml flask , then add water to the mark. Add 385.8 ml into small reactor.
- Add 4.24 ml of 30 % H_2O_2 into small reactor.

Take samples for COD and H_2O_2 concentration measurements at 0,5,10,20,30,40,50,60 mins

For COD: pre add 2ml NaOH. Using syringe to take 2ml of sample at designated time

For H_2O_2 : pre – add 2ml H_2SO_4 in vials. Using syringe to take 2ml of sample at designated time

COD analysis: pipet 2ml from sample vials into COD vial then put it inside the equipment to react for 2 hours at 150 degree Celsius.

H_2O_2 analysis: prepare 0.05N KMnO_4 solution. Titrate the whole content with KmnO_4 until the first pink color appears.

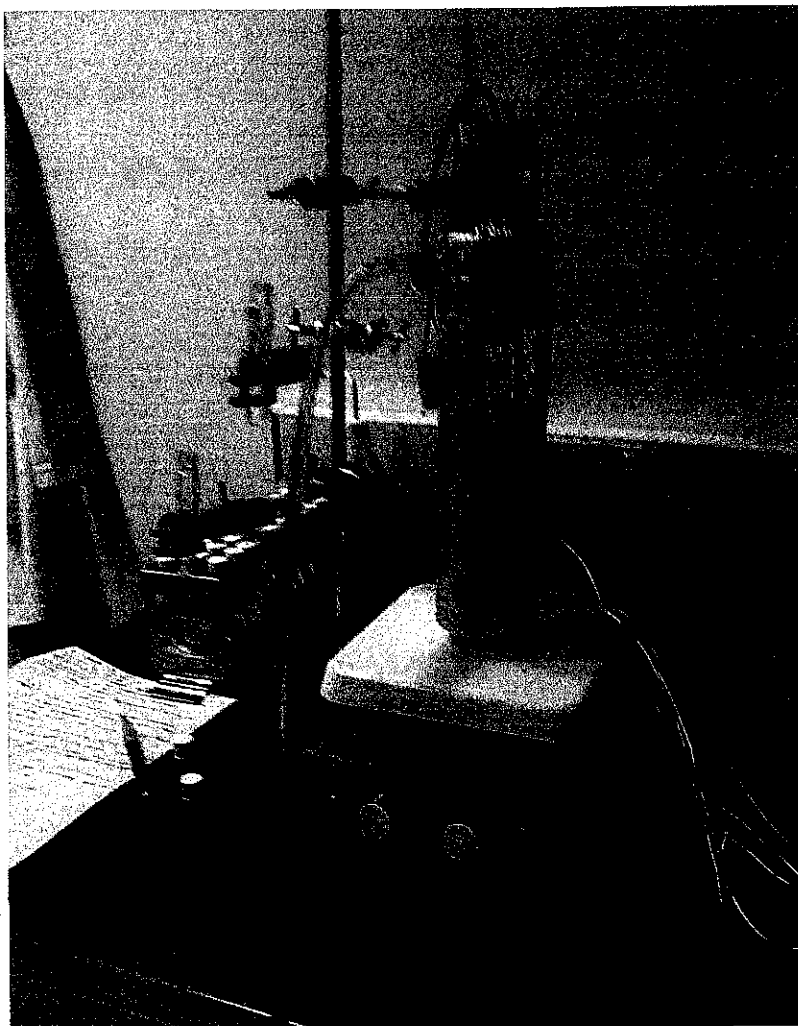


Figure 2: The reactor with UV light

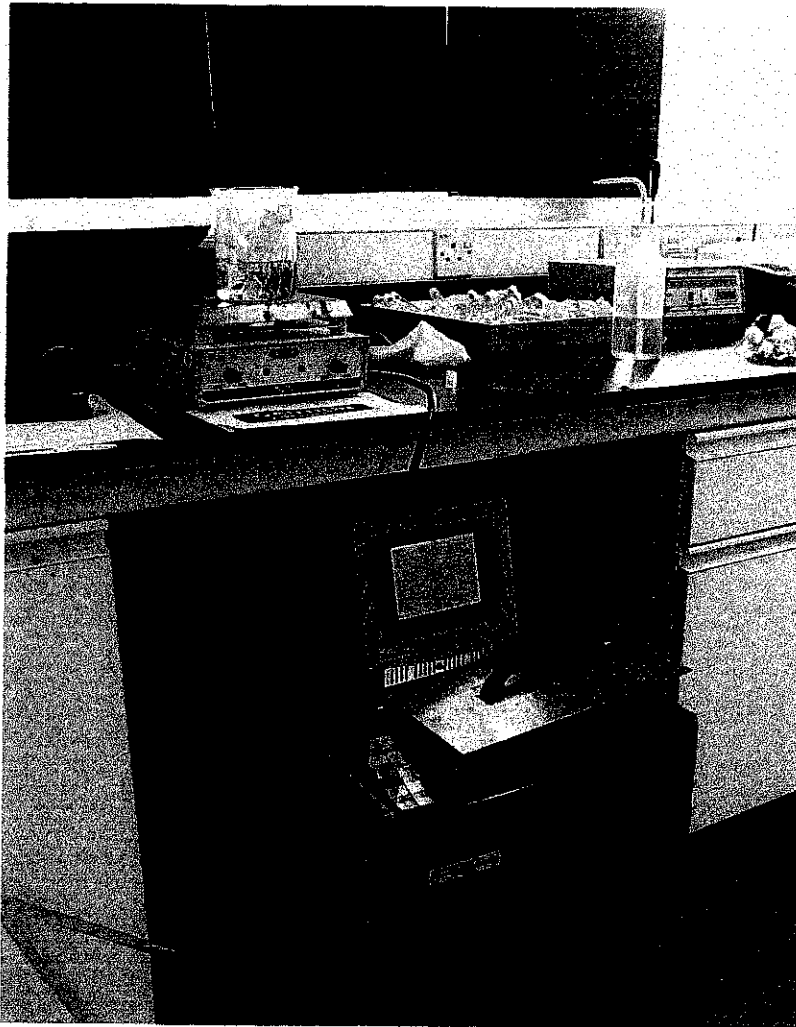


Figure 3: COD vials heating up

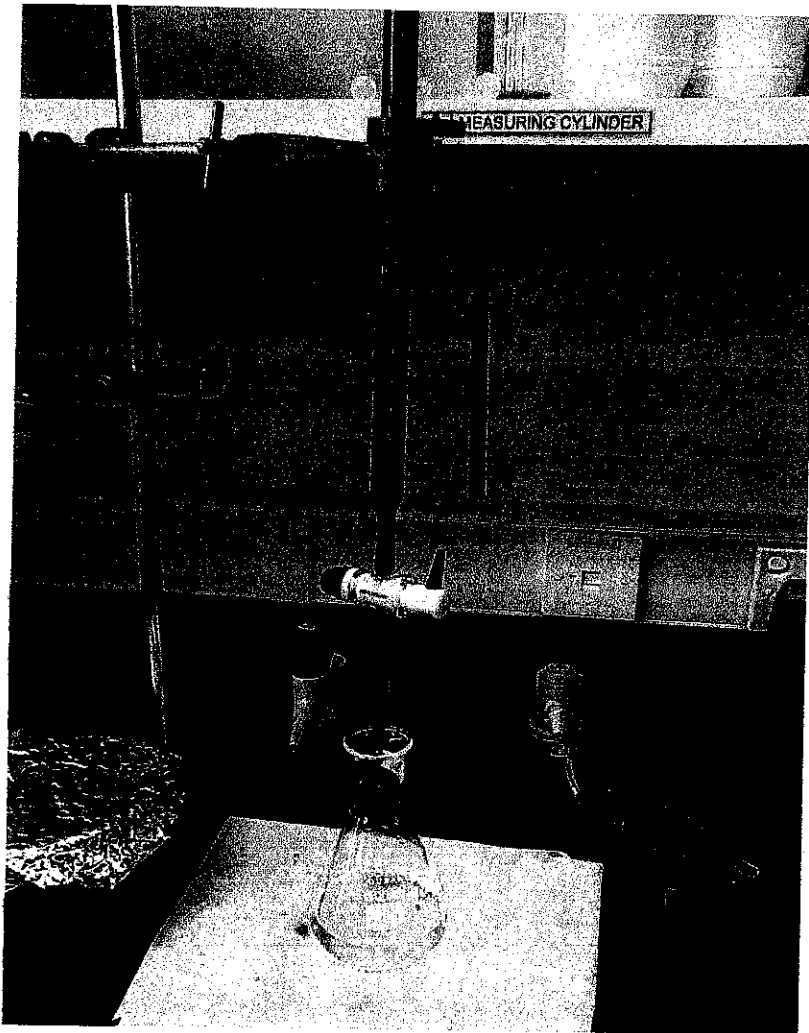


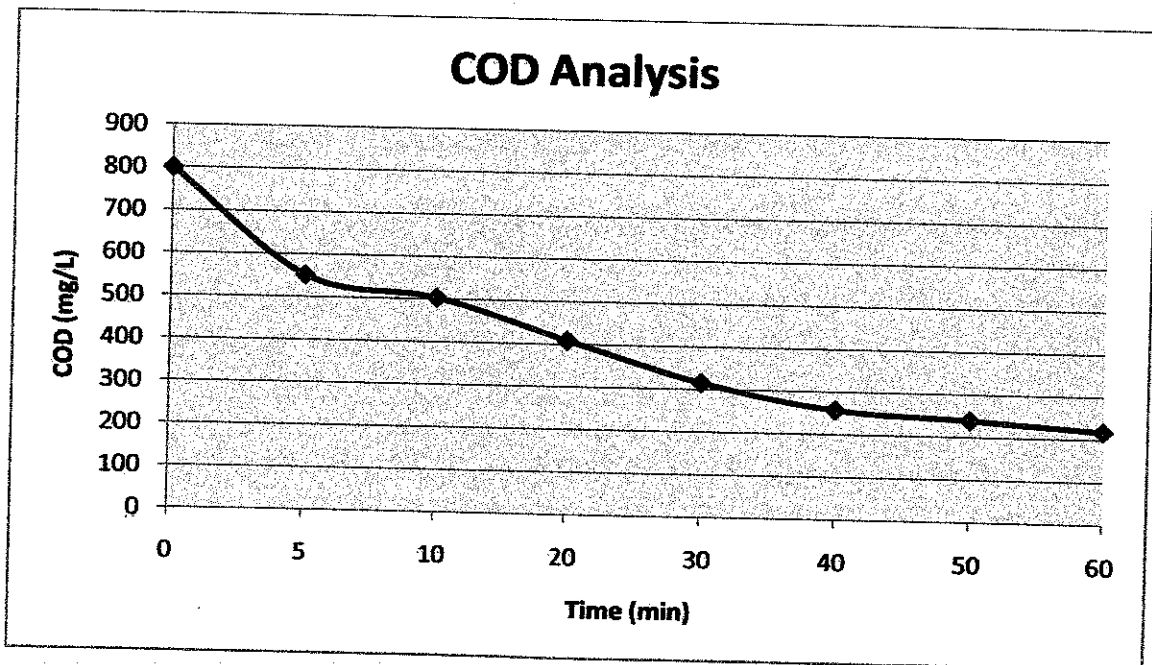
Figure 4: KmnO_4 titration

RESULTS AND DISCUSSION:

1. COD analysis:

Table 1 : COD reading for MEA

Time	COD(mg/L)
Blank	0
0	799
5	551
10	503
20	408
30	315
40	257
50	239
60	218



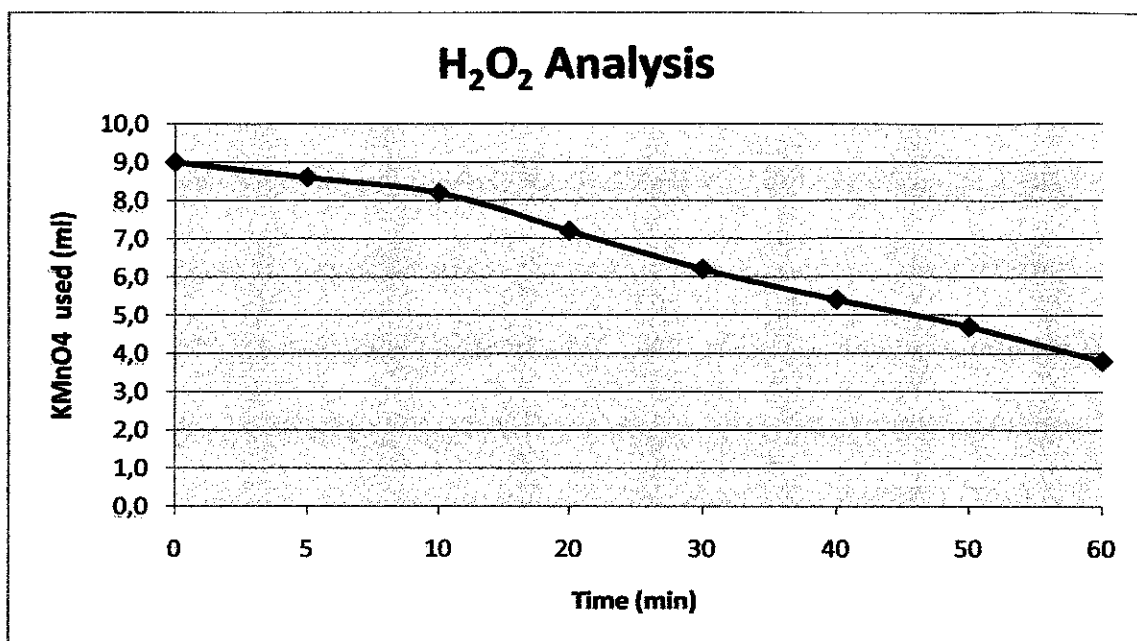
It can be seen from the table that the COD decrease with time and it shows a good trend because our goal is to reduce the COD with time. However, the COD is still a bit high.

The point here is the COD does not tell us how much the degradation we can get so we have to work out to see how much H_2O_2 is enough for supplying OH radicals in order to degrade MEA or at least can break it into smaller molecules which can be treated by biological technique.

2. H_2O_2 analysis:

Table 2 : $KMnO_4$ titration (MEA)

Time	$KMnO_4$ used (ml)
0	9
5	8.6
10	8.2
20	7.2
30	6.2
40	5.4
50	4.7
60	3.8



We can see the KMnO₄ used reduced with time. It is due to the H₂O₂ reduction with time. H₂O₂ was decomposed into OH radicals to oxidize the chemical. Thus, we need less KMnO₄ to consume H₂O₂. Less H₂O₂ presented means more H₂O₂ reacted during the time of experiment.

EXPERIMENT WITH MDEA

1. PROCEDURE:

Condition: T= 28°C, pH=2

- Prepare 5.501 ml MDEA in 500 ml flash, then add water to the mark. Add 341.5 ml into small reactor.
- Add 48.475 ml of 30 % H₂O₂ into small reactor.

Take samples for COD and H₂O₂ concentration measurements at 0, 5, 10, 15,20,25,30,40,50,60 mins

For COD: pre add 5ml NaOH. Using syringe to take 1ml of sample at designated time

For H₂O₂: pre – add 2ml H₂SO₄ in vials. Using syringe to take 2ml of sample at designated time

COD analysis: pipet 2ml from sample vials into COD vial then put it inside the equipment to react for 2 hours at 150 degree Celsius.

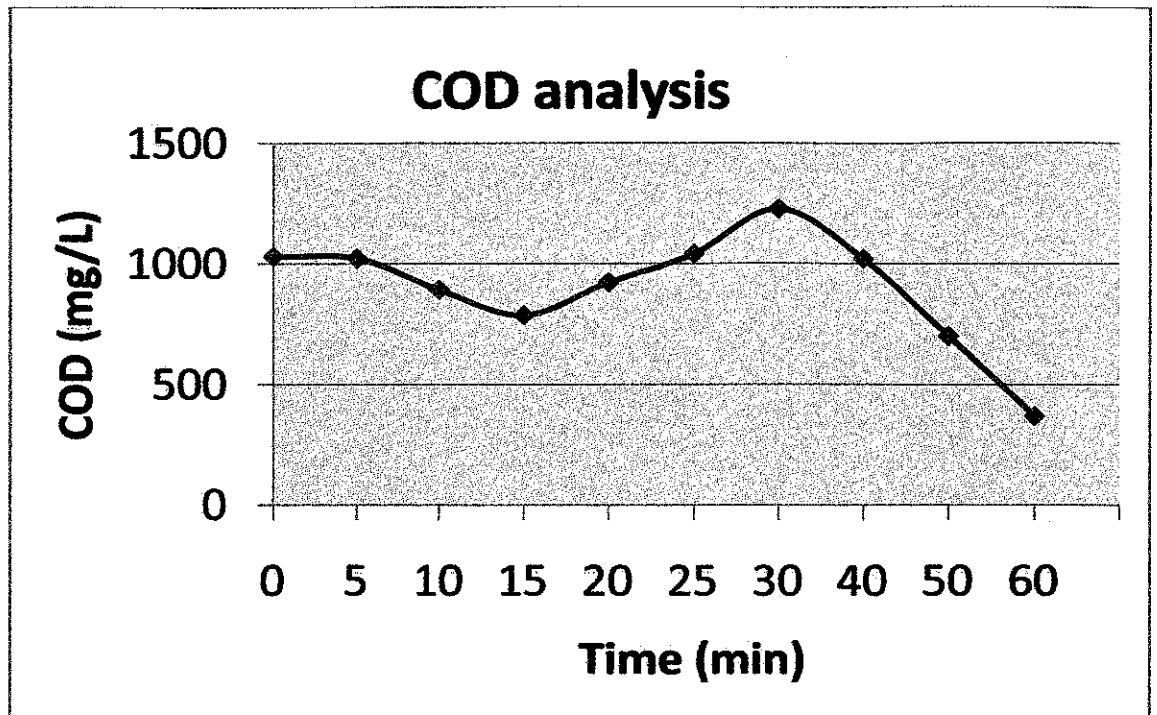
H₂O₂ analysis: prepare 0.5N KMnO₄ solution. Titrate the whole content with KMnO₄ until the first pink color appears.

RESULTS AND DISCUSSION:

1. COD analysis:

Table 3 : COD reading for MDEA

Time	COD(mg/L)
Blank	0
0	1030
5	1023
10	893
15	787
20	923
25	1041
30	1227
40	1020
50	702
60	370



As can be seen from the graph above, the COD does not reduce with time. The results show that the data fluctuates and it gives the bad trend. The COD was supposed to be less by time and to a certain amount of time it will not reduce anymore. That is when the saturated problem occurs.

The causes for these unwanted results can be human error, defective equipment or even some other kind of causes that was not identified yet. It can also due to the characteristics of the chemical. For the better conclusion, we should do more experiment.

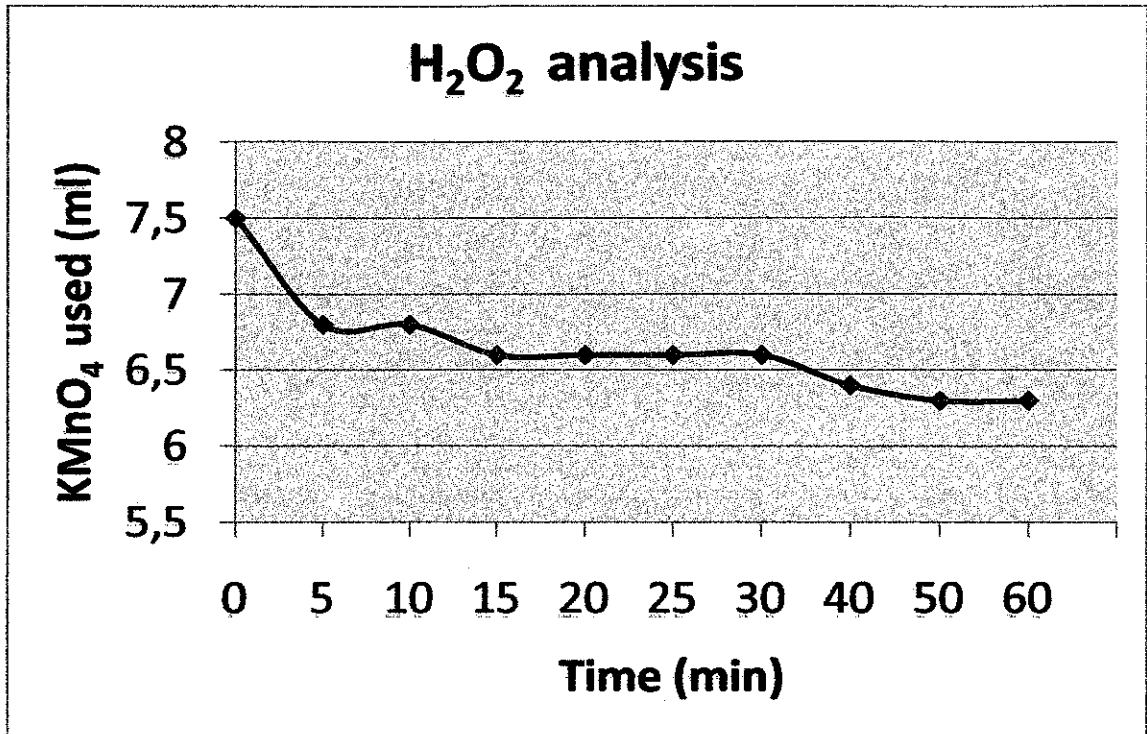
2. H_2O_2 analysis:

Table 4 : $KMnO_4$ titration(MDEA)

Time	$KMnO_4$ (ml)
0	7.5
5	6.8
10	6.8
15	6.6
20	6.6
25	6.6
30	6.6

40	6.4
50	6.3
60	6.3

From the table, the KMnO_4 used to dilute the residual H_2O_2 in the samples decreases with time. For this experiment, the KMnO_4 solution is 0.5 N, ten times more concentrated than that solution used in experiment with MEA. Thus, the result here in fact is 10 times more. For example, for the first sample, it is 75 ml of KMnO_4 that we have use.



EXPERIMENT WITH MDEA (RUN 2)

1. PROCEDURE:

Condition: $T = 28^{\circ}\text{C}$, $\text{pH} = 2$

- Prepare 5.501 ml MDEA in 500 ml flash, then add water to the mark. Add 341.5 ml into small reactor.
- Add 48.475 ml of 30 % H_2O_2 into small reactor.

Take samples for COD and H_2O_2 concentration measurements at 0, 5, 10, 15, 20, 25, 30, 40, 50, 60 mins

For COD: pre add 5ml NaOH and 2ml distilled water. Using syringe to take 0.5ml of sample at designated time

For H_2O_2 : pre – add 2ml H_2SO_4 in vials. Using syringe to take 2ml of sample at designated time

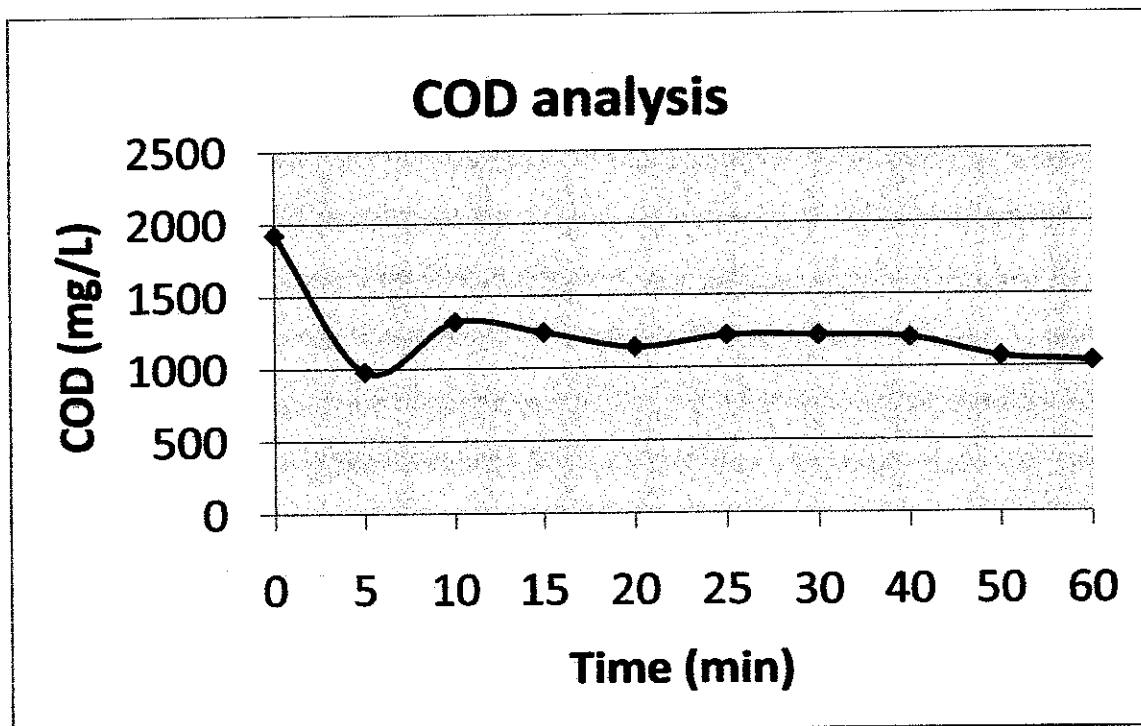
COD analysis: pipet 2ml from sample vials into COD vial then put it inside the equipment to react for 2 hours at 150 degree Celsius.

H_2O_2 analysis: prepare 0.5N KMnO_4 solution. Titrate the whole content with KMnO_4 until the first pink color appears.

COD ANALYSIS

Table 5: COD reading for MDEA(run 2)

Time	COD(mg/L)
Blank	0
0	1927
5	980
10	1322
15	1247
20	1142
25	1222
30	1219
40	1203
50	1071
60	1037



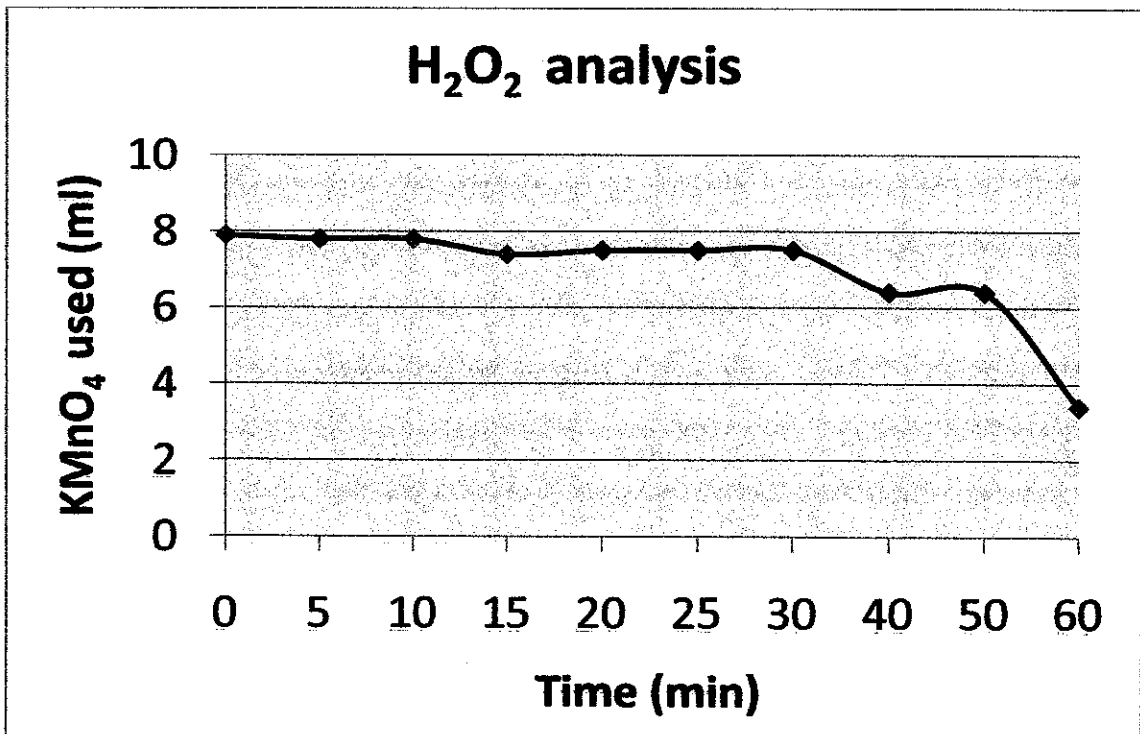
The graph showed the trend of COD from experiment result. From the beginning, COD reading was 1927 mg/L, then after 5 minutes it dropped to 980 mg/L. It

indicated that COD reduced with time. Surprisingly, at 10 minute record, the COD rose to 1322 mg/L, a bit far from the second reading. It might be caused by the unstable condition in a short of time. It was predicted that it would decrease after a period of time longer. To see clearly from the graph above, the COD readings gradually falled during 50 minutes of the experiment. However, the drop was not much among those readings.

H₂O₂ ANALYSIS

Table 6 : KMnO₄ titration(MDEA run 2)

Time	KMnO ₄ (ml)
0	7.9
5	7.8
10	7.8
15	7.4
20	7.5
25	7.5
30	7.5
40	6.4
50	6.4
60	3.4



In the graph, we can see the reduction of H₂O₂ with respect to time. It means how effective hydroxyl peroxide react on the degradation of MDEA. In the first 30 minutes, H₂O₂ decreased not too much, just a little by little. However, during the later 30 minutes, the H₂O₂ dose drop significantly, especially in the final 10 minutes.

We can conclude that H₂O₂ decrease with time.

CONCLUSION AND RECOMMENDATION

1. CONCLUSION

We can see that AOP works by producing the OH radicals in order to attack the molecular of toxic chemical and destroy it into water, carbon dioxide and inorganic or at least, into harmless products.

The methods based on chemical destruction, when properly developed, give the complete solution to the problem of pollutant abatement differently from those in which only a phase separation is realized with the consequent problem of the final disposal.

Our objective is to reduce the COD and find out the suitable amount for supplying H_2O_2 to produce enough OH radicals which can degrade the pollutant or can disintegrate it into smaller molecules to be easier treated.

2. RECOMMENDATION

The results were not very satisfying. It can be caused by human errors or equipment performance. It may be caused by the characteristic of the chemical as well. No matter what the reason is, we should repeat this experiment more times. Moreover, to get the better results, we have to focus more on setting up the equipment, doing steps precisely etc.

REFERENCES

1. <http://www.wisegeek.com/what-is-oxidation.htm>
2. www.huntsman.com
3. www.elsevier.com/locate/jhazmat
4. www.sciencedirect.com
5. <http://www.frtr.gov/matrix2/section4/4-45.html>
6. <http://www.advancepetro.com/mdea.htm>
7. <http://www.frtr.gov/matrix2/section4/D01-4-45.html>