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CATALYTIC WATER OXIDATION OF WASTEWATER CONTAINING ACETIC ACID

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Thesis submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Chemical Engineering (Biotechnology)

**Faculty of Chemical & Natural Resources Engineering
UNIVERSITI MALAYSIA PAHANG**

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LIST OF ABBREVIATIONS

<i>Al₂O₃</i>	aluminium oxide
<i>AOP</i>	advance oxidation process
<i>Atm</i>	atmosphere
<i>BET</i>	brunauer-emmett-teller
<i>HCl</i>	hydrochloric acid
<i>COD</i>	chemical oxygen demand
<i>Cu</i>	copper
<i>FTIR</i>	fourier transform infrared
<i>K</i>	kalium
<i>Pd</i>	palladium
<i>PdCl₂</i>	palladium chloride
<i>Wt.%</i>	weight percent
<i>XRD</i>	x-ray diffraction

Greek

γ	gamma
θ	theta
α	alpha

Subscripts

<i>g</i>	gram
<i>mg</i>	milligram
<i>M</i>	molar
<i>ml</i>	mililiter

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ABSTRACT

Treatment of wastewater containing significant amount of acetic acid has been recognized as a significant expense to the industry and the environment. The conventional ways usually requires a lot of energy and long residence time. Therefore, by using the catalytic water oxidation process which is done in normal operating condition, the process of wastewater treatment can be done in a more energy and cost efficient manner. The main objective of this experiment is to synthesize and characterize the palladium over the aluminium oxide and then to oxidize the acetic acid and study the effect of important parameters to the wastewater treatment process. The catalyst is synthesized using the wet impregnation method of palladium chloride with the support. For the reaction purpose, a 3-necked flask was used as the batch reactor. The catalyst synthesized is in crystalline form and consists of large surface area. It was found that in overall, the catalyst was able to oxidize the acetic acid at the given condition, such as that increasing the temperature and acetic acid concentration will increase the oxidation process.

ABSTRAK

Rawatan sisa kumbahan yang mengandungi sejumlah asid asetik yang ketara telah dikenal pasti dalam sisa buangan industri sebagai suatu yang perlu diberi perhatian. Rawatan konvensional kebiasaanya memerlukan jumlah tenaga yang besar dan masa yang lama. Oleh itu, penggunaan proses pengoksidaan air dengan pemangkin yang dilakukan pada keadaan persekitaran normal akan membolehkan proses perawatan air kumbahan dilakukan pada kadar yang lebih menjimatkan tenaga dan juga kos. Objektif utama eksperimen ini adalah untuk mensintesis serta mengkarakter palladium diatas aluminium oksida dan kemudian mengoksida larutan asid asetik serta mengkaji kesan-kesan parameter penting terhadap rawatan sisa kumbahan. Pemangkin itu kemudiannya diuji terhadap larutan asetik asid dibawah beberapa parameter yang berbeza. Pemangkin itu disintesis dengan menggunakan teknik rendaman basah oleh palladium klorida kepada larutan aluminium oksida. Bagi tujuan rawatan asetik asid, kelalang bulat berleher tiga digunakan sebagai raktor. Pemangkin yang disintesis berada dalam keadaan kristal dan mempunyai luas permukaan yang luas. Secara keseluruhan, pemangkin berupaya untuk mengoksida larutan asid asetik pada keadaan yang diuji, dimana apabila suhu dan kepekatan asid asetik semakin meningkat, proses pengoksidaan juga akan menjadi semakin cepat.

1 INTRODUCTION

1.1 Motivation and statement of problem

The amount of wastewater coming from the industrial activities keeps increasing by each passing year. This brings forward the concern on its effects towards the environment after being released into the surrounding. It is due to this fact that the process that enables the treatment of wastewater is becoming increasingly important. Several processes have been developed to treat the wastewater to meet the minimum concentration allowed for the wastewater release. However, the condition of the wastewater treatment process must also be considered as it will give impact to the cost of operation of the whole plant.

Acetic acid can be found in the textile wastewater because of its general use in cotton fibre dyeing. The acetic acid waste streams are being produced in large quantities by many petrochemicals, process and fine chemicals industries which are using acetic acid as a chemical reagent for the production of many chemical compounds. Furthermore, some of the oxidation process of wastewater with the use of hydroxyl radicals might form acetic acid as an intermediate or final product due to the oxidation. Not only that, the presence of acetic acid can affect significantly the wastewater characteristics because of the high COD values which it brings about.

Some of the industry recycles back the acetic acid in their wastewater if the concentration is high. However, the remaining acetic acid in the wastewater with a low concentration usually cannot be recycled, and there is a problem to oxidize it as it is a compound that is difficult to oxidize.

A numbers of conventional methods have been utilized for the wastewater contaminated with the organic and inorganic compound. Among them are the adsorption, reverse osmosis, and also distillation process. Unfortunately, most of the processes are not economically efficient, especially when the wastewater is produced in large quantity. Therefore the industries are in need of alternative processes that are not only efficient in terms of the process, but also economically viable and at the same time is environmental friendly.

Other technologies that have been used to treat wastewater efficiently are Advanced Oxidation Processes (AOPs), which appear to be promising field of study as

wastewater treatments. AOPs include several techniques such as ozonation, Fenton, photo-Fenton, photocatalysis, wet oxidation process, and also catalytic water oxidation process (Yang,2008).

1.2 Objectives

The following are the objectives of this research:

- To study and characterize the Palladium over alumina oxide
- To study the effect of important parameter to the wastewater treatment process

1.3 Scope of this research

The following are the scope of this research:

- i) Construction of experimental rig for gas-liquid and solid-liquid stirred tank performance analysis
- ii) Experimental analysis of hydrodynamics and performance of gas-liquid stirred tank
- iii) Experimental analysis of hydrodynamics and performance of solid-liquid stirred tank

1.4 Main contribution of this work

The following are the main contribution of this research:

- Discover the oxidizing capabilities of Palladium towards the acetic acid

1.5 Organisation of this thesis

The structure of the reminder of the thesis is outlined as follow:

Chapter 2 provides a description of the method of treatment of the wastewater that are being used right now. It includes the advantages and disadvantages of each method of treatment. This chapter also provide the catalyst preparation method, where several methods are available, with different precursor been mentioned such as the palladium chloride.

Chapter 3 gives a review of the chemical list that being used for the experiment, and also the list of main equipment used. It explains in details how the catalyst are being prepared and how the reaction and the analysis are being done.

Chapter 4 explains about the results of the experiments, which are the analysis of the experiments and also the catalyst characterization results. The results are being discussed in reference with the previous similar experiment.

Chapter 5 draws together a summary of the thesis and outlines the future work which might be derived from the model developed in this work.