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EVALUATION OF COCONUT HUSK BASED MAGNETIC SORBENT FOR DEFOAMING APPLICATION

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Bachelor of Engineering with Honours

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2022

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EVALUATION OF COCONUT HUSK BASED MAGNETIC SORBENT FOR DEFOAMING APPLICATION

FELICIA TERRY ANAK LO

A dissertation submitted in partial fulfilment

of the requirement for the degree of

Bachelor of Engineering with Honours

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Dedicated to my family and friends who become the continuous source of motivation and encouragement.

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ABSTRACT

The removal of undesired contaminants in activated Methyldiethanolamine (MDEA) solvent was conducted by utilizing magnetic activated carbon (MAC). In this work, MAC was synthesized from coconut husk through chemical activation and co-precipitation methods. The performance of this material as an adsorbent was evaluated based on the foaming behaviour of activated MDEA solvent after being contacted with MAC at different duration and varying amounts. Nitrogen gas was introduced into the amine solvent through a gas diffuser to create foam. Based on the results, the foam volume generated by activated MDEA solvent was identified to decrease with the increase in both MAC exposure time and amount. However, the removal efficiency of MAC decreases at 4 to 8 hours of contact time which results in greater foam volume as compared to other contact duration. The highest removal efficiency by MAC was identified to be at 1 hour contact time between MAC and activated MDEA solvent where the foam breaking time was reduced to 10-30 minutes. Meanwhile, the addition of 50% MAC into the solvent was able to further decrease the foam breaking time to 5-10 minutes. The characteristics of prepared MAC were also evaluated through Thermogravimetric Analyzer with Derivative Thermogravimetric Analyzer (TGA/DTG), Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM/EDX), Fourier-Transform Infrared Spectroscopy with Potassium Bromide (FTIR-KBr) and Brunauer-Emmett-Teller (BET) Surface Area Analyzer. This study shows that the MAC synthesized from coconut husk has a good potential as an adsorbent in removing the contaminants in activated MDEA solvent to reduce the foam formation.

Keywords: Magnetic activated carbon, coconut husk, foaming, activated MDEA, removal efficiency.

ABSTRAK

Penyingkiran bahan cemar yang tidak diingini dalam larutan Methyldiethanolamine (MDEA) yang diaktifkan telah dijalankan dengan menggunakan karbon teraktif magnetik (MAC). Dalam kerja ini, MAC telah disintesis daripada sabut kelapa melalui kaedah pengaktifan dan pemendakan bersama bahan kimia. Prestasi bahan ini sebagai penjerap dinilai berdasarkan tingkah laku larutan MDEA yang diaktifkan untuk berbuih selepas terdedah dengan MAC dalam tempoh dan jumlah yang berbeza. Gas nitrogen dimasukkan ke dalam larutan amina melalui penyebar gas untuk menghasilkan buih. Berdasarkan keputusan, isipadu buih yang dihasilkan oleh larutan MDEA yang diaktifkan telah dikenal pasti berkurangan dengan peningkatan masa pendedahan dan jumlah MAC. Walau bagaimanapun, kecekapan penyingkiran MAC berkurangan pada 4 hingga 8 jam masa sentuhan yang menghasilkan jumlah buih yang lebih besar berbanding dengan tempoh sentuhan lain. Kecekapan penyingkiran tertinggi oleh MAC dikenal pasti pada masa sentuhan 1 jam antara MAC dan larutan MDEA yang diaktifkan di mana masa pecah buih telah dikurangkan kepada 10-30 minit. Sementara itu, penambahan 50% MAC ke dalam larutan mampu mengurangkan lagi masa pecah buih kepada 5-10 minit. Ciri-ciri MAC yang disediakan juga dinilai melalui Penganalisis Termogravimetrik dengan Penganalisis Termogravimetrik Terbitan (TGA/DTG), Pengimbasan Mikroskopi Elektron dengan Spektroskopi Sinar-X Penyerakan Tenaga (SEM/EDX), Spektroskopi Inframerah Transformasi Fourier dengan Kalium Bromida (FTIR-KBr) dan Penganalisis Kawasan Permukaan Brunauer-Emmett-Teller (BET). Kajian ini menunjukkan bahawa MAC yang disintesis daripada sabut kelapa mempunyai potensi yang baik sebagai penjerap dalam menyingkirkan bahan cemar dalam larutan MDEA yang diaktifkan untuk mengurangkan pembentukan buih.

Kata kunci: karbon teraktif magnetik, sabut kelapa, berbuih, MDEA yang diaktifkan, kecekapan penyingkiran.

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Al	-	Aluminium
B	-	Bridging coefficient
C	-	Carbon
Ca	-	Calcium
Cl	-	Chlorine
CO_2	-	Carbon dioxide
E	-	Penetration coefficient
Fe	-	Ferum
Fe^{2+}	-	Ferrous ion
Fe^{3+}	-	Ferric ion
$FeCl_2.4H_2O$	-	Iron (II) chloride tetrahydrate
$FeCl_3.6H_2O$	-	Iron (III) chloride hexahydrate
Fe_3O_4	-	Iron (II,III) oxide
g	-	gram
HCl	-	Hydrochloric acid
H_2S	-	Hydrogen sulphide
H_2SO_4	-	Sulfuric acid
K	-	Potassium
kg	-	kilogram
kg/cap/day	-	kilogram per capita per day
KBr	-	Potassium bromide
KOH	-	Potassium hydroxide
kV	-	kilovolt
Mg	-	Magnesium
MJ/kg	-	Mega Joule per kilogram
mL	-	Millilitre
mm	-	Millimetre
µm	-	Micrometre
Na	-	Sodium
NaOH	-	Sodium hydroxide

N/N_2	-	Nitrogen
O	-	Oxygen
Pb^{2+}	-	Lead (II) ion
ppmv	-	Part per million volumes
rpm	-	Rotation per minute
σ_D	-	Surface tension of defoamer
σ_{int}	-	Interfacial tension between liquid and defoamer
σ_L	-	Surface tension of liquid
S	-	Spreading coefficient
S	-	Sulphur
wt%	-	Weight percent
$ZnCl_2$	-	Zinc chloride

LIST OF ABBREVIATIONS

AC	-	Activated carbon
AMP	-	2-amino-2-methyl-1-propanolamine
BET	-	Brunauer-Emmett-Teller
DEA	-	Diethanolamine
DGA	-	Diglycolamine
DIPA	-	Diisopropanolamine
EAC	-	Extruded Activated Carbon
FTIR-KBr	-	Fourier-Transform Infrared Spectroscopy with Potassium Bromide
GAC	-	Granular Activated Carbon
MAC	-	Magnetic Activated Carbon
MDEA	-	Methyldiethanolamine
MEA	-	Monoethanolamine
PAC	-	Powder Activated Carbon
PZ	-	Piperazine
SEM/EDX	-	Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy
SF	-	Surface factor
TCP	-	Trichlorophenol
TEA	-	Triethanolamine
TGA/DTG	-	Thermogravimetric Analyzer with Derivative Thermogravimetric Analyzer

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Defoaming is a process that is typically conducted in industries where the bubbles and air that are present in the liquid are being removed in order to enhance the quality of products, optimize production and prevent the occurrences of problems related to process control and equipment operation (Welti-Chanes, et al., 2017; Awad, et al., 2012). The implementation of defoaming process can be found widely in the oil and gas industry, food processing, wastewater management, textiles manufacturing as well as paper and pulp production. In the oil and gas industry, the defoaming process usually being applied in the amine treating unit where the formation of foam frequently occurs in the production line. According to Pal et al. (2020), the formation of foam in gas processing facilities is a general problem that needs to be addressed as it creates several consequences for the processes.

In industry, this defoaming process can be conducted by using two different methods which are through chemical additives or utilization on mechanical devices (Garrett P. R., 2015). As the usage of mechanical devices required high energy demand, therefore, some chemical additives were added into the solution to act as defoaming agents (Pal, et al., 2020). However, the selection of suitable defoaming agents is crucial in order to ensure the effectiveness of the material in controlling and minimizing the formation of foam in the process. Other than that, the usage of chemical additives as antifoams sometimes lead to the formation of contaminants in the process which makes the output of the process deviate from the targeted outcome (Pal, et al., 2020).

The presence of acid gases like hydrogen sulphide (H_2S) and carbon dioxide (CO_2) in the natural gas streams need to be removed in order to reduce the impacts of these hazardous gases on the environment (Pal, et al., 2020). This acid gases removal process from the natural gas stream is known as the natural gas sweetening process where alkanolamines are utilized as an absorbent in order to eliminate these corrosive and harmful gases (Alhseinat, et al., 2017). Nevertheless, the usage of these alkanolamines usually creates some operational problems in the production plant which including the formation of foam in the process stream. The presence of foams in the production plant contributes to several consequences where it can affect the production output of the plant. Due to this, some suitable approaches have been taken by the industry in order to cope with this issue to ensure the production output can be maintained at the desired outcome and reduce the operational losses.

The common approach that taken by the petrochemical industry to reduce the formation of foam is through the utilization of activated carbon (AC) as an adsorbent in the amine units. According to Engel, et al. (2015), this activated carbon has the ability in eliminating the soluble contaminants from amine solvent which makes the foaming tendency in the solvent can be reduced. This AC can be obtained from many types of resources like coal, lignite, coconut shell, sugar cane bagasse, coffee beans, rice husk, wood, and sawdust (Fazal-ur-Rehman, 2018). These different types of resources that are used to prepare the AC will have different absorption capacity and contaminants size that it can absorb (Engel, et al., 2015).

1.2 PROBLEM STATEMENT

The oil and gas industry are one of the most important industries that provide energy as well as plays a vital role in affecting the global economy due to its characteristic as the world's primary source of fuel (Burclaff, 2005). This natural gas typically being used by the power plant to produce electricity along with for domestic cooking and heating purposes. Natural gas or also known as fossil fuel is a non-renewable energy source which being extracted from underground up to the wellhead. However, during the extraction, the natural gas which mainly consists of a mixture from different types of hydrocarbons sometimes being contaminated with CO_2 and H_2S (Goodwin, et al., 2015). The presence of these acid gases causes the natural gas to become a sour gas in which the gas sweetening processes need to be conducted by the production plant in order to remove these acid gases from the natural gas content before it can enter the pipelines. Other than that, the removal of these acid gases is crucial as they will become highly corrosive when they are reacting with moisture which could harm the environment (Koros, 2020).

Due to this, the removal of these corrosive and harmful compounds from natural gas is conducted through the absorption process by utilizing alkanolamines as the absorption solvent due to their high absorption capacity towards acid gases (Rahimpour, et al., 2013). Even though this absorption process is the most common method that is being applied to sweeten the sour gas, but this process does have several consequences in which it will bring to the formation of foam where it can reduce the mass transfer efficiency and absorption capacity as well as amine solutions carryover to the downstream processes (Pal, et al., 2020). Thus, antifoaming agents are being added in order to minimize the foam generation in the amine solutions. The most widely used antifoaming agent in the amine solvent is AC where it can help in removing the soluble contaminants in order to reduce the foaming tendency in the amine treating units (Engel, et al., 2015). AC is an inert solid adsorbent material that can be prepared from materials that have carbon content like coconut shell, coal, sugarcane bagasse and lignite. To the best of my knowledge, there are still have limited studies on the utilization of coconut husk as the source for magnetic AC (MAC) preparation, thus, the focus of this project is to investigate the performance of MAC based coconut husk which will be used as a defoaming agent for the amine solution.

1.3 RESEARCH QUESTIONS

This project is focusing on the evaluation of coconut husk based magnetic sorbent for defoaming application and the research questions are as follows:

i. How the magnetic activated carbon (MAC) can be prepared from coconut husk?
ii. What are the significant effects of coconut husk-based MAC on the amine solution?
iii. How can this coconut husk-based MAC differ from other AC?

1.4 OBJECTIVES OF STUDY

As organic waste like coconut husk is believed could prepare another alternative in providing the source of activated carbon, therefore, the main aim of this project is to analyse the performance of magnetic activated carbon synthesized from coconut husk as the defoamer towards the solution defoaming. This main aim can be achieved through the fulfilment of the following objectives: