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TITLE: OPTIMIZATION PROCESS PARAMETERS OF PREPARATION ACTIVATED CARBON FOR CARBON DIOXIDE ADSORPTION: TAGUCHI APPROACH AND ISOTHERM STUDY

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Optimization Process Parameters of Preparation Activated Carbon for Carbon Dioxide Adsorption: Taguchi Approach and Isotherm Study

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ABSTRACT

Activated carbon is often used in numerous applications and very useful adsorbent. The aim of this research project is to develop an understanding on the parameters and level of the activated carbon production process using Taguchi Orthogonal Array design method. The orthogonal array design, analysis of variance (ANOVA), signal-to-noise ratio (S/N ratio), regression model and prediction for optimized value were used to investigate carbon dioxide (CO_2) adsorption efficiency. The control parameter investigated in this study were activation time, impregnation ratio and activation temperature. The statistical findings showed that the conditions that are optimized are the activation time of 30 min, impregnation ratio of 0.3 and the activation temperature of 700°C. The activation temperature has the greatest impact on carbon dioxide adsorption based on the highest delta in S/N ratio analysis. The linear regression model was performed and the result was well comparable between the simulated data and experimental data with R2 of 0.6159. The adsorption equilibrium data was well suited to the Freundlich isotherm.

Keywords: Activated carbon, Carbon Dioxide, Taguchi method, Analysis of variance, Optimization, Adsorption Isotherm

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1. INTRODUCTION

1.1 Problem Statement

The increased demand of energy utilisation worldwide has prompted awareness of the possible depletion of fossil fuel sources. The use of fossil fuel as a primary source of energy generation, transportation, machineries and etc. lead to the emission of CO_2 gas excessively.[1] Fossil fuel is abundantly available in Malaysia; the energy from the burning of fossil fuel is believed to be one of the main causes that threaten the sustainability of ecosystem thus creating many environmental problems. One of the detrimental effects are the emission of huge amount of greenhouse gases such as CO_2, NOx, and SOx into the atmosphere. Among the greenhouse gases, CO_2 is the most amount of gas that being released to the environment. Fig. 1 shows the emission of CO_2 in Malaysia and it is expected to increase every year as reported in BP Statistical Review of World Energy.[2]

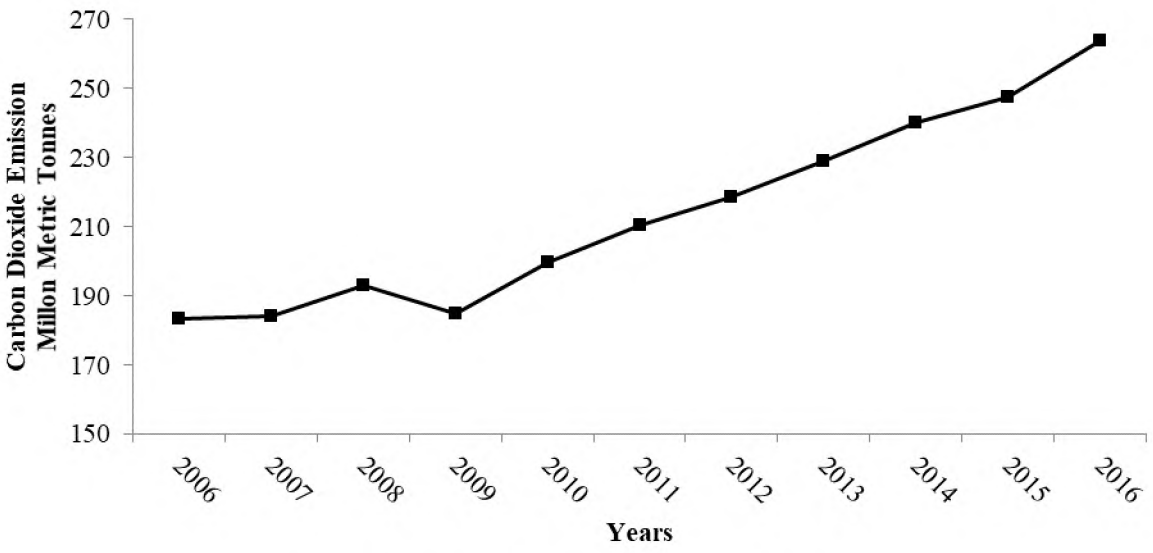

***Fig. 1* – Carbon dioxide emission in Malaysia**

The graph revealed that CO_2 emission in Malaysia had increased significantly from 183.3 million metric tonnes in 2006 to 263.8 in 2016 and it will be predicted to increase until 40 million tons if there is no action taken.[3] Furthermore, it is inventible that CO_2 emission will continue to increase as long as fossil fuel is used as the primary power source.[4] The power generation from the coal power plant emits high concentration of CO_2 gas mainly due to the composition of coal with high carbon content. As a result, the combustion of coal emits a large amount of CO_2 and SOx that create acid rain and other pollutions. Environmentally, from a

landscape point of view, the mining of coal may lead to the destruction of land and destroy the sustainability of natural resources.[5]

The Kyoto protocol was established in December 1997 in Kyoto, Japan, to monitor and control the emission of greenhouse gas around the world. Under Kyoto protocol, the industrial countries had agreed and committed to reduce the emission of greenhouse gases by 5.2 %, by 2012, based on the 1990 emission.[6] The aim of the conference was to reduce and eliminate six primary greenhouse gases which are methane (CH4), carbon dioxide (CO_2), sulphur hexafluoride (SOx), nitrous oxide (NOx), hydrofluorocarbon, and perfluorocarbons.[6] Many countries including Malaysia are now taking serious actions to accomplish the aims by reducing dependency on the fossil fuels.

Other than that, carbon capture technology can be considered in reducing the amount of CO_2 emission into the environment. Shorten of carbon capture, utilization and storage or sequestration (CCUS) is a type of technology designed to prevent the release of CO_2 generated through conventional power generation. This technology can store the CO_2 as well.

1.2 Literature and Objectives

Activated carbon (AC) is commonly used as an adsorbent in the treatment of liquid and gas phases as it comprises porous structures, a very significant feature of adsorption. The chemical agents used during the process was zinc chloride ($ZnCl_2$). Some researchers have also shown that activated carbon can absorb carbon dioxide (CO_2). This is dependent on the characteristics of activated carbons with a large active surface area that can provide high adsorption capacity due to its high surface area and porosity, well-developed porous structures and strong mechanical properties. The process of making activated carbon consists of carbonization and activation steps to remove volatile matter (H, S, N) and create many porous bonds. The structure of porous solids is random and has different pore sizes. According to the IUPAC (International Union of Pure and Applied Chemistry) activated carbon can be classified into three groups of pores: micropores (less than 2 nm diameter), mesopores (2-50 nm diameter) while macropores (more than 50 nm diameter). [20] There are two techniques or method of activation to produce activated carbon from carbonaceous material, which is a chemical and physical process. Usually, physical techniques are typically thermal processes carried out at temperatures below 700°C using oxidizing gasses such as air, CO_2 and H_2O steam as a second stage after pyrolysis resulting in the release of CO_2 from carbon surface. The chemical activation methodology is normally used and requires two main steps: the heating process and the process of chemical treatment. Organic materials rich in carbon are the most important precursors used in the preparation of activated carbons. Usually, the