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modeling of adsorption kinetic and equilibrium isotherms of hydrogen sulfide onto hydrogel biochar adsorbent

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ABSTRACT

Every process produces byproduct, byproduct can be dangerous or not. Hydrogen sulfide is one of the dangerous byproduct produced. In order to prevent hydrogen sulfide to harm workers or residents, control system is required. Currently, all industry has a control system such as adsorption system, to control dangerous component such as hydrogen sulfide. In order to optimize adsorption system, research is required. Researching using laboratory method is very dangerous due to nature of hydrogen sulfide. Thus isotherm and kinetic model is used as alternative method, as it doesn't involve researching in laboratory. Each isotherm model and kinetic model equation has different uses for adsorption process. The isotherm models used are Langmuir, Freundlich and Elovich, while kinetic models used are Pseudo-First Order and Pseudo-Second Order. The main objective of this experiment is to find the most suitable equation for adsorption of hydrogen sulfide. Suitability of equation is determined by correlation coefficient (R^2). The higher correlation coefficient, the more suitable the equation is to process. After result obtained, the most suitable isotherm and kinetic model are Elovich model and Pseudo-Second Order model respectively. R^2 for Elovich model is 0.9686 while R^2 for Pseudo-Second Order model is 0.9284. By comparing R^2 of each model, it is shown that Elovich and Pseudo-Second Order model are the most suitable for this adsorption process due to highest correlation coefficient.

CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

The most toxic gas is carbon monoxide while the second is hydrogen sulfide. The hydrogen sulfide can cause inhalational deaths. It is dangerous as mechanism is unknown to people. It can be produced naturally from organic matter that decays (Jiang et al., 2016). This production of hydrogen sulfide can be seen in the Petroleum production and refining, sewer and wastewater treatment and Agricultural silos (https ://www.osha.gov /SLTC/ hydrogensulfide/ hydrogensulfide_found.html). They are exposed to the hydrogen sulfide by inhaling the gas. Effects depend on how much and how long is the workers exposed to the hydrogen sulfide. By referring to Occupational Safety and Health Act (OSHA), symptoms can identify when workers exposed to high concentration. The worst scenario is that workers dead by rapid unconsciousness and stop breathing.

Hydrogen sulfide can be very dangerous but industry can take preventive action to protect their employees and their building. It can be corrosive toward metals and concrete. Commercialized process that used in industry is adsorption using activated carbon. Atoms, ions or molecules from adsorbate that can be in gas, liquid or dissolved solid adhere to a surface of the adsorbent is adsorption process. Atoms, ions or molecules adhere to a surface of adsorbent due to differences in concentration.There are many parameters in improving the adsorption rate, such as temperature, condition of adsorbent and adsorbent condition (Bajpai & Rajpoot, 1999).

Activated carbon is one of the adsorbent's examples. It is a carbonaceous, highly porous adsorptive medium that has a complex structure composed primarily that has complex structure composed primarily of carbon atoms. The pores in activated carbon are linked together with each other by chemical bond, to create a rigid skeleton of disordered layers of carbon atoms. Coconut shell, peat, lignite coal and empty fruit bunch are examples types of activated carbons. Each contains different carbon and different result will produce if used as an adsorbent.

Empty fruit bunch was used as the adsorbent for adsorption process in the experiment. Empty fruit bunch is a bulky and voluminous brown bunch left over at palm oil mills after removal of sterilized fruit by a rotary thresher drum. It is also a solid residue that contains 20% of the fresh fruit weight (Chang, 2014). It undergoes pyrolysis to turn into biochar. Pyrolysis can only be obtained when organic material undergoing thermal decomposition at high temperatures without oxygen presence.This process changes chemical composition, physical state and it is irreversible process. Then, prepared biochar is then treated with either acid solution or oxidizing agent to enlarge pores and remove impurities. Prepared biochar will change into hydrogel biochar after undergo polymerization process. Hydrogel biochar is hydrophilic, swell able and modifiable composite (Meri, Bahari, Talib, & Abdul, 2017). It is an improved version of activated biochar (Ahmed, 2015).

1.2 PROBLEM STATEMENT

Every experiment must be done in laboratory scale so that the damage or side effect is in minimal amount. The experiment can be scaled up into industry level by using adsorption isotherm and adsorption kinetic. The data from adsorption isotherm is used in designing adsorption system, as it is referring to equilibrium relationship of H_2S distribution in the bulk gas stream and on the surface of adsorbent. The most common isotherms uses in the analysis are Langmuir, Frendliuch and Temkin isotherms. Each isotherm contains different equation that differentiates from each other. Adsorption kinetic related to the adsorption rate onto surface of a unit. The rate requires in designing process adsorption system (Journal & Science, 2016). As conclusion, both adsorption kinetic and isotherm are required in designing adsorption system.

Currently the existing results from developed model are only focusing on the relationship between H_2S and activated carbon. The developed model for adsorption isotherm and adsorption kinetic are still not applied to the relationship between H_2S and hydrogel biochar. This analysis will apply both adsorption isotherm and adsorption kinetic to the H_2S and hydrogel biochar.

1.3 OBJECTIVE

There are two main objectives of this research, which are:

I. To analyze isotherm of adsorption of hydrogen sulfide (H_2S) onto hydrogel biochar with Langmuir, Frendliuch and Temkin.
II. To analyze the modelling kinetic of adsorption rate of hydrogen sulfide (H_2S) by using pseudo-first-order and pseudo-second-order.

1.4 SCOPE AND LIMITATION

I. The isotherms that will be used in analysis of hydrogen sulfide adsorption by hydrogel biochar are Langmuir, Freundliuch and Temkin isotherms.
II. The currently developed isotherms for hydrogen sulfide onto activated carbon will be used and modified for adsorption using hydrogel biochar.
III. To develop kinetic model of adsorption rate for hydrogen sulfide onto hydrogel biochar, pseudo-first and second order will be used.
IV. The limitation is that developed models for hydrogel biochar are based on previous developed models for activated carbon. Limitation for the previous models will be carried forward for the new models.