

Application of Freundlich and Temkin Isotherm to Study the Removal of Pb(II) Via Adsorption on Activated Carbon Equipped Polysulfone Membrane

Khairul Anwar Mohamad Said^{1*}, Nor Zakirah Ismail¹, Ramizah Liyana Jama'in¹, Nurul Ain Mohamed Alipah¹, Norsuzailina Mohamed Sutan², Genevieve George Gadung¹, Rubiyah Bains¹ and Nur Syuhada Ahmad Zauzi¹

¹Department of Chemical Engineering and Energy Sustainability, Universiti Malaysia Sarawak, Kuching, Sarawak.

²Department of Civil Engineering, Universiti Malaysia Sarawak, Kuching, Sarawak

*Corresponding author E-mail: mkanwar@unimas.my

Abstract

The aim of this study was to investigate the application of membrane equipped activated carbon for heavy metal removal. An adsorption capacity of the activated carbon inside membrane matrix was performed against environmentally problematic ions specifically Pb^{2+} , in aqueous solution. The adsorption process was examined by Temkin and Freundlich isotherm. From the SEM observation, membrane exhibit sponge-like structure with dense micro-void formation across the matrix. This phenomenon was usually observed with membrane mixed with polyethyleneimine. For the adsorption studies, it is shown that Freundlich isotherm show better fit based on R^2 value of 0.9893 with Temkin isotherm fitted with R^2 of 0.9009. Through the fitted model, the adsorption occur on the surface of activated carbon are possibly multilayer type adsorption based on theory by Freundlich isotherm and fall under non-ideal reversible adsorption.

Keywords: Activated carbon; Adsorption; Freundlich; Removal lead Pb(II); Temkin

1. Introduction

Waste in general can be defined as discarded substances after completion of certain process. It is divided into several classification including domestic and industrial waste, schedule or chemical waste and municipal waste. All of these waste must be treated before released to environment. Heavy metal were usually part of the waste associated with plating industries leachate from landfill, groundwater contaminated by hazardous waste disposal site [1]. When the presence of heavy metal exceeding the acceptable limit, it has the potential to affect human physiology and disrupting other biological system. The irony of heavy metal waste is it could not be destroyed and will stay in the soil to affect human and living organism. One of the main contributor is increment of heavy metal demand in the industries especially in electronic and heavy metal are usually found in natural water resources [2]. All heavy metal is considered poisonous including lead where acute exposure might damage gastrointestinal tract and affect nervous system [3]. A prolong exposure to lead will probably cause learning disabilities among children, organ failure especially to kidney, liver and heart as well as immunity disorder [4].

Adsorption isotherm can be interpreted as curve mainly to explain the phenomenon involving retention of liquid or substances found in porous media or aqueous environment on a solid phase usually at constant condition of temperature and pH. This study focused on interaction of adsorbate with adsorbent when equilibrium established between metal ion on the adsorbent and surrounding metal ion in the solution [5]. In other words, adsorption equilibrium can be considered as an expression which show the correlation between the adsorbed amount and the remaining of adsorbent in the solution after being in contact for sufficient time where in the

end a dynamic balance would be achieved corresponding to interface concentration and adsorbate concentration in bulk solution [6]. There exist several types of adsorption isotherm model including Langmuir, Freundlich, Temkin, Redlich-Peterson and et cetera.

Freundlich isotherm study the relationship which describes reversible adsorption limited to non-ideal and formation of multilayer. Unlike Langmuir isotherm that only focused on formation of monolayer adsorption. Freundlich isotherm explored the possibility to study a multilayer adsorption with heat and affinities scatter over a heterogeneous surface [7]. Freundlich isotherm are usually associated with heterogeneous system such as organic compounds, molecular sieves and interactive species found on activated carbon. However, there still limitation of choosing Freundlich isotherm because of lack fundamental thermodynamic basis when it is found not approaching Henry law at certain concentration.

This model demonstrates the ratio of the adsorbate onto a given mass of adsorbent to the solute was not a constant at different solution concentrations. The amount adsorbate is the total amount of the adsorption on all sites with the stronger binding sites must be occupied first until adsorption energy are exponentially decreased upon the completion of adsorption process. Nowadays, Freundlich isotherm is commonly applied in heterogeneous systems especially for organic compounds or highly interactive species on activated carbon and molecular sieves. However, at present, this type of isotherm is criticized for its limitation of lacking a fundamental thermodynamics basis, not approaching the Henry's law at vanishing concentration [6].

Temkin isotherm was developed to study the behaviour of hydrogen adsorption onto a platinum electrode inside acidic environment [6,8]. Several assumptions were proposed for the derivation of Temkin equation including the linearity of heat of sorption as a function of temperature rather than in logarithmic trends [8].