ACTIVATED CARBON FROM EMPTY FRUIT BUNCH OF OIL PALM AND ITS POTENTIAL IN BISPHENOL-A REMOVAL

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To my dearest:

Parents,

Siblings,

Family,

Supervisors

and

Friends

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ABSTRACT

. Powdered activated carbon (PAC) based adsorption method is one of the promising techniques in the field of wastewater treatment due to its high efficiency, and less time consumption. Unfortunately, its application in water treatment is rather restricted due to high cost. This study used an abundant and locally available waste product generated from palm oil mill called Empty Fruit Bunch (EFB) as an alternative substituent to produce activated carbon (AC). Alternative use of this waste not only gives economic solution but also reduces environment problems caused by the waste after being disposed of into landfills and left unused. The experimental design for production of EFB-AC was prepared using Design-Expert Software. The EFB-AC was produced inside a tube furnace where the effects of activation temperature, activation time, nitrogen gas flow were investigated. EFB-AC was chemically activated using Potassium Hydroxide (KOH) as activating agent under impregnation ratio of 3:1. The effectiveness of the EFB-AC produced in the removal of Bisphenol A (BPA) was determined. BPA is considered as a typical endocrine disrupting chemical which may influence human living systems. Effects of pH, AC-Dosage and contact time on the removal of BPA were investigated. The optimum conditions for preparing the activated carbon were found at temperature of 850^{o}C with activation time of 30 minutes and nitrogen flow gas at 90 mm/min. The results show that at contact time of 48 hours, AC-dosage 1.0 g and at pH 9.0, for EFB-AC gave optimum removal of BPA at 84.9%. For comparative study between EFB-AC and commercial AC, the removal of BPA was found at 84.9% and 96.2% respectively at 48 hours contact time, 1.0 g AC-dosage and at pH 9.0. The EFB-AC was analysed using SEM, EDX and FTIR to study the characterization and microstructure of the AC produced.

ABSTRAK

Kaedah penjerapan berasaskan serbuk karbon teraktif (PAC) merupakan salah satu teknik yang biasa digunakan dalam bidang olahan air sisa kerana ia mempunyai kecekapan tinggi dan mengunakan masa yang singkat. Malangnya, penggunaannya dalam bidang olahan air adalah terhad kerana kos yang tinggi. Kajian ini menggunakan bahan buangan yang banyak dan senang diperolehi yang dihasilkan daripada kilang minyak sawit iaitu tandan buah kosong (EFB) sebagai sumber alternatif untuk menghasilkan karbon teraktif (AC). Penggunaan sisa ini bukan sahaja merupakan penyelesaian yang menjimatkan, ia juga boleh mengurangkan masalah alam sekitar yang disebabkan oleh bahan sisa yang dibuang ke pusat kambus tanah dan tidak digunakan. Penghasilan karbon teraktif adalah berdasarkan reka bentuk eksperimen yang dibantu dengan menggunakan perisian Design Expert. Karbon teraktif telah dihasilkan dalam tiub relau yang mana kesan seperti suhu pengaktifan, masa pengaktifan, aliran gas nitrogen telah dikaji. EFB-AC telah diaktifkan secara kimia dengan menggunakan kalium hidroksida sebagai ejen pengaktifan di bawah pengisitepuan pada nisbah 3:1. Keberkesanan EFB-AC yang dihasilkan dalam penyingkiran Bisphenol A (BPA) telah dikaji. BPA merupakan bahan kimia pemusnah endokrin yang boleh mempengaruhi sistem hidup manusia. Kesan pH, Dos-AC dan masa sentuhan, terhadap penyerapan BPA telah ditentukan. Keadaan optimum untuk penyediaan karbon teraktif diperolehi pada suhu 850^{o}C, masa pengaktifan 30 min dan aliran gas nitrogen pada 90 mm / min. Keputusan bagi masa hubungan 48 jam, Dos-AC 1.0 g dan pH 9.0 untuk EFB-AC memberikan penyingkiran optimum BPA sebanyak 84.9%. Bagi kajian perbandingan antara EFB-AC dan AC komersial menunjukkan penyingkiran BPA pada 84.9% dan 96.2% masing-masing pada masa hubungan 48 jam, Dos-AC 1.0 g dan pH 9.0. EFB-AC telah dianalisis menggunakan SEM, EDX dan FTIR bagi mengkaji perincian dan strukturmikro EFB-AC yang dihasilkan.

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LIST OF ABBREVATIONS

EFB	-	Empty fruit bunches
AC	-	Activated carbon
EDC	-	Endocrine disrupting chemical
BPA	-	Bisphenol A
RSM	-	Response Surface Methodology
SEM	-	Scanning Electron Microscope
EDX	-	Energy-dispersive X-ray spectroscopy
ATR-FTIR	-	Attenuated Total Reflection-Fourier Transformation Infrared
EFB-AC	-	Empty fruit bunch activated carbon
ANOVA	-	Analysis of variance

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Adsorption process by activated carbon (AC) is one of the most effective and widely used methods to purify water stream. The sludge free operation makes absorption process better than other treatments available (Alam *et al.*, 2009). Numerous industries used activated carbon as adsorbents for removal of organic contaminants from water streams.

Activated carbons are carbonaceous materials that have high adsorption capability due to its high porosity. Activated Carbon is generally considered to have beneficial environmental effects, thus its recommendation by USEPA to treat waste water effluent from the food industry (USEPA, 2000).

However, the usage of activated carbon is limited by their high commercial costs which lead to high production cost. In recent years, many studies have been conducted in order to search the substituent that's abundantly available and less expensive materials for production of activated carbon. Agricultural wastes are the potential precursors because of the abundant supply and low cost. Moreover, transforming agricultural wastes into valuable end products may help to increase crop yields and production efficiency as well to reduce solid wastes disposal problem.

The production of activated carbon from Empty fruit bunches (EFB) seems to be a good approach as Malaysia is a giant producer of oil in the world, about two million tons (dry weight) of shell and one million tons of extracted fiber are generated annually. Normally, they are used as boiler fuels or building materials. This waste will pose great danger to environments as most of the Empty Fruit Bunch residues are left unused and being handled as a solid waste. This biomass creates problems with waste treatment and disposal, open dumping/landfill, and groundwater contamination from leachate.

Besides that, burning of biomass causes emission of haze hazard and toxic chemicals such as dioxins. Thus, it is necessary to make a better use of these cheap and abundant wastes, it is proposed to make them into effective adsorbents such as activated carbons (Guo *et al.*, 2005). In 2003, the biomass production of palm kernel shell was about 8 million tons are produced (www.mpob.gov.my, Malaysian Palm Oil Board). Accordingly studies of effective utilization and recovery of EFB become urgent and significant issue. Hence, the aim of this study was to evaluate the adsorption efficiency of the AC prepared from EFB for removing Bisphenol A.

Bisphenol A (BPA) widely used as a monomer for production of epoxy resins and polycarbonate in the plastic industry. BPA has been listed as one of endocrine disrupting chemical (EDC) which can pose a risk to human health and reproductive biology. The pollution of EDCs in surface water has aroused the public concern and significant effort need to be done to remove it from the drinking water.

This research's aim is to further explore the application of EFB as biosorbent for BPA adsorption. The effects of various experimental parameters on the adsorption of BPA were also being investigated.

1.2 Problem Statement

As one of the largest producer of palm oil in the worlds, Malaysia also generated huge amount of solid waste namely Empty fruit bunch (EFB) at about 12.4 million tons/year (fresh weight) (Tanaka *et al.*, 2004). This waste will pose great danger to environments as most of the empty fruit bunch residues are left unused and being handled as a solid waste. This waste will bring problems if not handled properly such as open dumpling and groundwater contamination from leachate. This study seeks to employ the conversion of empty fruit bunch, EFB into AC which has relevant application in many areas but for the purposes of this study it will be limited to the removal of Bisphenol A from aqueous solution.

Bisphenol A is widely used as a monomer for production of epoxy resins and polycarbonate in the plastic industry. It is widely used for manufactured of baby bottles, lining of food cans and also dental sealants (Bautista-Toledo *et al.*, 2005). As one of the phenolic endocrine disrupting chemicals (EDCs) Bisphenol A may cause potential risks to human health. The present of BPA in drinking water became serious health issues as this compound can affect the body's developments, growth and hormone balance by mimicking, blocking or disrupting the body's natural hormones. Accordingly, significant effort for developing an effective technology to remove it from the aqueous phase must be made.

1.3 Objectives

This research aims are:

1. To identify the psycho-chemical characterization of EFB-AC produced.
2. To determine the optimum conditions for Bisphenol A removal by EFB based AC.

3. To determine the adsorption capacity and adsorption rate of Bisphenol A removal by EFB-AC.

1.4 Scope of Study

This study investigates alternative and cheap source for production of activated carbon. Empty fruit bunch was waste product generated from the palm oil mill after extraction of their oil. This waste generated in large volumes constitute an environmental threats, thus a safe method for their disposal is sort through conversion to AC.

Response Surface Methodology (RSM) statistical software with Box-Benken application was applied to get the optimum conditions of experiment parameter (i.e. carbonization process, nitrogen gas flow and residence time). This raw material will undergo carbonization process under nitrogen gas flow at different range of carbonization temperature (i.e. 550 – 850 °C), residence time (i.e. 30 – 60 minutes) and Nitrogen gas flow (i.e. 2 – 3 L/min). Then, the optimal processing condition for adsorption of Bisphenol A in aqueous solution will be determined. Potassium hydroxide was used to activate the carbonized carbon samples under chemical activation. The AC produced was then characterized by Scanning Electron Microscope (SEM), Energy-dispersive X-ray spectroscopy (EDX), Attenuated Total Reflection-Fourier Transformation Infrared (ATR-FTIR).

The prepared sample's performances was then analyzed by Bisphenol A adsorption test at different pH, contact time, BPA initial concentration and activate carbon dosage.

1.5 Significances and Original Contributions of This Study

This study is being carried out in order to curtail the likelihood of waste being generated from palm oil processing from constituting challenges in landfill management among other agricultural byproducts. The Empty Fruit Bunch-Activated Carbon (EFB-AC) produced is considered a viable and economical substitute for commercial activated carbon.

As in 2002, the demand for activated carbon reached 200,000 ton per year in United States. The demands of AC were increase over the year and market growth was estimated at 4.6% per year (Bautista-Toledo *et al.*, 2005). The market has been increasing constantly as a consequence of environmental issues, especially water and air purification.

Furthermore, as more and more countries are becoming industrialized, the need for activated carbon to comply with environmental regulation will grow fast. The growth of the activated carbon market in the last two decades in the most industrialized region will very probably continue in the near future as more developing areas of the world will realize the importance of controlling water and air pollution. The continuous research has to be implementing to develop the high quality of AC for specific uses.

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