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PREPARATION, CHARACTERISATION AND APPLICATIONS
OF ACTIVATED CARBON FROM COCOA
(*Theobroma cacao*) NIBS WASTE

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PENYEDIAAN, PENCIRIAN DAN APLIKASI KARBON TERAKTIF DARI SISA BENIH KOKO (*Theobroma cacao*)

ABSTRAK

Penghasilan karbon teraktif yang ada di pasaran komersial dianggap mahal. Ini kerana ia dihasilkan daripada bahan pelopor yang tidak boleh diperbaharui dan dengan kos yang mahal seperti arang batu bitumen. Oleh itu, kajian ini dilaksanakan untuk menilai potensi sisa benih koko sebagai bahan pelopor karbon teraktif yang murah. Karbon teraktif yang terhasil ini boleh digunakan untuk menyingkirkan pewarna metilena biru, fenol dan asid salisilik serta larutan cecair Paracetamol. Karbon teraktif ini dihasilkan melalui pengaktifan kimia menggunakan kalium karbonat (K_2CO_3) sebagai bahan pengaktifan dan dibakar dalam keadaan lengai dengan kehadiran gas nitrogen. Keputusan eksperimen menunjukkan suhu pengkarbonan dan nisbah pengisitepuan K_2CO_3 merupakan faktor penting yang mempengaruhi hasil dan prestasi penjerapan pewarna metilena biru, fenol, asid salisilik dan Paracetamol oleh karbon teraktif. Karbon teraktif dengan kawasan permukaan tinggi dan liang mikro yang banyak yang terhasil dengan suhu pengkarbonan pada $800\text{ }^\circ\text{C}$ dan nisbah pengisitepuan K_2CO_3 kepada arang adalah pada 3:1 menunjukkan keputusan penjerapan yang terbaik. Ini kerana, karbon teraktif tersebut memiliki luas permukaan sebanyak $1.313\text{ m}^2/\text{g}$ manakala luas permukaan liang mikro adalah sebanyak $1.019\text{ m}^2/\text{g}$. Struktur liang karbon teraktif ini pula terdiri daripada campuran liang mikro dan meso (67 % isipadu liang mikro) dengan purata kelebaran liang (kiraan median) adalah 3.8 nm. Ia disokong dengan keputusan analisis mikroskop pengimbas elektron (SEM) yang memperlihatkan mikrograf permukaan karbon dengan struktur liang yang pelbagai. Analisis menggunakan teknik spektroskopi transformasian Fourier inframerah (FTIR) pula menunjukkan kehadiran kumpulan berfungsi oksigen pada permukaannya. Apabila karbon teraktif ini dirawat dengan asid hidroklorik, luas permukaan bertambah menjadi $1.932\text{ m}^2/\text{g}$ dan luas permukaan liang mikro menjadi $1.276\text{ m}^2/\text{g}$. Isipadu liang mikro menurun kepada 57 % dan purata kelebaran liang menurun kepada 3.4 nm. Penjerapan karbon teraktif yang telah dirawat ke atas pewarna metilena biru dan Paracetamol menunjukkan peningkatan berbanding penjerapan karbon teraktif tanpa dirawat. Kecekapan penyingkiran tertinggi bagi pewarna metilena biru dicatatkan pada pH 5 manakala bagi paracetamol adalah pada pH 5.2. Proses penjerapan pewarna metilena biru diterangkan dengan baik oleh model isoterma Langmuir. Penjerapan Paracetamol pula diterangkan dengan baik dengan model isoterma Langmuir dan Freundlich. Kedua-dua mekanisme penjerapan karbon teraktif yang dirawat dengan asid hidroklorik ke atas metilena biru dan Paracetamol boleh diwakili oleh model kinetik pseudo-tertib kedua.

PREPARATION, CHARACTERIZATION AND APPLICATIONS OF ACTIVATED CARBON FROM COCOA (*Theobroma cacao*) NIBS WASTE

ABSTRACT

The production of activated carbon in the commercial market is considered expensive. This is because it is made of non-renewable and cost-effective precursor such as bituminous coal. Thus, this study was conducted to assess the potential of cocoa nibs waste as a cheap activated carbon precursor. The resulting activated carbon can be used to remove the methylene blue dyes, phenol and salicylic acid, and dissolved Paracetamol in aqueous solution. The activated carbon is produced using chemical activation with potassium carbonate (K_2CO_3) as an activating agent and carbonized in an inert state with the presence of nitrogen gas (N_2). The experimental results showed that the carbonization temperatures and K_2CO_3 impregnation ratios were important factors affecting the results and performance of adsorption of methylene blue dyes, phenol, salicylic acid and Paracetamol by activated carbon. Activated carbon with high surface area and highly microporous that were produced with carbonization temperature at 800 °C and impregnation ratio of K_2CO_3 to charcoal at 30:1, showed the best adsorption results. This were due to the high surface area of the activated carbon (1,313 m^2/g) and the micropore surface area was 1,019 m^2/g . The prepared activated carbon comprises a mixture of micro- and meso- pores (67% of the micro pore volume) with average pore width (median) of 3.8 nm. It was supported by the results of scanning electron microscope (SEM) that exhibited a carbon surface micrograph with a diverse pore structure. The analysis using Fourier Transform Infrared (FTIR) technique showed the presence of oxygen functional groups on the surface. When activated carbon was treated with hydrochloric acid, the surface area increased to 1,932 m^2/g and the micropore surface area increased to 1,276 m^2/g . Eventually, the micropore volume decreased to 57% and the average pore width decreased to 3.4 nm. The adsorption of blue methylene dyes and Paracetamol onto the treated activated carbon showed an increase compared to the untreated activated carbon. The highest removal efficiency for methylene blue dye was recorded at pH 5 while for paracetamol was at pH 3.2. The adsorption process of methylene blue dye was well described by the Langmuir isotherm model. Paracetamol adsorption was well described with the Langmuir and Freundlich isotherms. The adsorption mechanisms for both adsorbates (methylene blue and Paracetamol) were best represented by pseudo-second-order kinetic model.

التجهيز والتوصيف والتطبيقات من الكربون المنشط من الدرجة الطبية من نفايات

مناقير الكاكو

الملخص

يعتبر إنتاج الكربون المنشط من الدرجة الطبية في السوق التجاري باهظ الثمن. هذا لأنه مصنوع من سلائف غير متجددة وفعالة من حيث التكلفة مثل الفحم البيتوميني. وهكذا ، أجريت هذه الدراسة لتقييم إمكانية نفايات حبيبات الكاكو باعتبارها سلعة كربون منشط رخيصة الثمن. يمكن استخدام الكربون المنشط الناتج لإزالة الصبغات الزرقاء للميثيلين ، وحمض الفينول وحمض الساليسيليك ، وباراسيتامول مذاب في محلول مائي. يتم إنتاج الكربون المنشط باستخدام التنشيط الكيميائي مع كربونات كعامل تنشيط ومتفحمة في حالة خاملة مع وجود غاز النيتروجين (K_2CO_3) البوتاسيوم كانت K_2CO_3 أظهرت النتائج التجريبية أن درجات حرارة الكربنة ونسب التشيع (N_2) عوامل مهمة تؤثر على نتائج أداء الامتصاص للأصباغ الزرقاء الميثيلين والفينول وحمض الساليسيليك والباراسيتامول بواسطة الكربون المنشط. أظهر الكربون المنشط ذو المساحة السطحية العالية والصغيرة جداً التي تم إنتاجها باستخدام درجة حرارة إلى الفحم عند 3:1 ، أفضل K_2CO_3 الكربنة عند 800 درجة مئوية ونسبة التشريب لـ (m^2/g) نتائج للامتصاص. ويعزى ذلك إلى ارتفاع مساحة سطح الكربون المنشط ($1,313$) يحتوي الكربون المنشط المحضرة $1,019 m^2/g$ *micropore* ومساحة سطح الصغرى على خليط من المسام الصغيرة والمتناهية الصغر (67٪ من حجم المسام الدقيقة) ومتوسط عرض المسام (متوسط) 3.8 نانومتر. وقد أيدته نتائج مسح المجهر الإلكتروني الذي أظهر صورة مجهرية على سطح الكربون مع بنية مسامية متنوعة. أظهر (SEM) وجود (FTIR) التحليل باستخدام تقنية فوريير للتحويل بالأشعة تحت الحمراء مجموعات وظيفية للأكسجين على السطح. عندما تمت معالجة الكربون المنشط بحمض الهيدروكلوريك ، زادت مساحة السطح إلى $1,932$ م² / جم وارتفعت مساحة سطح إلى *micropore* المسام الصغير إلى $1,276$ م² / جم. في نهاية المطاف ، انخفض حجم 57 ٪ وانخفض متوسط عرض المسام إلى 3.4 نانومتر. أظهرت امتزاز صبغات الميثيلين الزرقاء والباراسيتامول على الكربون المنشط المعالج زيادة مقارنة مع الكربون المنشط غير المعالج. تم تسجيل أعلى كفاءة إزالة للصبغة الزرقاء الميثيلين عند الرقم الهيدروجيني 5 بينما كان الباراسيتامول عند الرقم الهيدروجيني 3.2. تم وصف عملية امتزاز الصبغة الزرقاء للميثيلين بشكل جيد بواسطة نموذج متماوي تم وصف امتزاز الباراسيتامول بشكل جيد مع نظائر انجميور *Langmuir* الحرارة ميثيلين الأزرق و) *adsorbates* وفريندليتش. تم تمثيل أفضل آليات امتزاز لكل من من قبل النموذج الحركي الزائف من الدرجة الثانية (*Paracetamol*)

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