BIOCARBON FROM DIFFERENT BIOMASS PRECURSORS

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Abstract: Thermochemical conversion of lignocellulosic biomass is considered as a good opportunity to obtain liquid raw materials for biofuels and biochemicals. During this pyrolysis process a solid product, biocarbon, is obtained. Nowadays there is a growing interest in biocarbon, due to the potential benefits of its application in soil as a stimulant and CO₂ trap. The physicochemical and porous properties of biocarbon are suitable for development of effective and inexpensive sorbents for the removal of contaminants from water. Biocarbon has promising sorption properties for various pollutants in water, including polycyclic aromatic hydrocarbons and heavy metals. Banana and orange peels, as well as cocoa flakes, were used as precursors. The carbonization was carried out at temperatures from 500 °C to 900 °C. Some of the samples were subjected to physical and chemical activation. The obtained carbon adsorbents are characterized by adsorption of iodine, BET, etc. It is planned to study the possibilities for the successful application of the obtained carbon materials as adsorbents for water and air purification, catalysts, hydrogen depots, etc.

INTRODUCTION

Thermochemical conversion of lignocellulosic biomass has been considered as a viable option to produce intermediate liquid streams for biofuels and biochemicals. During the conversion process, biocarbon is generated as a by-product of pyrolysis; its optimization and application is essential to make the overall process economically feasible. Pyrolysis engineers have traditionally sought to minimize char production, as it has been considered as a low-value fraction, decreasing the yield of bio-oil. Recently, there is a growing interest in biocarbon due to the potential benefits of its application to soil as carbon sequestration and soil amendment [1-3]. The physicochemical and porous properties of biocarbon are attractive for the development of effective and low-cost sorbents for removal of water contaminants. Biocarbon has promising sorption properties for

various contaminants of water including polycyclic aromatic hydrocarbons and heavy metals [4-7].

The subject of this paper is production of biocarbon from different biomass precursors. The physicochemical and porous properties of biocarbon are suitable for development of effective and inexpensive sorbents for the removal of contaminants from water.

MATERIALS AND METHODS

Different biomass materials are used as precursors for biocarbon – banana peels, orange peels and cocoa husk. Fruit biomass materials are crashed to smaller pieces, dried and subjected to carbonization at 500°C. Further chemical activation with KOH and K₂CO₃, and subsequent activation at 550-800° C were carried out. Biocarbon samples are synthesized after hydro-pyrolysis and CO₂ activation at temperatures 550-750°C, and different duration (1-3 h). Synthesis scheme is depicted on Fig. 1.

Fig. 1. Synthesis of biocarbon from orange peels

1 – orange peels, 2 – crashed orange peels, 3 – dried orange peels, 4 – carbonize after chemical activation with K₂CO₃, 5 – hydro-pyrolysis at 550 - 750 °C in stainless-steel reactor in tube furnace, 6 – obtained biocarbon, 7 – grinded biocarbon, 8 – characterization of obtained biocarbon by iodine adsorption.

The porous structure of carbon samples is studied by nitrogen physisorption at 77 K using Quantachrome Instruments Quantachrome Autosorb ASiQwin (USA) apparatus. The specific surface area is determined from Brunauer–Emmett–Teller (BET) equation, the total pore volume was obtained at a relative pressure of 0.99, the micropores volume was elucidated by V-t-method. The mesopore size distribution is performed

by Non-Localized Density Functional Theory (NLDFT) method, using slit shape pore assumption for carbons, and the micropore size distribution is calculated by the Dubinin-Astakhov (DA) method.

RESULTS AND DISCUSSION

Elemental analysis is shown in Table 1.

Table 1. Elemental analysis of obtained biocarbons

Sample	W ^a %	A ^d %	C %	H %	N %	S %	O %
BC-OP	2.04	11.0	79.05	4.11	1.23	0.03	15.58
BC-CH	1.8	13.1	84.7	1.3	1.6	0.3	12.1
BC-BP	1.7	2.6	78	2.5	1.1	0.5	17.9

The results from iodine adsorption show that various biocarbons obtained are characterized by moderate and high adsorption capacity (200-900 mg/g). Banana peel based biocarbon is distinguished by very high iodine adsorption value of 910 mg/g.

Orange peel based biocarbon demonstrates much lower iodine adsorption capacity of 421 mg/g. Cocoa based biocarbon is characterized by moderate adsorption capacity of 703 mg/g.

Table 2. Textural characteristics of obtained biocarbons

Sample	Iodine adsorption, mg/g	S _{BET} ² m ² /g	V _t ³ cm ³ /g	V _{mi} ³ cm ³ /g	V _{meso} ³ cm ³ /g
Biocarbon from banana peel BC-BP	910	820	0.47	0.37	0.05
Biocarbon from orange peel BC-OP	421	400	0.17	0.11	0.05
Biocarbon from cocoa waste BC-CH	703	675	0.35	0.22	0.10

The porous structure of the sample activated at this temperature is investigated by low-temperature nitrogen adsorption at 77 K. The pore structure and the main textural parameters of the samples are presented (Table 2, Fig.2, Fig.3). The results indicate

the development of mesoporosity in parallel with microporosity. The presence of hysteresis also confirms the existence of significant amount of mesopores in the test sample. This observation is confirmed by pore size distribution by the DFT method.

Fig. 2. Nitrogen adsorption isotherm at 77 K and pore size distribution of biocarbon obtained from orange peel

Fig. 3. Nitrogen adsorption isotherm at 77 K and pore size distribution of biocarbon obtained from cocoa husk and banana peel

CONCLUSIONS

It was established that thermochemical conversion of lignocellulosic biomass (banana and orange peels, cocoa husk) is a good opportunity to obtain solid product, biocarbon, as well as liquid raw materials for biofuels and biochemicals. The physicochemical and porous properties of biocarbon are suitable for development of effective and inexpensive sorbents for the removal of contaminants from water. The biochars are produced by physical and chemical activation at 500 -900 °C. The obtained biocarbons are characterized by moderately high surface area, and high content of micro- and meso-pores, which determine their potential application as adsorbents for water and air purification, catalysts, hydrogen depots, etc.

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