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PORE STRUCTURE AND ADSORPTION CHARACTERISTICS OF STEAM PYROLYSIS CARBONS FROM *MORINGA OLEIFERA*

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Abstract—A series of activated carbons has been prepared from the waste seed husks of the tropical multi-purpose tree *Moringa oleifera*, using a single-stage steam pyrolysis activation. Carbons were characterised by N_2 adsorption, CHN analysis and scanning electron microscopy. Nitrogen adsorption isotherms were analysed by the BET, t-plot and Horváth and Kawazoe methods. All the carbons were microporous, with those activated at 750°C for 120 minutes (750/120) and 800°C for 30 or 60 minutes having the highest BET surface areas, of 730, 713 and 774 $m^2\,g^{-1}$, respectively. A simple acid rinse of the 800°C/30 minutes carbon increased the surface area to 932 $m^2\,g^{-1}$. The 800/60 carbon had the highest mesopore and macropore surface area, 135.7 $m^2\,g^{-1}$, compared to 92.7 $m^2\,g^{-1}$ for the 800/30 carbon. Scanning electron micrographs of the 800/30 carbon showed a lignocellulosic macropore structure, cleaned by the steam pyrolysis.

These results show that it is possible to produce a high quality microporous activated carbon from *M. oleifera* husks using a simple single-stage steam pyrolysis activation. © 1997 Elsevier Science Ltd

Key Words—A. Activated carbon, B. pyrolysis, C. adsorption, D. porosity.

1. INTRODUCTION

The characterisation of carbonaceous porous solids (active carbons, chars and composites) produced from agricultural by-products has been an established and productive field within carbon research for many years [1–4]. Our recent efforts have focused on the preparation of activated carbon from the tree *Moringa oleifera* for water treatment in those developing countries where the plant is grown [5–7].

Moringa oleifera is a perfect example of a so-called "multipurpose tree"; it grows quickly in dry conditions, its green pods are edible ("Drumstick" in India), its seeds both contain a good-quality vegetable oil, and can be used as a coagulant to replace conventional coagulants in drinking water treatment [8,9]. In addition, many parts of the plant have traditional medicinal uses [8]. The seed husks and pods left over from the production of the vegetable oil and coagulant are currently waste products, but we have demonstrated that steam activation of the husk material can produce a high quality, microporous carbon [5]. Our initial research used a two-stage production process, carbonisation under N_2 at 485°C, followed by physical activation under steam at 850°C. We now report an improved preparative strategy aimed at a much cheaper activated carbon product, and one that avoids the expense of excessive heating.

Previous workers [1] have reported that a single-stage steam pyrolysis activation procedure can yield high quality carbons, and our initial research on the production of carbon from *M. oleifera* by this method has also shown promising results [6,7]. The work described in this paper examines the physico-chemical characteristics of carbons produced under steam at 700, 750 and 800°C, with a view to identifying the optimum process characteristics for production of low-cost activated carbon. The adsorption of chemicals from aqueous solution by these carbons is described elsewhere [7].

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2. MATERIALS AND METHODS

2.1 *Materials*

M. oleifera husks were obtained from Malawi, where they had been produced as a waste product from the production of *M. oleifera* seed. Because of the nature of the seed–husk separation process, this husk material also contained a small amount of seed material, and was not of an even particle size, varying between powder and particles several mm in dimensions.