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Usefulness of raw bagasse for oil absorption: A comparison of raw and acylated bagasse and their components

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ABSTRACT

Raw bagasse or sugar cane cellulosic residues were modified using acylation grafting with fatty acid. The capability of the grafted bagasse to absorb oil from aqueous solution was studied and compared with the raw bagasse. It was found that the grafted material was significantly more hydrophobic than the raw bagasse. This grafted bagasse had little affinity for water and good affinity for oil. It was also found that bleaching of raw bagasse did not enhance its oil absorptivity. The grafted raw bagasse would be most suitable for applications where oil is to be removed from an aqueous environment. For oil absorbing applications in the absence of water, the raw bagasse was an excellent material.

1. Introduction

The importance of systematic utilization of bagasse or sugar cane cellulosic residues has been noted in the past decade. Environmental concerns have fueled this focus not only because of the quantity of bagasse produced annually but also because of the nature of the material (Almazan et al., 1998; Ritter, 2007; Arnaud, 2008). The growth of the sugar cane plant is remarkably efficient photosynthetically. The sugar product from this plant represents only thirteen percent of the biomass. Bagasse from sugar production is twenty eight percent of the biomass (Almazan et al., 1998). These numbers vary depending on the source of the sugar cane, as well as on the interpretation of an author. Even so, huge amounts of bagasse are and will continue to be generated and the utilization of this material is of growing importance. The use of bagasse in the production of paper products is becoming increasingly more important (Taylor, 2000; World Centric, 2008). While ethanol as a biofuel is currently produced from corn in the United States and from a sugar solution in Brazil, the use of bagasse for ethanol production instead has received considerable investment by major international chemical companies during this past year (McCoy, 2007, 2008). Bagasse has also received attention in the construction industry (Youngquist et al., 1996; Golbabaie, 2006). The study of bagasse as an absorbent of environmental pollutants has also received attention recently (Khan et al., 2004; Lee and Rowell, 2004; Igwe and Abia, 2006; Abia and Asuquo, 2006; Nada and Hassan, 2006; Deschamps et al., 2003; Hussein et al., 2008; Ludwick et al., 2002, 2005). Heavy metals are attracted to modified bagasse. These modifications are relatively simple processes that could be expanded to a pilot scale and then to full production.

Oil pollution remains a serious concern. Regulations (US EPA, 2008) have done much to prevent oil waste contamination during transport on the open seas. The Clean Water Act of the USA provides a model for an approach to achieve an environmentally safe water system (Davenport, 1992; Kenney, 2006). These national and international regulations have been evaluated periodically so as to maintain their viability (Davenport, 1992; Kenney, 2006; GEF/UNDP/IMO, 2008). When oil pollution does occur, the issue is not only the cleaning of the environment but also recovery of this precious commodity. Hence any oil absorbing material used must also be able to release the oil. Current studies examine not only oil absorbing properties of materials but also the ability to recycle of these materials (Deschamps et al., 2003; Hussein et al., 2008). In the present work, raw bagasse was modified using acylation grafting with fatty acid. The capability of the grafted bagasse to absorb oil from aqueous solution was studied and compared with the raw bagasse.

2. Experimental

2.1. Materials

Bagasse consists mainly of cellulose and lignin (Fig. 1a and b, respectively). In the current study the raw bagasse was obtained

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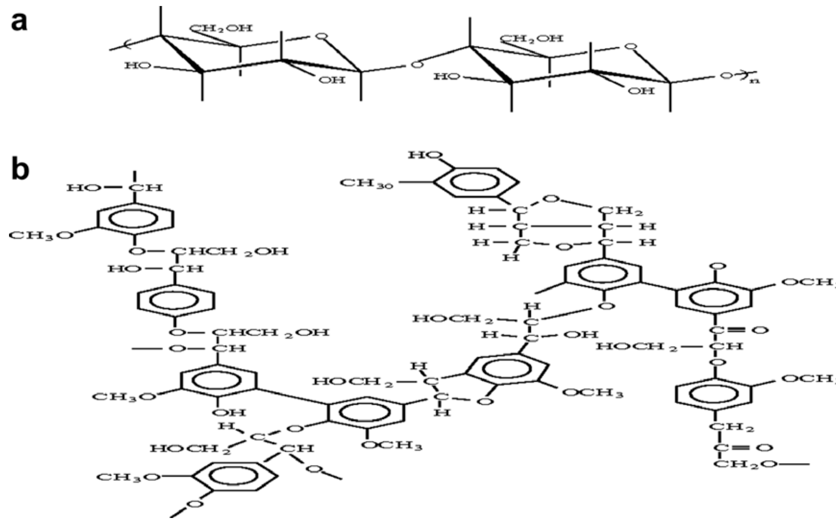

Fig. 1. Structure of bagasse: (a) cellulose and (b) lignin.

from Abou-Korkas Sugar Factory, El-Minia, Egypt. Treatment of this raw bagasse to remove lignin was carried out by Miser Edfu Pulp Writing and Printing Paper Company, Edfu, Egypt. Bleached cellulose (without pith and lignin) was developed by Quena Paper Industry Company, Quena, Egypt. The bleaching of cellulose resulting from pith and lignin removal was carried out by chlorine dioxide, ClO_2, (1.5%) and oxygen 75–85 °C and a pH of 4.5–5.5.

2.2. Synthesis

Grafted/modified bagasse components – each bagasse component was modified as follows: the bagasse component (raw, pulp, and pulp plus pith), in excess, was mixed for 2 h with stearic acid, basic compounds, and water. The mixture was dried in a vacuum at 60 °C for 20 h. This procedure resembles a patented procedure (Ceaser, 1988).

The morphology of the washed raw bagasse obtained from the sugar cane mill is shown in Fig. 2a. It consists of a mixture of cellulasic short fibers and fine particles. After removing the lignin, (Fig. 2b), the material is fairly hard coarse cellulosic particulates. The modified or grafted bagasse, shown in Fig. 2c, has a fluffy soft texture.

2.3. Method

Oil/water absorption procedure: The samples were weighed, placed in oil or water for 10 min, drained for 15 min, and then reweighed. Used Caltex Valor 100 motor oil, Caltex Egypt, was employed in the absorptivity study. The water used was distilled. Three replications were obtained for each data point. The average reproducibility of the data is +/−5.5%.

The percentage absorptivity was calculated according to the following equation.

$$\text{Absorptivity} = \frac{\text{Weight of sorbent containing absorbed fluid} \times 100}{\text{Initial weight of sorbent}} \quad (1)$$

A sample that did not absorb fluid (oil or water) gives an absorptivity of 100%. This equation can be expressed as a ratio between the weight of oil absorbed and the weight of sorbent. Thus,

$$\text{Sorption Capacity} = \frac{\text{Weight of sorbent containing absorbed fluid} - \text{Initial weight of sorbent}}{\text{Initial weight of sorbent}} \quad (2)$$

3. Results and discussion

Raw bagasse is a combination of cellulose, lignin, and other minor components. It is a material that absorbs hydrophilic and

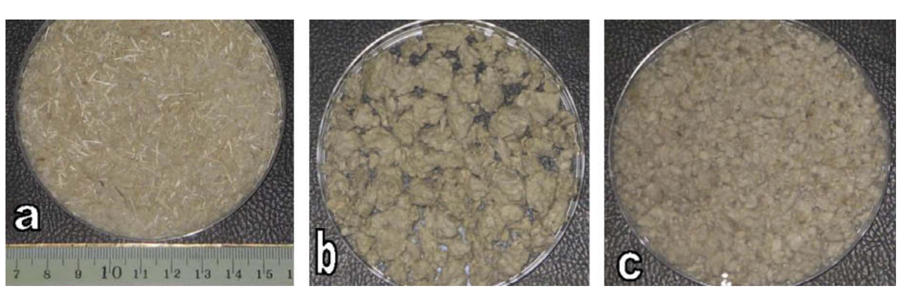

Fig. 2. Morphology of bagasse: (a) raw, (b) without lignin, and (c) grafted with fatty acid.