UTILIZATION OF MAHOGANY SAWDUST (SWIETENIA MACROPHYLLA) AS NATURAL TEXTILE DYE USING HYDROTHERMAL LIQUEFACTION METHOD TO SUPPORT SUSTAINABLE BIOMASS WASTE PROCESSING

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ABSTRACT

Mahogany sawdust is one of the most promising biomass waste due to its abundant and untapped existence. Utilization of mahogany waste is currently limited to solid fuels and a small portion for the mixture in particle board manufacturing. In this research, conversion waste of mahogany sawdust (Swietenia macrophylla) using hydrothermal liquefaction (HTL) method will be done to produce solid and liquid product. The liquid product will be characterized to find derivative compounds which may act as natural textile dyes. On the other hand, solid products are characterized to determine their properties as solid fuels. Experiments were conducted in temperature of 200oC, 240oC, 270oC, and 300oC at an initial pressure 1 MPa for 30 minutes. In addition, there was also a variation of biomass-water ratio (B/W ratio) with a ratio1:20, 2:20 and 3:20 (at temperature of 250 oC). The characterization of solid product was carried out by proximate analysis while the liquid product was characterized using HPLC and GC-MS. The last one is color testing by coloring the fabric, color quality test and color naming using Munsell color chart.

KEYWORDS : sawdust, mahogany, natural textile dye, hydrothermal liquefaction

INTRODUCTION

Background

Along with the development in Indonesia, the demand for wooden tools such as furniture and other household appliances is increasing. In addition, the government's policy of loosening the export of sawn timber makes woodworking exploitation taps was higher. This is evident from the data on sawnwood production that has increased over the last 5 years from 2009 to 2013, respectively 710.208 m3, 885.425 m3, 934.757 m3, 1.053.408 m3 and 1.217.868 m3 (BPS, 2015). This high wood sawing activity leaves a problem in the form of waste sawdust that is increasingly accumulated.

Currently the handling of sawdust waste is still a problem. Most are left to rot, stacked and burned, all of which can reduce the quality of the environment and even pollute the environment. Similarly, the utilization is still limited as a mixture in the manufacture of particle board and household fuel which efficiency is relatively small. One of the most widely used sawdust waste is mahogany (Swietenia macrophylla). The waste of mahogany sawdust is produced from the wood processing industry which utilizing Mahogany (Swietenia macrophylla) wood to make products such as sawn timber, construction timber, furniture and other preparations. Mahogany sawdust is known to be a natural textile dye because it contains flavoida which is a yellow - brown producing pigment (Kasmudjo, 2005).

On the other hand, the development of business synthetic textile dye is growing rapidly in Indonesia. This is marked by the many brands of synthetic textile dye products on the market. The high use of synthetic dyes in certain industrial activities has an impact on increasing the amount of pollutants in the resulting liquid waste (Nugroho, 2005). Approximately 10,000 types of dyes are used in the textile industry and more than 7 x 105 tons of dyes are produced annually. During the staining process, 10-15% of the textile dyes used will be discharged with the waste (Selvam et al., 2003).

Synthetic textile dyes are organic pollutants that are non-biodegradable. Generally they are made of compounds containing benzene groups that are difficult to degrade, such as methylene blue. If it is possible to degrade, it will take a long time. Compounds with benzene groups are carcinogenic and mutagenic (Maria Christina et al., 2007). Textile dyes also cause negative effects on aquatic organisms due to reduced sunlight intensity and can be toxic to flora and fauna because they contain aromatic compounds, metals, chlorides and others (Dhaneshvar et al., 2007).

Looking at the two problems above it is very important to find a solution to the problem of waste sawdust, especially mahogany sawdust and textile dyes that impact on the deterioration of environmental quality can be overcome simultaneously. The waste of mahogany sawdust has a negative impact on the environment if it is not handled properly. On the other hand a more environmentally friendly textile dye alternative is needed. Therefore, this research will convert waste of mahogany sawdust (Swietenia macrophylla) into natural textile dye using hydrothermal liquefaction (HTL) method. This method is chosen because it will eventually produce two products that is solid and liquid products. Solid product can be utilized to be fuel with good heat calority while liquid product can be utilized as natural dye. Utilization waste of mahogany sawdust is one of the efforts of sustainable biomass waste processing as it presents waste treatment solution which contribute to the improvement of environmental quality and also convert waste into product (waste to product) which has more added value and economic value, in line with the concept of sustainable development.

Methodology

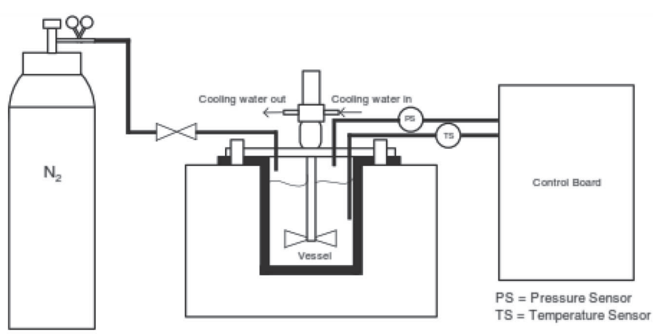
Materials

The waste of mahogany sawdust was collected from sawmills locations in Kalasan-Jogjakarta, Indonesia. Sample was mashed using a grinder, then sieved using a mesh Tyler 32 Mesh and 65 Mesh.

Experimental setup

Sample that was digested, sieved using a using a mesh Tyler -32, +65, put into an autoclave reactor as illustrated in figure 1 :

Fig.1 diagram of hydrothermal liquefaction



The hydrothermal liquefaction process was carried out by inserted ± 15 g of dissolved sample in 150 mL of water into an autoclave reactor and then purged using N2 at 0.5 MPa. The process runs at a temperature of 200oC, 240oC, 270oC, and 300oC at initial pressure 1 MPa for 30 min and variation of biomass-water ratio (B/W ratio) 1:20, 2:20 and 3.:20 ratio at 250oC, 1 Mpa for 30 minutes.

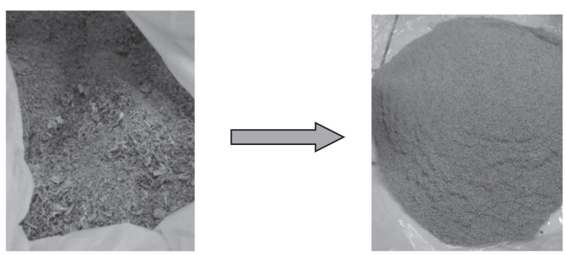
Analysis

Analysis was conducted on liquid products using HPLC and GCMS instruments. In this paper there are reported temporary results that have not shown the results of HPLC and GCMS analysis.

RESULT AND DISCUSSION

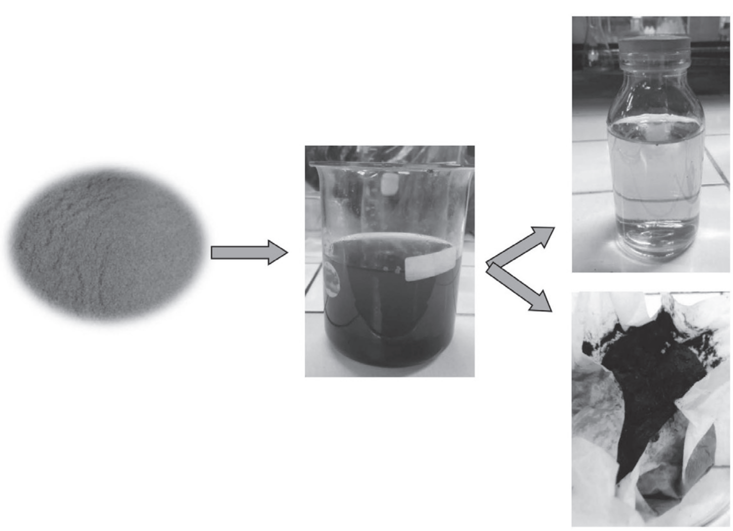
Samples were digested and shaped in -32, +65 mesh to make in uniform size and to help the hydrolysis process of the components contained in the mahogany sawdust such as cellulose, hemicellulose and lignin and other minor components.

Fig 2 sample of mahogany sawdust



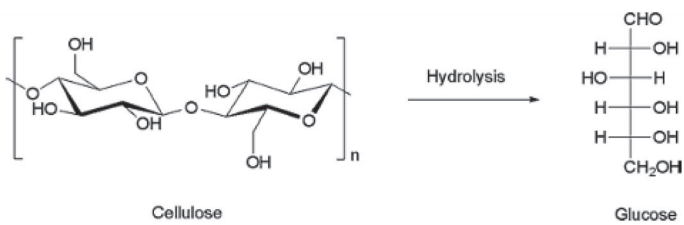
The results shown in this paper are temporary results showing HTL conversions at temperatures of 200oC and 240oC. A liquid product with clear yellow color has been obtained which may indicates the presence of potential flavoide derivative compounds which act as a dye.

Fig 3. Sample and products of hydrothermal liquefaction



From these results are suspected hydrolysis of the components of cellulose, hemicellulose and a small part of lignin. Hydrolysis is one of the main reactions and usually occurs at the beginning of a biomass conversion where the glycoside bond between the sugar units is broke to form simple sugars such as glucose and partially hydrolyzed oligomers (Huang and Fu, 2013). During the HTL process, decomposition and repolymerization reactions are occurred and forming biocrude, dissolved chemicals, solids and gases residues (Peterson et al., 2008). The content of compounds in the resulting product is not known because of unfinished analysis. However, it can be expected reactions that occur through the review of related research journals. The cellulose component will be hydrolyzed into its constituent units under subcritical conditions. The cellulose component which is often used as an example in hydrolysis using water is celobiose. This reaction was characterized by the adsorption of H2O followed by splitting simultaneously between water and glycoside bonds and form two units of glucose (Jin et al., 2014) as shown in the following figure:

Fig.4 Illustration of cellulose hydrolysis



Similarly, hydrolysis of hemicellulose can occur at a temperature of 230oC. It was also found that nearly 100% of the hemicellulose from various woods can be hydrolyzed at 230oC and 34,5 MPa for 2 minutes (Mok & Antal, 1992; Toor et al., 2014). In this study, the process of hydrothermal liquefaction at a temperature of 200oC allegedly has not been able to hydrolyze most of the hemicellulose. Another major component of biomass lignin will produce various phenol compounds and methoxy phenols formed due to hydrolysis of the ether bonds during the hydrothermal process. This product can still be derived by hydrolysis of the methoxy group (Liu et al., 2006). From several existing literatures, it is suspected that the hydrothermal liquefaction of mahogany sawdust can produce some derivative compounds from cellulose, hemicellulose and lignin, one of which can be extracted and used as a natural textile dye.

CONCLUSION

Hydrothermal liquefaction of Mahogany sawdust (Swietenia Macrophylla) is a potential method to produce natural textile dye, as well as to support the sustainable processing of biomass waste. Hydrothermal process was performed at temperature variations at 200oC, 240oC, 270oC, and 300oC at an initial pressure 1 Mpa for 30 minutes and variation of biomass-water ratio (B/W ratio) with a ratio1: 20, 2:20 and 3:20 (at 250oC). It was expected to produce some derivative compounds of cellulose, hemicellulose and lignin, one of which can be utilized as a natural textile dye. From the two results of hydrothermal liquefaction performed at the temperature 200oC and 240oC, liquid products, which are estimated to contain flavonoid derived compounds that act as a producer of yellow to brownish, were obtained. This will be ensured after all variations of experiments performed and analysis results using HPLC and GCMS. Similarly, solid products projected as solid fuels can be found after proximate test.

References

BPS, 2015, Produksi kayu hutan menurut jenis produksi (m3), 2000, 2002-2013, https://bps.go.id/linkTabelStatis/view/id/1718 accessed 16 April 2017.

Daneshvar, N., Ayazloo, M., Khataee, A.R. & Pourhassan, M., 2007, Biological decolorization of dye solution containing malachite green by microalgae Cosmarium sp., Bioresource Technology, 98(6): 1176-1182.

Huang Y-B, Fu Y., 2013, Hydrolysis of cellulose to glucose by solid acid catalysts, Green Chem 15(5):1095-1111.

Jin, F., Wang, Y., Zeng Xu., Shen Z., Yao, G., 2014, Water under high temperature and pressure conditions and its applications to develop green technologies for biomass conversion, Application of hydrothermal reactions to biomass conversion, Green Chemistry and Sustainable Technology, DOI: 10.1007/978-3-642-54458-3_1.

Kasmudjo., Panji, P.S., Widowati, T.B., 2005, Pemanfaatan limbah serbuk kayu mahoni sebagai pewarna alami batik, Fakultas Kehutanan, Univeritas Gadjah Mada.

Liu A, Park YK., Huang Z., Wang B., Ankumah RO., Biswas PK., 2006, Product identification and distribution from hydrothermal conversion of walnut shells, Energy Fuel, 20:446–454.

Maria CP., Mu'nisatun S., Rany S., Djoko M., 2007, Studi pendahuluan mengenai degradasi zat warna azo (Metil orange) dalam pelarut air menggunakan mesin berkas elektron 340 keV/10 mA., JFN 1(1):31-44, ISSN 1978-8738.

Mok WSL, Antal MJ., 1992, Uncatalyzed solvolysis of whole biomass hemicellulose by hot compressed liquid water, Ind Eng Chem Res, 31:1157–1161.

Nugroho, R., Ikbal, 2005, Pengolahan air limbah berwarna industri tekstil dengan proses AOPs, JAI 1(2).

Peterson AA., Vogel, F., Lachance, RP., Froling, M., Antal, MJ., Tester, JRJW., 2008, Thermochemical biofuel production in hydrothermal media: A review of sub- and supercritical water technologies, Energy Environ Sci, 1:32–65.

Selvam, K, Swaminathan K., Keon-Sang Chae, 2003, Decolourization of azo dyes and a dye industry effluent by a white rot fungus Thelephora sp., Bioresource Technology 88:115-119

Toor, S.S., Rosendahl, L.A., Hoffmann, J., Pedersen, T.H., Nielsen, R.P., and Søgaard, E.G., 2014, Application of hydrothermal reactions to biomass conversion chapter 9: Hydrothermal liquefaction of biomass, Green Chemistry and Sustainable Technology, DOI: 10.1007/978-3-642-54458-3_9.