PHYSICSOCHEMICAL PROPERTIES OF SURGANE BAGASSE BIOMASS WITH ACTIVATED CARBON (ACs) AS RENEWABLE ENERGY

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Abstract

Biomass is an industry term for getting energy by burning wood, plants and animal waste and other organic matter in nature. In this research, sugarcane bagasse biomass has been used as a raw material for the preparation of different activated carbons. Sugarcane bagasse is a solid residue, consisting of the dry fibrous mass remaining after the juice is extracted, which can cause serious environmental problem if disposed inadequately. The aim of this study was to use the bagasse in the preparation of activated carbons (ACs) followed by pyrolysis at 300°C, 400°C, and 500 °C for 1 h respectively. The sugarcane bagasse biomass was characterized by instrumental analysis such as infrared spectroscopy (FTIR), X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). Also, the pH and electrical conductivity (EC) of biomass was determined for physical properties. According to the experimental results, sugarcane bagasse biomass gave good strength results as well as the potential to be used as the source of energy. The results of this study present a simple, economical and environment-friendly method of improving the growth and enhancing the renewable energy in Myanmar.

Keywords - FTIR, XRD, SEM, sugarcane bagasse biomass

Introduction

Biochar can be used as fuel, for carbon sequestration, as activated carbon and soil amendment to reduce greenhouse gas emissions [Lehmann J et al 2006]. Activated carbon is a well-known as porous material, with large specific surface area, which is useful in various application of both gases and solutes from aqueous solution [Pragya P et al 2013]. The term biomass refers to all materials derived from living organisms (plants and animals). Biomass can be used as a material (such as food, timber products, fiber, fertilizer, chemicals, etc.) or energy. A wide range of biomass sources have been used to make biochar, including agricultural and food waste, woody plants and animal manures and waste from many industries. The application of biochar to soil can improve soil quality and plant growths. Properties of biochars are strongly dependent on biomass feed stocks and production conditions. Current study on the characterization of biochars mainly focused on their chemical functionality related to agricultural and environmental applications. Among them various types of biomass in our environment, optimizing studies were carried out on sugarcane bagasse as potential feedstock for biochar production.

Sugarcane is a member of the grass family. Sugarcane is a tree-free renewable resource and one of the most important agricultural plants that grown in hot regions [Rasula M G et al 1999]. Sugarcane is “carbon neutral” (i.e. emissions are equal to energy generated) and is the product of choice in the manufacture of bio-fuels due to its high energy conversion rate [Aigbodion V. S et al 2010]. Bagasse is lateral production of sugarcane that after treatment of sugarcane in the form of light yellow particles is produced. The bagasse ash is the remains of

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fibrous waste after the extraction of the sugar juice from cane [Kawade U R et al 2013].In many tropical countries there are substantial quantities of bagasse and husks from rice both are rich in amorphous silica, which react with lime. The bagasse ash is a pozzolanic material that would otherwise require disposal. The chemical composition of this product are cellulous fibers, water and some soil soluble material such as cube sugar, by passing time cube sugar is converted alcohol also the evaporation of bagasse fiber produce the methane gas which can cause fire in some circumstance [Subramani T and Prabhakaran M 2015]. Sugarcane consists of 25-30% bagasse whereas sugar recovered by the industry is about 10%. Bagasse is also used as a raw material for paper making due to its fibrous content and about 0.3 tons of paper can be made from one ton of bagasse. Bagasse is a byproduct during the manufacture of sugar and it has high calorific value [Nuntachai Chusilp et al 2009]. It is utilized as a fuel in boilers in the sugar mills to generate steam and electricity.

Materials and method

Preparation of Sugarcane Bagasse Biochars

Raw materials of sugarcane bagasse samples for this study were obtained from release of cold and drink shops, North Okkalapa Township. The collected sugarcane bagasse were washed several times with distilled water to remove dust and impurities and then dried in an oven at 120 °C for 24 h to remove all moisture. The bagasse were cut into small pieces, grained and sieved to an average particle size and stored in air-tight containers to prevent moisture buildup and other infections. The samples for activation process were then pyrolysis in a muffle furnace for activation temperature of 300 °C, 400 °C and 500 °C respectively. After activation period of 1 h the sugarcane bagasse biomass were allowed to cool down to the room temperature. The physiochemical and mechanical properties of sawdust biomass were successfully investigated. The block diagram of biochar preparation of sugarcane bagasse was shown in figure 1. The sugarcane bagasse biochar were measured for the value of change in pH and EC measurement. The chemical properties, structural properties and morphology structure of sawdust biomass were characterized FTIR, XRD and SEM analysis.

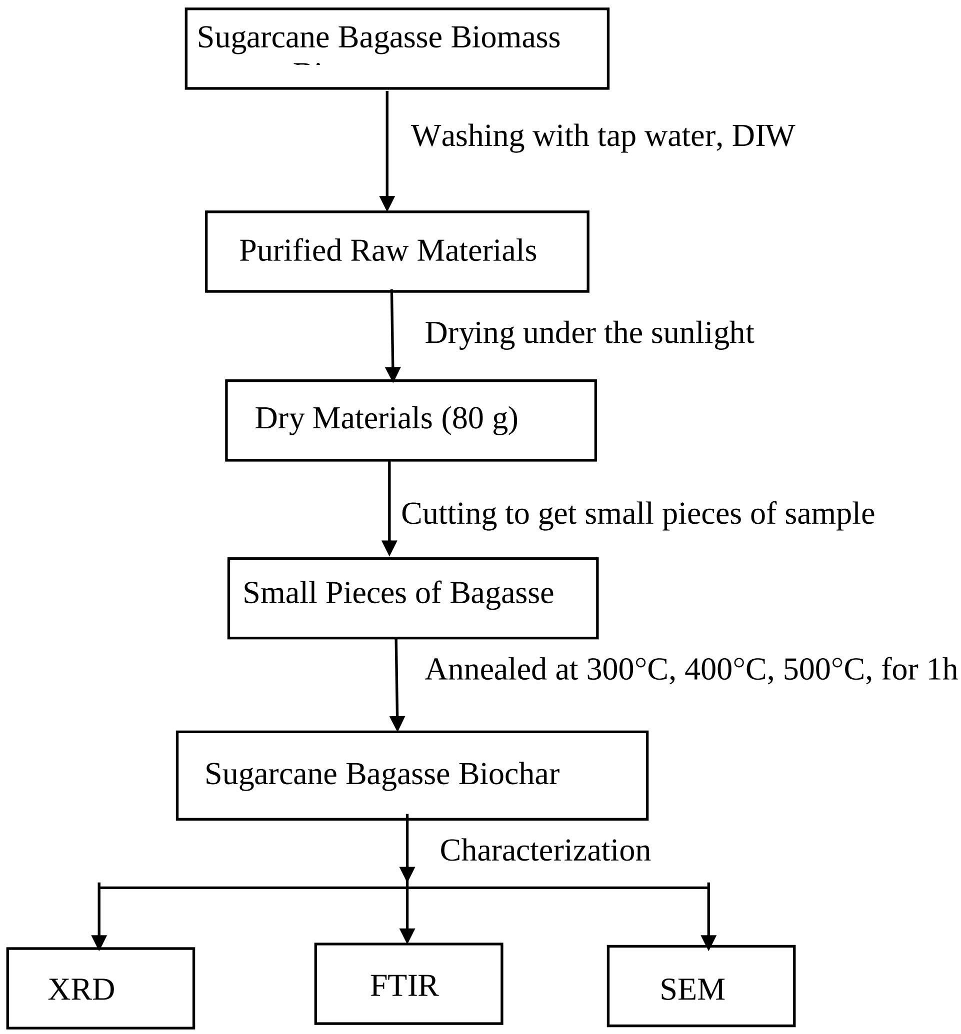

Figure 1 Block diagram of preparation of biochar Sugarcane Biomass

Biochar yield of Sugarcane Bagasse Biochar

In the preparation of biochar, the yield of biocahr is an important factor to be considered. The biochar yield (dry basis, %) is defined as the ratio of weight of biochar after pyrolysis (m_a (g)) to the weight of sugarcane bagasse before pyrolysis (m_b (g)) and is calculated by using the following equation,

$$\text{Biochar yield (\%)} = \frac{m_a\ (g)}{m_b\ (g)} \times 100\%$$

For all cases, the biochar yields of sugarcane bagasse biomass with various temperatures, the yields decreased sharply when the temperature was increased from 300°C to 500°C, and it decreased more slowly at increased temperatures. The variation of yield (%) is described in Table 1.

Table 1 Biochar Yield from Sugarcane Bagasse Biomass

Biochar	Pyrolysis Temperature (°C)	m_b(g)	m_a (g)	Biochar Yield (%)
Sugarcane bagasse Biomass	300	80	21.24	26..55
	400	80	17.42	21.78
	500	80	12.67	15.84

pH and Electrical Conductivity Analysis of Biochar

The pH testing of the sugarcane bagasse biochar were measured by pH meter Honiba F-51 (Japan). 2 g of dry biochar sample was dissolved 10 ml of deionized water for 15 min. Biochar was shaken with deionized water able at a constant temperature of 27 °C for 18 h. The pH values of the biochars in water ranged from slightly acidic 6.5 to alkaline 9.27. The value of pH increased considerably with the carbonization temperature from 300 °C to 500 °C. The value of pH slowly increased when the carbonization temperature was over 500 °C. The electrical conductivity is a measurement of the amount of soluble salts in biochar solutions, which is based on the principle that biochar solutions with a higher concentration of salts have a greater ability to conduct electricity. Electrical conductivity increases from 5.74 µS/cm to 7.49 µS/cm when the temperatures were increased. This is due to the presence of greater content in biochar prepared at higher pyrolysis temperature. Table 2 shows the pH value and EC measurement of sugarcane bagasse biochar. The graph of pH and EC measurement with different temperatures was shown in figure 2.

Table 2 The pH value and EC measurement of sugarcane bagasse biochar.

Temperature (°C)	pH value	EC (µS/cm)
300	6.5	5.74
350	7.8	6.21
400	8.89	6.61
450	9.15	7.01
500	9.27	7.49

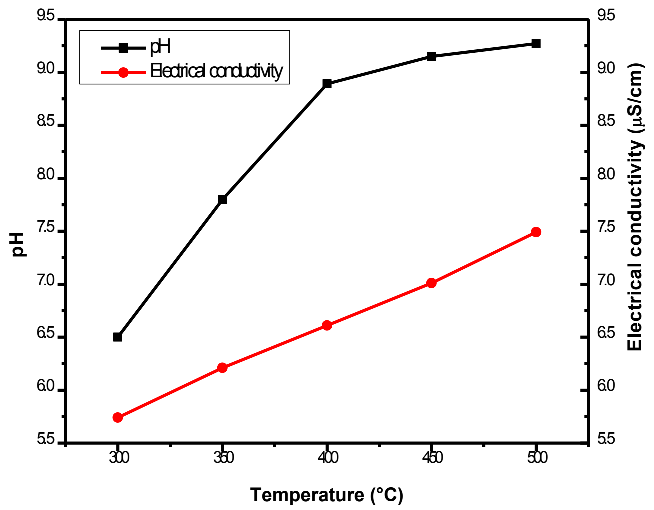

Figure 2 The graph of pH and EC measurement with different temperature

Results and Discussion

XRD Analysis of Sugarcane Bagasse Biochar

X-ray diffraction technique (XRD) is a powder technique for dimension of crystal structure, interplanar spacing by using X-ray beam. The sugarcane bagasse biochars were analyzed by XRD technique. According to XRD result, there are several diffracted peaks were observed. They were not perfectly identified. It could be say that the sugarcane bagasse samples were found to be amorphous structure with little crystalline. The absence of sharp peaks demonstrated the amorphous texture of the biochar sample. According to figure 3(a-c), it was examined that the dominant peaks were formed and they were matched with the peaks of carbon (graphite), diamond structure of carbon and chaoite structure. By analyzing XRD measurement, all the peak heights and peak position were in good agreement with library file of XRD machine.

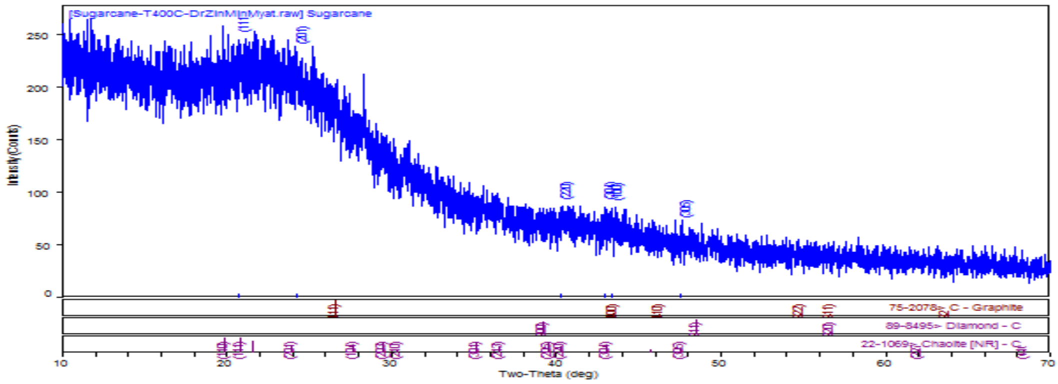

Figure 3(a) XRD Analysis of Sugarcane Bagasse Biochar at 300 °C

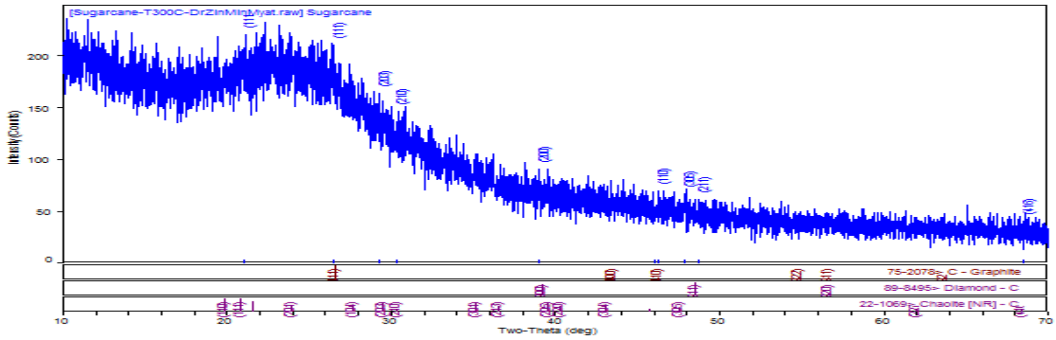

Figure 3(b) XRD Analysis of Sugarcane Bagasse Biochar at 400 °C

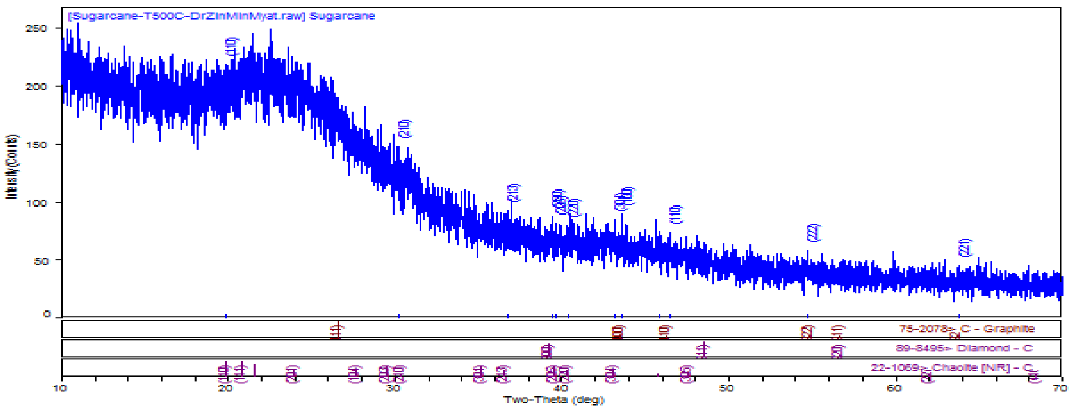

Figure 3(c) XRD Analysis of Sugarcane Bagasse Biochar at 500 °C

FTIR Analysis of Sugarcane bagasse biochar

Chemical functional groups were determined by Fourier Transform Infrared Spectroscopy (FTIR) analysis. The Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize biochar because carbon impurities, water, functional groups and chemical properties can be detected that may modify the sequestration capability. FTIR spectroscopy was applied to measure the chemical properties and absorption of energy from the range of 4000 cm^{-1} - 400 cm^{-1} by studied samples. Figure 4 shows the FTIR analysis demonstrated the functional groups presented on sugarcane bagasse biochar types with various temperatures (SB-300 °C, SB-400 °C and SB-500). The functional groups of these biochar samples have found to be C-H stretching vibration, C ≡ C ring stretching and C = C stretching vibration respectively. The spectrum of these samples showed some characteristic bands related to physical and chemical changes. As shown in figure 4, the infra-red spectra of these biochar types are comparable but there are some changes in the functional groups depend upon its pyrolysis temperature. The water O-H stretch can occur in the SB-400 °C about 3841.46 cm^{-1}. The strong hydroxyl group can display in the SB-300 °C, SB-400 °C and SB-500 °C for about 3367.25 cm^{-1}, 3350.82 cm^{-1} and 3331.96 cm^{-1}. The N = H ring stretching is associated with all of the biochar types. The peak observed at 1586.53 cm^{-1}, 1573.71 $cm^{-1}$and 1573.07 $cm^{-1}$with SB-300 °C, SB-400 °C and SB-500 °C, respectively, corresponded to aromatic C = C ring stretching. The peak located at 1117.30 $cm^{-1}$and 1035.84 cm^{-1} for SB -400 °C and SB -500 °C, respectively, assigned to C-Cl stretching vibration of the alkyl halide groups. The presence of the band located at 824 cm^{-1}- 600 cm^{-1} showed a C - H out-of-plane bending modes of aromatic compounds in SB-300 °C, SB-400 °C and SB-500 °C biochar types. It was previously reported that different type of oxygen containing functional groups which existed in the raw sugarcane bagasse. According to FTIR analysis, all of the absorption bands in different temperature biochar types SB-300 °C, SB-400 °C and SB-500 °C are suitable for their absorption bands due to hydroxyl group in cellulose, carbonyl groups of acetyl ester in hemicellulose, and carbonyl aldehyde in lignin.

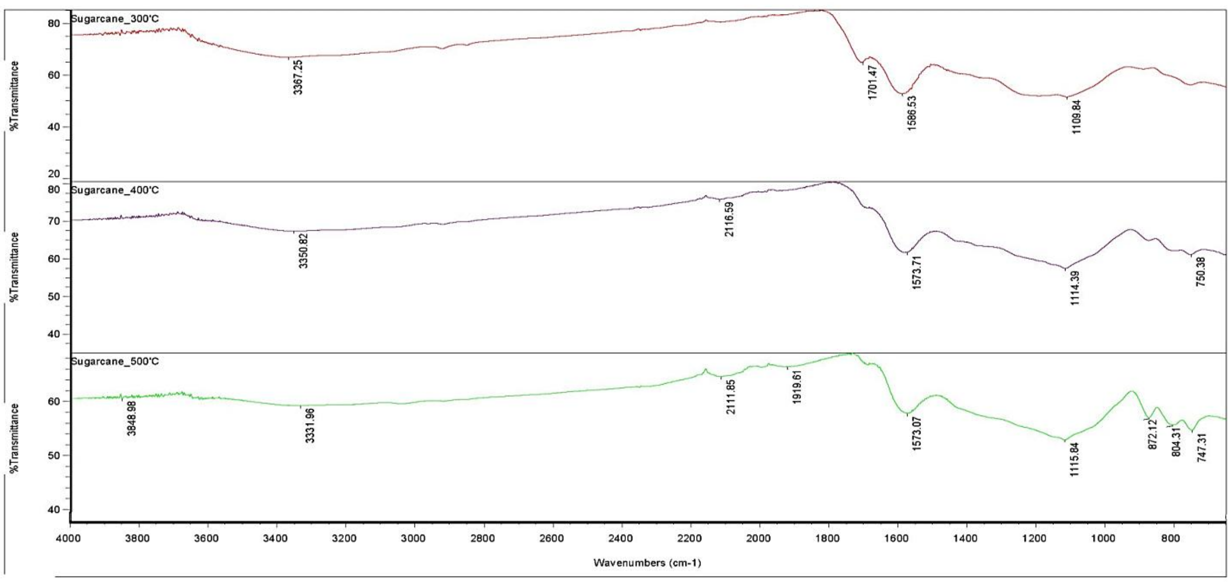

Figure 4 FTIR Analysis of Sugarcane Bagasse Biochar at 300 °C, 400 °C and 500 °C

SEM Analysis of Sugarcane bagasse biochar

SEM is one of the most versatile instruments available for the examination and analysis of the microstructure characteristics of a solid. The most important reason for using SEM is high resolution that can be obtained when bulk sample are examined. SEM micrographs for external morphology of sugarcane bagasse biochar at temperatures 300 °C, 400 °C and 500 °C for 1 h were shown in figure 5 (a-c). According to figure 5 (a), the clear porous nature had observed the sugarcane bagasse biochar at 300 °C and 400 °C. After increasing temperature, it was found that the sugarcane bagasse biochar had not clearly porous nature with macro- porous structure at 500 °C. From SEM analysis as shown in figure 5 (a-c), it can be observed that the microstructure of sugarcane bagasse biochar samples by varying the pore sizes with different temperatures. The average pore sizes of the samples were found to be about 6.7 μm at 300 °C, 10.2 μm at 400 °C and 11.7 μm at 500 °C respectively.

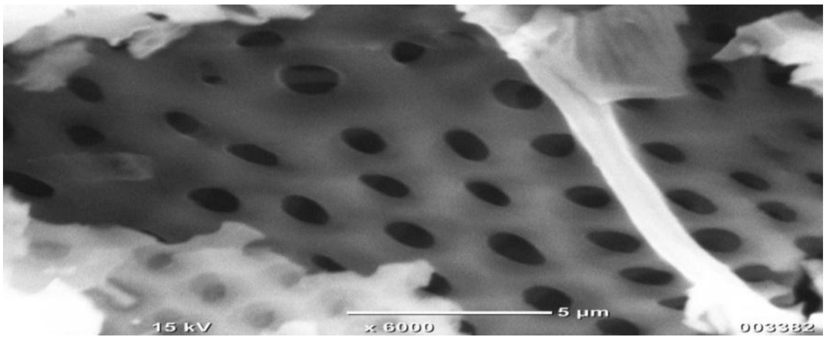

Figure 5 (a) SEM Analysis of Sugarcane Bagasse Biochar at 300 °C

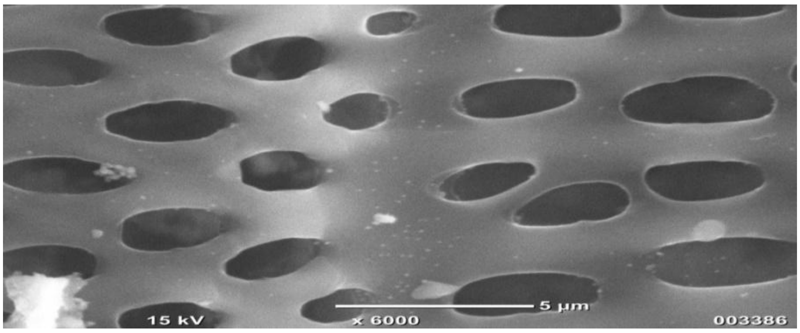

Figure 5 (b) SEM Analysis of Sugarcane Bagasse Biochar at 400 °C

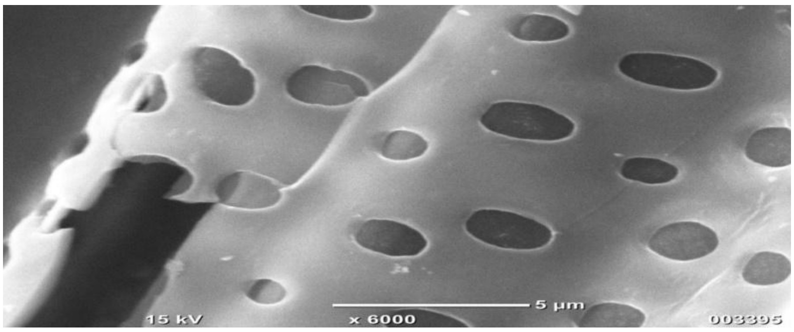

Figure 5 (c) SEM Analysis of Sugarcane Bagasse Biochar at 500 °C

Conclusion

The present investigation shows that the activated carbon obtained from sugarcane bagasse were prepared and characterized by studying physical, chemical and mechanical properties. In the physical properties measurements, the biochar yield % wt increased with increasing the carbonization temperatures. With the successive increase in temperature the pH and electrical conductivity (EC) values increased with elevated temperature. Sugarcane bagasse biomass provides the solution to use it and produce the low cost, energy efficient and clean energy in the form of briquetted biomass. According to FTIR analysis, low temperature, 300 °C biochar types is more suitable for their absorption bands due to hydroxyl group in cellulose, carbonyl groups of acetyl ester in hemicellulose, and carbonyl aldehyde in lignin. According to XRD result, the absence of sharp peaks demonstrated the amorphous texture of the biochar sample. They were not perfectly identified. It could be say that the sugarcane bagasse samples was found to be amorphous structure with little crystalline. XRD patterns of sugarcane bagasse were quite acceptable. Almost all the reflections were found to be consistent with carbon. SEM investigation showed that the macro- porous structure of sugarcane bagasse biochar. Sugarcane bagasse biomass can directly be used as a source of renewable energy because of their effective properties, environmental friendliness and low-cost production.

Acknowledgements

I would like to express my sincere gratitude to Professor Dr Khin Khin Win, Head of Department of Physics, University of Yangon, for her kind permission.

I would also like to mention my gratitude to Professor Dr Yin Maung Maung, University of Yangon for his encouragement on this research. This research was fully supported by the Department of Physics, University of Yangon, Myanmar (2018-2019).

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