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Thermal Analysis of Cellulose Fibres Extracted from Locally Available Rice Straw

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Abstract

Agriculture sector plays a vital role in Sri Lankan economy. Although the country is moving towards industrialisation, the agricultural sector still contributes substantially to both foreign exchange earnings and GDP. Paddy is cultivated in almost all parts of the country, except at very high altitudes. In 2018, around 3.9 million metric tonnes of paddy was harvested across the country from both Yala and Maha seasons. Rice straw is a by-product from the paddy cultivation and identified as agricultural production residue that is generated in equal or greater quantities than the rice itself with no commercial interest. Therefore, it is of ecological and economical point of view to discover an advantageous utilization of this material. Agricultural crop residues are rich in lignocellulosic materials with cellulose as the principle constituent. Study on the thermal properties of rice straw fibers are important in order to estimate their industrial applications. In this study, cellulose fibers were extracted from rice straw (BG352) via a series of chemical treatments. The structure and chemical composition of cellulose fibers were investigated using Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) and scanning electron microscopy (SEM). Thermal stability of each sample was determined using TGA SDT Q600 simultaneous thermal analyser (TA instruments, Delaware, USA). Analysis of individual samples was carried out at a constant heating rate of 10 °C/min between ambient temperature to 700^{o} C in a nitrogen atmosphere. FTIR analysis of fibers demonstrate that the chemical purification treatment results in sequential and complete removal of hemicellulose (1729 cm^{-1}, carbonyl stretching), lignin (1516 cm^{-1}, aromatic skeletal vibrations) and silica (796 cm^{-1} and 466 cm^{-1}, Si–O–Si stretching). XRD results also reveal the removal of lignin (shoulder peak at 16.4^{o}) and hemicellulose (weak peak at 34.76^{o}) from rice straw thus, confirms the final product as cellulose. Three endothermic peaks were observed in thermogravimetric analysis. Initially a small weight loss was observed around 100^{o} C due to the low molecular weight components in the fibers and the evaporation of remained moisture. Hemicellulose pyrolysis was occurred around 260^{o} C. A resistant increase in cellulose was observed due to the removal of almost all hemicelluloses from the rice straw. Pyrolysis of lignin in rice straw started at 200^{o} C and persisted till 700^{o} C. Further, a significant difference between the contents of the residues were remained which indicated that the thermal stability of cellulose was visibly improved. Based on the results obtained, the extracted cellulose fibers from locally available rice straw could be used to produce textiles, composites, all kinds of paper and paper boards, photographic films, moisture proof coatings for food packaging and other fibrous products similar to those produced from the synthetic fibers. Using rice straw as a source of high-quality fibrous applications will add value to the rice crops, mitigate concerns regarding burning or disposing of rice straw, and provide an environmentally friendly alternative to replace the synthetic fibers currently in use.

***Keywords*:** Sri Lankan rice straw, Cellulose fibers, Chemical treatment, Thermal decomposition, Thermal properties