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Effects of biomass types on flammability and mechanical properties of sustainable biochar based composites**Debes Bhattacharyya**

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The main aspects of green and sustainable chemistry are employment of renewable materials and effective utilisation of organic wastes. In the light of application of renewable materials, biochar aptly fits the paradigm due to the fact that it is a by-product of thermochemical conversion of organic waste biomass. On the other hand, organic wastes with the potential to degrade, aided by bacteria, can generate harmful greenhouse gases or leachates. Therefore, for the purpose of reducing pollution, conserving resources, and saving energy, it is required to reuse and recycle organic wastes. Various types of organic waste, such as sunflower/corn stalks, rice husks, wool, waste paper sludge, have already been used to manufacture biocomposites in the past. However, the synergistic behaviour of these organic wastes and biochar in a biocomposite is not yet fully understood. Therefore, four different biomass wastes (rice husk, coffee husk, wool and wood) were added with polypropylene (PP) and pinewood waste derived biochar to manufacture sustainable biocomposites. The biochar was characterised chemically using infrared spectroscopy (FT-IR) and X-Ray diffraction (XRD). It was observed that the biochar lacked surface functional group as no visible peaks appeared in FT-IR spectra. The XRD spectra illustrated the amorphous nature of the biochar having some degree of early short range order. The presence of turbostratic carbons in the biochar resulted in the hump at about 25° (2θ). The biocomposites were analysed for their thermal/flammability properties using cone calorimeter, thermogravimetry (TGA) and Differential Scanning Calorimetry (DSC). Their tensile and flexural properties were also measured using Instron universal testing machine. From the DSC it was observed that addition of biochar and biomasses did not restrict the flow of PP but, nonetheless the particles acted as nucleating agents aiding crystal growth and consequently causing an earlier onset of crystallisation. In TGA studies, all the biocomposites were seen to have two events of decomposition, one at 330-370°C and the other at 412-490°C. The first decomposition was due the degradation of cellulose in the biomasses (breakage of microfibril-matrix structure in wool) whereas the second decomposition was represented by the degradation of PP. It is interesting to note that due to the higher thermal stability of biochar, the decomposition events were delayed compared to neat biomass and PP. From the cone calorimeter, it was observed that the peak heat release rate (PHRR) of the wool based biocomposite was the highest (596 kW/m²) and that of coffee husk added biocomposite was the lowest (394 kW/m²). Although the neat rice husk had a lower PHRR than that of neat wood, its biocomposite exhibited higher PHRR (501 kW/m²) than wood based biocomposite (449 kW/m²). Among the different biocomposites, wood based sample had the highest tensile/flexural strength (36MPa/67 MPa) and flexural modulus (4.4 GPa). Its tensile modulus (4.73 GPa) was second to that of rice husk based biocomposite (4.87 GPa). Production of biochar retains the structure of the parent feedstock (in this case, pinewood). Therefore, it is possible that the biochar and wood were physically compatible with each other in the PP matrix through a lock and key mechanism. The compatibility of wood with the biochar, the good interfacial bonding of wood and PP matrix, and the mechanical interlocking of biochar and PP led to the better mechanical properties of wood based biocomposite. These conclusions have been supported by scanning electron micrographs. This study has clearly established the possibility of using biomasses as filler materials in biochar-based polypropylene composites if the processing is carried out to an extent under controlled conditions.

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