ABSTRACT

Increasing environmental awareness throughout the globe has forced researchers to produce new green materials that improve the environmental quality of products. Generally in most of their applications the properties of polymers are modified using natural fillers and natural fibers to suit the high strength/high modulus requirements. Natural fibers derived from bark of various plants such as jute, artichoke, okra, hemp, Grewia tilifolia, kenaf, ramie and flax have fascinated the scientists and technologists because of their desirable properties and accessibility. However, bark fibers derived from the Prosopis juliflora (PJ) plant which may presumably have all or most of the qualities of the bark fibers known till date. However, they have not been studied yet despite their global presence. This study aims to understand the physicochemical properties of raw and various chemically modified Prosopis juliflora fibers (PJFs) in comparison to other natural fibers known. To the best of our knowledge, the bark fibers of PJ as novel reinforcements have been studied for the first time.

The PJFs were extracted following traditional process which involves microbial degradation and combing. Examination of the PJ bark and fibers under a polarized microscope revealed that the PJFs belonged essentially to gelatinous or mucilaginous type. It is worth mentioning that the density (580 kg/m³) is relatively lower in comparison to bark fibers of other plants. An X-ray diffraction (XRD) and Fourier transform infrared (FTIR) analysis of raw PJFs showed the presence of cellulose-I with a crystallinity
index (CI) of 46%. Raw PJFs had a tensile strength of 558 ± 13.4 MPa with an average strain rate of 1.77 ± 0.04% and microfibril angle of 10.64 ± 0.45°. Thermal analyses (TG and DTG) showed that it started degrading at the temperature of 217° C with kinetic activation energy of 76.72 kJ/mol.

Incompatibility between hydrophilic natural fibers and hydrophobic matrix is known to affect the adhesion of the fiber and matrix. To enhance the interfacial adhesion between the fiber and matrix the chemical modification through alkali treatment has been optimized at 5% (w/v) NaOH and 60 min soaking time. It is intriguing to note that optimally alkali treated PJFs had higher cellulose (72.27 wt.%), lower hemicellulose (4.02 wt.%) and lignin (12.09 wt.%) contents, higher crystallinity index (73%), tensile strength and thermal stability.

The optimized fibers were further subjected to benzoyl peroxide (BPJF), potassium permanganate (PPJF), and stearic acid treatments (SPJF). The effect of various chemical modifications favorably changed the physiochemical properties of PJFs and undoubtedly diminished the amorphous and wax contents. Moreover, all chemical modifications caused imperative progress in thermal stability compared to raw of PJFs. Taken together the properties of the PJFs make them potential reinforcement for polymer matrices in composite structures, and textile industries.

Bark anatomy of the fast growing and perennial PJ plant revealed the usefulness of its fibers as an alternate new raw material for the paper production. The fiber properties were compared with other wood and non
wood fibers. The macerated length of PJFs was found to be $1.62 \pm 0.01$ mm and it’s quite close to other fibers that are used for paper production. The derived parameters of PJFs especially the slenderness ratio with a low runkel ratio play a vital role in paper production and expected to have increased mechanical strength, thus making it suitable for writing, printing, wrapping, and packaging purposes.