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Preparation and characterization of candelilla fiber (*Euphorbia antisyphilitica*) and its reinforcing effect in polypropylene composites

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Abstract Candelilla bagasse fiber (CBF) was prepared by a mesh sieve and ball-milling process and its reinforcing effect in a polymer matrix analyzed. Composites of polypropylene (PP) and CBF were prepared by melt blending with varying amounts (20, 25, and 30 wt%) of fiber using maleic anhydride PP as coupling agent. The chemical composition of CBF was analyzed according to Technological Association of the Pulp and Paper Industry (TAPPI) methods, and the morphology and thermal and chemical properties of CBF and its composites were analyzed by X-ray diffraction (XRD), thermogravimetric analysis (TGA), Fourier-transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC), scanning electron microscopy (SEM), and tensile testing. In general, fibers extracted from candelilla by a reduction process are comparable in terms of micro- and nanostructure to other lignocellulosic fibers. Dynamic light scattering (DLS) results reveal that sieve-milling reduces the fiber size. The results also show that the thermal stability of PP was enhanced when using CBF, but the crystallinity index of the PP composites decreased slightly according to DSC and XRD results. Furthermore, the Young's modulus was increased in PP/CBF samples with and without MAPP to obtain improved wettability and fiber–polymer adhesion. We found that CBF is an excellent alternative to replace conventional materials or synthetic fibers, as well as for reinforcement in polymer composites.

Keywords Fiber · Candelilla · Polypropylene · Composites · Tensile properties

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Introduction

Over the last few years, there has been considerable interest in use of natural fibers as fillers for thermoplastics due to their advantages such as low cost and density, high specific strength, biodegradability, and renewability. Such natural fiber–thermoplastic composites have been used in automotive parts, aerospace, construction, etc. (Karnani et al. 1997; Bledzki et al. 1996; Robin and Breton 2001; Herrera-Franco and Valadez-Gonzalez 2005). The commonest natural fibers for use in thermoplastics are wood flour, cotton, jute, kenaf, flax, bamboo, sisal, and hemp (Nabi-Saheb and Jog 1999).

The candelilla shrub is native to northern Mexico and the southwestern USA. It is an evergreen shrub (between 20 and 110 cm in height) with a few small

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Conclusions

New composites based on PP and CBF were obtained by fiber size reduction using a mesh sieve and ball-milling process. According to FTIR results, CBF has cellulose and lignin in higher amounts than typical fibers (hemp, sisal, jute, etc.). On the other hand, XRD and FTIR revealed a type of native cellulose (I_{β}) with chains in highly organized form, resulting in a more packed and stable structure until around 200 °C. The size reduction process of CBF by ball milling and mesh sieving improved the size distribution with a slightly higher crystallinity index of the cellulose. Moreover, the milling treatment increased the fiber–matrix adhesion due to the increased surface area (hydroxyl interaction –OH groups) from the reduced fiber particles. The Young's modulus of the PP composites was enhanced for higher amounts of CBF in the PP matrix, obtaining good adhesion and wettability between fiber bundles and the polymer matrix, whereas the elongation at break decreased.

Among the many different types of natural resources, CBF is a promising reinforcement for use in composites due to its low cost, low density, high specific strength and modulus, no health risk, easy availability, and renewability. We demonstrated that CBF is an alternative medium to replace conventional materials or synthetic fibers for reinforcement in composites, helping to create jobs in both rural and urban areas.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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