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Thermogravimetric analysis of *Dendrocalamus strictus* bamboo fibers

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Abstract—The primary thermogram of the bamboo fibers of *Dendrocalamus strictus* family was recorded. Using the primary thermogram and its derivative, the initial degradation, inflection point and final degradation were determined. The refractoriness and integral procedural degradation temperatures were also determined. These studies revealed the suitability of bamboo fibers as reinforcement even with thermoplastic polyolefin matrix materials.

Key words: Bamboo fibers; *Dendrocalamus strictus*; thermogravimetric analysis; degradation temperatures.

INTRODUCTION

The usage of polymer composites is increasing day by day because of their high strength-to-weight ratio, ease of fabrication, etc. Though, generally, glass fibers are used as reinforcements in making these composites, natural fibers are also used nowadays as these are ecologically friendly. Jindal [1] and Varada Rajulu *et al.* [2] developed short bamboo fibre reinforced epoxy composites and studied their performance. In order to increase the rate of production of these composites, nowadays thermoplastics are preferred as the matrix materials. At the melting temperature of the thermoplastics, most of the natural fibers may thermally degrade. George *et al.* [3, 4] carried further the thermogravimetric, dynamic mechanical thermal analysis, and mechanical analysis of pineapple fibre reinforced polyethylene composites. They reported that the pineapple leaf fibres were thermally stable at the processing temperature of polyethylene. So, before using the natural fibers as reinforcement with thermoplastic matrix materials, their

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thermal stability has to be assessed. In the present work, the authors carried out thermogravimetric analysis (TGA) of the bamboo fibers of *Dendrocalamus strictus* variety and the thermal degradation temperatures were determined.

EXPERIMENTAL

Bamboo fibers of the family of *Dendrocalamus strictus* (specific gravity = 0.841) were procured from the Tripura forest emporium, New Delhi, India. These were further dried in the sun for seven days, to ensure maximum moisture removal. After this, the fibres were dried in a hot air oven for several days at 100°C until a constant weight was recorded for the fibres. A small piece of the dried bamboo fibre was introduced into the weighing boat of the thermobalance. The TGA of these samples was carried out using a Perkin Elmer TGA-7 thermobalance in nitrogen atmosphere at a heating rate of 10°C/min in the temperature range of 35°C to 700°C. To find out the period of time for which bamboo fibres are stable at 300°C, isothermal experiments must be conducted, the facilities for which were not available with the authors.

RESULTS AND ANALYSIS

The primary thermogram of the *Dendrocalamus strictus* bamboo fibers is presented in Fig. 1. For convenience, its derivative is also presented in the same figure. From this figure, it is clearly evident that at 100°C, there is a sudden decrease in weight of the fibre indicating loss of water. Using this figure, the initial degradation, the inflection point (where the rate of degradation is maximum) and the final degradation temperatures were determined using the tangents at the curved portions of the thermogram and these values are presented in Table 1. Using the area under the curve, the integral procedural degradation temperature (IPDT), which is an index of the thermal stability and the refractoriness of the bamboo fibre, were determined according to the procedure of Doyle [5]. These values are also presented in Table 1. From the table, it is clearly evident that the fibre is thermally stable up to 300°C (i.e. up to 30 min). Generally, the processing time cycle for thermoplastic articles is only a few seconds, so bamboo fibres will be highly stable within this time. At the temperature of 300°C, the weight loss was found to be only ~10%. Thermoplastics are those polymers that soften on heating and then set on cooling. To make natural fibre reinforced thermoplastics, the fibres must be stable at the processing temperatures of the plastics. As bamboo fibres have better thermal stability, they can be used as reinforcement with either polyethylene or polypropylene (polyolefins) as matrix materials as their processing temperature is below 270°C. Moreover, the fibre is found to degrade up to 50% only at an elevated temperature of 377°C. The IPDT of 240°C and refractoriness of 408°C are found to be better than those of the generally used polymers.

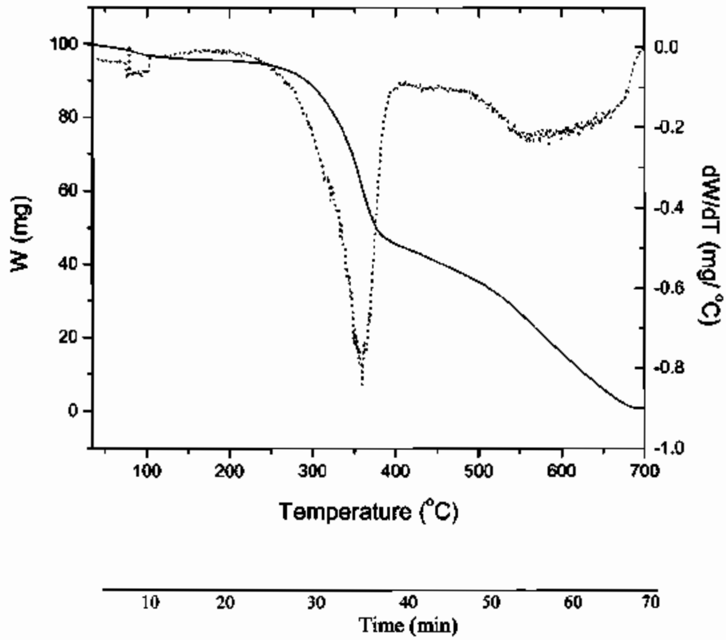

Figure 1. Thermogram of *Dendrocalamus strictus* bamboo fiber heated at the rate of 10°C/min in nitrogen atmosphere. (—) Primary thermogram, (···) derivative thermogram.

Table 1.
The thermal degradation temperatures of *Dendrocalamus strictus* bamboo fibre

Thermal degradation parameters	Values (°C)
1. Initial degradation temperature	300
2. Inflection point	347
3. Temperature corresponding to 50% degradation	377
4. Final degradation temperature	415
5. Refractoriness	408
6. Integral procedural degradation temperature	240

CONCLUSIONS

Thermogravimetric studies on the bamboo fibre *Dendrocalamus strictus* indicate that this fibre is suitable as reinforcement for making composites even with thermoplastic matrix materials whose processing temperature is less than 300°C.

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