Effect of Chemical Treatment on Thermal Properties of Natural Fibers

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Abstract. Natural fibers are widely use to replace the synthetic fibers in polymer composites due to their inherent properties. In the present study, Thermogravimetric analysis (TGA) of sisal, jute and ramie fiber was done before and after chemical treatment. This study includes the effect of chemical treatment on the thermal stability of sisal, jute and ramie fibers. The degradation of fibersand the phases of degradation were studied with increase in temperature. Results showed that chemical treatment improved the thermal stability of ramie and sisal fiber while jute fiber showed not much change in properties by chemical treatment.

1. Introduction

Natural fibers are potential to replace synthetic fibers due to their intrinsic characteristics. The main disadvantage of natural fibers as reinforcement in composite is poor wettability with matrix and the hydrophilic nature. Good surface adhesion with matrix may be enhanced by chemical treatment of fibers which in turn increases overall performance of composite [1-4]. Various type of treatments are carried out to modify the surface of fibers such as physical technique, chemical treatment and biological treatment. Different physical techniques such as steam explosion, thermomechanical process, plasma, dielectric barrier and corona fall are carried to separate bundles of fiber into individual filaments and to modify the fiber surface. Chemical treatment involves the chemical attack on the fiber surface to enhance surface adhesion with polymer and to increase its strength. In biological treatment, deposition of cellulosic bacteria on fiber surface during fermentation process took place to improve the fibers surface [5, 6]. Chaitanya and Singh [7] carried out the effect of sodium bicarbonate treatment on sisal fiber. Authors showed that thermal stability of sisal fiber improved by the alkaline treatment. Authors also concluded that sodium bicarbonate was cleaner technique to modify fiber surface. Panyasart et al. [8] investigated the effect of surface treatment of pineapple leaf fiber. Results showed that out of silane and alkali treatment silane treatment improved thermal and mechanical properties. Yu et al. [9] carried out alkali and silane treatment of ramie fiber. TGA results indicated improved degradation temperature due to the surface treatment. orlve et al. [10] investigated the effect of alkali, silane and their combination on thermal properties of sisal fiber. Thermal analysis indicated that reduction in hemi-cellulose and lignin content and optical microscopy resulted in rough surface of fibers. Fiore et al. [11] analysed effect of sodium bicarbonate treatment on sisal fiber. Results showed that due to removal of hemi-cellulose, rearrangement of cellulose took place to close structure. In the present study, Thermogravimetric analysis (TGA) of jute, sisal and ramie fiber were carried out both raw and treated fibers.

2. Materials and Method

2.1. Materials

Jute fiberswere procured by Jute N Fabrics, New Delhi. Sisal fibers were supplied by Women Development Organization, Dehradun and ramie fiberswere procured from Go Green, Chennai. The chemical composition of three fibers is shown in table 1. Sodium bicarbonate procured from local supplier from New Delhi.

Table.1 Chemical Composition of Jute, Sisal and Ramie [12]

Fiber	Cellulose (%)	Hemi-Cellulose (%)	Lignin (%)	Pectin (%)	Ash (%)
Jute	45-71.5	13.6-21	12-26	0.2	0.5-2
Sisal	47-78	10-24	7-11	10	0.6-1
Ramie	68.6-91	5-16.7	0.6-0.7	1.9	-------

2.2. Method

All the three fiber were cut into 6mm. for the surface treatment. Fibers were dipped into $NaHCO_3$ solution (20% W/V) in water at room temperature for 15 hours. After that, fibers were washed with distilled waterto remove any traces of $NaHCO_3$. Next, fibers were dried for 6 hours at 50^0C.

2.3. Thermogravimetric analysis (TGA)

TGA was performed using TGA perkin elmer diamond TG/DTA instrument at USIC, University of Delhi. Fibers in solid form were investigated in nitrogen environment to a maximum temperature of 450^0C at the rate of 10^0C/min. The relative mass change was recorded along the increase in temperature.

3. Results and Discussion

Relative mass change in percentage versus temperature is shown in figure 1. Thermogravimetric analysis of raw and treated jute, sisal and ramie fibers was performed and it was observed that fibers were degraded in three stages. Initially, degradation occurred at 40 ^{0}C to 110 ^{0}C due to the removal of water traces from the fibers. As observed from figure that due to treatment,affinity towards moisture absorption of ramie fiber was reduced. Further, degradation occurred at 210 ^{0}C to 320 ^{0}C due to the degradation of hemi-cellulose and cellulose content. It was observed from this step that improvement in thermal stability of ramie fiber was more than sisal and jute fibers. In last stage, from 340 ^{0}C to 450 ^{0}C, the removal of lignin from the fibers took place.Thermogravimetric analysis showed that thermal stability of ramie fiber had improved and small improvement in sisal fiber was also observed. The effect of treatment on jute fiber was not so much observed.

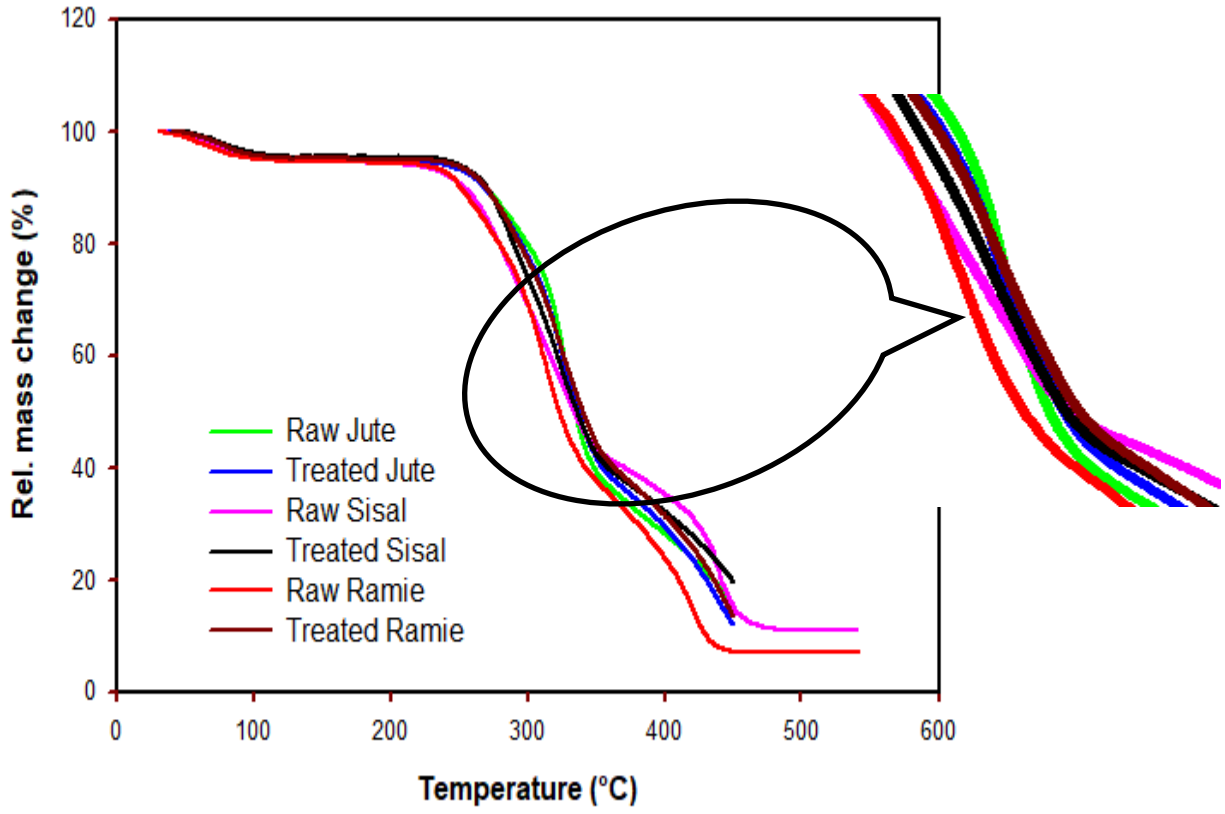

Figure 1. TGA of raw and treated fibers

4. Conclusion

The present study showed that chemical treatment of fibers improved their thermal stability. From TGA results, it is observed that $NaHCO_3$ can be used for the treatment of ramie and sisal fibers but it has negligible effect on jute fiber. The thermal stability of ramie fiber was highly affected by $NaHCO_3$ treatment.

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