



# Studies on the Thermal properties of untreated and chemically treated Palmyra Palm Leaf Base Fibres

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## Abstract

Palmyra ( *Borassus flabellifer* ) palm leaf base fibre, a natural fibre extracted from palmyra palm tree was chosen and chemicals such as sodium hydroxide, benzoylchloride, and potassium permanganate for pre treatment procedures. Effect of these treatments on the thermal properties were determined experimentally.

**Keywords:** Natural fibre, pre-treatments and thermal properties

## 1. Introduction

Natural fibers originate from the following sources, i.e., plant, animal and mineral. Examples for plant fibers are cotton, flax, hemp, sisal, jute, kenaf and coconut, For animal sources silk and wool and for mineral sources asbestos and metal fibers. Most of the natural fibers can be spun into filaments, threads or yarns and woven into fabrics. Some can be used to make mats which can be used to fabricate composite materials.

Plant fibers contain cellulose, hemicelluloses, lignin, pectin and wax. The strength, stiffness and structural stability are provided by the Cellulose. It consists of three hydroxyl groups (OH), one (OH) group is used for linking a cellulose molecule with the neighbouring cellulose molecule and the other two are used within the cellulose molecule itself. Fibers containing higher cellulose content has better strength than the fiber containing lower level of cellulose and [1].

Cellulose form the basic structure of fiber, Hemicellulose is bound to the cellulose by hydrogen bond. Lignin and pectin hold all the molecules together [2]. The other constituents are inorganic ash and organic extractives, the former is responsible for the abrasive nature of the fiber and the latter is responsible for color, odour and decay resistance of the fiber [3].

## 2. Materials and Methods

Palmyra Palm Leaf base Fibres were extracted from the leaf base of palmyra palm tree. The thorns and the skin of the leaf base was removed. These leaf base was kept immersed in water for 30 days and beaten slightly using a wooden hammer. The fibres in the stalks and the wax sticking on the surface were removed manually. Water wash was carried out to remove any impurities and then dried. Sodium hydroxide (NaOH), benzoylchloride, acetone, ethanol and potassium permanganate (KMnO<sub>4</sub>) of were used for pre treatment. All were of AR grade

### Pre treatments on natural fibres

Pre treatment using Alkali, Benzoylchloride and permanganate were carried out as mentioned in an earlier publication by Thiruchitrabalam and Shanmugam [7].

### Characterisation of fibres

#### Thermogravimetric Analysis (TGA)

Untreated and treated Palm leaf base fiber were subjected to TGA by using Perkin-Elmer Pyris equipment by passing nitrogen gas at 30 ml/min and heating from 30°C to 800°C at a heating rate of 10°C/min.

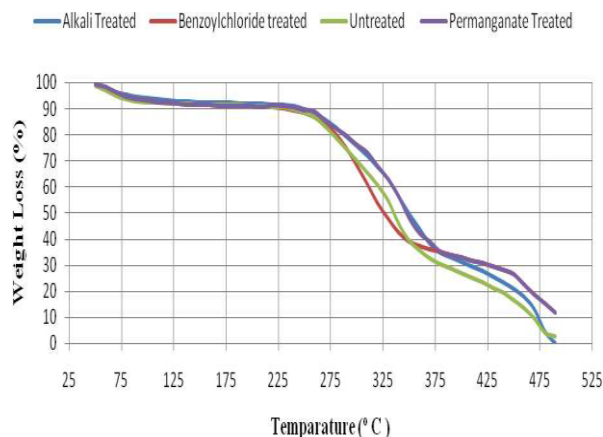
#### Differential Scanning Calorimetry (DSC)

Untreated and treated fibres were subjected to DSC using Perkin Elmer Pyris equipment. 1-2mg of fibres was used for the analysis. Fibre samples were heated at a rate of 10 °C/min from 30 to 400°. Nitrogen was flushed at the rate of 20 ml/min.

#### Thermo gravimetric analysis (TGA)

Three stages of weight loss can be seen for all the fibres both treated and untreated (Figure 3) with change in temperature. The 1<sup>st</sup> stage of the weight loss occurring around 100°C is attributed to removal of moisture from the fibre, the 2<sup>nd</sup> stage of weight loss occurring between 200-300°C was due burning of hemicellulose and lignin and the 3<sup>rd</sup> stage of weight loss occurring around 320-400 °C were because of burning of cellulose and its components. Finally beyond 400°C the tar/char is formed and ash [4,6]. Between 100 °C and 300° C the treated fibres were thermally stable, and in this temperature range the untreated fibres were found to lose more weight (~ 2%) than all the treated fibres. It was observed from the curve that the untreated fibres started degrading at around 230°C whereas in the case of treated fibres this value was found to increase, this can be attributed to the removal of

hemicelluloses and lignin. A steep drop in curve could be seen at this stage. The temperature at which the degradation starts for the treated fibres was more, at around 10 °C in comparison to the untreated fibres, this indicate that the thermal stability of the fibres improved due to chemical treatments. The temperature range up to which the fibres could be used is around 200°C -270°C beyond which the fibres degraded at a very high rate.



**Fig. 1:** TGA curves for untreated fibre, alkali treated, benzoyl chloride treated and permanganate treated PPLSF

### Differential Scanning Calorimetry (DSC)

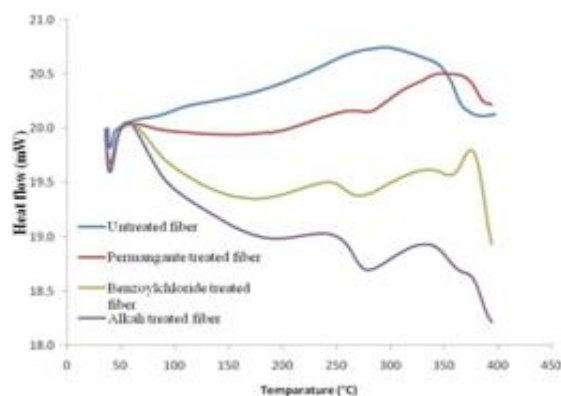
The effect of chemical treatments on the thermal stability can be determined using DSC [4,6]. Two peaks can be observed from Figure 2, One peak found at around 30 – 50 °C is an endothermic peak and the other found around 250- 390°C is termed the exothermic peak. Endothermic peaks are observed in the treated fibres as well as untreated fibres . This peak indicates the removal of moisture from the fibres due to increase in temperature. It can also be noticed that there exists some variation in energy required for decomposition of treated fibres in comparison to untreated fibres due to the effect of chemical pre-treatments. Also for the same reasons, there exists some change in moisture absorbed by the fibre. The exothermic peak observed between 250- 390 °C is indicates the removal of lignin, cellulose, hemicelluloses and wax [4]. For the Alkali, benzylchloride and permanganate treated fibres this peak was observed at 320°C, 370°C and 343°C respectively, while the untreated fibres had this peak around 279°C which shows the thermal stability of fibres had increased due to chemical pre-treatments. This change in degradation temperature is attributed to the removal of hemicelluloses, lignin, cellulose and wax due to chemical pre treatments.

### 3. Conclusion

Palm fibers extracted from the leaf stalks of palmyra palm tree were subjected to alkali, benzylation and permanganate pre-treatments. The changes in the thermal properties of untreated and treated fibres were analyzed and following was made.

The results of TGA, and DSC confirmed the removal of hemicellulose, lignin, cellulose and wax from the fibre which will result in reduced hydrophilic nature and enhanced thermal properties of the composites.

Therefore, the above results indicate that pre-treatment of the palm leaf fibers induced changes and it is also evident that when the pre-treated fibers are used for reinforcements may result in a composite with good thermal properties.



**Fig. 2:** DSC curves for untreated fibre, alkali treated, benzoyl chloride treated and permanganate treated PPLSF

### References

- [1] Chemical Modification of Hemp, Sisal, Jute, and Kapok Fibers by Alkalization Leonardo Y. Mwaikambo, and Martin P. Ansell, *Journal of Applied Polymer Science*, Vol. 84, 2222–2234, 2002.
- [2] Saheb, D.N. and Jog, J.P. Natural Fiber Polymer Composites: A Review. *Advances in Polymer Technology*, Vol 18, 351-363 , 1999 .
- [3] Recent developments in chemical modification and characterization of natural fiber-reinforced composites , MJ John, RD Anandjiwala - *Polymer composites*, Vol 29 , pp 187 - 207, 2008.
- [4] Guimaraes J.L., E. Frollini, C. G. Da Silva, F. Wypych, and K. G. Satyanarayana. Characterization of banana, sugarcane bagasse and sponge gourd fibres of Brazil. *Journal of Industrial Crops and Products* , Vol 30, pp 407-415, 2009.
- [5] Jawid M., H. P. S. Abdul Khalil, and A. Abu Bakar, Mechanical performance of oil palm empty fruit bunches/jute fibres reinforced epoxy hybrid composites. *Material Science and Engineering A* , Vol 527, pp 7944–7949, 2010.
- [6] Rosana, M., V. Francisco, K. Sigbritt K, and R. G. Amparo, Improved thermo-mechanical properties by the addition of natural fibres in starch-based sustainable bio composites. *Composites: Part A*, Vol 42, 30–40, 2009.
- [7] Thiruchitrabalam.M , and D. Shanmugam . Influence of pre-treatments on the mechanical properties of Palmyra palm leaf stalk fibre polyester composites. *Journal of Reinforced Plastics and Composites*, Vol 3, 400–1414, 2012.