

# Study of Thermal Properties of Eucalyptus Wood and its Polyacrylonitrile Composites.

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## ABSTRACT

In this study some thermal properties of Eucalyptus wood and its acrylonitrile impregnated wood composites were investigated. Polyacrylonitrile (2.27 mole/l) was impregnated into Eucalyptus wood through benzoyl peroxide (0.02 mol/l) to initiate the polymerization process forming free radicals in methanol medium at  $75\pm 1^\circ\text{C}$ . Modification of the thermal properties over untreated wood was evaluated in terms of differential thermogravimetry-thermogravimetric-differential thermal analysis (DTG-TG-DTA) in air. Resistance of wood against thermo-oxidation was improved with impregnation of polyacrylonitrile (PNA). Impregnation of polyacrylonitrile into Eucalyptus wood was confirmed through scanning electron microscopy.

(Keywords: benzoyl peroxide, polyacrylonitrile, impregnation, thermo-oxidative stability)

## INTRODUCTION

The performance of wood as a construction material for outdoor applications deteriorates under accelerated weather environments due to fluctuation in weather and humidity for longed outdoor applications as well as decreasing the cost of wood and avoiding the need of frequent replacements in permanent and temporary constructions. A number of wood preservatives and new wood treatment processes have been developed during those wood treatment processes and are under continuous demands which can develop the modified wood materials with improved mechanical strength, thermo-

oxidative stability, and resistance to bio-deterioration for their better outdoor applications.

The polymer loading of wood depends on the permeability of the wood species being treated. The void volume is approximately the same for sap wood and heart wood for each species. Because of this, it would be expected that the polymer would fill them to same extent [3]. In the past few decades a variety of commercially available vinyl monomers have been used for wood treatment to improve the mechanical and thermo-oxidative stability of low-grade woods [4, 5].

Advancement in the technology of thermoplastic impregnated wood composites have recently made great claims to replace quality woods with high grade wood polymer composites derived from low grade woods [1,6,7]. In many kinds of processing, wood has been subjected to treatment at elevated temperatures (e.g. drying), size stabilization, pulping, and production of particle and fiber boards.

Temperature affects the physical, structural, and chemical properties of wood. Several attempts have been made to establish the relationship between temperature and thermal stability of wood [8-12]. Reinforcement of several acrylic monomers like styrene, methylmethacrylate, and (chloropropyl)-2-propane phosphate has provided substantial thermal stabilities to various low grade woods. Recently dynamic mechanical thermal analysis has been recognized as a useful thermo analytical method of detecting relations polymers and composite molecules and the temperature is scanned over a range from sub ambient to above the material glass transition.

This analysis is more sensitive than other thermo-analytical methods [13-15]. Thermo-oxidative stability of wood polymer composites (WPCs) from the tropical wood Geonggang (*Cratogeomys arborescens*) and methyl-methacrylate, methylmethacrylate acrylonitrile, and styrene acrylonitrile combinations were investigated through thermo-gravimetric analysis and differential scanning calorimetry.

The thermal data indicated that wood had been thermally modified [2, 16, and 17]. Polymerization of methylmethacrylate into Jamun wood has also been reported and the composites indicated excellent moisture resistance and thermo-oxidative stability [18]. In the present research, efforts have been made to develop such polyacrylonitrile impregnated composites in a methanol medium, having improved thermal stabilities for their commercial exploitation for desirable purposes.

## **MATERIALS AND METHODS**

### **Starting Materials**

Acrylonitrile monomer was purchased from M/s C. D. H. Chemicals India Pvt. Ltd., Mumbai. The monomer acrylonitrile was purified by extracting it with aqueous NaOH (10%) to remove inhibitor contents followed by repeated washings with distilled water. The fraction distilled at 82°C was used for the impregnation polymerization reaction.

### **Preparation of Wood Specimens**

First the wood specimens were prepared for their treatment as per IS: 1708-1960. The moisture content of wood was deduced according to ASTM D 1037-72a and was found to be 12.75%.

### **Preparation of Solution**

The methanolic solution of acrylonitrile at concentration of 2.27M and methanolic solution of benzoyl peroxide at 0.02M have also been prepared.

### **Method of Treatment of Wood Specimens**

The prepared wood specimens were placed in an airtight stainless steel chamber of the dimensions 20×20×30cm<sup>3</sup>. The specimens were swelled in methanol (98%) for 5 hours. The solution of benzoyl peroxide (0.02M) and acrylonitrile (PAN) were added. The samples were then soaked in monomer solution for 12 hours at room temperature. The treated wood specimens were then wrapped in aluminum foil at 95±1°C for 2 hours to induce the polymeric reaction. Impregnation of polyacrylonitrile into Eucalyptus wood was confirmed through scanning electron microscopy.

### **Characterization of Wood and Impregnated Wood Composites**

A Perkin Elmer (Pyris Diamond) thermal analyzer model STA-78 was employed to study differential thermogravimetry-thermogravimetry-differential thermal analysis (DTG-TG-DTA) of untreated wood and its PAN impregnated wood composite in the atmosphere of static air at a heating rate of 10°C/minute up to 550°C using alumina as reference.

The sample size taken was 10mg. The crystallization temperature ( $T_c$ ) and oxidation temperature ( $T_{ox}$ ) have been deduced from DTA curve [19]. The maximum decomposition temperature ( $T_{max}$ ) and final decomposition temperature ( $T_f$ ) were measured from DTG. TG scans were exploited to evaluate the range for various decomposition stages electron micrographs of woods and their PAN reinforced wood composites were scanned on LEO-435 SEM. The morphologies of wood and its PAN reinforced composites were studied in view to get a clear understanding about the affinity of PAN with wood.

## **RESULTS AND DISCUSSION**

The various thermo analytical data of above referenced wood and its PAN reinforced wood composites as deduced from DTG-TG-DTA in air have been summarized in Table 1. Comparison of scanning electron micrographs with impregnation of polyacrylonitrile into Eucalyptus wood lumens was not uniform [17].

TG data has been used to study the weight loss in wood and related composites at various temperature range 0-550°C. TG profiles indicate that thermo-oxidative decomposition of wood was started at 204°C with 19.7% weight loss. A rapid weight loss in wood was recorded in the temperatures range of 322–449°C with 56% of weight loss and the weight loss further intensified to 99% up to 467°C.

The first and second DTA endotherms have represented the crystallization temperature ( $T_c$ ) at 327°C and oxidation temperature ( $T_{ox}$ ) at 467°C. Similarly the maximum ( $T_{max}$ ) and final ( $T_f$ ) decomposition temperature were recorded at

308°C and 459°C, respectively, from DTG endotherms.

Thermo-oxidative decomposition of PAN impregnated wood composites started at 246°C with 9.5% weight loss. From 321 to 457°C a rapid weight loss of 73% in the wood polymer composite was recorded which was further intensified to 99% at 487°C. Polyacrylonitrile (PAN) impregnated composites have shown improved thermal parameters over untreated wood.

Scanning electron micrographs of treated and untreated wood are shown below.

**Table 1:** DTG – TG – DTA Properties of Eucalyptus Wood Acrylonitrile Impregnated Wood Composites.

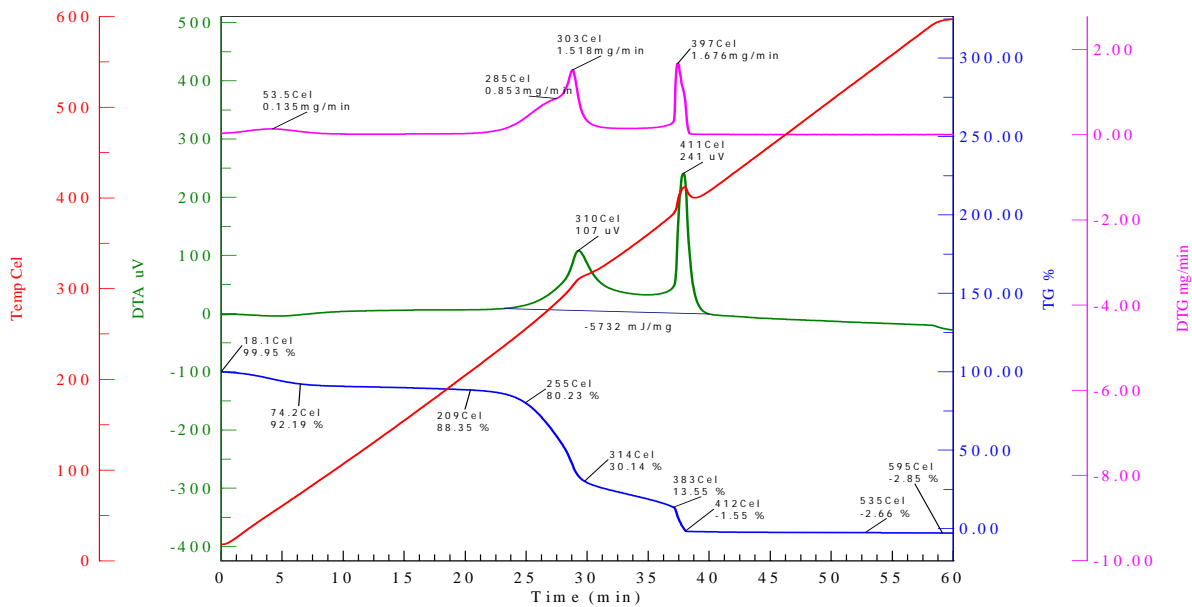
S. No.	Concentration	moles/liter	Sample (mg)	Decomposition ranges TA(°C) with percentage			DTA (°C)		DTG (°C)	
				I	II	III	$T_c$	$T_{ox}$	$T_{max}$	$T_f$
1	0%	Un-treated	10	204-322 9.62%	322-449 56.15%	449-467 99.19%	327	467	308	459
2	15%	2.27M	10	246-328 9.51%	321-457 73.19%	457-487 99.5%	324	457	307	454

$T_c$  → Crystallization temperature

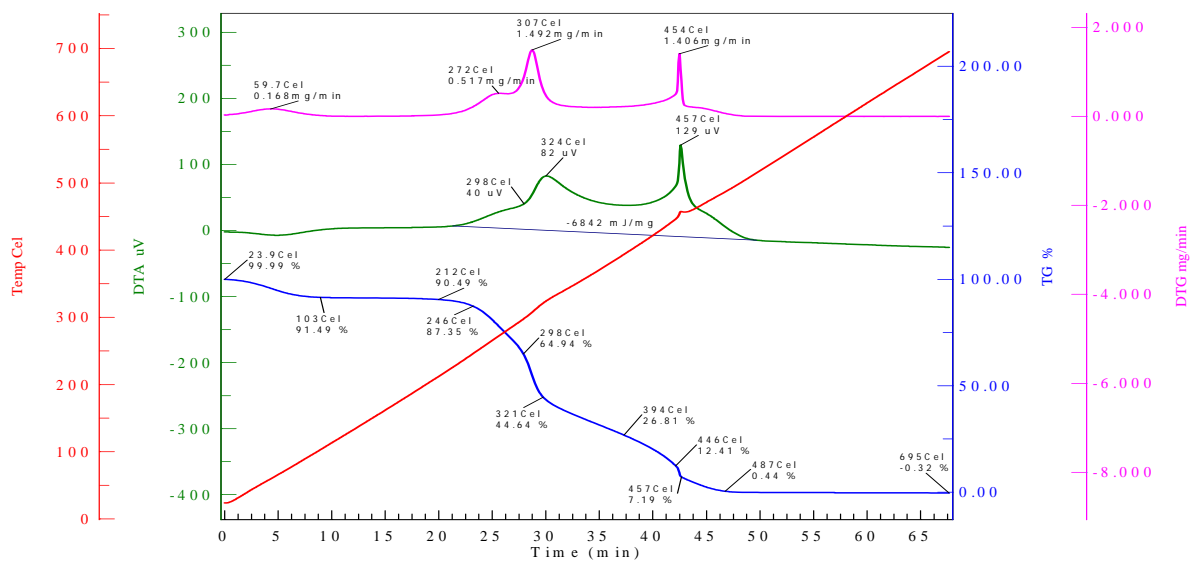
$T_{ox}$  → Oxidation temperature

$T_{max}$  → Maximum decomposition temperature

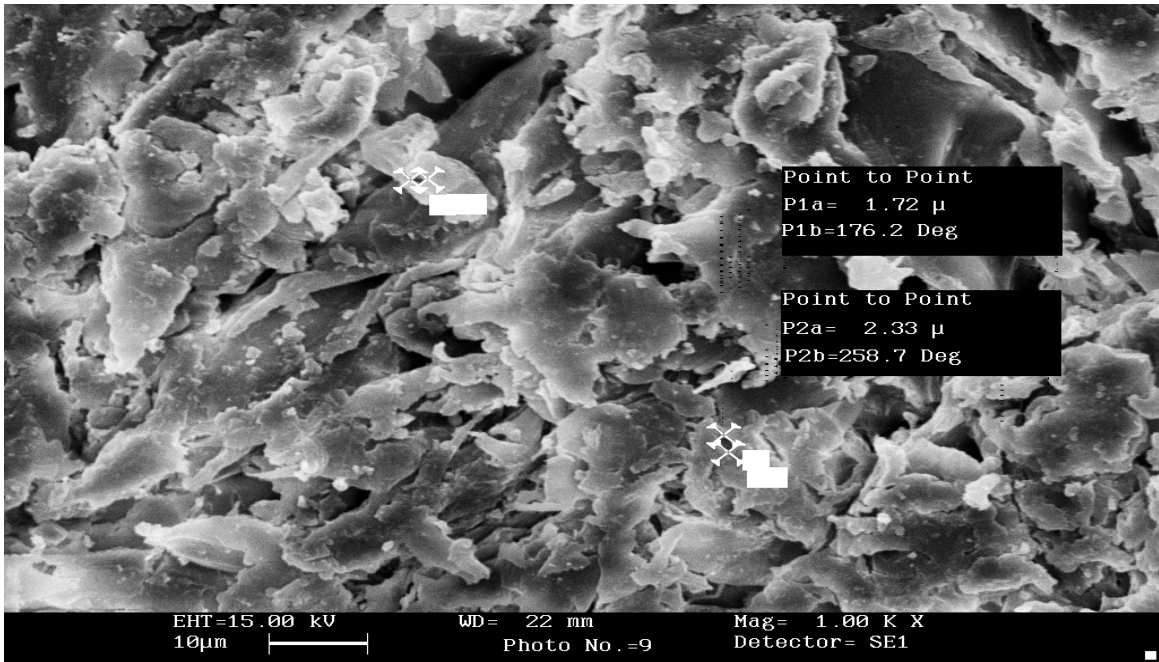
$T_f$  → Final decomposition temperature.



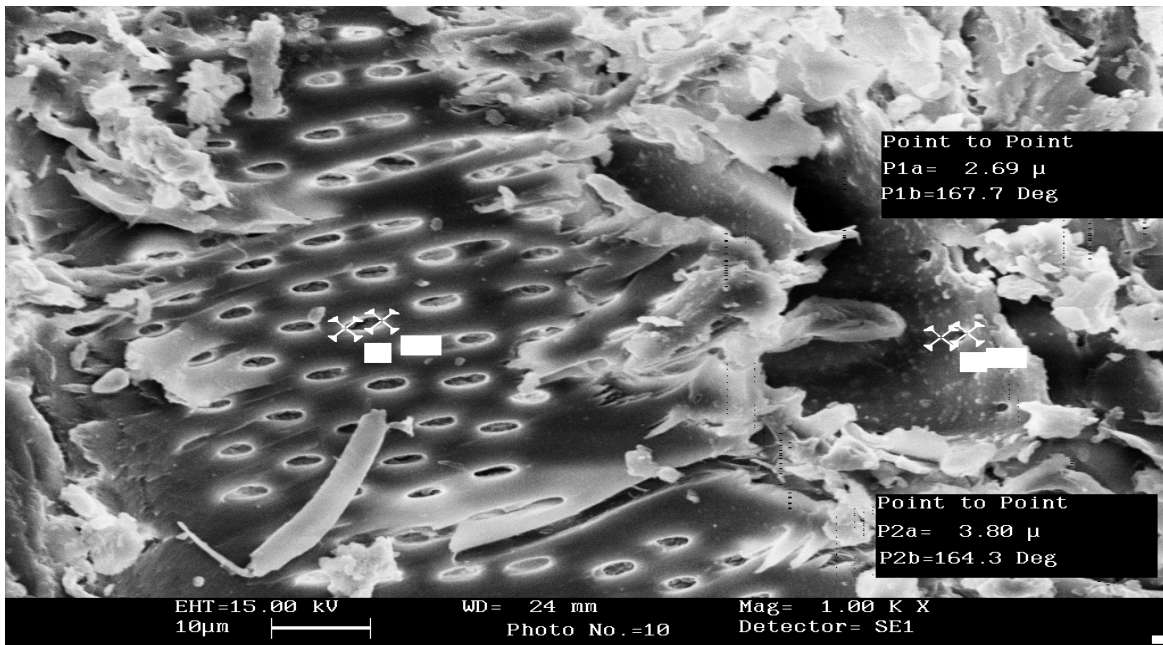
**Figure 1: DTG–TG–DTA Curve for Untreated Eucalyptus Wood.**



**Figure 2: DTG–TG–DTA Curve for Acrylonitrile of 2.27 M Concentration Treated Eucalyptus Wood.**



**Figure 1:** Microscopic View of Untreated Eucalyptus Wood.



**Figure 2:** Microscopic View of Polyacrylonitrile Affinity of 2.27 M Concentration Treated Eucalyptus Wood.



## CONCLUSION

It is concluded from the thermal data presented in this paper that the thermal stability of PAN reinforced composites was improved in comparison to untreated Eucalyptus wood.

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