Study of Thermal Properties of Babool Wood and its Polyacrylonitrite Composites.

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ABSTRACT

In this study some thermal properties of Babool wood and its acrylonitrite impregnated wood composites were investigated. Polyacrylonitrite (2.23 mole/l) was impregnated into Babool wood through benzoyl peroxide (0.02 mol/l) to initiate the polymerization process forming free radicals in methanol medium at 75±1°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 polyacrylonitrite (PNA). Impregnation of polyacrylonitrite into Babool wood was confirmed through scanning electron microscopy.

(Keywords: benzoyl peroxide, polyacrylonitrite, 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 (Cratoxylum arborescence) 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 Babool 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 polyacrylonitrite impregnated composites in a methanol medium, having improved thermal stabilities for their commercial exploitation for desirable purposes.

MATERIALS AND METHODS

This experiment was performed in June 2007 at the institute workshop and chemistry lab. The DTG-TAD-TA tests and electronic morphology was done at the instrumentation center, IIT-Roorkee.

Starting Materials

Acrylonitrite monomer was purchased from M/s-C. D. H. Chemicals India Pvt. Ltd., Mumbai. The monomer acrylonitrite 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^{o}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 ASTMD 1037-72a and was found to be 12.75%.

Preparation of Solution

The methanolic solution of acrylonitrite 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 $20\times20\times30cm^3$. The specimens were swelled in methanol (98%) for 5 hours. The solution of benzoyl peroxide (0.02M) and acrylonitrite (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^{o}C for 2 hours to induce the polymeric reaction. Impregnation of polyacrylonitrite into Babool 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 hating rate of 10^{o}C/minute up to 550^{o}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 polyacrylonitrite into Babool 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^{o}C. Figure 1 of untreated Babool wood TG profiles indicates that thermo-oxidative decomposition of wood was started at 209^{o}C with 11.6% weight loss. Further weight loss in wood was recorded in the temperature range of 255–314^{o}C with 20% of weight loss and the weight loss further intensified to 86.45% up to 383°C.

The first and second DTA endotherms have represented the crystallization temperature (T_c) at 310^{o}C and oxidation temperature (T_{ox}) at 411^{o}C. Similarly the maximum (T_{max}) and final (T_f) decomposition temperature were recorded at 303^{o}C and 397^{o}C, respectively, from DTG endotherms.

Thermo-oxidative decomposition of PAN impregnated wood composites shown in Figure 2 started at 211^{o}C with 9.5% weight loss. From 292 to 365^{o}C a rapid weight loss of 66.8% in the wood polymer composite was recorded which was further intensified to 94% at 457^{o}C. Polyacrylonitrile (PAN) impregnated composites have shown improved thermal parameters over untreated wood.

Scanning electron micrographs of treated and untreated wood are shown in Figures 3 and 4.

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

S. No.	Concentration	moles/ liter	Sample (mg)	Decomposition ranges TA(^{o}C) with percentage			DTA (^{o}C)		DTG (^{o}C)	
				I	II	III	T_C	T_{OX}	T_{max}	T_f
1	0%	0M	10	209-255 11.6%	255-314 20%	314-383 86.45%	310	411	303	397
2	15%	2.27M	10	211-292 9.5%	292-365 66.8%	365-457 94%	358	423	341	362

T_c → Crystallization temperature

T_{ox} → Oxidation temperature

T_{max} → Maximum decomposition temperature

T_f → Final decomposition temperature.

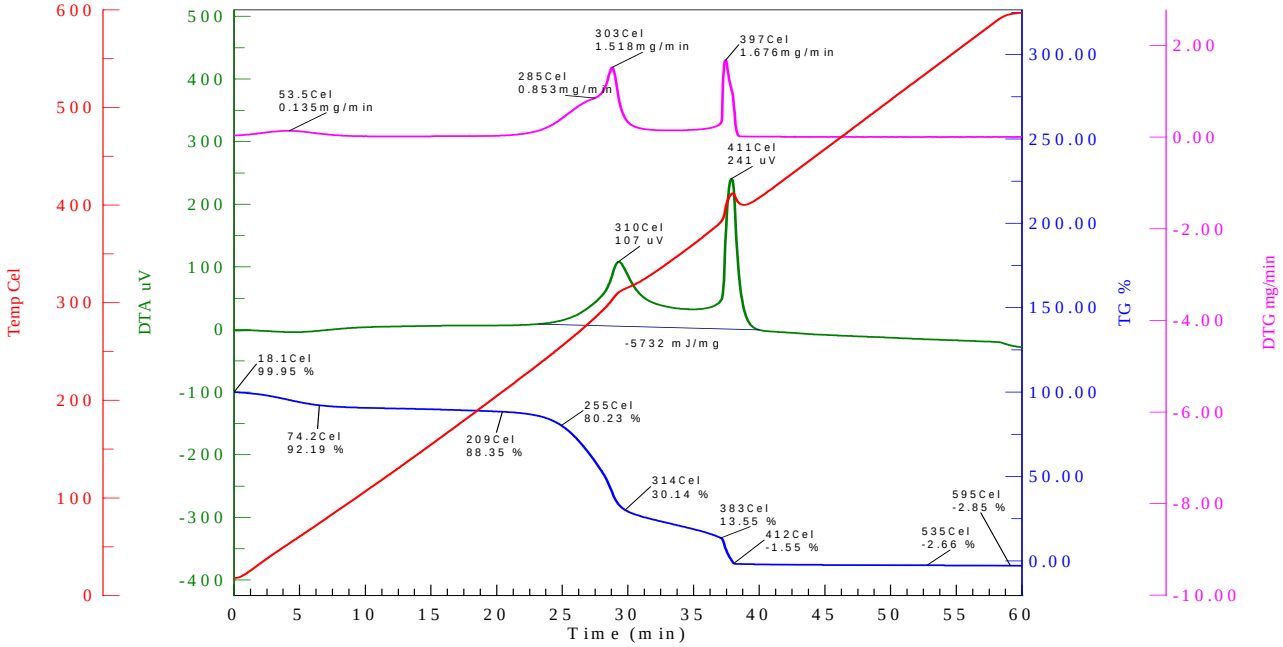

Figure 1: DTG–TG–DTA Curve for Untreated Babool Wood.

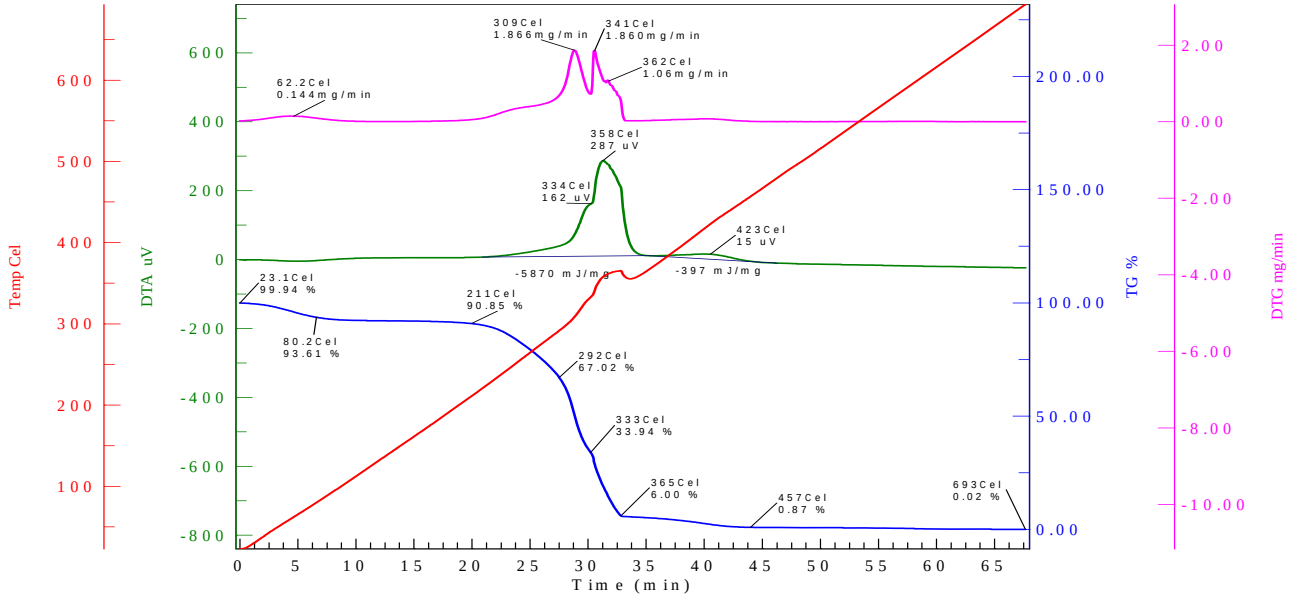

Figure 2: DTG–TG–DTA Curve for Acrylonitrile of 2.27 M Concentration Treated Babool Wood.

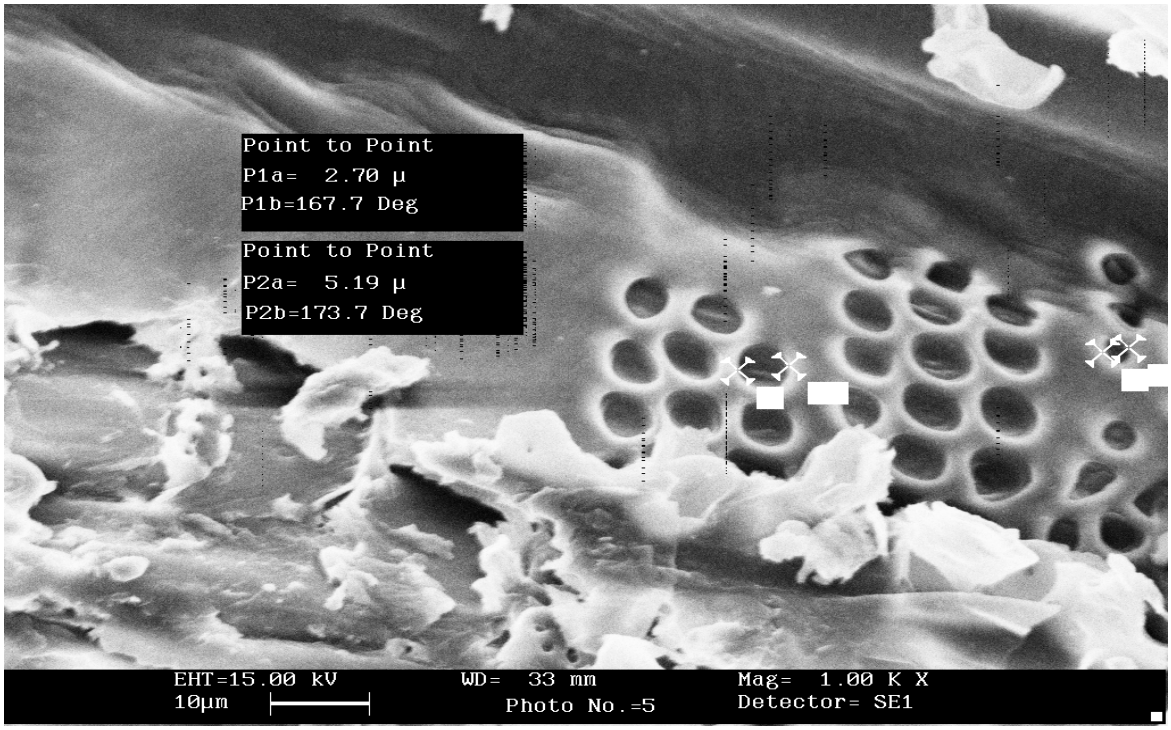

Figure 1: Microscopic View of Untreated Babool Wood.

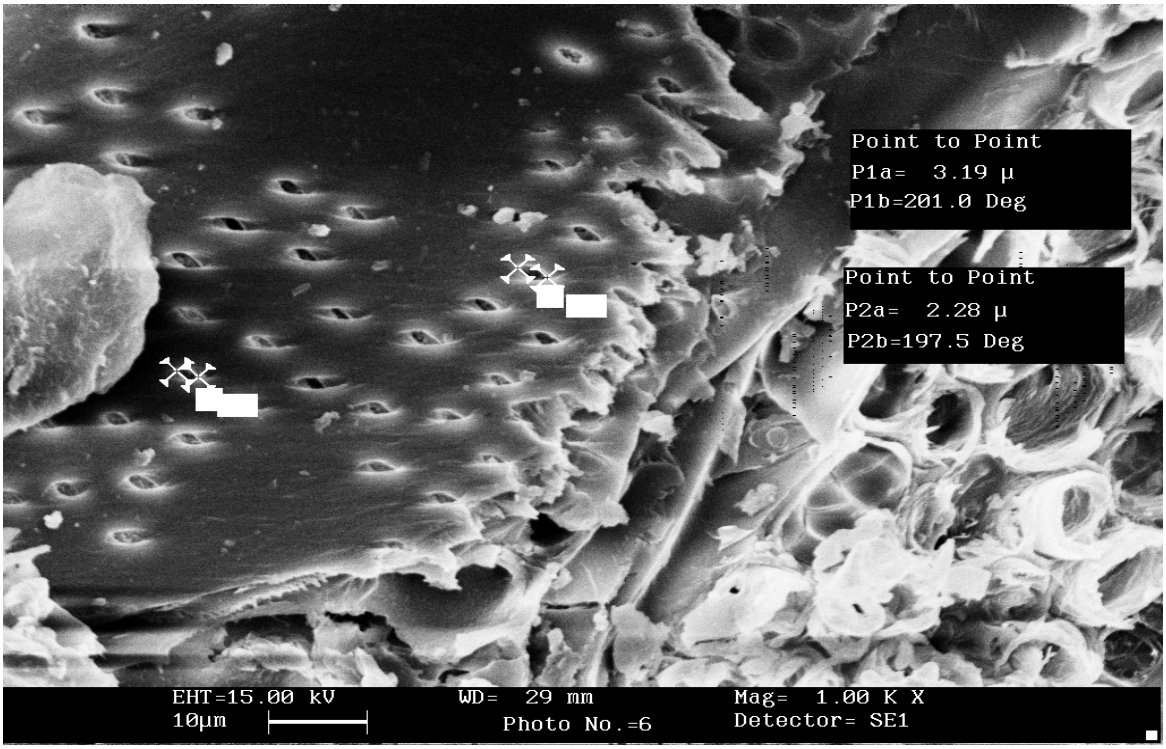

Figure 2: Microscopic View of Polyacrylonitrite Affinity of 2.27 M Concentration Treated Babool Wood.

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 Babool wood.

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