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Thermal and Mechanical Properties of Polymer Composites from Linseed Oil using Sisal Fiber and Coconut Fiber as Fillersp

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ABSTRACT

In this study polymer composites were synthesised by the polymerization of alkyd resin of linseed oil with the co-monomer methyl methacrylate(MMA) using fillers such as sisal fiber and coconut fiber. The newly prepared polymer composites were analysed for thermal and mechanical properties. Thermal properties such as decomposition temperature, temperature of maximum decomposition, melting point and glass transition temperature of the of the polymer composites were studied by thermo gravimetric analysis (TGA), derivative the rmogravimetry (DTG), differential thermal analysis (DTA) and differential scanning calorimetry (DSC) analysis. Mechanical properties of the polymer composites were studied from the tensile studies and hardness. Such polymers exhibit significantly large thermal stability and find applications in number of fields with better and more improved properties.

KEY WORDS: Alkyd resin, glass transition temperature, thermal analysis and mechanical properties.

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1. INTRODUCTION

Environmental concern and increasing demand for petroleum based products bring the attention of scientist to explore the use of renewable resource for the production of conventional polymeric materials and also polymer composites. Simplicity of processing, efficiency and cost reduction are some of the most important advantages of using polymers in various applications. The properties such as high strength and modulus requirements of polymers are improved using fillers and fibers. Among the fibers which are used as reinforcement materials, natural fibers have reasonably high strength, great rigidity and low density[1] and these fiber-reinforced polymer composites offer more advantages over other conventional polymeric materials.

Development of composites using natural fibers as reinforcing material has been an interesting topic for the last few years [2-5]. Since these fibers provide more advantages than other conventional reinforcement materials, more attention is paid by the scientists and researchers for the synthesis of polymeric materials containing natural fibers as reinforcing agents. These natural fibers possess specific properties like low-cost, low density, biodegradable, nonabrasive and are readily available when compared to other fibers used as reinforcing materials.

Natural fibers found to have widespread applications in construction and civil engineering fields. Even though composites based on synthetic fiber are useful in service, these materials are difficult to be recycled after calculated service life. Conversely, composites based on natural fiber are environment friendly to a great extent. Natural fibers are hydrophilic in nature and would therefore leads to composites with weak interface but the adhesion between fibers and the matrix phase is improved by pretreating the natural fibers. Pretreatment of natural fiber leads either activation of hydroxyl groups or addition of new groups that can efficiently interlock with the matrix [6–16].

The most frequently used natural fibers for the synthesis of polymer composites are jute, ramie, flax, and sisal fibers. Wood flour also used as natural fiber for the preparation of polymer composites. Fillers such as nylon, aramid, carbon, clay, glass or natural fibers are generally added to the resin matrix to produce composite materials in order to expand more high-performance engineering applications such as civil infrastructure and transportation[17–19]. Generally natural fibers from plant or vegetables are used for the preparation of fiber reinforced plastic materials. With a small amount of polymer as binding material aeroplane seats and fuel-tanks were prepared of natural fibers [20].

Variation in chemical composition of natural fibers is based on the type of fiber and mainly fibers contain cellulose, hemicellulose, pectin, and lignin. Each constituent present in the fiber contribute to the overall properties of the fiber. Hemicellulose present in fiber is least resistance and responsible for moisture absorption, biodegradation, and thermal degradation of the fiber but lignin is thermally stable and is responsible for the degradation by UV radiation.

Mehta et. al., 2004 synthesized bio based polymer composites by blending unsaturated polyester resin from vegetable oil with plant bio-fibers. These bio composites substitute existing glass fiber reinforced polyester composites which are used in household appliances. Badri et.al., 2006 synthesized bio composites from palm oil resources and study the effect of oil palm empty fruit bunch (EFB) on the mechanical properties of high density rigid polyurethane (PU). A series of bio composites from polyurethane (PU) sheet with different quantities of oil palm trunk (OPT) fiber dust was synthesized and characterized by Yaakob et. al., 2010. For this first a monoglyceride was obtained through direct esterification of oleic acid and then utilized the glyceride to prepare PU sheet.

In this work, we report the study of thermal and mechanical properties of polymer composites synthesized from linseed oil using sisal fiber and coconut fiber as fillers.

2. EXPERIMENTAL SECTION

2.1 Materials

Linseed oil and the fillers (sisal fiber, coconut fiber) were purchased from local market at Trivandrum. The chemicals Cyclohexane dicarboxylic anhydride (Sigma–Aldrich), Triethylene glycol dimethyl acrylate (TEGMA) (Sigma–Aldrich), Glycerol, Methyl methacrylate, Benzoyl peroxide, N,N – dimethyl aniline were used without purification.

2.2 Methods

Preparation of polymer composites

Linseed oil was glycerolysed by heating oil and glycerol in the ratio 2:1 at 220-230°C for 5 hours and mixture of glycerides is formed was heated with cyclohexane dicarboxylic anhydride at about 80°C to prepare alkyd resin. The resin was mixed with 60% methyl methacrylate (MMA) co-monomer, 2% of the fillers and 2.5% of benzoyl peroxide. 1 ml of TEGMA was added as cross linking agent and 2 drops of N, N-dimethyl aniline as accelerator. The mixture was then casted on a clean silicone oil spreaded glass mold and the mixture filled mold was placed in an oven at 50°C for 2 hours and the temperature was increased upto 100°C and curing takes place at this temperature for 2 hours and the sample was post cured for another one hour.[21]

2.3 Thermal analysis

Thermal analysis is used to study the thermal properties such as the decomposition temperature, temperature of maximum decomposition, relative thermal stability, melting point and glass transition temperature of the polymer composites. Thermo gravimetric analysis (TG-DTA) was performed by Perkin's Elmer thermo gravimetric analyzer over the temperature range 30 to 700 °C at a heating rate of 10 °C/min under nitrogen gas atmosphere. DSC analysis was carried out over the temperature ranging from -50 to 400 °C at a heating rate of 10 °C/min.

2.4 Mechanical properties

Mechanical properties of the polymer samples are studied from tensile strength which was determined using Instron UTM; 10 ton static Universal Testing Machine. The values of tensile strength of the prepared polymer samples represented were an average of about 4-5 samples. The crosslink densities of the polymer composites,ν_e, were determined based on the theory of elasticity $E' = 3\nu_e RT$ [22,23], where E' is Young's modulus of the cross linked biopolymer, R is the gas constant and T is the absolute temperature.

3. RESULTS AND DISCUSSIONS

3.1 TG-DTA analysis

Thermo gravimetric analysis was used to study the thermal stability of the polymer composites. Figures 1 and 2 show the TG-DTA curves of methyl methacrylate polymer composites obtained from linseed oil with fillers such as sisal fiber and coconut fiber which show the decomposition behavior of the polymer samples under nitrogen atmosphere. The study of TGA is supplemented by the study of its first derivative (DTG) curves. The DTG curves show the rate of thermal decomposition (mg/min) with respect to temperature. Figures 3 and 4 show the TG-DTG curves of the polymers composites.

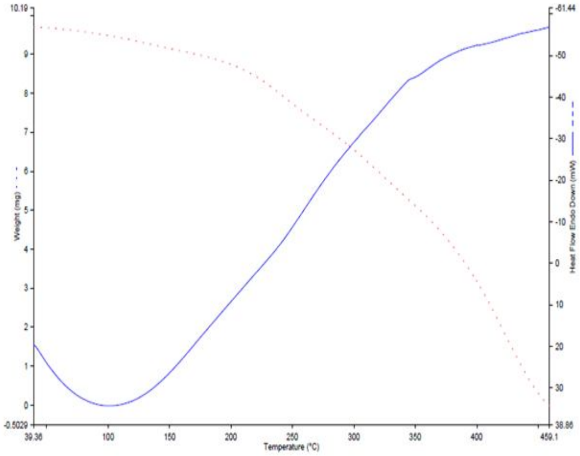

Figure 1. TG-DTA curve of polymer from linseed oil – methyl methacrylate (LINMGMMA) copolymer with sisal fiber.

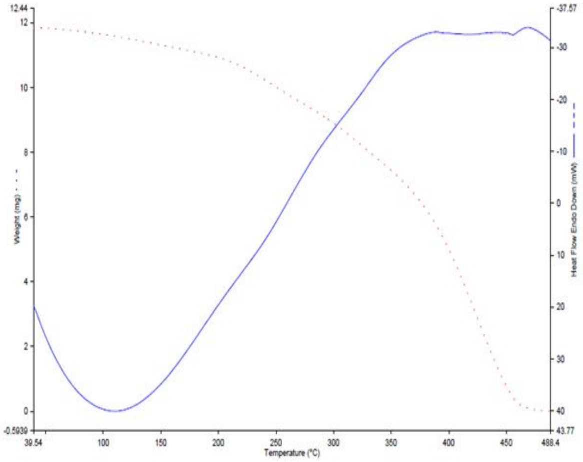

Figure 2. TG-DTA curve of polymer from linseed oil – methyl methacrylate (LINMGMMA) copolymer with coconut fibe

In the TGA curves of the polymer composites two different temperature regions were experienced where the samples experienced significant weight loss (150-250°C and 300-450°C). It was clear from the figure that most of the unreacted free oil disappears at the temperature between 150 and 250°C (stage 1), ie this region corresponds to the evaporation of the unreacted free oil. On the other hand, the insoluble substances were found to be highly cross linked thermo sets that decompose at temperatures greater than 350°C (stage 2). This decomposition stage corresponds to the carbonization of the cross linked polymer network. First stage of decomposition in the TGA curves of the polymer samples involves diffusion of the free oil to the surface of the polymer followed by evaporation. The diffusion of the free oil is retarded by highly crosslinked polymeric materials, but evaporation of the free oil at the polymer surface takes place quickly at high temperatures. From the foregoing results, it was obvious that the thermal stability of the polymers is restricted by the first decomposition stage in the TGA thermo grams, which is directly associated to the amount of free oil in the bulk polymer that is not reacted.

Temperature at 10% and 50% weight loss was chosen as a reference for evaluating the thermal stability of each polymer composites. From the TGA curve it is known that 10% weight loss occur in the I stage of decomposition and 50% weight loss occur in the II stage of decomposition. Table 1 shows the temperature at which the polymer samples shows 10% and 50% weight loss during the thermo gravimetric analysis.

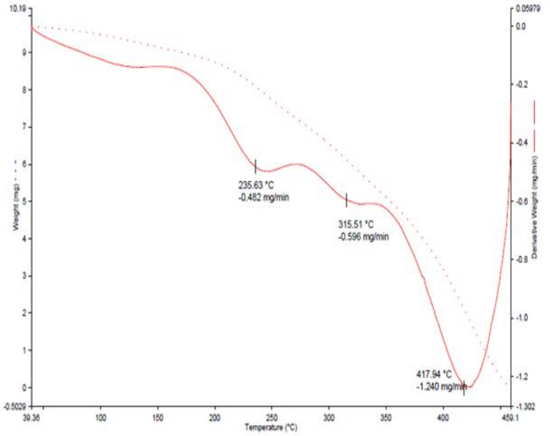

Figure 3 TG-DTG curve of polymer from linseed oil – methyl methacrylate (LINMGMMA) copolymer with sisal fiber.

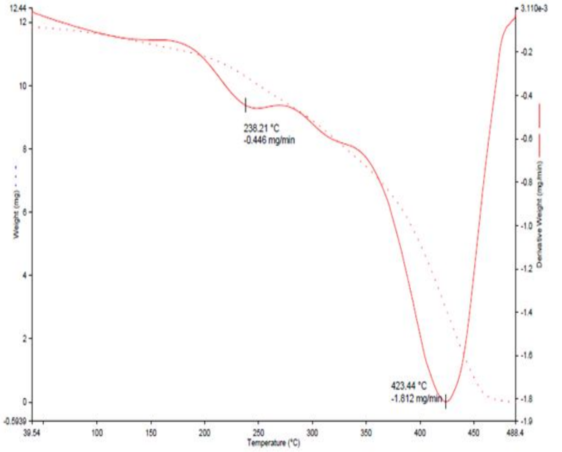

Figure 4 TG-DTG curve of polymer from linseed oil – methyl methacrylate (LINMGMMA) copolymer with coconut fiber.

From the thermal analysis it was observed that all the polymer composites decompose below 10% weight in the temperature range 0–200°C. There is a quick weight loss from 50–90% in the temperature range of 400–450°C. In the DTA curves of all the polymer composites, the endothermic peak at 100-120°C owing to the melting point and the endothermic peak around 420°C correspond to the decomposition temperature of the polymer network.

Table 1 TGA data of polymer composites from linseed oil

Polymer sample	Temperature	
	10% weight loss	**50% weight loss**
LINMMASIS	200ºC	370ºC
LINMMACOC	220ºC	390ºC

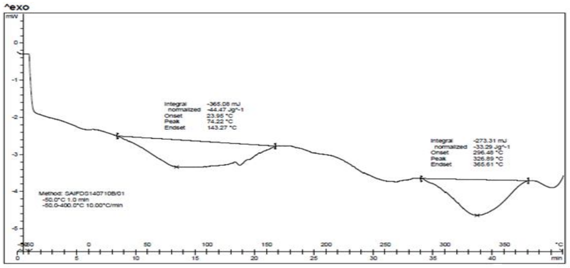

Figure 5 DSC curve of LINMGMMA

The study of TGA was supplemented by the study of its first derivative (DTG) curves. The DTG curves show the rate of thermal decomposition (mg/min) with respect to temperature. The DTG curve in Figure 3 shows that the polymer composite LINMMASIS has two significant peaks at 235.63^{o}C and 417.94^{o}C with corresponding 0.482mg/min and 1.240 mg/min rate of decomposition. The DTG curve in Figure 4 shows similar peaks at 238.21^{o}C with 0.446 mg/min and at 423.44^{o}C with 1.812 mg/min rate of decomposition for LINMMACOC polymer.

3.2 DSC analysis

The properties of the polymeric materials such as melting point, crystallisation temperature, glass transition temperature and degradation temperature can be determined by this analysis. Figure 5 shows the DSC curve of LINMGMMA polymer which shows the glass transition is less than the glass transition temperature of the corresponding polymer with fillers and melting point is greater than the melting point of the corresponding polymer with fillers. From the DSC curves of the polymer and polymer composites, it was known that the glass transition temperature increases and melting point decreases by the addition of fillers.

3.3 Mechanical properties

The tensile strength of the polymer composites prepared from linseed oil were determined using Instron UTM; 10 ton static Universal Testing Machine and are shown in the table 2. From the data it was known that the polymer composites were having high tensile strength and modulus than the corresponding biopolymers. Addition of fillers increases the tensile strength and modulus of the polymer samples to a greater extent. Mechanical properties of the reinforcing fibers improve the properties of the final polymer composites. Comparing the polymer composites prepared, fiber containing polymer composites especially sisal fiber containing polymer composites possess high tensile strength and modulus and wheat flour containing polymer composites possess less tensile strength and modulus. Cross link density also increases by the addition of fillers.

Table 2 Data of Mechanical properties of the polymer composites from linseed oil

Polymer sample	**Cross link density ($x10^{-3}$)**	**Tensile strength x 10^5Pa**	**% of elongation**	**Young's Modulus x 10^5Pa**	**Shore Dhardness**
LINMGMMA	7.62	14.02	103	576.6	60.4
LINMMASIS	15.73	34.13	104.78	1189.3	60.2
LINMMACOC	16.24	30.28	103.32	1227.35	57.9

4. CONCLUSION

1. A variety of polymer composites have been synthesized from linseed oil monoglyceride cyclohexane dicarboxylate with methyl methacrylate co monomer using the fillers such as sisal fiber and coconut fiber.

2. The polymer composites exhibited good tensile stress–strain behavior relatively to plastics. The tensile strength of the polymer samples increases to greater extent by the addition of fillers.
3. Two different temperature regions of decomposition are experienced upon thermo gravimetric analysis, which correspond to evaporation of the unreacted free oil present in the polymer and carbonization of the cross linked polymer network.
4. DSC analysis shows that the glass transition temperature of the polymer composites was greater than the corresponding parent polymer and melting point is less than the corresponding parent polymer.

5. REFERENCES

1. Bledzki AK, Gassan J. “Effect of coupling agents on the moisture absorption of natural fibre-reinforced plastics”. Angew Makromol Chem. 1996; 236:129-138.
2. Schneider, J P.; Myers, G E.; Clemons, CM.; English, BW. , “Biofibers as reinforcing fillers in thermoplastic composites”, Eng Plast 1995; 8(3); 207-222.
3. Reinforced Plastics 1997; 41(11):22.
4. Colberg, M.; Sauerbier, M. Kunstst-Plast Europe, 1997;87(12): 9.
5. Schloesser, Th.; Knothe, J. Kunstst-Plast Europe, 1997; 87(9):25.
6. Li X, Tabil LG., and Panigrahi S J.” Polym. Environ.”, 2007;15: 25.
7. Eichhorn SJ and Young RJ, “Compos. Sci. Technol”, 2003; 63: 1225.
8. Pothan L.A and Thomas S, “Compos. Sci. Technol.”, 2003;63,1231.
9. Sain M and Panthapulakkal S, “Ind. Crops. Prod”., 2005; 21: 185.
10. Van De Weyenberg, J. Ivens, A. De Coster, B. Kino, Baetens E and Verpoest I, “Compos. Sci. Technol”., 2003; 63:1241.
11. Wambua P, Ivens J, and Verpoest I, “Compos. Sci. Technol.”, 2003;63:1259.
12. Joshi SV, Drzal LT, Mohanty AK, and Arora S, Compos. A, 2004;35:371.
13. Nechwatal A, Mieck K.P, and Reubmann T, “Compos. Sci. Technol”, 2003;63:1273.
14. Mohanty A.K, Wibowo A, Misra M, and Drzal L.T, Compos. A, 2004;35:363.
15. Brahmakumara M, Pavithran C, and Pillai R.M., “Compos. Sci. Technol.” 2005;65:563.
16. Valadez-Gonzalez, JM,. Cervantes-UC, R. Olayo, and. Herrera-Franco PJ, Compos. B, 1999; 30: 309.
17. Deleglise M, Binetruy C, Krawczak P. “Solution to filling time prediction issues for constant pressure driven injection in RTM. Composites Part A,” 2005;36:339–44.

18. Mathews FL. “Techniques for manufacture of composites. In: Holloway L, editor. Handbook of polymer composites for engineers. Cambridge, UK” Wood head Publishing Limited; 1994;71–102.
19. Hayes BS, Seferis JC. “Modification of thermosetting resins and composites through preformed polymer particles: a review”. Polym Comp 2001;22:451–67.
20. Bledzki AK., Izbicka J, Gassan J, Kunststoffe-Umwelt- Recycling, Stettin, Poland, 1995;27–29,.
21. Irin Sheela. C, Begila David. S, “Study of cross linked biopolymers from linseed oil monoglyceride cyclohexane dicarboxylate with vinyl acetate and N-vinyl-2-pyrrolidone co-monomers.” Int. J. of Chem. Sci. and Res.,2014;4(4):9-19.
22. Flory P J, “Principles of polymer chemistry”. Cornell University Press, Ithaca ,1953.
23. Nielsen LE, Landel R F, ”Mechanical properties of polymers and composites.” Marcel Dekker, New York ,1994.