

# THERMAL AND MECHANICAL PROPERTIES OF POLYMER COMPOSITES FROM SESAME OIL USING WOOD AND WHEAT FLOUR AS FILLERS

<sup>1</sup>Irin Sheela.C, <sup>2</sup>Begila David.S

<sup>1</sup>Assistant Professor, <sup>2</sup>Assistant Professor

<sup>1</sup>Department of Chemistry

<sup>1</sup>Annai Velankanni College, Tholayavattam, Tamilnadu, India

## ABSTRACT

In this study polymer composites were synthesised by the polymerization of alkyd resin of sesame oil with the comonomer methyl acrylate(MA) using the fillers wood flour and wheat flour. 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 thermo gravimetry (DTG), Differential thermal analysis (DTA), and Differential scanning calorimetry(DSC) analysis. Mechanical properties of the polymer composites were studied from the tensile strength. Such polymers exhibit significantly large thermal stability and find applications in various fields with better and more improved properties.

## KEY WORDS

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

## 1.INTRODUCTION

Extensive research has been undertaken worldwide to explore renewable resource for the production of polymers and bio composites. Due to an increase in the levels of environmental awareness and health concerns currently there is an emergence in the support of producing natural fibre composites that offer sustainability, reduced energy consumption, low cost and comparable performance to synthetic fibre composites. Fiber-reinforced polymers offer advantages over other conventional materials when specific properties are compared. These composites are finding applications in diverse fields from appliances to spacecrafts.

Natural fibers have recently attracted the attention of scientists and technologists because of the advantages that these fibers provide over conventional reinforcement materials, and the development of natural fiber composites has been a subject of interest for the past few years. [1–4] These natural fibers are low-cost fibers with low density and high specific properties. These are biodegradable and nonabrasive, unlike other reinforcing fibers. Also, they are readily available and their specific properties are comparable to those of other fibers used for reinforcements. Among the various natural fibers; flax, bamboo, sisal, hemp, ramie, jute, and wood fibers are of particular interest.

Natural fibers are incompatible with the hydrophobic polymer matrix and have a tendency to form aggregates. These are hydrophilic fibers and thus exhibit poor resistance to moisture. To eliminate the problems related to high water absorption, treatment of fibers with hydrophobic aliphatic and cyclic structures has been attempted. These structures contain reactive functional groups that are capable of bonding to the reactive groups in the matrix polymer, e.g., the carboxyl group of the polyester resin. Thus modification of natural fibers is attempted to make the fibers hydrophobic and to improve interfacial adhesion between the fiber and the matrix polymer.[5–19]

Natural fibers in the form of wood flour have also been often used for preparation of natural fiber composites. The chemical composition of natural fibers varies depending upon the type of fiber. The ultimate material properties of fibre composites are primarily governed by the reinforcing supplied to the matrix in the form of fibres. Hemicellulose is responsible for the biodegradation, moisture absorption, and thermal degradation of the fiber as it shows least resistance whereas lignin is thermally stable but is responsible for the UV degradation.

Mehta et. al., 2004 synthesized bio based resin using plant bio-fibres and a blend of unsaturated polyester resin from derivatized vegetable oil. These bio composites replace existing glass fibre-polyester composites which are use in housing applications. Badri et.al., 2006 synthesized bio composites from oil palm resources to study the effect of oil palm empty fruit bunch (EFB) on the mechanical properties of high density rigid polyurethane (PU). Yaakob et. al., 2010 prepared a series of bio composites using prepared polyurethane (PU) sheet and different amounts of oil palm trunk (OPT) fiber dust and characterized. For this first they obtained a monoglyceride from oleic acid through a direct esterification process and then utilized it to prepare PU sheet.

In this work, we report the study of thermal and mechanical properties of polymer composites synthesized from sesame oil using wood flour and wheat flour as fillers.

## 2. MATERIALS AND METHODS

### 2.1 Materials

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

### 2.2 Methods

#### Preparation of polymer composites

Glycerolysis of sesame oil was carried out by heating 2:1 mixture of oil and glycerol at 220-230°C for 5 hours. The monoglyceride of the oil formed and cyclohexane dicarboxylic anhydride in the ratio 2:1 was heated to 80°C for 2 hours. The alkyd resin formed from sesame oil was mixed with 60% methyl acrylate (MA) co-monomer, 2% of the filler wood flour and 2.5% (by weight) of benzoyl peroxide (initiator). 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.

## 3. CHARACTERIZATION

### 3.1 Thermal analysis

Thermal properties such as the decomposition temperature, temperature of maximum decomposition, relative thermal stability, melting point and glass transition temperature of the polymer composites were studied from the thermal analysis techniques such as Thermo gravimetric analysis (TGA), Derivative thermo gravimetry (DTG), Differential thermal analysis (DTA), and Differential scanning calorimetry.

Thermo gravimetric analysis (TG-DTA) was performed by Perkin's Elmer thermo gravimetric analyzer over the temperature ranging from 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.

### 3.2 Mechanical properties

The tensile strength of the polymer composites prepared were determined from the specimen using Instron UTM; 10 ton static Universal Testing Machine. The values represented were an average mean of about 4-5 samples. The crosslink densities,  $v_e$ , were determined from the rubbery modulus plateau based on the theory of rubber elasticity  $E' = 3v_eRT$  [20, 21], where  $E'$  is the storage modulus (Young's) of cross linked polymer in the plateau region,  $R$  is the universal gas constant ( $8.314 \text{ J}\cdot\text{mole}^{-1}\cdot\text{K}^{-1}$ ) and  $T$  is the absolute temperature (K).

## 4. RESULTS AND DISCUSSIONS

### 4.1 TG-DTA analysis

Thermal stability of the polymer composites was determined from thermo gravimetric analysis (TGA). Figures 1 and 2 shows the TG-DTA curves of methyl acrylate polymers obtained from sesame oil with fillers such as wood flour and wheat flour. Figures 3 and 4 shows the TG-DTG curves of the above polymers composites.

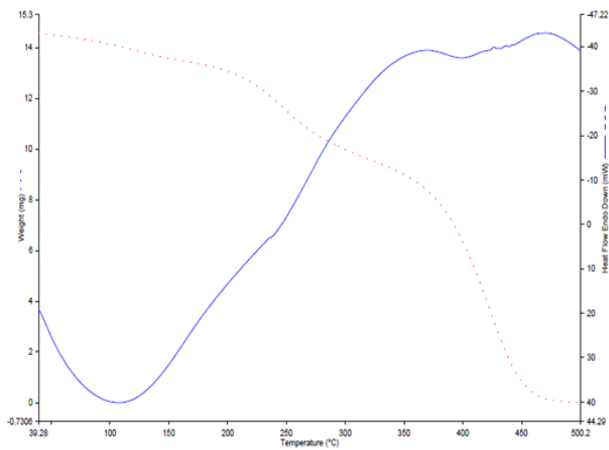


Figure 1 TG-DTA curve of polymer from sesame oil – methyl acrylate (SESMGMA) copolymer with wood flour.

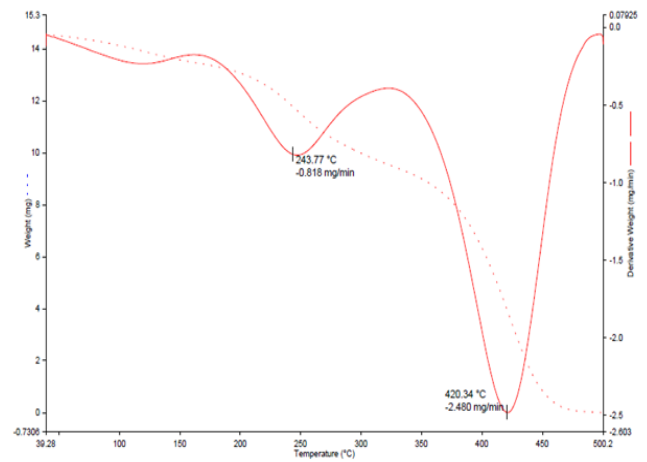


Figure 3 TG-DTG curve of polymer from sesame oil – methyl acrylate (SESMGMA) copolymer with wood flour.

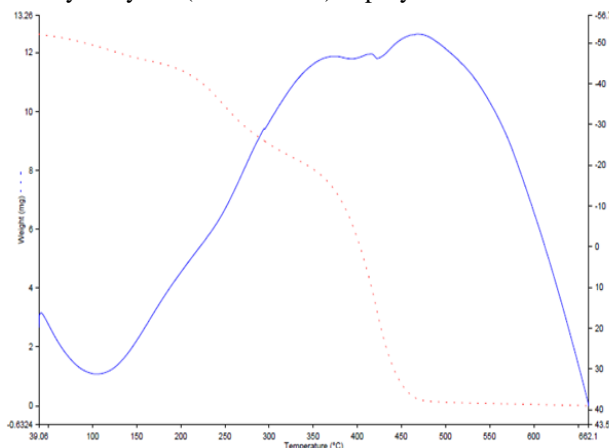


Figure 2 TG-DTA curve of polymer from sesame oil – methyl acrylate (SESMGMA) copolymer with wheat flour.

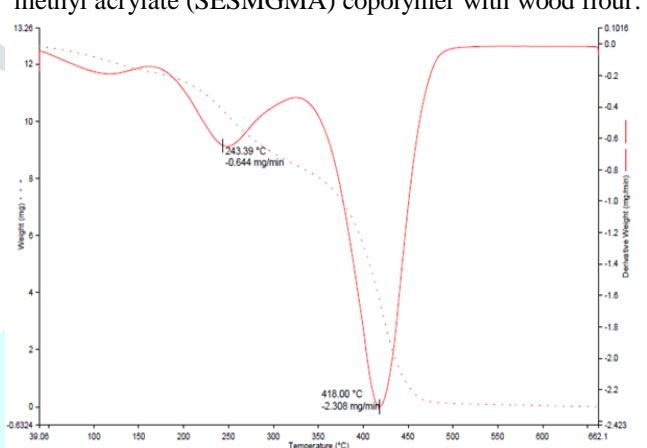


Figure 4 TG-DTG curve of polymer from sesame oil – methyl acrylate (SESMGMA) copolymer with wheat flour.

TGA curve of the polymer composites obtained from sesame oil shows two distinct temperature regions where the samples experienced significant weight loss (150-250°C and 350-450°C) which corresponds to the evaporation of unreacted oil and decomposition of cross linked polymer network. Similar to the DTA curve of the polymer samples obtained from sesame oil, DTA curves of the polymer composites obtained from sesame oil also shows an endothermic peak at 100-120°C owing to glass transition temperature, an endothermic peak around 250°C owing to melting point and an endothermic peak around 420°C owing to the decomposition temperature of the polymers.

The temperature at 10% and 50% weight loss was selected 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 composites shows 10% and 50% weight loss during the thermo gravimetric analysis. From the thermal analysis it is observed that all the polymer composites decompose below 10% weight in the temperature range 0–200°C. There is a rapid weight loss from 50–90% in the temperature range of 400–450°C.

Polymer sample	Temperature	
	10% weight loss	50% weight loss
SESMAWO	200°C	390°C
SESMAWH	200°C	390°C

Table 1. TG-DTG data polymer composites

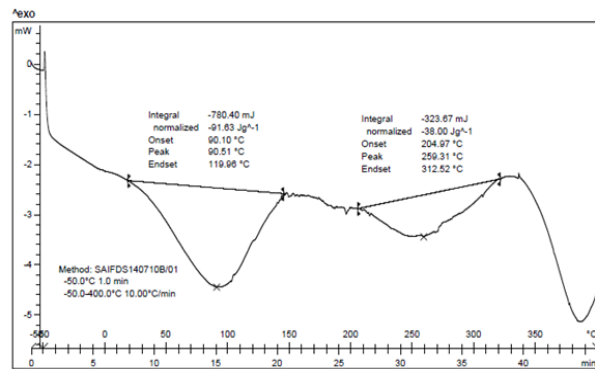


Figure 5 DSC of SESMG

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 SESMAWO has two significant peaks at 243.77°C and 420.34°C with 0.818 mg/min, and 2.480 mg/min rate of decomposition and the DTG curves of SESMAWH polymer composites (Figure 4) has two significant peaks at 243.39°C and 418.00°C with 0.644 mg/min and 2.308 mg/min rate of decomposition .

#### 4.2 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 curves of the polymers SESMGMA and from the DSC curves it is known that the glass transition temperature of SESMGMA 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 filler. 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.

#### 4.3 Mechanical properties

The tensile strength of the polymer composites prepared from sesame oil were determined using Instron UTM; 10 ton static Universal Testing Machine and are shown the table 3. 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. Comparing the polymer composites prepared from sesame oil, sisal fiber containing polymer composites possess high tensile strength and modulus and wheat flour containing polymer composites possess less tensile strength and modulus.

Table 3 Data of Mechanical properties of the polymer composites from sesame oil

Polymer sample	Cross link density ( $\times 10^{-3}$ )	Tensile strength $\times 10^5$ Pa	% of elongation	Young's Modulus $\times 10^5$ Pa	Shore D hardness
SESMGMA	0.715	5.94	111.35	54	60.4
SESMAWO	0.673	6.67	113.98	50.87	70.6
SESMAWH	0.736	5.42	111.21	55.63	66.5

## 5. CONCLUSION

1. A variety of polymer composites have been synthesized from sesame oil monoglyceride cyclohexane dicarboxylate with methyl acrylate comonomer using the fillers such as wood flour and wheat flour.
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.
4. Two distinct decomposition stages are found upon thermogravimetric analysis, which correspond to evaporation of the unreacted free oil present in the bulk polymer and carbonization of the crosslinked polymer. The thermal stability of the polymers is mainly determined by the amount of the unreacted free oil present in the bulk polymer.
5. 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.

## 6. REFERENCES

- [1] Schneider, J. P.; Myers, G. E.; Clemons, C. M.; English, B. W, 1995, Eng Plast 8 (3), 207.
- [2] Reinforced Plastics 1997, 41(11), 22.
- [3] Colberg, M.; Sauerbier, M. Kunstst-Plast Europe 1997, 87 (12), 9.
- [4] Schloesser, Th.; Knothe, J. Kunstst-Plast Europe 1997, 87 (9), 25.
- [5] Rowell, R. M. ACS Proceedings, Polym Mater Sci Eng 1992, 67, 461.
- [6] Rowell, R. M.; Clemson, C. M. Proceedings of the 26th International Particleboard/Composites Symposium, WA, 1992, p 251,.
- [7] Bledzki, A. K.; Reihmane, S.; Gassan, J. J Appl Polym Sci 1996, 59, 1329.
- [8] Mohanty, A. K.; Singh, B. C. J Appl Polym Sci 1987, 34, 1325.
- [9] Muzumdar, P.; Sanyal, S.; Dasgupta, B.; Shaw, S. C.; Guha, R. Indian J Fibre Technol 1994, 19, 286.
- [10] Andersson, M.; Tillman, A. M. J Appl Polym Sci 1989, 37, 3437.
- [11] Sahoo, P. K.; Samantaray, H. S.; Samal, R. K. J Appl Polym Sci 1986, 32, 5693.
- [12] Samal, R. K.; Samantaray, H. S.; Samal, R. N. J Appl Polym Sci 1986, 37, 3085.
- [13] Mannan-Kh., M.; Latifa, B. L. Polymer 1980, 21, 777.
- [14] Huque, M. M.; Habibuddowla, Md.; Mohamood, A. J.; Jabbar Mian, A. J Polym Sci, Polym Chem Ed 1980, 18, 1447.
- [15] Samal, R. K.; Sahoo, P. K.; Samantaray, H. S. JMacromol Sci Chem, Rev Macromol Chem Phys 1986, C26, 81.
- [16] Mani, P.; Satyanarayan., K. G. J Adhes Sci Technol 1990, 4, 17.
- [17] Liao, B.; Huang, Y.; Cong, G. J Appl Polym Sci 1997, 66, 1561.
- [18] Samal, R. K.; Ray, M. C. J Polym Mater 1997, 14, 183.
- [19] Yap, M. G. S.; Chia, L. H. L.; Teoh, S. H. J Wood Chem Technol 1990, 10, 1.
- [20] Flory P. J.: Principles of polymer chemistry. Cornell University Press, Ithaca (1953).
- [21] Nielsen L. E., Landel R. F.: Mechanical properties of polymers and composites. Marcel Dekker, New York (1994).