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FULL LENGTH ARTICLE

Preparation of Bio based Polymers from Epoxidised Soyabean Oil

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ABSTRACT

The dependence on petrochemicals for production of polymers has been declining not only because of the depletion in fossil fuels but also due to environmental concerns. Extensive research has been undertaken worldwide to explore renewable resource for the production of polymers and biocomposites. Among the various sources of bio-based feedstock, vegetable oils are one of the most widely used starting materials in the polymer industry due to their easy availability, low toxicity, and relative low cost. Bio-based nanocomposites have been developed from epoxidized soybean oil, diglycidyl ether of bisphenol-A (DGEBA) and Bentonite clay. The mechanical properties (tensile and flexural properties) were determined. There is noticeable increase in the tensile and flexural properties of the prepared composites upon the reinforcement of Bentonite clay. These high performance monomers, polymers, and composites have potential to replace petroleum-based epoxy as value-added products from vegetable oils compared to epoxidised vegetable oils.
Keywords: *Epoxidized soybean oil, Bentonite clay, bio-based nanocomposites, mechanical properties.*

INTRODUCTION

Biobased polymers are defined as materials for which at least a portion of the polymer consists of material produced from renewable raw materials. For example, biobased polymers maybe produced from corn or sugarcane. The remaining portion of the polymers maybe from fossil fuel waste carbon.. Biodegradable and biobased materials are receiving increased attention due to their availability from renewable resources and their environmental advantages in comparison to petroleum-based materials [2]. Requirements for sustainability, cost reductions, concerns for environmental issues, and competitive properties are the bases for the development of new bio-based materials [1]. Bio based polymers are sustainable polymers synthesized from renewable resources such as bio mass instead of conventional fossil resources such as petroleum oil and natural gas preferably based on biological or bio chemical processes. Biobased polymers generally have a lower CO_2 footprint and are associated with the concept of sustainability. Because of concerns about the depletion of fossil resources and the global warming associated with the use of petrochemicals, new biobased polymers continued to be developed. The conversion of biomass to useful polymers or composites has considerable economical and environmental value. With the rapid development of bio-based materials, more and more natural resources, such as vegetable oil [3], starch [5], soy protein [6] and cellulose [4] have been used as the renewable feedstock to produce polymeric materials. Several new biobased polymers have been commercialized. A biobased polycarbonate, isosorbide polycarbonate can potentially be used as alternative to petroleum waste polycarbonate. Corn based isosorbide is used as a replacement for bisphenol-A(BPA) monomer. Biobasedpolybutylenesuccinate (PBS) resin prepared from biobased succinic acid &biobased 1,4-butanedion can replace biodegradable petrochemical based. Green polyethylene has been commercialized with biobased ethylene. Vegetable oil has attracted increasing attention as one of the most promising options because of its ready availability, relatively low cost, environmental sustainability, and low eco-toxicity. Biological vegetable oils are outstanding renewable raw materials for developing new monomers and polymers. Vegetable oils are an abundantly available bio resource, which can be used at relatively lower cost for biopolymer synthesis. Because synthetic polymers create various problems, biobased polymers are expected to be used to partially reduce the high demand for traditional monomer-based polymers. The ample chances to modify triglyceride-based oils and their low-cost and easy availability have allowed these raw materials to be used fruitfully for the preparation of biopolymers. The reported properties of various types of biopolymers have already shown their novelty, and this has attracted investigators and researchers to work more on them. Various types of polymers, such as polyesters, PUs, polyamides, and vinyl polymers, can be produced with different types of polymerization reactions. These biobased polymers are important for various kinds of applications, such as adhesives, paints, printing inks, surface coatings, foams, and binders, for composite preparation. Investigations of these materials have found them to be comparable to traditional monomer-based ones in terms of their physicochemical, thermal, mechanical, anticorrosive, antimicrobial, and other related properties. Although a few drawbacks and challenges are associated with these vegetable-oil-based polymers, extensive studies on them may open a wide scope for potential use in advanced material sectors. Moreover, improvements in the processes and end properties of these materials with cost feasibility analysis are essential to draw attention from other possible scopes of vegetable oils, such as biodiesel and lubricant preparation, because they are considered potential competitors of biopolymers from the same source of raw materials. Epoxidized vegetable oil (EVO) is one of the largest industrial applications of vegetable oils (VOs) and is widely used as a plasticizer and as a synthetic intermediate for unsaturated polyester. Several attempts have been taken to improve the properties of vegetable oil based polymers by reinforcing fibers and metal oxides. Reinforcement of clay into the matrices however improves the mechanical and thermal properties to some extent, poor thermal stability and flexible nature of the materials makes it less suitable for structural applications. Therefore, the current study was undertaken with the main objective of developing bio-nanocomposite films based on epoxidized soyabean oil and bentonite clay with enhanced mechanical and barrier properties.

MATERIALS AND METHODOLOGY

Preparation of soy-based epoxy matrix

Soy-based epoxy matrix was prepared by mixing soy epoxy resin with base diglycidyl ether of bisphenol A (DGEBA) resin at 30/70 wt % at 60^{o}C with vigorous stirring. The homogeneous solution thus obtained was mixed with stoichiometric amount of 4, 4'-diamino diphenyl methane (DDM) at 90^{o}C. The mixture was degassed to remove the trapped air bubbles and poured into a preheated mould. The casting was cured at 120^{o}C for 3 hours and post cured at 180^{o}C for 2 hours and finally removed from the mould and characterized.

Preparation of Bentonite soy-based epoxy nanocomposites

Soy-based epoxy resin (30/70 wt %) mixed with different Bentonite clay concentrations (1 wt%, 3 wt%, 5 wt% and 7 wt % based on the total weight of the resin mixture) at 70°C for 24 hours using a mechanical stirrer. A stoichiometric amount of the amine curing agent corresponding to epoxy equivalents were added then cast and cured at 120°C for 3 hours. The castings were then post cured at 180°C for 2 hours and finally removed from the mould and characterized.

RESULTS AND DISCUSSIONS

Tensile strength and Flexural strength

The tensile properties of soy-based epoxy nano composites significantly enhanced according to the percentage incorporation of Bentonite clay when compared to plain soy-based epoxy matrix, the values of tensile strength of 1 wt%, 3 wt%, 5 wt% and 7 wt % of Bentonite reinforced soy-based epoxy nano composites were found out. The Tensile properties and Flexural properties of the sample are as shown in Table1 and Fig.1. As to the flexural strength, soy based epoxy possess decreased value of flexural strength and modulus due to the rubbery nature imparted by the triglyceride chains of soy epoxies. The nano composites have greater values of flexural strength than that of the matrix system. The flexural properties of the nano composites significantly improved according to the percentage incorporation of Bentonite clay. The maximum increase in flexural strength is about 25% while the flexural modulus is maintained.

Table 1: Tensile strength and Flexural strength for different compositions of Bentonite Clay

Composition (Wt%)			Tensile Strength (Mpa)	Tensile Modulus (Mpa)	Flexural Strength (Mpa)	Flexural Modulus (Mpa)
DGEBA	Soy Epoxy	Bentonite clay				
100	0	0	60.4	6542.1	104.2	1841.4
70	30	0	75.2	7289.6	98.6	1398.7
70	30	1	81.7	7621.4	102.1	1488.3
70	30	3	90.1	7910.7	106.8	1539.2
70	30	5	94.9	8197.5	113.9	1939.9
70	30	7	97.1	8545.2	127.8	2239.1

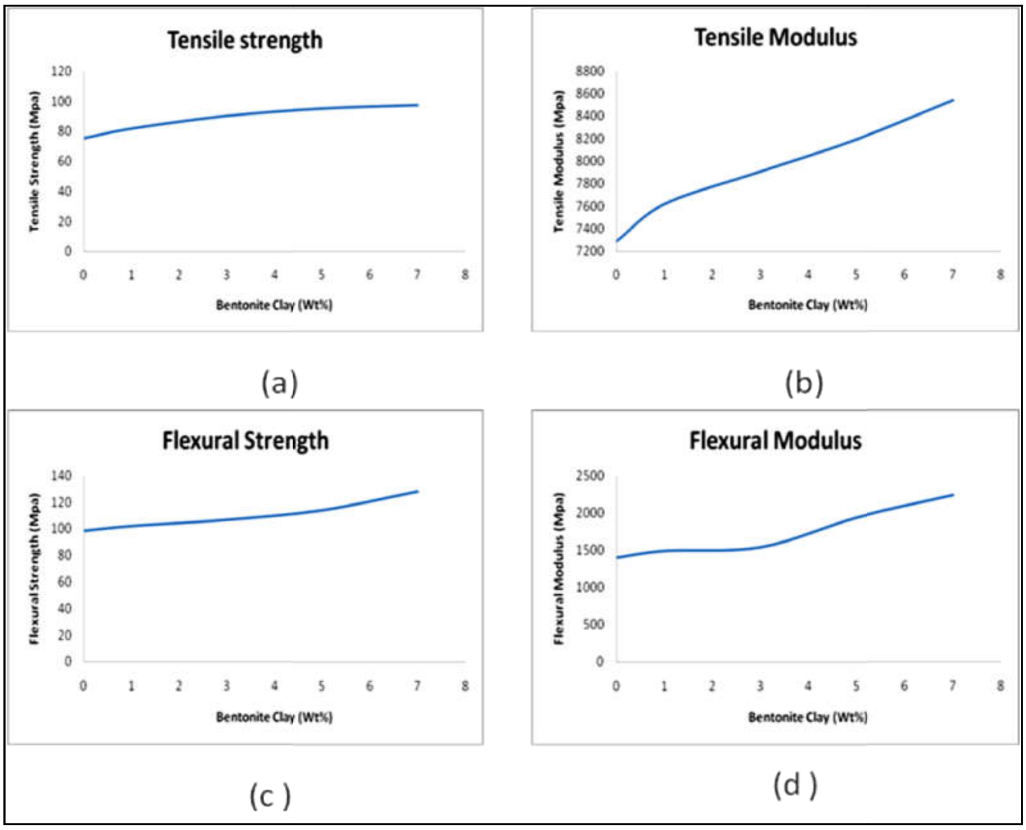

Fig. 1: Tensile and Flexural strength for different compositions of Bentonite Clay

Compression Test

A compression test determines behaviour of materials under a crushing load. The specimen is compressed and deformation at various loads is recorded.1 wt%, 3 wt%, 5 wt% and 7 wt % of Bentonite reinforced soy-based epoxy Nanocomposites was added. The compressive strength goes on decreasing on incorporation of bentonite clay as shown in Fig. 2.

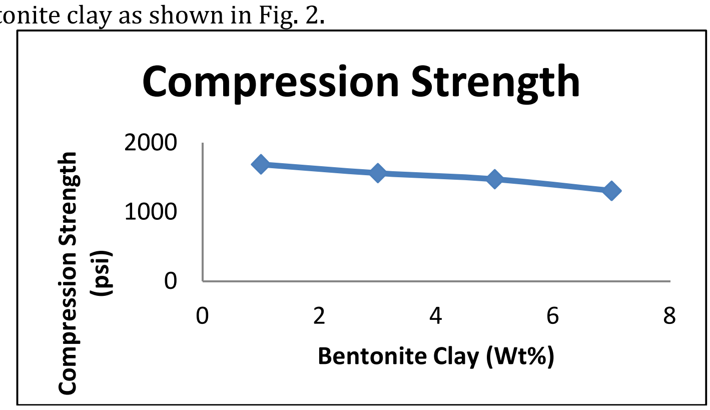

Fig 2: Variation of Compression strength by adding different weights of bentonite.

CONCLUSION

The biobased polymer was developed in which dynamic mechanical properties of the composites were improved, compared to epoxy matrix, with addition of bentonite clay. Strengthening of the polymer matrix was also observed. As a result, it can be safely concluded that Bentonite clay reinforced epoxy nano composites, with enhanced mechanical performance, can be prepared using soya based epoxy resin and diglycidyl ether of bisphenol (DGEBA) monomers.

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