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SYNTHESIS AND CHARACTERISATION OF JUTE AND COTTON FIBRE REINFORCED EPOXY COMPOSITES FROM CORN OIL

T. VIJITHRA[1,*] and Dr. N. J. SANGEETHA[2]

[1]Research Scholar, Department of Chemistry, Women's Christian College, Nagercoil-629001, Tamil Nadu, India.
[2]Assistant Professor, Department of Chemistry, Women's Christian College, Nagercoil-629001, Tamil Nadu, India.

[*]Corresponding Author: Tel: 9894974925; E-mail: vijithravinu1993@gmail.com.
[2]Tel: 9787791700; E-mail: sangeeakil@gmail.com

Abstract

Corn oil is readily available and inexpensive can be used to fabricate different types of polymers. In the present study, epoxidised corn oil has been prepared by corn oil is treated with acetic acid and hydrogen peroxide. The epoxidation is confirmed by FT-IR, iodine value and oxirane oxygen analysis. Natural fibres such as coir, banana, jute, sisal etc are locally available in abundance and can be used to fabricate the composite materials for different applications. Epoxy composites are prepared from natural fibres with different weight ratios using tryethylamine as hardner and phthalic anhydride as curing agent. The soil burial degradation and solvent absorptivity percentage are observed. Soil burial degradation study of polyesters and their composites are confirmed by SEM analysis.

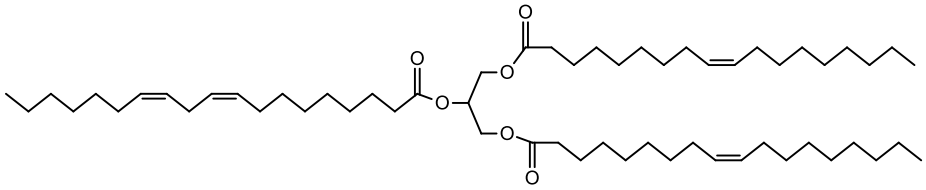
Keywords: Corn oil, epoxy resin, Natural fibere, Epoxy composites, Degradation.

1. Introduction

Corn oil is obtained from seeds (kernels) that contain only 3-5% of oil. Corn oil has become an important vegetable oil in the mix of products manufactured from America's most important crop, and it is the co-product of starch manufacture.[1] The physical and chemical properties are most important to the application of corn oil in several industries. It has pleasing flavor, high levels of polyunsaturated fatty acids and low levels of saturated fatty acids.

The corn oil has glycerides of the following fatty acids: myristic acid 0.1-1.7%, palmitic acid 8-12%, stearic acid 2.5-4.5%, hexadecenoic acid 0.2-1.6%, oleic acid 19-49%, and linoleic acid 34-62%. The corn oil has unsaponifiable fraction ranges between 1-3%, which is relatively high compared with other commercial vegetable oils.[2]

Corn oil contains higher unsaturation of long hydrocarbon chain make the crosslinking easy on polymerisation contributes to improve the flexibility and strength. From the triglyceride structure of corn oil, it is possible to functionalise the triglyceride with polymerisable chemical groups. Corn oil is widely used for many industrial applications. It is generally used in soap manufacturing units, salve industries, inks, paint units and textile industries etc.[3] The triglyceride structure of corn oil is given in Scheme 1.



Scheme 1. Triglyceride structure of corn oil

Epoxy resin is the thermosetting resin or matrix materials, having one or more epoxide groups in the molecule. The epoxy resins are extensively used in fabrication of natural fibre reinforced composites and used to making its different industrial products. The oligomers when react with the hardener, the epoxy resin get cured and becomes a thermosetting polymer.[4]

Jute fibre is also known as golden fibre, jute fibre is one of the most used natural fibre for various textiles applications. Jute fibre is composed primarily of the plant materials cellulose and lignin. Cotton fibre is a soft; feathery the fibre is most often spun into yarn or thread and used to make a soft, breathable textile. Cotton is used to make textile products; these include terrycloth for highly absorbent bath towels and robes.[5]

Composite materials are classified into three main categories; they are metal matrix composites, ceramic matrix composites and polymer matrix composites. Among these, polymer matrix composites is the greater part commonly used composites, due to its advantages such as low cost and high strength. When the matrix material is polymer, the composite is called polymer matrix composites. The composite materials reinforced with jute fibres are cheaper, abundant, low density and biodegradable. The wide ranges of products are presently being produced from jute composites they are sheet, board, window, furniture etc.[6]

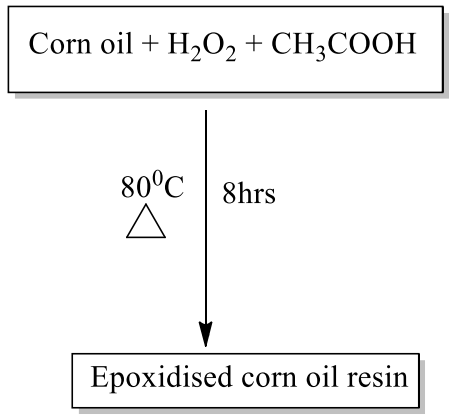
2. Materials and methods

The corn oil used in this study is obtained from local company. Hydrogen peroxide and 99% glacial acetic acid were obtained from Merck. The jute and cotton fibres are collected

locally. The hardener triethylamine and curing agent phthalic anhydride and acetone purchased from Sigma-Aldrich.

2.1 Preparation of epoxidised corn oil resin

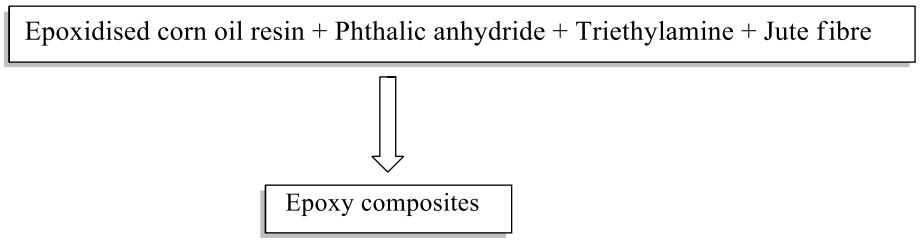
The calculated amount of corn oil is taken in a 500ml three neck flask then add required amount of acetic acid. The flask is equipped with reflux condenser, and then the calculated amount of hydrogen peroxide is added dropwise with continuous stirring about 2hrs. Thereafter, the temperature of the reaction mixture is raised to 80^0C and maintained at this temperature for a period of 8 hrs. After the completion of reaction the yellowish viscous liquid is obtained this product is washed with warm water and separated it.



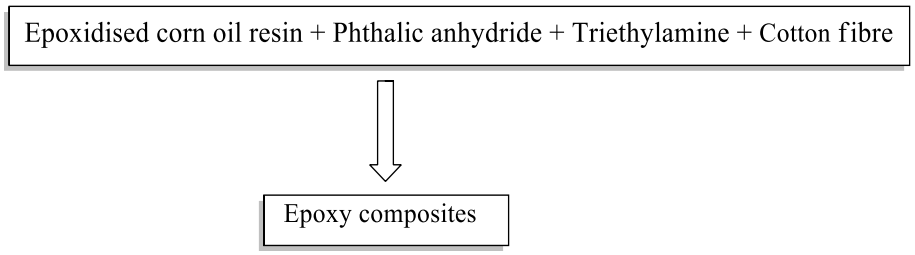
Scheme 2. Epoxidation of corn oil

2.2 Preparation of composites

The calculated amount of epoxidised corn oil resin and phthalic anhydride are dissolved in a minimum amount of acetone. The mixture is condensed with reflux condenser to 80^0C for 4hrs. The hardener triethylamine was added. Different amount of jute fibre and cotton fibre (5, 10 and 15wt. %) is added separately in the above mix and stirred. The mould is coated with silicone grease, and the above mixture is poured into moulds. The sample is cured in an oven at 100^0C for 24hrs. The prepared neat sheet was coded as CPS. The cotton fibre reinforced composites were coded as CPC5, CPC10, and CPC15. Similarly the jute fibre reinforced composites were coded as CPJ5, CPJ10, and CPJ15.



Scheme 3. Formation of jute fibre reinforced composites



Scheme 4. Formation of cotton fibre reinforced composites

3. Characterisation

3.1 Physicochemical properties

The iodine value and oxirane oxygen content of epoxy corn oil resin was characterised by using standard procedures.

3.2 FT-IR analysis

Infrared spectrum of epoxidised corn oil resin was taken in a Shimadzu, FT-IR 8400S spectrometer by KBr pellet method.

3.3 Solvent absorptivity percentage

Each prepared composites were put in 3ml of different solvents for 24 hours. After 24 hours, the excess solvent present on the surface of polyester composites were removed by using filter paper. Then it was weighed and the solvent absorptivity percentage was calculated using the following equation,

$$\text{Solvent absorptivity percentage} = \frac{W_2 - W_1}{W_1} \text{ X } 100$$

Where

W_1- Weight of the dry sample, W_2 - Weight of the sample after absorption of the solvent

3.4 Soil burial degradation

The newly prepared neat and fibre reinforced composites (20 x 5 cm) were buried in the soil at a depth of 30 cm from the ground surface for 30 days. After 60 days the samples were removed, washed with distilled water and dried at room temperature. Then the samples were weighed and the degradation was calculated using the given equation,

$$\text{Weight loss} = \frac{W_0 - W_t}{W_0} \times 100$$

Where, W_0 - Initial mass, W_t - Remaining mass at any given time t.

3.5 Scanning electron microscope analysis

Scanning electron microscope analysis (SEM) was conducted (ESEM- Quanta 200, Fei) to study the degradation of newly prepared polyester and their composites before and after soil burial degradation test

4. Results and discussions

4.1 Physicochemical properties

The data of physico-chemical properties of epoxidised corn oil resin are shown in Table 1

Table 1 Physico-chemical properties of epoxidised corn oil resin

Properties	**Epoxidised corn oil resin**
Colour	Yellow
Odour	Unpleasant
Specific gravity (g/cc) 30^0C	1.1
Viscosity (at 30^0C)	215
Iodine value (Wij's method)	8.70
Oxirane oxygen	2.1

In this present study showed that the reduction in iodine value indicates the oxidation of double bonds during epoxidation. The oxirane oxygen present in the epoxidised corn oil resin is confirmed by the formation of epoxy corn oil resin.

4.2 FT-IR analysis

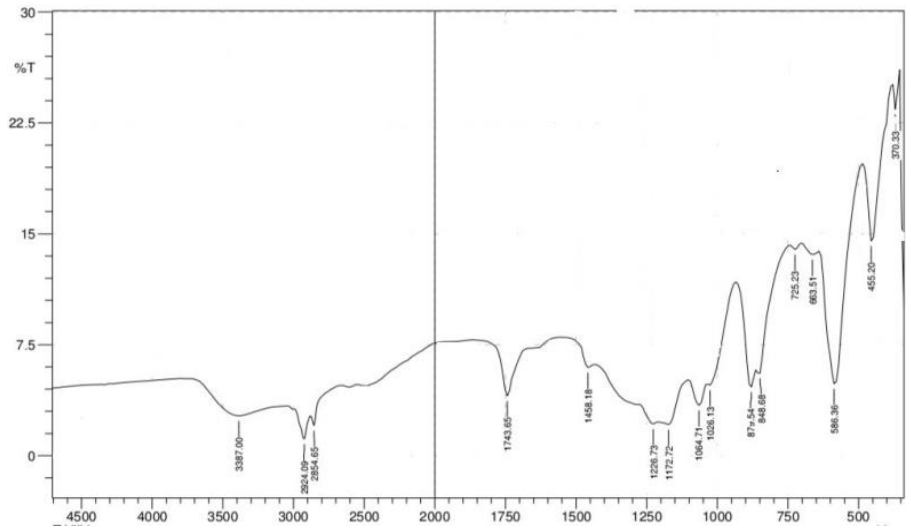


Figure 1. FT-IR spectrum of Epoxidised corn oil resin

In the FT-IR spectrum of epoxidised corn oil resin (Fig.5) reveals that the disappearance of 3005.24 cm^{-1} peak shows –C=C- has been used for epoxidation. The appearance of peak at 848.68 cm^{-1} is corresponds to the formation of epoxy groups confirmed by the formation of epoxy resin.

4.3 Solvent absorptivity percentage (SA %)

The solvent absorptivity percentage is carried out in different solvents such as chloroform, acetone, ethanol and glycerol. These datas are given in Table 2.

Table 2 Solvent absorptivity percentage of polyester and their composites

Polyesters and their	**Solvent absorptivity percentage %**

composites	Chloroform	Acetone	Ethanol	Glycerol
CPS	30.45	28.00	17.14	8.34
CPC5	36.24	28.69	17.58	9.13
CPC10	42.67	28.05	15.98	8.96
CPC15	40.10	25.42	15.10	8.3
CPJ5	34.26	26.54	18.17	9.75
CPJ10	39.56	26.76	18.78	9.80
CPJ15	37.44	26.27	18.56	8.2

In the present investigation 5% and 10% jute and cotton fibre reinforced composites have the high solvent absorptivity percentage than other composites. The neat epoxy composites have low solvent absorptivity percentage than other fibre reinforced composites.

4.4 Soil burial degradation

Biodegradability depends not only on the origin of the polymer. Weight loss of newly prepared neat epoxy and fibre reinforced composites are given in Table 3.

Table 3 Soil burial degradation of polyester and their composites

Polyesters and their composites	Weight (g)	
	Initial	Final
CPS	1.40	1.40
CPC5	1.52	1.52
CPC10	1.60	1.60
CPC15	1.68	1.66
CPJ5	1.54	1.54

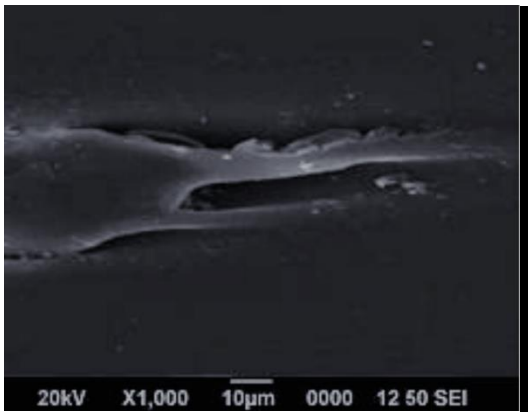
CPJ10	1.59	1.57
CPJ15	1.88	1.83

Soil burial test shows that the no weight loss in the neat sheet, cotton fibre reinforced composites, and 5% jute fibre reinforced composites. But small weight loss is observed in the 10% and 15% jute fibre reinforced epoxy composites. This results shows that the neat and cotton fibre reinforced composites are non- biodegradable but 10% and 15% jute fibre reinforced composites are biodegradable.

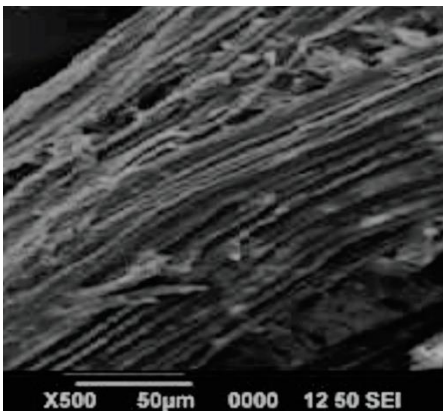
4.6 Scanning electron microscope (SEM) analysis

Scanning electron microscopic analysis is used to study the morphological behavior of polymers. SEM micrographs of the newly prepared polyester and their composites were analysed which shows the degradation of polymers by microbial action. Fig. 6 shows the SEM micrographs of the CPJ10 and CPJ15 before and after degradation.

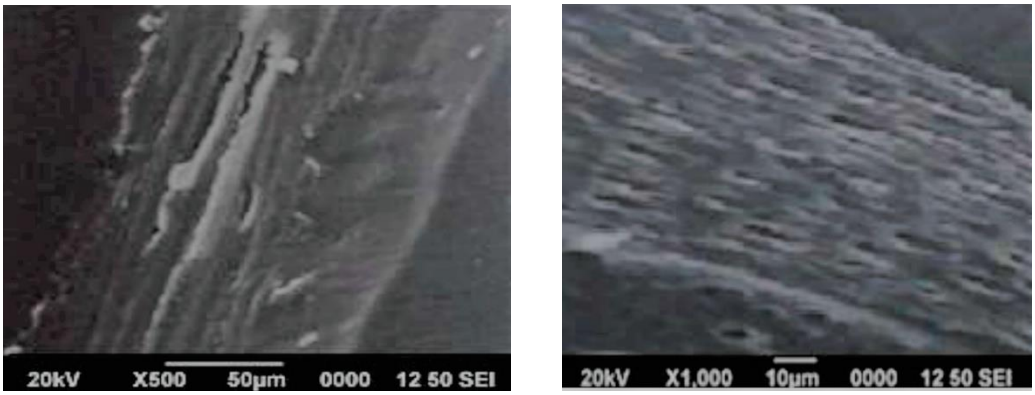
After 60 days in the soil, large number of holes, cavities and pinholes are observed in CPJ10 and CPJ15 indicated that the 10% and 15% jute fibre reinforced composites are attacked by the microorganism under soil environment.



CPJ10 (before)



CPJ10 (after)



CPJ15 (before) **CPJ15 (after)**

Figure 2. SEM images for the biodegradable composites CPJ10 and CPJ15 before and after soil burial test

5. Conclusions

The synthesis of epoxy corn oil resin is confirmed by FT-IR analysis. The fibre content of composites increases solvent absorptivity percentage also increases. In this study 5% and 10% cotton and jute fibre reinforced composites have high solvent absorptivity percentage than other composites. Soil burial degradation study shows the neat polyester and cotton fibre reinforced composites are non-biodegradable but 10% and 15% jute fibre reinforced composites are biodegradable. As the percentage of fibre content increases, the degradation rate also increases. The biodegradation of newly prepared polyester and their composites are confirmed by SEM analysis.

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