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FTIR analysis of Bamboo and Flax (BFBF) Mat Reinforced Epoxy Hybrid Composite

Ravi Shukla[1], A. K. Srivastava[2]

[1] Research Scholar, M.Tech., MUIT, Lucknow, Uttar Pradesh, India

[2] Associate Professor, Mechanical Engineering Department, Ansal Technical Campus, Lucknow, Uttar Pradesh, India

Abstract-

Hybrid composite materials are the great potential for engineering material in many applications. Hybrid polymer composite material offers the designer to obtain the required properties in a controlled considerable extent by the choice of fibers and matrix. The properties are tailored in the material by selecting different kinds of fiber incorporated in the same resin matrix. In the present investigation, the mechanical properties of Bamboo and flax mat reinforced epoxy hybrid composite were studied. The hand lay-up technique was adopted for the fabrication of hybrid composite materials. FTIR spectrum was performed on a Perkin Elmer Spectrum 100 FTIR spectrometer in the range of 4000–500 cm^{-1} at room temperature. The spectrum was an average of 10 scans at a resolution of 2 cm^{-1}, corrected for background.

Keyword- Hybrid Composite, Hand Layup Technique, FTIR.

I. INTRODUCTION

Composites are multi-functional materials consisting of two or more chemically distinct constituents, on a macro-scale, having a distinct interface separating them. More than one discontinuous phases are embedded in a continuous phase to form a hybrid composite. The discontinuous phase is usually harder and stronger than the continuous phase and it is called thehybrid reinforcement and the continuous phase is termed the matrix. The matrix material can be classified into metallic, polymeric and ceramic. Recently, the polymer matrix composites have been widely used for many applications like automotive parts, airplanes interior parts, household appliances and construction materials [1].The reinforcing phase can either be fibrous or non-fibrous (particulates) in nature and if the fibers are derived from plants or some other living species, they are called natural fibers. The environmental issues have resulted in considerable interest in the development of new composite materials with addition of more than one reinforcement that are biodegradable resources, such as natural fibers as low-cost and environment-friendly alternative for synthetic fibers[2].The hybrid fibers in the composites can withstand higher load compared to single-fiber reinforcements in different direction based on the reinforcement, and the surrounding matrix keeps them in the desired location and orientation, acting as a higher load transfer medium between them[3].The increased environmental consciousness is promoting the use of eco-friendly fibers, extracted from plants, vegetables, minerals and animals instead of synthetic fibers [4].Automobile sector has various applications of NFRP composites to manufacture different parts such as door panels, headliners, package trays, dashboards and interior parts of vehicle [5].In recent years, the use of flax fibers as reinforcement in composites has gained popularity due to an increasing requirement for developing sustainable materials. Flax fibers are cost effective and offer specific mechanical properties comparable to those of synthetic fillers. Composites made of flax fibers with thermoplastic, thermoset, and biodegradable matrices have exhibited good mechanical properties [6].The mechanical properties of composite materials depend on many factors, which include fiber length, shape, size, composition, orientation and distribution, as well as volume fraction, mechanical properties of the polymer matrix, manufacturing techniques and adhesion or connection between the fibers and the matrix[7].

Mid infrared spectroscopy has been widely used for characterization of organic compounds and plenty of reliable information and spectra libraries can easily be found. Both qualitative and quantitative information can be obtained by this technique, although its use in epoxy systems is quite restricted because of the location and intensity of the oxirane ring absorptions. Two characteristic absorptions of the oxirane ring are observed in the range between 4000 cm-1 and 400 cm-1. The first one, at 915 cm-1, is attributed to the C-O deformation of the oxirane group, although some works done by Dannenberg [8]showed that this band does not correspond exclusively to this deformation but also to some other unknown process. The second band is located at 3050 cm-1 approximately and is attributed to the C-H tension of the methylene group of the epoxy.

ring. This band is not very useful since its intensity is low and it is also very close to the strong O-H absorptions; but in low polymerization degree epoxy monomers it can be used as a qualitative indicative of the presence of epoxy groups. Near IR is far more useful for epoxies. nIR spectrum covers the overtones of the strong vibrations in mIR and combination bands. In this range, fewer and less overlapped bands are observed so it has been used by several authors [9],[10],[11],[12],[13] for monitoring the curing reaction. The intensity of the bands in this region is much lower than in the mid range, allowing the use of thicker and undiluted samples to get good quality data.

II. EXPERIMENTAL

Natural Fibre and Matrix

Flax and Bamboo mat were supplied by Compact Buying Services, Faridabad, Haryana. Bi-directional mats of these fibers have been used for fabrication of bio- composites. Epoxy resin and hardener was supplied by Excellence Resins, Meerut, UP

Bamboo Fiber:

Bamboos include some of the fastest-growing plants in the world due to a unique rhizome-dependent system. Certain species of bamboo can grow 91 cm (36 in) within a 24-hour period, at a rate of almost 4 cm (1.6 in) an hour (a growth around 1 mm every 90 seconds, or 1 inch every 40 minutes). Giant bamboos are the largest members of the grass family. Bamboos are of notable economic and cultural significance in South Asia, Southeast Asia and East Asia, being used for building materials, as a food source, and as a versatile raw product. Bamboo has a higher specific compressive strength than wood, brick or concrete, and a specific tensile strength that rivals steel. Density of bamboo fibre is 1.1gm/cm3[12].

Flax Fiber:

Flax (*Linum usitatissimum*),also known as common flax or linseed, is a member of the genus *Linum* in the family Linaceae. It is a food and fiber crop cultivated in cooler regions of the world. Textiles made from flax are known in the Western countries as linen, and traditionally used for bed sheets, underclothes, and table linen. Its oil is known as linseed oil. In addition to referring to the plant itself, the word "flax" may refer to the unspun fibers of the flax plant. The plant species is known only as a cultivated plant, and appears to have been domesticated just once from the wild species *Linum bienne*, called pale flax.Density of flax fibre is 1.5gm/cm^3[13].

Fig 1 – Bamboo Mat(0^0/ 90^0orientation)

Fig 2 – Flax Mat(0^0/ 90^0orientation)

Epoxy Resin

Araldite LY 556 is manufactured by Huntsman Advanced Materials having the following outstanding properties has been used as the matrix material. Epoxy Resin was purchased from Excellence Resins, Meerut, UP. Epoxy shows long open time ,high shear, peel strength, easy to apply, electrically insulating, good resistance to static and dynamic loads.

Hardener

Hardener is a curing agent for epoxy resin. Epoxy resins require a hardener to initiate curing. It is also called the catalyst, the substance that hardens the adhesive when mixed with resin. It is the specific selection and combination of the epoxy and hardener components that determine the final characteristics and suitability of the epoxy coating for a given environment. Optimum levels of a hardener are used to formulate epoxy coatings. The ratio differs from product to product. The use of an improper hardener may result in an undercatalyzed or overcatalyzed product. In the present work hardener (HY951) is used. This has a viscosity of 10-20MPa at25ºc.

Fig 3–Epoxy and Hardener

Processing

Hybrid composites were fabricated with the help of detachable closed mold of mild steel using hand lay-up technique. The silica gel was applied to the inner surface of mold plates to avoid sticking of polymer with the steel plates during curing.

Fig 4–Mould

Fig 5–Roller

Fig 6- Wooden Frame

Fig 7- Composite Processing

The matrix was prepared by proper mixing of epoxy resin of Araldite LY556 grade and hardener HY951in proportion of 10:1as per manufacturer (Huntsman). Epoxy resin and hardener were properly mixed to reduce the air bubbles present in the liquid of resin and hardener. A wooden frame of dimension (250*260*5) was prepared. Flax and bamboo mat were washed with 10 % Sodium Hydroxide (NaOH) solution for 30 min and was cleaned with normal water until normal pH was attained .Now these fibers were dried by keeping them in sunlight for 8-10 hours. The liquid matrix was then uniformly spread on the inner surface of the mold and the resin was rolled by the steel roller to achieve the equal thickness of resin layer over the surface of the mold. Fiber mats were cut in equal size as of Frame cavity and placed over the layer of resin. Roller was again rolled over to remove any air bubble trapped within the layer. This process was repeated again and again till the pre-decided specifications. For each type of developed composite, the weight fraction of fiber was 28%.Load is applied with the help of C- Clamp . Composite is left for curing for 48 hours at room temp with humidity 55%.

Fig 8- Final Sheet (Top View)

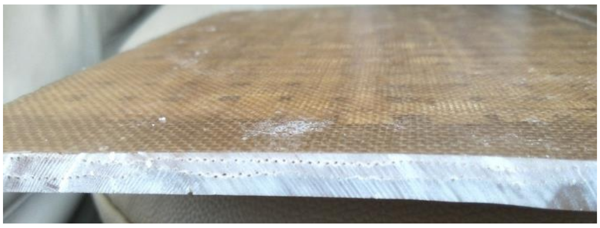


Fig 9 (a)- Final Sheet (Side View)

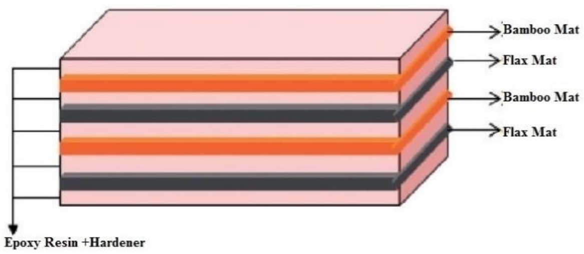


Fig 9 (b) Systemic view of hybrid composite

III. TESTING AND RESULT

FTIR -Fourier Transform Infrared Spectroscopy

FT-IR stands for Fourier Transform Infrared, the preferred method of infrared spectroscopy. In infrared spectroscopy, IR radiation is passed through a sample. Some of the infrared radiation is absorbed by the sample and some of it is passed through (transmitted). The resulting spectrum represents the molecular absorption and transmission, creating a molecular fingerprint of the sample. This makes infrared spectroscopy useful for several types of analysis.

- ✓ It can identify unknown materials
- ✓ It can determine the quality or consistency of a sample
- ✓ It can determine the amount of components in a mixture
- ✓ FTIR spectrum was performed on a Perkin Elmer Spectrum 100 FTIR spectrometer in the range of 4000–500 cm-1 at room temperature. The spectrum was an average of 10 scans at a resolution of 2 cm-1, corrected for background.

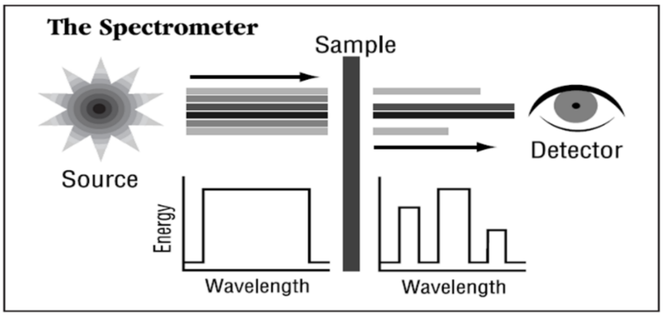
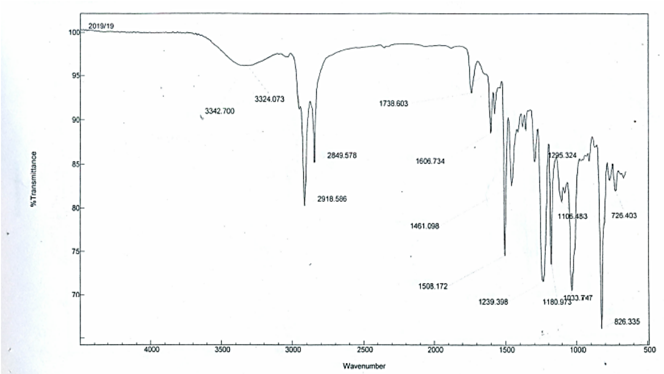


Fig 10 - FTIR

FTIR for BFBF Composite.



The FTIR spectra show a broad peak in the region at 2918.56 cm-1 corresponding to the hydroxyl (OH) stretching vibration of free and hydrogen bonded –OH groups [14], and the absorbance peak around 1239.39 cm-1 is attributed to the bending vibration of absorbed water . The presence of bands in the regions 1180.97–1003.74 cm-1 is an indicator of the atmospheric carbonation on the surface of the matrix where it reacts with carbon dioxide [15]. The presence of flax fibres in the composites can be recognised by the peak at 1418 cm-1, which is attributed to the CH3 bending vibration of cellulose [16]. The intensity of the bands at 3385 and 1653 cm-1 increases in response to the existence of absorbed water in the cellulose fibres.

IV.CONCLUSION

FTIR appears to be a valuable tool for both qualitative analysis and quantification of these processes. It has been shown how to extract relevant information from spectra to identify typical components of resins and hardeners. Following time variations of specific bands allows extracting relevant kinetic parameters to get more insight about the specific reaction mechanism of curing process. Inspection of subtle changes in baseline can be correlated with both, miscibilization or phase separation processes. Detailed analysis of OH bands allows extracting information about intermolecular interactions within the components of the resin. And, finally, water uptake can be easily quantified and both diffusion coefficients and dimensional changes can be measured with less error than other common methods.

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