# Synthesis of an Environmental Friendly Material as Cocos Nucifera Leaves Reinforced Epoxy Composite and Effect of Alkali Treatment of Fibers on Mechanical Properties

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***Article Info***
***Page Number: 2102 – 2107***
***Publication Issue:***
***Vol 70 No. 2 (2021)***

***Abstract:*** Nowadays, plastic pollution presents a great threat for the world environment and health of the living beings. In past three decade, various natural fiber composites were investigated to find a solution for plastic pollution. In this paper, a natural fiber composite as midrib of coconut leaves (MCL) reinforced epoxy resin was developed and studied. The investigation was aim to find out the effect of reinforcement and chemical treatment at different soaking period, on mechanical properties of the composite. Results showed that mechanical properties have been increased due to the MCL reinforcement and chemical treatment of MCL. The maximum tensile and Impact strength was found for alkali treated fiber composites with 12 hours soaking period while maximum flexural strength was found with 6 hours soaking period.

***Article History***
***Article Received:*** *15 October 2021*
***Revised:*** *24 November 2021*
***Accepted:*** *18 December 2021*

**Keywords**: - Environment friendly material, Cocos Nucifera, Reinforced, Alkali treatment, lapox b-11, lapox k-6

## 1. Introduction

In the field of materials the natural fiber composites (NFCs) is an effective step to save the environment from the plastic pollution due to their various advantages[1]. In past few decades, several NFCs have been successfully synthesized by reinforcing natural fibers such as Jute, Sisal, Flax, Hemp and Coir in polymer matrix[1,2]. The mechanical performance of a NFC mainly depend upon interfacial bonding between fiber and matrix material. This bonding is inherently weak due to the incompatibility between polymeric matrix and cellulosic fibers. To improve the adhesion between fiber and matrix several chemical and physical methods have been suggested[3].Treatment of fibers by soaking in NaOH solution is also a popular method to enhance the interfacial bonding[4].

In a previous research a composite comprise of midrib of *Cocos Nucifera* leaves (MCL) and polyester resin was developed and studied for the mechanical properties [5]. In which no attempt was made to improve the interfacial bonding strength by any chemical method. In the present investigation MCL have been reinforced in epoxy resin to develop the MCL/Epoxy composite. The MCL fibers were also treated in NaOH solution for different soaking time period to study the effect on mechanical performance of the composite.

## 2. Material and Method

### 2.1 Material

In the present investigation, the MCL sticks were purchased from the local market in the form of the brooms.Epoxy resin (lapox b-11) and hardener (lapox k-6) were supplied from MP polymers, Govindpura, Bhopal, M.P., India. Two mild steel moulds were used to cast the specimens for tensile, flexural and impact tests. The cavity on moulds was made to produce specimens according to ASTM standards. Silicon wax was used as releaser of specimen from the mould. For chemical treatment of MCL, 4% NaOH solution was taken.

### 2.2 Method

MCL were cleaned with mild soap solution to remove dirt and other impurities and allowed to dry under sunlight. Density of MCL and solidified resin were measured by liquid displacement method. MCL were soaked in 4% NaOH solution for 6 hours and 12 hours in two different containers. MCL were allowed to dry under sunlight for 24 hours after the alkali treatment. All samples of MCL were again dried in a hot air oven for 6 hours at 80°C to remove moisture.

For casting the specimens, the required amount of epoxy resin mixed with 10% hardener (by volume) and catalyst in a glass beaker and then the mixture were stirred for 1 minute. The hand layup method was adopted for casting the specimens. Cavities of the moulds were polished by silicon wax before pouring the resin to ensure easy release of the specimens. The MCL fibers were taken 15% weight fraction and laid uni-axially in the mould cavities and then resin was poured to fill the cavities. The moulds were pressed by a screw fitted cover plate to remove entrapped air from the resin. Resin for all specimens was allowed to cure for 48 hours. After curing, the specimens were released from the mould with the help of a chisel and hammering from the backside of the die. Figure1 (A, B, C) shows the specimens for flexural, tensile and impact tests, respectively.


**Figure 1: Specimens for (A) Flexural Test (B) Tensile Test (C) Izod Impact Test**

For the evolution of mechanical properties of the MCL, Epoxy resin and composites, different tests such as tensile, flexural and Izod impact were conducted in the laboratory of CIPET, Bhopal, M.P. India at 27°C and 50% RH. Tensile and flexural test were conducted on a UTM of Instron model 3382 whereas for Izod impact test a plastic impact tester of Tinius Olsen, USA Model IT 504 was used. Tensile, Flexural and Impact test were conducted according to ASTM D 638,790 and 256 respectively and minimum five samples of each type were tested to ensure the repeatability of the results. Figure 2 (A, B, C) is showing the setup for tensile, flexural and Impact tests respectively.


**Figure 2: Setup for (A) Tensile (B) Flexural and (C) Impact tests**

## 3. Results and Discussion

This research focuses on the effect of alkali treatment of the MCL, on the mechanical properties of the MCL/epoxy composite. Different test results for pure resin, untreated MCL/Epoxy composite and alkali treated composite with 6 hours and 12 hours soaking period, are presented in the following sections. All composite specimens are developed with 15% fiber loading by weight.

### 3.1 Tensile Test Result

Tensile strength for different specimens is presented in Figure 3. The tensile strength of pure resin is very low (13.2 MPa) as it is general-purpose resin but the strength increases two times (28.8MPa) due to reinforcement of untreated MCL. This increase in strength is due to high tensile strength of MCL (177 MPa) and efficient load transfer between matrix and fiber[5]. Tensile strength increases further to 39.5 and 52.7 Mpa for the alkali treated specimens for two soaking periods of 6 hours and 12 hours respectively. This enhancement of the strength is mainly due to the removal of impurities and waxy layer from the surface of fibers as well as formation of a rough topography due to alkali treatment[6].Moreover, the wetting of fiber surface with the resin and contacting area between fiber and matrix is also improved[4,7].

Figure 4 shows tensile modulus of different specimens, under study. It can be observed that tensile modulus decreased due to reinforcement of the fibers. This is mainly due to the presence of a waxy layer on the surface of the fiber, which results in weak bonding at the interfacial surface of the fiber and matrix. Also, aggregation of fibers inside the matrix reduces the force transferring efficiency[3]. Although, tensile modulus of the composites increased about three times (3.48 GPa) due to alkali treatment of fibers for 6 hours soaking time and increased further (3.72 GPa) for 12 hours soaking time period. This enhancement in the tensile modulus attribute to the same effect, as that in the case of tensile strength.

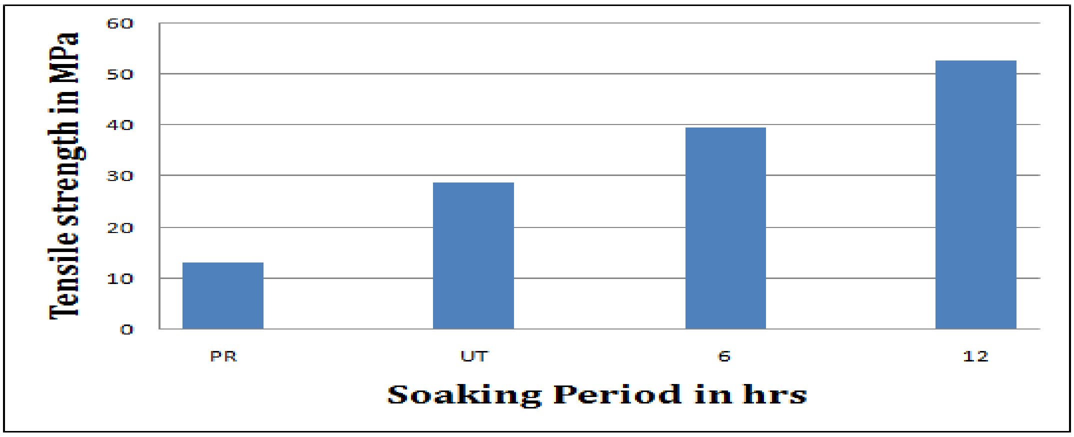


**Figure 3: Tensile strength of pure resin and MCL/Epoxy composites.**

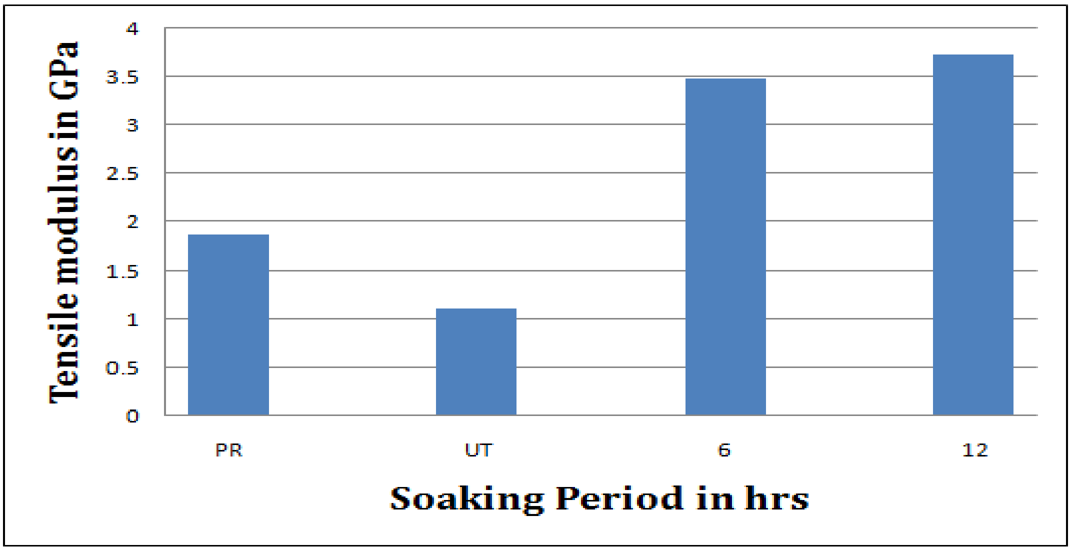


**Figure 4: composite tensile modulus of pure resin and MCL/Epoxy.**

### 3.2 Flexual Test Result

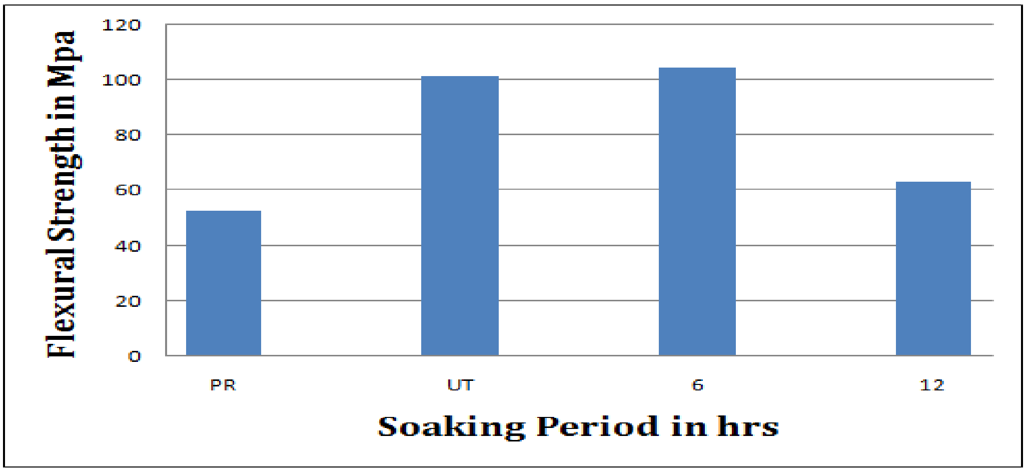


**Figure 5: Flexural strength of pure resin and MCL/Epoxy composites.**

Flexural strength and Flexural Modulus of different specimens are shown in Figures5 &6 respectively. It can be observed that due to reinforcement of fibers the flexural strength was increased two times (from 52.64 to 101.73 MPa), which was mainly due to high flexural strength of MCL (316.04 MPa)[8]. Flexural strength further increased slightly for the soaking period of 6 hours (104.53 MPa) and then decreased for the soaking period of 12 hours. A similar trend was observed for flexural modulus also. The Maximum flexural modulus (6.86 GPa) was achieved for 6 hours soaking period. These results confirmed the improvement of the flexural properties due to both reinforcement and alkali treatment of fibers which is mainly due to the high flexural strength of the fiber and improved crystallinity of cellulose fibers respectively[9]. The flexural properties decreased for higher soaking time period (12 hours) which was mainly due to increased brittleness of the cellulose fiber[10].

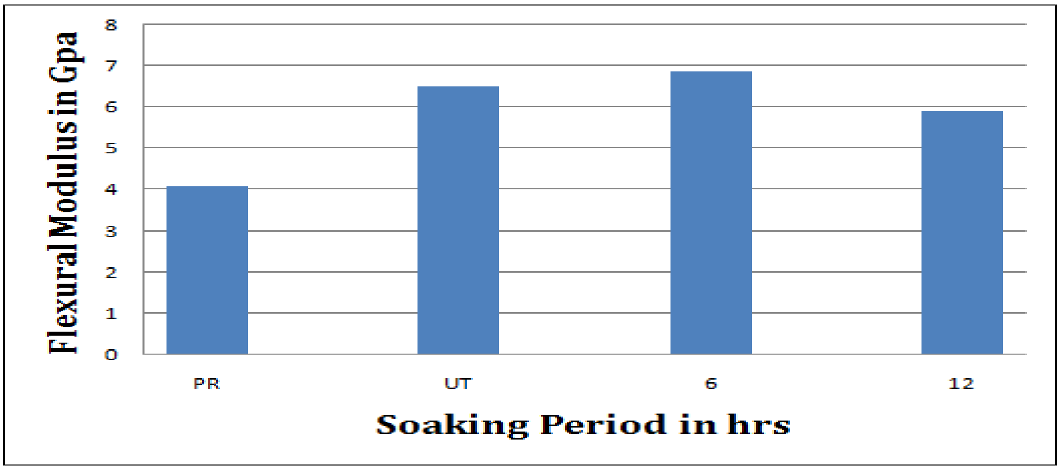


**Figure 6: Flexural modulus of pure resin and MCL/Epoxy composites.**

### 3.3 Impact Test Result

Figure 7 shows the Izod impact strength of different specimens. It can be observed that impact strength decreased due to reinforcement of composite but improved appreciably due to fiber alkali treatment. A small increment was observed in the case of 12 hours in comparison to 6 hours soaking period. The Maximum impact strength was found as 2620.31J/m for treated fiber with 12 hour soaking time. These impact test results confirm the improvement of the toughness of composite due to alkali treatment, which can be attributed to the enhanced bonding between fiber and matrix[11].

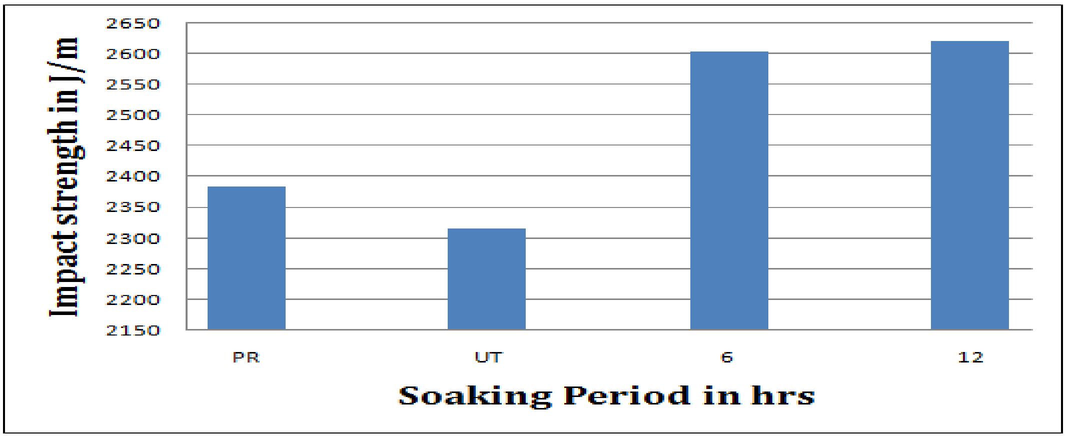


**Figure 7: Impact strength of pure resin and MCL/Epoxy composites.**

## 4. Conclusion

From the present investigation, it can be concluded that alkali treatment improved the overall mechanical properties of MCL/Epoxy composite. The tensile strength increased continuously with soaking period and all most 300% enhancement in the tensile strength observed for 12 hours soaking period. Tensile modulus decreased due to reinforcement of untreated fiber. However, a continuous enhancement in the modulus observed for the treated fiber with respect to soaking period.

Flexural strength and modulus enhanced upto two times due to reinforcement of both treated and untreated MCL fibers. Maximum strength obtained for treated fiber at 6 hours soaking period. Although, flexural strength deteriorated for further increase in soaking period. Impact strength decreased due to reinforcement of untreated fibers, but it enhanced by 12% for treated fibers. However, a small increment in the impact strength observed for six to twelve hours soaking period.

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