Int.J.HIT.TRANSC:ECCN.Vol.2: Issue 2A (2016) Page 85-89 ISSN: 0973-6875

Available Online at www.hithaldia.in/locate/ECCN


ORIGINAL CONTRIBUTION

# JUTE REINFORCED BIO-COMPOSITE USING EUPHORBIA LATEX AS ADHESIVE

Pijus Kanti Khatua[1], Gourisankar Roymahapatra[1] and Rajib Kumar Dubey[1]

[1]*Dept. of Applied Sciences, Haldia Institute of Technology, Haldia-721657, India*

(Received Date: 12th May, 2016; Revised Date: 24th June, 2016; Acceptance Date: 15th July, 2016)

**Abstract**

Euphorbia latex obtained from desert plants like i.e. *E. royleana*, *E. nivulia*, *E. nerfolia*, *E. caducifolia* having 96% *cis*-polyisoprene whereas latex of Euphorbia contains 60-80% of resinous mass along with 10-20% *cis*-polyisoprene, 20-30% protein and small amount of ash content. Jute composite made from jute woven fabric as reinforcement and resin isolated from Euphorbia latex coagulum as matrix were found to be better than the jute composite made from non-woven fabric. Jute composite made from woven as reinforcement and resin isolated from Euphorbia latex or latex coagulum as matrix was found to be better than the jute composite made from jute non-woven fabric as matrix. This paper deals with the preparation of Jute reinforced composite using bio-adhesive Euphorbia latex. Swelling characteristic of jute composites showed that composites made from woven jute absorbed more water compared to jute nonwoven composite.

**KEYWORDS**— Bio-composite, Euphorbia latex, Bio-adhesive.

## 1. INTRODUCTION

Bio-adhesives are natural polymeric materials that act as adhesives. The term bio-adhesives [1-2] have got the attractions of scientist, researchers, industrialists and even environmentalist because it add to the major subject of biopolymer and green technology [3-4]. The term is sometimes used more loosely to describe a glue formed synthetically from biological monomers such as sugars, or to mean a synthetic material designed to adhere to biological tissue. Bio-adhesives may consist of a variety of substances, but proteins and carbohydrates feature prominently. Proteins such as gelatin and carbohydrates such as starch have been used as general-purpose glues by man for many years, but typically their performance shortcomings have seen them replaced by synthetic alternatives. Highly effective adhesives found in the natural world are currently under investigation but not yet in widespread commercial use. For example, Bio-adhesives secreted by microbes and by marine molasses and crustaceans are being researched with a view to biomimicry [2]. Bio-adhesives [1, 3-4] are of commercial interest because they tend to be biocompatible, i.e. useful for biomedical applications involving skin or other body tissue. Some work in wet environments and under water, while others can stick to low surface energy – non-polar surfaces like plastic. In recent years, the synthetic adhesives industry has been impacted by environmental concerns and health and safety issues relating to hazardous ingredients, volatile organic compound emissions, and difficulties in recycling or re mediating adhesives derived from petrochemical feed stocks. Rising oil prices may also stimulate commercial interest in biological alternatives to synthetic adhesives. There are over 2000 species of Euphorbia’s in the world. They all have latex and a unique flower structure. A significant percentage is succulent and mostly originates from Africa and Madagascar. The Euphorbia’s are named after a Greek surgeon called Euphorbus. He was physician of Juba-II who was the Romanised king of a North African kingdom, and is supposed to have used their milky latex as an ingredient for his medicines. The desert plants i.e. *E. royleana*, *E. nivulia*, *E. nerfolia*, *E. caducifolia* originates at Indian Himalayan region and Bhutan at medium elevation; are deciduous succulent trees and easily propagated by normal cutting. Natural latex obtained from the desert plants i.e. *E. royleana*, *E. nivulia*, *E. nerifolia*, *E. caducifolia* known as Euphorbia latex, are inferior to Haevea brasiliensis (natural rubber latex) [2, 5] which comprises 96% *cis*-polyisoprene, whereas latex of Euphorbia contain 60-80% of resin mainly contain terpenes along with 10-20% *cis*-polyisoprene and 20-30% protein and small amount of ash [6-7]. Composites [5, 8-13] are defined as the material created when at least two different relatively homogeneous phases are combined to produce a homogeneous material of more complex structure having properties which are not obtainable by any of the constituents alone. The constituents/materials are separated by a less clearly defined phase known as the interface. Thus, most of the composites are made of two materials *i.e.* the matrix or the binder and reinforcement the resin for the cluster of fibers. National Institute of Research on Jute and Allied Fiber Technology (NIRJAFT) has developed jute based composites using jute [3, 15-17] fabric (woven and non-woven) as reinforcing materials and the resin of Euphorbia latex (obtained from *E. royleana latex* by solvent extraction process) as well as the latex coagulum (containing both the resin and the rubber) obtained by dissolving latex in toluene. However, the drawback associate with jute fabric is that due to the presence of hydroxyl and other polar functional groups, the moisture in resign is very high which leads to poor wettability with organic resin matrix, resulting weak interfacial bonding with jute fabric and ultimately in poor environmental performance. Thus it is most necessary to block the polar groups by chemical means which will ultimately enhance the reinforce character of jute. Jute is one of the most important bast-fiber grown to the tune of 1.5 million tons from *Corchorus* (white jute) and *Corchours olitorius* (tossa jute). Jute fiber consists of the collection of filament and ultimate fibers of length being 0.8 ~ 6.0 mm and breadth 0.005 ~ 0.025 mm. Jute is a lignocellulosic fiber composed of cellulose (58-60%), hemicellose (21-24%) and lignin (12-14%). Jute composite [18-20] made from jute woven fabric [18] as reinforcement and resin isolated from Euphorbia latex or latex coagulum as matrix was found to be better than the jute composite [22-23] made from jute non-woven fabric as matrix. Jute composites made from jute fiber pulp using 1% sulphur along with 1% benzoylperoxide as coupling agent was found to be of much higher strength compared to composite made from jute non-woven or jute woven fabric as reinforcement under the same condition. To increase the compatibility between the latex and the jute fiber of 0.2% Silane (dichlorodimethyl silane) as coupling agent [24] showed better results than the control or the 2% NaOH pretreated [25] jute.

## 2. MATERIALS AND METHODS

**Euphorbia resin:** The Euphorbia latex was obtained from *Euphorbia royleana* plant (as shown in figure 1) from Sahasradhara at Derhadun by solvent extraction process and supplied by Shriram Institute for Industrial Research, University Road, New Delhi. This resin contains unsaturated oligo-terpenoids.

Figure 1: *Euphorbia royleana* plant at Derhadun Sahasradhara

**Euphoria latex coagulum:** The latex coagulum (containing both the resin and the rubber) was obtained from the Euphorbia latex by dissolving 60-80% of the resinous mass along with 10-20% cis-polyisoprene and 20-30% protein and small amount of ash in toluene (supplied by Shiram Institute for Industrial research , University Road, New Delhi).

**Preparation of the composite:** Jute fiber woven and non-woven were used as the reinforcing agent and the resin or the latex coagulum were used as the matrix in the reinforcement / matrix ratio of 1:3, 1:2 and 2:1. The composites were cured in a hot press at a specific pressure of 10-12 $Kg.cm^{-3}$, two minutes more than desire thickness.

**Tensile Strength:** Tensile strength of the composite was measured in the in $Kg.cm^{-3}$ and elongation at break % in the Instron-Universal Testing Machine (Model no.1185).

**Impact strength:** Impact strength of the composite was measured in the pendulum type impact testing machine in Kg.f.m manufactured by M/s. Fuel Instrument & Engineers Pvt. Ltd., Yadrav (Maharastra).

**Hardness:** Hardness of the composite was measured in Rubber Harness Testing Manufactured by M/s. Blue Star Steel Engineers Pvt. Ltd., Mumbai, in Shore-D.

## 3. Results and discussion:

Jute composites of considerable strength could be prepared using jute fabric (woven/non-woven) as reinforcement and latex coalgulum as the matrix in the ratio of 3:1 or 2:1 (Jute fabric:L coagulum) in a hot press at specific pressure 10 $Kg.cm^{-3}$ for 6-7 minutes at $120^0C$. In case of jute fiber as reinforcement better results were obtained in the isotropic from (As shown in Table1). Improved strength properties were obtained by incorporating benzoyl peroxide (1-1.5 %) in the latex coagulum, before hot pressing. This was achieved by better cross linking of the resin component consisting of unsaturated oligo-terpenoids (see table 2). Composite made from jute pulp obtained by pulping with 1% NaOH + 0.5% $Na_2S$ for 1 hr at $120^0C$ with the latex coagulum containing 1% sulphur and 1% benzoylperoxide, gave very high strength. The pulping action results in cleaning and opening the surface which increases better penetration of the resin making composites more stable with low moisture resign and having improved strength properties [Table 2]. Composites obtained from jute woven fabric as reinforcement and latex coagulum 0.2% Silane (dichlorodimethyl silane) produced a very high strength composite. This increased the compatibility between the latex and the jute fiber [Table 3]. Swelling characteristics of jute composites showed that jute woven based composites absorbed more water compared to jute non-woven composite [Table 4].

**Table.1 Composites strength properties made from jute and Euphorbia Latex as matrix**

| Sl. No. | RM (R) | Matrix (M) | Catalyst | Ratio R/M | Temp ($^0C$) | Pressure ($Kg/cm^2$) | Curing time (min.) | T S ($Nm^{-2}$) | EB (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | JN | Resin | - | 3:1 | 140 | 12 | 6-7 | 19.40 | 2.81 |
| 2. | JW | Resin | - | 2:1 | 140 | 12 | 6-7 | 55.00 | 6.12 |
| 3. | JN | LC | - | 3:1 | 120 | 10 | 6-7 | 22.50 | 1.94 |
| 4. | JW | LC | - | 3:1 | 120 | 10 | 6-7 | 50.50 | 6.36 |

RM: Reinforcement Materials; LC: Latex Coagulum; JN: Jute Non-woven; JW: Jute woven; TS: Tensile Strength; EB: Elongation at break

**Table 2: Jute composites based on Euphorbia Latex as matrix and their strength properties**

| Sl. No. | RM (R) | Matrix (M) | Catalyst | Ratio (R/M) | Temp ($^0C$) | Pressure ($Kg.cm^{-2}$) | Curing time (min.) | TS ($N.m^{-2}$) | EB (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | JN | LC | 1% BP | 2:1 | 120 | 10 | 6-7 | 26.50 | 0.42 |
| 2. | JW | LC | 1% BP | 2:1 | 120 | 10 | 6-7 | 65.40 | 6.32 |
| 3. | JN | LC | 1% S + BP | 2:1 | 120 | 10 | 6-7 | 82.00 | 3.50 |

RM: Reinforcement Materials; LC: Latex Coagulum; JN: Jute Non-woven; JW: Jute woven; BP: Benzoyl Peroxide; TS: Tensile Strength; EB: Elongation at break

**Table 3: Jute composites based on Euphobia Latex as matrix and their strength properties**

| Sl. No. | RM (R) | Matrix (M) | Catalyst | Ratio R/M | Temp ($^0C$) | Pressure ($Kg.cm^{-2}$) | Curing time (min.) | TS ($N.m^{-2}$) | EB (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | JN | LC | Control | 1:2 | 120 | 30 | 20 | 120.00 | 1.04 |
| 2. | JN | LC | Boiling + 0.2% TMC | 1:2 | 120 | 30 | 20 | 140.5 | 1.63 |
| 3. | JN | LC | 0.2% TMC | 1:2 | 120 | 50 | 20 | 148.5 | 1.63 |
| 4. | JW | LC | 0.2% TMC | 1:2 | 120 | 50 | 20 | 212.50 | 1.88 |
| 5. | JW | LC | Control | 1:2 | 120 | 50 | 20 | 198.5 | 0.98 |

RM: Reinforcement Materials; LC: Latex Coagulum; JN: Jute Non-woven; JW: Jute woven; TMC: Tetramethyle silane; BP: Benzoyl Peroxide; TS: Tensile Strength; EB: Elongation at break

**Table 4. Swelling characteristics of jute composite**

| Sl. No. | RM (R) | Sample size ($cm^2$) | Catalyst used | Wt. of Sample (gm) | Time of soaking (hr.) | WWA (gm) | WA (%) |
|---|---|---|---|---|---|---|---|
| 1. | JN | 5×5 | BP | 19.0 | 24 | 0.32 | 1.68 |
| 2. | JW | 5×5 | BP | 16.8 | 24 | 0.59 | 3.51 |
| 3. | JN | 5×5 | - | 19.5 | 24 | 0.37 | 1.89 |
| 4. | JW | 5×5 | - | 14.8 | 24 | 0.95 | 6.41 |

RM: Reinforcement Materials; LC: Latex Coagulum; JN: Jute Non-woven; JW: Jute woven; BP: Benzoyl Peroxide; WWA: Wt. of water absorbed; WA: Water absorption

## 4. CONCLUSION

Jute based composites were developed using jute fabric (woven and non-woven) as reinforcing material and the resinous mass of Euphorbia latex (obtained from *E. royleana* latex by solvent extraction process) as well as latex coagulum (containing both the resin and rubber) obtained by dissolving in toluene were used as matrix. Jute composite made from woven as reinforcement and resin isolated from Euphorbia latex or latex coagulum as matrix was found to be better than the jute composite made from jute non-woven fabric as matrix. This may be due to the higher strength characteristic of jute woven fabric compared to jute non-woven. Jute composites made from jute fiber pulp using 1% sulphur along with 1% benzoyl peroxide as coupling agent was found to be of much higher strength compared to composite made from jute non-woven or jute woven fabric as reinforcement under the same condition. To increase the compatibility between the latex and the jute fiber use of 0.2% Silane (di-chlorodimethyl silane) as coupling agent showed better results than the control as well as 2% NaOH pretreated jute. Swelling characteristic of jute composites showed that composites made from woven jute absorbed more water compared to jute nonwoven composite.

**Acknowledgment:**
Authors are thankful to Indian Council of Agricultural Research, India, for funding the A. P. Cess Project and to Haldia Institute of Technology, Haldia-721657, for providing infrastructure facility.

**References:**


[1] A.M. Smith, J. A. Callow, eds., **2006**, *Biological Adhesives*. Springer, Berlin. ISBN 978-3-540-31048-8,

[2] A. Scott, *Chemical week (Sep. 13)*, 2000, **162,** 34, 73.

[3] G. Roymahapatra, P. K. Khatua, **2016**, *Bioplastic: the Green Technology; and concern on biodegradability* [ISBN:978-81-926694-0-3, CHAPTER-18, pp 200-222]

[4] P. K. Khatua, G. Roymahapatra, **2016**, J*ute-bamboo composites as an alternative building material for seismic and cyclone prone (coastal) zone* [ISBN:978-81-926694-0-3, CHAPTER-18, pp 173-189].

[5] D. A. Dabholkar, P. K. Kaicker, H. K. Sikri and R. K. Diwan, *Workshop on petro crops*, Dehradun, India, **1986**, 20.

[6] R. K. Diwan, P. K. Kaicker and D. A. Dabholkar, *Euphorbia laex- its chemistry and industrial applications: Part I*, *Res. Ind.*, **1991**, 36, 126.

[7] U. V. Mallavadhani, K. V. Satyanarayana, A. Mahapatra and A. V. Sudhakar, *Nat Prod. Res.*, **2004**, 18(1), 33.

[8] P. Chaowana, *Journal of Materials Science Research*, **2013**, 2(2), 90.

[9] D. N. Saheb and J. P. Jog, *Adv. Polym. Technology,* **1999**, 18(4), 351.

[10] A. W. C. Lee, X. Bai and A. P. Bangi, *Forest Prod. J.,* **1997**, 47(6), 74.

[11] M. N. M. Yusoff, A. A. Kadir and A. H. Mohamed, *Proceedings of national bamboo seminar I*, Kuala Lumpur, Malaysia, **1994**.

[12] I. M. Sulastiningsih, S. M. Nurwati and S. Kawai, *ACIAR Proceedings No. 107*, Canberra, Australia, **2002**.

[13] U. C. Jindal, *J Composite Mater,* **1986**, (20), 19.

[14] G. Sebe, N. S. Cetin, C. A. S. Hill and M. Hughes, RTM hemp fabric-reinforced polyester composites. *Appl. Comp. Mat*., **2000**, (7), 341.

[15] S. V. Joshi, L. T. Drzal, A. K. Mohanti and S. Arora, *Composite Part-A,* **2004**, 35(3), 371.

[16] P. Naha and S. Sen, *IPIRTI, Research Report No. 131*, **2004**.

[17] S. Luo and A. N. Netravali, *Polym. Comp*., **1999**, (20), 729.

[18] P. K. Khatua, S. Maity, G. Das, S. C. Shahoo and S. C. Bhattacharya, *International Journal of Soft Computing and Engineering*, **2011**, (1), 9.

[19] A. K. Mohanty, M. Mishra, *Polym. Plast. Tech. Engg*. **1995**, (34), 729.

[20] A. K. Mohanty, M. A. Khan, S. Sahoo and G. Hinrichsen, *J. Mat. Sci.,* **2000**, (35), 2589.

[21] *Manual on Jute Composites*, *Indian Jute Industries Research Association, UNDP Jute Program*: (**1992 – 1997**).

[22] A. K. Mohanty, M. Mishra and L. T. Drzal, *J. polm. Env.*, **2000**, (10), 12.

[23] A. K. Mohanty, M. Mishra and G. Hinrichsen, *Macromol. Mat. Engg.* **2000**, (276/277), 1.

[24] S. R. Anantha Krishnan, *Textile Research Journal.* **1988**, (94), 54.

[25] P. Bajpai, '*Biotechnology for Pulp and Paper Processing'*, Springer, New York Dordrecht Heidelberg London, ISBN: 978-1-4614-1408-7 (Print) 978-1-4614-1409-4 (Online)