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Effect of Alkali Treatments on Natural Filler Content Performance of Polymer Composites

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***Abstract*— A study has been carried out to investigate the mechanical properties of alkali treated and untreated coconut shell powder filled content with chopped glass fiber reinforced Hybrid Composites. The mechanical behavior of composites is influenced mainly by the adhesion between matrix and fibers. The chemical modification method was incorporated to improve the fiber–matrix adhesion resulting in the enhancement of mechanical properties of the composites. Effect of filling content treatment on compression strength and also flexural strength and hardness has been investigated experimentally. It has been observed that the compressive properties increases with increase in HCl and H_2SO_4 treated coconut shell powder. The results reveal that the properties of 15 wt. % of HCl – treated filled coconut shell powder composites can be considerably improved by incorporation of glass fibers. The layer sequence has greater effect on hardness. Also for 15 wt. % filled composites of NaOH – treated shows maximum flexural strength compared to other three.**

Keywords*— Coconut shell powder, Polymer matrix, Compressive, Flexural and Hardness properties

1 INTRODUCTION

Bio – composites are much significant today due to growing environmental consciousness. The advantages of natural fibers over synthetic fibers such as glass and carbon are: renewability, manufacturing ease and biodegradability. Natural fibers are being considered as potential reinforcement with both thermoplastic and thermoset matrices. Today, natural fiber composites are widely used in automotive, furniture, construction fields. Natural fiber reinforced polyester composites are being used in the engine and transmission covers of Mercedes – Benz buses. A good combination of mechanical properties and eco – friendliness makes natural fiber composites more attractive. Jute, kenaf, flax, ramie and hemp are widely accepted for their good mechanical properties. Despite having several merits, natural fiber composites show lower modulus, lower strength and poor moisture resistance in comparisons with the composites reinforced with synthetic fibers such as glass and carbon. To overcome these limitations and to obtain a great diversity of material properties, hybrid composites have been conceived wherein two or more fibers are reinforced in a single matrix. In hybrid composites higher performance of synthetic fiber and environmental advantages of natural fibers are combined. Glass fibers are widely used these days with polymer matrices due to their higher strength, light weight, dimensional stability, resistance to corrosion, etc. Several investigators have developed hybrid composites by reinforcing natural fibers with glass fibers and have shown improved properties [1].

Most of the natural fibers and reinforcements used in polymer composites are hydrophilic in nature, whereas synthetic polymers are hydrophobic. Poor adhesion between the natural fibers and polymer matrix often prevents the possibility of natural fibers to act as fillers, resulting in poor dispersion, inadequate reinforcement, and low mechanical properties. Therefore, natural fibers require the addition of coupling agents or the chemical modification for final applications in composite materials [2]. Natural fibers have become alternative reinforcing fillers in various areas of polymer composites due to their advantages over synthetic fibers, e.g. low density, less tool wear during processing, low cost, non-toxic, easy process, environmentally friendly, and biodegradability [3].

Chemical modification of fibers helps to make it less hydrophilic. It is well known that the fiber–matrix interface is crucial to the stress transfer between the two components. Reinforcement of hydrophilic natural fibers into the polymeric matrix leads to a heterogeneous system whose properties are inferior due to poor fiber–matrix adhesion. Chemical treatment or surface modification of fibers improves adhesion between fiber and matrix which is the critical issue to develop advance composites. The treatment of the fibers may be alkali, acetylation, bleaching, grafting of monomer [4].

Although strength and stiffness reduce considerably with the use of discontinuous reinforcements for composite materials in comparison to continuous fibers, there is wide interest in the use of short-fiber. The major advantage obtained with the use of short-fiber reinforced materials is that it can be molded to a much wider variety of shapes than continuous-fiber counterparts. Recently, composites based on short-fibers obtained from agricultural resources are being developed. These fibers are usually of lower density than inorganic fibers, environmental-friendly, and relatively easy to obtain. It is likely that the fibers would not contribute to the wear and tear of polymer processing equipment and may not suffer from size reduction during

processing, both of which occur when inorganic fibers or fillers are used. Lignocellulosic fibers such as jute, sisal, hemp, coir, and banana have been successfully used as reinforcing materials in many thermo set and thermoplastic matrices to study mechanical, thermal, electrical, and wear characterization. Inorganic fiber reinforced composites; the increase in the absolute property is not expected to be nearly as high as inorganic fiber reinforced composites, but the specific properties increases with the use of natural fibers due to the much lower density of the organic fibers. In short-fiber reinforced polymer composites, the integrity of the fiber/matrix interface needs to be high for efficient load transfer. Ideally, the molten polymer would spread over and adhere to the fiber; thus creating a strong adhesive bond. Inorganic fibers like glass and cellulosic fibers have hydrophilic surfaces that make them incompatible with hydrophobic polymers. Therefore, inorganic and cellulosic fibers usually require chemical modification to increase fiber/polymer interaction. In composites, aged fiber composite shows better mechanical properties than fresh fiber composites. The reason is that mechanical properties of composites not only rely upon the fiber strength alone, which is better with fresh fiber, but also on the interfacial adhesion between the fiber and the matrix which assists stress transfer. An attempt has been made in this study to characterize the compressive strength, flexural strength, and hardness behavior of untreated and treated coconut shell powder as a filler reinforced composites [5].

2.1 MATERIALS AND METHODS

2.1 Matrix

Epoxy resin L – 12 with a density of 1.1–1.5 g/cm^3 with hardener K – 6. The matrix material was prepared with a mixture of epoxy and hardener at a ratio of 10:1.

2.2 Reinforcements

Two types of fibers were used in this study to reinforce polymer composite, namely coconut shell powder as natural filler and glass fiber as a synthetic fiber. Compared to synthetic fiber, coconut shell powder has two advantages, light weight and reliability. Coconut shells, locally disposable and available were obtained from local sources and then dried for a week under the sun. During refining, the coconut shell is crushed to produce a large volume of powder. Then the powder is sieved to collect required particle size of 100 – 200 microns. The glass fiber used was in the form of chopped strand mat.

Fig. 1 Coconut shell powder

Fig. 2 Glass fiber

2.2.1 Surface treatment

Alkali treatment of cellulosic fibers, also called mercerization, is the usual method to produce high quality fibers. Alkali treatment improves the fiber-matrix adhesion due to the removal of natural and artificial impurities. Moreover, alkali treatment reduces fiber diameter and thereby increases the aspect ratio. Therefore, the development of a rough surface topography and enhancement in aspect ratio offer better fiber-matrix interface adhesion and an increase in mechanical properties. This increases the number of possible reaction sites and allows better fiber wetting. Treatment of the natural filler was done by soaking in 0.1N molL^{-1} solutions has (NaOH, HCl and H_2SO_4) for 3 hours and followed by washing with deionized water. The treatment has removed wax and fatty substances which has changed the surface morphology [6].

2.3 Preparation of Composites

Hand lay – up process was adopted. Composites were made from Epoxy and hardener taken in the ratio of 100 and 10 parts by weight, respectively. The mould inner surface was coated with a releasing agent to avoid the sticking of the composite with mould and then filled with a mixture of matrix and reinforcements in random orientation with varying fiber content (5, 10, and 15 % by weight) and allowed to cure at room temperature. The cured composites were cut to required size as per ASTM standards.

2.4 Mechanical Testing

Compression and bending tests were carried out as per ASTM standards D 695 and D 790. Hardness test on impact tester (MT-3016, Pendulum type) is used as per ASTM D 6110- 97. Results were taken as the average value of three samples.

3 RESULTS AND DISCUSSION

3.1 Compressive Strength of Composites

Fig. 3 shows the effect of Un – treated filled composite on compressive strength of the different combination composites. Deformation starts in 10% filled content above the 2000N compared to the other two composite combinations. This is due to the proper adhesion of fillers with matrix load materials. As load increases 10% filled composite has get less

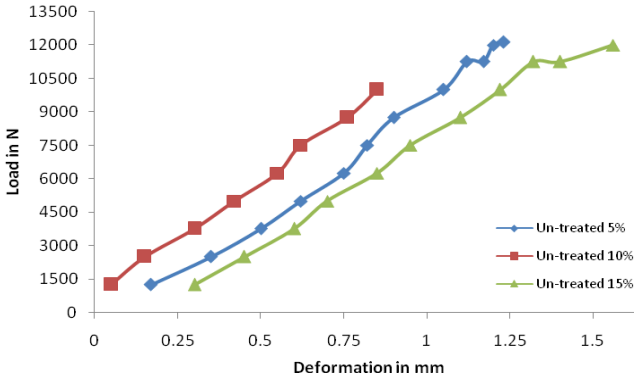

Fig. 3 Influence of Un – treated filled composite on the compressive strength of polymer composites

deformation in comparisons with other two, but 5% filled composite has failed early due to improper bonding of filler.

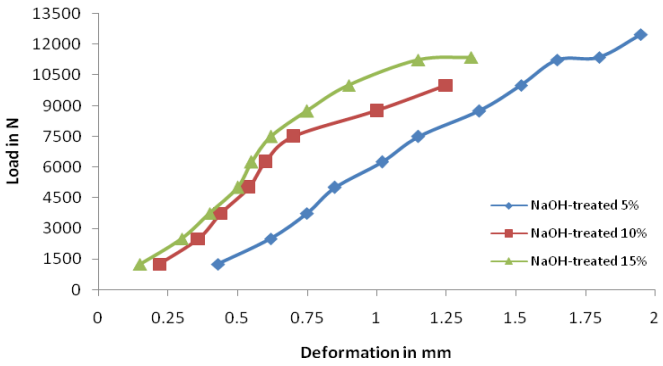

Fig. 4 Influence of NaOH – treated filled polymer composites compressive strength

The Fig. 4 shows the effect of NaOH – treated filled composite on compressive strength for different combination. 15% filled composite deforms faster than 10%. Deformation shows more with 5% filled composite compared to the other two combinations. 5% and 15% filled composites starts deformation early compared to the 10% filled composite, this may be due to the sufficient interfacial adhesion between matrix material and reinforcement. It indicates that the compressive strength of composites decrease with increasing filler content. This result reflects the lack of interfacial adhesion between matrix and fibers which behave like voids in the continuous phase [7]. The lignin and hemicelluloses have been partially removed from natural fiber after NaOH treatment. The NaOH treatment increased hydroxyl group concentration on the fiber, which would provide more active site for fiber – matrix interface [8].

Relation between the load and deformation for HCl – treated different combination composites under compressive test are shown in Fig. 5. It is observed that load bearing capacity of HCl – treated specimen with 5% filled composites is very less Compared to the other two filled composites. Filled composites with 15% composite shows more load bearing capacity than other two composites. This is due to the sufficient of filled composites to interface the matrix of the composites [9]. This is due to the fact that coconut filled

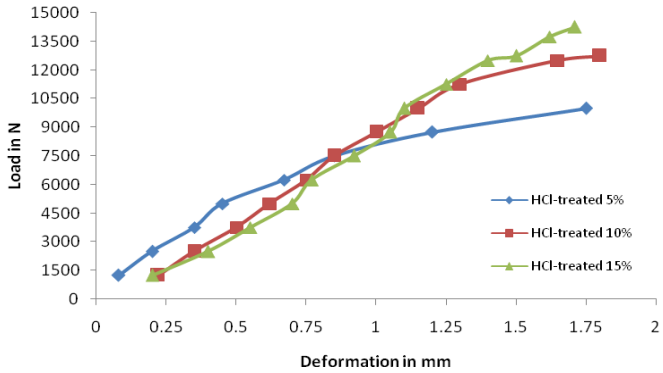

Fig. 5 Influence of HCl – treated filled composite on the compressive strength of polymer composites

particles strengthen the interface of resin matrix and filler materials [10].

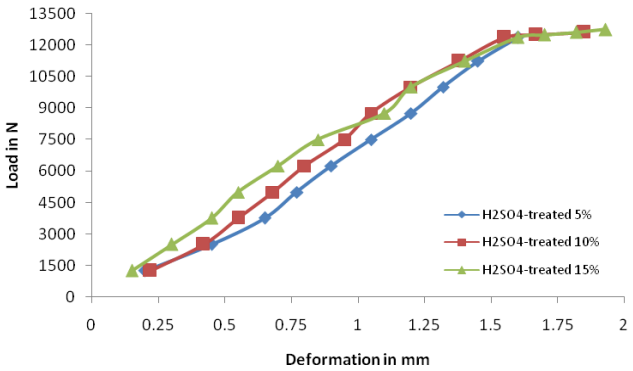

Fig. 6 Influence of H_2SO_4 – treated filled composite on the compressive strength of polymer composites

Fig. 6 shows the compressive strength results of H_2SO_4 – treated filled composites for three different combination composites. As percentage of filler content increases, strength also increases irrespective of treatment. This is due to interface of filler material and resin matrix. This increases the ability of filler to support stress transferred from the matrix.

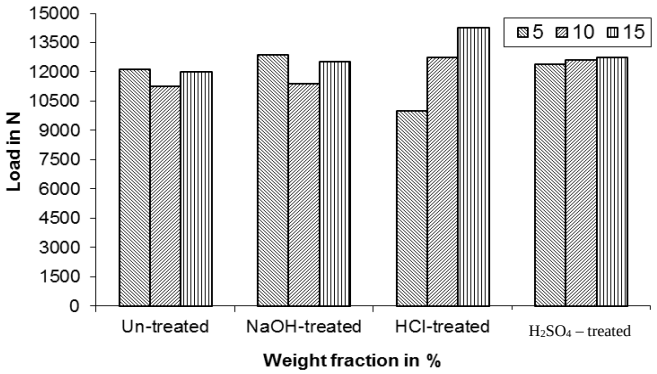

Fig. 7 comparisons of compressive strength of Un – treated and treated filled composites different combination

From Fig. 7 we can see that the compressive strength for the Un – treated and treated filler content different combination composites. Specimen with 5% NaOH – treated filler content shows the maximum strength whereas Un – treated and H_2SO_4 – treated are shows almost same results. But HCl – treated shows very less resistance to elongation compared to the other composites. In 10% filler content specimen the HCl – treated having more load bearing capacity, and H_2SO_4 – treated also shows more are less similar value of strength as compared to the HCl – treated. Here Un – treated showing less strength this is due to in treated filler content the adhesive property between filler and matrix material is more that leads to improve the mechanical properties. In 15% filler content the HCl – treated specimen shows maximum load absorbing capacity compared to the others. From figure it is evident that as filler content increases the compressive strength increases. And also the HCl – treated shows effective alkali treatment on filler content in all composites.

3.2 Flexural Strength of Composites

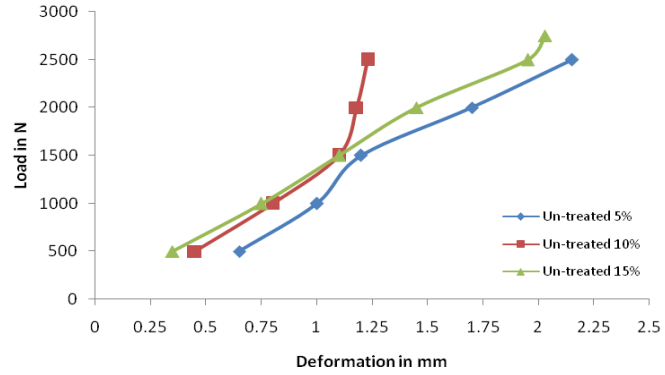

Fig. 8 Flexural Strength versus Deformation for Un – treated filler content

Fig. 8 shows the flexural strength for Un – treated filled composites different combination. It is observed that 15%filled composites are having highest resistance to deformation. The specimen with 5% filled composite has exhibited low flexural strength. At lower concentration of the filler materials, specimen demonstrated slightly nonlinear behaviour leading to sharp failure. This means that specimen deformed plastically immediate after elastic deformation. This increase is due to the relationship between the interface of fillers and matrix in which the fillers strengthen the composite materials. Therefore, the elongation decreases as filler materials reduce the ductility of matrix [10].

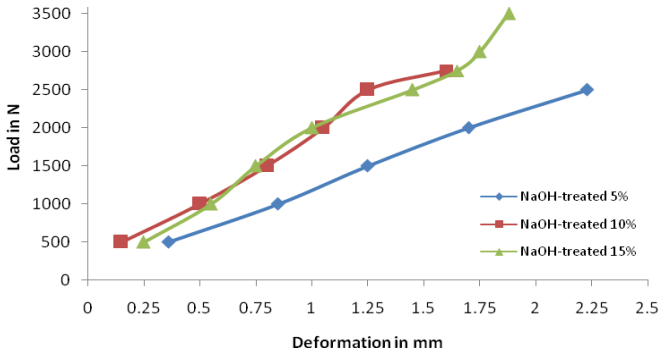

Fig. 9 Flexural Strength versus Deformation for NaOH – treated filler content

Fig. 9 shows that as filled composites increases the strength of the composite also increases. 5% filled composites showing linearity in deformation. Due to decrease in elongation of the filler will be less and there is a strong interfacial bond between the filler and matrix. Crack travel movement is less through the strong interfacial region and hence there is a decrease in elongation. Maximum flexural strength for 15% filled composite in comparisons with (5% and 10%) filler content. At lower concentration of filler material, specimen demonstrated slightly nonlinear behaviour prior to sharp failure or fracture. This is due to plastic deformation of the specimen that has occurred immediately after elasticity [10].

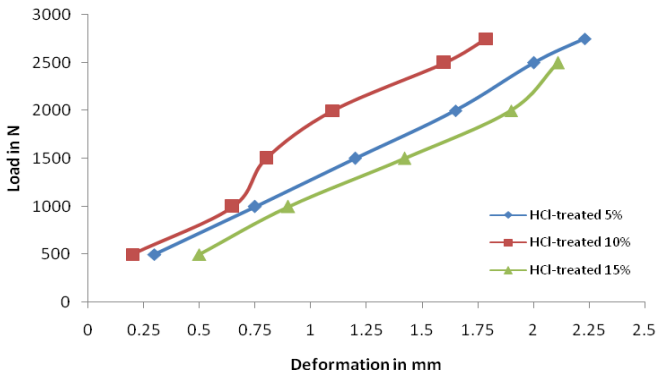

Fig. 10 Flexural Strength versus Deformation for HCl – treated filler content

From Fig. 10 the results of flexural strength for HCl – treated filled composites as the filler increases the strength of the composite also increases.10% filled composites has showed better that of strength compared to 15% filled composite. This is due to the effect of chemical modification on filled composite that leads to the pure adhesive bonding between filler and matrix material. 5% filled composite shows linearity in deformation with load because of the less elongation of the filled composite. This is due to the fact that alkali treatment improves the fiber surface adhesion characteristics by removing natural and artificial impurities, thereby producing a rough surface topography [11].

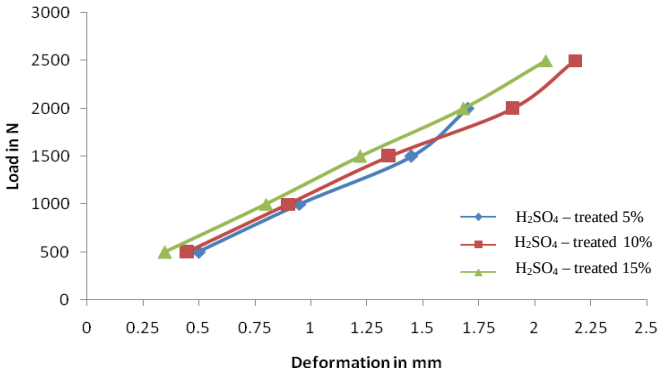

Fig. 11 Flexural Strength versus Deformation for H_2SO_4 – treated filler content

Fig. 11 shows the flexural strength for H_2SO_4 – treated filled composites for three combinations. From figure it can be clearly seen that all three filled composites shows similarity in deformation with load. 15% filled composites shows maximum strength compared to other two fillers. This is due to that as filler content increases the strength also increases. It is also observed that alkali treated 15% filled composite shows superior flexural property than other two fillers. The treatment of filler content improves the adhesion characteristics of coconut shell powder, removing hemicelluloses and lignin. This surface offers better filler – matrix interface adhesion and an increase in mechanical properties.

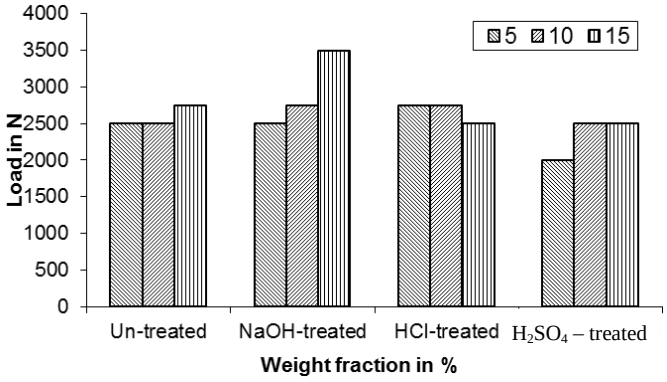

Fig. 12 The effect of flexural strength comparison for Un – treated and treated filled composites

From Fig. 12 it is observed that specimen with 5% filled composite of HCl – treated is having more resistance to Flexural strength than H_2SO_4 – treated. In 10% filled composite the Un-treated and H_2SO_4 – treated are having same load absorbing capacity but for H_2SO_4 – treated is having more deformation compared to Un – treated. NaOH – treated and HCl – treated shows almost same flexural strength. 15% filled composite NaOH – treated is having maximum resistance to elongation compared to other three composites. 15% NaOH – treated filled composite is having maximum resistance to elongation. Chemical treatment with NaOH removes moisture content from the fibers thereby increasing its strength also; it enhances the flexural rigidity of the fibers [12].

3.3 Hardness of Composites

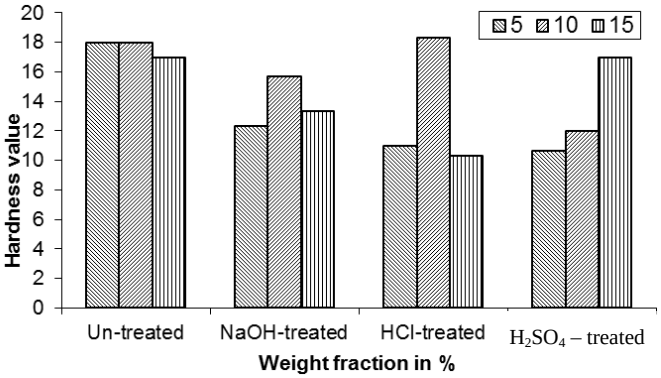

Fig. 13 the comparisons of hardness for Un – treated and treated filled composites

From Fig. 13 it is observed that 5% Un – treated filled composite shows maximum hardness compared to the other 5% treated filled composites, whereas HCl – treated shows less hardness. For 10% filled composite of Un-treated and HCl – treated having almost same hardness value. H_2SO_4 – treated filled composites shows less hardness value. 15% filled composites of H_2SO_4 – treated and Un – treated are having almost same hardness value, but whereas for HCl – treated filled composites has got lesser hardness value. Un-treated filled composites show maximum hardness value than filled one. Alkali treatment improves the adhesive characteristics of coconut shell powder filled composite surface by removing hemicelluloses and lignin, this offers an excellent fiber – matrix interface adhesion and results in the increase in the mechanical properties [13]. Treatment also clears all the impurities that are adjoining to the fiber material and also stabilizes the molecular orientation [12].

4. CONCLUSIONS

Fabrication of chopped glass fiber untreated and alkalized coconut shell powder filler content reinforced epoxy composites have been developed by hand-lay-up techniques. It is observed from the study that there is a significant influence of filler content and treatment on physical and mechanical behavior of composites. The mechanical properties of the treated coconut shell powder filled composites are found to be superior in comparison to those of untreated filled composites. The use of alkalized coconut shell powder and incorporation of chopped glass fiber modifies mechanical characteristics of the composites. Coconut shell particles treated with alkali solutions improve the hardness property of the polymer matrix composite.

REFERENCES

1. Govardhan Goud and R. N. Rao, "Mechanical And Electrical Performance Of Roystonea Regia/Glass Fibre Reinforced Epoxy Hybrid Composites", Bull. Material Science, Vol. 35, No. 4, August 2012, pp 595 – 599, Indian Academy of Sciences.
2. Sun-Young Lee, Sang-Jin Chun, Geum-Hyun Doh And In-Aeh Kang, "Influence of Chemical Modification and Filler Loading on Fundamental Properties of Bamboo Fibers Reinforced Polypropylene Composites", Journal of Composite Materials, Vol. 43, No. 15/2009, 0021-9983/09/15 1639–19, DOI: 10.1177/0021998309339352.
3. Uma Maheswari C., Obi Reddy K., Muzenda E. and Shukla M., "Effect of Surface Treatment on Performance of Tamarind Fiber–Epoxy Composites", International Conference on Innovations in Chemical Engineering and Medical Sciences (ICICEMS'2012), PP 16 – 20, December 26-27, 2012 Dubai (UAE).
4. Jawaid M., and Abdul Khalil H.P.S., "Cellulosic/Synthetic Fibre Reinforced Polymer Hybrid Composites: A Review", Accepted 18 April 201, doi:10.1016/j.carbpol.2011.04.043, Carbohydrate Polymers 86 (2011) 1– 18.
5. Mahapatra S.S. and Vedansh Chaturvedi, "Modelling and Analysis of Abrasive Wear Performance of Composites Using Taguchi Approach", International Journal of Engineering, Science and Technology Vol. 1, No. 1, 2009, pp. 123-135.
6. Girisha C., Sanjeevamurthy and Gunti Rangasrinivas, "Tensile Properties of Natural Fiber-Reinforced Epoxy-Hybrid Composites**",** International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.2, Mar-Apr 2012 pp-471-474, ISSN: 2249-6645.
7. Bujang I.Z., Awang M. K. and Ismail A.E., "Study on the Dynamic Characteristic of Coconut Fiber Reinforced Composites", Regional Conference on Engineering Mathematics, Mechanics, Manufacturing & Architecture (EMARC) 2007, pp.185 – 202.
8. Shubhashini Oza, "Thermal and Mechanical Properties of Recycled High Density Polyethylene/Hemp Fiber Composites", International Journal of Applied Science and Technology, Vol. 1 No. 5; September 2011, pp.31 – 36.
9. Husseinsyah S. and Mostapha Zakaria M., "The Effect of Filled compositeon Properties of Coconut Shell Filled Polyester Composites", Malaysian Polymer Journal, Vol. 6, No. 1, 2011, pp.87 – 97.
10. Sapuan S. M. and Harimi M., "Mechanical Properties of Epoxy/Coconut Shell Filler Particle Composites", The Arabian Journal for Science and Engineering, Volume 28, Number 2B. October 2003, pp.171 – 181.
11. Morsyleide F. Rosa, Bor – sen Chiou, Eliton S. Medeiros, Delilah F. Wood, Tina G. Williams, Luiz H. C. Mattoso, William J. Orts, and Syed H. Imam, "Effect of Fiber Treatments on Tensile And Thermal Properties of Starch/Ethylene Vinyl Alcohol Copolymers/Coir Bio composites", Bio resource Technology 100 (2009) 5196 – 5202, doi:10.1016/j.biortech.2009.03.085.
12. Chandramohan D. and Dr. Marimuthu K. "Tensile and Hardness Tests on Natural Fiber Reinforced Polymer Composite Material", International Journal of Advanced Engineering Sciences and Technologies Vol. No. 6, Issue No. 1, 097 – 104, ISSN: 2230-7818.
13. Ashok Kumar M., Ramachandra Reddy G., Siva Bharathi Y., Venkata Naidu S. and Naga Prasad Naidu V., "Frictional Coefficient, Hardness, Impact Strength, and Chemical Resistance of Reinforced Sisal – Glass Fiber Epoxy Hybrid Composites", Journal of Composite Materials Online First, published on pp.1 – 8, September 3, 2010 as DOI: 10.1177/0021998310371551.