Khan et al., J Material Sci Eng 2016, 6:1
DOI: 10.4172/2169-0022.1000300

Journal of Material Sciences & Engineering

Research Article Open Access

Synthesis of Alumina Fibre by Annealing Method using Coir Fibre

Khan A[1]*, Ahmad MA[2], Joshi S[1] and Lyashenko V[3]

[1]Department of Physics, Motilal Vighyan Mahavidhyalaya, Bhopal, India
[2]Department of Physics, Faculty of Science, University of Tabuk, Saudi Arabia
[3]Laboratory "Transfer of Information Technologies in the Risk Reduction Systems", Kharkov National University of Radioelectronics, Kharkov, Ukraine

Abstract

The present study report the synthesis of alumina fibre by annealing method using coir fibre. In this study chemical treatment of coir fibre has been done using a nitro compounds at higher temperature. The composite formed after the chemical treatment has been characterized by Xrd, SEM and FTIR technique. Successful synthesis of alumina fibre has been confirmed after the chemical treatment of coir fibre.

Keywords: Coir; Annealing; Nitro compound; Alumina fibre

Introduction

Currently scientist are showing ardent attention in synthesizing composites from recycled waste specially by means of the natural environment-friendly fibres as reinforcing fillers and thermosetting polymers as matrix [1]. Natural fibres play a vital role as fillers in the fabrication of composites. The use of these fibres is beneficial not only as biodegradable substance but also it affects the cost of composite and also boost life of the composites. Natural fibres are being used as a reinforcing agent in place of synthetic fillers such as glass, aramid, talc, and silica; as they are having low density and they do not leave any by-product at the time of manufacture of composites as they are bio-degradable in nature. Also, processing of these fibres can be done at low temperature and thus may play an essential role in energy consumption for the production of composites [2-9]. Natural fibres has been used as reinforcing agent in polymer composites and becomes the point of attention and attraction among several researchers during last many years owing to their easy accessibility and biodegradable nature [3,4].

As natural fibres are having low density so they can be used, easily available, renewable and biodegradable in nature. Natural fibres (NFs) have provided raw materials to meet the human requirements of fibres in their life. The first utilization of natural fibre composite (NFC), made with clay in Egypt, can be dated back to 3000 years ago. With the high-tech developments of man-made fibres, NF lost much of its interest and many of the ancient natural fibres are no longer in use. However, as a result of a growing awareness of the interconnectivity of global environmental factors, the principles of sustainability, industrial ecology, eco-efficiency, and green chemistry and engineering are being integrated into the development of the next generation of materials, products, and processes. Though their use as a reinforcing agent is strongly reduced because of their hydrophobic nature, their tendency to amass at the time of processing and their poor resistance to moisture [10]. Chemical treatments has been done for treating natural fibres as the bonding between the fibre and matrix can be improved by physical and chemical modification of fibre surface. A study has been done to show the effect of chemical treatment on the structure and morphology of coir fibre [5]. The present study shows some important effects of chemical treatment on the structure and morphology of coir fibre. The objective of the present study is to optimise overall properties of coir fibre so as to use coir fibre as a reinforcing agent in thermoplastic and thermosetting polymers. In the present study, coir fibre is treated with ferric nitrate salt. A thermal treatment has been done at temperature of 1000°C by using annealing method. X-ray diffraction of the treated coir fibre reveals the crystalline nature of the fibre. Change in morphology has been found in coir fibre when subjected to scanning electron microscopy. Finally, the Fourier transform and infrared spectrographs show the presence of traces of iron oxide:fibre in the prepared composite.The present study deals with the chemical treatment of coir fibre at higher temperature by nitro compounds and the synthesis of alumina fibre after the treatment of coir fibre has been done using coir fibre.

Materials and Method

In the present study chemical treatment of coir fibre has been done with aluminum nitrate salt in order to find the change in the structure and morphology of fibre embedded composites.

Processing of coir fibre

The fibre used for the experimental studies was kept dipped in water for 24 hours and then washed so as to remove impurities like dust etc. On drying in direct sunlight chemical treatment as under was given to it [11].

Chemical treatment of coir fibre

Chemical treatment done by aluminum nitrate salt: Aluminium nitrate [Nonahydrate, Extra pure, $Al(NO_3)_3.9H_2O$] and ammonium chloride (NH_4Cl) salts were used for the chemical treatment of the fibre. The coir fibre used was collected from the Temples of Bhopal city.

Process - In 500 ml of distilled water dissolved aluminum nitrate salt and ammonium chloride salt in the proportion of 10:4 respectively. 100 g of fibre was kept in this solution and then 100 drops of ammonia was poured to it and left it for one hour. After one hour the mixture was dried for 48 hours at room temperature and then annealed the mixture in a muffle furnace at 1000°C. The fired mixture was kept for 15 minutes at that temperature [11].

The scanning electron microscopy of the untreated coir fibre and

***Corresponding author:** Khan A, Department of Physics, Motilal Vighyan Mahavidhyalaya, Bhopal, India, Tel: 07552551460; E-mail: khanalveeera@gmail.com

Received August 11, 2016; **Accepted** November 10, 2016; **Published** November 20, 2016

Citation: Khan A, Ahmad MA, Joshi S, Lyashenko V (2016) Synthesis of Alumina Fibre by Annealing Method using Coir Fibre. J Material Sci Eng 6: 300. doi: 10.4172/2169-0022.1000300

chemically treated coir fibre was carried out by JSM 6390A (JEOL Japan) at different magnifications. Gold coating was done on the samples by gold coating unit before taking it for examination. Figures 1a-1b show the pictorial view of crushed raw coir fibre and chemically treated coir fibre. One can notice from the figures that there is change in the morphology of coir fibre embedded composites by chemical treatment done on it. The Scanning Electron pictographs of crushed to powder form of raw coir fibre shows needle shaped structure at small intervals. It is clear that after chemical treatment of coir fibre done by aluminum nitrate salt the composite material appeared to be in fibrous form and the composite is said to be synthesized alumina fibre as the presence of alumina has been confirmed by Xrd of the composite using coir fibre as template. Similar work has been done by Khan et al., [12] in which synthesis of gamma alumina fibre has been done by bio-replica technique using sisal fibre as template.

X-Ray Diffraction Analysis

The XRD measurements were done with the help of Bruker D8 Advance X-ray diffractometer. The X-rays used had wavelength of 0.154 nm (Cu-Kα), produced in a sealed steel tube.

The diffracted X-rays were detected by a fast counting detector based on silicon strip technology (Bruker Lynx Eye Detector). Measurements of diffraction parameters of the samples were carried out in the range from 5° to 70° (of 2θ) at a scanning rate of 1°/min from Figure 2. it is clear that after the chemical treatment of coir fibre by aluminium nitrate salt, the XRD peaks were obtained at 2θ values of 10.60°, 20.06°, 25.44°, 32.82°, 37.00°, 39.48°, 45.72°, 61.08° and at 67.04°. These indicated the extent of crystallinity of the composite. The XRD peaks resembled with the peaks obtained for alumina. Hence we can expect the presence of Al_2O_3 in the composites. The peaks corrosponds to 20.06°, 37.00°,45.72° and 67.04° resembled the peaks of γ-alumina as Sivadasan et al., [13] reported similar peaks of γ-alumina in their work of synthesis of γ-alumina. They inferred from the studies done by microwave assisted hydrolysis of aluminum metal. While the peaks at 39.48° resembled the peak of α-alumina as is reported by Hong et al., [14] in their work in which they prepared the precursor sol of alumina by sol gel method by taking aluminum nitrate and malic acid as raw materials [14]. Similar peaks of α-alumina and γ-alumina found by Guerro et al., [12] fired at 1000°C in their work in which synthesis of γ-alumina fibre has been done using sisal fibre as template [12]. Similar results have been found by other scholars too [15,16]. As the composite material consists of phases of α-alumina and γ-alumina so the resultant composite may be considered as alumina [12-14].

The XRD peaks of composites with raw coir are shown in Figure 3. It shows a peak at 12.9° while after chemical treatment of coir fibre by aluminium nitrate, there is a shift in the peak of coir fibre which is seen at 10.66° after the treatment. Thus, it is obvious from the above discussion that the cystallinity of composites made from coir fibre are affected on chemical treatment. It may thus be said that presence of coir fibre along with the synthesis of alumina affects the crystallanity

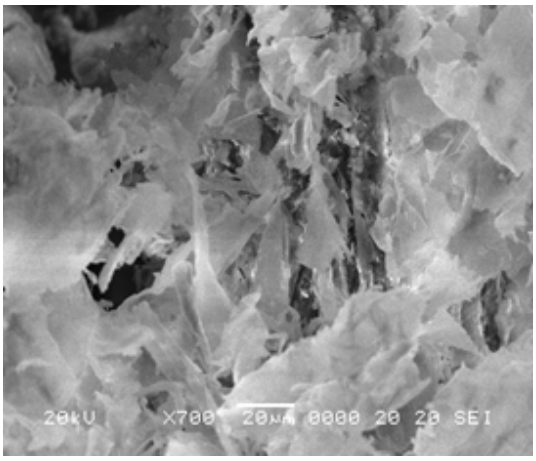

Figure 1a: Crushed Raw Coir Fibre.

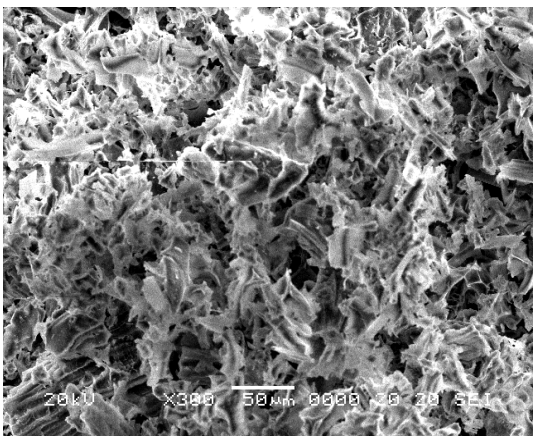

Figure 1b: Synthesized Alumina Fibre.

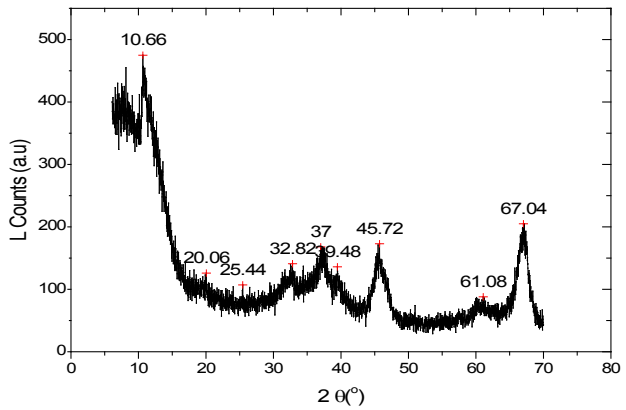

Figure 2: XRD pattern of Alumina (chemical treatment done by aluminum salt).

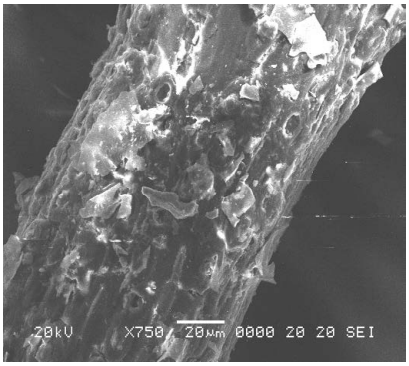

Figure 3: XRD of Raw Coir Fibre.

of the final composites. The change in the *d* value in composites with coir fibre after chemical treatment may be due to the carbonization of coir fibre.

FT-IR analysis was done for our samples. The results are shown in Figure 4. The 3446 cm^{-1} broad intense peak, in raw coir fibre included sample is due to the O-H stretching for hydrogen-bonded hydroxyl group present in polysaccharides. The broad, strong band emanates from cellulose, hemi-celluloses and lignin present in coir fibre. The weak intensity peak occurring at 1386 cm^{-1} in raw coir fibre used sample may be due to the presence of hemi-celluloses. It can be assign to the group of C = O stretching bonds. However, the broad intense peak at 1049 cm^{-1} is the absorption peak of (C-OH) bonds. The peak at 2928 cm^{-1} refers to alkyl C-H group. The peak at 2359 cm^{-1} refers to the presence of water. The peak at 1633 cm^{-1} in composites with raw coir is due to the C = C aromatic skeletal ring-vibration, which is most likely due to the presence of lignin[17-19].

FT-IR response is as shown in Figure 5. The FT-IR study reveals that the peak 3446 cm^{-1} shifts to 3517 cm^{-1} and becomes narrower. It suggests that after the chemical treatment to the fibre, the peak gets narrower due to the reduction of O-H bond, and is shifted due to partial removal of lignin, cellulose and hemi-cellulose. Similar results have been reported by one of the authors of our laboratory [18]. After the chemical treatment the peak at 1633 cm^{-1} in composite formed from raw coir fibre, shifts to 1636 cm^{-1}. Hence chemical treatment on fibre can be assumed to be responsible to this kind shift due to structural change.

The other cause can be removal of lignin on chemical treatment.

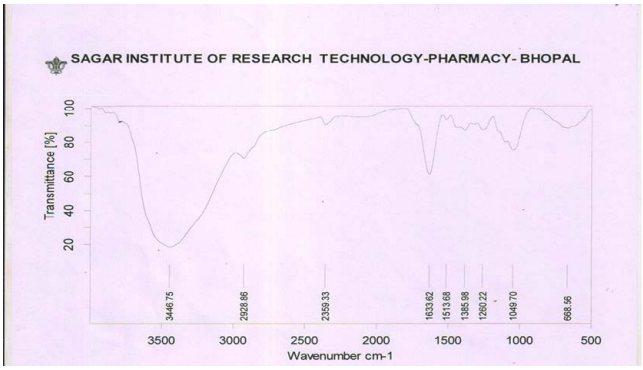

Figure 4: FT-IR of Raw Coir.

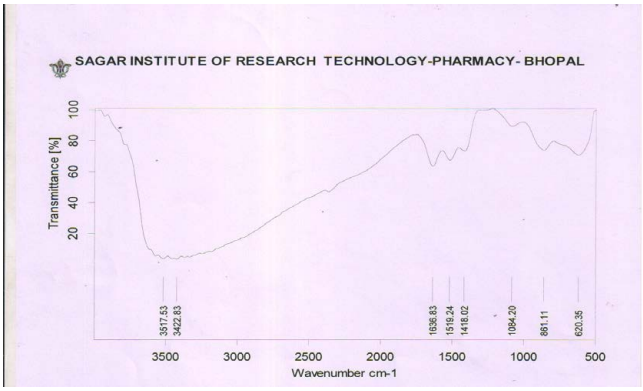

Figure 5: FT-IR of Chemically treated coir fibre.

However, the broad intense peak at 1049 cm^{-1} shifts to 1084 cm^{-1} and becomes narrower due to absorption of (C-OH) bond. However, the peak at 1418 cm^{-1} refers to Al-OH bonding mode [15,20,21], while the peak at 620 cm^{-1} and at 861 cm^{-1}, suggests the presence of stretching mode of Al-O-Al [21,22].

From the above study it is clear that there can be a trace of coir fibre in the sample (may be in oxidized form), which might be carbonized coir fibre, that causes succinct removal of impurities present in the fibre. However the peaks at 1418 cm^{-1}, 620 cm^{-1} and at 861 cm^{-1} suggest probable presence of Al_2O_3 in the sample. So, it can be inferred that there has been successful synthesis of Alumina, Al_2O_3 fibre by annealing method.

Results and Discussions

Present study was carried out with a primary objective of undertaking chemical treatment to coir fibre, to use a waste product by nitro-composites in order to synthesize metal-oxides and to convert a non-degradable waste product into useful product for the welfare of the society. It was specifically done in order to improve the structure and morphology of coir fibre composites. It, in future, can be used as a good replacement of synthetic fibre in polymers. Some more details are given in our recent publications [23-28]. The important findings of the present investigation are as follows:

Satisfactory modification in the morphology of the coir fibre was noticed. The newly formed composites results in the form of alumina fibre may be used in polymers as fillers in place of synthetic fibres so as to monitor the properties of polymers to our advantage. Crystalline nature of the newly synthesized composites by chemically treated coir fibre may help in synthesizing of different composite by different permutations in further studies.

Conclusions

Chemical treatment prior to composite synthesis is an effective method which is very likely to change the morphology of coir fibre. The treatment done by nitro compounds improves the surface coarseness of the surface of coir fibre in contrast to untreated coir fibre composites. It is clear that after chemical treatment of coir fibre done by aluminum nitrate salt the composite material appeared to be in fibrous form while powdered form of raw coir fibre shows needle shaped structure at small intervals

The XRD studies reveal the crystallinity of the resulting composites. The composite formed by the treatment of aluminium nitrate salt is crystalline in nature. Similar peaks of α-alumina and γ-gamma alumina was found in the composite material so the resultant composite may be said to be alumina. So, it can be concluded that when coir fibre is treated with aluminum nitrate, alumina fibre is found after the treatment.

FT-IR study done on chemically treated coir fibre (treatment was done by aluminum nitrate) showed traces of coir fibre which may be in the form of carbonized coir fibre. There are various samples in which there was progressive removal of impurities with each successive treatment on the fibre. However, the peaks obtained at 1418 cm^{-1}, 620 cm^{-1} and 861 cm^{-1} suggest the presence of Al_2O_3 in the sample. As a result it can be inferred that the synthesis of alumina (Al_2O_3) was successful by annealing.

References

1. Son J, Kim HJ, Lee PW (2001) Role of paper sludge particle size and extrusion temperature on performance of paper sludge–thermoplastic polymer composites. J Appl Polym Sci 82: 2709-2718.

2. Choi NW, Mori I, Ohama Y (2006) Development of rice husks–plastics composites for building materials. Waste Manage 26: 189-194.
3. Zeng Z, Ren W, Xu C, Lu W, Zhang Y, Zhang Y (2010) Maleated natural rubber prepared through mechanochemistry and its coupling effects on natural rubber/ cotton fiber composites. J Polym Res-Taiwan 17: 213-219.
4. Thwe MM, Liao K. (2002) Effects of environmental aging on the mechanical properties of bamboo–glass fiber reinforced polymer matrix hybrid composites. Compos Part A-Appl S 33: 43-52.
5. Yang HS, Kim HJ, Son J, Park HJ, Lee BJ, et al. (2004) Rice-husk flour filled polypropylene composites; mechanical and morphological study. Compos Struct 63: 305-312.
6. Rana AK, Mandal A, Bandyopadhyay S (2003) Short jute fiber reinforced polypropylene composites: effect of compatibiliser, impact modifier and fiber loading. Compos Sci Technol 63: 801-806.
7. Karmarkar A, Chauhan SS, Modak JM, Chanda M (2007) Mechanical properties of wood–fiber reinforced polypropylene composites: Effect of a novel compatibilizer with isocyanate functional group. Compos Part A-Appl S 38: 227-233.
8. Haque MM, Rahman R, Islam MN, Huque MM, Hasan M (2009) Mechanical properties of polypropylene composites reinforced with chemically treated coir and abaca fiber. J Reinf Plast Comp
9. Rimdusit S, Wongsongyot S, Jittarom S, Suwanmala P, Tiptipakorn S (2011) Effects of gamma irradiation with and without compatibilizer on the mechanical properties of polypropylene/wood flour composites. J Polym Res 18: 801-809.
10. Choudhury A, Kumar S, Adhikari B (2007) Recycled milk pouch and virgin low-density polyethylene/linear low-density polyethylene based coir fiber composites. J Appl Polym Sci 106: 775-785.
11. Khan A, Joshi S (2014) Mechanical and Morphological Study of Coir Fiber Treated with Different Nitro Compounds. International Journal of Advancement in Electronics and Computer Engineering 2: 276-279.
12. Alveera K, Mohammad A, Shirish J, Lyashenko V (2015) Dielectric and Electrical Characterization Study of Synthesized Alumina Fibre Reinforced Epoxy Composites. Elixir Crystal 87: 35801-35805.
13. Sivadasan AK, Selvam IP, Potty SN (2010) Microwave assisted hydrolysis of aluminium metal and preparation of high surface area γ Al2O3 powder. B Mater Sci 33: 737-740.
14. Hong-bin T, Congsheng G (2011) Malic acid sol-gel method of long alumina fibers. Transactions of Non Ferrous Metals Society of China 21: 1563-1567.
15. Sedaghat A, Taheri-Nassaj E, Naghizadeh R (2006) An alumina mat with a nano microstructure prepared by centrifugal spinning method. J Non-Cryst Solids 352: 2818-2828.
16. Hosseini SA, Niaei A, Salari D (2011) Production of γ-Al_2O_3 from Kaolin. Open Journal of Physical Chemistry 1: 23-27.
17. Choudhury R (2012) Fabrication and characterization of raw and dewaxed coir fiber reinforced polymer composites. Doctoral dissertation, National Institute of Technology Rourkela.
18. Samal N(2012) Fabrication and characterization of acetone treated natural fibre reinforced polymer composites. Department of physics, National Institute of Technology.
19. Zuraida A, Norshahida S, Sopyan I, Zahurin H (2011) Effect of fiber length variation on coir fiber reinforced cement–albumen composites. IIUM Engineering Journal 12: 63-75.
20. Chandradass J, Balasubramanian M (2006) Sol–gel processing of alumina fibres. Journal of Materials Processing Technology 173: 275-280
21. Tan H, Ma X, Fu M (2013) Preparation of continuous alumina gel fibres by aqueous sol–gel process. B Mater Sci 36: 153-156.
22. Padmaja P, Anilkumar GM, Mukundan P, Aruldhas G, Warrier KGK (2001) Characterisation of stoichiometric sol–gel mullite by fourier transform infrared spectroscopy. Int J Inorg Mater 3: 693-698.
23. Alveera Khan M, Ahmad A, Shrish J, Abd. El-Khalek AM (2013) Study of Mechanical and Electrical Behavior of Chemically Treated Coir Fibre Reinforced Epoxy Composites. Int J of Multidisciplinary Research & Advcs in Engg 5: 171-180.
24. Khan A, Ahmad MA, Joshi S, Al Said SA (2014) Abrasive wear behavior of chemically treated coir fibre filled epoxy polymer composites. Amer J of Mech Eng and Auto 1: 1-5.
25. Ahmad MA, Lyashenko VV, Lyubchenko VA, Khan A, Kobylin OA (2016) The Methodology of Image Processing in the Study of the Properties of Fiber as a Reinforcing Agent in Polymer Compositions. Int J of Adv Res in Computer Science 7: 15-18.
26. Khan A, Ahmad MA, Joshi S (2015) A systematic study for electrical properties of chemically treated coir fiber reinforced epoxy composites with ANN model. Int J of Sci and Res 4: 410-414.
27. Alveera KS, Vyacheslav JL, Nicolina P, Ayaz Ahmad M(2015) Artificial Neural Networking (ANN) Treatment on Electrical Properties of Coir Fiber Reinforced Epoxy Composites. Saudi International Meeting on Frontiers of Physics 17-19.
28. Agag T, Takeichi T (2003) Synthesis and characterization of novel benzoxazine monomers containing allyl groups and their high performance thermosets. Macromolecules 36: 6010-6017.