ISSN: 0971-1260

Vol-22-Issue-16-August-2019

Comprehensive Review on Water Absorption and Thermal Properties Evaluation of Plant Fibers Reinforced Composites

J. Ronald Aseer[1*], S. Renold Elsen[2], Subhash[1], Sankaranarayanasamy[3]

[1]School of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab, India
[2]School of Mechanical Engineering, VIT University, Vellore, Tamil Nadu, India
[3]Dept. of Mechanical Engg, National Institute of Technology Puducherry, Karaikal, India
[*]Corresponding Author: Tel: +91-9818510793, Email address: ronald.25014@lpu.co.in

Abstract

Natural fibre used as reinforcement agents for manufacturing composites due to their costless ad environmental advantage. In this review, the water absorption and thermal properties are discussed. Water absorption properties such as diffusivity, sorption and permeability are detailed. Thermal properties like thermal diffusivity, specific heat and thermal conductivity values are required for manufacturing composite material. These properties vary with fibre content. Electro kinetic, wetting and moisture properties of different natural fibre are characterized. Theoretical thermal conductivity characteristics are discussed. A comprehensive literature review has been carried out in the area water absorption and thermal properties of natural fiber.

1. Introduction

Lignocellulosic characteristic strands are exceptionally hydrophilic because of the nearness of hydroxyl bunches in cellulose and lignin. Joining of cellulose fiber into polymer matrix improve the water absorption properties. It is accounted for that a lignocellulosic material retains water by framing H-bonds among water and hydroxyl gatherings of hemicellulose, lignin and cellulose [1]. The retention of water happens through cross sectional zone of the composites. The cross connected thermoset matrices won't allow water into it. The retention of water happens through the interfaced and cross sectional area of the fiber by capillary device [2]. Some studies have been conducted to analyze the water absorption properties of composites. Mathew contemplated the dispersion and transport properties of styrene through crosslinked regular elastic (NR) at different temperatures. The impact of temperature on the sorption has been determined. The water take-up is lower in peroxide system. The nearness of inflexible C-C linkages and high crosslink thickness of peroxide system is liable for the least water take-up [3]. Lin contemplated the dampness retention and mechanical properties of wood flour occupied polypropylene composites in aqueous conditions. The level of dampness retention was reliant on the change of the matrix, weight rate, work measure and surface behavior of wood flour [4].

2. Kinetics of Water Absorption

Comprehensive examination on the impact of chemicals and hybridization process with glass strands on the water sorption energy of oil palm fiber fortified phenolic composites was done by

Sreekala et al. Chemical treatment reduced the sorption characteristics of composites [5]. Swelling of linseed oil reinforced polymers was studied by [6]. The vehicle condition indicated the non-Fickian trend in polymers. The coefficient of dispersion in cationic examples diminishes with an expansion in oil substance. The coefficient of diffusion increased to 30% oil substance and diminished. Sreekumar broke down the impact of the morphology on mechanical and water assimilation attributes of sisal fiber added polyester composites. It is uncovered that water retention is low for the treated fiber-fortified composites at all temperatures contrasted with untreated [7]. The surface treatment process of bamboo atoms on water immersion properties of poly vinyl chloride composites was carried out [8]. The impact of change with three sorts of chemical treatment operator, for example, alkali, silica and oxidant was inspected. Alkali treatment brought down the substance of hemicelluloses in bamboo particles and along these lines decreased water retention. Water absorption properties of kenaf fiber reinforced polyester laminates was analyzed [9]. Water absorption increases due to the increasing numbers of hydrophilic fibers. The thickness of composite is increased with addition of fiber volume fraction. Kakroodi investigated addition of tire rubber on mechanical, water absorption, rheological and morphological properties of maleate polyethylene-hemp composites. Addition of hemp percentage increases the water uptake and requires lengthier saturation time [10].

3. Thermal Properties of Polymer Composites

Fiber reinforcement polymer composites are mentioned as attractive materials for the domestic appliances like air coolers and air conditioners etc to decrease the energy consumption. Natural fibers are added with polymers to decrease the thermal conductivity properties of composites. Studies conducted to analyze the thermal properties of composites are reported. Mechanical property and thermal property of particle sheet made from ranch residues were determined [11]. The result shown that particle sheet made from paddy straw and had a less value of thermal conductivity and high value of groundnut-shell sheet. Thermal conductivity was varying linearly with density. Thermal diffusivity reduced with increase in density value of the particle sheets. The thermal properties of sisal/glass fiber reinforced polyethylene (GRP) were evaluated [12]. It was observed that the thermal conductivity increased with temperature. The improved thermal conductivity of glass is due to the presence of ferrous ions. The difference of thermal diffusivity with temperature was decreased due to reduction in the mean free path of phonons.

Agarwal broke down the variety of thermal properties of the banana fiber reinforced polyester composites brought about by expansion of glass fiber. Results indicated that thermal property of banana fiber strengthened polyester composite is high when contrasted with the polyester lattice. Be that as it may, expansion of glass fiber diminishes the thermal conductivity of the composites [13]. Idicula analyzed that thermal conductivity of treated fiber composite is 43% higher than raw fiber of sodium hydroxide. The treatment reduces all non-cellulosic content. Some pores are formed on the fiber surface due to the dissolution of lignin by alkali treatment which increases the surface area between the fiber and matrix [14]. Thermo physical properties of the composites as a component of banana fiber stacking and for different chemical treatment were broke down [15]. It was indicated that thermal conductivity properties and thermal diffusivity properties reduce with fiber load. Treated banana fibers increased thermo physical properties of fiber composites. The thermal conductivity, specific heat and diffusivity of flax fiber reinforced high thickness polyethylene (HDPE) composites were explored [16]. It was understood that specific heat, thermal conductivity and diffusivity diminished with expanding fiber content. Yet, thermal

ISSN: 0971-1260

Vol-22-Issue-16-August-2019

properties didnot change through temperature. In any case, the specific heat of the bio-composites expanded steadily through temperature. Panyakaew and Fotios delivered low thickness thermal protection sheets produced using coconut husk and bagasse deprived of the utilization of concoction restricting added substances. The density impact and squeezing parameters on properties of the protection sheets were investigated. Thermal property of the bagasse and coconut husk was estimated and announced that both protection sheets have low thermal conductivity which were compared with cellulose strands and mineral fleece [17].

Substance change as a zein covering was applied to the flax. Expansion of fiber content in polypropylene grid brought about a decline of thermal properties of composites. Chemical treatment of flax fiber diminished the thermal conductivity and thermal diffusivity of treated fiber composite. This was because of expanded bond which prompted decline in speed and mean free way of phonons [18]. The influence of chemical modifications of the banana fiber for mechanical properties of the Polypropylene composites was analyzed [19]. The studies revealed that coarser fiber topography is formed due to the removal of lignin and other content. Ramanaiah developed partially bio degradable sansevieria fiber reinforced polyester composites. Addition of fiber increases the thermal properties. Also, there was a decrease in thermal properties with increase of temperature [20]. Thermal corruption of composites can be contemplated through Thermo-gravimetric investigation (TGA). TGA curves were dissected the Thermal corruption of PLA/bamboo fiber composite and PBS/bamboo fiber composite and its parts [21]. The composites with bamboo fiber have lower corruption temperature than the raw polymers. It was discovered that unbleached fiber composites began to deteriorate sooner than faded fiber composites. Lignin and hemicellulose substance diminished with fading in this manner bolsters the expansion in thermal stability [22, 23].

3. Theoretical Thermal Conductivity Models

Theoretical and mathematical model used to determine the thermal conductivity of composites. This section argued the applicability of various models which act to be extra capable [24, 25]. For a two-segment composite, either parallel or series arrangement concerning heat stream gives the upper or lower limits of thermal conductivity. Mathematical models were established to predict the thermal conductivity of short natural fibers [26, 27]. Maxwell examined the successful thermal conductivity of heterogeneous materials. The powerful thermal conductivity of an arbitrary suspension of circles inside a nonstop medium was dictated by utilizing Laplace's condition. These thermal conductivity models accept that the atoms are adequately far separated that the potential round every circle won't be impacted by the nearness of different particles [28].

4. Summary

Hydrophobic and hydrophilic properties of natural fibres with different polymers are discussed. The effect of impact temperature on the sorption, diffusivity and permeability has been considered. The level of dampness retention was reliant on the change of the matrix, weight rate, work measure and surface behavior of wood floor. It found that chemical treatment reduced the sorption characteristics of composites. Water absorption increases due to the increasing numbers of hydrophilic fibers of kenaf fibre. Due to these properties, thickness of composite is increased with addition of fiber volume fraction. Improve in hemp contented increases the water uptake and require lengthier saturation time. Natural fibers are added with polymers to decrease the thermal properties of fiber composites. Studies conducted to analyze the thermal properties of fiber composites are reported. Thermal conductivity was varying linearly with density. Thermal diffusivity reduced with increase in density value of the particle sheets. Thermal conductivity of composite decreased with addition of fiber ratio. Also, there was reduced in thermal conductivity with increase of temperature.

References

[1] H. D. Rozman, R. N. Kumar, M. R. M. Adlli, A. Abusamah, and Z. A. Mohd Ishak, “The effect of lignin and surface activation on the mechanical properties of rubberwood-polypropylene composites,” J. Wood Chem. Technol., vol. 18, no. 4, pp. 471–490, 1998.

[2] G. Andreopoulos and P. A. Tarantili, “Water sorption characteristics of epoxy resin-UHMPE fibers composites,” J. Appl. Polym. Sci., vol. 70, no. 4, pp. 747–755, 1998.

[3] A. P. Mathew, S. Packirisamy, M. G. Kumaran, and S. Thomas, “Transport of styrene monomer through natural rubber,” Polymer (Guildf)., vol. 36, no. 26, pp. 4935–4942, 1995.

[4] Q. Lin, X. Zhou, and G. Dai, “Effect of hydrothermal environment on moisture absorption and mechanical properties of wood flour-filled polypropylene composites,” J. Appl. Polym. Sci., vol. 85, no. 14, pp. 2824–2832, 2002.

[5] M. S. Sreekala, M. G. Kumaran, and S. Thomas, “Water sorption in oil palm fiber reinforced phenol formaldehyde composites,” Compos. - Part A Appl. Sci. Manuf., vol. 33, no. 6, pp. 763–777, 2002.

[6] V. Sharma, J.S. Banait and P.P. Kundu,“Swelling Kinetics of Linseed Oil-Based Polymers,” J Appl Polym Sci., vol. 111, pp. 1816–1827, 2009.

[7] P. A. Sreekumar, S. P. Thomas, J. marc Saiter, K. Joseph, G. Unnikrishnan, and S. Thomas, “Effect of fiber surface modification on the mechanical and water absorption characteristics of sisal/polyester composites fabricated by resin transfer molding,” Compos. Part A Appl. Sci. Manuf., vol. 40, no. 11, pp. 1777–1784, 2009.

[8] H. Wang, K. C. Sheng, T. Lan, M. Adl, X. Q. Qian, and S. M. Zhu, “Role of surface treatment on water absorption of poly(vinyl chloride) composites reinforced by Phyllostachys pubescens particles,” Compos. Sci. Technol., vol. 70, no. 5, pp. 847–853, 2010.

[9] S. Rassmann, R.G. Reid and R. Paskaramoorthy, “Effects of processing conditions on the mechanical and water absorption properties of resin transfer moulded kenaf fibre reinforced polyester composite laminates,” Compos Part A, vol. 41, pp. 1612–1619, 2010.

[10] A. Ramezani Kakroodi, Y. Kazemi, and D. Rodrigue, “Mechanical, rheological, morphological and water absorption properties of maleated polyethylene/hemp composites: Effect of ground tire rubber addition,” Compos. Part B Eng., vol. 51, pp. 337–344, 2013.

[11] A. Sampathrajan, N. C. Vijayaraghavan, and K. R. Swaminathan, “Mechanical and thermal properties of particle boards made from farm residues,” Bioresour. Technol., vol. 40, no. 3, pp. 249–251, 1992.

[12] G. Kalaprasad, P. Pradeep, G. Mathew, C. Pavithran, and S. Thomas, "Thermal conductivity and thermal diffusivity analyses of low-density polyethylene composites reinforced with sisal, glass and intimately mixed sisal/glass fibres," Compos. Sci. Technol., vol. 60, no. 16, pp. 2967–2977, 2000.

[13] R. Agarwal, N. S. Saxena, K. B. Sharma, S. Thomas, and L. A. Pothan, "Thermal conduction and diffusion through polyester composites," Indian J. Pure Appl. Phys., vol. 44, no. 10, pp. 746–750, 2006.

[14] M. Idicula, A. Boudenne, L. Umadevi, L. Ibos, Y. Candau, and S. Thomas, "Thermophysical properties of natural fibre reinforced polyester composites," Compos. Sci. Technol., vol. 66, no. 15, pp. 2719–2725, 2006.

[15] S. Annie Paul, A. Boudenne, L. Ibos, Y. Candau, K. Joseph, and S. Thomas, "Effect of fiber loading and chemical treatments on thermophysical properties of banana fiber/polypropylene commingled composite materials," Compos. Part A Appl. Sci. Manuf., vol. 39, no. 9, pp. 1582–1588, 2008.

[16] X. Li, L. G. Tabil, and S. Panigrahi, "Chemical treatments of natural fiber for use in natural fiber-reinforced composites: A review," J. Polym. Environ., vol. 15, no. 1, pp. 25–33, 2007.

[17] S. Panyakaew, and S. Fotios, "New thermal insulation boards made from coconut husk and bagasse," Energ Build., vol. 43, pp. 1732–1739, 2011.

[18] M. J. John, R. Tlili, R. D. Anandjiwala, A. Boudenne, and L. Ibos, "Effect of amphiphilic coupling agent on heat flow and dielectric properties of flax-polypropylene composites," Compos. Part B Eng., vol. 43, no. 2, pp. 526–532, 2012.

[19] S. A. Paul, K. Joseph, G. D. G. Mathew, L. A. Pothen, and S. Thomas, "Influence of polarity parameters on the mechanical properties of composites from polypropylene fiber and short banana fiber," Compos. Part A Appl. Sci. Manuf., vol. 41, no. 10, pp. 1380–1387, 2010.

[20] K. Ramanaiah, A. V. Ratna Prasad, and K. Hema Chandra Reddy, "Mechanical, thermophysical and fire properties of sansevieria fiber-reinforced polyester composites," Mater. Des., vol. 49, pp. 986–991, 2013.

[21] V. A. Alvarez and A. Vázquez, "Thermal degradation of cellulose derivatives/starch blends and sisal fibre biocomposites," Polym. Degrad. Stab., vol. 84, no. 1, pp. 13–21, 2004.

[22] S. H. Lee and S. Wang, "Biodegradable polymers/bamboo fiber biocomposite with bio-based coupling agent," Compos. Part A Appl. Sci. Manuf., vol. 37, no. 1, pp. 80–91, 2006.

[23] M. D. H. Beg and K. L. Pickering, "Accelerated weathering of unbleached and bleached Kraft wood fibre reinforced polypropylene composites," Polym. Degrad. Stab., vol. 93, no. 10, pp. 1939–1946, 2008.

[24] H.J. Ott, "Thermal conductivity of composite materials," Plast Rub Proce Appl., vol. 1, pp. 9–24, 1981.

[25] R. C. Progelhof, J. L. Throne, and R. R. Ruetsch, "Methods for predicting the thermal conductivity of composite systems: A review," Polym. Eng. Sci., vol. 16, no. 9, pp. 615–625, 1976.

[26] J.R. Wills,"Bounds and self-consistent estimates for the overall properties of anisotropic composites," J Mech Phys Solids, vol. 25, pp.185,1977.

[27] S. Normura, and T.W. Chou, " Bound of effective thermal conductivity of short fiber compsites," J Comp Mater, vol. 14, pp. 120-129, 1980.
[28] J.C. Maxwell, "A treatise on electricity and magnetism," 3rd edition, New York, Dover, 1954.

