MECHANICAL TENSILE STRENGTH ANALYSIS OF POLY VINYL ALCOHOL(PVA) POLYMER REINFORCED WITH WASTE SCRAPED TIRE RUBBER FIBERS

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Abstract

The waste tire fibers were sourced and processed to reinforce Poly Vinyl Alcohol (PVA) polymer. The blended composite materials were prepared and tested for mechanical tensile strength analysis using a universal testing machine, EEU/20kN. The mechanical properties such as tensile strength, elongation at break, tensile modulus, yield strength and ultimate strength were determined by the Stress-Strain Analysis. Five PVA tested samples for each mix ratio are experimentally tested until the failure occurs by the Universal Material Testing Unit, EEU/20kN. The pure PVA has tensile strength is 48.71 MPa and the highest Scraped Tire Reinforced mixed with PVA by the 20 w/v% ratio has highest tensile strength is 52.218 MPa. The value of Elongation break (%), Tensile modulus (MPa), Yield strength (MPa) and Ultimate strength (MPa) are decreased as the filler percent increased. The waste tire fibers can be effectively utilized as a reinforcing agent in PVA composites, leading to improved mechanical properties. The significant implications for the development of sustainable composite materials and could contribute to reducing the environmental impact of waste tire disposal.

Keywords: Scraped Tire Rubber fibers, PVA, composites

Introduction

Nowadays PVA based polymers are being widely used in additive manufacturing. Poly (vinyl alcohol) PVA is a water-soluble synthetic polymer. It has the idealized formula $[CH_2CH(OH)]_n$. Polyvinyl alcohol has a melting point of 180 to 190°C. Poly vinyl alcohol is a hydrophilic semi-crystalline polymer produced by polymerization of vinyl acetate to poly vinyl acetate (PVAc), and subsequent hydrolysis of PVAc to PVA. Commercial PVA is available in highly hydrolyzed grades (degree of hydrolysis above 98.5%) and partially hydrolyzed ones (degree of hydrolysis from 80.0 to 98.5%). The content of hydrolysis or the content of acetate groups in PVA affects its chemical properties, solubility and crystal growth ability [Wang T, M. T, S. G, et al., 2004].

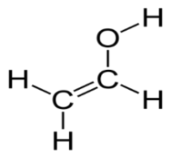

Figure-1 Molecular Structure of Poly vinyl alcohol (PVA)

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Polymeric scraped tire rubber fiber (STRF) is one of the byproducts derived from the processing of used vehicle tires. Presently, significant quantities of STRF are generated annually in most developed countries of the world. However, and unfortunately, STRF been an amalgam of crumb rubber, steel and other particles, its reusability has been limited. Hence, STRF is mainly used as a fuel source in kilns or landfilled. Sulfur vulcanization of rubber is the most commonly used chemical process, by which cross-links are formed between rubber polymer chains by heating, thereby enhancing the physical properties of vulcanizes. Thus, as a consequence of vulcanization, a typical tire rubber contains about 1.52–1.64% sulfur and other chemical constituents such as 81.2–85.2% carbon, 7.22–7.42% hydrogen, 1.72–2.07% oxygen and 0.31–0.47% nitrogen [Chen J, K, L, et al., 2001], nitrogen oxides (NO_x), Sulfur dioxide (SO_2), carbon monoxide (CO) and polycyclic aromatic hydrocarbon (PAH) are emitted during scrap tire combustion [Levendis Y, A, J, Y, P, et al., 1996]. The sulfur gases are also produced during scrap tire pyrolysis [Murena F, 2000]. Toxic hydrogen sulfide gas was also observed as a major byproduct of scrap tire pyrolysis [Tang L, H, et al., 2004]. Therefore, to avoid the inherent environmental pollution associated with the combustion of waste car tire rubber, it is imperative that alternative benign and value-added applications for STRF be developed.

The waste tire fibers were sourced and processed to reinforce Poly Vinyl Alcohol (PVA) polymer. The blended composite materials were prepared and tested for mechanical tensile strength analysis using a universal testing machine, EEU/20kN. The mechanical properties such as tensile strength, elongation at break, tensile modulus, yield strength and ultimate strength were determined by the Stress-Strain Analysis. Five PVA tested samples with the five weights per volume mix ratios of the waste scraped Tire fibers are experimentally tested until the failure occurs by using the Universal Material Testing Unit, EEU/20kN.

Materials and Experimental Methods

2.1. Materials

Poly Vinyl Alcohol (PVA, molecular weight of 186,000 g/mol, Sigma Aldrich, Germany) was purchased and used without further purification. The waste car tire was collected from the car workshop and cleaned to scrap the rubber filament from the waste vulcanized rubber car tire. Deionized water was used in the preparation of the blending PVA.

2.2 Preparation and Characterization of Waste Scraped tire rubber fiber

The waste car tire was collected and washed in water by using iron brush. The scrap tire rubber fibers were scraped from the washed pieces of the waste car tire by the iron brush rotor machine and put the scraped tire rubber fibers into the pure water to separate the rubbers and the iron dust, metal pieces of the tire by the floating method. The floating scraped tire rubber fibers were filtered and dried in the oven at 150°C for 2 hr. Finally, the remaining iron dust in the scraped tire rubber fibers were eliminated by the magnet.

The 2 g of PVA were dispersed in 10ml of deionized water and was stirred for 20 min at 80 °C with 500 rpm to get the transparent and homogeneous 20 w/v% PVA solution. The 20 w/v% PVA solution was poured into the ceramic mold to cast the pure PVA by solution-casting method and the resultant PVA was dried at 60 °C in the desiccator to synthesize pure PVA. The 0.5 g of the scraped tire rubber fiber (STRF) were slightly added into the homogenous 20 w/v% PVA solution and was stirred for 20 min at 80 °C with 500 rpm. The resultant rubber fiber mixed PVA solution was casted into ceramic mold by the solution casting method to get the 5 w/v%, STRF reinforced PVA. The 10 w/v%, 15 w/v% and 20 w/v% STRF reinforced PVA were also prepared by the use of 1 g, 1.5 g and 2g of the scraped tire rubber fiber (STRF) as the above solution-casting method. The resultant STRF blended PVAs were dried and kept at 60 °C in the desiccator. The sample preparation procedures of the pure PVA and scraped tire rubber fiber (STRF) blended PVA were exhibited as in the Figure-2. Five PVA- tested samples with the five weights per volume mix ratios of the waste scraped Tire fibers are experimentally tested until the failure occurs by the Universal Material Testing Unit, EEU/20kN, as in the Figure-3.

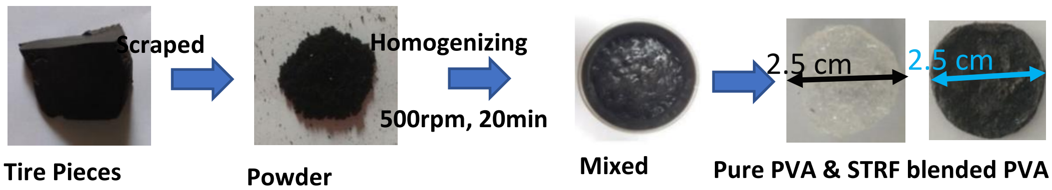

Figure-2 Preparation of the Waste Scraped Tire Rubber Fibers (STRF) Blended Polyvinyl Alcohol (PVA).

Figure-3 EEU 20KN/Universal Testing Machine Unit.

Results and Discussions

The pure PVA has tensile strength is 48.71 MPa and the highest mixed ratio of the Scraped Tire Reinforced mixed with PVA by the 20 w/v% has maximum tensile strength, 52.218 MPa. The value of Elongation break (%), Tensile modulus (MPa), Yield strength (MPa) and Ultimate strength (MPa) are decreased as the filler percent increased. Mechanical Properties of PVA Reinforced with Waste Scraped Tire Rubber Fibers were shown in the Table-1. The Stress-strain analysis curves of PVA and PVA reinforced with STRF were depicted as in the Figure- 4 to 8. The effect of Scraped tire rubber fibers (STRF) fillers on the stress-strain mechanical properties were depicted as in the Figure 9 to 13. The optimum w/v% ratio of the STRF filler is the 20 w/v% to achieve the maximum tensile strength, 52.218 MPa. The mechanical stress -strain analysis value of the pure PVA is well agreed with the literature, Research work of the Naman Jain, G.B Pant University of Technology, India [Jain, Naman et al., 2017].

Table-1 Mechanical Properties of PVA Reinforced with Waste Scraped Tire Rubber Fibers.

Properties	**Result**				
	Pure PVA	**(5w/v%)**	**(10w/v%)**	**(15w/v%)**	**(20w/v%)**
Tensile strength (MPa)	48.71	38.62	28.089	28.93	52.218
Elongation break (%)	223.5	3.625	4.094	5.07	3.93
Tensile modulus (MPa)	705.07	144.31	36.217	7.62	91.6
Yield strength (MPa)	47.056	3.63	26.71	24.21	40.27
Ultimate strength (MPa)	68.459	38.623	28.089	28.93	52.218

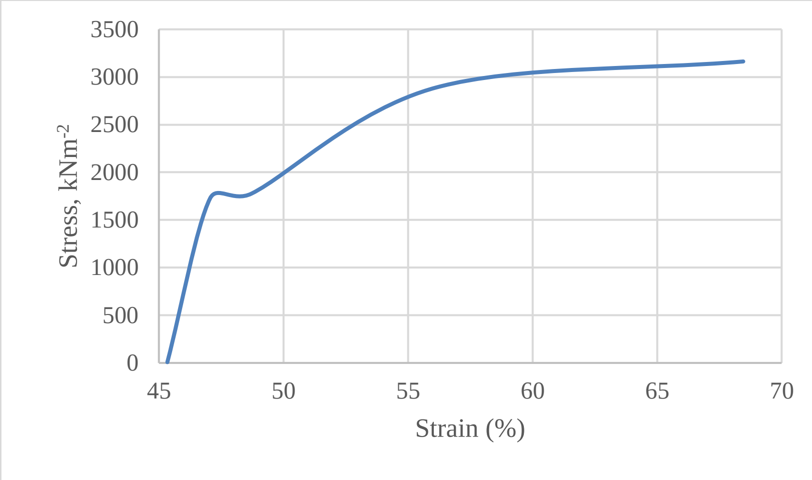

Figure 4- Stress-strain analysis curve of pure PVA

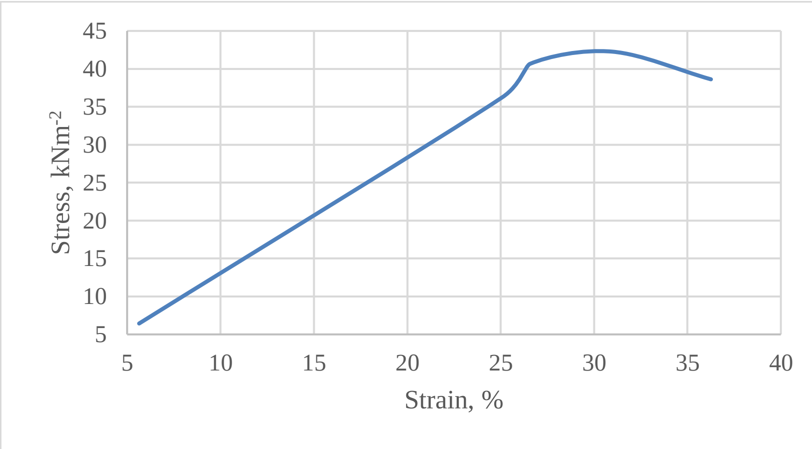

Figure 5- Stress-strain analysis curve of (5w/v%) pure PVA reinforced STRF

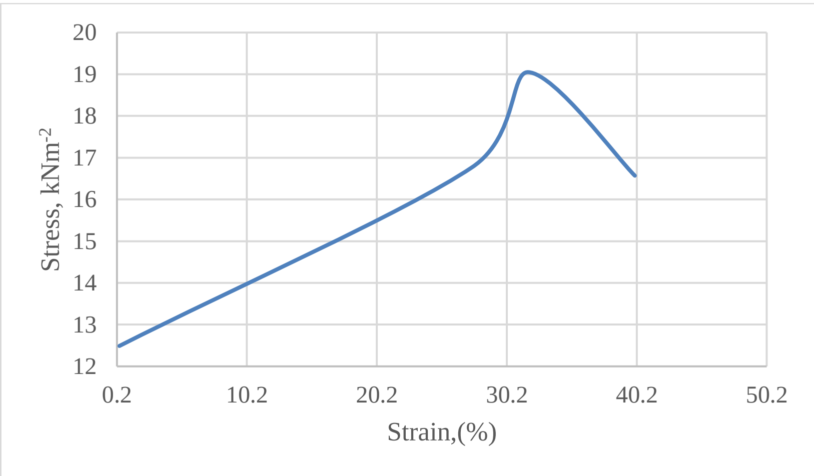

Figure 6- Stress-strain analysis curve of (10 w/v%) pure PVA reinforced STRF

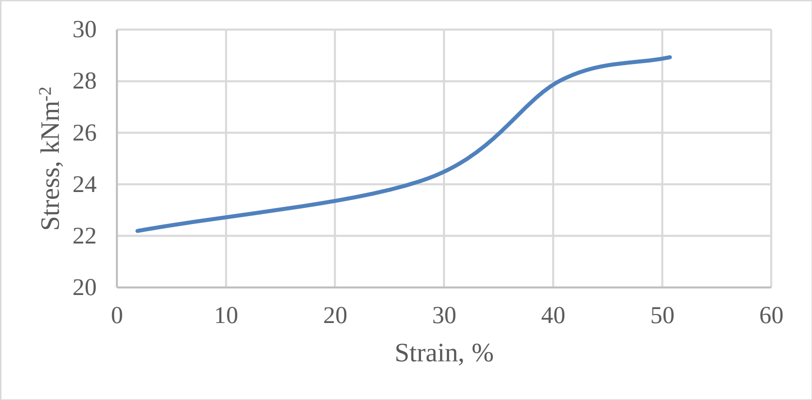

Figure 7- Stress-strain analysis curve of (15w/v%) pure PVA reinforced STRF

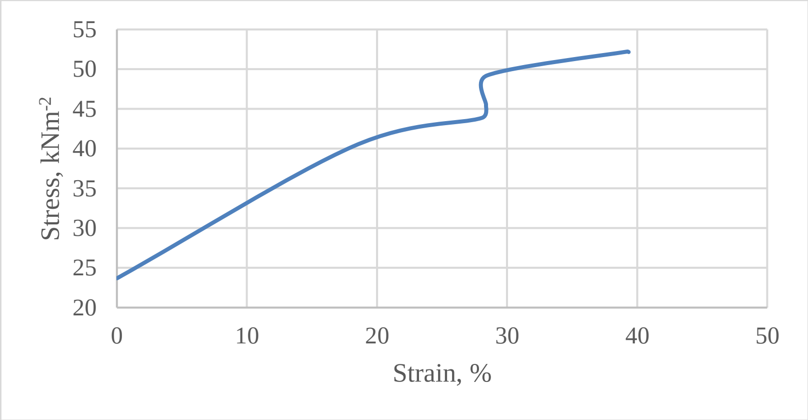

Figure 8- Stress-strain analysis curve of (20w/v%) pure PVA reinforced STRF

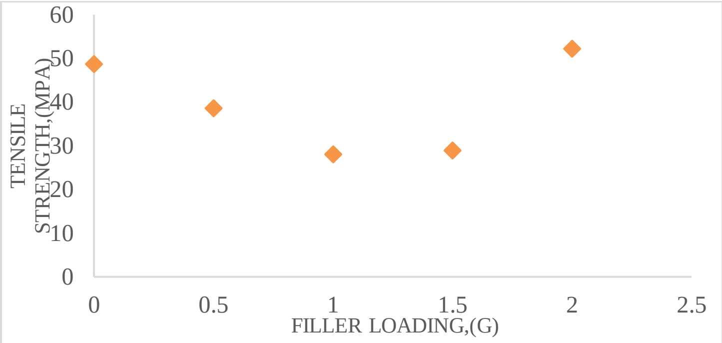

Figure 9 - Effect of filler loading on tensile strength of Pure PVA and PVA reinforced STRF

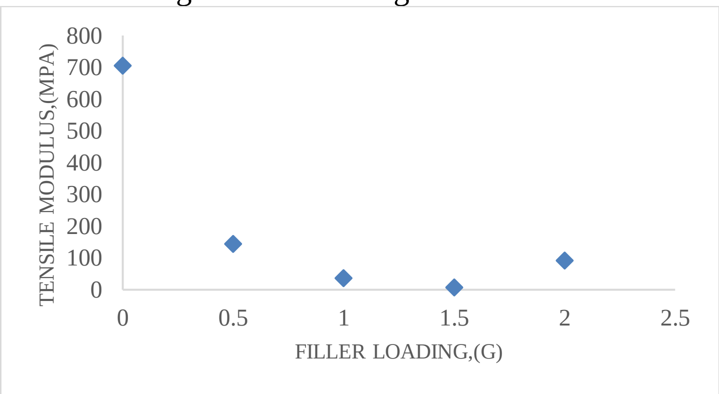

Figure 10- Effect of filler loading on tensile modulus of Pure PVA and PVA reinforced STRF

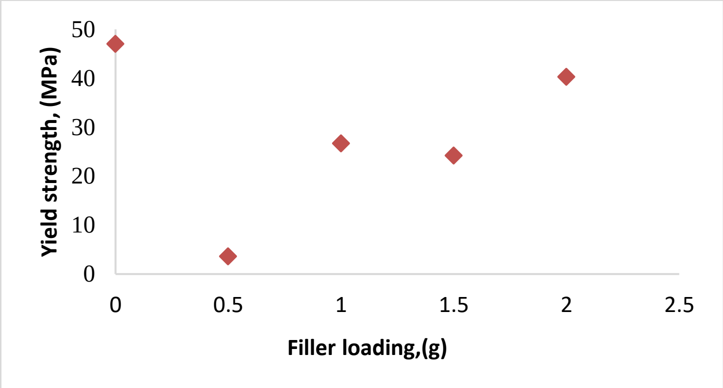

Figure 11- Effect of filler loading on yield strength of Pure PVA and PVA reinforced STRF

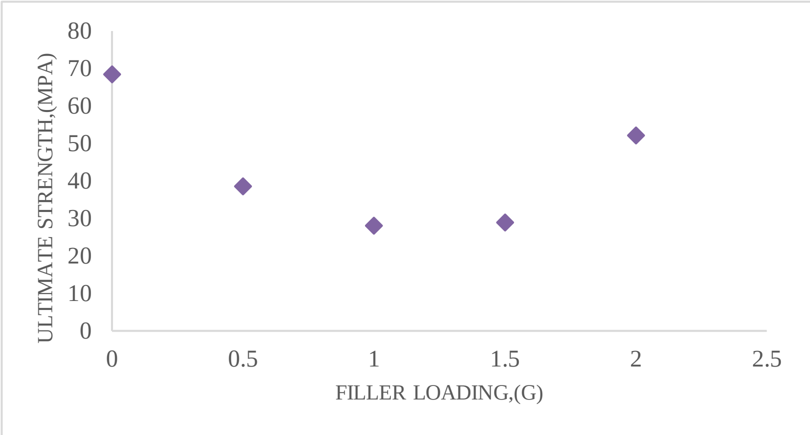

Figure 12- Effect of filler loading on ultimate strength of Pure PVA and PVA reinforced STRF

Figure 13- Effect of filler loading on Elongate break of Pure PVA and PVA reinforced STRF

Conclusion

Although the values of the mechanical stress-strain were decreased as weight per volume ratio of the STRF increased, the maximum value of the Tensile Strength, 52.218 MPa was achieved at the 20 w/v% ratio of the STRF filler. The waste tire fibers can be effectively utilized as a reinforcing agent in PVA composites, leading to improved mechanical properties. The significant implications for the development of sustainable composite materials and could contribute to reducing the environmental impact of waste tire disposal.

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