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ENHANCEMENT IN MECHANICAL AND ELECTRICAL PROPERTIES OF P. M. M. A. NANO COMPOSITES COATED WITH KEVLAR PULP

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ABSTRACT

In this examination, P. M. M. A nano composites PMMAnc were covered with Kevlar pulp (KP), utilizing a powerful and persistent covering process. PMMAnc were specifically submerged in the KP suspension and covering prerequisite was streamlined with the end goal to get a reasonably good thickness of homogeneously and very much scattered KP. Hand lay out method has been used to cover Kevlar pulp (KP) in PMMAnc, and flexural strength as a measure of mechanical property followed by one more property of the composite i.e. electrical conductivity has been surveyed. The KP covered PMMAnc composites demonstrated 49%, 5% and 15% increment in examination, in comparison to uncovered PMMAnc composites, for 90^0 flexural strength, 0^0 flexural strength along with interlaminar shear strength, separately. In the interim, enhancement in electrical conductivity after fusing KP in the PMMAnc interphase essentially produced a conductive way between the films.

***KEYWORDS:** Polymethyl Methacrylate Nano Composites (PMMAnc), Kevlar Pulp (KP), Electrical Conductivity & Flexural Strength*

Original Article

INTRODUCTION

Owing to the high strength light weightiness, FRP composites are progressively used in applications, like aviation or flight businesses etc. Kevlar fibers draw in high intrigue in view of their predominant quality and modulus, low thickness and sensible expense [1, 2]. Be that as it may, the utilization of traditional PMMA composites might be limited due to poor quality, split opposition, de-lamination etc [3–6]. Moreover, KFs strengthened polymer composites still don't meet specific requests to fulfill the tough environmental conditions under which higher strength and desired electrical conductivity. As of late, film fortified polymer composites consolidating coating of Kevlar films/pulp have sparked significant concern owing to implicit utilities which ordinary FPC can't propose [7-9]. In examination along with different nano composites, Kevlar coating made of a couple of Kevlar layers piled over one another in a cell form, developed as a potential interest amongst researchers and scientists due to their enhanced mechanical and electrical properties like, stress-strain ratio etc with minimal effort [10-13]. The basic reason behind this standout amongst much imperative variables in assembling KP/PMMAnc intercross composites has been idea of KP scattering. The natural, bonding force associations subsisting amongst constrain them to total, adding to the improvement of neighborhood push at the point when an outside power is connected on these platelets which may fundamentally influence quality of nanocomposites. e.g., Aradila et al. [14] detailed that, level of KP scattering within films estimating arrangement emphatically impacted the deciding and desired engineering properties of comparing nanocomposites. KP may be all around scattered in few natural solvents, for example, Phosphonium Chloride (diatomic)), Tetrabutylphosphonium chloride (TBPC) [15]. The inclusion of KP in film strengthened composites pulled in some intrigue as of late [16, 17], particularly as far as desired engineering properties which essentially accounted for de-lamination/clasping of filaments [18], consequently deferring the break proliferation in the interphase area [19]. In any case, scaling up the maker of KP covered PMMAnc what's more, their composites is as yet a test, on the grounds that past investigations were centered around lab-scale handling which usage in the KF business is by all accounts traded off in cathodic or surface deposition EPD, chemical vapors deposition [20] or on the other hand solvo thermal techniques [21]. Another technique for creating KP covered PMMAnc by a straightforward plunge covering method was considered. Homogenous covering by KP layer, that to a large thickness of very much scattered KP were accomplished, which has shown in figure 1while non-coated SEM visual depicted as figure 2.

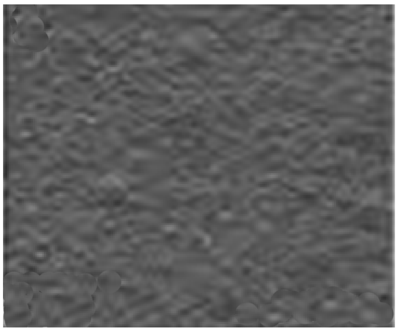

Figure 1: SEM Micrograph of KP Coated PMMAnc.

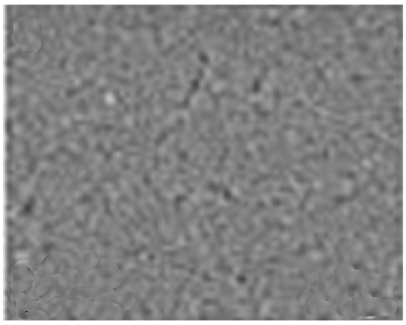

Figure 2: SEM Micrograph of Non-Coated Film Surface.

Amidst this procedure, PMMAnc was plunged into KP/ TBPC aliquot, at that point KP covered PMMAnc has been dehydrated in oven kept for an hour at 70^{0}C. This technique may be effortlessly extended to inevitable ceaseless generation for KP covered PMMAnc on a mechanical level. Consequently, other important properties like 90º flexural quality, ductile properties and inter-laminar shear properties [22] studied with the end goal to completely comprehend what is the impact of the joining of KP in the interphase locale contrasted with different associations (film-film cooperation, scattering of the single films in the lattice, void substance connected to the assembling procedure). In this examination, PMMAnc were covered with KP utilizing a direct non-stop arrangement covering method.

EXPERIMENTAL

Materials

Kevlar pulp (KP) utilized in this examination were Kevlar pulp supplied by VK Minerals & Chemicals, Ghaziabad (UP). PMMA and clay was provided by Merck Specialties Pvt. ltd. Toluene and Tetrabutylphosphonium chloride (TBPC), ILS an ionic liquid used as supplied by Sigma Aldrich Chemicals Pvt. Ltd, New Delhi.

Preparation of KP Suspension as the Covering ARRANGEMENT

Kevlar pulp was dissolved in Tetrabutylphosphonium chloride (in an equal wt %) stirred well by a magnetic stirrer for 2 hours, the suspension was then kept in an oven for overnight maintained at 40^0C temperature. The newly arranged KP suspension was exchanged to the covering shower and ceaselessly blended amidst the film covering technique.

Preparation PMMAnc film by Spinner Technique on p-Si substrate (Separable)

30g PMMAnc composite diluted in 20 ml toluene solvent. In order to ensure complete dissolution, it was stirred for an hour on a magnetic stirrer, the arrangement kept arranged to put on waxed silicon wafers. Si-wafers were sliced in to 2"*2" pieces, and kept on headway spinner over which few drops of the arrangement was poured carefully, (each time the drop check was kept up) the revolution and time kept settled for spinner. The film has been segregated from Si-substrate, using forceps and saw under SEM for their homogeneity. The non-coated and few PMMAnc films were plunged in the Kevlar suspension, the coating solution shaken well and passed through steel rollers. To ensure a homogeneous coating of the films, tow was unrolled with utmost care. These films were then dried in to a furnace set at 70 °C for 3 minutes. Thereafter, these were kept in an oven at 55 °C for 3 hours.

2.4 Composite Preparing by Hand Lay-up Technique

Before composite manufacture, the KF covered PMMAnc films were kept at room temperature for around two hours. Fourteen layers were piled up by hand; the films stacks were arranged between two Teflon-lined plates. The thickness of the last composites was controlled by a spacer having high temperature tape. This get together was embedded in a nylon vacuum sack, in which essential vacuum was made, and put into the oven for two hours at 70 ºC pursued by two hours again at 70 ºC with 0.60 MPa. Vacuum pack evacuated after the 25 minutes of the level at 60^0C. When relieved, the KF coated PMMAnc were prepared for flexural testing in both 0^0 and 90^0 headings, short beam shear test. The KF/PMMAnc volume fixation (Vf) in non-covered PMMAnc and KF Coated PMMAnc were kept 60 % and 61 % separately.

RESULTS AND DISCUSSIONS

Film Topography observation: The surface of the film before and after coating has been seen by SEM. Figure 1 shows KP coated film and figure 2 depicts SEM micrograph of non-coated PMMAnc. Non coated film have slight troughs and edges while KP coated films have shown roughness.

Fracture and SEM Analysis of KP Coated PMMAnc Film

The analysis of the surface of KP coated PMMAnc was done by Jeol JBX-3200MV 50 KV, Carl Zeiss microscope at the acceleration of two kilo volt adjustments while fracture profile was configured by accelerating five kilo volt after flexural test. Prior to this test, the coating of tungsten on the sample was carried out by higher vacuum sampler.

Mechanical Properties

Flexural Test

The ASTM D790 is the most precise flexural test to measure flexural strength and flexural modulus on a three point bend fixture bench for both 90^0 and 0^0. The test was performed on 100 mm (L) *12.7 mm(W) 8 *2.3 mm (Th) specimen pieces on five samples sequentially by fixing the cross head @ 1.27 mm per minute.

90^0 Flexural Characterizations

The flexural strength relating to composites prepared by KP covered PMMAnc resulted in a lot higher than the flexural strength of composites prepared by non-covered PMMAnc. It is noticed that there is an increment of 49 % (Figure 3a &b)

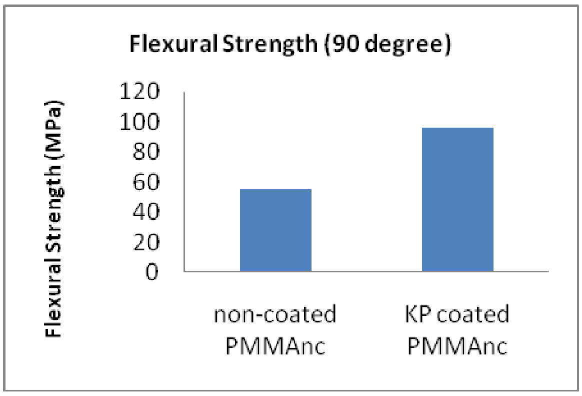

Figure 3(a): Evolution of 90º Flexural Properties; Flexural Strength.

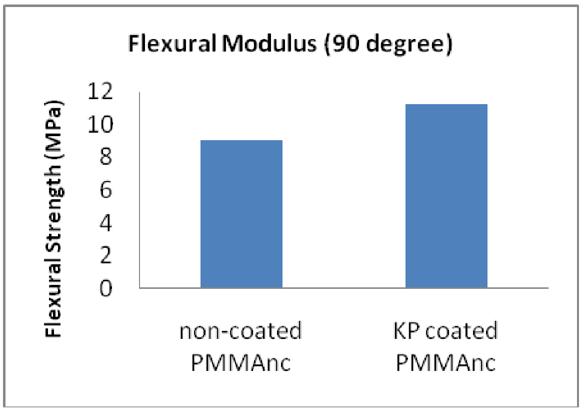

Figure 3(b): Evolution of 90º Flexural Properties; Flexural Modulus.

It was because of higher interfacial adhesion and expanded shear modulus in the (90^0 flexural strength) interphase locale [23, 24]. This is likewise upheld by Cox's examination [25] of the stress modulus of the matrix in nearness of KP. The fractured surfaces were seen by SEM (Figure 4).

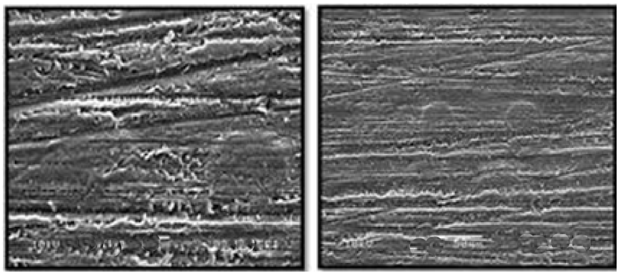

Figure 4: SEM Observations of the Fracture Surface after the Flexural 900 Test (a) Non-Coated PMMAnc, (b) KP Coated PMMAnc.

For the composites prepared by non-covered films, the crack had a brush-like viewpoint, with many broken single films, no outstanding network on their surface, demonstrating that the interfacial bond between the PMMAnc and the framework was exceptionally feeble. The fractured surface comparing to composites made with KP covered PMMAnc was level and perfect, the single film being reinforced together. A lot of framework stayed on their film surface. The failure mode was firm, which related to a sharp increment in interfacial adhesion.

0^0 Flexural Characteristics

The outcomes comparing to the 0^0 flexural tests are shown in figure 5(a) and (b).

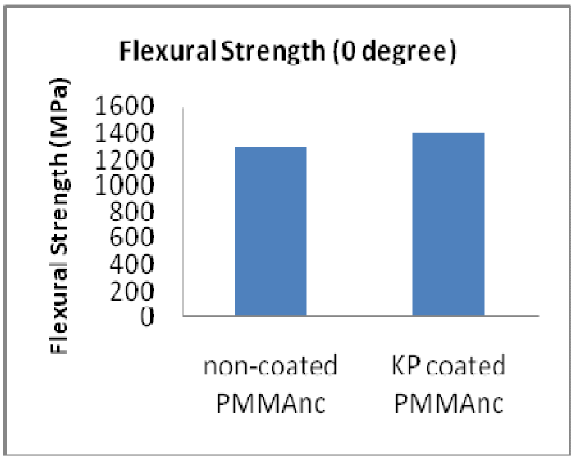

Figure 5(a): Evolution of the 0º Flexural Properties: Flexural Strength.

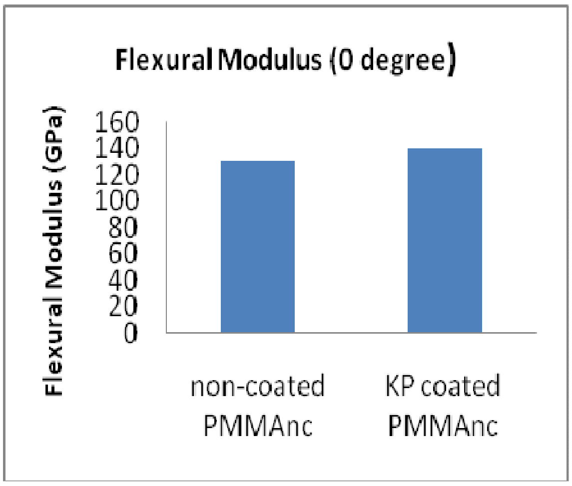

Figure 5(b): Evolution of the 0º Flexural Properties: Flexural Modulus.

The flexural quality of composites prepared by KP covered PMMAnc demonstrates a slight enhancement (6%) contrasted with the flexural quality of the composites prepared by non-covered PMMAnc, it is in accordance with recently referred studies [26] demonstrating that 0^0 flexural isn't extremely touchy to the interfacial bond and depends principally on the volume part and mechanical properties of corresponding films. Two references also demonstrated a comparable pattern with regards to 0^0 flexural modulus and were free of the film-network attachment. SEM observations of fracture surfaces related to the fractured surface region of the sample that was under strain amidst the test are shown in Figure 6 for the composites prepared by non-covered films.

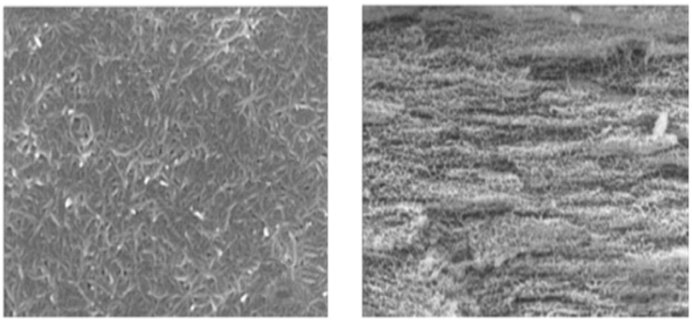

Figure 6: SEM Micrographs of KF Composites Fracture Samples after Flexural 0^0 test at different Magnification: (a) Non-Coated PMMAnc, (b) KP Coated PMMAnc.

A reasonable interfacial crack discerns visually at the bottom of the film at high amplification and a large number of films were hauled out of the grid, uncovering powerless interfacial grip. The composites prepared by KP covered PMMAnc nonetheless, were scarcely projecting from the framework and a lot of network stayed on their film surface and neither interfacial burst nor film haul out was visible at high amplification. The interfacial grip was well built. The flexural quality of composites prepared by KP covered PMMAnc demonstrates a minute enhancement contrasted with the flexural quality of the composites prepared by non-covered PMMAnc. This is as per recently referred studies [27-28] demonstrating that 0^0 flexural isn't extremely delicate to the interfacial grip and depends fundamentally on the volume division and mechanical properties of the films. The 0^0 flexural modulus of two references demonstrated a comparative pattern and was free of the film-lattice grip. The composites prepared by KP covered PMMAnc in any case, were scarcely jutting from the grid and a lot of lattice stayed on their film surface and neither interfacial break nor film haul out has been observed at high amplification. The interfacial attachment was solid.

InterLaminar Shear Strength (ILSS)

The ASTM D2344 is the most precise ILSS test to measure conducted by having 13.6 mm (L) *4.6 mm(W) 8 *2.3 mm (Th) specimen pieces by fixing the cross head @ 1.27 mm per minute.

ILSS of composites is capacity of the film/grid bond strength, the stress-strain tracts of the framework (crack defiance) and the dimension of porosity. Considering that the dimension of porosity has been low that a similar network was utilized for the distinctive composite frameworks. It tends to be sensibly expected that any adjustment in the estimation of the ILSS will be connected to a change in interfacial attachment. The ILSS esteems are accounted for in Figure 7.

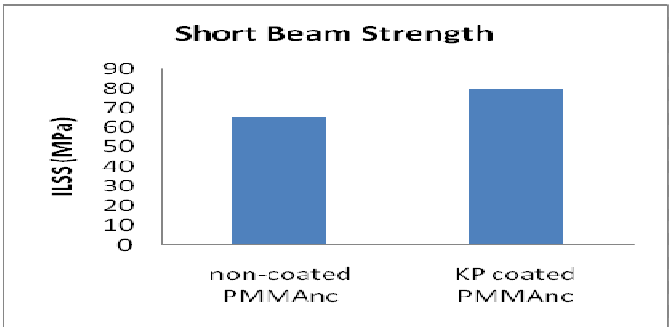

Figure 7: Interlaminar Shear Strength of the Different Composite Systems.

A reasonable raise was acquired with the inclusion of KP in the interphase area (plus 15 % in contrast with non-covered PMMAnc). The inclusion of KP expands the shear modulus of the grid in the interphase zone and combined with the mechanical interlinking among film and framework, lessens between laminar strain-stress engrossment at a given load

Electrical Conductivity

The electrical conductivity (EC) of the PMMAnc composites was measured through their thickness using Solartron 1260A Frequency Response Analyzer and 1294A Impedance Interface. The resistance noticed in between 10^5Hz to 0.1Hz, due to low difference in resistance, has been fixed at 1Hz , equation used to calculate was : $\sigma = L/AR$, here σ designated as EC having thickness (S*cm-1), L has taken as length of the specimen in (cm), R is resistance in ohm, A, was designated as cross sectional area (cm^2)

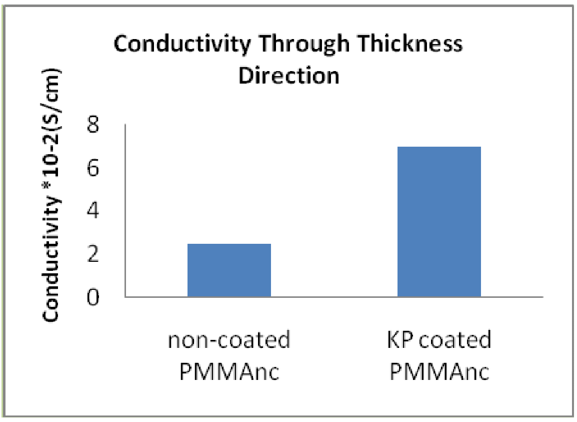

Figure 8: Evolution of the Electrical Conductivity Through the Thickness Direction Before and After the Adding of KP in the Interphase Region.

Figure 8 demonstrates the EC for PMMAnc composites. The EC of KP covered PMMAnc demonstrated substantial expansion (more than 100% plus) in contrast with the non-covered PMMAnc. Thickness of KP covering has been 600 nm prior to the assembling of composite which dictated through FESEM. It has induced that KP pulp relocate somewhat far from the film surface and the films are compressed amid the composite assembling constraining the interphase on contiguous films to associate bringing about an interphase zone having KP molecules that contains a thickness more noteworthy than the starting thickness of the coating. The KPs may migrate generating a continuous conductive way among films and KP from one area of the composite to the next [29]. This demonstrates the inclusion of KP pulp in interphase zone enhances both mechanical properties furthermore its electrical conductivity. Hybridized PMMAnc/KP composite materials with this mix of properties and electrical conductivity can be alluring for auxiliary applications requiring the dissemination of friction based electricity.

CONCLUSIONS

In this examination, PMMAnc was handled with a straightforward, yet powerful strategy that brought about the statement on their surface of a high thickness of homogeneously and well scattered KP pulp. This brought about an expansion of interfacial attachment between the films and the KP pulp, prompting a noteworthy enhancement on the free movement of pulp on all directions of the composites (90º flexural strength, ILSS and 0º flexural and compressive strength. The perception of the fractured surfaces likewise concurred with enhancement of interfacial attachment demonstrating a change from an absolutely interfacial failure mode with non-covered films to a firm failure mode between films when the KP was present in the film-matrix interphase. The electrical conductivity trough the thickness of the composite was significantly upgraded too in light of the capacity of the conductive KP pulp to permeate with one another and interface adjoining PMMAnc films. The persistent covering process showed itself of vigorous and conceivably prepared to be executed in a PMMAnc creation line, empowering the generation of hybridized PMMAnc /KP composites with upgraded mechanical and electrical properties.

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REFERENCES

1. *Qin, W., Vautard, F., Drzal, L. T., Yu, J., Mechanical and Electrical Properties of Carbon Film Composites with Incorporation of Graphene Nanoplatelets at the Film-Matrix Interphase, Composites: Part B 2014.10.014*
2. *Cai HW, Aref AJ. On the design and optimization of hybrid carbon film reinforced polymer-steel cable system for cable-stayed bridges. Compos Part B 2015; 68: 146–152.*
3. *Lou TJ, Lopes SMR, Lopes AV. Factors affecting moment redistribution at ultimate in continuous beams prestressed with external KFRP tendons. Compos Part B 2014; 66: 13–146.*
4. *Song Q, Li KZ, Qi LH, Li HJ, Lu JH, Zhang LL, Fu QG. The reinforcement and toughening of pyrocarbon-based carbon/carbon composite by controlling carbon nanotube growth position in carbon felt. Mater Sci Eng A 2013; 564: 71-75.*
5. *Boroujeni AY, Tehrani M, Nelson AJ, Al-Haik M. Hybrid carbon nanotube-carbon film composites with improved in-plane mechanical properties. Compos Part B 2014; 66: 475–483.*
6. *Zaldivar RJ, Nokes JP, Kim HI. The effect of surface treatment on graphite nanoplatelets used in film reinforced composites. J Appl Polym Sci 2014; 131(6): 39994.*
7. *Oleiwi, J. K., & Hadi, A. N. (2018). Experimental and numerical investigation of lower limb prosthetic foot made from composite polymer blends. International Journal of Mechanical and Production Engineering Research and Development, 8(02), 1319–1330.*
8. *Scholz S, Kroll L. Nanocomposite glide surfaces for FRP hydraulic cylinders-Evaluation and test. Compos Part B 2014; 61: 207–213.*
9. *Park OK, Kim SG, You NH, Ku BC, Hui D, Lee JH. Synthesis and properties of iodo functionalized kevlar 49 oxide/polyimide nanocomposites. Compos Part B 2014; 56: 365–371.*
10. *Lee JH, Marroquin J, Rhee KY, Park SJ, Hui D. Cryomilling application ofkevlar 49 to improve material properties of kevlar 49 /chitosan nanocomposites. Compos Part B 2013; 45: 682–687.*
11. *Dong, A., Zhao, Y., Zhao, X., & Yu, Q. (2018). Cure Cycle Optimization of Rapidly Cured Out-of- Autoclave Composites. Materials, 11(3), 421*
12. *Vairagade S, Kavita S, Comparative Study of Steel Film Reinforced Over Control Concrete International Journal of Scientific and Research Publications, Volume 2, Issue 5, May 2012 136 ISSN 2250–3153*

13. *Diba, M., Fam, D. W. H., Boccaccini, A. R., Shaffer, M. S. P., Electrophoretic deposition of graphene-related materials: A review of the fundamentals, Progress in Materials Science (2016),*
14. *Bhowmick M, D. S. (2015). Mechanical Properties of Unidirectional Jute-Polyester Composite. Journal of Textile Science & Engineering, 05(04).*
15. *Aradilla D, Estrany F, Oliver R, Alemán R, Properties of nanometric and micrometric multilayered films made of three conducting polymers. European Polymer Journal 2010; 46: 2222–2228.*
16. *Behera AK, Avancha S, Sen R, Adhikari B (2013) Development and Characterization of Nanoclay-Modified Soy Resin-Based Jute Composite as an Eco-friendly/Green Product Polymer-Plastics Technology and Engineering 52: 833–840.*
17. *Oleiwi, J. K., Salih, S. I., & Fadhil, H. S. (2018). Water Absorption and Thermal Properties of PMMA Reinforced by Natural Fibers for Denture Applications. International Journal of Mechanical and Production Engineering Research and Development, 8(3), 1105–1116.*
18. *Salem, I. A. S., Rozyanty, A. R., Betar, B. O., Adam, T., Mohammed, M., & Mohammed, A. M. (2017). Study of the effect of surface treatment of kenaf film on chemical structure and water absorption of kenaf filled unsaturated polyester composite. Journal of Physics:*
19. *Tijjani Adam, U Hashim, Design and fabrication of micro-mixer with short turns angles for self generated turbulent structures, Microsystem Technologies, Vol. 22(2) 433-440, 201 silsesquioxanes in the interphase, 2014, 4, 12198–12205*
20. *Sarkar, S., & Basak, D. (2014). Defect mediated highly enhance ultraviolet emission in P-doped ZnO nanorods. RSC Adv., 4(74)39095–39100.*
21. *Ma, L., Meng, L., Wang, Y., Wu, G., Fan, D., Yu, J., Huang, Y. (2014). Interfacial properties and impact toughness of dendritic hexamethylenetetramine functionalized carbon film with varying chain lengths. RSC Adv., 4(74), 39156–39166.*
22. *Pu, D., Liu, F., Dong, Y., Ni, Q., & Fu, Y. (2018). Interfacial Adhesion and Mechanical Properties of PET Fabric/PVC Composites Enhanced by SiO2/Tributyl Citrate Hybrid Sizing. Nanomaterials, 8(11), 898.*
23. *Jabbari, M.; Akesson, D.; Skrifvars, M.; Taherzadeh, M. J. Novel lightweight and highly thermally insulative silica aerogel-doped poly (vinyl chloride)-coated fabric composite. J. Reinf. Plast. Comp. 2015, 34, 1581–1592.*
24. *Ambroziak, A.; Klosowski, P. Mechanical properties for preliminary design of structures made from PVC coated fabric. Constr. Build Mater. 2014, 50, 74–81. [CrossRef].*
25. *Kumagai, S.; Hirahashi, S.; Grause, G.; Kameda, T.; Toyoda, H.; Yoshioka, T. Alkaline hydrolysis of PVC-coated PET films for simultaneous recycling of PET and PVC. J. Mater. Cycles Waste 2018, 20, 439–449.*
26. *Yan Ma1, Masahito Ueda2, Tomohiro Yokozeki3, Toshi Sugahara4, Yuqiu Yang5, Hiroyuki Hamada1 Investigation of the Flexural Properties and Failure Behavior of Unidirectional CF/Nylon 6 and CF/Epoxy Composites Open Journal of Composite Material Vol.07 No. 04(2017).*
27. *HASSAN, Q. M., Bakr, H., Sultan, H. A., Hassan, R. M., & Emshary, C. A. (2017). Evolution of far-field diffraction patterns and nonlinear optical properties of SAE 70 oil. International Journal of Applied and Natural Sciences, 6, 181–188.*
28. *Cox, H. L. (1952). The elasticity and strength of paper and other fibrous materials. British Journal of Applied Physics, 3(3), 72–79.*
29. *Al-Dwairi, Z. N., Tahboub, K. Y., Baba, N. Z., & Goodacre, C. J. (2018). A Comparison of the Flexural and Impact Strengths and Flexural Modulus of CAD/CAM and Conventional Heat-Cured Polymethyl Methacrylate (PMMA). Journal of Prosthodontics.*

30. *Yan, J. and D. C. Webster Thermosets from highly functional methacrylated epoxidized sucrose soyate. Green Materials, 2014. 2, 132–143*

31. *Etcheverry, M., & Barbosa, S. E. (2012). Glass Film Reinforced Polypropylene Mechanical Properties Enhancement by Adhesion Improvement. Materials, 5(12),*

32. *Tarver J, Yoo JE, Loo YL. 4.14 - Organic Electronic Devices with Water-Dispersible Conducting Polymers. Comprehensive Nanoscience and Technology 2011; 4:413–446.*

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Rohit Singh Raghuwanshi has completed his high School 12th Class with 74.8% marks in physics, Chemistry&Maths in 2016. He has been a scholar & captain of the school i.e. Ryan International School, Greater Noida where from he does his schooling. After schooling he took admission in Manipal University Jaipur ,Rajsthan to persue his B.Tech degree course in Automobile engineering. Right now he is in final year of the degree course, during course of this journey he inspired by his mentor & guide , Mr.Dalip Singh who is involved in various project & research work , Rohit was associated with one the project which is associate with material science and engineering where he took this problem of air craft canopy made up of PMMA , the material was susceptible with gamma rays ,so he in association with mentor tried to improve the property of this material by incorporation of Kevlar and other suitable materials. As a result this research paper has been designed. Prior to this ,Rohit has done his training and internship in Honda cars India limited , where he solved one problem associated with paint shop of the company, that sort of project was also completed successfully by him. He had also been worked a track marshal in BND motorsports where he successfully completed few tasks on time and scoring, pit and grid, registrations ,Radio networking , scruitneers ,flagging and communications.

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