Enhancement in mechanical properties of EDTA reinforced KP/ PMMA composite

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Abstract : Mechanical properties of hybrid poly (methyl methacrylate) (PMMA) fortified with KP (8:2, by vol.%) were explored. In this work, the impact of KP treatment on tensile, flexural, and impact strength of PMMA were contemplated. The KP loadings were changed from 5% to 20%. Impact of EDTA (disodium) blended composite on tensile and impact strength has likewise contemplated. The expansion of KP had caused increment in the tensile strength of the PMMA composite. The three-point bending strength of the surface-blended KP presents slope increase, while the unblended one abatements gradually. If there should arise an occurrence of blended KP/PMMA, the impact strength discernibly expanded with the KP content. Results uncovered that the nearness of disodium salt of EDTA at first glance blended KP has additionally upgraded the effectiveness of stress exchange from the framework to the KP in this way enhanced the interfacial adhesion between the KP and PMMA lattice.

Keywords : Composition, interphase, impact Strength, Kevlar Pulp (KP), Polymethyl methacrylate (PMMA)

Introduction

Fiber-strengthened polymer demonstrates striking mechanical properties.[1,2] Especially, the KPs have been broadly examined because of the light-weight, high explicit tensile strength, and magnificent thermal stableness. KP-strengthened plastics are progressively utilized for an assortment of elite applications particularly in flight related and aviation business as a result of their astounding explicit mechanical appropriate ties.[3– 5] Very low segment of nano-particle in composites has frequently caused a noteworthy enhancement in mechanical properties while the polymer qualities of low thickness and easy in make preparing were maintained.[6– 8] While compound and thermal properties of essentially rely upon matrix materials, mechanical properties of, for example, quality rely upon properties of fillers, and KP/network interfacial bond strength.[9– 11] Generally polar groups were presented on the KP network, and the surface area proportion expanded after the treatment.[12] A precise assessment of fracture and harm is a vital guide for composite plan and application. Along these lines, damage patters and modes should be completely distinguished utilizing suitable characterization procedures for inward damage evaluation. PMMA is a linear thermoplastic polymer generally utilized, showing adjusted mechanical properties, resistant to easy chemical attack, impermeability to water, economical, and simple preparing advantages.[13,14] The mechanical properties of PMMA composite loaded up with polyethylene terephthalate (PET), CNT, or CF have been studied widely.[15,16] The structure and properties of the interface among KP and lattice are essential issues in the investigation of [17] Wettability can likewise influence considerably the interfacial attachment between the KP and the matrix.[18] In this examination, we meant to get ready KP/PMMA composite with various substance of KP by twin screw extrusion to describe the impt properties of incorporated polymer. Furthermore, the impacts of composition on the enhancement of between facial bond between the EDTA blended KP and the polymer lattice were additionally watched.

I. Experimental

Materials and Samples

The Kevlar pulp, poly phenylene terephtalamide (PPTA), was employed as reinforcement material ,which has supplied by VK Minerals & Chemicals, Ghaziabad (UP). PMMA and clay were 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 process

The Kevlar pulp was first immersed in a Tetrabutylphosphonium chloride (TBPC) for two hours to and polarizes the pulp surfaces. All blends were mechanically stirred. Kevlar pulp and PMMA(dissolved in toluene) were injected into a steel mold, cured at 60^0 C for two hours, and post cured for an hour at 150^0 C to obtain the sample. All PMMA with and without disodium salt of EDTA were prepared at the same conditions. The composite test samples with its constituents with different compositions depicted in table 1-4 were prepared accordingly using same method.

Mechanical test

Tensile properties were measured using UNITEK 9405, according to ASTM: D 790. The specimens were prepared by cutting them into dumbbell shapes. Five specimens for each sample were tested with crosshead speed of 5 mm/min. Three-point bending test was used to measure the apparent ILSS of laminates. According to ASTM D 2344(Touchstone), the span was 13.2 mm. Tests were carried out with a 5 kN load cell at room temperature and 1 mm/min. Charpy impact tests were carried out by using a FIT-01 Pendulum Impact Tester according to the standard of ASTM D256.

II. Results and discussion

Test samples were prepared as per the data depicted on tables 1-4

Table: 1. Composite samples with varying proportions of its constituents with fixed (1%) volume of EDTA. (data to check the effect of KP & Content & EDTA on tensile strength of the composite. The graphical representation is as per figure 1.

Ingredients of the Composite	Composite sample 1	Composite sample 2	Composite sample 3	Composite sample 4	Composite sample 5
PMMA(% Vol)	99	94	89	84	79
KP	0	5	10	15	20
EDTA(disodium)	1	1	1	1	1

Table: 2. Composite samples with varying proportions of its constituents without EDTA

Ingredients of the Composite	Composite sample 1 (Vol%)	Composite sample 2 (Vol%)	Composite sample 3 (Vol%)	Composite sample 4 (Vol%)	Composite sample 5 (Vol%)
PMMA(% Vol)	100	95	90	85	80
KP	0	5	10	15	20
EDTA(disodium)	0	0	0	0	0

Table: 3. Composite samples with varying proportions of its constituents. (Data is to check the effect EDTA content on three –point bending strength of the composite. The graphical representation is as per figure 2.

Ingredients of the Composite	Composite sample 1 (Vol%)	Composite sample 2 (Vol%)	Composite sample 3 (Vol%)	Composite sample 4 (Vol%)
PMMA(% Vol)	100	94	87	80
KP	0	5	10	15
EDTA(disodium)	0	1	3	5

Table: 4. Composite samples with varying proportions of its constituents. Data is to check the effect EDTA content on Impact strength of the composite. The graphical representation is as per figure 3.

Ingredients of the Composite	Composite sample 1 (Vol%)	Composite sample 2 (Vol%)	Composite sample 3 (Vol%)	Composite sample 4 (Vol%)
PMMA(% Vol)	100	99	97	95
KP	0	0	0	0
EDTA(disodium)	0	1	3	5

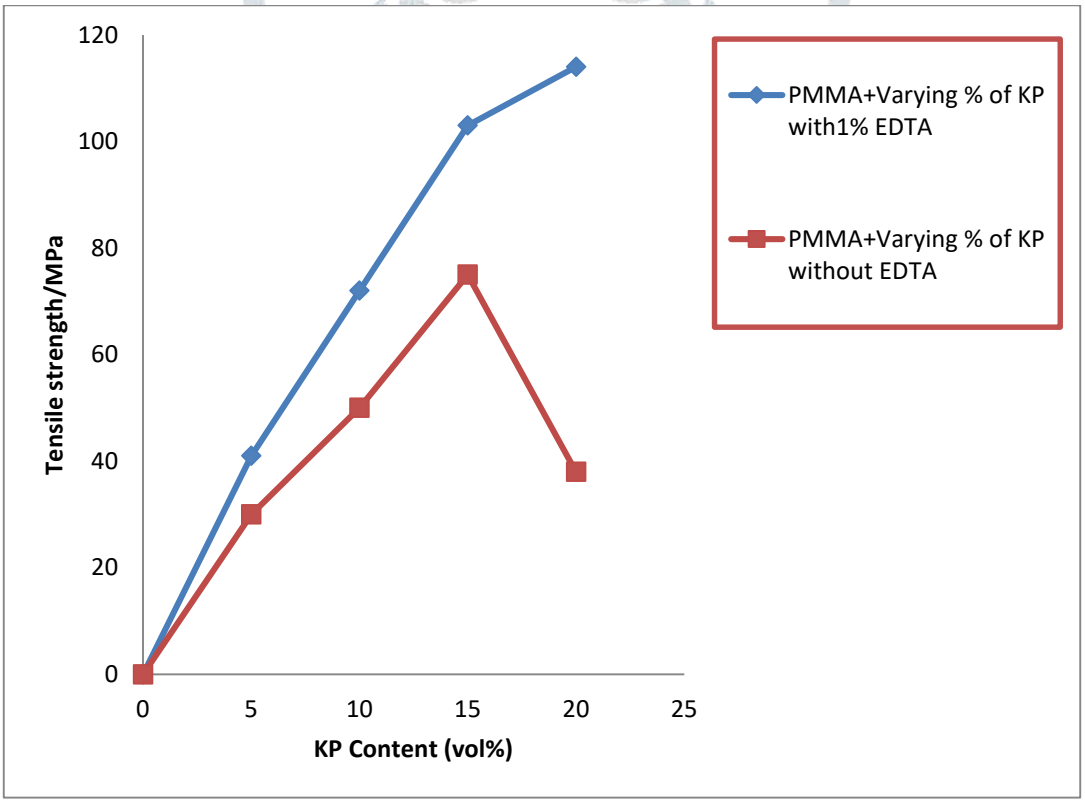

Figure1. Effect of Kevlar pulp content on tensile strength of PMMA composite.

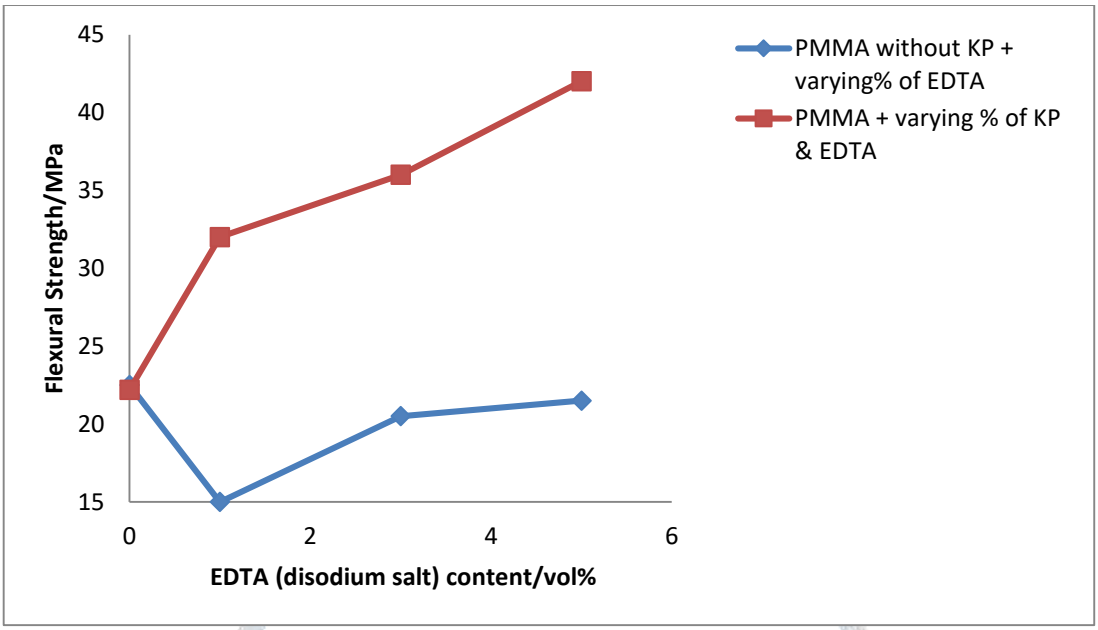

Figure2. Effect of EDTA (disodium salt) content on three-point bending strength of Kevlar pulp-filled PMMA

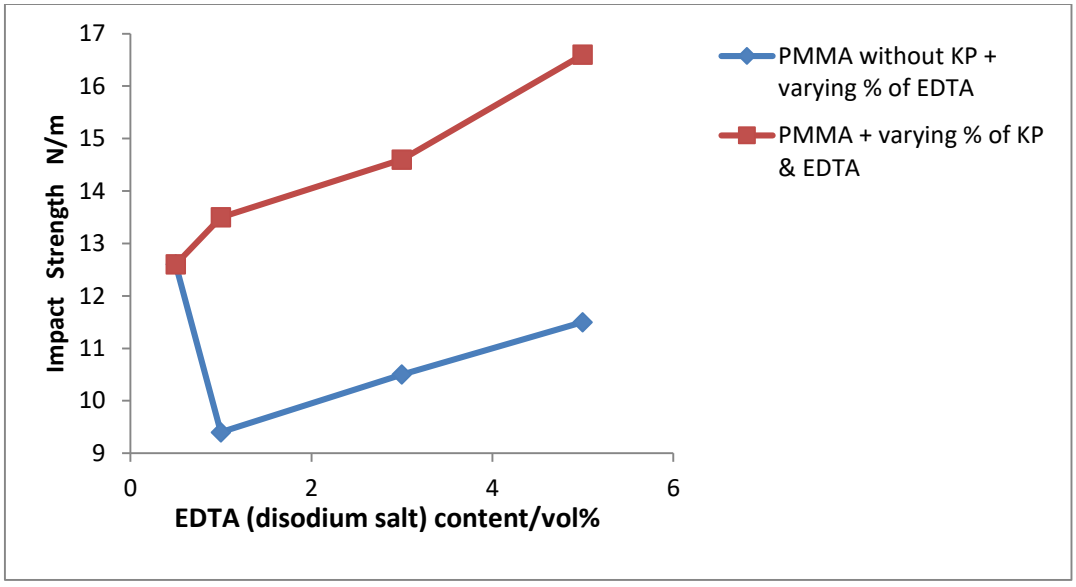

Figure3. Effect of disodium salt of EDTA content on impact strength of Kevlar Pulp-filled PMMA.

Figure1. Shows tensile properties of KP filled PMMA as a function of filler content together with KP treatment. The tensile strength is 32 MPa, 51 MPa, 75 MPa, and 38 MPa for 5%, 10%, 15%, and 20% KP content, respectively. It can be seen in Figure 1 that KP filled PMMA shows increment in tensile strength up to 15 vol. %, and then it has continuously decreased with increasing filler content. Drop in tensile strength is attributed to the poor KP /matrix interfacial bonding. It can be seen that the strength increases until 20 vol. % fillers. This indicates the good interfacial bonding between KP and filler matrix. In this case, KPs are effectively participating in the stress transfer. The incorporation of stiffer KP into the matrix enhanced the tensile strength of the matrix. The use of KP as reinforcement can overcome the disadvantages of PMMA, but poor interfacial interaction between KP and PMMA can lead to the decrease in mechanical properties. The increase of tensile strength is attributed to the increase in mechanical shear that is required to mix larger amounts of KP into smaller amounts of molten polymer. On the other hand decline

in tensile strength is attributed to the weak bonding between the polar hydrophilic KP and non polar hydrophobic PMMA . After the KP is blended with EDTA , the tensile strength has increased up to 15 vol.%, and also shows higher strength than KP filled composite . The tensile strength of KP filled composite with 1%loading of EDTA is sufficient to produce a significant increase in strength as opposed to those without disodium salt of EDTA. However, a further increase in the amount of Disodium salt of EDTA (after15%KP) results in a slight decrease in the strength. First, the reason for enhancement of tensile properties is more likely the exfoliation structure of EDTA in the PMMA matrix. It is believed that the nano-scale dispersion of EDTA provides large interfacial interaction which can cause a substantial restriction on the polymer chain mobility at the polymer KP inter-face region, secondly, the reason behind slight decrease in strength(after15%KP) is due to filling of interstices and vacant positions in the entire system, so no further enhancement in scattering of was possible.

Moreover, the three-point bending strength of the two increases with the increase of EDTA content (Figure 2). The three-point bending strength of the blended KP presents gradient increment along the EDTA content, while the unblended one increases slowly. As the EDTA content increases to 5 wt%, the flexural strength increases to 40 MPa. It is observed that the flexural strength for blended one shows an increment of 50% by incorporating 1 wt% of EDTA, than unblended one.
Results show that addition of 5 vol. % EDTA in PMMA improves the impact resistance by 34%, indicating the beneficial effect of well-dispersed EDTA on the resins' impact toughness (Figure 3). In case of blended KP/PMMA the impact strength noticeably increased with the

K P content and the results show a significant dependence on the inter-facial interactions as indicated by the higher impact strength of the blended KP. Owing to the surface modification and the beneficial presence of the nano-filler within the matrix, hybrid exhibits a considerable improvement in impact strength when compared to non-hybrid at the same EDTA loading. From the surface images, there is a difference in the interfacial adhesion of KP/PMMA with or without EDTA. The fractured surface of pure KP /PMMA composite with some KPs pulled out with relatively blended KP composite samples. From the scanning electron micrograph of the tensile-fracture of PMMA reinforced with unblended K P, it has been found that the surfaces of the KP were very smooth and without any coverage. On the KP/matrix interface of KP/PMMA, the rough fracture surface with clear sliding steps and some KP pull-out from the matrix with long length can be observed. The interaction between KP and resins are strongly dependent on the contact surface. The PMMA resin is distributed more uniformly with the increasing KP/matrix contact surface. This leads to better contacts between filers and resin and, therefore, excellent inter-matrix compacting and bonding. The excellent bonding is able to efficiently distribute the stress along the KP and matrix interface during loading and improve the mechanical properties of the composite. This work carried forward and may be represented in next paper.

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Conclusions

The use of KP as reinforcement can overcome the disadvantages of PMMA, but poor interfacial interaction between KP and PMMA can lead to the decrease in mechanical properties. At similar-filler content, EDTA blended KP -filled composite has the highest tensile strength. The flexural strength for blended one shows an increment of 50% by incorporating 1 wt% of EDTA. The addition of 5 vol. % EDTA in PMMA improves the impact resistance by 33%. It is believed that the nano-scale dispersion of

EDTA provides large interfacial inter-action which can cause a substantial restriction on the polymer chain mobility at the polymer–KP interface region.

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