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"Thermo-Mechanical Behavior of SLS Modified Fly Ash Filled Epoxy Composites"

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ABSTRACT:
A study on performance characteristics of Epoxy resin composite by incorporation of Sodium Lauryl Sulfate (SLS) modified Fly Ash as filler fabricated using Hand Layup Technique is carried out. The modified Fly Ash was observed to disperse more uniformly than unmodified counterpart. The filler (SLS modified Fly Ash) concentration was varied from 0-25 wt%. The effects of varying concentration of filler (SLS modified Fly Ash) on Mechanical, Thermal properties were discussed. The filler loading optimization were discussed. The incorporation of different weight percentage loading of Fly Ash (0-25 wt%) improved the tensile modulus. The optimum strengthening improvement occurs in composition with 20 wt% of treated Fly Ash. Greater the concentration than 25 wt% lowers the tensile strength because of agglomeration and clustering problem. The optimum loading percentage is investigated with optimum performance characteristics with ecology.

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I. INTRODUCTION

Performance characteristics of thermosetting polymer composites depend on various factors like the characteristics of the filler, also on its dispersion and polymer-filler interactions, and more specifically on the properties and thickness of interphase between polymer and filler [1,2]. Interphase plays an important role in the final performances of the composites as it transmits the stress from the matrix to the filler. Chemical surface modification will improve the performances of engineering composites as it will affect filler wetting and dispersion through surface energy modification but also allows an optimization of the interphase design. The filler dispersion can be improved during the processing of composite and organosilanes are widely used in filled polymer composites to help the wetting and dispersion of fillers [3]. Fly ash is fine and powdery in nature with the particles essentially spherical in nature [4–5]. Fly ash filled polymer matrix composites have been studied by various workers [6–9] to improve the bulk properties of the matrix polymer predominately and have driven high volume applications. Fly ash particles were introduced into Epoxy compound, Sodium Lauryl Sulphate was chosen as a chemical modifier to improve the interaction between Epoxy Resin and fly ash composites.

II. MATERIALS & SURFACE MODIFICATION:-

In the present experimental work, commercially available Epoxy resin Lapox®L-12, of medium viscosity with room temperature curing agent Lapox®K-6 product of Atul Ltd, Polymer Division, India, supplied by Link Composites, Pune used as matrix. The filler fly ash (C-Class) separated at Electrostatic Precipitator collected from Paras Thermal Power Station, Paras, Akola Maharashtra. Sodium Lauryl Sulphate (SLS) surfactant supplied by Jyoti Chemporium, Akola M.S., An E type glass fiber (Woven roving fabric GW 123-800L5 E-glass of 803 g/m^2) and S type glass fiber (Chopped strand mat) both was purchased from Arvind P D Composites Pvt. Ltd. Kalol, Gujrat.

Surface treatment of fly ash required SLS (Sodium lauryl sulphate) 2% by weight of the fly ash. For 100 g of fly ash requires 1000 ml of water and 2 g of SLS. Heat and stir the solution at temperature of 60 ^{O}C for 6 hr. the modified fly ash was filtered by filter paper and then dried at 95-100 ^{O}C for 12 hr in an oven until a constant weight was achieved [10].

Composite Characterization:
Mechanical Properties :

Table 1: Tensile Properties of Epoxy/SLS Modified FA Composites

Wt % Fly Ash (SLS Modified)	Tensile Strength (MPa)	Stiffness (N/mm)	Young's Modulus (Mpa)
0	61	2076	4446
5	62	3323	5968
10	52	2550	4671
15	60	2913	4941
20	79	3263	5892
25	77	3356	5753

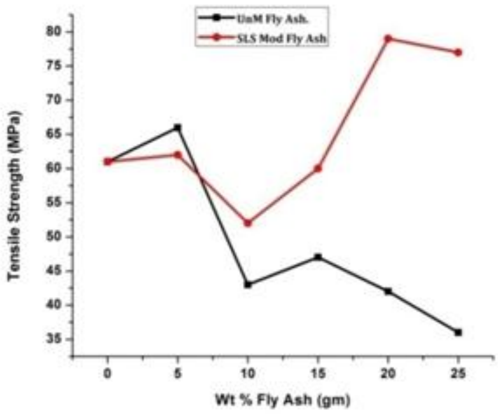


Fig: A Tensile Strength Epoxy/SLS Mod. FA Compo.

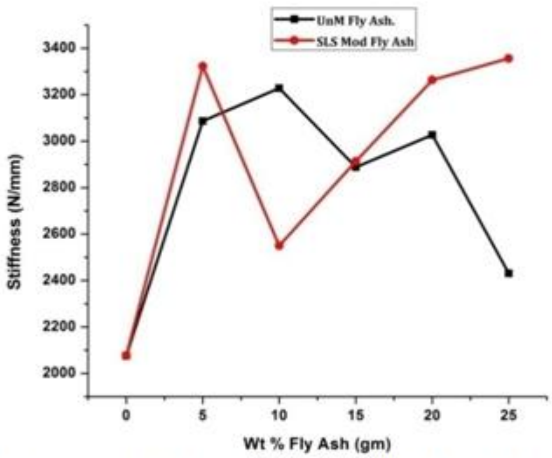


Fig: B Stiffness Epoxy/SLS Mod. FA Compo.

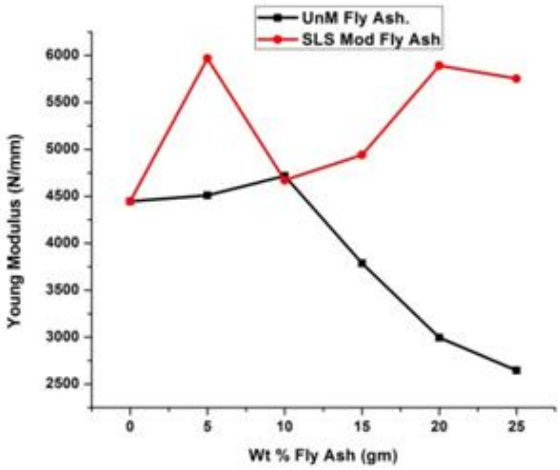


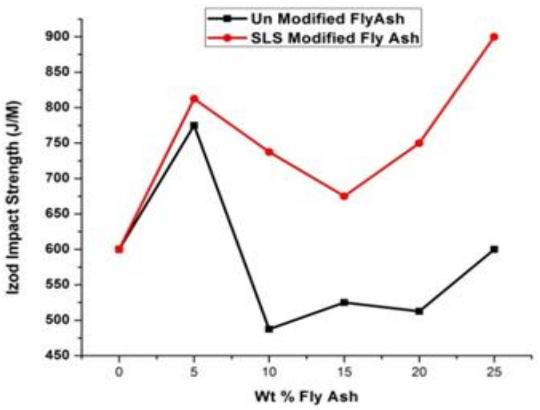
Fig: C Young Modulus Epoxy/SLS Mod. FA Compo.

Figure A, B, C shows the results of magnitude of room temperature tensile modulus, stiffness and Young's Modulus of SLS Modified filled fly ash Epoxy composites respectively. The tensile modulus of both unmodified and modified fly ash filled Epoxy composites shows a linearly increasing trend with the increasing concentration of SLS modified fly ash from a weight percentage of 10 wt% as compared to untreated fly ash epoxy composites. Moreover, the tensile modulus values of the SLS treated fly ash filled Epoxy composites are higher than those of the untreated Epoxy composites and optimized at 20 wt%. It was found that due to surface modification of fly ash with SLS make more uniform dispersion and improves particle-particle interaction. Figure B shows stiffness performance of the resulting EPOXY composites, the peaks are highest at the filler content of 20 wt% for both the unmodified and modified fly ash filled Epoxy composites. The Young's modulus increases linearly with increase in concentration of SLS modified Fly Ash composites up to 20 wt%. Higher concentration of filler showed a decrease in Young's modulus. Comparing the effect of the surface treatment with SLS on the tensile strength, stiffness and Young's modulus it is shown that there is significant increase between the modified and unmodified fly ash filled Epoxy composites.

Flexural and Impact Properties Epoxy/SLS Fly Ash composites:

Table: 8.A.2: Flexural & Impact Properties of Epoxy/SLS Modified FA Composites

Wt % Fly Ash (SLS Modified)	Modulus of Bending (MPa)	Modulus of Rupture (Mpa)	Secant Modulus (Mpa)	Charpy Impact Strength (J/M)	IZOD Impact Strength (J/M)
0	6606.37	63.09	5880.68	376.66667	600
5	11002.11	101.74	8565.57	500	812.5
10	15138.53	84.76	8051.48	633.33333	737.5
15	16830.74	119.34	7454.07	733.33333	675
20	8157.43	125.42	8093.99	804.16667	750
25	8275.53	102.29	8591.86	831.66667	900



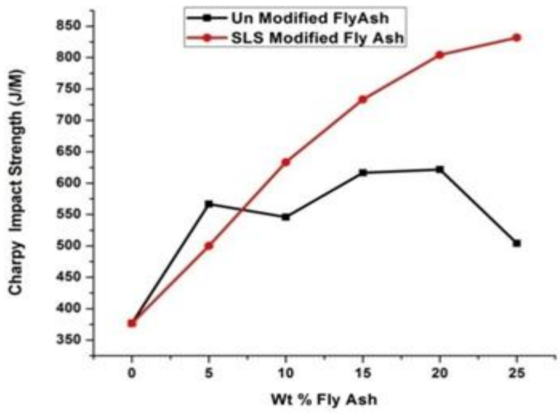
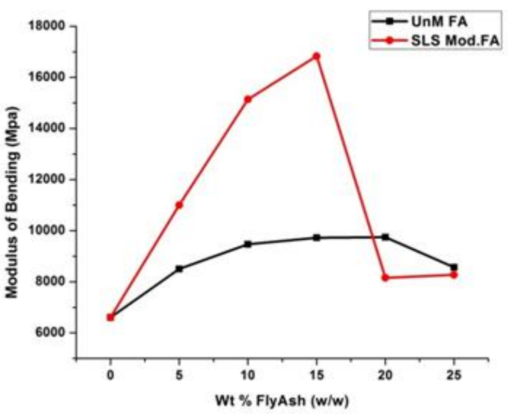


Fig: D Izod Impact Strenngth Epoxy/SLS Mod. FA Compo. Fig: E Charpy Impact Strength Epoxy/SLS Mod.

The magnitude of Izod impact strength and Charpy impact strength are shown in figure D & E shows improved 87 % SLS treated fly ash compared to untreated fly ash Epoxy composites. SLS treatment help to disperse filler more homogenous and reducing the probability of crack formation up on impact. The SLS modify the hydrophilic surface to hydrophobic to disperse the filler, which may facilitate a better transfer of stress. As impact strength is a measure of the energy needed to break a material, the result shows the more energy was required to break the surface modified fly ash filled composites the enhancement of impact strength is due to the improvement of adhesion at the interface of the polymer and the filler particles. The increased impact at 25 wt% is consistent with Izod impact strength and Charpy Impact strength which is considered due to increased bonding between the filler and matrix.



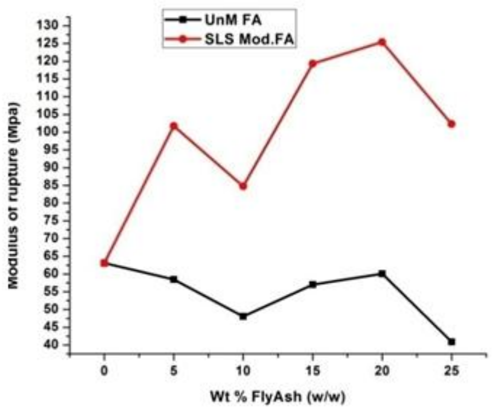


Fig: F Modulus of bending Epoxy/SLS Mod **Fig: G Modulus of rupture Epoxy/SLS Mod. FA Compo**

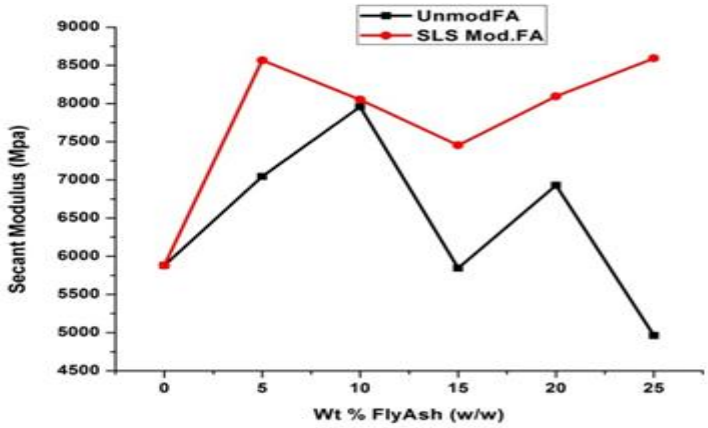


Fig: H Secant Modulus Epoxy/SLS Mod. FA Compo

Figure F, G, & H depicts the variation of modulus of bending, modulus of rupture and secant modulus of untreated and treated fly ash Epoxy composites. It is seen that modulus of bending increases drastically with increasing concentrations of SLS modified fly ash up to 15 wt% of SLS treated fly ash addition Flexural modulus drastically improved 60% compared to untreated fly ash epoxy composites then after which 1 wt% flexural modulus dropped. This change in the phenomenon of variation in flexural modulus of treated and untreated fly ash composites may be due to an increase in interfacial interaction of filler matrix due to surface treatment. Figure G depicts the variation of modulus of rupture of SLS modified and untreated or unmodified fly ash. It is evident that modulus of rupture increases with the increasing concentration of modified fly ash. The modulus of rupture increases by 80% on addition of 20 wt% of SLS modified fly ash as compared to unmodified fly ash. This change in the variation of modulus of rupture of modified and unmodified fly ash may be due to increasing interfacial interaction of filler and matrix by using sodium lauryl sulphate. It is also observed that secant modulus increases with the concentration of modified fly ash up to 25 wt%. The increase in secant modulus may be due to better interaction between the fly ash and polymer matrix.

Thermo Gravimetric Analysis Epoxy/SLS Mod. Fly Ash composites:

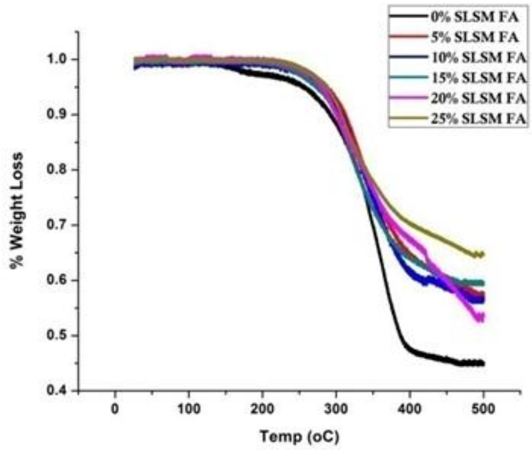


Fig: (I)

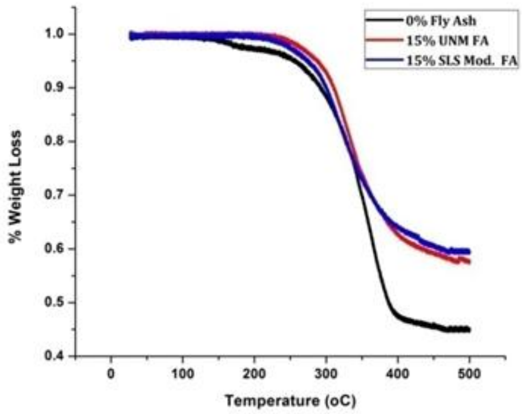


Fig: (J)

Figure (I-J) shows the TGA weight loss curve for the SLS treated fly ash filled epoxy and untreated fly ash filled epoxy composites. Test results indicate that the incorporation of Fly Ash into epoxy polymer matrix increases the thermal stability. The introduction of SLS modified filler increases the thermal stability owing to high temperature degradation as compared with the untreated polymer matrix. It is evident that the weight loss temperatures of Fly Ash filled composites are higher than that of untreated fly ash epoxy composites. SLS treated FA composite shows higher thermal stability over the entire temperature range. However, it is evident from figure (J) that treated fly ash composites show less derivative weight value, which indicated higher stability and the amount of residue is more at the end of the test, which signifies that the loss of weight against temperature is less. Hence, SLS silane treated FA/Epoxy composites display higher thermal stability as compared to untreated composites. This is primarily due to the high bonding between the Fly Ash particles and epoxy matrix, restricting the mobility and breaking of chains even at higher temperatures. Figure (J) shows the derivative weight loss curves for untreated and treated FA composites. It is evident that, the treated FA composite shows peaks, at round 500°C and the other at around 550°C, which can be seen from the curve. These two peaks may represent the treatment performed on the FA particles and having less weight loss as compared to other treated FA composites

III. CONCLUSION:

The modified fly ash filled Epoxy composites shows better interaction and more uniform filler dispersion. However unmodified fly ash/Epoxy do not revel this effect. The epoxy composite filled with SLS modified fly ash would shows higher and improved mechanical properties with optimize filler loading as compared with unmodified fly ash epoxy filled composites. SLS treated fly ash shows better reinforcement properties than Unmodified fly ash. Thus Fly Ash can be successfully used as filler in thermosetting polymer composites with improved mechanical properties. Utilization of fly ash in thermosetting polymer composites opens a new area for its use as a substitute for industrial used filler also provide way for fly ash management and disposal.

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