

## The Effect of S-Glassfibre Loading Tribology of Epoxy Composites

<sup>1</sup>Bisike Chidiebere Egere, <sup>2</sup>Uche Ibeneme, <sup>3</sup>Ibe Ejiogu, <sup>4</sup>Philip Abubakar, <sup>5</sup>Oseshi Catherine Okaigbo, <sup>6</sup>Yusuf Lawal Omezie

<sup>1&5</sup>Department of Chemical Engineering, Nasarawa State University Keffi.

<sup>2</sup>Department of Polymer Technology, Nigerian Institute of Leather and Science Technology, Zaria.

<sup>3</sup>Directorate of Research and Development, Nigerian Institute of Leather and Science Technology, Zaria.

<sup>4</sup>Department of Civil Engineering, Nasarawa State University Keffi, Nigeria

<sup>6</sup>Department of Polymer and Textile Engineering, Ahmadu Bello University, Zaria

### ABSTRACT

The effect of S-glassfibre loading on the tribology of epoxy composite was premeditated. Different concentrations of E-glassfiber were used to reinforce epoxy material. Epoxy/S-glass composite with glassfibre contents 0, 10, 20, 30, 40, 50, 60 and 70 wt % were fabricated. The fabrications were performed with hand layout method using open mould. The wear properties of the composites were characterized using abrasion wear resistance testing machine manufactured by Taber Industries. ASTM D 958 method and scanning electron microscopy (SEM) were used to study the impact glassfibre concentrations and distributions on the tribology of the composites fabricated. It was found that S-glassfibre addition improves the wear resistant property epoxy material. As the concentrations of glassfibre increased, the wear resistant property of the composites also improves, until the saturation point was reached i.e. 40:60 wt percentage contents of glassfibre and epoxy. The composites with glassfibre content beyond 40-wt percentage pose smaller or reduced wear resistant property. Composite F with 40:60 wt percentage epoxy to S-glassfibre is the best wear resistant composite with wear value of 4.41 wt % and improvement of 65 % when compared to the control sample A. Furthermore, SEM images show that the more the addition of S-glassfibre into the epoxy matrix, the better the wear resistant values of the composites until saturation points and after which, the wear resistant values begins to diminish due to poor interface between the matrix and the reinforcements.

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### INTRODUCTION

Abrasion wear resistant property of a material is the ability of the material to resist damage, gradual removal or deformation due to contact with another surface [1]. Wearing occurs when a hard or rough surface slides across a softer surface, usually an adhesive material, causing the undesired removal of material from the weaker material's surface [2]. Wear behaviour of composites can be studied using a pin-on-disc apparatus under dry sliding condition [3]. Weight loss of composites is measured using precision electronic balance with accuracy of 0.1 mg [4].

The specific wear rate ( $W_s$ ) of the material is given by the equation 1.0 [5].

$$W_s = \frac{\Delta m}{\rho_c \cdot t \cdot V_s \cdot F_N} \dots\dots\dots 1.0$$

Where,

$\Delta m$  = Difference in mass of the samples before and after the test,

$\rho_c$  = Density of composite (gm/mm<sup>3</sup>),

$t$  = Duration of test (sec),

$V_s$  = sliding velocity (m/s) and

$F_N$  = Applied normal load (N)

It is worthy to note that when performing the weight loss experiment, loose particulate may

Corresponding author: Bisike Chidiebere Egere,

[egerebisike@nsuk.edu.ng](mailto:egerebisike@nsuk.edu.ng)

Department of Chemical Engineering, Nasarawa State University Keffi.

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adhere to specimens during testing [6]. It is crucial to clean off the test specimens to the best of one's ability prior to weighing [7]. This research publication X-rayed the tribology / wear properties of the epoxy/S-glassfibre composite

## MATERIALS AND METHODS:

### Materials

The test specimens for the tribology in this research work, were fabricated with the following materials and chemicals with specifications as follows: Montmorillonite

nanoclay ( $\geq 20$  nm, 10- 400 GPa, 1.72 gm/cm<sup>3</sup>, 682608-500G), S-glassfibre in fabric form (300 GSM Specific gravity 2.6 gm/cc), and epoxy resin (Araldite LY 506 Specific gravity 1.15-1.20 gm/cc). Others are epoxy resin hardner (Aradur HY 951 Specific gravity 0.97-0.99 gm/cc) and mould releasing agent (Poly vinyl alcohol PVA) all sourced from Zayo-Sigma Germany.

### Equipment

**Table 1:** list of equipment used for the research experiment

S/N	Instrument	Model / standard	Capacity
2.	Wear/Abrasion Tester	11884	230-1-50
4.	Open Glass Moulds	-	-
5.	Diamond cutter	-	-
6.	Motorized Stirrer	-	1000 rev/min

### Methods

#### **Mould Design and Fabrication Method:**

The moulds used for fabricating all the composites were prepared from silicate glass and have the same dimensions of 200 x 200 x 3

mm dimension. They were all fabricated in the locally.

#### **Composites Formulation and Fabrication Method:**

**Table 2:** The Compositions of Epoxy/S-glassfibre Composites Formulated

	Composite Name	Composite Code	Epoxy (wt %)	S-Glassfibre (wt %)
1	EP100GF0	A	100	0
2	EP90GF10	B	90	10
3	EP80GF20	C	80	20
4	EP70GF30	D	70	30
5	EP60GF40	E	60	40
6	EP50GF50	F	50	50
7	EP40GF60	G	40	60
8	EP30GF70	H	30	70

Table 2.0 show the formulation compositions of epoxy/S-glassfibre composites consisting mixtures of 90, 80, 70, 60, 50, 40 and 30 wt % epoxy with 10, 20, 30, 40, 50, 60 and 70 wt % S-glass fibre respectively made by hand layup method. The moulds were left undisturbed for 24 hours to cure. The samples were removed

and cut into rectangular shapes with diamond cutter according to 985 ASTM standards.

#### **Tribology Testing Method:**

The scratch wear resistance test were carried out on all the composites samples using abrasion wear resistance testing machine with serial number 01554, supply number 230-01-50,

Corresponding author: Bisike Chidiebere Egere,

[egerebisike@nsuk.edu.ng](mailto:egerebisike@nsuk.edu.ng)

Department of Chemical Engineering, Nasarawa State University Keffi.

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manufactured by Taber Industries, ASTM D 958 was employed. The test specimens were prepared in rectangle of 50 mm x 10 mm x 3 mm similar to flexural properties test specimen.

## RESULT AND DISCUSSION

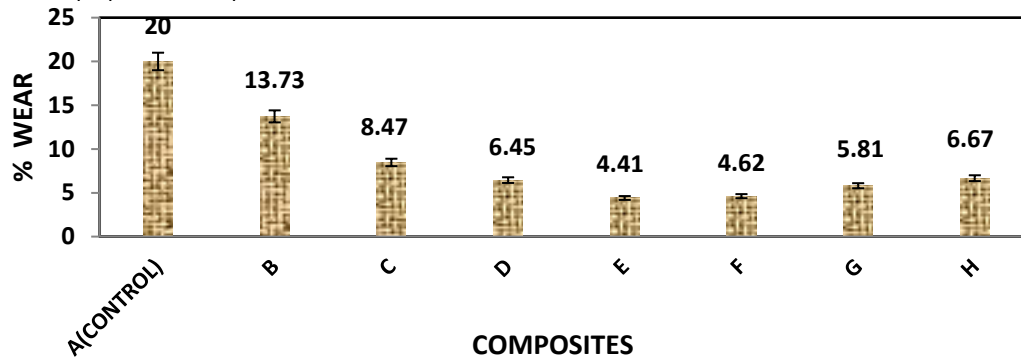


Figure 1: Wear Behaviour of the Epoxy//S-glassfibre Composites Fabricated.

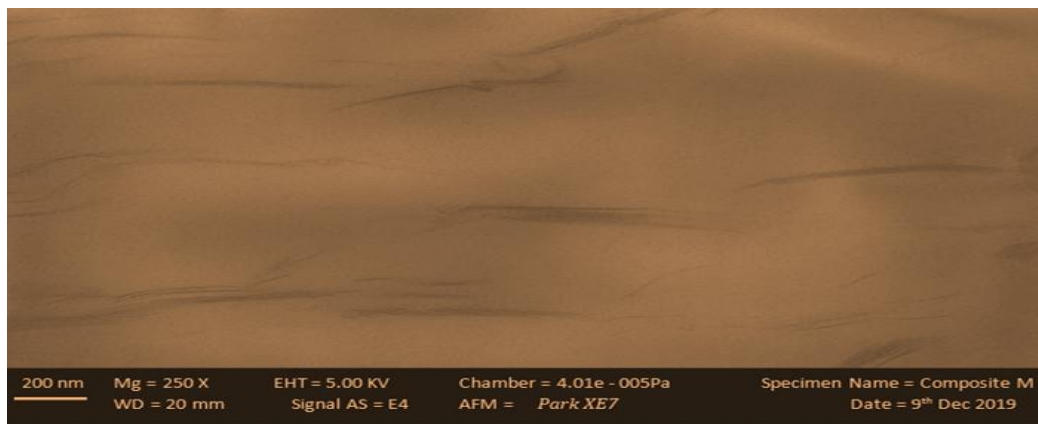


Plate 1: SEM Image of Control Sample A (100 wt % epoxy)

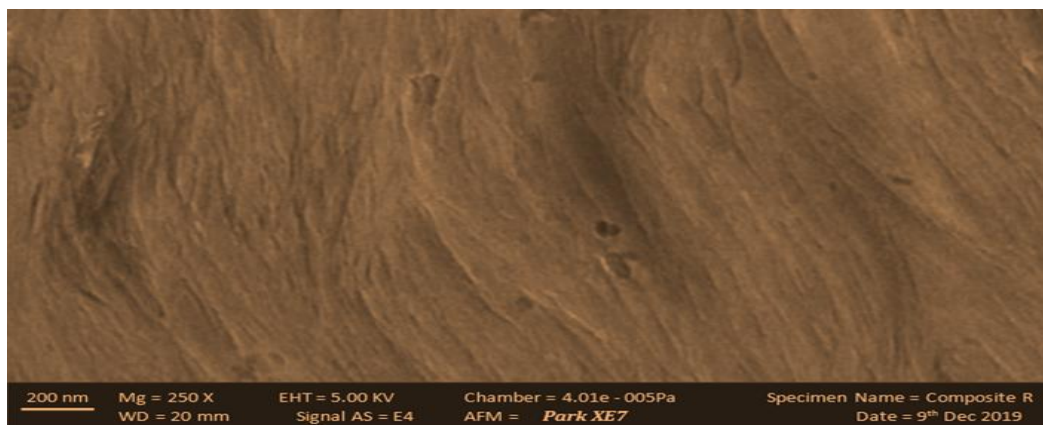


Plate 2: SEM Image of S-glass/epoxy Composite E (4 wt % nanoclay & 96 wt % epoxy)

Corresponding author: Bisike Chidiebere Egere,

[egerebisike@nsuk.edu.ng](mailto:egerebisike@nsuk.edu.ng)

Department of Chemical Engineering, Nasarawa State University Keffi.

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### ***Wear Property Analysis of the Composites Fabricated:***

Comparative studies on the effects of fillers loading on the wear (abrasion) properties of epoxy/S-glassfibre composites and epoxy/nanoclay composites were carried out and reported thus. The percentage wear varies from 20 to 4.41 % for all the composites fabricated. The highest wear value of 20 % was obtained for the control sample A with 100 wt % epoxy while the least wear value of 4.41 % recorded for epoxy/S-glassfibre composites E with 60: 40 wt % epoxy to S-glassfibre contents. In general the decrease in percentage wear from sample A (control) to composite E were because of the S-glassfibre's ability to enhance the wear resistance ability of the composites and good interaction between the reinforcement (S-glassfibre) with the epoxy (matrix) this show similar trend with the reports of [8 and 9].

Composites E to H experienced increase in wear value of the composites F, G and H because of poor interactions between the epoxy matrix and the glassfibre as the as the mixtures are saturated. Epoxy could no longer accommodate the quantity S-glassfibre reinforcement the report of [10 and 11] showed similar trends. The highest wear value of 20 % was recorded for sample A (control) with 100 wt % epoxy while the best wear resistant value of 4.41 % recorded for epoxy/S-glassfibre composite E with 40 wt % glassfibre.

### ***Morphology Analysis:***

The morphology of the control sample A and the best performing composites i.e. epoxy/S-glassfibre composites were analysed and comparatively discussed thus; The SEM image shown in plate 1.0 reveals no traces of E-glassfibre in the sample but random intermolecular void and surface fracture formations due to surface shrinking and entrapped air bubbles [10 and 11]. During the fabrication process as the hardener was added, the reaction that took place was exothermic and as such, air bubbles were created [5 and 8]. Although much care was taken to remove these bubbles, small bubbles were still present and these showed up as

voids at a later stage. The scattered lighter sections are the voids, which were created during the mixing process. Furthermore, as the epoxy cures, there exist shrinking (uneven reduction in the surface area) leaving the formation of cracks and faults on the surface of the control sample [5 and 6]. These intermolecular voids and surface cracks make the controls sample to be weak thereby wears out more than the reinforced composites during the test.

Plate 2.0 revealed the SEM morphology of epoxy/S-glassfibre composite E the composite with the best wear resistant value of 4.41 percentage. The pattern shows uniform fashion of S-glassfibre reinforcements in the composite and there are no traces of void. Furthermore, the SEM image revealed that the inherent shrinking that exists in epoxy materials due to uneven reduction in the surface area leading to the formation of cracks and faults were perfectly taken care of by the reinforcing S-glassfibre making epoxy/S-glassfibre composites to have better wear resistant property. This confirms the works of [7, 9, 10 and 12]

### **CONCLUSION**

The tribology on epoxy/glassfibre and epoxy/nanoclay composite were comprehensively and comparatively done and the following conclusion where made.

1. S-glassfibre reinforced epoxy composites have improved abrasive (wear) resistant ability with epoxy/E-glassfibre E having the best wear resistance value of 4.41 wt %.
2. AFM images reveals that the abrasion wear performance of the composites were due to their degrees of interactions between the matrix and the reinforcements as the epoxy/glass fibre composites with 40 wt % reinforcement possesses the best surface interactions and thus best wear resistant composite fabricated.
3. The composite produced can serve in engineering applications such as floor cover, automobile body part, ship body parts, shoe sole, pedals etc where



materials with high surface wear (abrasion) resistant are required see the report of [9, 11 and 12].

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