# Study of Wear Analysis of Chitosan Epoxy Polymer Composites

M. Om Prakash(✉), Harshavardhan Rebelly, Raviteja Shivakoti, Kirti Gorremuchu, and Deepika Nalla

Department of Mechanical Engineering, Kakatiya Institute of Technology & Science, Warangal 506015, India
omprakash5424@gmail.com

**Abstract.** Though there is an extensive research work available on mechanical behavior of composite materials. The tribological study of biodegradable composites is still need comprehensive study. In this regard, the current paper emphasized analysis of two body abrasive/sliding wear phenomenon of chitosan epoxy composite materials. In current research work composites are prepared by reinforcing 5%, 10%, 15%, and 20% chitosan into epoxy matrix. The composites with 10% chitosan yielded better wear results because of strong bond between matrix and chitosan and modification of brittle behavior of epoxy resin. 10% chitosan composites offered 61% more resistance when compared to neat epoxy. Friction co-efficient exhibited proportionality trend with loads applied. Wear studies suggest that composites with optimum percentage of chitosan in conjunction polymer matrix ensue materials with constructive wear properties.

**Keywords:** Wear · Chitosan · Polymer composites

## 1 Introduction

Materials play very significant role and greatly influence the performance of any component; therefore, enormous research will be done on the selection of materials before it adopted for end application. There have been numerous engineering materials like metals, ceramics and polymers exist and already in use in different applications. To obtain advantageous properties of different materials in a single material scientists developed composites which are combination of two or more materials. Extensive research has been done on composite materials and researchers have been successful in developing various metal, ceramic and polymer-based composites. Composite materials are versatile with excellent mechanical, thermal and tribological properties, therefore these materials are used in high end applications like aerospace, defense, shipping industry and in many other applications. From the past few decades, the researchers have been extensively worked on natural polymer composites to replace conventional materials in that process various natural materials in the form of fibers and particulate/powder form were used as reinforcements. Natural reinforcements are obtained from nature, which are lignocellulose materials there the composites with natural filler are known as green composites.


B. Raj et al. (Eds.): ICETE 2023, AER 223, pp. 1016–1021, 2023.
https://doi.org/10.2991/978-94-6463-252-1_102

Most of the researchers were successful in fabricating a natural polymer composite with excellent mechanical properties [1]. It was proved that natural fiber polymer composites have certain advantages over conventional materials such as low cost, high specific strength, biodegradability and ease of processing [2]. The inclusion of natural materials into polymer resins not only changes the mechanical properties of composites but also modifies the tribological behavior of the composite materials [3]. The tribological properties refers to different wear mechanisms such as erosion wear, abrasive wear etc. Among different wear phenomenon abrasive wear which often occurs between the contact surface which have relative motion between them. Generally, when two different surfaces with different material characteristics are in contact and glide over each other results in loss of material from weak surface and this damage is referred as two body abrasive wear [4]. If there come any foreign particles in between the sliding surface and cause the removal of material, then it is termed as three body abrasive wear [5]. From the past research it was observed that abrasive wear of composite materials is influenced by factors such as reinforcements/filler (type and amount of content), hardness of composites, fracture toughness, and operating conditions etc. To evaluate and analyze the abrasive wear behavior of green composites different types of testing equipment and methods were adopted by researchers.

Chitosan is a biodegradable material which is being widely used in many engineering applications and medical field. One such application is bioimplants, though it degradable properties and strength were studied, there is no much research regarding wear analysis of chitosan polymer composites In the current research work an attempt was to utilize chitosan material as reinforcements in polymer composites. The resistance to material loss when in contact with foreign surfaces and having relative motion between them was experimentally analyzed by testing the composite materials on coarse surfaces.

## 2 Materials and Methods

### 2.1 Materials

In the current study chitosan is chosen as reinforcement and epoxy as matrix phase. Chitosan was procured from Vedayukt India private limited. The particulate size of chitosan material is 15 μm.

### 2.2 Chitosan Epoxy Composite Fabrication

For fabrication of the test samples, plastic cylindrical containers with dimensions (d*l = 1*3.2 cm) are used to make smooth moulds for the test samples. Epoxy chitosan composites are prepared by combining chitosan powder and epoxy (LY556) in four different ratios (5%, 10%, 15%, 20%) and a hardener HY951 was used as a curing agent. A mechanical stirrer is used to mix the reinforcement and resin to achieve homogeneous and void free mixture. The most common issue encountered during the preparation of the particulate reinforcement and resin combination is void development, which occurs due to the resin's excessive viscosity. Throughout the mixing operation, this issue was given top priority. The composite mixture is put into all of the moulds, ensuring a constant

**Fig. 1.** Chitosan epoxy polymer composites Pin on Disc test specimen

volume of mixture in each mould. The moulds are set aside for 36 h for curing and then the cured composites are carefully removed. The test specimens are grinded till their length is less than 3 cm. For a superior quality, the grinded specimens are finished against P1000 and P1200 abrasive paper.

### 2.3 Abrasive Wear Test

The test samples are weighed and labeled. To improve contact with the counter surface, all specimens were polished against fine graded SiC paper. The Pin on disc test rig supplied by magnum engineers was used to test the epoxy chitosan composite materials for two body abrasive wear resistance. The composites are tested on coarse abrasive surface at different loading conditions to analyze sliding wear behavior. In the current study P600 SiC paper is selected as abrasive surface and loading conditions starting with 10 N load with increments of 5 N up to 20 N. The wear test and wear rate calculations were carried similar to the procedure discussed by om prakash et.al. [6]. The samples are slide against abrasive surface at a suitable rpm such that each sample will slide 100 m distance.

## 3 Results and Discussions

The sliding wear behavior of epoxy chitosan composites was determined by testing specimens don pin on disc test rig. Figure 2 presents wear rate of epoxy chitosan composite materials at different loading conditions. It was observed bare epoxy offered poor resistance to sliding wear when compared to epoxy with chitosan composites. Epoxy is a thermoset polymer exhibits brittle nature, when it is in contact with coarse surface i.e., P600 abrasive paper and has relative motion results in brittle fracture of the contact surface due to friction. Therefore, poor wear resistance of the epoxy material can be ascribed to brittle failure of contact surface because of friction [7]. It is also evident from Fig. 1 that reinforcement of chitosan has enhanced wear resistance of epoxy chitosan composites. The increase in wear resistance with addition of chitosan implies that reinforcement has modified the brittle behavior of epoxy thermoset. It can be inferred that chitosan particulate reinforcement acted as load barrier against friction and therefore resulted in low material removal rate.

With increase in addition of reinforcement percentage i.e., chitosan the endurance against wear has increased up to 10% of chitosan. Further addition of chitosan to epoxy resulted in decrease of wear resistance of composites which can be observed in Fig. 3. The chitosan in particulate form dispersed in the epoxy matrix functions as load carrier while the matrix phase acts as load distributor. Better results of 10% chitosan epoxy composites can be attributed to the proper wetting phenomenon between the epoxy matrix and chitosan and also homogenous distribution of chitosan in epoxy resin. The degradation of wear resistance beyond 10% reinforcement of chitosan can be imputed to poor binding strength between the matrix and reinforce because of insufficient resin. Prajapati Naik et al. [8] reported similar results while analyzing wear behavior of biowaste epoxy composites. In their authors observed high wear rate in neat epoxy, while enhancement of wear resistance with the reinforcement of biowaste was credited to strong interfacial bonding strength.

Eroding of contact surfaces is mainly due to friction which arise when surfaces have relative motion. It is therefore significant to comprehend the phenomenon of friction between the chitosan composite surface rubbing against P600 SiC surface. Figure 4 shows the coefficient of chitosan epoxy composites as a function of load. As the load is directly proportional to normal load applied, co-efficient of increased with increase

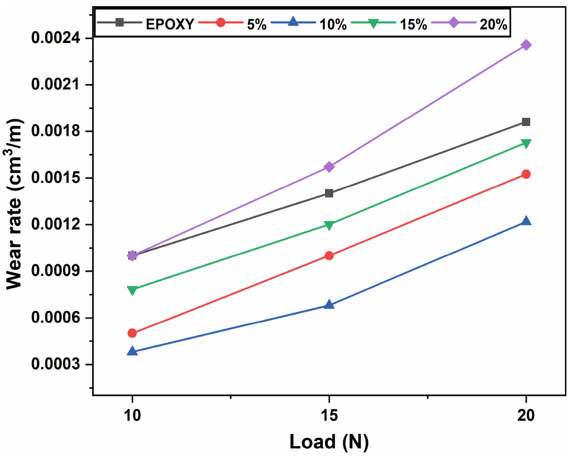


**Fig. 2.** Wear rate of epoxy chitosan composites at different loads

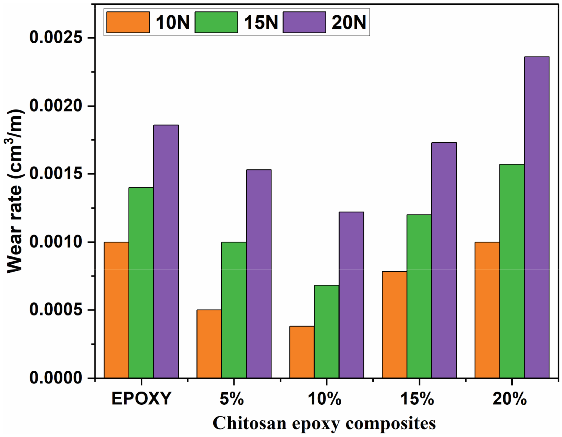


**Fig.3.** Comparison wear rate of chitosan composites as function of applied load

in load. As the sample were tested coarse surface irrespective of load and amount of reinforcement, all the composites exhibited co-efficient of friction above 0.5. Similar results were reported by Hitesh Sharma et al. [9] the decrease in co-efficient of friction because of optimum reinforcement in epoxy was ascribed to typical bond formation between the biowaste filler and epoxy matrix.

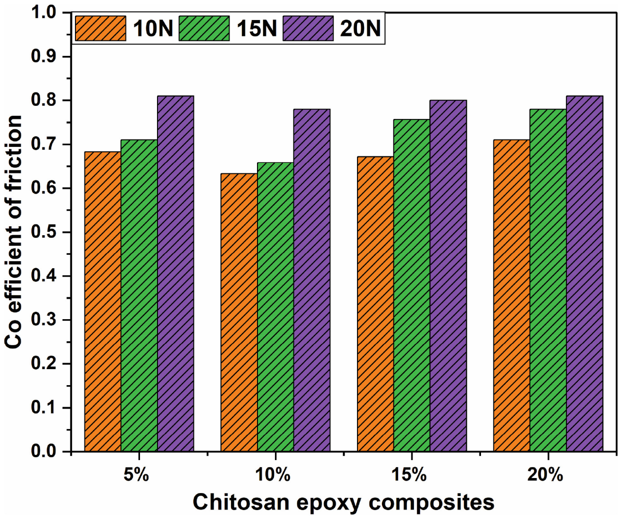


**Fig. 4.** Co-efficient of friction of chitosan epoxy composites tested at different loading conditions

## 4 Conclusions

Composites with different weight percentages were fabricated by using chitosan materials as reinforcement and epoxy as polymer matrix. 10% chitosan epoxy composite materials exhibited good wear resistance. Irrespective of amount of reinforcement all the composites exhibited subjected to gradual loss material to frictional phenomenon. The loss of material on epoxy surface was inferred to brittle fracture. From the analysis of wear rate, it can be concluded that chitosan can be chosen as reinforcement element in fabrication of wear resistant polymer composite.

## References

1. S. Biswas, B. Deo, A. Patnaik, A. Satapathy, Effect of fiber loading and orientation on mechanical and erosion wear behaviors of glass-epoxy composites, Polym. Compos. 32 665–674 (2011).
2. Y. Parulekar, A.K. Mohanty, Biodegradable toughened polymers from renewable resources: Blends of polyhydroxybutyrate with epoxidized natural rubber and maleated polybutadiene, Green Chem. 8, 206–213 (2006).
3. M. Om Prakash, G. Raghavendra, M. Panchal, S. Ojha, B. Anji Reddy, Effects of environ-mental exposure on tribological properties of Arhar particulate/epoxy composites, Polym. Compos. 39, 3102–3109 (2018).
4. U.K. Dwivedi, N. Chand, Influence of wood flour loading on tribological behavior of epoxy composites, Polym. Compos. 29 1189–1192 (2008).
5. N. Chand, U.K. Dwivedi, S.K. Acharya, Anisotropic abrasive wear behaviour of bamboo (Dentrocalamus strictus), Wear. 262, 1031–1037 (2007)
6. Prakash, M. O., Raghavendra, G., Ojha, S., Panchal, M., & Kumar, D. Investigation of tribological properties of biomass developed porous nano activated carbon composites. Wear, 466, 203523, (2021).
7. Barczewski, M., Sałasińska, K., & Szulc, J. Application of sunflower husk, hazelnut shell and walnut shell as waste agricultural fillers for epoxy-based composites: A study into mechanical behavior related to structural and rheological properties. Polymer Testing, 75, 1–11, (2019).
8. Naik, P., Acharya, S. K., Sahoo, P., & Pradhan, S., Abrasive wear behaviour of orange peel (biowaste) particulate reinforced polymer composites. Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, 235(10), 2099–2109, (2021).
9. Sharma, H., Misra, J. P., & Singh, I., Friction and wear behaviour of epoxy composites reinforced with food waste fillers. Composites Communications, 22, 100436, (2020).