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WEAR AND BIOCOMPATIBILITY PROPERTIES OF POLYPROPYLENE/PERIWINKLE SHELL PARTICULATES COMPOSITES FOR DENTAL IMPLANT APPLICATION

*[1]Dodo R. M., [1]Musa, Z., [1,2,3]Abdulwahab, M., [1]Bello, K. A., [4]Abdullahi U., [1]Hamisu, A.

[1]Department of Metallurgical and Materials Engineering, Ahmadu Bello University, Zaria, Nigeria
[2]Department Metallurgical and Materials Engineering, Air Force Institute of Technology (AFIT), Kaduna, Nigeria
[3]Department of Chemical, Metallurgical and Materials Engineering, Tshwane University of Technology, Pretoria, South Africa
[4]Department of Mechanical Engineering, Bayero University Kano, Nigeria

*Corresponding authors' email: rdmamuda@abu.edu.ng

ABSTRACT
The present study explored wear and biocompatibility characteristics of polypropylene (PP)/ periwinkle shell particulates (PWS) composites for dental implant application. Wet-sliding the stainless steel ball against specimen disc revealed the abrasive wear behaviour of the composites under load and linear speed of 5 N and 10 cm/s respectively. In the wear tests, the specimens were wetted with simulated human saliva with and without sodium fluoride (NaF) additive. On the other hand, a mouse specimen was used to carry out a biocompatibility test. The composite demonstrated superb wear resistance at 40 and 50wt% reinforcement loading. Further, results showed that wear rate decreased considerably with increasing PWS content. Higher wear rate was noted on composites under condition of simulated human saliva with NaF addition. The biocompatibility test reveals that developed composite is harmless to the living tissues. Thus, PP/PWS composites could be recommended to be used as dental restorative material.

Keywords: wet wear, biocompatibility, polypropylene, periwinkle shell particulates, dental implant

INTRODUCTION
Dental implants have become increasingly accepted worldwide, exceeding over 2 million placements annually. Implant therapies are also reported to be highly successful with implant survival rates of 91.5 % after 16–22 years (Cruz *et al.,* 2015). Nevertheless, despite great improvements, dental implants may still fail mainly due to micro motions in the bone–dental implant interface during normal functions, which is often regarded as fretting from the viewpoint of tribology (Hai-Yang *et al.,* n.d). Thus, wear resistance of dental implant is of great significance.

The application of tribology in dentistry is a growing and rapidly expanding field. Intensive research has been conducted to develop an understanding of dental tribology for successful design and selection of artificial dental materials (Zhou and Zheng, 2008). In general, oral biomechanical functions can result in some tribological movement of teeth, restorations and implants occurring in the mouth. Therefore, the present study explored wear and biocompatibility properties of the polypropylene/PWS composites for dental implant applications.

MATERIALS & METHODS
Synthesis of the polypropylene (PP) and periwinkle shell particulates (PWS) composites
Periwinkle shells obtained from Rivers State of Nigeria were dried and ground for forty eight hours using ball miller. The composite samples were fabricated by a compounding process involving the addition of the PP, upon achieving a paste like matrix, the PWS material was then introduced manually. The percentage of periwinkle shell was varied from 10 to 50 %wt with a regular interval of 10 %. ASTM G99-05 standard procedure was used in the wet wear analyses. The normal load and linear speed used were 5N and 10 cm/s respectively. A dwell time of 506 seconds was used. In the wear analysis, the specimens were wetted with simulated human saliva with and without NaF additive. Simulated human saliva was prepared by adopting the composition reported by (Mariano *et al*., 2009). In the Biocompatibility test, a mouse specimen was used to carry out the biocompatibility test, the mouse was weigh and a mass of 29.16g was obtained. The composite was converted into fine powder and mixed with a viscous liquid called tween-80 (having composition of oleic acid, ≥58.0% balance primarily linoleic, palmitic, and stearic acids) to convert it into liquid form. A syringe was used in order to get the dosage required (0.06 mm^3). It was then injected into the mouth of the mouse. A study time of 1 day successively was used to observe if any reaction took place and to determine the extent of damage done to the mouse. The maximum number of study time was 7 days.

Wear Analysis

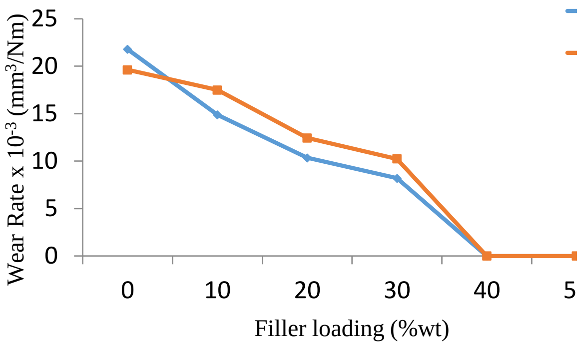

Figure 1: Wear Rate of PP/PWS composites in simulated human saliva (A is a solution of pure simulated human saliva while B is a solution of simulated human saliva with NaF)

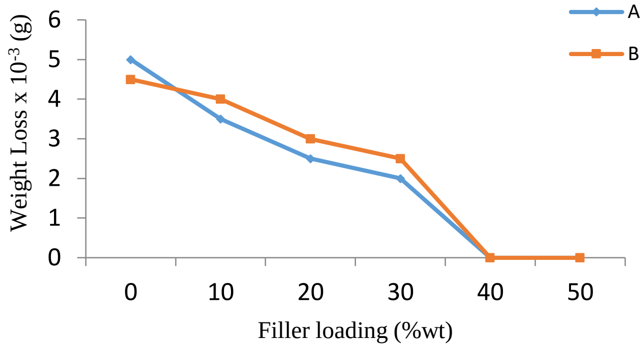

Figure 2: Weight loss of PP/PWS composites in simulated human saliva (A is a solution of pure simulated human saliva while B is a solution of simulated human saliva with NaF)

From Figure 1, it is clear the wear rate of the PP/PWS composites increases mildly when the composites is in contact with solution B due to strong chemical action of NaF. Similarly, a gradual increase in wear resistance is noted with the filler loading. This is attributed to the fact that PWS act as hard solid particles and enhance the wear resistance. Notwithstanding, Figure 2 indicates that least weight loss occurs in the composite containing 40 and 50 wt% reinforcement, while the highest weight loss is observed for the pure PP. This is similar to the results of Çam*et al.* 2016).

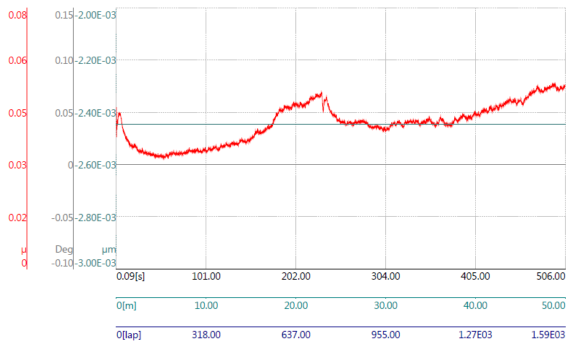

Figure 3**:** Friction curves for ball-on-disk tribometer testing on 10 %wt PP/PWS composite in solution A

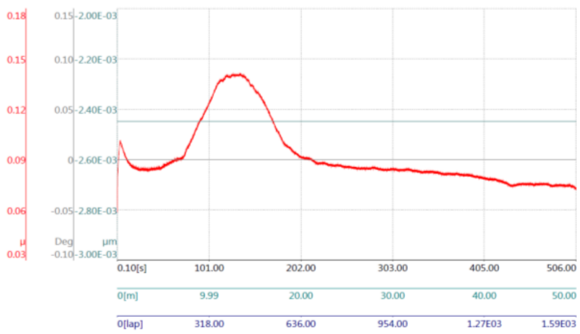

Figure 4: Friction curves for ball-on-disk tribometer testing on 10 %wt PP/PWS composite in solution B

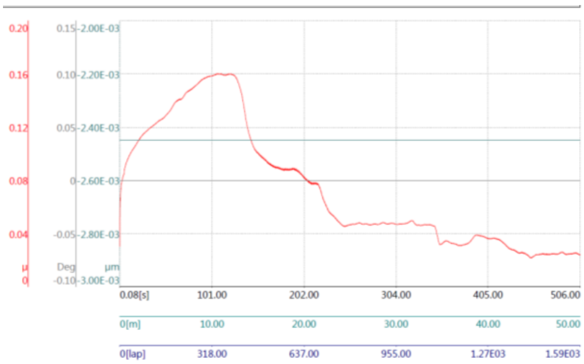

Figure 5: Friction curves for ball-on-disk tribometer testing on 20 %wt PP/PWS composite in solution A

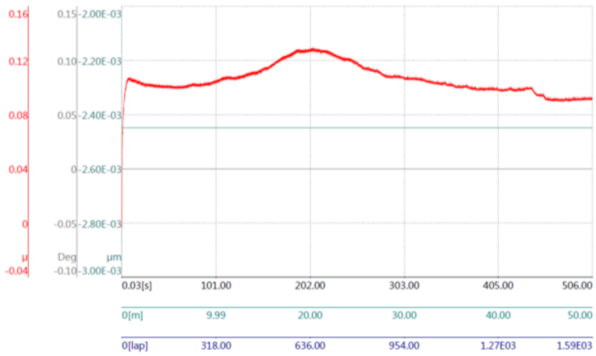

Figure 6: Friction curves for ball-on-disk tribometer testing on 20 %wt PP/PWS composite in solution B

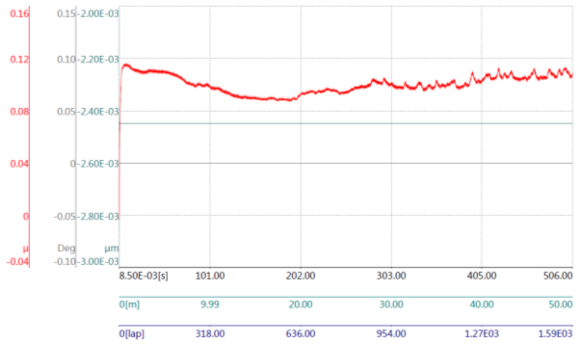

Figure 7**:** Friction curves for ball-on-disk tribometer testing on 40 %wt PP/PWS composite in solution A

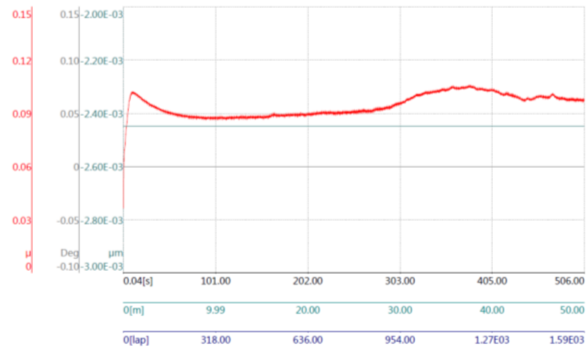

Figure 8**:** Friction curves for ball-on-disk tribometer testing on 40 %wt PP/PWS composite in solution B

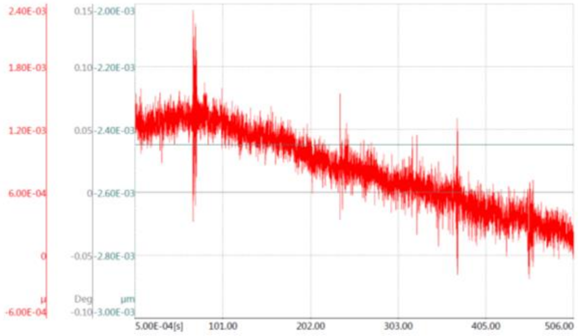

Figure 9**:** Friction curves for ball-on-disk tribometer testing on 50 %wt PP/PWS composite in solution A

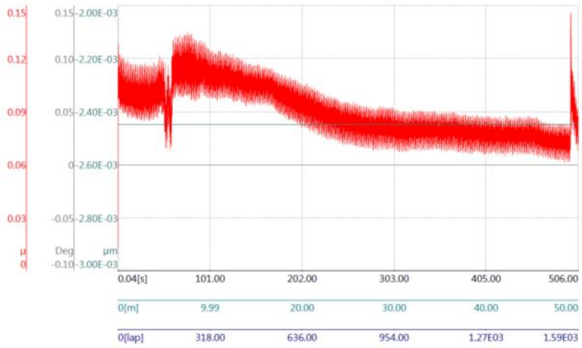

Figure 10: Friction curves for ball-on-disk tribometer testing on 50 %wt PP/PWS composite in solution B

Figures 3 - 10 represent the friction curves for wet ball-on-disk tribometer testing versus number of rotational cycles (lap). An unhurried chemical attack by the additive NaF makes the composites surfaces rougher. Hence, a modest rise in wear rate resulted. This confirmed the relative splendid wear resistance exhibited by the composites tested in solution A. alike trend was reported by Jeffrey *et al.* (2014).

Worn surface examination

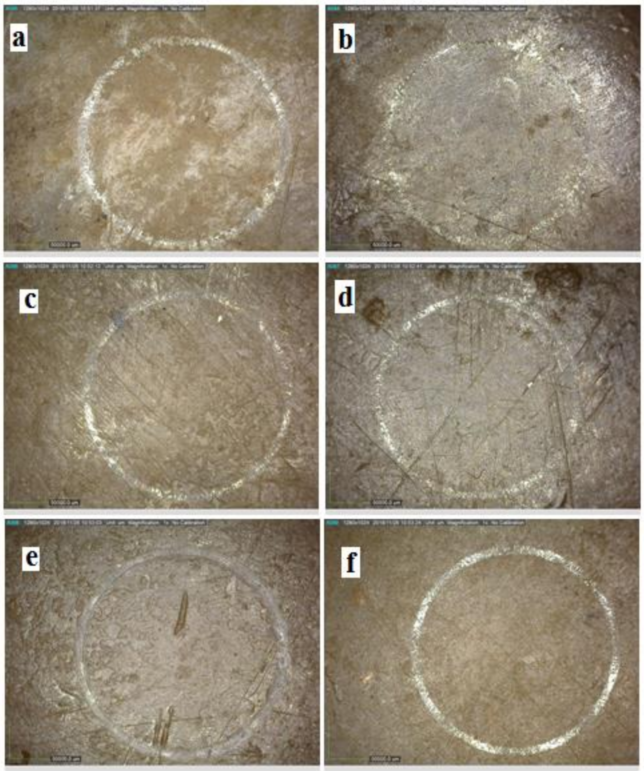

Figure 11**:** Images of wear track for (a) 10 %wt PP/PWS composite in solution A (b) 10 %wt PP/PWS composite in solution B (c) 20 %wt PP/PWS composite in solution A (d) 20 %wt PP/PWS composite in solution B (e) 30 %wt PP/PWS composite in solution A (f) 30 %wt PP/PWS composite in solution B

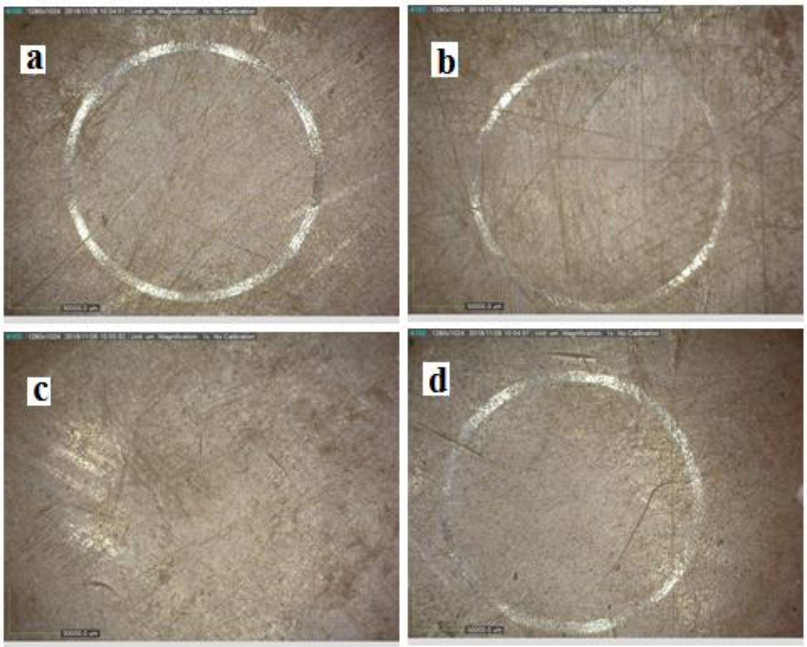

Figure 12**:** Images of wear track for (a) 40 %wt PP/PWS composite in solution A (b) 40 %wt PP/PWS composite in solution B (c) 50 %wt PP/PWS composite in solution A (d) 50 %wt PP/PWS composite in solution B

Figures 11 and 12 show the wear tracks on the PP/PWS composites. Composites tested in solution B demonstrated wider wear track compared to their counterpart tested in solution A. This corresponds to the progressive removal of the material from the surfaces by chemical action of the added NaF (Minoru, 2015).

Biocompatibility Property

During the first day of observation, there was no noticeable reaction of the composite placed inside the mouth of the mouse. During the course of the observation carried out on the fourth day, it was observed that the composite was beginning to blend and attaching itself to the cavity of the mouse without any side effect taking place as regards to affecting the normal operational function of the mouse. It was letter observed that there is no adverse reaction such as necrosis (abscess formation) or adverse inflammatory reaction in the neighborhood of the implant. This Imply that the composite is biocompatible and non-toxic to the living tissue at relative acute phase. A similar observation was encountered by Minoru (2015).

CONCLUSION

Based on the result of the biocompatibility test, the developed composites have better biological properties and so as dental restorative material it's harmless to human tissues. Likewise, the wear resistance of the PP has been appreciably improved on addition of the PWS. It is noted that material removal in pure PP is more severe than that for the PP reinforced with 40 and 50 wt% filler. In comparison to composite in solution A, composites wetted with solution B displayed inferior wear resistance due to the presence of additive NaF. In consequence, composite with 50 wt% filler loading indicated sterling wear resistance compared with all other composites. This could be recommended to be selected for artificial dental material.

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