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Assessment of the Scanning Electron Microscopy (SEM) Properties of Buffing Dust (BD)/Footwear Leather Offcuts Reinforced Waste HDPE (wHDPE) Composites

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Abstract

Scanning electron microscopy provides an excellent technique for the study of surface morphology of buffing dust and footwear leather offcuts reinforced waste High Density Polyethylene (wHDPE) composites. This was aimed at studying the effect of voids, fibre pull-out and interfacial gap on the mechanical properties of a composite materials. The unreinforced (control samples) at X 9000 magnifications indicated that the matrix were well arranged. The untreated and treated composites at various weight fractions of reinforcement and at X 9000 showed some level of voids, fibre pull-out and interfacial gap. This interfacial gap could serve as stress concentration point when load or force is applied on the material and could cause the material to fail easily. The interfacial gap led to the low mechanical properties exhibited by the BZ5 (50 wt% benzoyl chloride treated BD/FLO-wHDPE) composite. Give a concluding sentence on the application(s) of the finding(s) in an industrial setting or the economic relevance.

Keywords: Buffing dust, Footwear Leather Offcuts, Morphology, Voids, Interfacial

Introduction

Polymer morphology is the order within macromolecular solids at a level of nanoscale, submicron and micron scale [1]. The morphological properties of polymer composites played an important role in the processing and application of polymeric materials [2]. It includes the processes of formation such as crystallization, deformation, material properties and product performance. The leather industry plays a significant role in the present socio-economic development [3], yet generating large quantity of solid wastes.

Leather solid waste generated from the leather processing industry creates significant environmental problems due to the generation of huge amounts of solid waste and wastewater [4]. Thus, these wastes could be suitably used for thermal treatment, mainly incineration and pyrolysis [5]. Apart from using the solid waste for thermal treatment, it could be used in the production of composites that have end use applications such as: aerospace, footwear, ceiling tiles etc [6]. Therefore, this study was undertaken to assess the morphology of the composites of buffing dust/footwear leather offcuts and wHDPE composites to give insight into the most suitable area of its industrial application(s).

Materials and Methods

Materials

Polymer Waste Collection and Pre-treatment

Discarded waste gallons made from High-Density Polyethylene (HDPE) with recycling code "2" (Society of Plastic Industries, 1987) were collected from a recycling centre at Sabon-Gari Recreational Club Road, Kaduna State. It was ensured that all the samples collected were of the same colour, since this is one of the criteria considered in plastic waste recycling. Plate I represent samples of HDPE plastic wastes obtained from the collection centre.

Buffing Dust

The Buffing dust fibre was obtained locally from Unique Leather Finishing, Sharada, Kano. Thereafter, the removal of impurities such as sand and oil were done and dried for about 3 days. Finally, it was sieved to obtain sample particle size of 2 mm.

Methods

Composite Production

The thin film specimen of the composites was obtained through the addition of waste HDPE flakes into the rolls as it rotates in anti-clockwise direction for 10 mins and at a temperature of 150 Celsius. After the matrix melted, the buffing fibres were introduced manually through a gradual application at 500 rpm. The formulation adopted were 0, 10, 20, 30, 40 and 50 % fibre loads, while the 0 % is the control. The mould was lubricated using paraffin oil and the melted sample was poured into it. Thereafter, the pressing of the sample was done under the compression moulding machine at a temperature of about 150 ºC. The curing was achieved at 5 mins under cooling and the final composite sample was removed [7].

Micro-structural Analysis

Scanning Electron Microscopy JOEL-JSM 7600F in the Department of Geology, University of Ibadan, Oyo State was used for the morphology of the composites. Samples are coated with platinum coating of electrically conducting material, deposited on the sample by low-vacuum sputter coating. SEM instruments place the specimen in a relative high-pressure chamber where the working distance is short and the electron optical column is differentially pumped to keep vacuum adequately low at the electron gun. The high-pressure region around the sample in the ESEM neutralizes charge and provides an amplification of the secondary electron signal. The samples imaging was done at accelerating voltage of 15 kV at various magnifications.

Results and Discussion

Scanning Electron Miscroscopy (SEM)

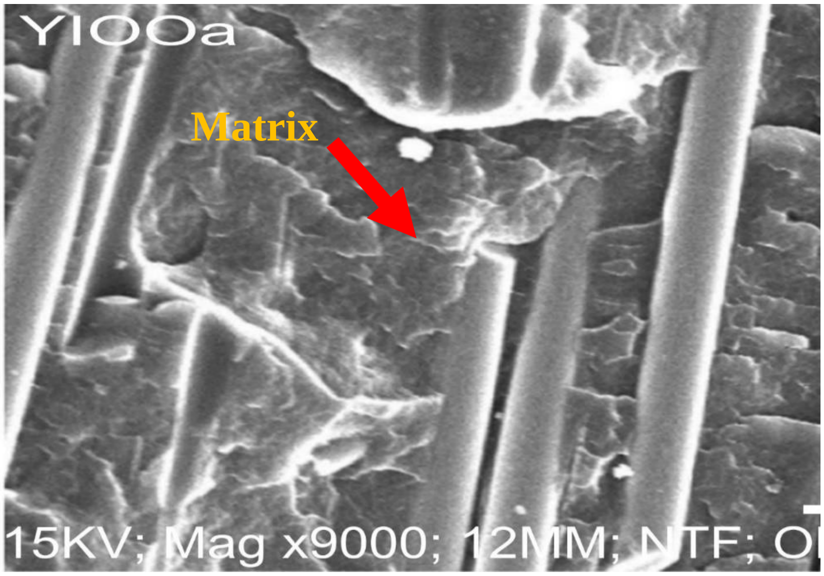

Plate I: SEM Micrograph of wHDPE (control) Sample at X 9000

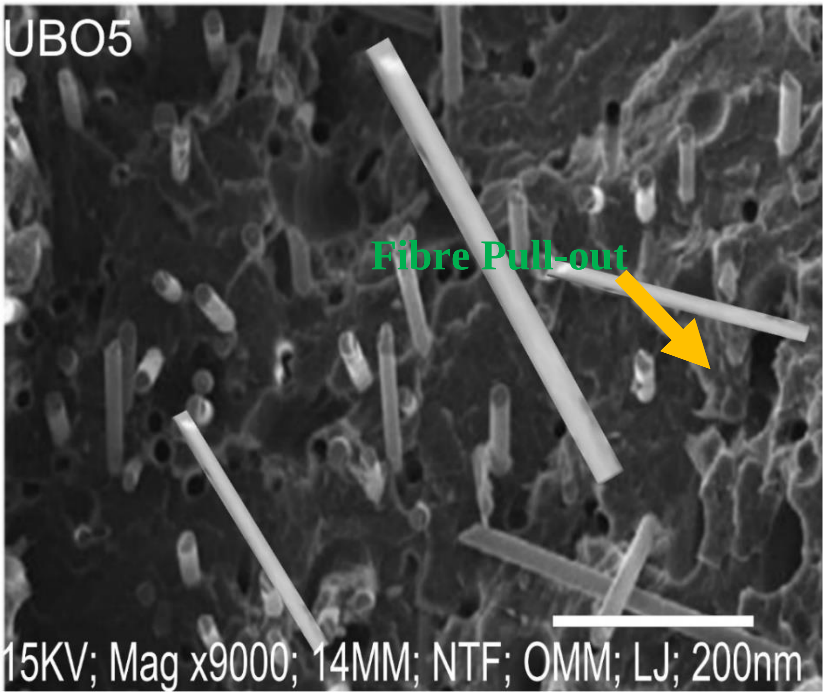

Plate II: SEM Micrograph of 50 wt% Untreated BD-wHDPE Composite at X 9000

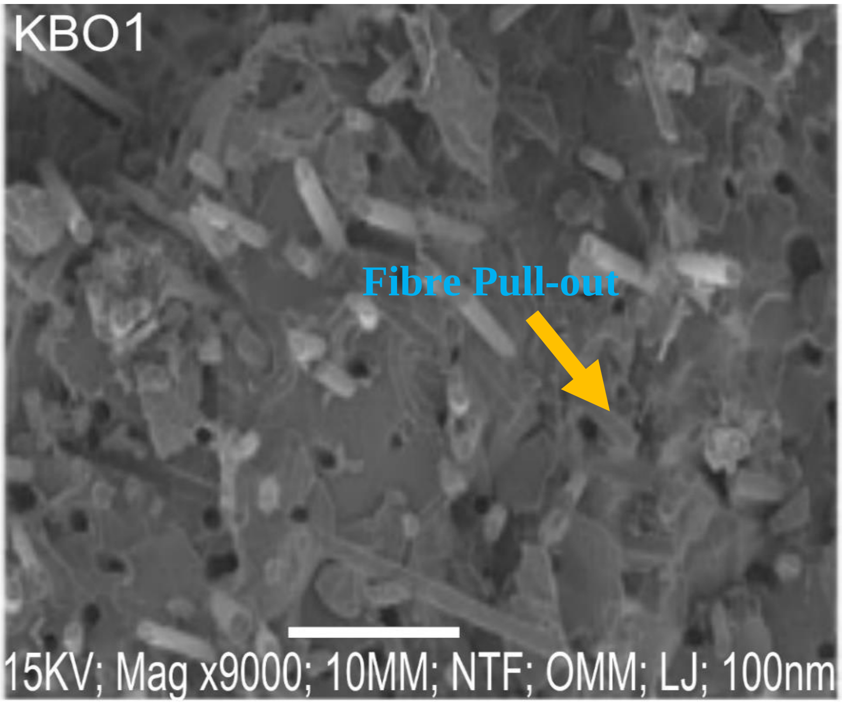

Plate III: SEM Micrograph of 10 wt% Potassium Permanganate Treated BD-wHDPE Composite at X 9000

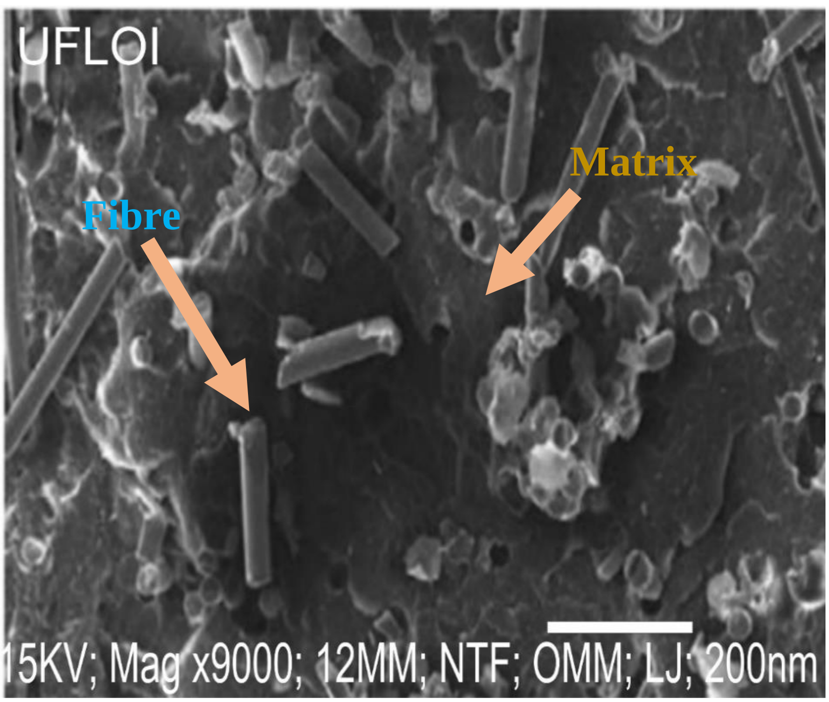

Plate IV: SEM Micrograph of 10 wt% Untreated FLO-wHDPE Composite at X 9000

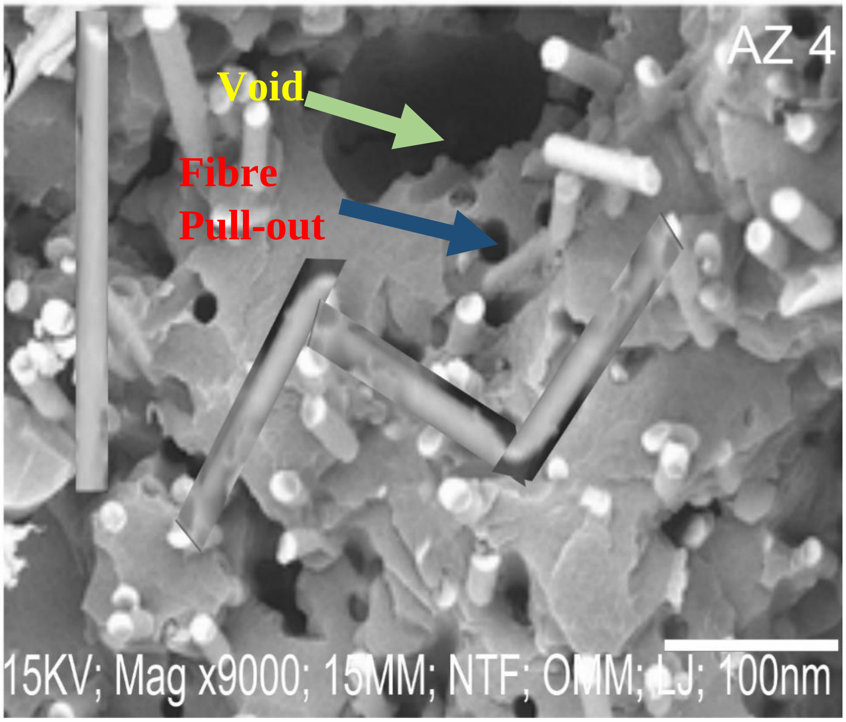

Plate V: SEM Micrograph of 40 wt% Ammonium Hydroxide Treated BD/FLO-wHDPE (hybrid) Composite at X 9000

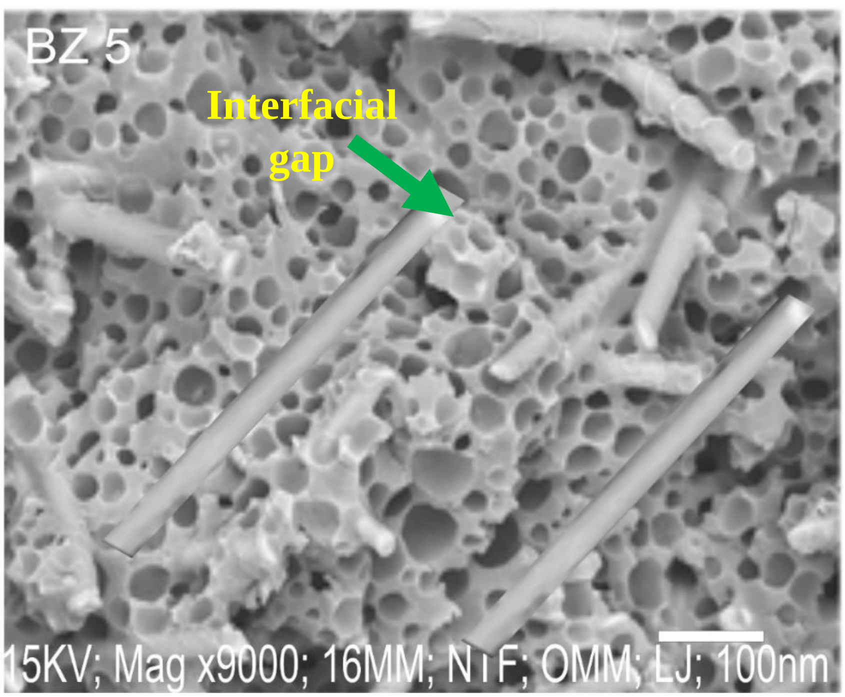

Plate VI: SEM Micrograph of 50 wt% Benzoyl Chloride Treated BD/FLO-wHDPE (hybrid) Composite at X 9000

Scanning electron microscopy provides an excellent technique for the study of surface morphology of buffing dust and footwear leather offcuts reinforced wHDPE composites. Plate I – VI represent the surface morphologies of the unreinforced (control samples), untreated and treated composites at various weight fractions of reinforcement at X 9000 magnifications. Plates I depict the micrograph of the unreinforced wHDPE (control) sample at X 9000. It could be observed that, the surface is smooth without voids, fibre pull-outs and interfacial gap.

From the micrograph represented in the Plates II-VI, it could be observed that there are a lot of voids. These voids are suspected to be caused by trapped air during compounding and compression moulding process. These voids could be the reason why the materials are said to fail easily as they are called stress concentration points [8]. The distribution of the fibres in this case is somehow good, but many fibres are pulled out from the matrix structure and this could be the reason why the material failed easily.

It could also be observed that, in between the fibre and matrix there is an interfacial gap. This interfacial gap could serve as stress concentration point when load or force is applied on the material and could cause the material to fail easily [9]-. This could be the reason for the lowest mechanical properties exhibited by the BZ5 (50 wt% benzoyl chloride treated BD/FLO-wHDPE) composite. Plate V which represents the SEM micrograph of 40 wt% benzoyl chloride treated BD/FLO-wHDPE (hybrid) composite at X 9000 (AZ4), shows that fewer voids were observed. This could be the reason for the better mechanical properties exhibited by the composite. The fibres are fully encapsulated or imbedded by the matrix. Only but fewer fibre pull-outs were observed from the matrix structure.

The reason for the fewer fibre pull-outs could be as a result of better interfacial adhesion between the matrix and the fibres [10]. Plates II-IV, it could be observed that there are no interfacial gabs between the matrix and the fibre with less voids. The reason could be that, the matrix and fibre were mixed thoroughly during compounding process leading to fibre-matrix adhesion and contributes directly to the superior mechanical properties of bulk composites [11].

Conclusion

In this study, 40 wt% benzoyl chloride treated BD/FLO-wHDPE (hybrid) composite at X 9000 (AZ4), shows improvement on its mechanical properties due to fewer number of voids observed.

Therefore, the study provides valuable insights into the microstructural characteristics and opens the window for the potential applications of these sustainable composite materials. This study underscores the feasibility of repurposing waste HDPE with buffing dust and footwear leather offcuts to create environmentally friendly composites.

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