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Characterization and Evaluation of Mechanical Properties of Dolomite as Filler in Polyester

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Abstract
This research work is to characterize dolomite found in southern Nigeria and evaluates the mechanical properties of Dolomite as filler in Polyester. The use of Dolomite as one of the major fillers in Polyester was harnessed. Polyester resin was used as the matrix while the dolomite sample serves as filler. The filler was used at different percentage compositions of weight/weight. A single particle size was chosen for all the percentage compositions. Instron Universal tester and Leco Micro Hardness Tester were used to determined mechanical properties of the composite product. The result of the mechanical test revealed increase effect of the dolomite at 20% and 30% on the Modulus and Hardness of the composite. This makes the dolomite-polyester composite material more suitable for industrial application especially for structural application where high hardness and modulus properties are required.
Keywords: Composite, Dolomite, Mini X-ray Diffractometer, Polyester.

INTRODUCTION

Dolomite is the name of a sedimentary rock and a mineral, both composed of Calcium Magnesium Carbonate ($CaMg(CO_3)_2$ found in crystalline form. Most, if not all dolomite is a replacement of pre-existing limestone and this process is known as Dolomitization [1]. Dolomite appears to form in many different types of environment and can have varying structural, textural and chemical characteristics [2].
Dolomite has being found to be a solid mineral of great importance, which has found its uses in various aspect of life. Some of the uses of dolomite are as an ornamental stone, a concrete aggregate, and a source of magnesium oxide and in the pidgeon process for the production of magnesium. It is a good additive in manufacturing of paper, plastics, tiles and as cheap filler. Dolomite usage is increasingly important in different branches of industries, production of fertilizer, glass, building materials and even the kinescopes (picture tubes) for colour television [3]. Unfortunately, dolomite is now used mainly as a building material or as filler for glass, plastics and colours, in spite of its ability to absorb certain poisonous substances [4].
Dolomite is a kind of primary sediment mineral and has a widespread geologic distribution across Nigeria [5]. This non-metallic mineral is relatively cheap and affordable. Dolomite with high hardness due to its rock characteristic, make it suitable filler in polymer materials with low hardness value [6].
A composite, or reinforced plastic (RP), is a combination of two or more materials with properties that the component materials do not have alone. Thermosetting polyester resins are used in reinforced plastics for small to very large structural parts, corrugated and flat translucent sheets, water-resistance coating, chemical and heat resistant moldings and laminates, and many other application [7].
Fillers or extender are finely divided solids added to resin systems to improve properties and/or processing, and reduce cost. They can be minerals, metallic powders, organic by-products, synthetic inorganic compounds, and recycled post-consumer reinforced plastics and/or plastics [7].
The aim of this research work is to evaluate the effect of Dolomite filler on the mechanical properties of composite produced from dolomite-polyester reinforcement.

MATERIALS AND METHODS

X-Ray Diffraction Analysis

The X-ray diffraction analysis was carried out at Engineering Materials Development Institute, Akure Nigeria.
The sample shown in Figure3 was made into a fine powder and small portion of the fine powder sample was filled into the XRD curvette. The curvette with the sample was then loaded into the sample holder of XRD machine. The machine has an automated interface with the computer. The sample was automatically run for 1200sec, after which the diffractogram with the corresponding data of intensity versus 2θ are being display on the computer monitor. The diffractogram was analyzed using International Center for Diffraction Data (ICDD) database for the search match of the sample with the database compounds, to obtain the accurate result.

Composite Production

The composites were prepared at different percentage of dolomite powder in the polyester resin matrix. The percentage compositions of dolomite used were; 5%, 10%, 20%, 30%, 40% and 50% mass/mass ratio.

After weighing the appropriate quantity of dolomite and the polyester resin matrix on the weighing balance, the dolomite was poured into the polyester. The mixture was stirred manually in the container using stirring rod. 1g and 0.5g of catalyst and accelerator respectively were added to the mixture. The mixture, after stirring was then cast into an Aluminum mould which have a shape of Instron tester test piece and into a Teflon mould for Micro Hardness shape test piece. The mixture was allowed to cure in the mould for several minutes. The formed composite was later removed from the mould and set for mechanical properties determination.

Mechanical Test

The mechanical tests were carried out on the polyester (blank) and other composite products using the same procedure.

The modulus, tensile strength and maximum load tests were carried out with the use of universal testing machine (Instron); 3369 Model.

The hardness test was performed with the use of Micro hardness tester; Leco LM700 AT.

RESULTS AND DISCUSSION

X-Ray Diffraction Analysis (XRD)

The results of the XRD analysis were given in the Figure1 and Figure 2 below. Figure1 contains the diffractogram of the dolomite sample as it was observed from the computer. The plot of the diffractogram is that of 2θ versus intensity (count/sec).

Figure 2 is the result of the search match of the sample phase analysis with that of compound in International Center for Diffraction Data (ICDD) database.

The 2Θ of the sample diffractogram was evaluated with that of the standard. There are four prominent peaks from the sample diffractogram, these peaks are at 2Θ: 31.29, 41.07, 44.82 and 50.49 which correspond approximately to the 30.9389, 41.1281, 44.9503 and 50.5271 respectively for the standard.

This result shows that the sample is a Dolomite having matched with that of the International Center for Diffraction Data (ICDD) powder diffraction files (PDF) database.

Mechanical Test

Results of the tests on Modulus, tensile strength, Maximum Load and Hardness obtained from Instron Universal Tester and Micro Hardness Tester are represented in figures below:

It was observed from Figure 4 that the highest modulus is attained at 30%, while 5% has the lowest value. From 10% to 30% the Modulus (MPa) increased above that of the 0% (polyester), it reduced at 40% and later increased at 50%.

Figure 5 contains the values of Tensile strength (MPa) of each of the volume ratios of Dolomite-Polyester composite in percentage. From the plot, it was observed that the tensile strength of the 0% (Polyester) is the highest of all the values, while 40% was seen to have the lowest value. This is as a result of strong molecular bond that exist within the structure of atoms in the polyester at 0% which is greater than what is obtainable in other percentage compositions. The lowest value obtained for the 40% volume ratio is due to saturated interruption of the dolomite on the structural arrangement of the atoms in the polyester, therefore reduces the strong bond that existed within the polyester molecule. This is also applicable to Figure 6 which contains the values of Maximum Load of each of the volume ratios of Dolomite-Polyester composite in percentage. The plot is similar to the one observed for the Tensile Strength, 0% (Polyester) which has the highest value of Maximum Load and 40% has the lowest value.

$$\underset{\text{Unsaturated Polyester}}{[\ OOC\ C_6H_4\ COO\ CH_2\ CH_2]_n} + \underset{\text{Dolomite}}{CaMg(CO_3)_2} = \text{Composite Material}$$

Figure 7 contains the values of Hardness of each of the volume ratio of the composite in percentage. The result of the Micro Hardness revealed the effect of Dolomite on the hardness of the polyester. It was observed that there was increase in the Hardness at 20% and 30%. At these points, the molecules of dolomite which are harder than that of the polyester were at optimum volume to contribute to the hardness of the composite formed which resulted to the higher values of hardness and modulus recorded.

CONCLUSION

The result of this work has revealed the importance of reinforcement on modulus and hardness of polyester.

From the result, it was observed that for all the parameters 40% has the lowest value. It was also observed that there was an increase in all the parameters moving from 40% to 50%. This suggests that there was an improvement in the properties of the composite moving from 40% to 50%.

The implication of this study is that the polyester could be more suitable for industrial application especially for structural application where higher hardness and modulus properties than that of polyester are required.

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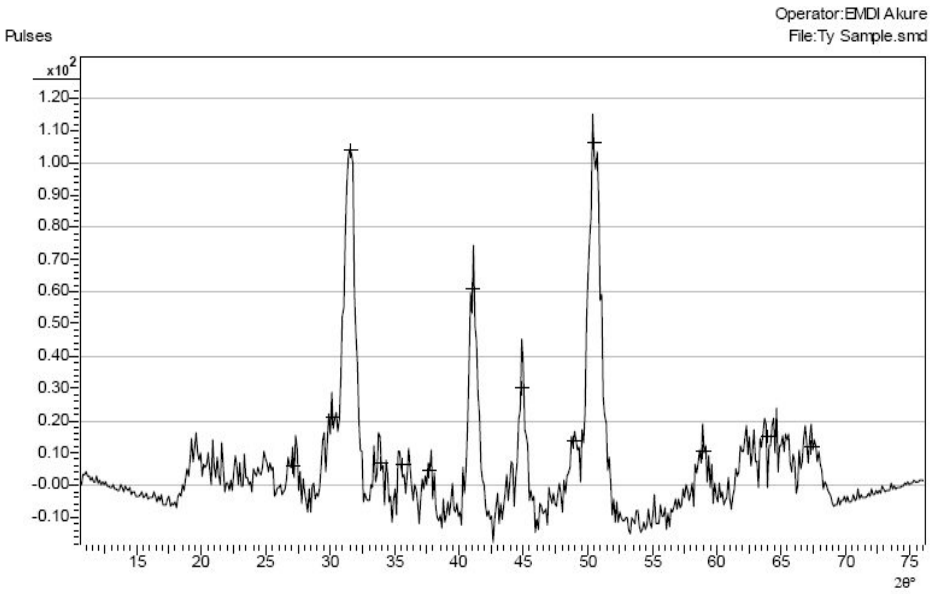

Figure 1. *Diffractogram of the Dolomite*

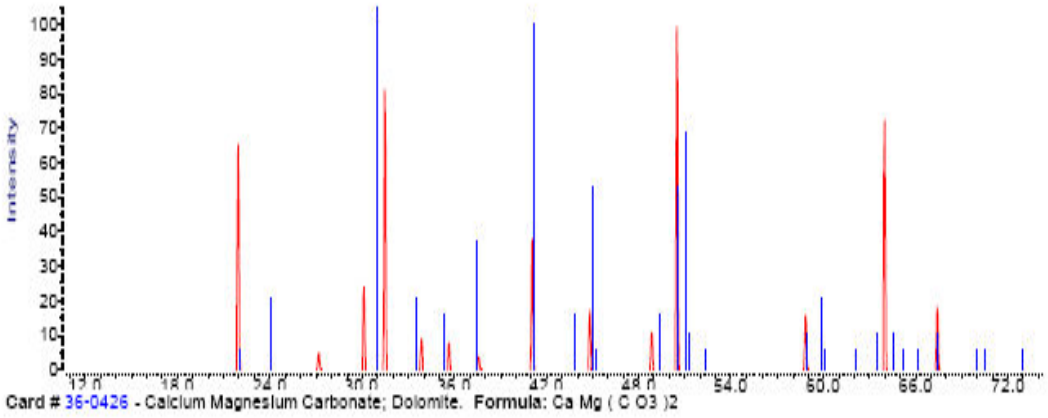

Figure 2: *The peak search match of the Dolomite (ICDD database)*

Figure 3: Dolomite sample from South-western Nigeria

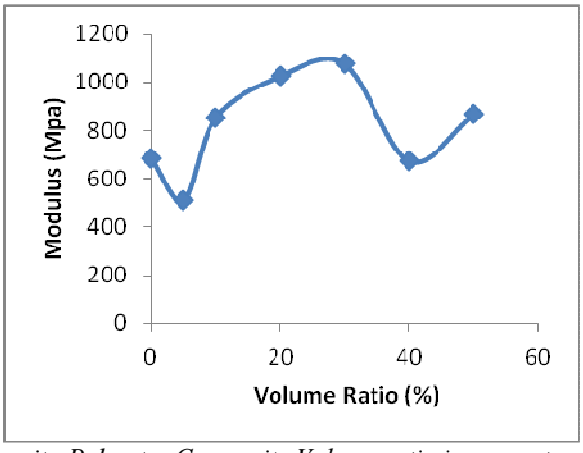

Figure 4: *Plot of Dolomite-Polyester Composite Volume ratio in percentage against the Modulus*

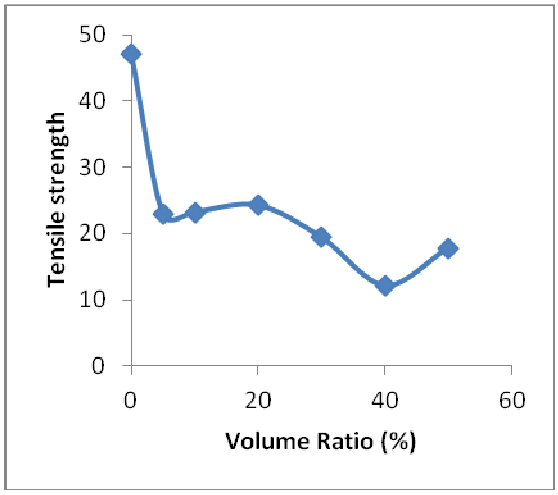

Figure 5: *Plot of Dolomite-Polyester Composite Volume ratio in percentage against the Modulus*

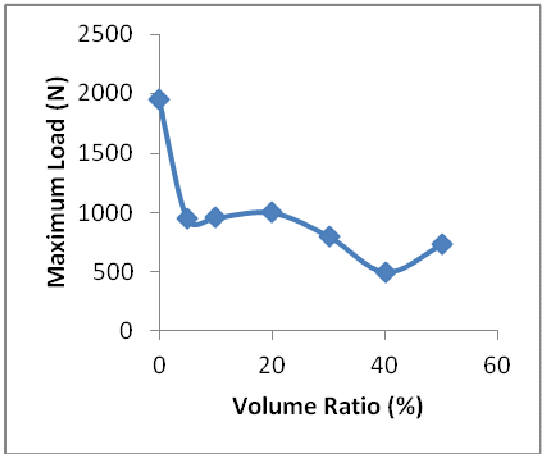

Figure 6: *The plot of Dolomite sample in percentage against the Max Load (N).*

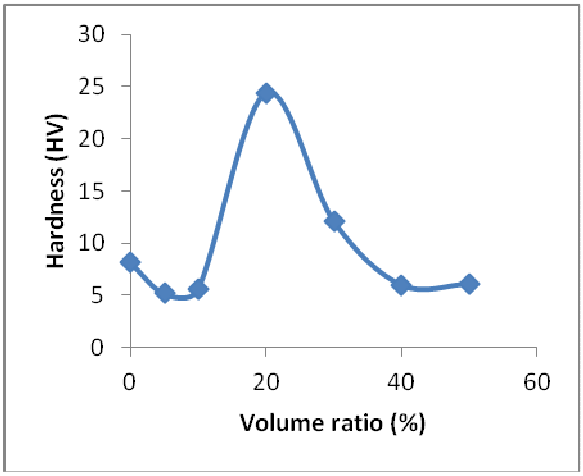

Figure 7: *The plot of Dolomite sample in percentage against the Hardness (HV).*

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