# TENSILE BEHAVIOUR OF COCOA POD FILLED POLYPROPYLENE COMPOSITES

**Onuegbu, G. C., Obasi H. C. & Onuoha F. N.**
Department of Polymer and Textile Engineering
Federal University of Technology, Owerri Imo State, **NIGERIA**
Corresponding Author Email: gc.onuegbu@yahoo.com

## ABSTRACT

The tensile behaviors of polypropylene filled with cocoa pod have been investigated at filler contents of 0, 1.33, 2.67, 4, 5.33, 6.67 wt %. The cocoa pod was sieved to two different particle sizes namely 15 and 25µm respectively. The effect of maleated polypropylene (MAPP) compatibilizer, filler content and filler particle size were determined. The compatibilized and uncompatibilized polypropylene composites at a given cocoa pod filler particle sizes were prepared using an injection moulding machine. Results showed that the tensile strain, true strain at yield, true strain at maximum load and true stress all decreased with increases in filler content but tensile stress, energy at yield, modulus and tensile extension at yield decreased with increases in filler contents. All the tensile properties studied decreased with increases in MAPP content and filler particle size.

**Keywords**: Filler,Composites, Compatibilizer, Cocoa pod, particle size, polypropylene, maleated polypropylene and textile properties.

## INTRODUCTION

Despite the successful utilization of many polymers in various fields of Engineering there is still a growing demand for materials that satisfy more stringent requirement such as high tensile strength, thermal conductivity, improved heat distortion temperature, lower thermal expansion, and reduce material cost (Milewsky et al.) 2005. These requirements which involve a combination of many difficult to attain properties can often be satisfied by utilizing a composite material whose constituents may act synergistically to meet the needs of a particular application.

There is growing trend in the use of organic filler in the manufacture of polymer composites due to their low density, low cost, nonabrasion nature, ( Clemon, 2002) and (Mengelogbu et al.) 2000, possibility of high filling levels, low energy consumption, high specific properties and availability throughout the world ( Abu-Sharch et al.) 2004 and (Matuana et al.) 1998. Numerous studies have used grafted copolymers of synthetic polymers such as ( PP and PE ) and maleic anhydride (M.A) as coupling agent for thermoplastic composites,( Maldas et al.) 1994 and (Kazayawoko, 2006). In order to improve the similarity and adhesion between wood flour and thermoplastic matrices, several chemicals have been employed and maleated coupling agents were found most suitable for organic filler . The coupling agent (MA-PP or MA-PE) can modify the interface by interacting with both the filler and the matrix, thus forming a link between the components( Felix and Gatenholm, 1991). (Wang et al.)2012 investigated the interfacial compatibility of wood flour/polypropylene composites. It was reported that addition of maleic anhydride-grafted- polypropylene coupling agents increased the modulus at higher wood content. (Yali, 2012) investigated the influence of coupling agent concentration wood content and size on the mechanical properties of wood/polypropylene. It was found that the tensile and flexural properties increased with increases in particle sizes and coupling agent but decreased with the increase in fiber content.

## MATERIALS AND METHODS

The polypropylene used in this study was obtained from Eleme Petrochemical Company Limited, Rivers State, Nigeria. It has a melt flow index of 2.5-3.5g/min, and density 0.926g/cm$^3$. The cocoa pod was obtained locally within Imo State, Nigeria. The cocoa pod was dried crushed and sieved to two particle sizes namely, 15 and 25µm. The coupling agent used is maleic anhydride-grafted-polypropylene (MAPP) and was bought from Sigma Aldarich Company U.S.A.

### Preparation of Polypropylene/Cocoa Pod Composites

The polypropylene composites of cocoa pod powder were prepared by thoroughly mixing 150g of polypropylene with appropriate filler quantities (1.33, 2.67, 4, 5.33 and 6.67 wt%) and different compatibilizer contents (1, 1.5 and 2 wt%) .

### Testing

The tensile test was generally performed on universal tensile machine (UTM) Instron 1195 (ASTM D638) which generated the following results; Tensile extension, Tensile strain at yield, True strain at yield, True strain at maximum load, Modulus, Energy at yield, Tensile stress and True stress.

## RESULTS AND DISCUSSION

The tensile behaviours of cocoa pod filled polypropylene composite prepared in this study have been determined and the results are illustrated graphically as shown in figure 1-8.

### Tensile Extension and Tensile Strian at Yield

Figure 1 and 2 shows the effect of filler contents, MAPP and filler particle sizes on the tensile extension and tensile strain at yield of cocoa pod filled polypropylene. The tensile extension and strain at yield of polypropylene composites were observed to decrease with increases in MAPP content, filler content and filler particle size. The decrease in tensile extension of the polypropylene/cocoa pod (PP/CP) composites at high MAPP contents could be attributed to the migration of too much of the compatibilizer around the filler causing self-entanglement among the compatibilizer rather than the polymer matrix resulting in slippage. Similar observation have been reported by( Sanadi et al.) 1995 . Also,( Onuegbu and Madufor) 2012 who studied the effect of filler loading on the Mechanical properties of Maize tassel filled high density polyethylene reported same observation.

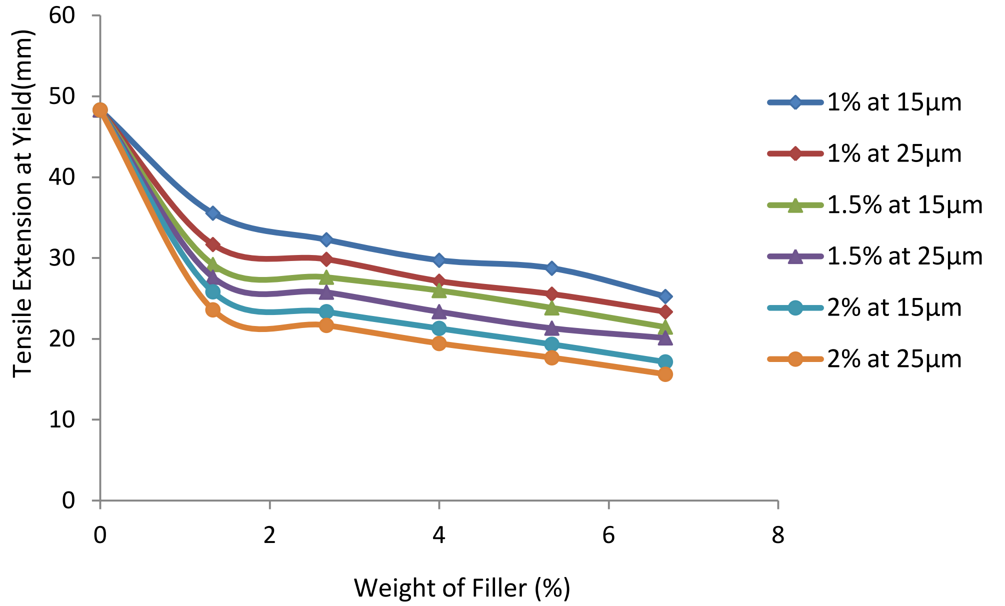


**Figure 1**: Plot of Tensile Extension at Yield versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

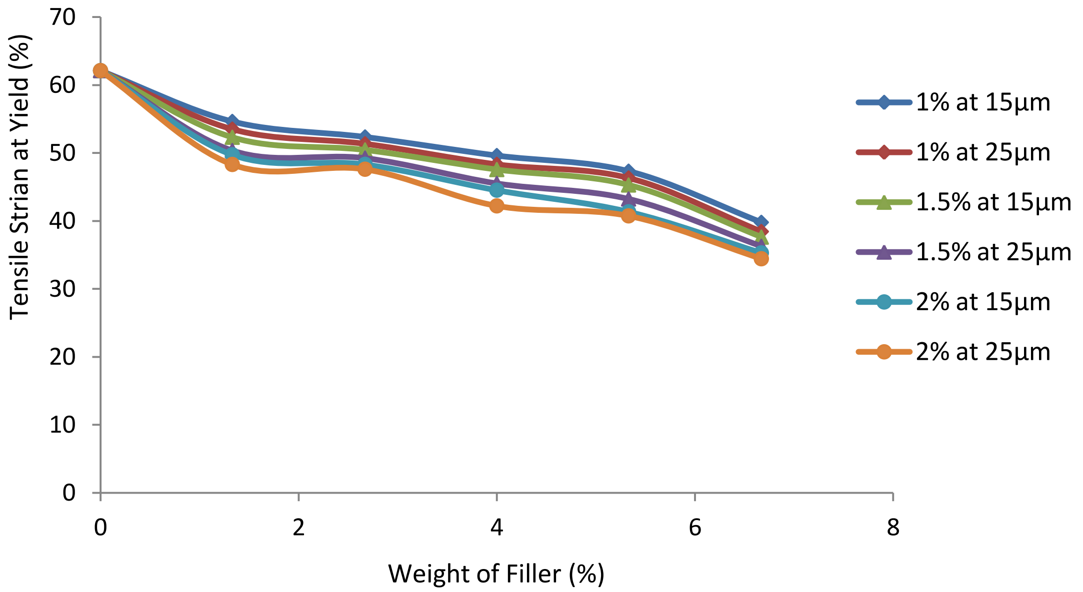


**Figure 2**: Plot of Tensile Strian at Yield versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

**True Strian at Yield and at Maximum Load and True Stress at Maximum Load**

From figure 3, 4, and 5 the true strain at yield, at maximum load and true stress at maximum load are observed to decrease with increases in MAPP content, filler content and filler particle size. Such a reduction in true strain of a composite with increases in filler content, irrespective of filler particle size has been reported by (Ismail,2010)

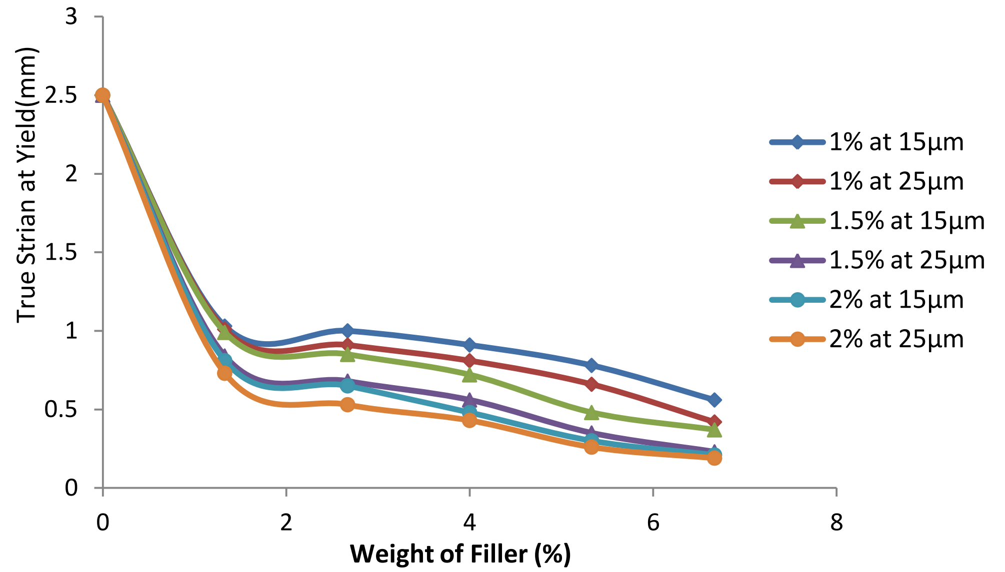


**Figure 3**: Plot of True Strian at Yield versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

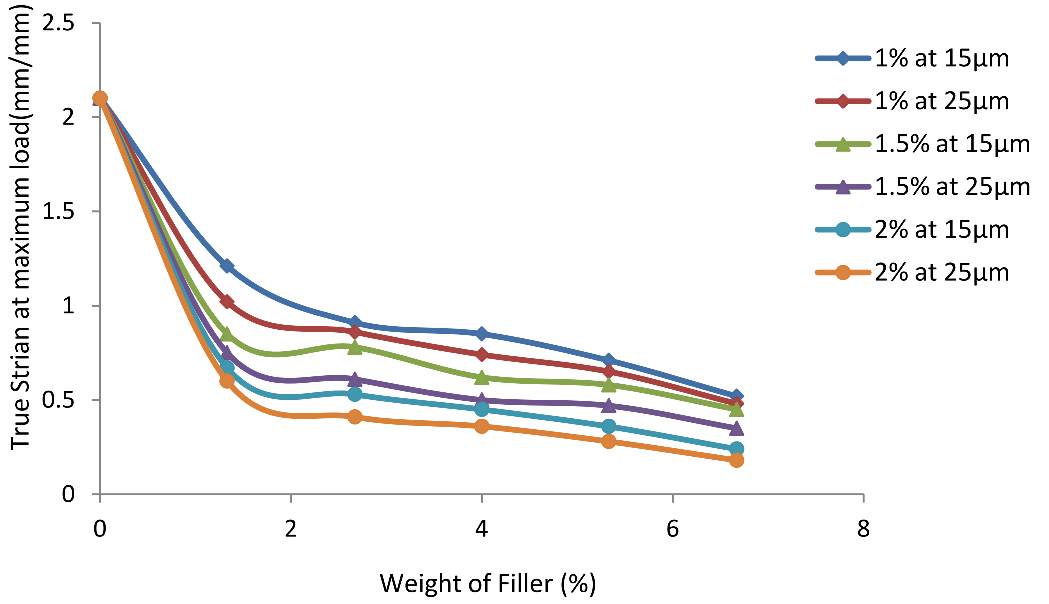


**Figure 4**: Plot of True Strian at maximum load versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

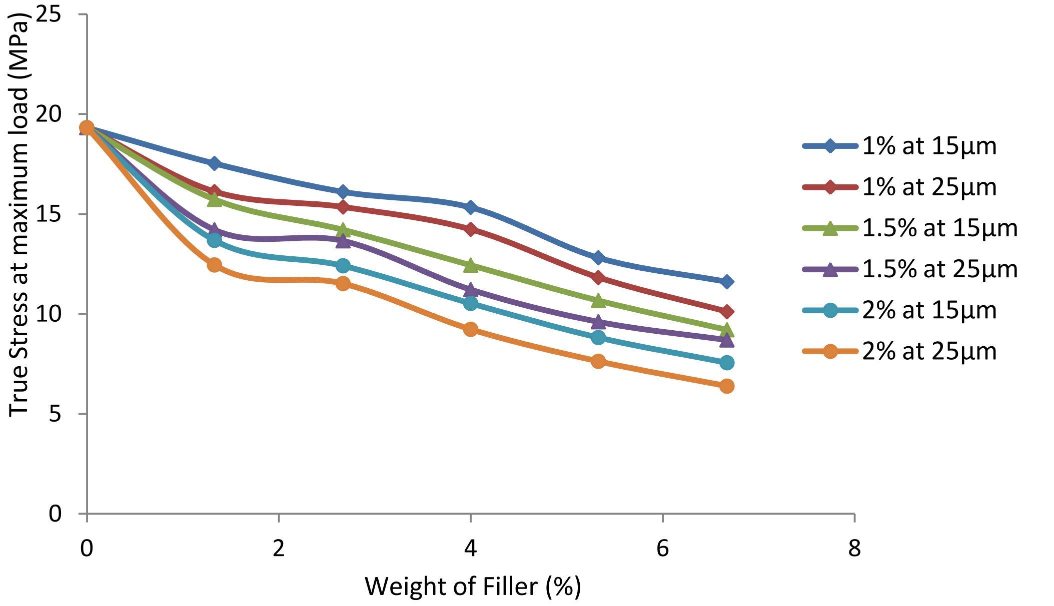


**Figure 5**: Plot of True Stress at maximum load versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

## Modulus and Tensile Stress

Figure 6 and 7 shows the effect of MAPP content, filler content and filler particle size on the modulus and tensile stress of polypropylene/cocoa pod composites. It is observed that modulus decreased with increases in compatibilizer content and filler particle size. There is also a sharp increase in modulus up to 1.33 wt.% of filler before it started decreasing as filler contents continued to increase. This observation highlights the fact that the incorporation of fillers and MAPP into polymer matrix reduced the stiffness of the composites ( Dan, 2002). The decrease in tensile stress of PP/CP composites is probably due to the change in molecular morphology of the polymer near the filler surface or in the bulk of the plastic phase.

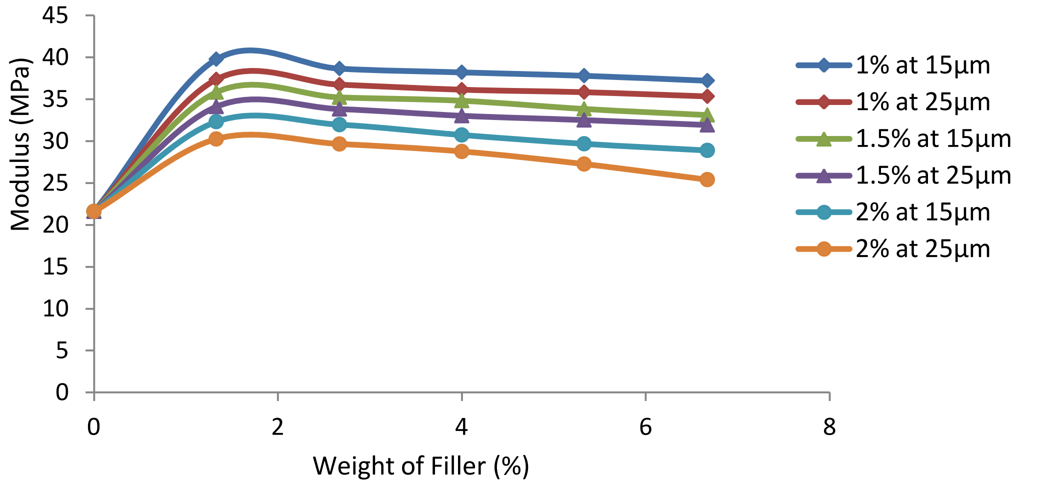


**Figure 6**: Plot of Modulus versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

## Energy at Yield

The energy at yield of compatibilized polypropylene composites of cocoa pod at a particular filler particle size was observed to increase with increases in filler content, but decreased with increases in MAPP content and filler particle size (figure 8). The decrease in energy at break with reduction in filler particle size is attributed to the great and more uniform dispersion of the smaller sized filler in the polymer matrix.

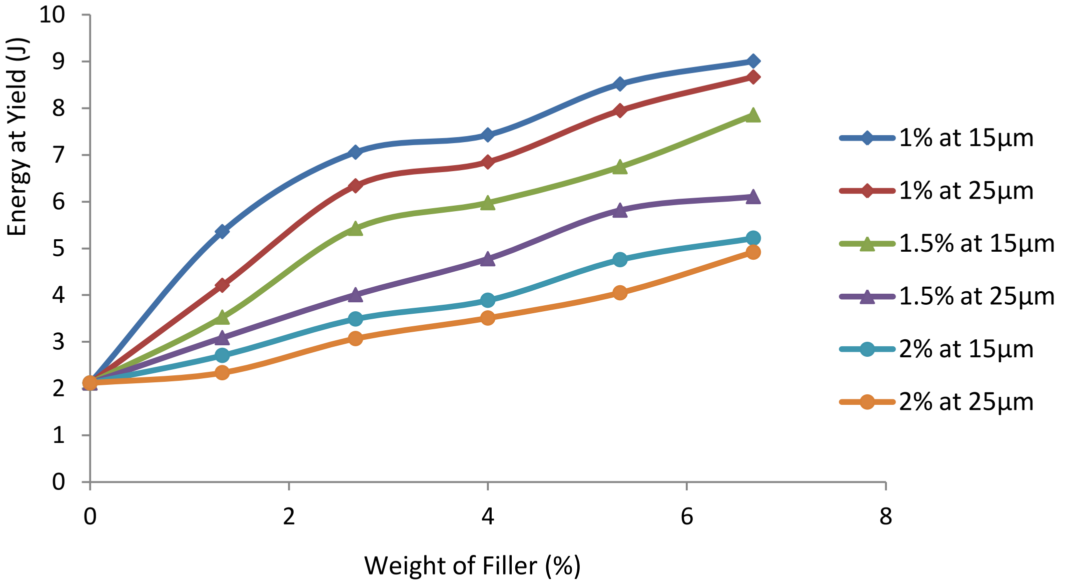


**Figure 8**: Plot of Energy at Yield versus Weight of Filler for Polypropylene Composites at three Concentrations of Coupling agent and two Particle sizes.

## CONCLUSION

The tensile behaviours of cocoa pod powder filled polypropylene have been determined in the presence of maleic anhydride-grafted-polypropylene. All the tensile properties considered decreased with increases in MAPP content and filler particle size. The tensile strain, true strain at yield, true strain at maximum load and true stress all decreased as filler content increases but tensile stress, energy at yield, modulus, tensile extension at yield all increased as filler content increases. The results obtained suggest that the scope of application of cocoa pod and MAPP can be greatly broadened with the use of polypropylene.

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