STUDIES ON THE MECHANICAL AND PHYSICAL PROPERTIES OF HIGH DENSITY POLYETHYLENE (HDPE) AND POLYVINYLCHLORIDE (PVC) BLEND

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ABSTRACT

Studies on the mechanical and physical properties of high-density polyethylene (HDPE) and polyvinylchloride (PVC) blend was investigated. The pure high-density polyethylene, pure polyvinyl chloride, and composite samples were characterized for tensile strength, hardness test, water absorption test, and modulus of elasticity (MOE). The results of the tests indicated that pure high-density polyethylene (100%PE) and pure polyvinyl chloride (100%PVC) shows high tensile strength than those composite samples, and pure polyvinylchloride shows a higher tensile strength and modulus of elasticity (MOE) than pure HDPE. Blends containing 50%PE/50%PVC have the best mechanical and physical properties with a high modulus of elasticity (MOE) at 179.4MN/m2 and a percentage moisture content of 0.2% with 68.4DM (Durometer) as the value of hardness.

Key words: Polyethylene, Polyvinylchloride, Blend, Mechanical, Physical, Properties, Polymer

1.0 INTRODUCTION

The term polymer is very wide, and it consists of different classes of polymeric materials. Polymers are giant molecules built from identical or cognate repeatable units called monomers (Momoh, 2006). The use of polymers has changed our lives positively. Polymers contribute to meeting our basic human desires, including food, shelter, clothing, health, and transportation. It is not easy to imagine what the world was like before the advent of synthetic polymers. It is not easy to contemplate what the world would be like without polymers with all their luxury and comfort (Ebewele, 2000).

In today's world, existing molecules cannot always meet required applications; therefore, the need to develop new materials with improved properties to meet specific applications. To achieve this, polymer blending has been identified as one of the ways because it is faster and more economical than the development of new chemistry (Harper, 2002). Polymer blends are physical mixtures of two or more polymers and are commercially prepared by mechanical mixing, achieved through screw compounders and extruders (Momoh, 2006).

Several works have been carried out on PVC and PE: Biofilm formation on PVC, PE, and stainless steel exposed to ozonated water (Eila et al., 2000). The solid structure of melt blended incompatible polymeric mixtures involving PVC has also been studied (James, 2004). Works on the blend of PVC and PE are scanty despite the polymers being widely used individually but can be blended to produce a polymer material of distinct properties from the two.

2.0 Materials and methods

2.1 Materials

The high-density polyethylene and polyvinylchloride were purchased at Z. Chemical store in Zaria. The density of high-density polyethylene is 0.95g/cm3, while the density of polyvinylchloride is 1.36g/cm3. The melting temperature range of high-density polyethylene is 150^{O}C to 180^{O}C, while the melting temperature range for polyvinylchloride is 100^{O}C to 220^{O}C.

The following materials were used:

1. High density polyethylene pellets
2. PVC pellets
3. Paraffin oil
4. Aluminum foil
5. Water

2.2 Methods

Samples were prepared using 10g of pure high-density polyethylene. A dry Petri dish was first weighed with the electronic weighing, and then the high-density polyethylene was added until the weight reached the required point. 10g of PVC was also similarly weighed to prepare a pure PVC sample. Then, a blend of high-density polyethylene and PVC samples was prepared, weighing the polymers such that the sum of two corresponding pairs collectively weighed 10g. The following proportions were used:

Table 2.1: Sample composition

S/N	**Sample**	**Composition %**
1	A	100%PE
2	B	80%PE/20%PVC
3	C	60%PE/40%PVC
4	D	50%PE/50%PVC
5	E	40%PE/60%PVC
6	F	20%PE/80%PVC
7	G	100%PVC

The samples were compounded using a two-roll mill. High-density polyethylene was first applied in-between the rolls of the two roll mill and allowed to soften until a bank was formed around the rolls. Then the PVC was added to the polyethylene banks and allowed to mix into the polyethylene bank until an even sheet was formed. The even sheet formed around the rolls was removed and allowed to harden. This was done for each sample (HDPE and PVC blend), including the control samples (pure HDPE and PVC).

A metallic mold of dimension 35mm x 10.3mm x1.5mm was cleaned with foam to remove all adhered particles and then coated with petroleum jelly. Then, aluminum foil was spread inside the mold, which served as a release agent for easy removal of the molded samples.

After compounding, the samples were formed into test samples by wrapping them in aluminum foil and placing them in a mold which was placed in the hot plate of the hydraulic compression machine at 150^{O}C and pressure of 4000 psi for 20 minutes. After 20 minutes, the cured samples were removed from the hot plate, and the samples were quickly removed from the mold before it cooled so as to prevent the sample from breaking. Since the chain are flexible when soft but hard after solidification. The samples were taken for characterization.

3.0 Results and discussion

3.1 Effect of polymer proportioning on the tensile strength blend result

Figure 3.1 depicts the effect of blend proportion on tensile strength. The results show how the tensile strength varies from sample A to G, and this variation resulted from proportioning of the polymers. Moreover, the variation is a function of temperature since temperature affects the mechanical properties of polymers (Ebewele,2000). The results indicated that sample G with (100%PVC) has the highest tensile strength (Figure 3.1), conforming with the literature. Since literature testify that the tensile strength of pure PVC is higher than pure HDPE

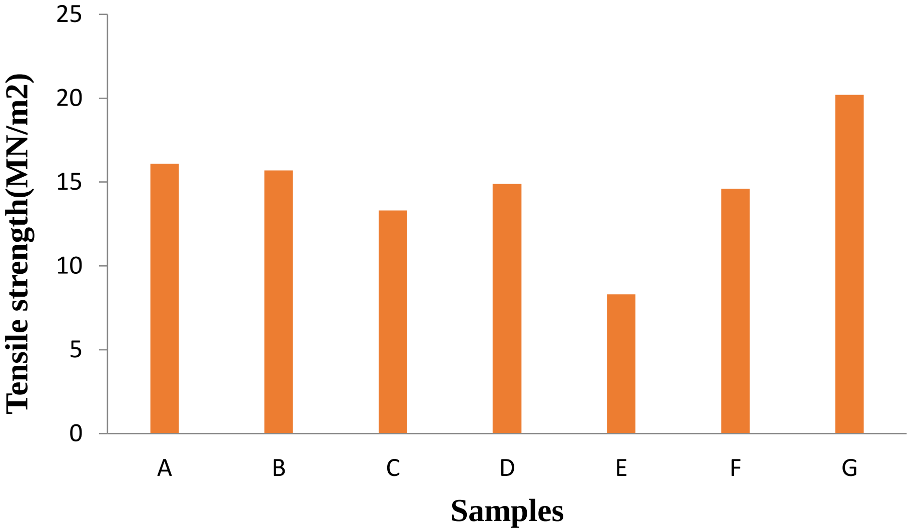

Figure 3.1: Effect of blend composition on tensile strength samples

3.2 Effect of polymer proportioning on the elongation of the blend result

Figure 3.2 depicts the effect of blend proportion on elongation properties, figure 3.2 shows that sample A is the most ductile material among other samples. as justified by literature, samples A to E shows a decrease in elongation properties (Ebewele, 2000). But samples F and G increase instead of decrease. These might be as a result of degradation of PVC. Harper (2002) reported that PVC degrade at a temperature above 70^{O}C.

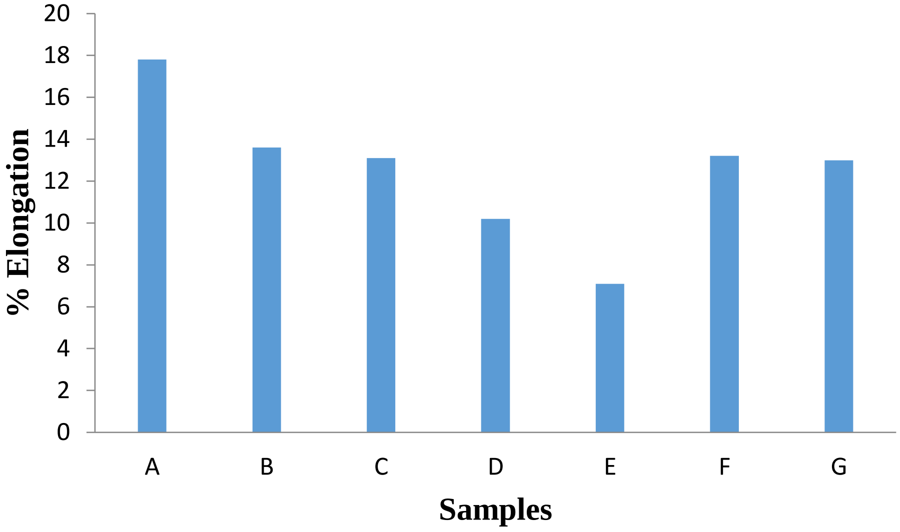

Figure 3.2: Effect of blend composition on percentage elongation samples

3.3 Effect of polymer proportioning on the m.o.e of blend result

Figure 3.3 depicts the effect of blend proportion on the M.O.E. results. The results show how modulus of elasticity (M.O.E.) varies in each sample as a result of differences in their composition and also the effect of temperature. The result on the chart shows that sample G(100%PVC) has the highest modulus of elasticity (M.O.E.) of 211MN/m2 and sample A (100%PE) with a value of 83.4MN/m2 has the lowest M.O.E. while sample D (50%PE/50%PVC) has the second-highest M.O.E. of 179.4MN/m2 which make it the best-modified sample.

The strength and stiffness of the material are derived from the stress-strain test. These two parameters are of particular significance from a design point of view. The ultimate tensile strength is useful for some applications, but most polymer products are loaded well below their breaking points. Indeed, some polymers deform excessively before rupture, and this makes them unsuitable for use. Therefore, for most polymer applications, stiffness is the parameter of prime importance. Moreover, the modulus is a measure of stiffness. Hence, the modulus is of prime importance for most polymer applications (Ebewele, 2000).

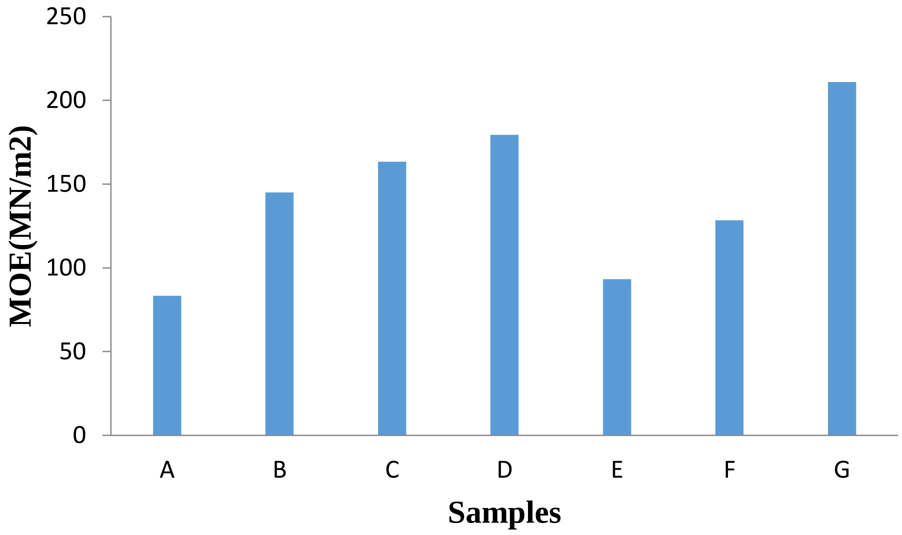

Figure 3.3: Effect of blend composition on M.O.E (MN/m^2) samples

3.4 Effect of polymer proportioning on the moisture content of the blend result

Figure 3.4 depicts the effect of blend proportion on the moisture content. The results in figure 3.4 show that sample A (100%PE) has the lowest percentage moisture content, and sample F (80%PVC/20%PE) has the highest percentage water content, but it was expected that pure PVC should have the highest percentage moisture content. This may be as a result of contaminants during the water test. Thus, no experiment is perfect.

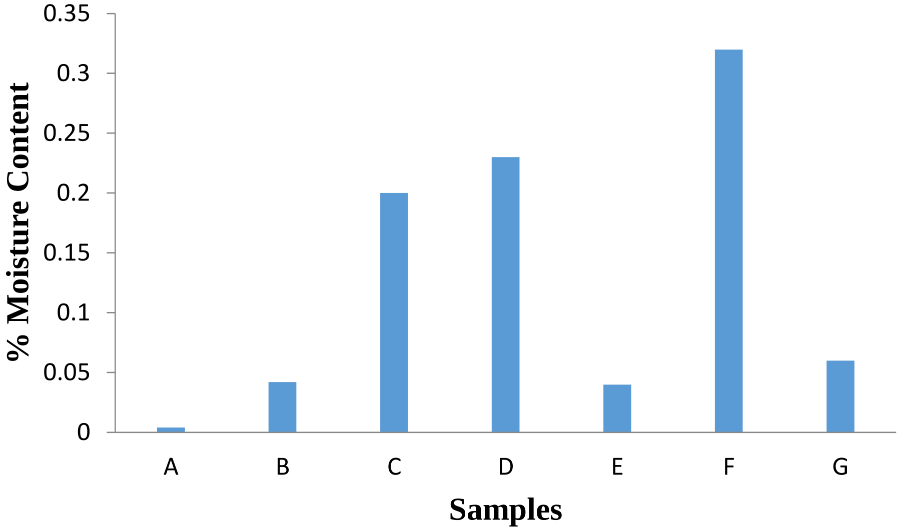

Figure 3.4: Effect of blend composition on moisture content samples

3.5 Effect of polymer proportioning on the hardness of the blend result

Figure 3.5 depicts the effect of blend proportion on the hardness of the samples. Figure 3.5 shows the variation in hardness of each sample, sample G (100%PVC) is the hardest, and sample A (100%PE) is the softest of the samples. Sample D (50%PE/50%PVC) follows sample G in terms of hardness. Stiffness is a measure of MOE, and MOE contributes to the hardness properties of a sample.

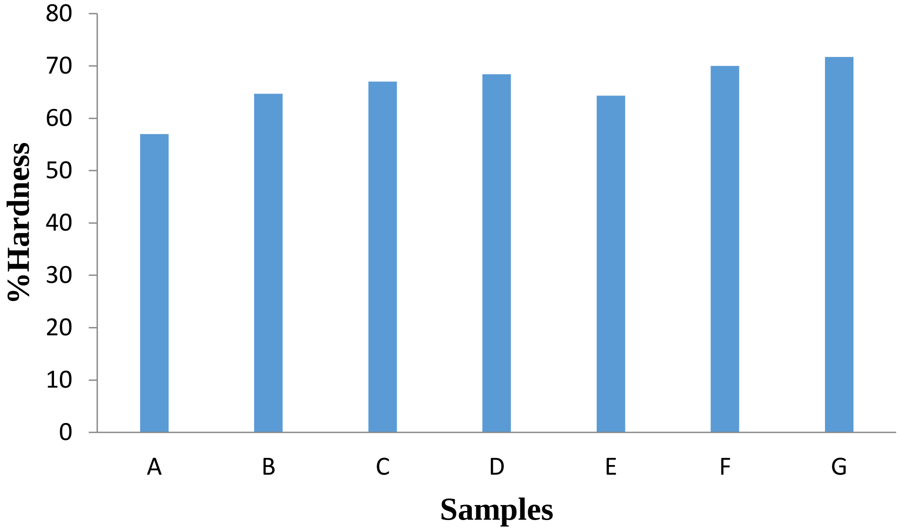

Figure 3.5: Effect of blend composition on percentage hardness samples

4.0 Conclusion and recommendation

4.1 Conclusion

The following conclusion may be deduced from this research work. Virgin HDPE (100%PE) and virgin P.V.C. (100%PVC) show higher tensile strength than those containing varying proportions. Pure P.V.C. shows higher tensile stress and M.O.E. than pure HDPE, so blends containing 50%PE/50%PVC show better mechanical properties than other blends. 50%PE/50%PVC showed the best tensile stress with a high modulus of elasticity (M.O.E.) at 179.4MN/m2. However, depending on the end-use, any blend compositions could be used to meet the desired property.

4.2 Recommendation

The following were suggested for the improvement in properties of the composite sample.

1. The use of stabilizers to reduce degradation.

2. Properties such as thermal, microscopic should be investigated

3. The blend of other forms of PE such as LLDPE and LDPE with PVC should be investigated.

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