TRANSPORT BEHAVIOUR OF XYLENE THROUGH COMPATIBILIZED LOW DENSITY POLYETHYLENE COMPOSITE

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ABSTRACT

The transport behaviour of xylene through compatibilized low density polyethylene (LDPE) composite was investigated at different temperatures 40 ^{0}C, 60 ^{0}C and 80 ^{0}C. The kola nut used was ground to 25 µm particle size. In preparation of the composite, 0 – 5 wt% of kola nut powder and 0 – 2.5 wt% of the compatibilizer were thoroughly mixed with 200g of low density polyethylene in an injection moulding machine. The injected LDPE/Kolanut composites were taken for sorption test. The sorption data obtained for the composite at different temperatures investigated were expressed as the mole percentage uptake, Q_t (mole %). Results showed that the mole percent uptake of xylene at the five filler contents (0 – 5 wt%) generally increased with increase in sorption temperature but decreased with increase in compatibilizer and filler content. This can be seen at 80 ^{0}C and 0, 1, 1.5 and 2.5 wt% of the comptbilizer respectively. The molar percentage uptake of xylene at 1 wt% of the filler yielded the following values; 8.7876, 8.5962, 8.4056 and 8.3111 respectively. At 2 wt5, it yielded 7.9812, 7.9104, 7.7423 and 7.7199 respectively; at 3 wt% it gave 7.8232, 7.6351, 7.5663 and 7.4652 respectively; at 4 wt%, it yielded 8.4120, 8.3315, 8.2132 and 7.9667 respectively and at 5 wt% it gave 7.9635, 7.8630, 7.6256 and 7.5013 respectively.

Keywords: Sorption, kolanut, polyethylene, composite, xylene.

INTRODUCTION

Incorporating a cost-effective filler in polymeric matrix will only be feasible if it does not drastically alter the matrix main characteristics. The determinant issue here is the compatibilizer between the interfaces of a filler and the polymer matrix. This is important in order to have property-stable composite system. For this reason, various compatibilizers or coupling agents were suggested by some studies in the past to formulate efficient bio-composites based on polymer matrices (Chen et al., 1995; Asha et al., 2003; Sareen et al., 2013, and Sant et al., 2012). Wang et al (2009) have shown that incorporating a coupling agent for the composites of wheat straw/polyethylene (PE) increased its properties.

A coupling agent is a compound which provides a chemical bond between two dissimilar materials, usually an inorganic and organic (Chen et al., 1995). The polymer solvent interaction through the low density polyethylene composite are affected by various factors such as crystallinity and polarity of fillers, adhesion and compatibility with the polymer matrix, size and nature of penetrants, etc. The sorption properties using organic solvents will give an idea about internal structure of polymer (Sareena, 2015).

The main objective of the present work is to investigate the effect of compatibilizer (maleic anhydride grafted polyethylene) on the transport behaviour of xylene through low density polyethylene at different kolanut contents.

METHODOLOGY

Materials

Low density polyethylene (LDPE) granules (density: 0.915 g/cm^3; melt flow index: 8 g/10 min measured at 190 ^{0}C using 2.16 kg standard weight; melting temperature: 110 ^{0}C) were obtained from CeePlast Industries Ltd, Aba, Abia State, Nigeria. Kolanut was obtained from Eziudo Market in Ezinihitte Mbaise, Imo State, Nigeria. The solvent, xylene and MAPE used were obtained from Sigma Andrich Company, U.S.A.

Preparation of LDPE/KN Composite

The LDPE composites of kolanut powder (KN) were prepared by thoroughly mixing 200 g of low density polyethylene with appropriate filler quantities (0,1,2,3,4 and 5 wt%). The low density polyethylene and kolanut (or kolanut powder) were melted and homogenized in an injection moulding machine at 173 ^{0}C and the resultant composites were produced as sheets.

Sorption Experiments

The sorption behaviour of the PE compatibilized and uncompatibilized LDPE/KN composites, prepared at five different weight of kolanut, viz 1, 2, 3, 4 and 5 wt% were studied at three different temperatures namely; 40, 60 and 80 ^{0}C. Uniform sized samples of dimensions 2 x 2 cm with thickness variation ranging from 0.4 to 0.5 cm were used in sorption experiments. Initially, the samples were dried in a vacuum oven at room temperature for about 24 h. The original weight and thickness of the samples were measured before sorption experiments. They were then immersed in xylene (20 ml) in closed diffusion bottles, kept at a particular temperature in a thermostatic water bath. The samples were removed periodically from the bottle and damp dried between filter papers to remove excess solvent on the surface. They were then weighed immediately using an electronic balance that measured to the nearest 0.0001g. The samples were immediately placed back into the test bottles.

RESULTS

The sorption data of xylene (solvent) into LDPE/KN for compatibilized and uncompatibilized LDPE composites of different kola nut contents at different compatibilizer contents and different temperatures are presented graphically in Figures 1 – 15.

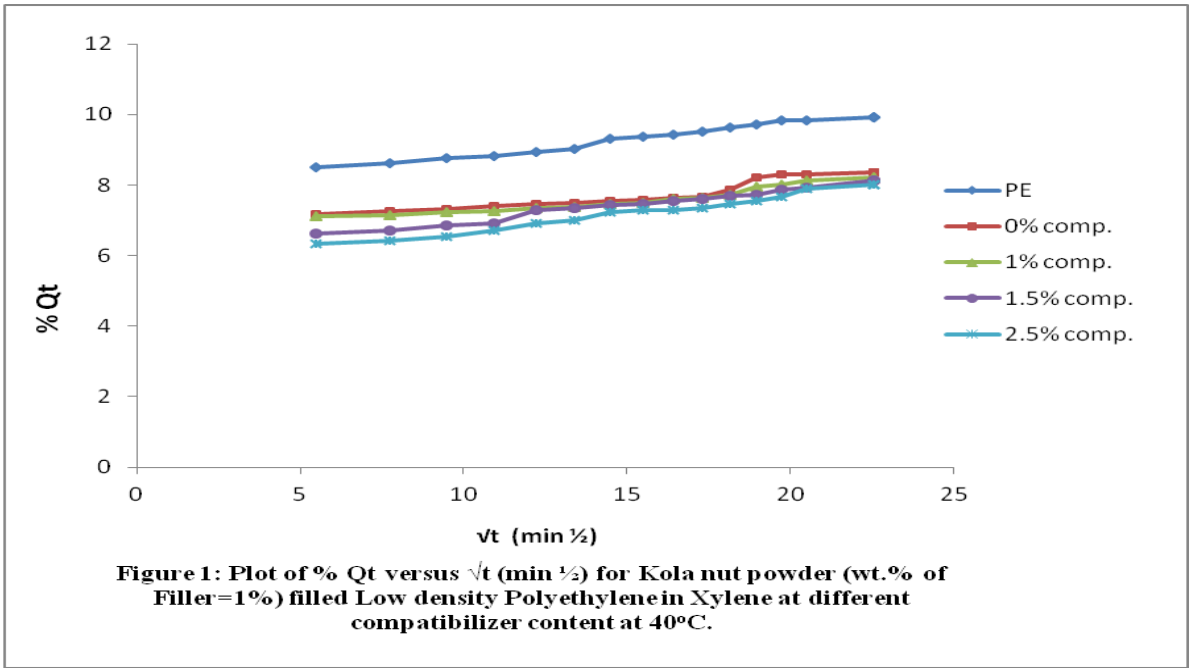

Figure 1: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=1%) filled Low density Polyethylene in Xylene at different compatibilizer content at 40°C.

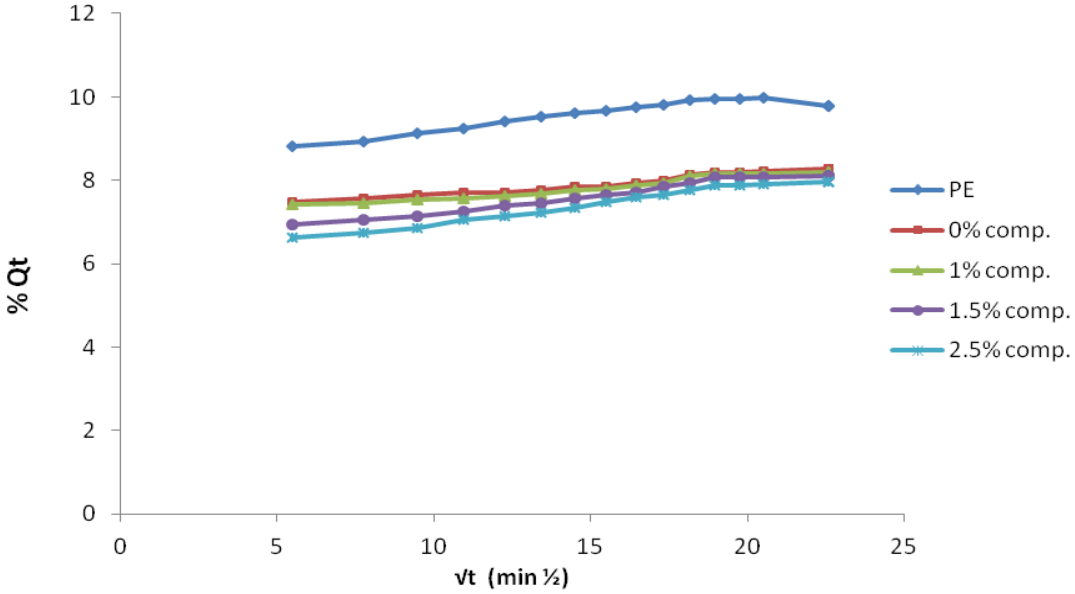

Figure 2: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=1%) filled Low density Polyethylene in Xylene at different compatibilizer content at 60°C.

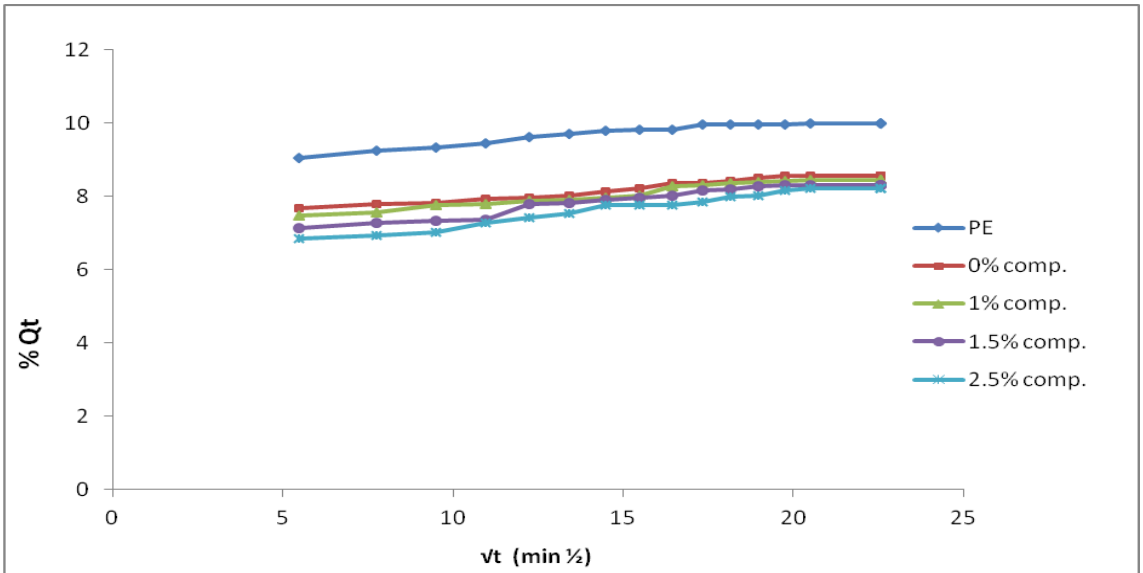

Figure 3: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=1%) filled Low density Polyethylene in Xylene at different compatibilizer content at 80°C.

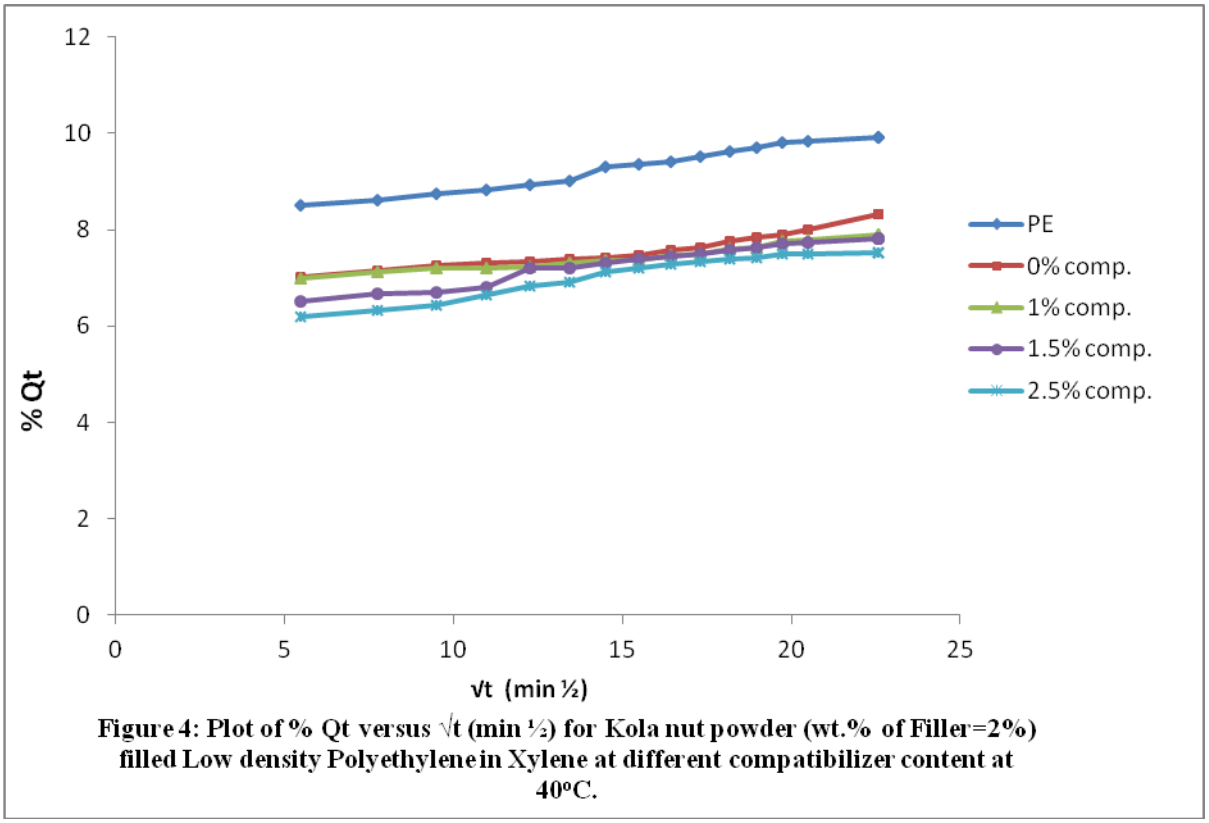

Figure 4: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=2%) filled Low density Polyethylene in Xylene at different compatibilizer content at 40°C.

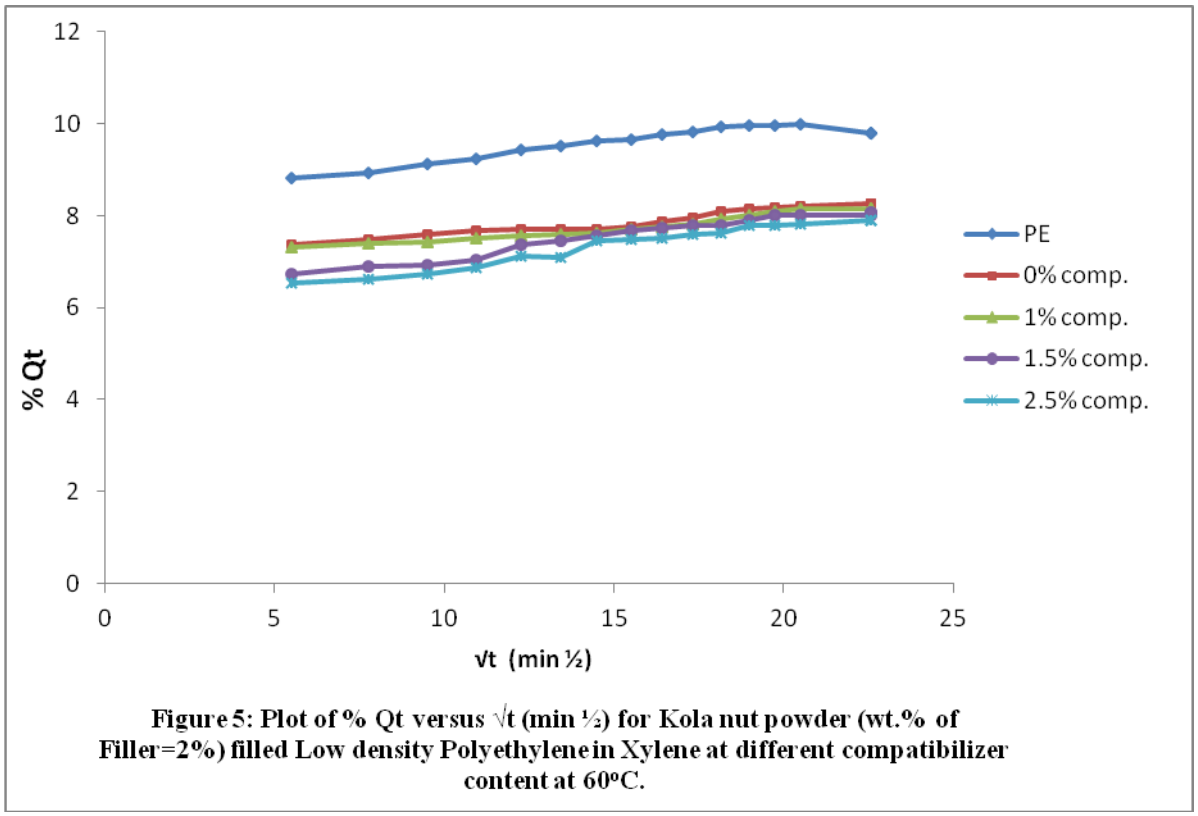

Figure 5: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=2%) filled Low density Polyethylene in Xylene at different compatibilizer content at 60°C.

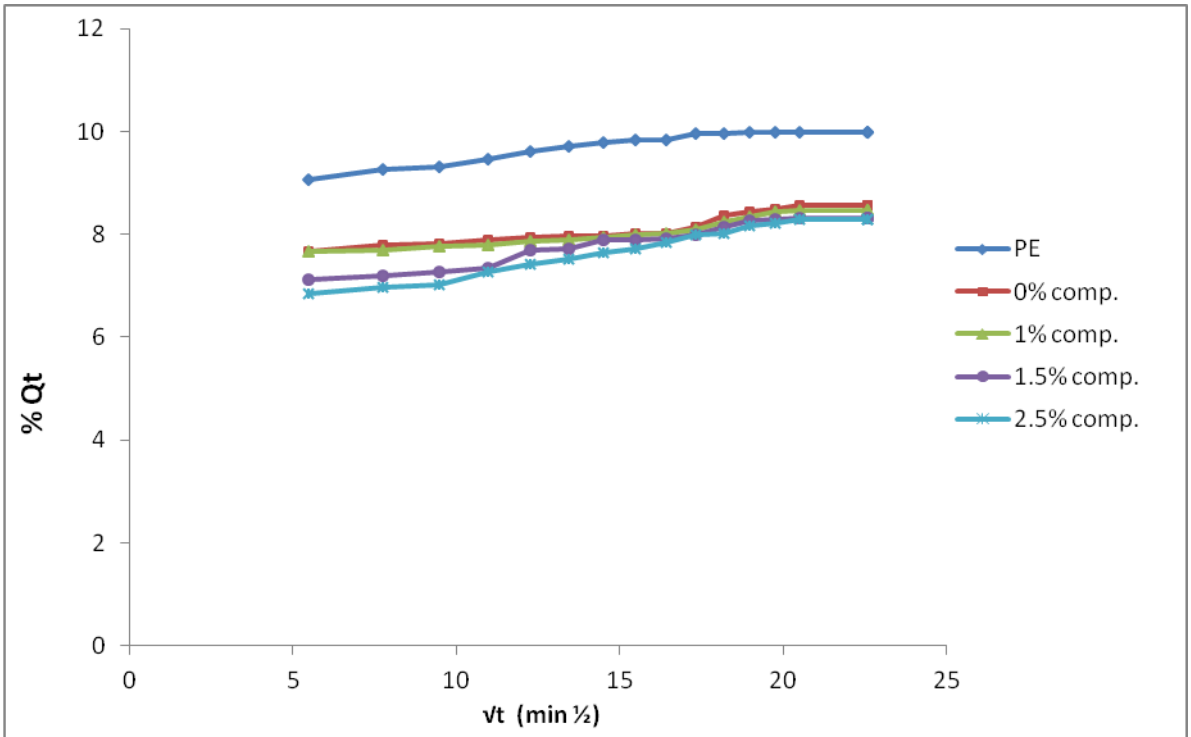

Figure 6: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=2%) filled Low density Polyethylene in Xylene at different compatibilizer content at 80°C.

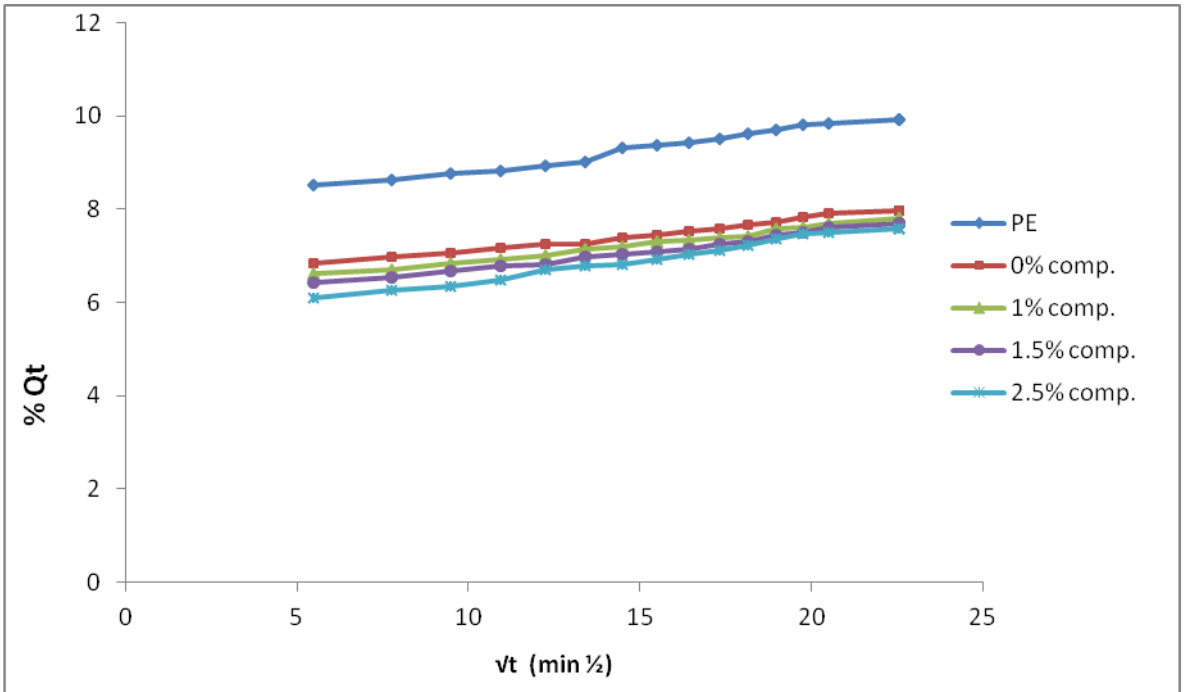

Figure 7: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=3%) filled Low density Polyethylene in Xylene at different compatibilizer content at 40°C.

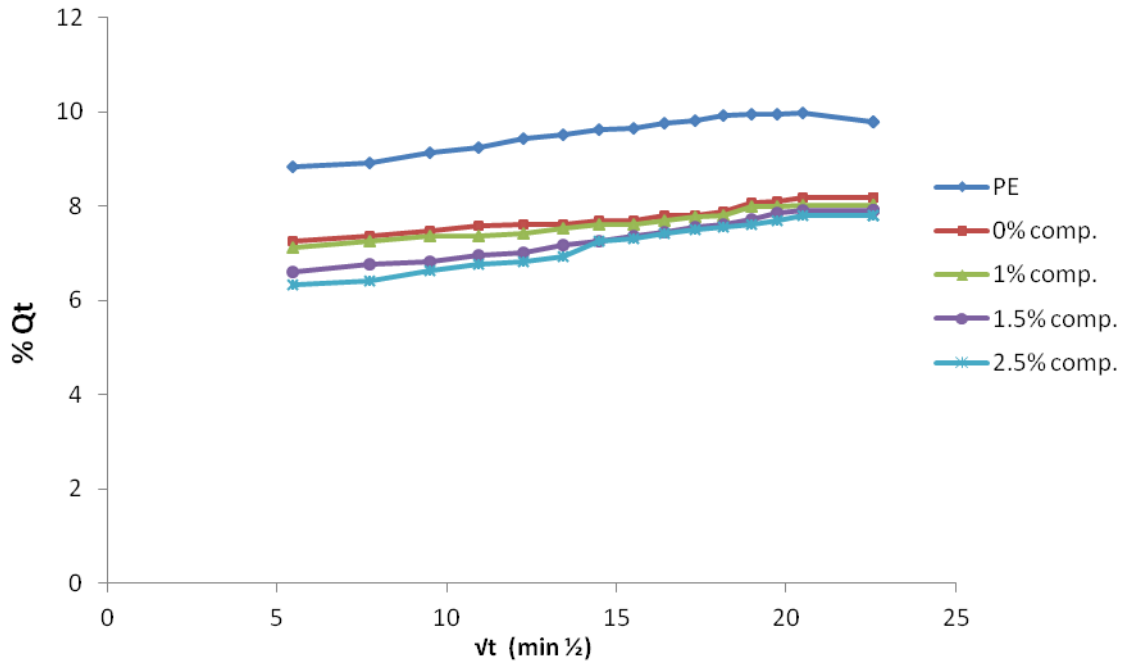

Figure 8: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=3%) filled Low density Polyethylene in Xylene at different compatibilizer content at 60°C.

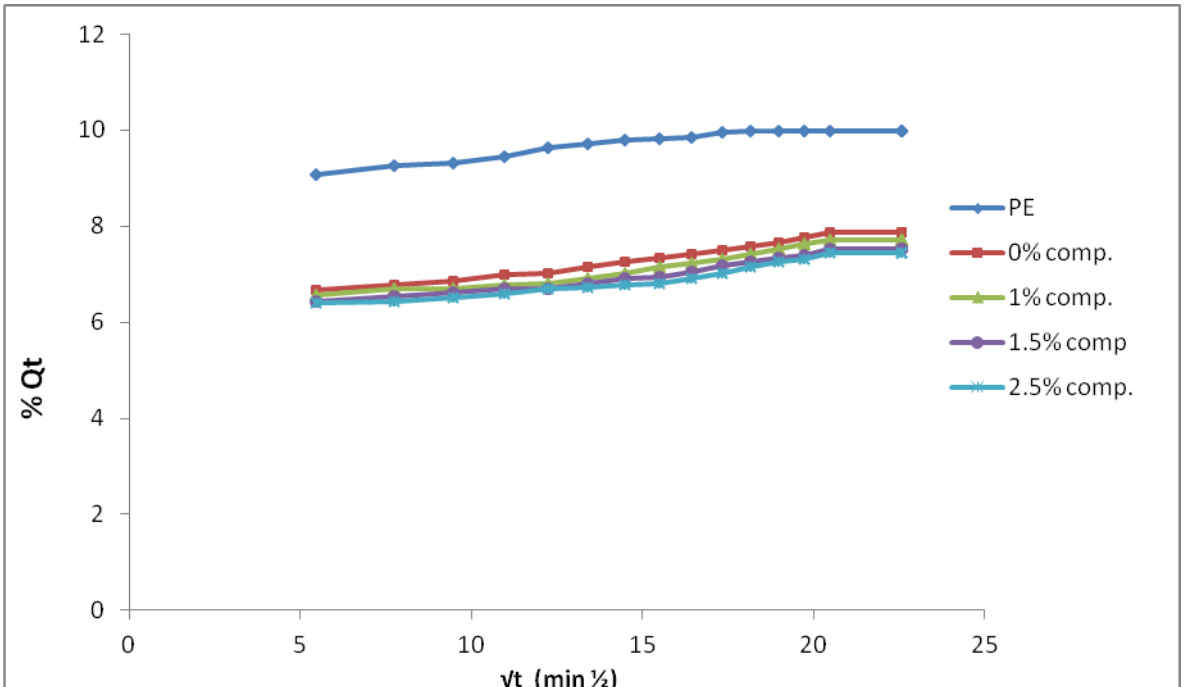

Figure 9: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=3%) filled Low density Polyethylene in Xylene at different compatibilizer content at 80°C.

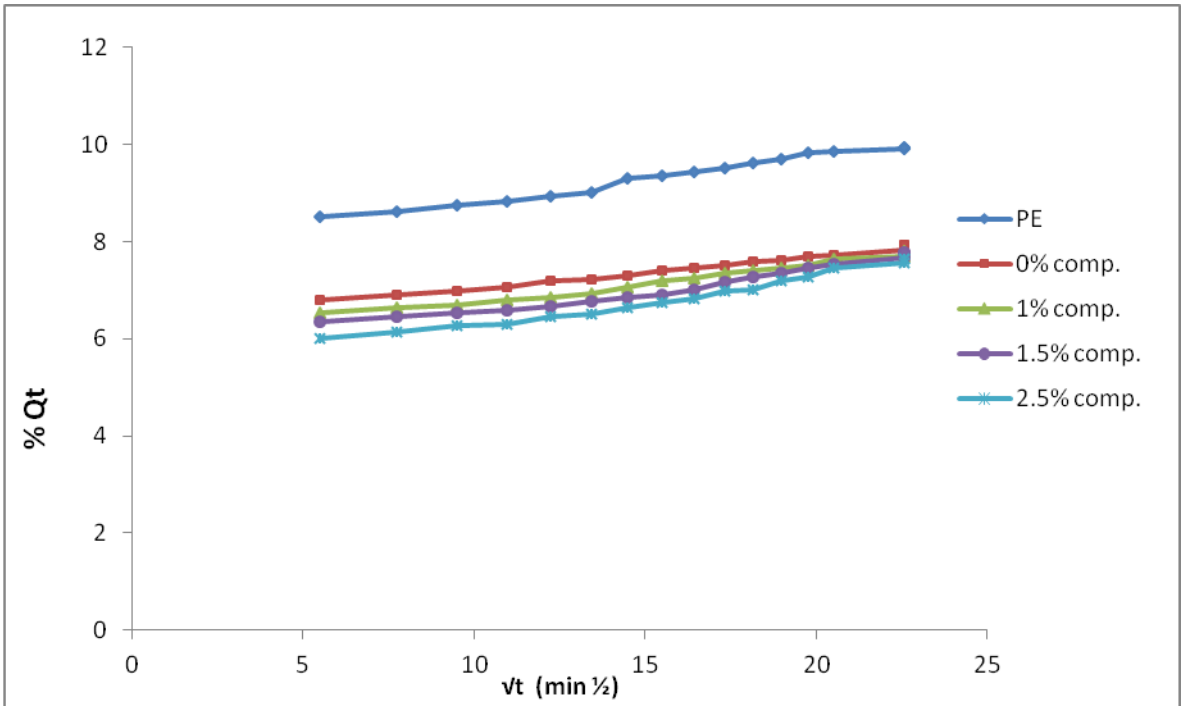

Figure 10: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=4%)filled Low density Polyethylene in Xylene at different compatibilizer content at 40°C.

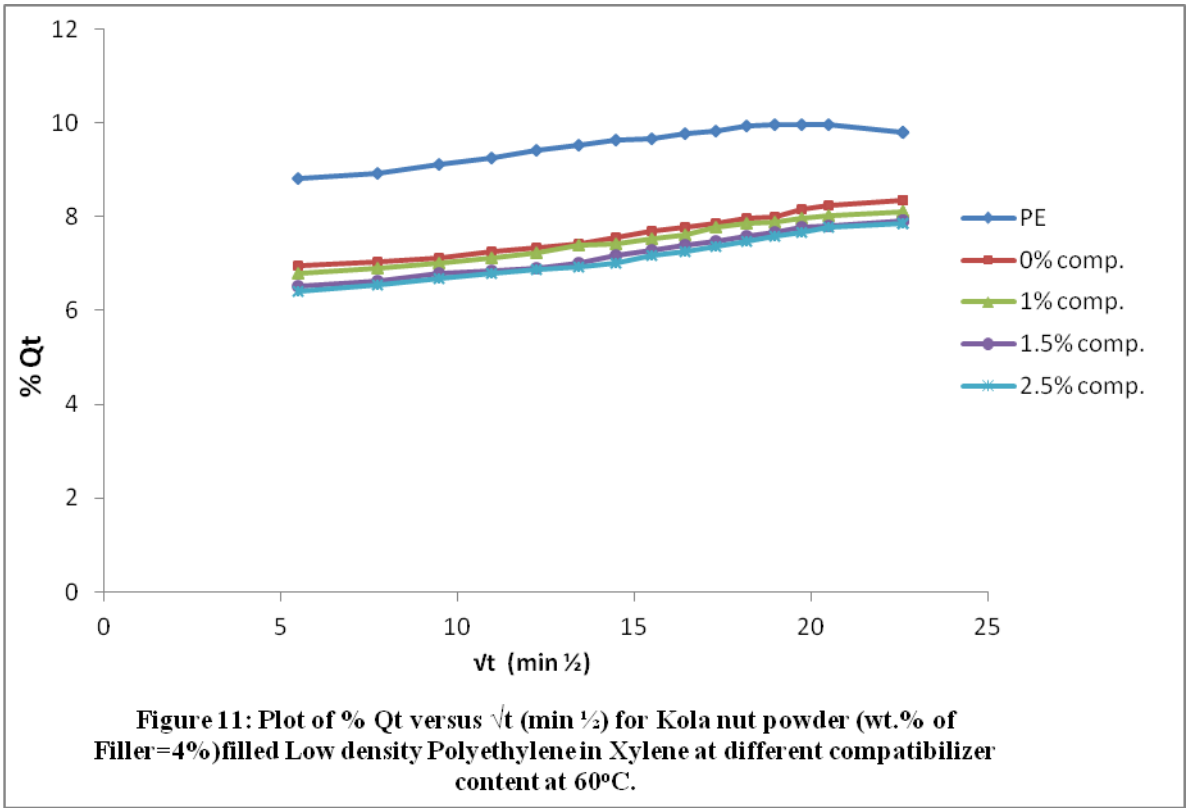

Figure 11: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=4%)filled Low density Polyethylene in Xylene at different compatibilizer content at 60°C.

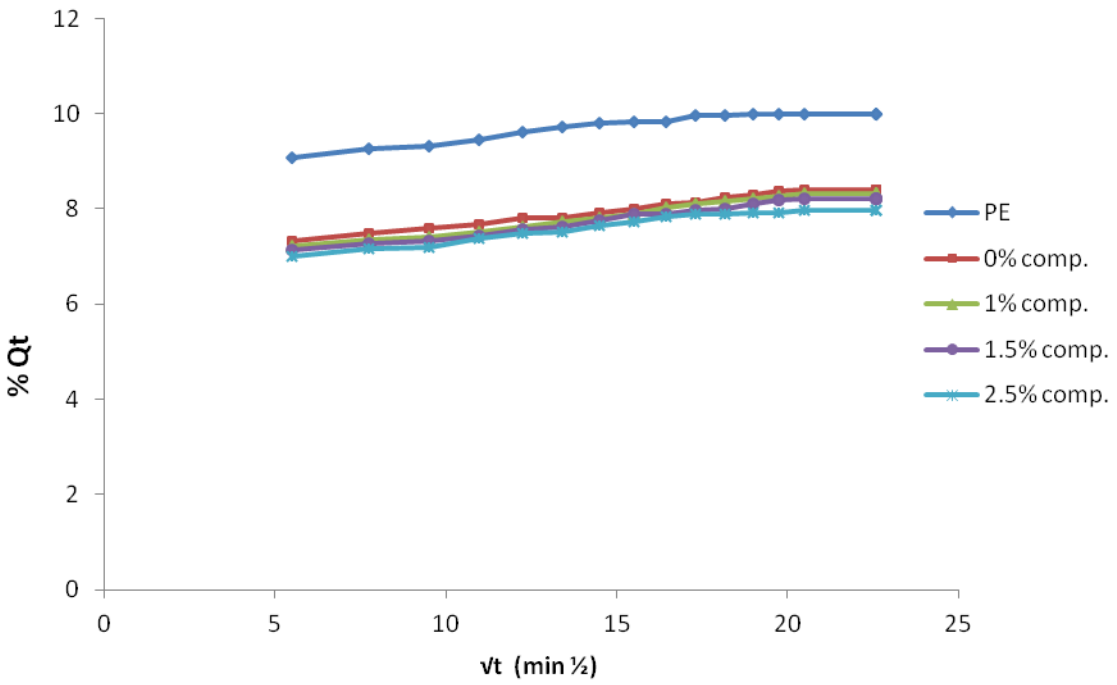

Figure 12: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=4%)filled Low density Polyethylene in Xylene at different compatibilizer content at 80°C.

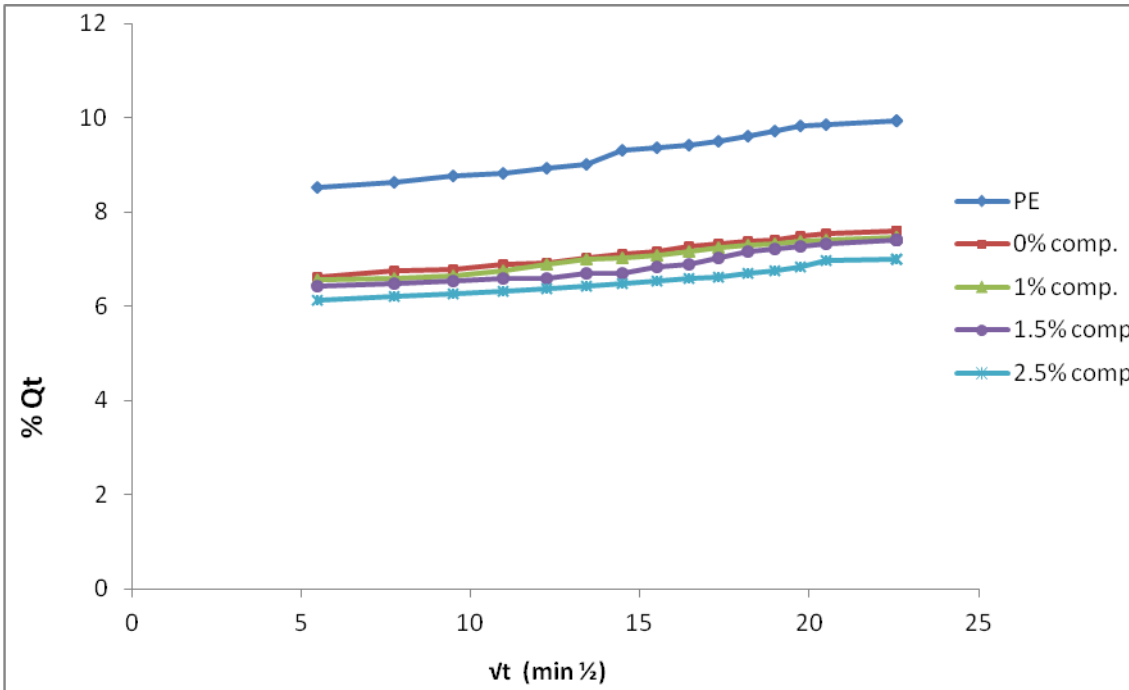

Figure 13: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=5%)filled Low density Polyethylene in Xylene at different compatibilizer content at 40°C.

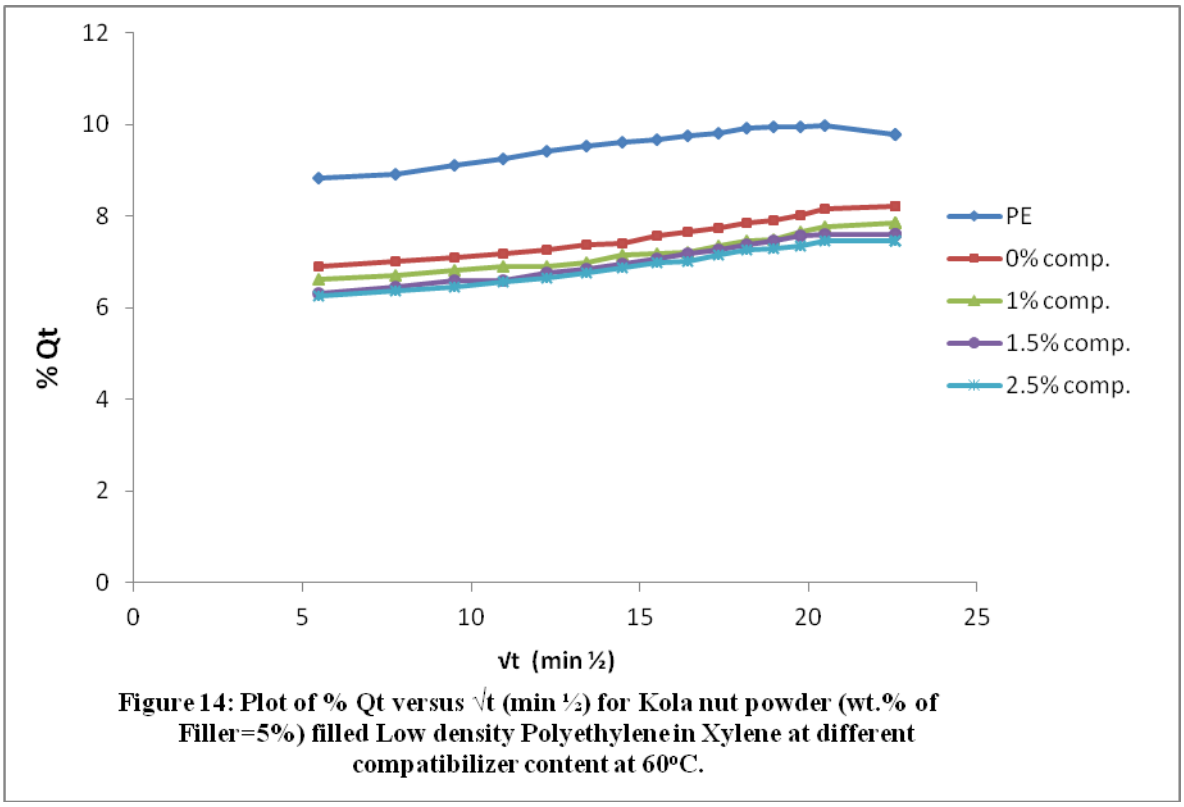

Figure 14: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=5%) filled Low density Polyethylene in Xylene at different compatibilizer content at 60°C.

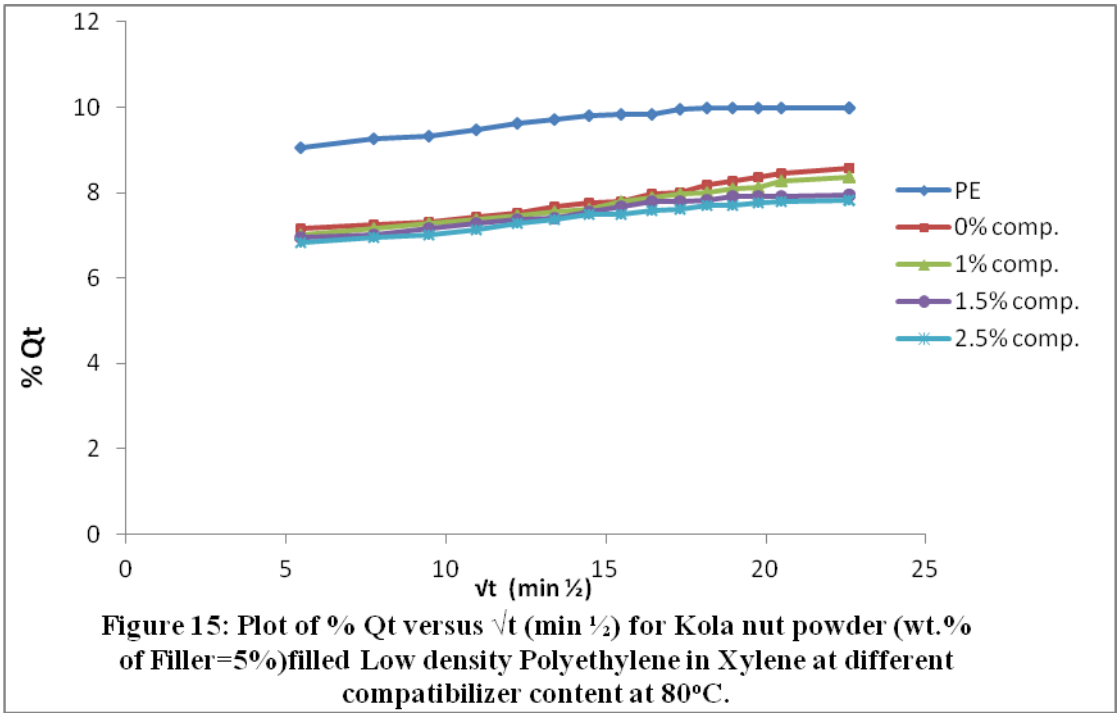

Figure 15: Plot of % Qt versus √t (min ½) for Kola nut powder (wt.% of Filler=5%)filled Low density Polyethylene in Xylene at different compatibilizer content at 80°C.

DISCUSSION

Sorption Properties

The sorption data of xylene (solvent) into LDPE/KN for compatibilized and uncompatibilized LDPE composites at different kola nut contents have been determined. It is expressed as the mole

percentage uptake (%Q_t) of solvent per gram of LDPE/KN composites and was calculated using the formula (Ramesan, 2015).

$$Q_t \text{ (mol \%)} = \frac{Mass\ of\ solvent\ absorbed/Molar\ Mass\ of\ solvent}{Mass\ of\ Polymer}\ x\ 100$$

The transport baheviour of xylene through compatibilized LDPE composites was investigated at 40 ^{0}C, 60 ^{0}C and 80 ^{0}C. The sorption of composites with decreasing filler concentration in xylene are given in Figures 1 – 15. In all concentrations, there is an initial increase in the mass of the solvent absorbed. The effect of filler and compatibilizer contents on the mole % uptake of solvent (Q_t) is plotted against square root of time. At the temperatures, as the filler loading and compatibilizer content decrease, the sorption value is found to be increasing. The LDPE/KN filled with 1% filler at 80 ^{0}C shows maximum sorption and LDPE/KN filler with 5 % at 40 ^{0}C shows minimum sorption. This trend is explained using free volume theory, that is, the diffusion rate of molecules depends mainly on the ease with which the polymer chains exchange their position with penetrant molecules. The mobility of polymer depends on the free volume inside the polymer matrix, on increasing the penetrant size, the exchangeability decreases and thus sorption also decreases (Jasna and Ramesan, 2016).

The effect of temperature on the sorption of compatibilized LDPE filled kola nut are shown in Figures 1 – 15. All the filler and compatibilizer contents show similar trend. The rate of sorption of solvent uptake increases with increase in temperature. It reveals the rate of solvent sorption into the composites is time and temperature dependent. It is due to the increased segmented mobility and free volume inside the matrix on increasing the temperature.

CONCLUSIONS

LDPE/KN composites were prepared and the transport properties of compatibilized LDPE/KN composites had been studied using xylene as penetrant with respect to the loading of 25 µm particle size of kola nut at different temperatures. The transport of xylene through the composites generally increased with increase in sorption temperature but decreased with increase in compatibilizer and kola nut contents.

ACKNOWLEDGEMENTS

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