

Full Length Research Paper

Equilibrium sorption properties of palm kernel husk and N330 filled natural rubber vulcanizates as a function of filler volume fraction

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Accepted 2 April, 2007

The absorption and diffusion of organic solvents such as toluene, diesel and kerosene into natural rubber vulcanizates filled with palm kernel husk and N330 was studied at ambient temperature, using the immersion/weight gain method. The results showed no further weight change after 24 h. The absorption and the diffusion characteristics of the solvents in the palm kernel husk and N330 filled natural rubber vulcanizates were evaluated and the variation properties discussed in terms of the nature of the solvent, filler loading and nature of the filler.

Key words: Absorption, diffusion, palm kernel husk, filler, vulcanisates and natural rubber.

INTRODUCTION

Polymers swell if they interact with the solvents at all, and the degree of this interaction is determined by the degree of cross linking. The degree of the swelling can be measured or related to the thermodynamic properties of the system (Labana, 1986). Considerable interest has been focused on the absorption and diffusion of organic solvent because their ability to permeate at different rate enhances the separation of component of their liquid mixture through polymeric membrane (Hofmann, 1962; Frollini et al., 2003; Morton, 1987; Parkinson, 1957).

The density of chain entanglement and chain ends, cross link density, compatibility of both polymer and liquid type and amount of filler in addition to viscosity of the penetrant liquid and the functionality of the cross links are determinants of the molecular transport of organic solvent in rubber vulcanizates (Patterman, 1986). Previous studies revealed that the transport of solvent through polymers is affected by polymer structure, cross linking density, mode of cross linking, presence of fillers, penetrant size and temperature (Ski and Baker, 1970). Thus, an understanding of the membrane transport properties, sorption, diffusion coefficient and penetration rate with respect to toluene, diesel and kerosene is Necessary in ord-

order to commercialize the use of the substrate under investigation. This experiment focused on the permeation of toluene, diesel and kerosene, into natural rubber vulcanizates filled with palm kernel husk and carbon black respectively.

MATERIALS AND METHODS

Natural rubber conforming to the Nigeria Standard Rubber Grade 10 (NSR10) was purchased from Iyayi Rubber Factory, Egba, Benin City.

The palm kernel husk was obtained from a local palm oil mill in Ihievbe town and washed with hot water and solution of 2 M potassium hydroxide. The palm kernel husk were cut into small pieces, air-dried, milled and sieved through a 212 μm mesh size and retained by 80 μm mesh size.

The sieved fraction retained by 80 μm mesh size was used for this experiment; the other compounding ingredients such as stearic acid, zinc oxide, MBTS, processing oil, and sulphur were purchased and used as supplied.

All the samples were compounded using the recipe in Table 1. The compounds were mixed on a laboratory-size two-roll mill maintained at a temperature of below 80°C to avoid any cross-linking during mixing.

Cure characteristic measurement

Monsanto rheometer (MDR, 2000) was used to determine the processing characteristics of the compound mixes. The test was carried out at a curing temperature of 185°C. The minimum torque,

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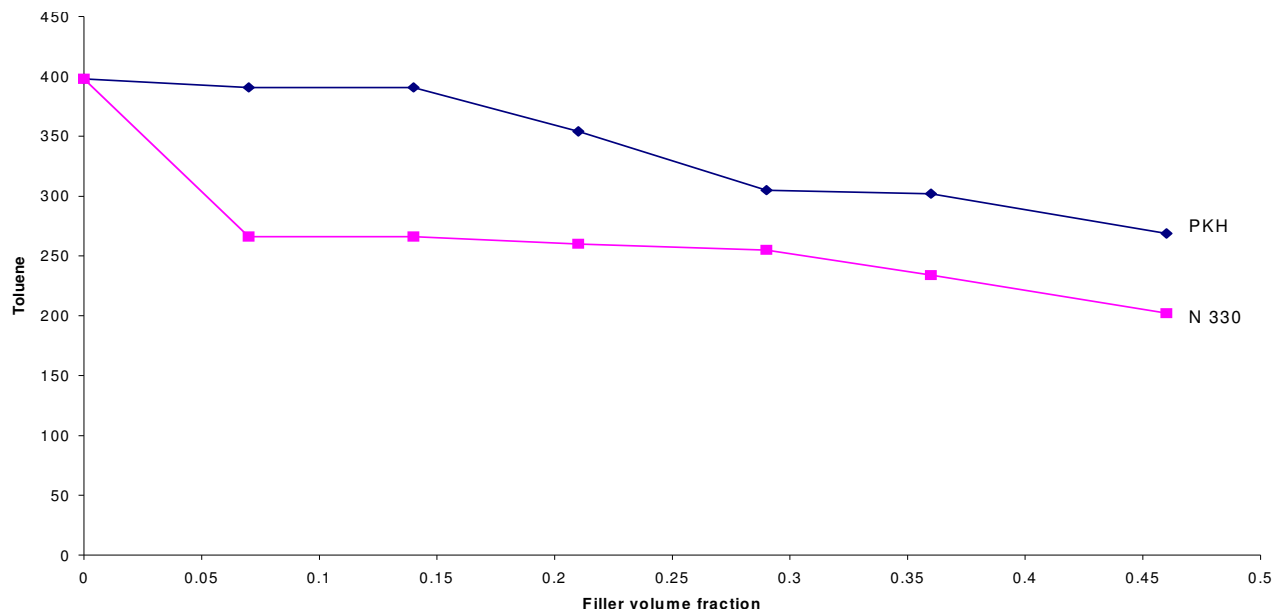


Figure 1_ Equilibrium sorption of natural vulcanizates filled with palm kernel husk and N330 in toluene.

Table 1. Typical formulation for palm kernel husk and carbon black (N330)-filled natural rubber.

Materials`	% (ph)
Natural rubber	100
Filler*	0-60
Stearic acid	4.0
Zinc oxide	2.0
Sulphur	1.5
Mecaptobenzothiazole	1.5
Processing oil	2.0

*Filler loading 0, 10, 20, 30, 40, 50 and 60 (phr)

maximum torque, scorch time and cure time were determined from the rheometer rheograph.

Sorption experiment

The equilibrium swelling of the vulcanizates in toluene, diesel and kerosene were studied using immersion/weight gain method (Abdeen and Abdel, 2001; Joaquin and Pierota, 2001) at ambient temperature. Three different pieces of the cured sample were cut from the 1mm thickness mould, weighed and then immersed in three air tight glass bottles containing the respective solvents. The three different samples were removed from the bottle containing the solvents after 24 h, blotted dry with filler paper to remove excess solvents from the surface of the sample and reweighed immediately.

The change in weight of the sample was expressed as percentage swelling.

$$\% \text{ swelling} = \frac{S_2 - S_1}{S_1} \times 100 \text{ ----- (1)}$$

Where S¹ and S² are the initial weight and weight of the swollen sample respectively.

RESULT AND DISCUSSION

While unvulcanized rubber dissolves in a good solvent, vulcanized rubbers can only be swollen in solvent to an extent determined by cross link density and the nature of the solvent.

Figures 1, 2 and 3 shows that, the values of equilibrium sorption decrease with increase in filler loading. The decreasing equilibrium sorption values of the palm kernel husk with, increasing filler-loading indicate its reinforcing ability. The factors, which can influence the equilibrium sorption in organic solvent of gum and filled vulcanizates, are nature of solvent and filler, level of cross-link and filler dispersion in the polymer matrix. The equilibrium behaviour of an elastomer, when exposed to fluid is very important in many applications (Okieimem et al., 2003). As for the higher sorption values obtained for kerosene over that of diesel, is due to the fact that when a cross-linked rubber is brought in contact with a solvent, the network absorbs a certain amount of liquid to an extent which is determined by the molecular weight of the liquid (Donnelly, 1957).

The decrease in sorption with increasing filler concentration may be accounted on the basis of the fact that each filler particles behaves as an obstacle to the diffusing molecules. As concentration of filler increases in the rubber matrix, more and more obstacles are created to diffusing molecules which ultimately reduce the amount of penetrant solvent. For the two fillers investigated, equilibrium sorption decreases with increases in filler loading, suggesting a swelling restriction of the rubber matrix due

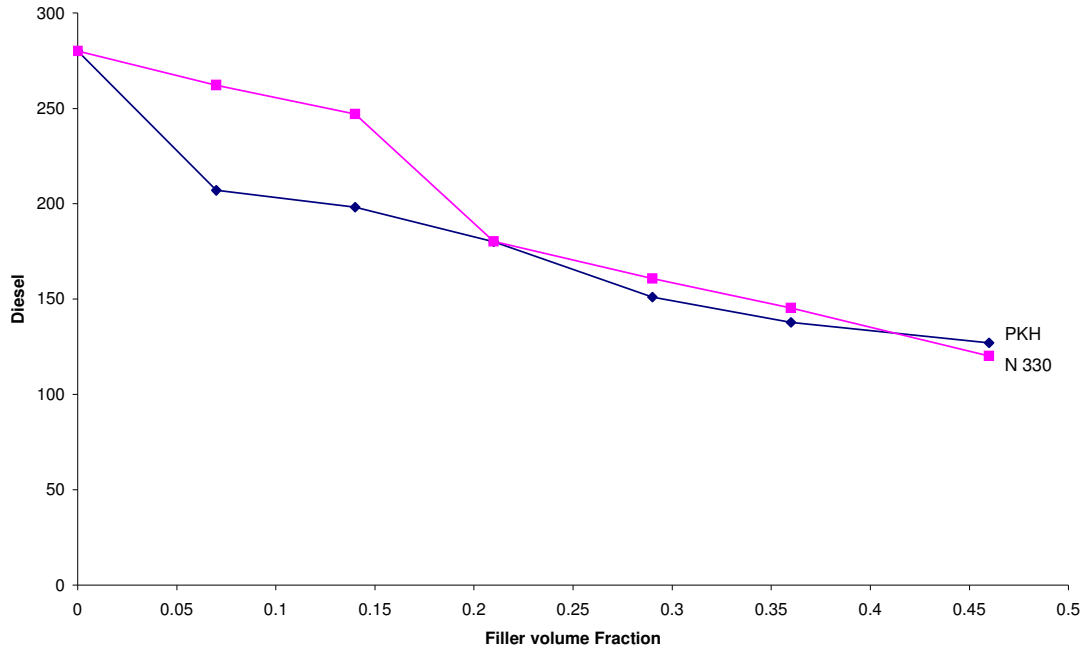


Figure 2. Equilibrium sorption of natural rubber vulcanizates filled with palm kernel husk and N330 in diesel.

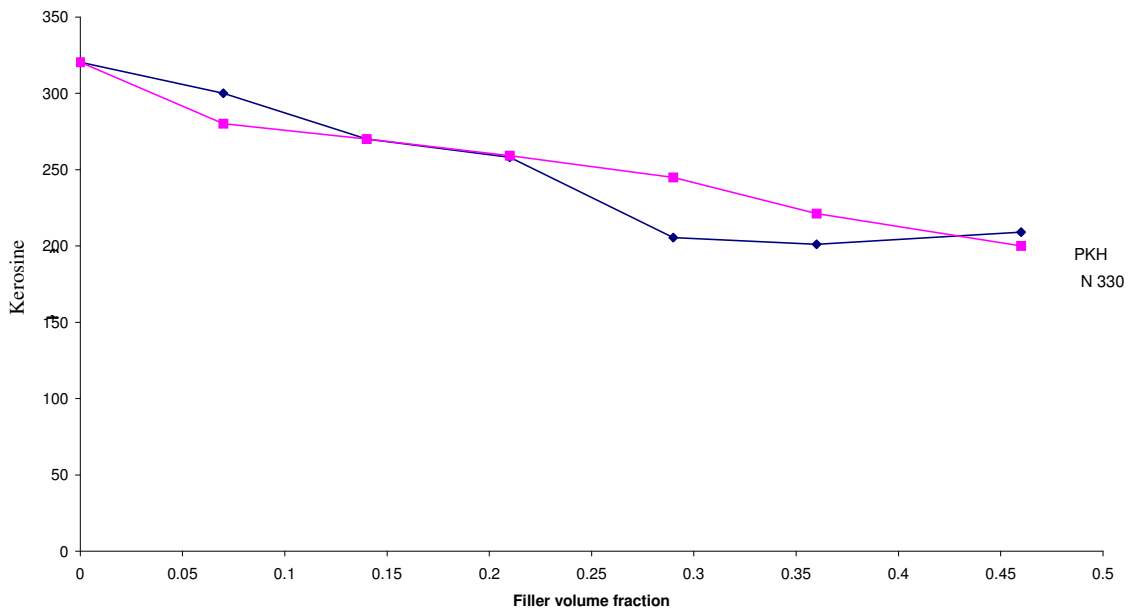


Figure 3. Equilibrium sorption of natural rubber vulcanizates filled with palm kernel husk and N330 in Kerosene.

to the presence of the filler. The swelling restriction caused by carbon black is smaller than that of the palm kernel husk; this is attributable to the better cross links formed by carbon black with the elastomer when compared with the palm kernel husk.

Cases where the cross link density is not affected by the addition of fillers, Kraus developed an equation to

describe the relationship between equilibrium swell and filler loading (Kraus, 1984).

$$V_g/V_f = \frac{1 - M \phi}{1 - \phi} \quad \text{----- (2)}$$

With

$$M = 3 C (1 - V_g^{1/3}) + V_f - 1$$

Where V_g and V_f are the volume fractions of the rubber in the swollen gum and filled compound, respectively, Q is the filler volume fraction, and C is a characteristic parameter of the filler. For reinforcing filler such as carbon black the C values can directly be used to characterize the restriction of swelling caused by the filler. A high value of C indicates a high swelling restriction, and V_g/V_f would decrease more rapidly with ϕ ($1-\phi$).

Although the value of C is mainly dependent on filler-rubber interaction, it was found that, both the primary and the secondary structures of the filler have a significant effect on C (Elias, 1984; Rigbi and Boonstra, 1967, 1968).

Figures 1, 2 and 3 show curves using toluene, diesel and kerosene as solvents. The restriction of solvent is obviously more pronounced for the carbon black [N330] than palm kernel husk. Since polymer-filler interaction is much weaker for palm kernel husk than for N330, the greater swelling restriction can be attributed mainly to highly developed filler-filler networking of the palm kernel husk. It is assumed that a strong filler network should limit the polymer network in the solvent.

CONCLUSION

Agricultural waste products constitute a large proportion of rural solid waste in developing countries. This study has shown that vulcanizates with higher concentration of palm kernel husk tend to be more soluble in organic solvents than the vulcanizates with higher concentration of carbon black.

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