RHEOLOGICAL BEHAVIOUR OF SHORT SISAL FIBRE REINFORCED NATURAL RUBBER COMPOSITES

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Introduction

Since the processing of polymer in most cases involves flow of the material, a thorough understanding of the flow characteristics of the composite is essential. Viscosity data and knowledge on melt elasticity behaviour at different temperatures and shear rates are highly useful in selecting the processing conditions and also to design processing instruments as described by Brydson[1]. Studies on the rheological behaviour and the extrusion characteristics of polymer melts have been reported by White and Tokita[2] and White[3]. Setua studied the rheological behaviour of short silk fibre filled elastomers and confirmed the pseudoplastic nature of the composite. The rheological behaviour of short jute fibre reinforced natural rubber composites has been studied by Murthy et al.[4]. The present paper deals with the rheological characteristics of short sisal fibre reinforced natural rubber composites. The effects of shear stress, fibre concentration, bonding agent and temperature on melt viscosity and elasticity characteristics have been investigated.

Experimental

Sisal fibre was chopped to a length of 10 mm. The acetylated fibre was prepared from the raw sisal fibre as per the method reported by Chand *et al.*[5] The mixes were prepared in a laboratory model two roll mixing mill. Rheological studies were carried out using a capillary rheometer attached to the Zwick universal testing machine model 1474.

Results and discussion

Formulation of mixes were given in Table 1. It is observed that during mixing the fibre has undergone severe breakage and the critical 10 mm length of the sisal fibre is reduced to varying sizes. During extrusion the fibre again undergone breakage and at a shear rate of 3300 s^{-1}, more than 50 per cent of the fibres are reduced to below 2 mm. Table 2 presents the data on variation of viscosity with shear stress at 100°C. It is evident that the composite behaves like a pseudoplastic material, as the shear viscosity decreases with the increase in shear stress. The increase in viscosity due to fibre loading is due to the fact that the presence of fibre restricts molecular mobility under shear. It is also observed that the fibres are mainly concentrated at the periphery of the extrudate at low shear rate, but form a uniform dispersion through out the matrix at high shear rate.

The variation of shear viscosity with temperature showed that as the temperature increases shear viscosity decreases. It is seen that die swell decreases by the addition of fibres. The reduction of die swell in presence of fibres has been reported earlier[6]. It is also observed that presence of fibre reduces the extrudate distortion at high shear rates.

Table 1. Formulation of mixes.

Ingredients	J	P	Q	R	E
Natural rubber	100	100	100	100	100
Stearic acid	1.5	1.5	1.5	1.5	1.5
Zinc oxide	5.0	5.0	5.0	5.0	5.0
Resorcinol	0.0	2.5	5.0	7.5	8.75
Hexa*	0.0	1.6	3.2	4.8	5.6
Sisal fiber (acetylated)	0.0	10.0	20.0	30.0	35.0
Sisal fiber (untreated)	0.0	0.0	0.0	0.0	0.0
TDQ**	1.0	1.0	1.0	1.0	1.0
CBS***	0.6	0.6	0.6	0.6	0.6
Sulphur	2.5	2.5	2.5	2.5	2.5

* Hexamethylene tetramine.
** 2:2:4 trimethyl 1,2-dihydroquinoline polymerized.
*** N-cyclohexyl benzothiazyl sulphenamide.

Table 6. Viscosity (NS mm^{-2}) of mixes at selected shear rates.

Shear rate (s^{-1})	J	P	Q	R	E
8.33	2797.03	12120.51	13985.52	13052.86	20511.69
83.31	2703.8	2517.33	2797.04	2890.27	3729.39
833.17	391.58	382.26	428.87	447.52	596.70
8331.77	55.94	62.46	74.58	83.91	111.88

References

1. Brydson, J.A., Flow properties of polymer melts. 2nd Edn. George Godwin, London, 1981.
2. White, J.L. & Tokia, N., J. Appl. Polym. Sci., **11** (1967) 321.
3. White, J.L., Rubb. Chem. Technol., **50** (1977) 163.
4. White, J.L., Rubb. Chem. Technol., **42** (1969) 257.
5. Chand, N., Varma, S. & Khazanchi, A.C., J. Mater. Sci. Letters, **8** (1989) 1307.
6. Setua, D.K., Int. J. Polym. Mater., **11** (1985) 67.
7. Murthy, V.M., Gupta, B.R. & De, S.K., Plast. and Rubb. Proc. and Applications, **5** (1985) 307.
8. Kutty, S.K.N., De, P.P. & De, S.K., Plast. Rubb. and Composites Proc. and Applications, **15** (1991) 23.