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STRESS RELAXATION IN ALUMINIUM POWDER FILLED NATURAL RUBBER COMPOSITES

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Stress relaxation measurements in tension were made on aluminium powder filled natural rubber vulcanizates and the results were compared with those containing high abrasion furnace black, general purpose furnace black, acetylene black, china clay and precipitated silica. A two-stage relaxation mechanism was observed in all cases except for the unfilled stock. The rate of relaxation increased with aluminium powder loading. The relaxation process was also found to be influenced by the presence of bonding agents such as hexamethylene tetramine-resorcinol system, bis [3-(triethoxy silyl) propyl] tetrasulphide, cobalt naphthenate and toluene diisocyanate. Composites containing bonding agents showed a slower rate of relaxation and higher cross-over time than those without bonding agents. This is due to the improved adhesion of aluminium powder with natural rubber in presence of bonding agents, which was confirmed by the equilibrium swelling values and scanning electron photomicrographs.

Key words: Aluminium powder, Composites, Natural rubber, Stress-relaxation.

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INTRODUCTION

The behaviour of composites consisting of an insulating polymer and conductive filler is quite interesting as such materials offer advantages of conducting heat and electricity. Higher thermal and electrical conductivity of these polymeric composites make them suitable for many applications such as dissipation of electrostatic charge, protection against electromagnetic radiation and development of friction-antifriction materials. The importance of conductive polymeric systems has been well documented (Norman, 1970; Crossman, 1985; Nobile *et al*, 1988; Lee, 1992 and Lin *et al*, 1993). Incorporation of conductive fillers in rubber offers advantages in the moulding of thick rubber articles like dock fenders and rice polishers. The increased thermal conductivity reduces the cure time of thick rubber articles and gives uniform cure throughout the material (Vinod *et al.*, 2001). The conductivity of polymers can be increased by adding conductive blacks, intrinsically conductive polymer or metallic powders (Meyers, 1986). Polymer based composites are more cost effective, less corrosive than metals and have easy processability. Fluctuation in composite properties is observed with particulate-filled polymer systems due to poor adhesion and non-uniform dispersion of the discrete phase in the matrix. Addition of a suitable coupling/bonding agent reduces this problem by enhancing surface interaction between the two phases. The use of silane coupling agent for improving polymer-filler interaction in silica-filled epoxidised natural rubber was reported (Alex and Mathew, 1989). Buchan (1959) presented a detailed study of various bonding agents for enhancing adhesion between rubber and metal. Resorcinol-silica-hexamethylene tetramine has been used for improving the adhesion between natural rubber and aluminium powder in various vulcanization systems (Vinod *et al.*, 1998; 2000).

Stress relaxation properties assume importance in static and dynamic applications under stress. The stress under a constant deformation decays by an amount substantially proportional to the logarithm of the period under deformed state. Stress relaxation