ABSTRACT

Rubber goods like seals, gaskets, mounts, dust covers etc., use large quantity of NBR, NR and EPDM. Laboratory tests play a vital role for control purpose in such products. Accelerated ageing studies could provide scope for extending the findings to life prediction of rubber products. But the role of ageing on structure - property relationship is not fully known.

The overall objective of this work is to provide useful informations to the Rubber Goods Industry on compounding, processing, characterisation and ageing through typical formulations based on NBR, EPDM and NR. Standard procedures for formulations and testing are adapted.

The following sequence is used:

Two roll mill mixing/ Mixing on Rheomix.

Cure studies using R100, ODR 2000, and MDR 2000.

Preparation of standard test vulcanisates and test specimens.

Conducting standard tests such as hardness, tensile properties, tear strength, compression set, stress relaxation, rebound resilience and dynamic-mechanical properties.

Study the effect of ageing on various properties and their retention indices. Structural studies using DSC, IR and TGA in typical cases. Structure - Property relationship using SEM at higher magnifications are also obtained in select cases.
In case of nitrile rubber the following formulations are studied: (i) Black loaded mixes and (ii) Mixes added with aramid cut fibre/ fibre pulp, and (iii) Formulations containing aramid pulp and HRH additives.

From the experiments, it is seen that reinforcements by carbon blacks and sulphur vulcanisations impart appreciable variations in cure and vulcanisate properties. Retention indices of tensile properties, resilience and strain energy illustrate the ageing behaviour of these formulations much better. The trend in Mooney-Rivlin plots and in the corresponding constants is seen to be similar to such trends in M20 values. Tensile stress relaxation is seen to suit the purpose in this investigation. But such conclusions are not forthcoming from the time to rupture values deduced from the ultimate elongation.

Shelf ageing data indicate that laboratory ageing done at 100°C for a duration over 24 hours could serve useful purpose. IR data indicate that oxidative degradation of these formulations is probably through some mechanism other than the formation of carbonyl groups. SEM micrographs of aged specimens at higher magnifications present distinct features of inherent flaws and brittle fracture after ageing. Exceptional case of ductile fracture, primarily controlled by cure system (sulphur donor) is also observed.

Addition of short aramid fibre and fibre pulp in NBR is seen to increase the rubber modulii without appreciably affecting the heat build-up behaviour. The role of HRH additives is controlled by the matrix type, viz.,
gum and black added. An Interaction Parameter and Reinforcement Index based on cure and vulcanisate properties respectively are proposed. These parameters present a better picture of HRH system.

Dependent upon the curing system (sulphur and peroxide) in EPDM, the short cellulose fibre influence the stress-strain properties. The magnitude is more pronounced after ageing. DSC study provides additional informations on this phenomenon. Study on hysteresis in uniaxial tension shows that ageing has comparatively less effect in short cellulose fibre formulations.

Based on a generic NR mount formulation, $2^3$ experiments are designed (two level three factorial DOX) to study the factor-effects on shear modulus, tensile strength, ultimate elongation, compression set, resilience, heat build-up adhesion strength and swell index. The three factors are: N330, Aromatic oil & Sulphur. A design matrix satisfying orthogonality condition to design the experiments and a response table to compute regression coefficients are used. These coefficients are used to construct linear response equations. Confirmatory tests results show that there is a fairly good agreement between the values deduced from the equations and experimental values.

Rubber formulations are mostly made out of past experience and trial. A scientific approach embracing various properties and ageing behaviour and relating them to such formulations is probably attempted for the first time in this work.