A novel route is attempted for preparing latex stage masterbatches using different types of natural rubber latex with HAF (N330), fluffy carbon black (carbon black powder before pelletisation), silica and nanoclay either alone or in combination. The effect of masterbatching on natural rubber/polybutadiene rubber (NR/BR) blend compounds prepared by mixing the dried masterbatches with the required quantity of BR and other compounding ingredients was also investigated.

Mixing of carbon black, silica and nanoclay with dry rubber is a highly energy consuming process and is accompanied by pollution of the surrounding air due to flying of the particles to the atmosphere. Silica and nanoclay is extremely difficult to disperse in dry natural rubber using a two roll mixing mill. The concept utilised in the present work to minimize air pollution and minimize energy consumption results in enhancement in filler dispersion in the vulcanizates and enhanced properties.

Fresh natural rubber (NR) latex coagulates immediately by sensitisation with fatty acid soaps. Though the basic objective of the new process was to shorten the coagulation time, the use of surfactants plays a major role in improving cure characteristics and mechanical properties. Shortening of coagulation time is advantageous in the latex stage incorporation of fillers. The conventional slow coagulation leads to filler
loss whereas the soap sensitised quick coagulation ensures homogeneous dispersion of fillers with minimum loss. This benefit cannot be achieved by addition of appropriate quantity of higher fatty acids during the dry compounding of the rubber. The coagulation of natural rubber latex in presence of acids is accelerated by addition of small quantities of an anionic surfactant. A proportion of the surfactants added to latex gets adsorbed on rubber particles and are retained in rubber after coagulation. The surfactants retained on rubber activate the vulcanization and enhance the filler dispersion thereby improving the mechanical and solvent ageing characteristics of recovered rubber. The carbon black filled rubber vulcanizates based on natural rubber obtained by modified coagulation show significantly higher abrasion resistance mainly due to the lubricating action of the fatty acids formed in rubber.

Carbon black masterbatches prepared with different forms of natural rubber latices like fresh latex, preserved filed latex (PFL) and concentrated latex with fluffy carbon black show higher rheometric torque. The cure time observed for the masterbatches was comparable to the conventional dry rubber compound. As compared to the control dry rubber vulcanizate, the masterbatch vulcanizates made from fresh latex show higher modulus, tensile strength, hardness, and tear strength. The masterbatch vulcanizates prepared from fresh latex show lower compression set, heat build-up and abrasion resistance. The ageing resistance too was superior for vulcanizates prepared from the latex based masterbatches. This is attributed to a uniform dispersion of fluffy carbon black in rubber in the latex based masterbatches.

For the silica filled compounds a lower minimum torque and lower scorch time is recorded for the latex based masterbatches as compared to the mill
mixed dry rubber compounds. For same filler loadings, the master batch based mixes recorded a higher rheometric torque and lower cure time as compared to the compounds based on dry rubber. Similar results were observed in the case of the compounds containing higher dosages of the fillers (50phr and 60phr) also. During the preparation of masterbatches, the filler-latex mixture co-coagulates along with a portion of the surfactant that apparently got converted into the corresponding fatty acid. This helps in better vulcanization characteristics of rubber as fatty acids are activators of vulcanization.

In the case of these latex based vulcanizates too the mechanical properties like tensile strength, modulus, tear strength, abrasion resistance and hardness were superior as compared to the conventional dry rubber vulcanizates. The heat build–up values were considerably low for the latex filler masterbatch based vulcanizates. Slightly lower tan delta values were also observed for the latex filler masterbatches. The silica filled mixes showed comparatively very good mechanical properties in the absence of any coupling agent. The filler masterbatches prepared by this method shows a higher level of vulcanization along with better filler dispersion compared to conventionally prepared mixes. Due to this, a comparatively low tan delta value at 60 °C that correlates to a lower rolling resistance is observed for the masterbatch vulcanizates.

A process for production of carbon black/silica/nanoclay ternary filler masterbatches from fresh natural rubber (NR) latex was standardized.

The masterbatch compounds containing 25/25 and 30/30 carbon black/silica fillers recorded higher rheometric torque compared to the corresponding dry rubber compounds. The masterbatch compounds containing 25/25/3, 25/25/5, 25/25/10 carbon black/silica/nanoclay
recorded higher rheometric torque compared to dry rubber compounds that contain only carbon black/silica.

The mechanical properties like tensile strength, modulus, tear strength, abrasion resistance and hardness increased with proportion of nanoclay in the masterbatch vulcanizates up to 5 phr and with further amount the change was only marginal. Lower tan delta values were observed for all the masterbatch vulcanizates containing nanoclay in the ranges 3-10 phr compared to the dry rubber vulcanizate containing 25/25 carbon black/silica. The improvement in mechanical properties and dynamic properties shown by the masterbatch vulcanizates over the conventional dry rubber vulcanizates was attributed to factors related to filler dispersion as evidenced from the data of Dispersion Analyzer images and X-ray diffractograms, and higher level of vulcanization. The vulcanizate properties of the nanoclay containing masterbatches prepared by latex stage mixing show excellent improvement in abrasion resistance, lowering of heat build-up and lower tan delta at 60 °C compared to a conventional dry rubber. These compounds can be used to manufacture tyre treads with better fuel efficiency and improved wear resistance.

Fresh natural rubber latex - carbon black/silica masterbatches were prepared. The dried masterbatches and polybutadiene rubber (BR) was separately masticated and mixed with the required quantity of carbon black and silica (based on the quantity of polybutadiene in the blend) on a mixing mill so as to have 25 phr each of carbon black and silica in 100:0, 80:20 and 60:40 natural rubber/polybutadiene blends. The compounds were vulcanized and characterized for mechanical and dynamic properties.
The fresh natural rubber latex based carbon black-silica masterbatch and polybutadiene blend compound vulcanizates shows better mechanical properties like tensile strength, modulus, tear strength, abrasion resistance, hardness and lower heat build-up compared to the blends prepared using conventional dry rubber vulcanizates. As the proportion of BR in the blend increased abrasion loss reduced while hardness and heat build-up increased due to the unique micro structure of cis-1, 4-polybutadiene rubber.

There was reduced filler-filler interaction on blending natural rubber with polybutadiene rubber for the blends based on the masterbatch vulcanizates. Filler dispersion data indicated that dispersion was not adversely affected on blending. Plots of tan δ versus temperature show a lowering of tan δ peak height in the case of the masterbatch vulcanizates indicating better polymer-filler interaction compared to the dry rubber vulcanizates. The tan δ value at 60 °C show lower and hence the rolling resistance was lower for the 80/20 NR/BR blend prepared with the masterbatch vulcanizates.

......MORE......