ABSTRACT

Radiation crosslinking of polymers is a rapidly expanding technology, because of some of the more important advantages it has over conventional chemical crosslinking. The process is fast, simple and pollution free. A thermoplastic elastomer (TPE) is a special type of polymeric material with properties and functional performance similar to those of conventional vulcanised rubbers at ambient temperature, yet can be processed in a molten condition as a thermoplastic polymer at elevated temperatures. A suitable crosslinking agent can vulcanise a thermoplastic elastomer, which can be electron beam (EB) radiation also. It can also be crosslinked with ultraviolet (UV) radiaton of suitable frequency and intensity preferably in the presence of a suitable photoinitiator. The crosslinking improves the mechanical and chemical properties of the resulting material. When styrene-butadiene-styrene (S-B-S) block copolymer which is a thermoplastic elastomer is exposed to EB radiation, then along with crosslinking, chain scission may also take place to some extent. Crosslinking to chain scission ratio can be calculated and the ultimate properties depend on these two opposing factors occurring simultaneously. Conventional S-B-S grades generally have about 8-10 % of vinyl (1,2 content) groups in the mid block polybutadiene unit, but in specially prepared grades the value may go up to as high as 50 %. The main objective of the present work is to study in details the influence of EB and UV radiations at varied irradiation doses on the mechanical, thermal, rheological and morphological properties of a high vinyl (~ 50 %) S-B-S TPE variously compounded with suitable compounding ingredients.

The appropriate electron beam radiation dose has been predicted to give the best combination of mechanical properties. The extent of crosslinking and the extent of chain scission were quantified by the application of Charlesby-Pinner plots. In presence of EB radiation, nanosilica alone was not effective in enhancing the mechanical properties but along with a dispersing agent, namely TESPT there was a tremendous improvement in the properties of the high vinyl S-B-S polymer. The overall best balance in properties was achieved at 25 kGy radiation at 2 phr of nanosilica and 0.1 phr of TESPT. The recyclability of the compounded and irradiated was found to be very good. Modification of the polymer in the direction of physical properties with ultraviolet radiation has also been established. Design of Experiments (DOE) methodologies was adopted to identify the influential effects of the process variables on the final physical properties of UV crosslinked S-B-S block copolymer. The effects of process parameters (time and distance) as a function of photoinitiator (PI) concentration and molecular characteristics (vinyl content) on the physic-mechanical properties was pursued. Responsive Surface Methodologies (RSM) was successfully employed to optimise the variables. It was found that high vinyl S-B-S at 1 weight % of PI concentration on 35 s treatment time and 15 cm packing height give best overall balance of properties. In other words, closer distance to the UV lamp with lesser irradiation time is sufficient to give the desired balance of properties. The thickness of crosslinking UV in presence of a photoinitiator has been correctly predicted. It was observed from the results that with an increase in the PI concentration, the tensile strength decreased while the modulus increased upto 1 phr and then decreasd at 1.5 phr. This was due to the phenomenon of inner shielding effect for which the inner layers remained uncrosslinked.

Keywords: Electron beam, UV radiation, Thermoplastic elastomer, S-B-S block copolymer, Nanosilica, Dispersing agent, Mechanical properties and Design of experiments