Elastomers Radiation Vulcanization

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Introduction

The elastomer have applications when their plastic properties are changed to elastic properties by vulcanization process. The radiation vulcanization are crosslinking is one process that releases any chemical reagents and it happens at room temperature. The process is appropriated to fabricate polymeric medical supplies whose purity degree is one of the most important factors.

The vulcanization of natural rubber latex (NRL) used in the world occurs in the presence of sulfur and another reagents and it needs heat. Mean while the supplies fabricated by this process are citotoxicants, they have nitrosamines that are toxicants and carcinogen and when they are incinerated the air pollutants are discharged such as SO_x and NO_x gases and ashes. The radiation vulcanization, one alternative process, produces supplies that they have citotoxic potential five times minor, more softness, transparency and biodegradability and neither haven't nitrosamines nor air pollutants (Machi, 1989).

The conventional silicone rubber (SR) vulcanization happens in the presence of heat and organics peroxides which must take off from medical supplies. By another way the radiation vulcanization process happens without peroxides and catalysers at room temperature (Delides, 1977).

Therefore Brazil pretends to develop the radiation utilization in the fabrication of polimeric medical supplies getting from elastomers. In this paper we are discussed the radiation vulcanization of NRL and SR by both radiations, gamma rays and electrons beams in function the tensile strength (TS) besides the commercial aspects of surgical gloves fabrication for national conditions and the recovery of SR supplies.

Experimental

Both NRL and SR were vulcanized by gamma rays form ^{60}Co source (dose rate = 1.0 kGy/h) and electron beams from dynamitron accelerator (E=1.5 MeV, i=25 mA, dose rate = 2.0x10^5 kGy/h) with dose up to 300 kGy.

The 60 % concentrated NRL was irradiated with sensitizer (3.0 phr n-BA/2.0 phr KOH) and after the 1 phr of antioxidant was added. The dose effect relating to TS was evaluated using the test specimens from rubber plates getting by casting process.

The commercial SR produced by policondensation (n=2.000-4.000) has 0.8 - 4% of vinyl groups, 25% of fillers and 4% of aditives and it was pressed between two policarbonate plates and irradiated by gamma rays or electrons beams. The measurements of TS was realized in function of dose.

Results and discussion

Elastomers vulcanization

When NRL is irradiated by gamma rays or electrons beams with sensitizer (Figure 1) the vulcanization dose (VD) is smaller than without sensitizer. The sensitizer becomes in one economical process (Zhongai, 1983). The TS increases when the dose increases until VD. After VD the crosslinking predominantes also but the TS decreases because the crystallization is hindered during the TS assay and the physical interactions among the rubber particles decrease (Makuuchi, 1983) (Souza, 1994).

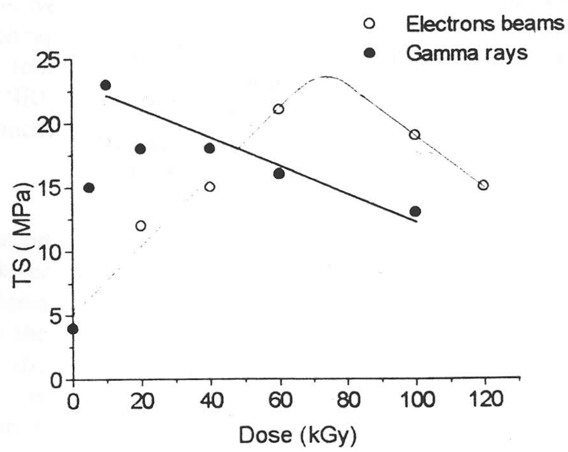

Figure 1 - Dose effect on the tensile strenght of NRL.

The dose rate effect on the VD occurs in the presence of n-BA sensitizer. The VD is 7.5 times minor when NRL is irradiated with gamma rays.

When SR is irradiated by gamma rays or electron beams without peroxides or catalysers (Figure 2) the TS also increases in function of dose up to the maximum and decreases. The SR behaviour is similar to NRL behaviour

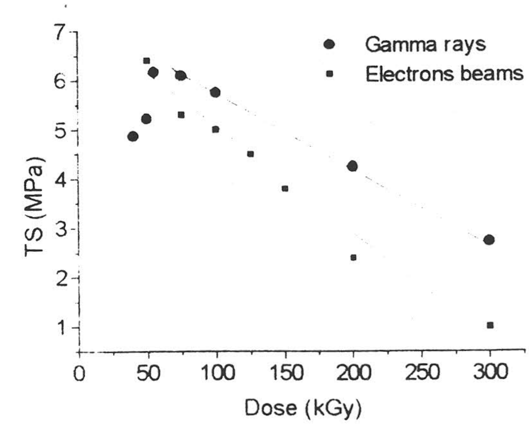

Figure 2 - Dose effect on the tensile strenght of SR.

But the dose rate effect happens because the electrons beams promote the greater increase of the crosslinking density.

Developped applications

Surgical gloves fabrication

Surgical gloves were fabricated by dipping process with coagulant from the NRL vulcanized by gamma rays. The parameters of process were studied (temperature, time of flowing off and permanece, and outlet time of former and coagulant concentration) in function of gloves thickness (T) and evaluated by statistical fractional factorial desing. Only 2 parameters affect the thickness: the coagulant concentration (C) and outlet time (PT) of NRL former. The experimental mathematical relation is (Chirinos, 1995).

$$T = 0.213 + 0.025\,C + 0.019\,PT$$

The surgical gloves aging or not aging have good mechanical properties as surgical gloves fabricated by conventional process.

Relating to economical aspects the surgical glove couple fabricated by radiation process is 17% more cheap than by conventional process. From among of four studied convencional options the plant of benefited NRL by gamma rays is more atractive according to economical aspects.

Recovery of silicone rubber nipples

The demonstration assays of radiation vulcanization of SR by gamma rays and the electrons beams for "Bayer do Brasil" was realized in IPEN. When one of the clients of Bayer lost the first fabrication lot of SR nipples by the conventional process (peroxides and heat) because the vulcanization degree was not adequately we try to its recovery by gamma radiation. Therefore preliminaries assays by gamma rays from commercial ^{60}Co (dose rate = 20 kGy/h) was realized to define the vulcanization dose of 30 kGy in function of elongation (88%) and Shore A hardness (43) (Lorena and Guedes, 1995). In this way we recovered 2.000 SR nipples hindering the prejudice and material waste.

Catheter fabrication

Our research group already began the development of NRL catheter by gamma rays vulcanization using the gravity. After irradiation the NRL viscosity increases about 8 times during 5 days of storage and 30 days of storage the viscosity value becomes igual to the initial value. This reversible perturbance in the colloidal stability of NRL is caused by radiolitic species absorption that promotes the increase of particle size (Canavel. 1994).

Conclusions

The studied elastormers, NRL and SR, are easily vulcanized with ionizing radiation. The NRL vulcanization requires the presence of sensitizer (n-BA) to decrease the VD.

The surgical glove fabrication by alternative process is 17% more cheap than conventional process for Brazil although the irradiation price is the most higher among the countries that use radiation process.

The interaction between radiation and NRL promotes properties changing that can be explored in the medical supplies fabrication such as viscosity and higher transparence.

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