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SURGICAL GLOVES FABRICATION BY RADIATION VULCANIZATION OF NATURAL RUBBER LATEX

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INTRODUCTION

Natural latices are produced by a large number of countries but Malaysia dominates with 92 % (0.4 millions of tonnes / 1992). 60 % of this world production is employed to fabricate rubber goods by dipping process and 85 % these rubber goods are gloves [1].

Vulcanization process of natural rubber latex in the presence of sulfur is the most used in the world, however there is an alternative vulcanization process with toxicological, economic and no pollutant advantages and producing rubber goods with the best qualities. This alternative process is the radiation vulcanization of natural rubber latex [2]. The method consists in the 1,4-cis-poliisoprene cross linking, dispersed in aqueous fase. It happens by radiation interaction of gamma rays from ^{60}Co or electrons beam from accelerators with polymeric molecules.

The objective of this work is to establish the best conditions for surgical gloves fabrication by radiation vulcanization process of natural rubber latex. The study of vulcanization conditions was carried out with rubber plates of 2 mm of tickness obtained by casting process.

GAMMA RAYS

The vulcanization dose of 60 % DRC national natural rubber latex was 200 kGy when it was vulcanized by gamma rays. Addition of

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compounds with high G value (sensitizer) to the latex increased the cross linking degree and decreased the vulcanization dose [3]. Consequently this process becames more economical than traditional process when the vulcanization dose is small than 10 kGy [4]. The vulcanization dose of 200 kGy for natural rubber latex decreased to 40 kGy, to 10 kGy and to 9 kGy in the presence of CCl_4 / potassium laurate(PL), n-butyl acrylate (n-BA) and n-BA/t-butyl hydroperoxide (t-BHP), respectively. Both n-BA and t-BHP tend to destabilize the natural rubber latex. The most effective stabilizer is KOH [5].

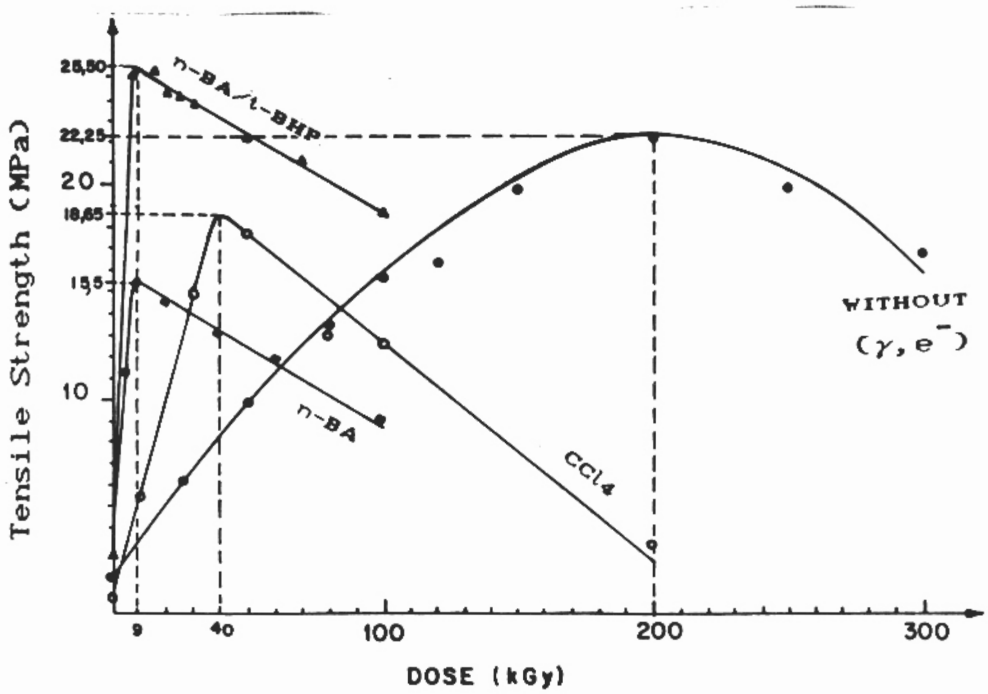

FIGURE 1 - Sensitizer effect on γ rays vulcanization.

The Figure 1 shows the sensitizing efficiency of three different systems. The CCl_4 / potassium laurate decreased 5 times the vulcanization dose (VD) and maximum tensile strength (TS) was small than without sensitizer. The n-BA / KOH decreased 20 times the vulcanization dose but in the presence of only 0.1 phr t-BHP decreased bellow 10 kGy and maximum tensile strength increased a little when compared with latex without sensitizer. The Figure 2 shows the [n-BA] = 3.5 phr is the best for gamma rays vulcanization. The best sensitizer system was 3.5 phr n-BA / 0.1 phr t-BHP / 0.2 phr KOH. The vulcanization dose is 9 kGy.

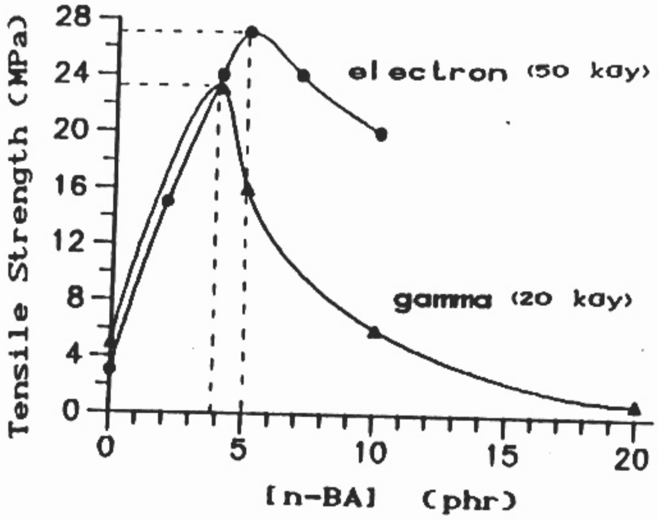

FIGURE 2 - Effect of [n-BA]. γ-vulcanization.

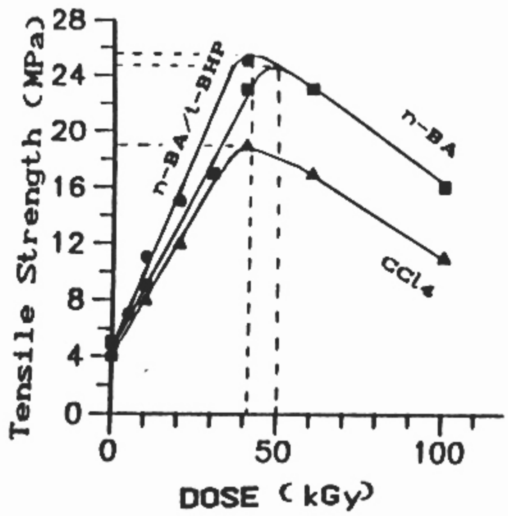

FIGURE 3 - Sensitizer effect on electron beam vulcanization.

ELECTRONS BEAM

The vulcanization dose of 60 % DRC national natural rubber latex was the same, 200 kGy (Figure 1). Therefore the dose rate did not affect the radiation vulcanization process without sensitizer [6]. In the presence of the same sensitizer systems the vulcanization dose decreased to 50 kGy for CCl_4 and n-BA and to 32 kGy for n-BA/t-BHP (Figure 3). The best concentration of n-BA is 5 phr for electrons beam vulcanization (Figure 2).

The effect of dose rate (DR) is on sensitizer. When the dose rate increased the vulcanization dose also increased and the maximum tensile decreased a little (Table 1). The best sensitizer system for radiation vulcanization process with electrons beam was 5 phr n-BA / 0.1 phr t-BHP / 0.2 phr KOH. The dose rate and the vulcanization dose are 23 Kgy/s and 50 kGy respectively.

SURGICAL GLOVES FABRICATION

National natural rubber latex was vulcanized by gamma rays and electrons beam using each sensitizer system. Also it was vulcanized by the traditional process using sulfur. Surgical gloves were made in an factory by coagulant dipping process.

The comparative study of surgical gloves quality was carried out by physical and mechanical properties (Table 2). The gamma rays

TABLE 1 - Dose Rate Effect.

RADIATION	DR (kGy / s)	VD (kGy)	TS (MPa)
Gama	7×10^{-4}	10	22
Electron	10	30	22
Electron	15	48	20
Electron	23	45	28
Electron	50	60	21
Electron	91	75	24

vulcanization process is better than electrons beam vulcanization process.

TABLE 2 - Properties of surgical gloves.

PROPERTIES	S	γ		e^-
		n-BA/t-BHP	CCl_4/PL	CCl_4/PL
Perforation (kg/mm)	3.36	2.20	2.33	1.5
Permanent set (%)	7.0	7.5	6.5	1.0
Elongation (%)	950	950	1025	750
Tensile strenght (MPa)	40	30	38	34
Modulus at 700 % (MPa)	27	19	22	32
Angular tear (kg/cm)	126	73	95	30
Crosslinking degree	4.35	4.20	4.10	5.00
Vulcanization dose (kGy)	——	9	40	40

When the surgical gloves was made by latex vulcanized by gamma rays the physical properties were the same and the mechanical properties obtained before and after aging at 70°C for 7 days (Table 3) were a little different for each sensitizer systems but they meet ASTM specification for surgical gloves. All properties were comparable to those of sulfur vulcanization gloves.

TABLE 3 - Properties of surgical gloves after aging at 70 °C for 7 days.

PROPERTIES	S	γ	
		n-BA/t-BHP	CCl_4/PL
Elongation (%)	950	950	1025
Tensile strenght (MPa)	40	30	38
Modulus at 700 % (MPa)	27	19	22
Angular tear (kg/cm)	126	73	95

At point of view of mechanical properties the CCl_4 sensitizer was the best. But the economic point of view the n-BA / t-BPH was the best because can be vulcanized by gamma rays at small dose of 9 kGy. We chosen the last sensitizer system because the vulcanization dose was bellow 10 kGy and the mechanical properties were acceptable for surgical gloves commercialization.

CONCLUSIONS

1) The process of natural rubber latex vulcanization can be induced by gamma rays and electrons beam in the presence or absence of sensitizer.
2) The dose rate effects is on sensitizer.
3) The best conditions for surgical gloves fabrication by radiation vulcanization of natural rubber latex (60 % DRC) were these: a) sensitizer 3 phr of n-BA / 0.1 phr of t-BHP / 0.2 phr of KOH; b) vulcanization dose = 9 kGy; c) gamma rays vulcanization.

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