MANUFACTURE OF SURGICAL GLOVES FROM NATURAL RUBBER LATEX VULCANIZED BY GAMMA RAYS

COLLANTES, H.D.C. & GUEDES, S.M.L.
Instituto de Pesquisas Energéticas e Nucleares
IPEN-CNEN/SP, Cx.P. 11049, CEP 05499-970, São Paulo, Brasil

INTRODUCTION

The vulcanization of the natural rubber latex (1,4 cis-poliisoprene) in the presence of sulphur and heating is world-wide employed [1]. During 1980's decade, an alternative process of vulcanization appeared in which the reticulation was obtained as a consequence of the ionizing radiation (γ-ray or electron beams) interaction with the rubber molecules [2]. By this alternative process rubber goods with best quality properties regarding to health, toxicological and environmental aspects can be manufactured. The advantages of this process are: small consumption of chemical reagents and energy, and that the vulcanization occurs in one step, at room temperature [3]. The objective of the work summarized in this paper was to define the best conditions for surgical gloves manufacturing using the vulcanization of the natural rubber latex by γ-ray process and the mold immersion technique in a coagulant solution. This involved the study of the parameters that influence the surgical glove thickness.

METODOLOGY

The concentrated latex at 60% was formulated with 3 phr of n-BA (normal butyl acrylate)/0,2 phr of KOH [4]. This latex solution was irradiated at room temperature in the presence of air, by gamma rays from a ^{60}Co source. The vulcanization dose (VD) was 10 kGy. Surgical gloves were manufactured by the immersion method, using coagulant [2], and after that the effects of the process parameters on the surgical gloves thickness were analized.

RESULTS AND DISCUSSION

The experiments were carried out by the statistical technique of two-level fractional factorial of resolution five design [5] for evaluating the main effects and interactions of each parameter on the thickness. The variation of the parameters was established according to actual industrial practices (Table 1).

Table 1: Range of the parameters variation.

Parameters	Range	
A: $CoCl_2$ concentration, %	8	19,7
B: Mold temperature, °C	30	80
C: Total time of coagulant trickling from the molde, s	3	10
D: Inmersion time in the latex, s	3	12
E: Velocity at which the molde is taken out from the latex, cm/s	2,5	10

The factorial rearrangement of 16 runs in Yates order of the A, B, C, D and E variables is presented in the table 2 [5]. All the experiments were made randomly to eliminate any kind of dependence.

Table 2: Two-level fractional factorial of resolution five, 2_V^{5-1}

Run	Design A B C D E	Thickness (mm)
1	− − − − +	0,165 ± 0,001
2	+ − − − −	0,214 ± 0,001
3	− + − − −	0,183 ± 0,002
4	+ + − − +	0,233 ± 0,002
5	− − + − −	0,157 ± 0,002
6	+ − + − +	0,208 ± 0,001
7	− + + − +	0,175 ± 0,001
8	+ + + − −	0,215 ± 0,002
9	− − − + −	0,205 ± 0,002
10	+ − − + +	0,250 ± 0,002
11	− + − + +	0,223 ± 0,001
12	+ + − + −	0,291 ± 0,004
13	− − + + +	0,199 ± 0,004
14	+ − + + −	0,239 ± 0,003
15	− + + + −	0,192 ± 0,003
16	+ + + + +	0,254 ± 0,002

Table 3: Analysis of fractional factorial design.

Parameter	Estimates (mm)
Average+ ABCDE	0,213 ± 0,002
A + BCDE	0,050 ± 0,003
B + ACDE	0,016 ± 0,003
C + ABDE	−0,016 ± 0,003
D + ABCE	0,038 ± 0,003
E + ABCD	0,001 ± 0,003
AB + CDE	0,004 ± 0,003
AC + BDE	−0,003 ± 0,003
AD + BCE	0,003 ± 0,003
AE + BCD	−0,005 ± 0,003
BD + ACE	0,001 ± 0,003
BE + ACD	−0,001 ± 0,003
DE + ABC	−0,002 ± 0,003

From these results (Table 3) it is possible to observe: a) the thickness of the rubber film decreased 0,016 mm for the longest trickling time of the coagulant solution (C parameter), because that solution is carried in excess by the mold and could give other wise a thicker rubber deposit. b) when the mold is heated and immersed in the latex (B parameter) the thickness increased 0,016 mm, because the heat from the mold produces more deposition of rubber. The effect of B and C parameters are compensatory. c) when the coagulant concentration (A parameter) increases up to 19,7%, the thickness of rubber film increases 0,05 mm. d) for the longest immersion time the molde in the latex (D parameter) the thickness increases 0,038 mm. e) the velocity at which the mold is taken out from the latex (E parameter) does not interfere in the thickness.

The equation 1 was obtained from the correlation between the gloves thickness and the process parameters by a linear model with 0,94 correlation index:

$$Esp = 0{,}213 + 0{,}025\,A + 0{,}019\,D \qquad (1)$$

Esp is the surgical glove thickness (mm), A is the coagulant concentration factor and D is the inmersion time factor of the mold in the latex.

CONCLUSIONS

The glove thickness is linearly dependent on both, the coagulant concentration and the inmersion time of the mold in the latex. The studied parameters are independent among themselves, and the velocity at which the mold is removed from the latex does not influence on the glove thickness.

REFERENCES

[1] RAYMOND, B.S.; CHARLES, E.C., *Polymer Chemistry*, New York, Cap. 6, 1987

[2] UTAMA, M., Viena, International *Atomic Energy Agency*, 18/01/90 (IAEA-RU-2080). (Final Report)

[3] TSHUSHIMA, K.; MAKUUCHI, K.; YOSHII, F.; ISHIGAKI I. Takasaki, *Japan Atomic Energy Research Institute.*, 1989 (JAERI-M-89-228). p. 127-131.

[4] SOUSA, A.; CANAVEL, V.; ARÁUJO, S.C.; GUEDES, S.M.L., In BRAZILIAN NUCLEAR ENERGY ASSOCIATION: Annals of the IV General Congress of Nnuclear Energy, realized in Rio de Janeiro, Brazil, July 5-10, 1992. v.1 p 345-348.

[5] BOX, G.E.P.; HUNTER, W.C.; HUNTER, J.S., *Statistic For Experimenter*. New York-Wiley, 1978.