PRODUCTION OF RVNRL AND MANUFACTURE OF PRODUCTS FROM IT

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ABSTRACT

The procedure of the trial irradiation of latex at the pilot plant are discussed. Factors influencing the quality of RVNRL during trial production are identified. Procedure for processing of radiation prevulcanised latex into end products has been standardised. Household gloves, industrial gloves, toy baloons, blood transfusion tubes and nipples are manufactured commercially from RVNRL produced at Rubber Board.

INTRODUCTION

The pilot plant for producing prevulcanised latex using gamma radiation was loaded with 0.37 PBq. of Cobalt-60 during April 1992. Trials started immediately following the source installation. 33 batches of latex have been irradiated under different conditions for standardising the parameters of radiation vulcanisation of latex. In association with Bhabha Atomic Research Centre, Mumbai frequent dosimetry studies were also carried out in the plant for estimating the correct dose required for obtaining the optimum properties to the processed latex. The RVNRL thus processed was supplied to different small scale product manufacturers in various fields and their feed back was collected.

Materials and Method

a) Latex: Highly stabilised low ammonia latex processed and supplied by PLPC, Rubber Board. The field latex is preserved with 0.3% ammonia and 0.025% TMTD/ZnO (1:1). 0.15% ammonium laurate is then added. Required amount of DAHP is added, stirred and allowed to stand for 3 days and centrifuged. The ammonia content of the centrifuged latex was adjusted to 0.3% and TMTD/ZnO (1:1) was adjusted to 0.025% on the latex. The latex thus processed has the following properties.

DRC	- 60%	Coagulum content	- Trace
TSC	- 61.5%	Sludge content	- Trace
MST	> 1600 Secs.	Manganese	- Trace
KOH No.	- 0.4 to 0.5	VFA	< 0.02
Copper	- Below 1 ppm	Magnesium	- Below 10 ppm
NH_3%	- 0.35		

b) Butyl Acrylate: IPCL, Baroda.

c) Carbon Tetra Chloride, Potassium Hydroxide, Ammonia : Merck (India) Ltd., Qualigens fine chemicals.

Stabilised low ammonia latex is transferred to the product vessel (1000 litres capacity) after one week maturation. The latex is compounded as per the formulation given below.

60% H.S.LA latex	- 167
10% KOH	- 2
n-BA	- 1
CCl_4	- 1
0.2% ammonia water	- 2

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During compounding latex is stirred at 30 to 40 rpm. The product vessel with compounded latex is taken to the radiation chamber and aligned in position. There the latex is placed for maturation for 12 hours. The matured latex under slow stirring is exposed to gamma radiation by operating the plant. Irradiation is continued till 25 KGy is received by the latex. After completion of irradiation, ZDC is added to the irradiated latex at 0.75 phr and the product vessel is taken out to the material handling area for transferring RVNRL to drums for subsequent product development/testing operations.

As a reference method the gamma-chamber 900 is made use to correlate the results obtained. For that a sample of the compounded latex is taken from the product vessel and irradiated in the gamma chamber to the level of 25 KGy for complete vulacanisation. After adding the required antioxident, films are casted using both gamma-chamber irradiated and pilot plant processed RVNRL. The partially dried films are then leached in cold water for four hours and dried at room temperature. The final drying is done at 80^{0}C for five hours. Dumbell samples are cut from these sheets and tested for tensile properties.

Standardised Process Parameters

33 batches of RVNRL were processed in the pilot plant with a view to standardise process parameters. Trials were carried out by varying the following conditions:

1. Quality of latex taken for irradiation.
2. Quantity of latex per batch.
3. Sensitisers and compounding.
4. Dose rate.
5. Irradiation atmosphere.

1. Quality of Latex

The physical properties of the RVNRL produced mainly depend on the quality of the latex irradiated. Studies revealed that a latex having very low VFA and high stability is best suited to produce good quality RVNRL. Moreover fresh latex is more suitable than aged latex.

2. Quantity of Latex per Batch

According to the observations made during trials of irradiation the quantity of latex taken in the product vessel has a profound effect in the radiation dose absorbed by the latex. In the exposed condition, the Cobalt-60 source unit occupies the centre of the product vessel and maximum dose absorption is noted when latex is taken to the full capacity (1000 Litres). Wastage of energy at various levels of loading the product vessel has been measured using gamma area monitor. Results are given in Table 1.

Table 1: Wastage of energy at various levels of loading

Quantity of latex in the product vessel	Wasted energy in terms of dose rate (microSievert per hour)
1. Empty product vessel	65-70
2. 600 litres of latex filled	20-25
3. 800 litres of latex filled	15-20
4. 1000 litres of latex filled	5-10

Hence the varying quantity of latex in the vessel, the final product will give different properties for the same period of irradiation. Therefore for maximum efficiency, the product vessel has to be charged with the full capacity.

3. Sensitisers and Final Compounding

The effect of various sensitisers at different doses were studied. On the basis of this, the most suitable sensitiser for RVNRL processing at the pilot plant was found to be 5 phr dose of n-butyl acrylate (n-BA) or a 2 phr dose of n-BA and carbon tetra chloride in the ratio 1:1. But the product manufacturers are reluctant to buy RVNRL processed using 5 phr n-BA due to the smell of n-BA. So a 2 phr dose of n-BA and ccl_4 in the ratio 1:1 is adopted for RVNRL processing at the pilot plant. The final compounding was tried at 55 drc and 58 drc.and got comparable resutls in both cases. As most of the products are made by dipping and since the present consumers are preferring a higher drc material, at pilot plant the final compounding is practiced at 58 drc.

4. Dose Rate Effect

At present the dose rate of RVNRL plant facility as on June 1996 is only 0.108 KGy per hour. So, for delivering 25 KGy, it requires nearly 232 hours of exposure. For processing one batch, nearly 15 days are needed when two shifts are planned per day.The results obtained for the processed latex are not fully satisfactory. This may be due to the low dose rate that ultimately results in long irradiation time required for processing RVNRL. For processing good quality RVNRL, definitely the processing time has to be reduced to such an extent that the processing will be completed within one or two days by continuous irradiation. This can be achieved only by increasing the dose rate by using a high activity Cobalt-60 source.

5. Irradiation Atmosphere

This factor has influence on determining the quality of RVNRL produced. The existing product vessel do not have much flexibility for irradiation under different conditions. The oxygen entrapped in the latex and in the empty space of the vessel is converted to ozone during irradiation. This ozone formed is likely to react with the latex which is under constant stirring during irradiation.

In the preliminary trials,the tensile properties were very poor since the vessel was frequently opened for collecting samples. Later some methods were adopted to prevent entry of air in the product vessel. The RVNRL thus processed has got superior properties. Moreover, when the processing is made continuous, it is seen that the physical properties are further improved. Hence it is expected that by complete replacement of air from the vessel by an inert gas like nitrogen, the tensile properties of the processed latex can be further improved.

Dose Estimation Procedure

1. Alanine Dosimetry and
2. Fricke Dosimetry.

Since alanine dosimetry measurement system is costly, fricke dosimetry is being used for the regular dosimetry studies.

Water was taken in the product vessel and the vessel was aligned in position. The dosimetric solution was filled in the irradiation vials ($4 \times 10^{-6} m^3$ glass tube with stopper) and are kept inside the product vessel at different positions and irradiated for 60 minutes. Optical density with respect to unirradiated fricke solution was measured using the spectrophotometer and the absorbed dose was calculated. The values are given in Table 2.

Table 2: Optical density with respect to unirradiated fricke solution

Sl. No.	Distance from top of the product vessel	Measurement positions	Absorbed dose rate (KGy/hour)
1.	0.315 m	Top	0.050
2.	0.473 m		0.057
3.	0.630 m	Middle	0.160
4.	0.788 m		0.205
5.	0.945 m	Bottom	0.089
6.	1.200 m		0.111

Note: Date of measurement - 14/3/1996
Product vessel - 1.2m dia X 1.2m height
Average dose rate = 0.112 KGy/hour.

So the calculated average dose rate inside the product vessel is found to be 0.112 KGy/hour as on 14/3/96. Using this value the irradiation time required to deliver 25 KGy to rubber latex is 223 hours.

Fields of Application of RVNRL Produced

From 1992 to 1995, 33 batches of RVNRL were produced. Since the source strength of the facility is low and medium of irradiation is not free from air, the RVNRL produced was not having properties comparable to that of conventionally pre-vulcanised latex. Yet the RVNRL processed in all the batches was accepted by the product manufacturers for producing following types of dipped goods.

Table 3: The production of RVNRL and its consumption in different product manufacturing applications from 1992 to 1995.

Sl No.	Year	Quantity.produced in litres	Consumption in %			
			Gloves (household & industrial)	Nipples	Toy baloons	Tubes
1.	1992	7000	60	27	13	
2.	1993	13000	46	39	15	
3.	1994	4000	92	6	2	
4.	1995	6000	60	15	23	2

Discussions with the RVNRL consumers showed that the products manufactured with it have the following merits and demerits.

Merits

1. Better product acceptability by the consumers.
2. Better clarity of the products.
3. Lower modulus.
4. Simple process.
5. Less man power during production
6. Lower ash content
7. Lower latex viscosity .
8. Better latex stability.

Demerits

1. Inferior ageing property.
2. Low tensile strength.
3. High set.

CONCLUSION

RVNRL can find applications in the field of surgical and examination gloves, catheters, baloons, pharmaceutical tubings etc. The RVNRL pilot plant at Rubber Board, India can be effectively utilized by modifying the existing product vessel and enhancing the source strength.

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