APPLICATION OF RADIATION VULCANIZED NATURAL RUBBER LATEX IN INDONESIA

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ABSTRACRT

The center has carried out R&D of Radiation Vulcanization Natural Rubber Latex (RVNRL) technology and introduced it to the industries since the inauguration and operation of the latex pilot plant in 1983. After years of experiences and the environmental consideration, n-butylacrylate (n-BA) has replaced CCl_4 as the sensitizer. Until now the introduction program shows that radiation vulcanized latex is more suitable for home industries than large industries. The obstacle of the program is the marketing of the dipped products. In spite of these problems, the introduction of this technology to the people in some undeveloped area of Java has supported the national program to improve their living standard. The problems of nitrosamine and protein allergic have turn up RVNRL to be the substitute of sulfur vulcanized latex in the future. The cooperation with a national condom manufacturer (PT. Mitra Banjaran) has applied RVNRL for condom production in the large scale. Soft condoms with less probability of pinhole are obtained, but the technical problem is stickiness after pilling. Supply to a baby teat and a rubber thread manufacturer offers great advantages by not using any chemicals. In spite of the advantages, the problem of latex viscosity for dipping and the low modulus of elasticity of the threads arise. Through those input CAIR-BATAN is conducting the research and development in improving the crosslinking among the rubber particles that are supposed to be the reason of the stickiness and low modulus of elasticity. This effort is expected to be able to broaden the application of RVNRL, and it will be achieved only by the involvement of rubber chemist, rubber technologist, and radiation chemist.

INTRODUCTION

Indonesia has started the study on Radiation Vulcanization of Natural Rubber Latex (RVNRL) as early as 1970. The operation of the 215 kCi latex irradiator in 1983 has made CAIR-BATAN the pioneer of RVNRL among the RCA member countries. Since its operation, this facility has become a training center for the member countries attended by national and international research institutes as well as the private sectors. However, the research and development of the technology were carried out by each member country (Makuuchi 1990).

Along with the improvement of the radiation technique, introduction of RVNRL technology to the related industries has been carried out. Development of new sensitizer and the stringent environmental regulation have shifted CCl_4 as the main sensitizer. Since 1993, n-butylacrylate (n-BA) is the only sensitizer in RVNRL technology in Indonesia. In spite of the promising technique, the introduction to the industries faces many problems, especially in the large scale industries. Those problems are not just the economic consideration, but also the technical problems arise due to the changing of process.

This paper describes the experiences and the recent R&D program carried out at CAIR-BATAN to improve the transfer to the industries.

DEVELOPMENT OF SENSITIZER

Chlorinated hydrocarbon, specially CCl_4 was the first common sensitizer in developing RVNRL (Minoura and Asao 1961). In spite of its efficiency, this compound is not accepted under the health aspects. New sensitizers have been developed in effort to reduce or totally replace this sensitizer. Acrylic compounds were the candidates therefore. The development of acrylic sensitizers as single compounds or combination with other compounds has been reported at the first symposium in Tokyo (1990).

In order to reduce the concentration of CCl_4 in the pilot plant operation, a combination of n-BA with CCl_4 (1 phr/1 phr) was used (Yanti and Sundardi 1988). Irradiation dose of 20 to 30 kGy gave the maximum tensile at break (Tb) and good aging properties of the rubber film. For several years this sensitizer was applied in the RVRNL that were supplied to the industries at that time.

Considering our intention to promote more intensively RVNRL as well as the health consideration, n-BA was the only sensitizer in the RVNRL technology since 1993. This monomer is available in the local market, and the stabilization of several local concentrate latex against this monomer has been evaluated.

The standard concentration of n-BA until now is 2 phr (part per hundred rubber), and the latex is stabilized with 0.2 phr KOH. The analysis of residue showed that n-BA disappeared in 2 weeks after irradiation.

APPLICATION OF RVNRL

The introduction of RVNRL to the industries of latex dipped product such as rubber gloves, condoms, rubber thread manufacturer, etc. was initiated in 1985.

Rubber gloves industries

This technology was introduced mainly to technical rubber gloves manufacturer which were mostly home industries. The purpose was to raise the rubber gloves production to meet the local demand. Since they were mostly home industries, this sector was very weak. The quality of the gloves produced in the laboratory scale have meet the consumer's standard. However, when it was transferred to this sector, their products were very difficult to meet the consumer's standard due to the lack of dipping skill.

Unlike technical rubber gloves, rubber examination and rubber surgical gloves' manufacturers were large industries. A trial production has been carried out under the cooperation with a manufacturer. The products have met the Indonesian Standard Industry (SII), but the technical problems for producing dipped goods and the market situation were the problems of the introduction to this sector.

The above situation indicates that the problems are not the irradiated latex, but they are more on the technical problem in producing dipped products and the market situation. The same problems are faced if conventional vulcanized latex is used. The competition of the price and quality with the imported products are very tough.

Condoms

The study in using RVNRL for condom production has been carried out in the laboratory and factory scale. While the products have met the BSI and JIS standard in the laboratory scale, the product of the first trial at PT Mitra Banjaran, Bandung in 1987 were totally rejected due to stickiness. After some improvement of the processing, better quality (10% reject) condoms were obtained at the second trial in 1990. The latex was irradiated by using n-BA/CCl_4 sensitizer with a total absorbed dose of 25 kGy.

Table 1 showed the specification and physical properties of the products including those obtained from sulfur vulcanized (SVNRL) one (Sundardi 1990).

Table 1: Specification and physical properties of the condoms

		RVNRL	**SVNRL**	**ISO 4074 (1992)**
Specification :	thickness (mm)	0.066	0.061	0.045-0.075
Phys. properties :	M 300% (MPa)	1.01	1.64	-
	M 600% (MPa)	2.42	5.68	-
	Tb (MPa)	22.06	30.59	min 17.0
	Eb (%)	970	840	min 700
	Bursting vol. (liter)	42	35	min 13.5 (depends on the diameter)
	Color	milky white	milky white	-

Condoms made from RVNRL have lower modulus, higher elongation at break (Eb) and bursting volume than those made from SVNRL. However, the tensile at break (Tb) were lower due to the less crosslink density.

During the laboratory scale the condoms did not stick each other after pilling and drying. However, this problem arose in the factory scale due to the technique of production. To overcome this problem, antistick agent has been added in the rinsing water. Two kinds of commercial soaps have been selected as the antistick agent.

The production of concentrated latex that meets the requirement of condom production decline with the time, whereas the world demand increases. Therefore the R&D for the condom production has become more intensive in the last 2 years. In the cooperation with the R&D group of PT Mitra Banjaran, we carried out the specification of NR latex for the condom production.

Table 2 shows the specification of both concentrated and the irradiated latex. Most of the field latex in Indonesia has relatively high magnesium content. The latex used in the experiments were those after DPA (diammonium phosphate) treatment to reduce the magnesium content.

The radiation vulcanized latex is suitable for condom production, since the specification is in the range of the standard latex for condom. Degradation of proteins by irradiation is assumed to have increased the VFA number.

The interest in the RVNRL as a promising material for condom production has turns up the company and the center to sign a memorandum of understanding in developing this technique. By using RVNRL a chemical free and energy saving process, less probability of pinhole can be obtained so that the products are expected to meet the standard and also the export qualification. The products are free of nitrosamine and protein allergic, because the protein has been destroyed by irradiation.

Table 2: Specification of the concentrated latex (HA) and RVNRL for condom production.

	Non irrad. Latex *) (HA)	RVNRL**)	Standard for Condom
Total Solid Content (%)	61.44	53.79	min 61.50
Dry Rubber Content (%)	60.18	52.04	min 60.50
TSC - DRC (%)	1.26	1.75	1.3 -1.5
NH_3 content (%)	1.8	not determined	1 - 2
Volatile Fatty Acid	0.0176	0.0510	max 0.02
Viscosity (cp)	115.2	70.4	max 120
Mechanical Stability Time (sec)	1790	2820	1600 - 1800
Magnesium content (%)	0.0124	not determined	max 0.005

*) obtained from Jalupang plantation, West Java (tapped during the dry season)
**) 2 phr n-BA, 0.2 phr KOH, 35 kGy

Other industries

Unlike the rubber gloves' industries, other small home industries of dipping goods show more interest in the application of RVNRL. The simple processing and cheaper production cost are the reason for using RVNRL. Those industries are decorated balloons, finger gloves for electrical industries, and a movie industry. For these industries, the center is the RVNRL supplier, and as the consequence therefore it must be able to supply the latex regularly to those companies.

The consumption of the balloon manufacturer was highest among those industries (100 kg/month) at that time. However, this manufacturer stopped its consumption after 7 years due to the market situation. The finger gloves manufacturer consumes less than 50 kg/month, but the center still continuously supplies until now (about 10 years). The movie industry occasionally consumes the latex for making mask, artificial animals, part of human body, etc.

The most regular consumer is a factory producing sealing for cans. This factory's consumption gradually increases from 20 kg/month to 1.5 tons/month within 9 years. The products have supplied the local demand for can sealing. Since 1989, the company itself brings the latex to be irradiated at the center.

So far the evaluation shows that RVNRL is more suitable for small industries with simple or manual processing. Moreover, it gives higher added value to the products, because of the chemical free process and less energy consumption. To apply RVNRL in the large industries such as examination, surgical gloves, and condom factories, modification of the process must be done. For some products the dipping process may need a modification due to the low viscosity of the latex. Any heating during the process must be controlled, because RVNRL does not need high temperature for processing.

More recently we have introduced RVNRL to a baby teat manufacturer in Surabaya, East Java. They produce teats of natural and synthetic rubbers, and the products are mostly for local consumption and partly for export to neighboring countries. Since May 1996 we have sent 3 tons of RVNRL in two batches. They are satisfied with the trial production, but the complain about the process. Unlike SVNRL, RVNRL needs twice as much dipping. Instead of the dipping problem, they have been able to reduce the temperature for drying and get better clarity of the products. They are able to develop a new process to produce the teats from RVNRL. The application of RVNRL by this manufacturer will significantly suppress the nitrosamine content of the products and protein allergic that means high added value of the products.

RECENT R&D TO SUPPORT THE APPLICATION OF RVNRL

The introduction of RVNRL technology to those home industries must be supported by continuous research. The purpose of the research is not only helping the industries to solve their problems, but also to develop new techniques that can be offered in the future.

The low modulus given by RVNRL is one of the merit of this technology in dipping process, because it gives convenience for surgical gloves, condom, baby teats, and balloons. This low modulus is due to low crosslink density. However, low crosslink density results in low tensile strength that is not preferred for surgical gloves, and decorated balloons quickly deflate after blown up. Low crosslink density is also supposed to be the reason of stickiness of the condoms.

All these input have urged us to try to improve the crosslink density. As it has been reported at the previous symposium in Tokyo that high tensile strength of the rubber film will be obtained after irradiation only if the green strength of the latex is high. The latex we use has very low green strength. In order to increase the crosslink density, hydroperoxide or tert-butylperoxide has been added into the latex. The concentration of either peroxide is 0.2 phr, and it is added either before or after irradiation. It is expected that the green strength can be increased before irradiation through peroxidation. The increase of tensile strength is also expected by peroxidation after irradiation through heat treatment of the film.

Blending of RVNRL with latex-g-PMMA is carried out to produce rubber threads. The purpose of blending is to improve the modulus elasticity of the thread. A previous research showed that blending of RVNRL/SVNRL (1/1) produced good quality thread (Utama 1986, Utama and Kusumawati 1991). Since we are going to avoid nitrosamine and protein allergic problems, it has been changed to MMA grafted latex (irradiation grafting). The research is still going on under the cooperation with a national thread company. The results are also presented in this symposium.

We are convinced that RVNRL will be a candidate in the rubber industries in the future. Clean processing is expected, and competition in the international market will force our products to meet the international standard ISO. In order to turn up the role of RVNRL, the radiation technique as well as the RVNRL technology must be improved. We have to concern seriously about the scientific as well as the economical aspects to be able to convince the industries. For this purpose the cooperation of radiation chemist, rubber chemist, and rubber technologist is needed. Through this cooperation, it is expected that the above problems faced by the industries can be solved.

THE IMPACT OF RVNRL TECHNOLOGY ON THE NATIONAL PROGRAM

In spite of those problems, in the past 3 years the institute has offered this technology in participating at the national program to improve the living standard of people in the undeveloped area. The people in that area were trained to produce dipped goods such as gloves, balloon toys, and finger coats either to supply their own needs or their neighboring area. The success of the program depends on each community, those who understand technology are easily stimulated, but those without technology just absorb the knowledge of the training. One example of the success is that a small company in Jakarta (PT. Indrasari) is willing to be a main distributor of the dipped products for a nearby area. These products are consumed by the local cleaning service company, home industries, and the local people as decorating balloons.

The application of RVNRL in the medical rehabilitation is also studied. The price of RVNRL is much cheaper than the silicone rubber for artificial part of human body. It is expected through this technology the low income community can be supported.

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QUESTIONS & ANSWERS, and COMMENTS

Session III

Q1	Thomas	What is the cause of stickiness in RVNRL films?
A1	**Yanti Soebianto**	**The incidence of stickiness occurred when hydrogen peroxide is used as the co-sensitiser which promotes degradation of rubber.**
Q2	Bez	Is it possible to make foam products from RVNRL? This is not possible with SPVL due to instability of the foam.
A2	**Marga Utama**	**The MST of latex needs to be reduced to 500 seconds to make foam products from RVNRL.**
C3	**Thomas**	**Low modulus RVNRL would be unsuitable for the production of foam products.**
	Shukri A. Wahab	**It could be used for products such as inner soles of shoes.**
Q4	Tan	Are the dipping parameters for RVNRL similar to that of SPVL?
A4	**Wan Manshol**	**The dipping parameters are somewhat similar needing only minor modifications.**
Q5.	Ken	What is the most suitable antioxidant for RVNRL?
A5	**Wan Manshol**	**I cannot reveal at the moment.**