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Role of Surface Active Agents to Prevent Coagulation of Natural Rubber Latex Against The Addition of n-Butyl Acrylate

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ROLE OF SURFACE ACTIVE AGENTS TO PREVENT COAGULATION OF NATURAL RUBBER LATEX AGAINST THE ADDITION OF n-BUTYL ACRYLATE

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ABSTRACT

The stability of natural rubber latex against the addition of n-butyl acrylate was determined. The effects of surface active agents, ammonium laurate and commercial powder soap on the prevention of coagulation of natural rubber latex were investigated. Both the surface active agents are effective in preventing coagulation of the latex.

INTRODUCTION

The radiation vulcanization of natural rubber latex has been investigated for several decades. Vulcanization of natural rubber latex by radiation can be carried out without any sensitizer [1]. But to reduce the radiation dose for vulcanization various kinds of sensitizers are used. It is reported that halogenated hydrocarbons can be used as sensitizers for irradiation to reduce the dose to a considerable extent [2-4]. But for environmental considerations a sensitizer like carbon tetrachloride should be avoided.

Polyfunctional monomers (diacrylates) were used as sensitizers by some authors [5-7]. The skin irritating property of the diacrylates has led researchers to seek new sensitizers. In this context, monofunctional acrylates were shown to be the effective sensitizers for vulcanization. In this category, 2-ethylhexyl acrylate has very bad smell and n-butyl acrylate (n-BA) tends to destabilize the latex [8]. The effect of sensitizers on the stability of latex and the influence of radiation dose, dose rate on the mechanical properties of the latex film were discussed by several authors [9-13]. To overcome the problem of destabilization of latex due to the addition of sensitizer, various stabilizing agents were investigated among which potassium hydroxide was seemed to be particularly effective [14]. In this paper the role of surface active agents, ammonium laurate and commercially available powder soap were evaluated by observing their effects on the coagulation of latex caused by the addition of n-BA.

MATERIALS AND METHODS

Natural rubber latex was collected from Satgaon Rubber Estate, Sylhet, Bangladesh. The clone of the latex is RRIM-600. The rubber trees were planted in 1983. The field latex was preserved with ammonia and concentrated by centrifuging the latex by means of a laboratory scale centrifuge, SPL-100, Saito Separator Ltd., Japan. The latex was then mixed with aqueous ammonia solution to make it a high ammonia latex.

Ammonium laurate and commercially available powder soap were used as stabilizing agents. Ammonium laurate was prepared by mixing aqueous ammonia solution (5%) with lauric acid obtained from Fluka, Switzerland. Commercially available powder soap was obtained from Kohinoor Product, Bangladesh. n-BA from Kanto Chemical Co. Inc., Japan, was used as sensitizer. The emulsions of sensitizer were prepared by mixing the sensitizer with the stabilizing agent for 1 hour. The emulsions were then added to the latex at various concentrations and stirred for 1 hour.

The total solids content (ISO 124), dry rubber content (ISO 126), alkalinity (ISO 125), mechanical stability (ISO 35), coagulum content (ISO 706), volatile fatty acid number (ISO 506), potassium hydroxide number (ISO 127), sludge content (ISO 2005), copper content (ISO/R 1654), manganese content (ISO 1655) were determined following ISO methods. Viscosity was measured at 25°C and 10 rpm by Visconic ELD. R, Tokimec Inc., Japan, connected with viscometer controller, E-200, Toki Sangyo Co. Ltd., Japan. Mechanical stability was measured by a natural rubber latices mechanical stability apparatus, TO B. S. 1672: 1972, Klaxon Signal Ltd., England. Metals were determined by UV-visible spectrophotometer, SP 8-100, Pye Unicam, England.

The latex was irradiated for a total dose of 15 kGy at the dose rate of 10 kGy/h by Co-60 γ-ray source at room temperature (25-30°C). The irradiated latex was cast on raised rimmed glass plates for making rubber film. The film was air dried until transparent. They were leached in water for 24 hours at room temperature and then again air dried until transparent. They were then heated at 100°C for 1 hour. Tensile properties were measured by INSTRON, 1101, testing machine, England, using dumbbell shaped test pieces of the rubber film.

RESULTS AND DISCUSSION

The natural rubber latexes are concentrated, preserved and vulcanized for manufacturing goods for various kinds of usage. The commercially available latexes are not always suitable for radiation vulcanization due to their low stability to sensitizer for radiation. To stabilize the latex against the addition of n-BA, surface active agents were added to the latex in varying quantities. Table 1 shows the physico-chemical properties of the latex used for this investigation. The total solids content was adjusted to 52% by diluting with aqueous ammonia solution. All other properties are fully consistent with the values as required by ISO 2004 (1974) for centrifuged latex concentrate.

TABLE 1

Physico-chemical properties of the latex.

Total solids content, (%)	52.00
Dry rubber content, (%)	50.44
Non-rubber content, (%)	1.56
Alkalinity as ammonia, (wt. % on latex)	0.90
Mechanical stability, (s)	1180.00
Volatile fatty acid number	0.021
Potassium hydroxide number	0.75
Copper content, (mg/kg solid)	0.50
Manganese content, (mg/kg solid)	1.25
Sludge content, (%)	0.005
Coagulum content, (%)	0.015
Viscosity, (mPa.s)	30.25

Table 2 shows the change of viscosity of the latex after various storage times by adding different quantities of n-BA. It is seen from this table that the viscosity increases with the addition of increased amount of n-BA. Without n-BA the viscosity of the latex is ~30 mPa.s. It is about 48 mPa.s when 5 phr n-BA is added and the latex coagulates immediately after the addition of 8 phr n-BA. After the addition of varying quantity of n-BA, the viscosity of the latex was measured at one week intervals.

It was found that viscosity increases with increasing storage time. It is remarkable that the viscosity of the latex with n-BA increases more rapidly than that of the latex without n-BA. For radiation vulcanization of natural rubber latex 5 phr concentration of n-BA is supposed to be the optimum concentration. So the viscosity change of the latex with this concentration of n-BA is important

TABLE 2

Viscosity of latex at different storage times with different quantities of n-BA.

Quantity of	Viscosity [mPa.s] at					
n-BA, (phr)	1st week	2nd week	3rd week	4th week	5th week	6th week
0	30.25	32.19	35.13	32.14	30.40	30.28
4	37.74	39.04	48.38	49.68	54.40	50.54
5	47.80	52.14	52.26	54.02	58.92	57.66
6	54.72	77.88	77.52	70.02	65.42	70.76
7	89.34	102.00	Coagulated			
8	Coagulated					

phr = "per hundred rubber" which can be defined as the percentage of the total amount of rubber content in the latex. If it is expressed in wt.% then total amount of rubber content in gram/100.

for practical application. It is found that with this concentration of n-BA, the change of viscosity with storage time is not as great up to at least 6 weeks as found with other concentrations of n-BA.

In view of this practical use the stability of latex with 5 phr n-BA was tried to increase by adding surface active agents which are assumed to be the preventive for coagulation of the latex. Table 3 shows the effect of different concentrations of ammonium laurate on the viscosity of latex mixed with 5 phr n-BA. It is evident from this table that the viscosity decreases with the increased concentration of ammonium laurate and it becomes lowest at 5 phr concentration of ammonium laurate. On further increase of concentration of ammonium laurate the viscosity remains almost unchanged (38.28 ± 0.24 mPa.s).

So 5 phr ammonium laurate seems to be optimum concentration to reduce viscosity at a suitable stage. When the latex was stored with the laurate the viscosity change was also noticeable. However the change of viscosity with this

TABLE 3

Viscosity of latex mixed with ammonium laurate at various storage times.

Quantity of NH_4-laurate [phr]	Viscosity [mPa.s] at					
	1st week	2nd week	3rd week	4th week	5th week	6th week
0	47.80	52.14	52.26	54.02	58.92	57.66
1	45.68	45.72	45.24	45.18	50.30	55.56
3	43.68	45.60	44.12	43.84	38.12	47.54
5	38.52	37.78	39.02	37.70	36.44	45.84
10	38.16	38.46	41.90	37.58	35.60	45.36
15	38.04	38.22	37.28	36.98	34.58	44.52

optimum concentration of ammonium laurate is very slow and after 6 weeks the increment is not too high (from 38.52 to 45.84 mPa.s).

Table 4 shows the effect of commercially available powder soap which is normally used as detergent. It is seen that with increased concentration of this soap the viscosity of the latex containing 5 phr n-BA decreases and it becomes almost constant (37.89 ± 0.09 mPa.s) when the concentration of soap solution reaches to $\geq$ 0.25%. The viscosity was also measured after various storage times. The viscosity with the soap concentration of 0.25% or more remains more or less same (37.98 ± 1.52 mPa.s) after different storage times. So this agent is very useful for stabilizing the latex for at least 6 weeks (experimental time). This is very cheap and easy to use. The effect is similar to that of ammonium laurate; moreover very small amount of this agent is needed.

Table 5 shows the tensile properties of the films made from the latexes having 5 phr n-BA and mixed with 5 phr ammonium laurate and 0.25% soap solution separately, after storage for different lengths of time. It is evident

TABLE 4

Viscosity of latex mixed with powder soap at various storage times.

Quantity of soap, [%]*	Viscosity [mPa.s] at					
	1st week	2nd week	3rd week	4th week	5th week	6th week
0	47.80	52.14	52.26	54.02	58.92	57.66
0.1	42.26	47.17	48.34	50.74	52.62	52.80
0.25	37.80	38.10	36.46	38.54	39.50	38.52
0.5	37.80	43.04	39.12	38.68	38.20	40.54
0.75	37.98	43.14	37.62	38.86	36.22	34.38

*Based on weight of latex

TABLE 5

Tensile properties of the films prepared from the latexes mixed with NH_4-laurate and powder soap after storing for various lengths of time period.

Storage time, [week]	Tensile strength, [MPa]		Elongation at break, [%]	
	NH_4-laurate	Soap	NH_4-laurate	Soap
0	31.17	30.16	950	1000
1	32.25	31.28	900	950
2	31.31	30.36	950	1000
3	30.70	29.68	995	987
4	31.12	31.45	950	1000
5	29.83	31.53	900	950
6	30.25	30.78	950	1000

that the tensile strength (31.04 ± 1.21 MPa & 30.61 ± 0.92 MPa with ammonium laurate and commercial soap respectively) and elongation at break (947.5 ± 47.5% and 975 ± 25% for ammonium laurate and commercial soap respectively) of these films have almost same values although they are irradiated after storing the latex for different time periods.

If a comparison is made between the two agents it is seen that both the agents have the same effect on the stabilization of the latex. However, the amount needed for stabilization varies. The amount of commercially available powder soap needed for stabilizing the latex is about ten times smaller than that of the ammonium laurate. Moreover it is cheaper than laurate and can be used as obtained in the market. Both of the agents have no influence on vulcanization i.e., they do not suppress or promote the cross linking reaction. Experiments on tensile properties show that the values for tensile strength and elongation at break are similar to the film prepared from the latex which is vulcanized without these agents.

From these observations a remark can be made. By using this surface active agents the latexes as well as the films made from these latexes remain stable for considerable time periods. This is very important for radiation vulcanization of natural rubber latex.

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