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Room temperature prevulcanized NR latex compounds

FOR BETTER LATEX-BASED PRODUCTS

Products such as balloons, industrial gloves, rubber bands, etc produced from room temperature prevulcanized natural rubber (NR) latex show better clarity, colour and technological proper-ties than those made from conventional prevulcanized samples

Abstract: *Room temperature prevulcanized natural rubber latex prepared by a combination of accelerator systems was investigated with Zinc diethyl dithiocarbamate/ Zinc dibutyl dithiocarbamate/ Sodium dibutyl dithiocarbamate/ Zinc isopropyl xanthate/ Zinc 2-mercaptobenzothiazole (ZDEC/ZDBC/ SDBC/ZIX /ZMBT). The colloidal stability and mechanical properties of the room temperature prevulcanized latex compound was investigated. The mechanical properties of prevulcanized latex compound was compared with that of a ZDEC system using heating method 60°C for 4h. The first combination of room temperature system using ZDEC ZDBC/ZMBT (RT1), second ZDEC/ZIX ZMBT (RT2) and third ZDEC/SDBC/ZMB (RT3). The test results showed that RT1, RT2, and RT3 can bring about prevulcanization at room temperature. The latex film prepared from the room temperature prevulcanized latex compound gives better clarity than conventional prevulcanized samples.*

Key words: *accelerator; crosslinking; swelling; compounding; prevulcanization*

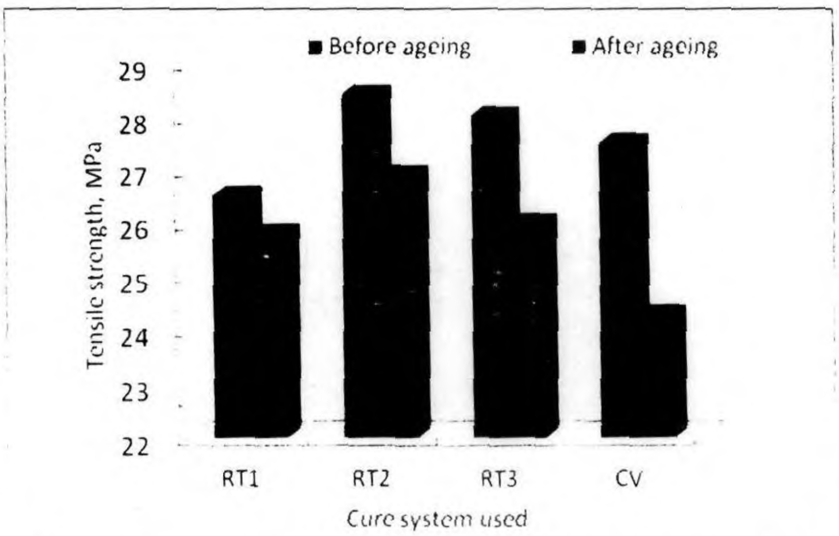


Figure 1. Variations of tensile strength before and after ageing

Natural rubber latex compound can be vulcanized in the liquid state and then used to form a deposit of vulcanized rubber without further heating for cure, only drying is necessary [1,2]. When latex is vulcanized, it retains its original fluidity and general appearance [3]. Vulcanization takes place in the individual latex particles without altering their state of dispersion [4]. Room temperature prevulcanized latex compounds are convenient materials for the manufacture of latex goods, especially dipped goods [5]. They are also used in adhesives, textiles, carpet backing and casted rubber products. The products (gloves, rubber bands, balloons etc.) showed better clarity, colour and technological properties [6]. The cost involved in the use of room temperature prevulcanized latex are consequently lower than conventional prevulcanized latex products.

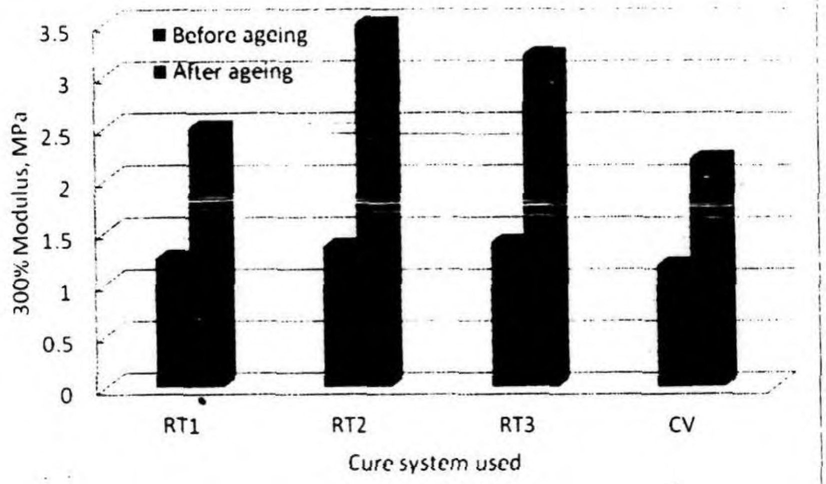


Figure2. Variations of modulus before and after ageing

This work presents the details of the studies conducted on:

- Prevulcanization of natural rubber latex compounds under room temperature using the systems RT1, RT2, RT3 and the conventional under heating system at 55°C 4 h (CV).
- Prepared casted films from RT1, RT2, RT3 and CV prevulcanized latex.
- The crosslink efficiency, colloidal stability and tensile properties of prevulcanized latex.

Experimental

Materials used

The specifications of the centrifuged natural rubber latex (high ammonia) type as per ASTM D 1076-2010) collected from Central Experiment Station, Rubber Board, Chethackal, Ranni, Kerala, are given in Table 1

The accelerators; Zinc diethyl dithiocarbamate, Zinc dibutyl dithiocarbamate, Zinc 2-mercaptobenzothiazole collected from M/s. Merchem Chemicals Limited, Cochin, and Sodium dibutyl dithiocarbamate, Zinc isopropyl xanthates collected from M/s. Robinsons Brothers Limited, Phoenix Street, West Bromwich, West Midlands, United Kingdom, B70 0AH, Sulphur, zinc oxide etc., commercial grades were used.

The equipment used in this study compried a prevulcanizer supplied by M/s Inlab Instruments, Kochi, India, Brookfield viscometer LVT model supplied by M/s Brookfield Engineering Laboratories Lnc. (Strongton, m A, the US), Universal tensile tester UTM Model 4411 (M/s Instron, Buckinghamshire, the UK), Mechanical stability apparatus (M/s Klaxon Signals, Birmingham, the UK).

Experimental procedure

The latex compounds were prepared as per formulation given in Table 2. The dispersions of the ingredients were added into centrifuged natural rubber latex conforming to ASTM D 1076-2010). The conventional prevulcanization conducted under heating system at 55°C for 4 hours in the prevulcanizer. Constant stirring of the latex compounds were maintained through

Table 1
Properties of centrifuged natural rubber

Properties	Value
Dry rubber content (% by mass)	60
Non rubber solids (% by mass)	1.0
Sludge content (% by mass)	0.04
Ammonia content (% by mass)	0.8
Potassium hydroxide number	0.5
Mechanical stability time (s)	1000
Volatile fatty acid number	0.01
Coagulum content (% by mass)	0.03
Copper content (ppm)	1
Manganese content	Traces

the course of prevulcanization and rapid cooling of prevulcanization was carried out to arrest further prevulcanization and was transferred to storage tanks for maturation for a period of 24hours. The room temperature compounds RT1, RT2, and RT3 were transferred to storage tanks and stirred for a period of 24 hours at 40 revolutions per minute at room temperature (28°C). Films were cast with samples. After drying, test pieces were taken from each sample film and tested for tensile properties according to ASTM D 3138.

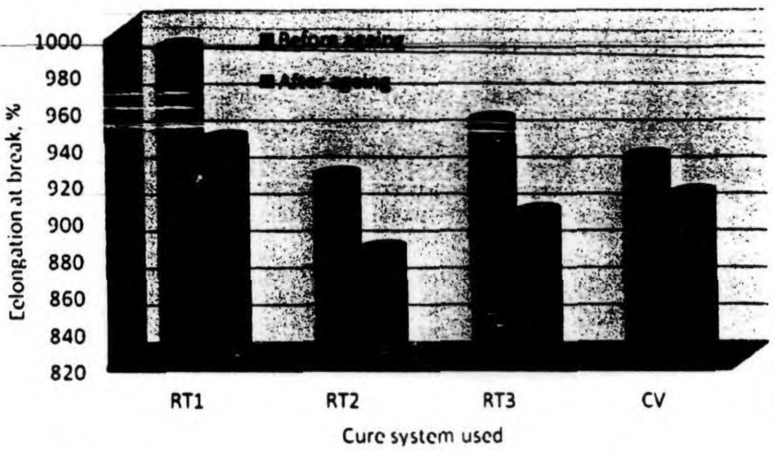


Figure 3. Variations of elongation at break before and after ageing

Table 2: Formulation of prevulcanized latex

Ingredients	Parts by wet weight			
	RT1	RT2	RT3	CV
60% Centrifuged natural rubber latex (HA)	167	167	167	167
10% Potassium oleate (aqueous solution))	0.5	0.5	0.5	0.5
10% Potassium hydroxide (aqueous solution))	2	2	2	2
50% ZDEC (dispersion)	0.9	1.2	0.9	1.71
50% ZDBC (dispersion)	0.8	0	0	0
40% SDBC (dispersion)	0	0	1.0	0
50% ZIX (dispersion)	0	0.5	0	0
50% ZMBT (dispersion)	0.01	0.01	0.01	0
50% Zinc oxide (dispersion)	0.3	0.3	0.3	0.3
50% Sulphur	2.2	2.2	2.2	2.2

ZDEC - Zinc diethyl dithiocarbamate
ZDBC- Zinc dibutyl dithiocarbamate
SDBC- Sodium dibutyl dithiocarbamate
ZIX- Zinc isopropyl xanthate
ZMBT Zinc 2-mercaptobenzothiazole

Swelling ratio (Q) of prevulcanized NR latex vulcanizates was determined by keeping 1g of the sample sheet immersed in toluene for 48 hours at 25°C. The sample was taken out and blotted quickly with filter paper and weighed. Q was calculated with the following formula: Q = 1 + (dl/d2) (W2/ WI) - (dl/d2), where W1 is the weight of film before immersion, W2 is the weight of the film after immersion, and dl and d2 are densities of rubber and toluene, respectively. The variation of the swelling ratio with the crosslink density for conventionally vulcanized natural rubber in toluene may be broadly described as follows: Unvulcanized (>15), lightly vulcanized (7- 15), moderately vulcanized (5-7), and fully vulcanized (<5).

The chloroform number test was performed through the coagulation of a sample of the latex via mixing with an equal volume of chloroform. After 2-3 min, the coagulum was examined and graded according to the texture of the coagulum. The chloroform number was expressed as follows: 1) unvulcanized, 2) lightly vulcanized, 3) moderately vulcanized, and 4) fully vulcanized.

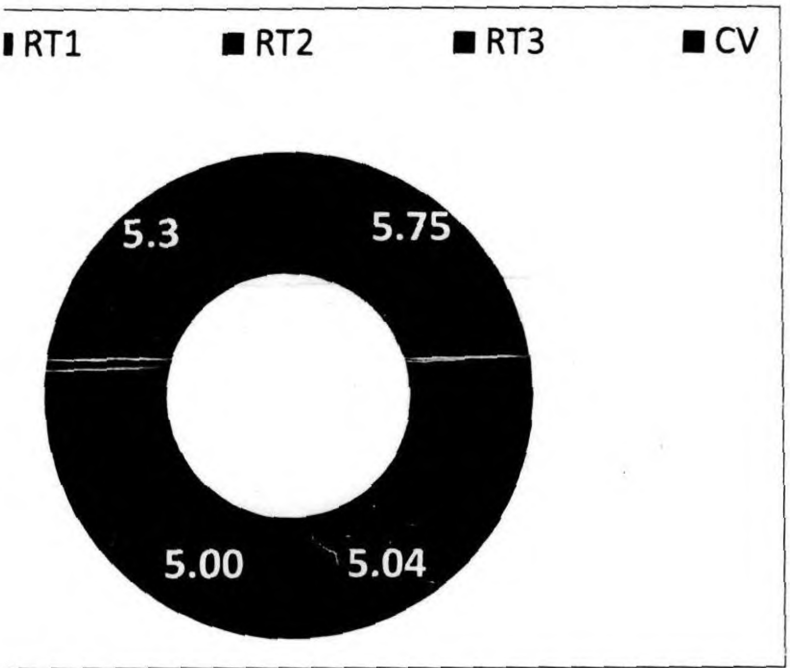
The chemical and physical properties of room temperature and conventional prevulcanized latex are given in Table 3.

Results and discussion

The mechanical stability time (MST) values shown in Table 3 are comparable with conventional method. The colloidal stability of the prevulcanized latex depends on many factors, such as the properties of the natural rubber latex, the amounts of potassium hydroxide and carboxylate soap added, the dosage of other vulcanizing ingredients, and prevulcanization conditions [7-9]. Brookfield viscosity, chloroform number, swell index, pH, total solids contents are given in Table 3.

The tensile properties before and after ageing of the prevulcanized latex RT1, RT2, RT3 and also that prepared from CV are given in Table 3. The results also show that the elongation at break decreased as swelling ratio decreases. The tensile strength (Figure 1),modulus (Figure 2 and Table 3) and elongation at break (Figure 3) in line with swelling ratio (Figure 4) and showed comparable with conventional heating prevulcanized latex films. According to Blackley et al., tensile strength, elongation at break, modulus, and swelling ratio are comparable due to the uniform crosslinking of rubber particles. [11]

Blackley and Merril [12,14] has reported that the tensile strength of films from pre-vulcanized natural rubber latex compounds depends on the ability of the particles to coalesce and integrate when the film dries and on the concentration of the crosslinks in the rubber.



ure 4. Variations of swelling ratio.

e 3: Properties of pre-vulcanized latex				
ile Properties before ageing	RT1	RT2	RT3	CV
ile strength, MPa	26.5	28.4	28	27.5
% Modulus, MPa	1.25	1.36	1.4	1.18
% Modulus, MPa	6.74	8.6	9.5	7.26
gation at break, %	990	920	950	930
;ile properties after ageing (70°C 10 days, hot air oven)				
ile strength, MPa	25.8	26.9	26.0	24.3
% Modulus, MPa	2.5	3.5	3.2	2.2
% Modulus, MPa	7.8	9.8	10.5	9.2
gation at break, %	940	880	900	910
	10.5	10.0	10.5	10.8
kfield viscosity, mPas	65	80	60	60
solids content, %	58.4	58.0	58.5	57.5
(s)	690	700	700	710
roform number	3	3	3	3
ling ratio	5.75	5.04	5.0	5.3

Conclusion

Room temperature prevulcanization of centrifuged natural rubber latex was done as per the combination of accelerators RT1, RT2, RT3 and also with a conventional pre-vulcanization under heating system. The results showed that the combination of accelerators can bring about prevulcanization at room temperature. Products such as balloons, industrial gloves, rubber bands, etc produced from room temperature prevulcanized latex showed better clarity, colour and technological properties. ■

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(This paper was presented at International Conference on Advances in Polymer Technology, Feb 25 & 26, 2016)