THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Effect of Processing Characteristics on Heat Sensitization of PVME Blended Natural Rubber Latex Compound

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Abstract:
This paper reports the results of a systematic investigation of the major processing characteristics which affect the heat-sensitization of natural rubber (NR) latex compound by polyvinyl methyl ether (PVME). Possible mechanisms for the heat-sensitization of aqueous lattices by water soluble polymers such as PVME are outlined, and observations concerning the behavior of PVME in high ammonia natural rubber latex compound and the effects of total solid content, former temperature, and dwell time are reported and discussed. Results for the effects of the variables listed above upon the heat-sensitization being a consequence of PVME adsorbed at the surface of the rubber particles at the cloud point temperature of PVME.

Keywords: *heat-sensitization, polyvinyl methyl ether, cloud point temperature, non-ionic stabilizer, adsorption*

1. Introduction

Natural rubber latex is found to yield from over 2000 species of plants on tapping. '*Hevea brasiliensis'* plant is the only one of commercial importance and accounts for 99% of World's NR production (Verheye, 2010). Preserved field latex can be concentrated in different methods like creaming, centrifuging, evaporation etc. These concentrated lattices are used for different product manufacturing techniques such as dipping, casting, extrusion etc. The properties of rubber latex make it an extremely versatile raw material for dipping and moulding processes. The ability of the rubber particles to coalesce and produce a coherent polymer film that is impermeable to water and air makes latex suitable for an extremely wide variety of products.

Most of the latex products available are prepared by the dipping process. There are different methods of dipping such as straight dipping; coagulant dipping and heat sensitized dipping. Heat sensitized dipping involves immersing a hot former in to a suitably heat sensitized latex compound (Blackley, 1997, vol. 3). Heat sensitization of NR latex can be imparted by zinc amine ions and hydrophilic polymers. Poly vinyl methyl ether (PVME) is a hydrophilic polymer with a cloud point in the range of 32-34^{0}C (Blackley, vol. 3, 1997 and Vladimir *et.al*., 2006).

Blackley, vol. 3,1997 and Ben, 2003 have been reported that heat sensitized NR latex by PVME can be used for the manufacture of a variety of latex products such as dipped products like teats, baby soothers, meteorological balloons, foamed carpet backing, extruded latex tubing etc. The advantage of heat sensitized dipping compared to usual dipping technique is higher thickness in a single dip. This reduces the problems related to delamination and labour. In heat sensitized dipping the latex compound is formulated so as to be heat sensitive and a deposit is allowed to form around the former by dipping a hot former into the latex compound. The degree of heat sensitization can be estimated by measuring the gelling time or the thickness of the deposit in heat sensitized dipping (Blackley, 1997, vol. 3). The thickness of the dry deposit formed will depend on a number of processing parameters such as rate of immersion, dwell time, temperature of the former, heat capacity of the former etc. including the compounding characteristics.

The literature survey on heat-sensitization of NR latex by PVME reveals that publications giving detailed investigation about the effect of different compounding parameters and processing parameters on heat sensitization are very limited. This work has been undertaken to standardise the effect of few processing parameters such as temperature of the mould, dwell time and total solid content of the compound on the heat sensitization of a typical natural rubber latex compound containing PVME.

2. Materials and Methods

2.1. Raw Materials

The raw materials used were 60% centrifuged latex conforming to BIS 5430-1981, Vulcastab VL a non-ionic stabilizer manufactured by M/s Alkali &Chemical corporation of India Ltd., Calcutta, the molecular formula is given below in (Fig. 1).

H $(C_2H_4O)_a$ $(C_3H_6O)_b$ OR

Figure 1: Vulcastab VL- Ethylene oxide and/or propylene oxide condensation product

Wherein R is selected from the group consisting of hydrogen and hydrocarbon chains having from 2 to 20 carbon atoms, 'a and b' are each from 0 to 35 and a+b is from 5 to 35.

Zinc dibutyl dithiocarbamate(ZDBC) an ultra-accelerator manufactured by M/s R.T. Vanderbilt Company Inc, USA, laboratory grade sulphur, ZnO and formaldehyde manufactured by EMERK Ltd, Mumbai and dispersing agent DispersolF manufactured by M/s ICI Ltd., Calcutta. The base ingredient of this study poly vinyl methyl Ether (PVME) was procured from M/s. BASF Ltd. Cheadle, UK. It was a water soluble synthetic polymer of the composition and its structure is given below

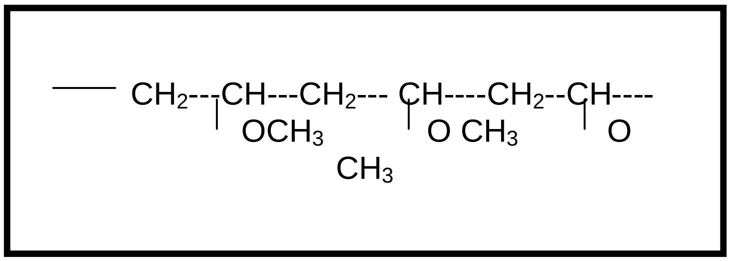

Figure 2: Chemical structure of PVME

2.2. Preparation of Latex Compounds

For preparing latex compound fifty per cent dispersion of sulphur, ZnO and ZDBC were prepared separately by grinding in a ball mill using Dispersol F as the dispersing agent. For the study an optimum latex compound was prepared. The prepared latex compound was kept for 24h maturation. Formulation of this compound is given in Table 1.

Sl. no	Ingredients	Parts by weight	
		Dry	Wet
1.	60% Centrifuged latex (HA)	100	167
2.	20% Vulcastab VL solution	0.75	3.75
3.	50% Sulphur dispersion	1	2
4.	50% ZnO dispersion	1	2
5.	50% ZDBC dispersion	1	2
6.	5% Formaldehyde solution	To pH 9	To pH 9
7.	10% PVME solution	1	10

Table 1: Formulation of the base latex compound used in the study

3. Experiment

The effect of processing variables on heat-sensitization of latex by PVME was studied with the compound given in Table 1. The processing parameters studied using the above latex compound were

i. Former temperature(60-100^{0}C)
ii. Dwell time (10- 60 sec)
iii. Total solid content of the latex compound (40-50%).

The dipping process was carried out using steel formers at 60 to 100^{0}C giving a dwell time of 10- 60 sec. Thicknesses of the films were measured using digital micrometre. The effects on different processing parameters on heat sensitization were represented as graphs in (Figs 4 to 6).

4. Results and Discussion

A general aspect of Poly vinyl methyl ether as a heat sensitizer is explained below.

Only a small amount of PVME (1-2phr) required to impart significant heat sensitivity to ammonia preserved natural rubber latex (Cockbain, 1956). The increase in thickness may be due to the fact that when the PVME was added in to the latex, which was adsorbed on the surface of the rubber particle, but when sufficient amount capable of producing heat sensitivity has been adsorbed, further increase in PVME has no effect. The effect of PVME on natural rubber in a latex compound are schematically represented in the ((Fig. 3) given below

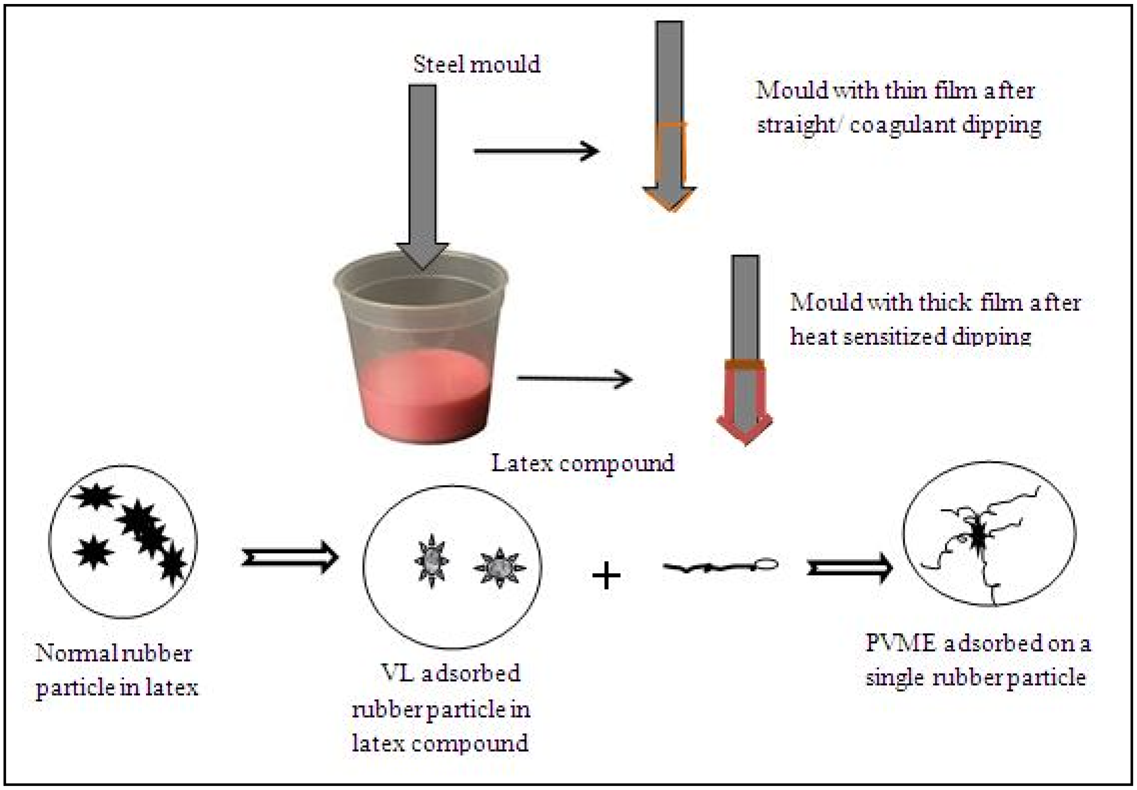

Figure 3: Schematic representation of the effect of PVME on a natural rubber particle in the latex compound

4.1. Effect of Processing Parameters

4.1.1. Former Temperature

From the (Fig.4) it was clear that as the mould temperature increased the thickness of the deposit also increased. This may be because of the higher the mould temperature, higher the opportunities for heat transfer occur from the former to the latex compound. Gelation of the latex initially occurs in the region where the temperature has just reached the cloud point transition in aqueous solution.

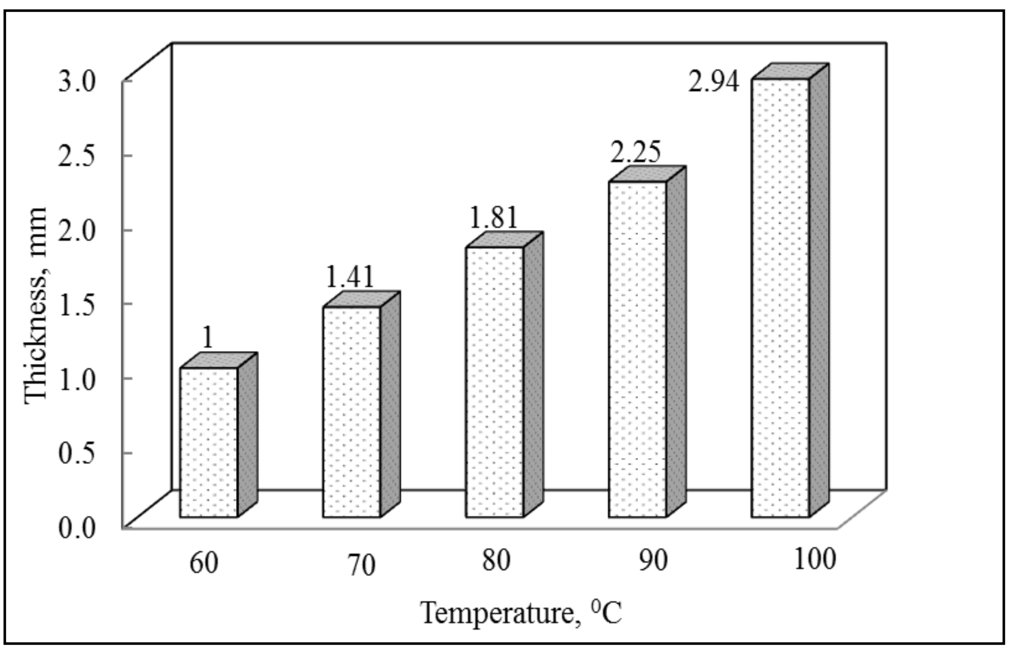

Figure 4: Effect of former temperature on heat sensitization of latex compound

As the heat continuous to transfer from former to latex, so this region moves out wards from the former and the thickness of the gelled deposit increases. This may be due to the temperature-responding polymers present a fine hydrophobic-hydrophilic balance in their structure, and small temperature changes around the critical temperature, make the chains to collapse or to expand responding to the new adjustments of the hydrophobic and hydrophilic interactions between the polymeric chains and the aqueous media (Aguilar et al, 2007).

4.1.2. Dwell Time

In the Fig. 5 illustrated that as the dwell time increased the thickness of the deposit increased to a particular level and remained constant. It was reported by T.D.Pendle in 1995. During dwell period the heat transferred from the hot former to the latex compound and consequently gelation occurred.

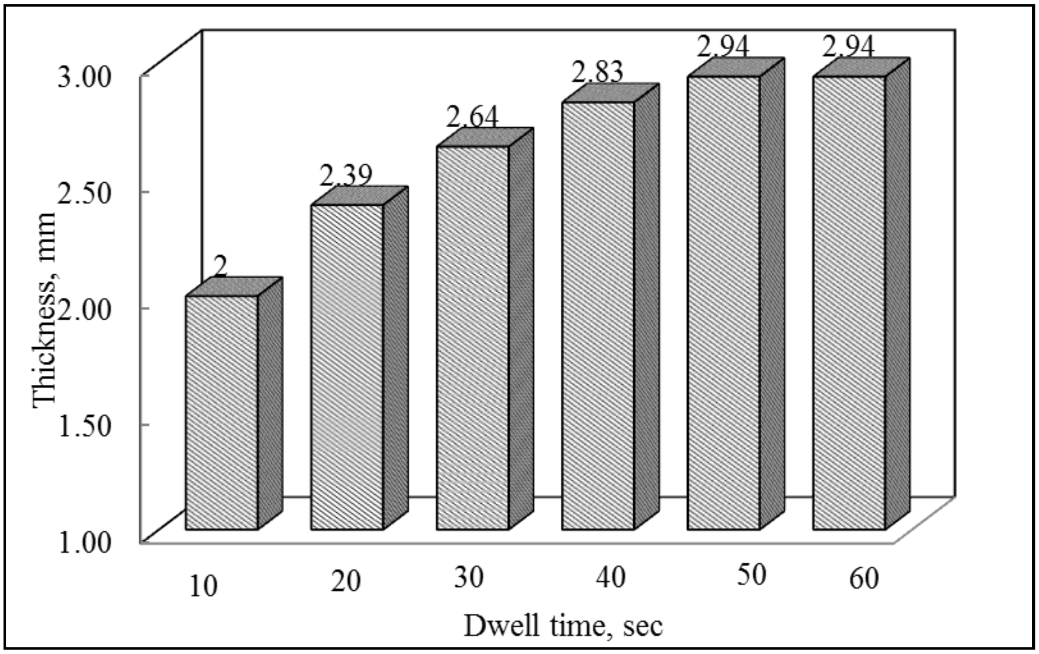

Figure 5: Effect of dwell time on heat sensitization of latex compound

4.1.3. Total Solid Content

From the (Fig. 6) as the total solid content was reduced, thickness also decreased. Maximum thickness of 2.94mm was obtained at a total solid content of 50%.

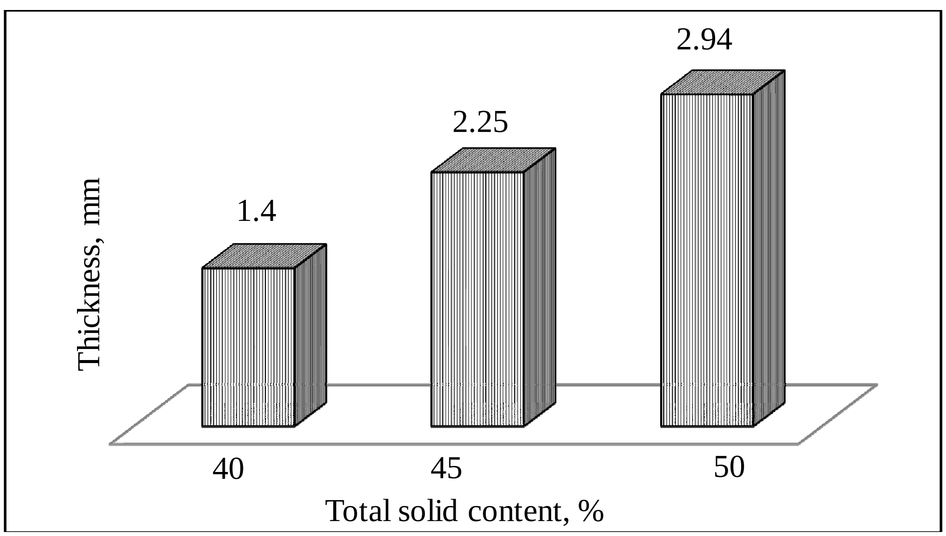

Figure 6: Effect of total solid content on heat sensitization of latex compound

4.2. Storage Stability of the Standardised Compounds

From the Table 2 it was observed that on storage at all temperatures namely 15^0C, 25^0C and room temperature (32^0C), the viscosity first increased and after one or two days decreased and reached a stable value. The viscosities at 60 rpm were less than the viscosities at 6 rpm for all the samples at temperatures 15^0 and, 25^0C. This showed that the compound behaves like a pseudo plastic fluid at those temperatures.

Brookfield viscosity, Cp in different days						
Viscosity	RPM	I st	II nd	III rd	IV th	VII th
At 15^0C	6	200	175	125	125	125
	60	32.5	32.5	35	30	35
At 25^0C	6	175	160	125	125	150
	60	25	27.5	27.5	30	30
At room temperature, (32^0C)	6	200	175	150	150	150
	60	35	60	177.5	200	200

Table 2: Compound Stability Study

After storage time of four or five days at room temperature viscosity increased at higher shear rates. This may be due to the fact that colloidal stability of the latex might had reduced at 32^0C, which was near the cloud point temperature of PVME.

4.3. Technological Properties

The tensile properties of latex films prepared from the heat sensitized latex compound are given in Table 3. It was seen that the films have good tensile properties and ageing resistance.

Property	Before ageing	After ageing (70^0C for 7 days)
Tensile strength, MPa	18.95	16.4
Elongation at break, %	1200	831
Modulus at 100% elongation, MPa	0.63	0.73
Modulus at 300% elongation, MPa	0.97	1.38

Table 3: Technological Properties

5. Conclusion

In this paper heat sensitization of natural rubber latex by polyvinyl methyl ether was investigated. The effects of processing parameters were evaluated in the optimum base latex compound. Optimum compound formulation for the system had been standardized and their stability also was noted. From the study following conclusions were drawn.

Thickness of the latex deposits depended on processing parameters such as former temperature, dwell time and total solid content of the latex compound. The optimum dwell time was found to be 50 sec. When the mould temperature was 100^0C and the total solid content was 50% a thickness of 3mm was obtained by a single dip from the latex compound. These compounds were having good storage stability at 15^0C and 25^0C. The vulcanized film from the above latex compound had good technological properties and ageing resistance.

6. Acknowledgement

I sincerely acknowledge the support received from former Rubber Technologists of Technical Consultancy Division Mrs. G. Rajammal and Dr. N.R. Peethambaran towards the help for conducting the study.

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