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Preparation and Properties of Low Protein Latex

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ABSTRACT

Residual proteins present in natural rubber (NR) latex products can cause allergic reactions in sensitized people. Chlorination and leaching are the methods commonly employed for reducing extractable proteins (EP) in latex products. Chlorination can adversely affect the physical properties of latex films. Well leached films on storage again show the presence of EP. This is due to the migration of EP to the surface from interior layer. Hence reduction of EP in latex itself can solve allergic reactions to latex proteins to a great extent. This paper reports the preparation and properties of a latex low in EP. In conventionally sulphur vulcanized films of this low protein latex (LPL), EP content is very low. Physical properties of vulcanized LPL films are good, eventhough slightly less than that of films prepared from standard centrifuged latex (SCL).

INDTRODUCTION

Allergic reactions due to the prolonged use of latex products are currently discussed in length (1-4) Nutter (5) has attributed these allergic reactions to the presence of EP in latex products. Proteins cause contact urticaria and anaphylaxis in sensitized people (6). Leaching (7,8) and chlorination (9) are the most commonly used methods in reducing EP. Very long on-line leaching is impossible in a commercial dipping plant. Chlorination reduces the physical properties of latex films (10) and imparts an yellow colour at high chlorine concentration. Well leached latex films on storage again show the presence of EP on the surface. This is believed to be due to the migration of soluble proteins from interior layers to the surface. Reducing extractable protein content in latex can probably solve the problem to a great extent.

A method for deproteinizing latex (11) was reported earlier. The method is based on enzymic process. This method is rather expensive as latex has to be diluted to 10% DRC and again concentrated to 60% DRC. Dilution and concentration has to be repeated several times depending on the level of deproteinization required. Another approach is production of 'Loprol' (12) which is also based on an enzymic process (13). Also there are reports that it is not unlikely that the enzymes themselves may be proved to be allergic (14). Several chemicals/ chemical combination were screened in there ability to reduce EP. This paper reports the results of a study to produce latex low in EP using a proprietary non-enzymic chemical formulation R 318. The chemical formulation in subject to a patent application and will not be discussed.

EXPERIMENTAL

Preparation of Low Protein Latex

R 318 Added to commercial high ammonia preserved 60% natural rubber latex at different concentrations and allowed to equilibrate for about 20 hrs. The treated latex was diluted to 30% DRC by adding 0.8% ammonia. Since this process is based on protein displacement from the surface of latex particles, a portion of the latex was stirred for one hour to evaluate its possible effect. After 24 hours the diluted latex was centrifugally concentrated to low protein latex (LPL) of 60% DRC. Standard centrifuged latex (SCL) and the double centrifuged latex (DCL) and LPL processed out of the original SCL were evaluated.

Testing of Latices

The general quality parameters of latices were evaluated as per relevant Indian Standards :

Testing of Latex Films

Latex was compounded using sulphur and accelerator as per formulation given in table 1. Compounded latex was matured for 24 hours and cast films were prepared on level glass plate and dried in air. Films were vulcanized by heating for one our at 100ºC in air. Vulcanized films were leached for 5 minutes in water at 30ºC using rubber to water ratio 1:400. Leached films were air dried. EP content in the films were determined by Lowry method (15) of color development, as modified by RRIM (16). Crosslink density of vulcanized films were determined by solvent swelling method, using Flory-Rhener equation (17). Tensile properties of the vulcanized films were determined by using the relevant Indian Standards.

Result and Discussion

Effect of Concentration of R318 on EP Content in Vulcanized Films

Table 2 shows the variation of EP content in cast films against concentration of R 318, and also the effect of stirring. EP content in film prepared from SCL is given for comparison. There is a progressive reduction in EP content in the films. Initially there is considerable fall and the rate of fall decreases at higher concentrations of R 318. It was expected that mechanical stirring will facilitate protein removal from the surface of rubber particles. However, contrary to expectation, at higher concentrations of R 318, EP content in films prepared from stirred latex showed slightly higher values, eventhough the increase is only marginal. EP is only a small fraction of the total protein in latex film (6). This is also evident from the data on total nitrogen content provided in table 3. Reduction in the rate of fall in EP content with increasing concentration of R318 may be probably due to the preferential removal of less tightly bound proteins at the rubber-serum interface. A possible explanation to the marginally less EP content in films from latex not stirred is as follows: In presence of R 318, part of least firmly adsorbed proteins are displaced by surface active molecules of R 318. Also R 318 can get adsorbed over the rubber particles carrying proteins, making them less extractable. During stirring the equilibrium.

Proteins at rubber-serum interface ⟷ proteins in aqueous phase

will be shifted towards the right. Simultaneously aqueous phase contains R 318 also. When stirring is stopped proteins and R 318 can get adsorbed at the surface of rubber particles, small quantities of proteins probably forming an outer layer. These proteins became easily extractable.

Also it is observed that the optimum concentration of R 318 is 0.2% on the wet weight of latex and this concentration is used for subsequent work. EP content in these LPL films are very comparable to that reported for chlorinated gloves (18).

Raw Latex Properties

Table 3 shows the raw latex properties of LPL and a comparison is made with SCL and DCL also. Lower values of non-rubber solids, VFA No. and KOH No. for DCL and LPL are due to recentrifuging of SCL. Non-rubber content in LPL is somewhat lesser than that reported previously for enzyme deproteinized low protein latex (12). Lower viscosity of DCL and LPL is attributed to the fall in ionic concentration of latex by second cetrifuging. LPL exhibits, lower viscosity than SCL, showing LPL to be a material suitable for making thin dipped articles. LPL shows high chemical stability as evidenced by low zinc oxide thickening and high ZST value. This may be due to the lesser availability of anionic surface active materials on rubber particles in LPL. Nitrogen content int he dry film of LPL is not much less than that of DCL. This shows that only the easily extractable proteins are displaced from rubber particle surface.

Properties of Vulcanized Films

Table 4 shows the tensile properties of sulphur vulcanized films of SCL, DCL and LPL, both before and after ageing. The physical properties of DCL are generally lower compared to SCL. This is attributed to the reduction of non-rubber materials, especially proteins. Proteins are believed to contribute to tensile strength of vulcanized natural rubber through Hydrogen bonding. A similar result on the role of proteins in radiation vulcanization of natural latex has been reported (19). However LPL showed tensile properties similar to SCL eventhough protein content is even lesser than that in DCL. This is attributed to the Hydrogen bonding capacity exhibited by R 318 which compensates for the protein removal. The physical properties of LPL films are found to be better than that has been reported for enzyme deproteinized low protein latex films (13). The changes in tensile properties of LPL films by heating at 70°C for seven days also are similar to those of SCL films. The high retention of tensile properties is due to the antixoidant activity accelerator residues from zinc diethyl dithiocarbamates. For DCL, improvement in physical properties are observed on heat aging. This is probably due to the increased state of cure on continued heating and also due to the antioxidant activity of dithiocarbamate residues.

Conclusions

Low Protein latex, produced by non enzymic process exhibits very low levels of EP in vulcanized films compared to ordinary natural latex films. Vulcanized LPL films exhibits high tensile properties comparable to conventional sulphur vulcanized natural latex films. Retention of physical properties on heat aging are good. Thus LPL can find applications in the manufacture examination/surgical gloves, condoms etc.

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