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EFFECT OF IMMERSION IN TAP WATER ON THE REDUCTION OF TACKINESS OF THE FILM PREPARED FROM RADIATION VULCANIZED NATURAL RUBBER LATEX

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ABSTRACT

The tackiness property of the film obtained from the radiation vulcanized natural rubber latex was reduced to a level of commercially available natural rubber hand gloves by dipping in tap water at elevated temperature (above 50 ℃), only ten minutes heating is necessary. It was found that decrease in tackiness is due to the increase of surface roughness by deposition of calcium carbonate contained in tap water.

INTRODUCTION

It is well known that irradiation by gamma ray and electron beam is effective for the modification of polymer materials by grafting, crosslinking and degradation. Formation of network structure is useful to improve heat stability of insulation cable and shrinkable tubes. Radiation grafting is often used to add new properties to trunk

polymer. Now a days, these technologies are being practically applied in industry to enhance properties of polymer materials.

Radiation vulcanization is also effective for modification of natural rubber latex (NRL) . Minoura and Asao found that films prepared by radiation vulcanization of NRL (RVNRL) possess sufficiently good tensile properties by crosslinking between the rubber molecule [1, 2] . We found that monomers such as n-butyl acrylate, hexanediol diacrylate and neopentyl glycol diacrylate are useful to reduce required dose for vulcanization of NRL. The vulcanization dose by such monomers were reduced to 15-20 kGy from 200 kGy [3,4,5] .

The film obtained from RVNRL has several advantages compare to those of sulfur vulcanized one, e. g. absence of carcinogenic nitrosamines, low cytotoxicity, low emission of sulfur dioxide on combustion, softness and transparency [6] . But the problem is that the tackiness of RVNRL film is higher. Normally powders are used to reduce the tackiness of rubber surface. The powder contaminate the area of interest when come in contact or by diffusing in air. In order to overcome such problem, protective rubber products coated by hydrogel were developed using conventionally vulcanized latex [7,8] . In our laboratory, various methods to reduce tackiness from RVNRL films have been tried. This article reports that immersion in water containing calcium carbonate is effective for improvement of the tackiness of RVNRL film.

EXPERIMENTAL

The NRL was irradiated by gamma rays from Co-60 source for 250 kGy at a dose rate of 10 kGy/h without sensitizer. The films were cast on glass plates and air dried till transparent by removing water contained in the film. Then the films were leached in 1% aqueous ammonia for 24 hours and air dried again until transparent and then heated in oven at 70 ℃ for 1 hour for complete dryness. The RVNRL film thus prepared, were heated in water containing various amount of calcium carbonate or only in tap water at various temperatures. The tackiness was measured by tackiness tester, model TACII, Rhesca Co., Ltd., Japan. Gloss was measured by Uni-Gloss 60, MINOLTA, Japan. Photographs of the surfaces of RVNRL films were taken by Scanning Electron Microscope (SEM) and deposition of calcium on the surface was detected by X-ray Microanalyzer (XMA) , JEOL, Japan. Calcium carbonate was obtained from Wako Pure Chemical Industries Ltd., Japan and was used as obtained.

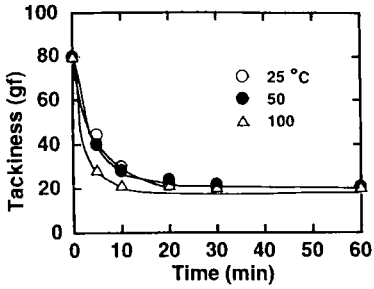

Fig.1 Tackiness of RVNRL film at various heating time in water.

RESULTS AND DISCUSSION

Figure 1 shows the tackiness of the RVNRL film immersed at different temperatures in tap water for various time periods. It can be seen that tackiness reduces sharply for 10 minutes. The highest temperature, 100 ℃, tackiness reduction is slightly faster than at other temperature. The tackiness for 20 minutes corresponds to a level of comercially available hand gloves (25 gf) . The comercial rubber gloves coated hydrogel or talk powder to reduce tackiness. This is more convenient compared with conventional method. Tackiness of RVNRL films is not reduced by warming in distilled water.

After heating the film it was found that the transparency of the film was reduced due to the formation of a thin layer of substances dissolved in tap water. That layer was seemed to be responsible for the reduction of tackiness. Figure 2 shows the reduction of gloss of the film heated in tap water for various time periods. From this figure it is seen that heating at 50 ℃ the gloss decreases up to 30 minutes heating and then become constant. The nature of the curve of gloss versus heating time in water is same as that of tackiness curve. So tackiness of RVNRL film corresponds well to gloss.

On the other hand, the roughness of the film increases with the decrease of tackiness. The photographs 1 (a) obtained by the Scanning Electron Microscope shows the surface of untreated RVNRL film. The surface is uniform having no rough or spotted phenomenon. The photographs (b) , (c) and (d) show that, there is a layer of

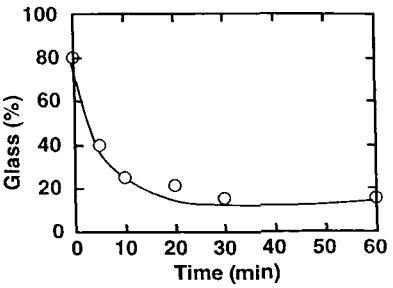

Fig.2 Gloss of RVNRL film heated in water for various time periods at 50 ℃

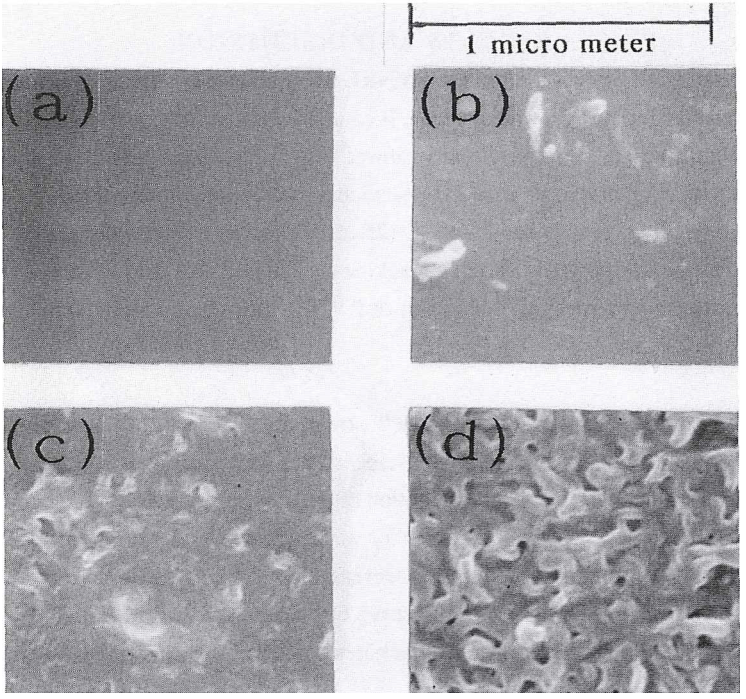

Photo. 1 SEM photographs of the surfaces of RVNRL films ; (a) original, (b) 5 minutes, (c) 30 minutes, (d) 60 minutes. Heating temp., 50 ℃

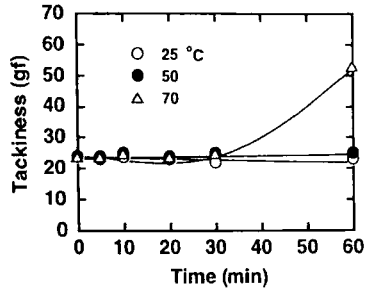

Fig. 3 Tackiness of the coated RVNRL film after dipping in distilled water for various time periods.

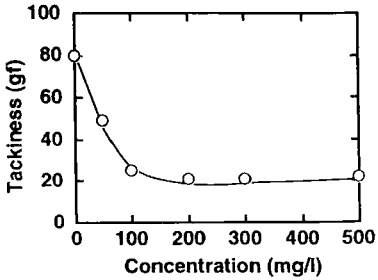

Fig.4 Tackiness of RVNRL film heated at 50 ℃ in water containing various concentration of calcium carbonate.

some substances deposited from tap water. It is seen that with the increase of heating time the roughness increases. With the increase of roughness the dry friction decreases [9] .

To evaluate the stability of the layer thus formed, the film was heated in distilled water at different temperatures for various time periods (Figure 3) . It was found that at 25 ℃ and 50 ℃ there was no change of tackiness till 1 hour heating but at 70 ℃ it remains constant for 30 minutes.

In order to confirm the substance responsible for the reduction of tackiness of RVNRL film the tap water was analyzed by Japanese Standard Methods. Various ionic species

together with other impurities were present in tap water. Among those the concentration of Cu, Fe, Mn, Zn, Cr ions were below 0.01 mg/l. The total concentration of Ca and Mg ions was 167.6 mg/l. To find out the specific compound and /or ion responsible for the reduction of tackiness various inorganic compounds such as calcium carbonate, calcium chloride, calcium nitrate, magnesium nitrate, magnesium sulfate and magnesium chloride were used. The compounds were mixed with water separately or in combination with two or more and the latex film was heated after dipping in it. Among the compounds used calcium carbonate responded positively. Figure 4 shows the reduction of tackiness with various concentration of calcium carbonate dipped for different time periods in water heated at 50 ℃. It is seen that about 100 mg/l of calcium carbonate in water is sufficient to reduce the tackiness to the level of commercially available hand gloves if heated for 20 minutes. The deposition of calcium carbonate on the surface of RVNRL film was detected by XMA. Other compounds e. g. calcium chloride was not deposited on the surface of the film because it remained in dissolved condition in the bulk of the water. It can be concluded that calcium carbonate dissolved in water is effective to reduce the tackiness of RVNRL film.

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