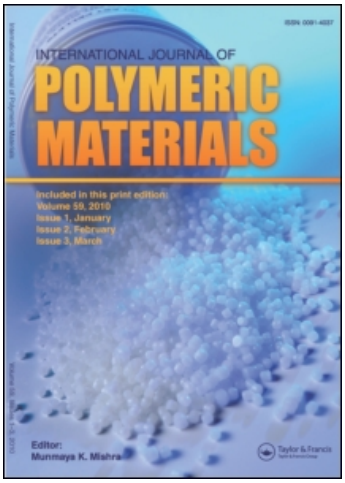

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Microwave Oven for the Rapid Determination of Total Solids Content of Natural Rubber Latex

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SHORT COMMUNICATION

Microwave Oven for the Rapid Determination of Total Solids Content of Natural Rubber Latex

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The suitability of using the microwave oven for the rapid determination of total solids content (TSC) of natural rubber latex has been established over a broad range of dry rubber content (DRC). The total solids content values obtained by the microwave oven method are compared with the values obtained by heating in a conventional convection oven. Heating in a microwave oven is advantageous as the measurement time could be reduced considerably.

Keywords: dry rubber content, microwave, natural rubber latex, total solid content

INTRODUCTION

Latex is a stable colloidal dispersion of polymeric particles in an essentially aqueous medium [1]. Natural rubber latex was the first latex to be used industrially [2]. Total solids content (TSC) of latex is the mass percentage of the solid material (both suspended and dissolved), measured by evaporating a known mass of latex to dryness at a temperature of 100°C–105°C.

Dry rubber is normally prepared from natural rubber field latex (obtained from rubber tree) by acid coagulation, washing, sheeting or

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crumbling, and drying. The dry rubber content (DRC) is the mass of the rubber coagulated by acid, and dried from 100 parts mass of latex. This test is of great commercial significance as it determines the pricing of latex. The difference between the percentage of TSC and percentage of DRC gives a measure of the percentage of nonrubber solids. Lattices with a high percentage of nonrubber solids have low mechanical stability.

Dry rubber product manufacturing plants use heavy-duty machinery such as internal mixers, mills, and calendars. Latex product manufacturing plants use very light and simple machinery like colloid mills, ball mills, and stirrers. The main energy requirement in latex product manufacture is in ovens for drying the products [3].

Microwave heating has many applications such as the removal of moisture of polar organic liquids [4], and the promotion of organic and inorganic reactions [5,6]. Some unique properties of microwaves have been recognized with respect to conventional methods. Microwave irradiation enhances the reaction speed significantly and reduces the reaction temperatures greatly in some processes [7]. The efficiency of the microwave oven lies in the fact that the heating is internal. In a conventional oven the substance is heated from the outside, and it must be left to heat until its center has been raised to a sufficiently high temperature. In microwave heating the molecules with permanent dipole moment absorb the radiation and rotate. As with many other excited states, the excess rotational energy of these molecules is re-emitted as heat and so heating times are drastically reduced [8].

The objective of this short communication is to present the suitability of the microwave oven for the rapid determination of total solids content of natural rubber latex over a broad range of dry rubber content. The total solids content values obtained by the microwave oven method are compared with the values obtained by heating in a conventional convection or hot-air oven.

EXPERIMENTAL

Materials

Njavallil Latex (P) Ltd. (Cochin, India), supplied centrifuged latex of DRC 60 used in this study. This latex was diluted using distilled water to obtain lattices of different dry rubber contents. Acetic acid and ethanol used were of commercial grade.

Estimation of Total Solids Content

The total solids content of natural rubber latex samples were estimated as per the conventional method [9] by pouring a test sample

(about 2 g, weighed to the nearest 1 mg) into a flat-bottomed dry dish, swirling the dish to spread the latex over the entire bottom of the dish, and evaporating to constant mass at 70°C in a convection oven. If m_0 is the initial sample mass, and m is the mass after drying, then the total solids content is defined as $100\,m/m_0$.

Estimation of Dry Rubber Content

The dry rubber content of natural rubber latex was determined as per the normal procedure [10] by taking a sample (about 10 g, weighed to the nearest 1 mg) into a glass beaker (100 mm in diameter and 50 mm deep), coagulating using 2% m/v aqueous acetic acid solution, adding a few drops of ethyl alcohol, heating the contents of the beaker for 15–30 min on a steam bath until the aqueous phase is clear, collecting the small particles of coagulated rubber with the main bulk, washing the rubber coagulum with pure water until it is neutral to litmus, and pressing with a roller to expel water and make a uniform sheet of 2 mm thickness. The sheet was then rinsed in water, allowed to drip, and evaporated to constant mass at 70°C in a hot-air oven. If m_0 is the mass of the latex sample, and m is the mass of the coagulum after drying, then the dry rubber content is defined as $100\,m/m_0$.

Determination of TSC Using Microwave Oven

Test sample (about 2 g, weighed to the nearest 1 mg) was taken into a flat-bottomed dry glass dish. The dish was swirled to spread the latex over the entire bottom of the dish. Five dishes containing test samples were placed at equal distances on the rotary plate of the microwave oven and heated for 3 min, cooled in a desiccator, and weighed. If m_0 is the initial sample mass, and m is the mass of the residue after drying, then the total solids content is defined as $100\,m/m_0$. The microwave oven used was a LG Microwave Oven (MS-1911HE). The full power was 1000 W and the frequency was 2450 MHz.

Preparation of Lattices of Different DRCs

The dry rubber content of the centrifuged latex concentrate was determined as per conventional procedure and the latex was diluted according to Eq. (1) given below, to obtain lattices of different dry rubber contents:

$$W = ((V \times D_s)/D_r) - W \tag{1}$$

where W = volume of distilled water required for dilution to the desired DRC, V = Volume of sample, D_s = DRC of the latex concentrate, and D_r = DRC desired in the diluted latex.

RESULTS AND DISCUSSION

Table 1 shows the dry rubber content of the nine latex samples prepared by diluting the centrifuged latex concentrate of DRC 60. The dilution was done by adding the required quantity of distilled water. The formula (1) explained in the experimental section was used to calculate the correct volume of distilled water to be added for each one of the DRC desired. Test samples were taken from all the nine diluted latex samples and the DRC of the samples were determined by the conventional method described in the experimental section. As shown in Table 1, the experimentally measured DRC values are in very good agreement (within experimental error), with the DRC calculated as per formula (1). The experimental results confirm the validity of the formula.

Table 2 shows the total solids content of the nine samples (L1 to L9) determined by the conventional (hot-air or convection oven) method as well as the microwave method. The variation of the total solids content of the latex samples measured using the conventional method as a function of DRC is shown in Figure 1. Figure 2 shows the variation of the total solids content of the latex samples measured using the microwave method as a function of DRC.

While the drying time required for the determination of total solids content using a conventional hot-air oven was several hours, the

TABLE 1 Calculated and Experimentally Measured Values of DRC

Sample	DRC_{cal} (%)	DRC_{exp} (%)
L1	20	20.10
L2	25	25.12
L3	30	30.15
L4	35	35.17
L5	40	40.20
L6	45	45.23
L7	50	50.25
L8	55	55.27
L9	60	60.30

DRC_{cal} = DRC calculated as per formula (1).
DRC_{exp} = Experimentally measured DRC values.

TABLE 2 Total Solids Content Values Measured using Conventional and Microwave Oven Methods

Sample	TSC conv (%)	TSC microwave (%)
L1	20.34	20.36
L2	25.43	25.45
L3	30.51	30.54
L4	35.59	35.63
L5	40.68	40.72
L6	45.77	45.81
L7	50.85	50.90
L8	55.94	55.99
L9	61.02	61.08

TSC conv = Total solids contents measured using convection oven.
TSC microwave = Total solids contents measured using microwave oven.

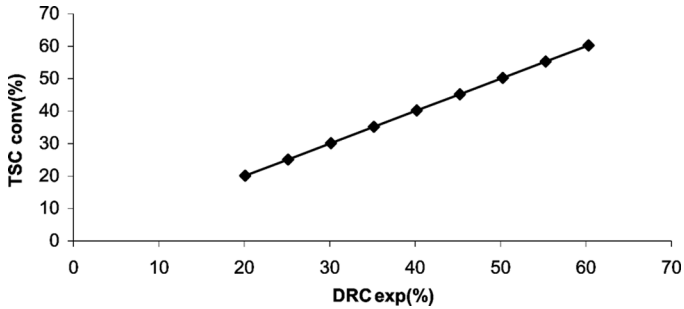

FIGURE 1 Variation of total solids content of the latex samples measured by conventional method with the experimentally measured DRC values.

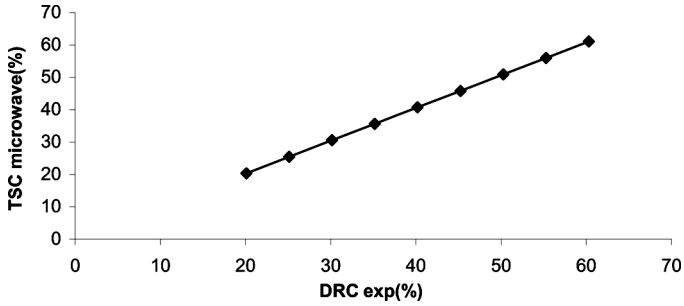

FIGURE 2 Variation of total solids content of the latex samples measured by microwave oven method with the experimentally measured DRC values.

drying in a microwave oven could be completed in three minutes. In microwave heating, the polar molecules throughout the bulk of the substance are simultaneously excited and heated, thus the time required for heating is drastically reduced [8]. A comparison of the determination of total solids content by the conventional method and the microwave oven heating method shows that the microwave method is more economical, and faster.

CONCLUSIONS

Natural rubber lattices of desired dry rubber content could be prepared from a latex concentrate of known dry rubber content by adding a correctly calculated volume of distilled water. Total solids contents of the lattices could be quickly determined by using a microwave oven to dry the samples. The total solids content values for the same sample determined by using the microwave oven heating method are in good agreement with the values obtained by the conventional hot-air oven method.

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