Updated Model for Fast Dry Rubber Content Determination in Natural Rubber Latex Using Shortwave Near Infrared Spectroscopy

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ABSTARCT

The analysis of dry rubber content (DRC) of Para rubber latex including field latex and concentrated latex, using near-infrared spectroscopy was carried out by a ultra violet/visible/near-infrared (UV/VIS/NIR) Spectrometer in transmittance mode over the wavelength range of 350–1100 nm. The original model provided the best accuracy of prediction was developed using the partial least square regression (PLSR) from the spectra which were pretreated by the smoothing and range normalization in the wavelength range of 700-950 nm. The slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias were 1.0154, -0.6286, 0.9960, 1.190% and0.0322%, respectively. The updated model was done by adding the 180 samples merged into the 280 original samples. The slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias were 1.0126, -0.3729, 0.9931, 1.2654% and 0.1103%, respectively. Therefore, it is needed to make more robust updated model by NIRS technique for determining the DRC of Para rubber latex, for both field latex and concentrated latex.

Keywords: Natural Rubber Latex, Dry Rubber Content, Shortwave, Near Infrared Spectroscopy

1. INTRODUCTION

Dry rubber content (DRC) is defined as a percentage by mass of the latex which is coagulated under specified conditions of colloidal destabilization[1].

At present determination of DRC is carried out by the international standard method as in ISO126:2005[2] which involve coagulating the rubber with acid, separating the rubber solids from the serum, pressing the rubber solid and heating the coagulated sample for over 16 hours at 70°C in a conventional oven. Hence this method is time consuming and unsuitable for a factory producing large quantities of centrifuged latex for production.

Natural rubber latex is the raw materials for manufacture of various types of dipped and extruded latex products such as gloves, condoms, baby teats, catheters, latex thread etc.

The field latex is centrifuged to produce latex concentrate. The factory purchases the field latex from numerous small holders based on the dry rubber content of the latex. The dry content rubber of field latex can be determined quickly with hydrometer known as "Metrolac" which is instantaneous but inaccurate

In the concentrated latex factory, the latex concentrate is produced at 60 % DRC. DRC is an important parameter for the purpose oftrade for both field latex and latex concentrate. Other than this, DRC is required to calculate the non-rubber solids content (NRC) as well as the volatile fatty acids number (VFA) of the latex using the standard method, ISO 506:1992[3]. These are the other important process control parameters.

Near infrared (NIR) spectroscopy is a rapid technique, accurate, and enviromental friendly where there is no chemical use, no or less sample preparation and the parameter prediction model is developed from the relationship between the interested constituents and the NIR spectral data. This NIR spectroscopy technique has been applied to a few agricultural products similar to rubber latex. Takeno *et al.*[4] describe the Fourier transform near infrared spectroscopy (FT-NIR) technique coupled with a partial least squares (PLS) regression model to quantify natural polyisoprene in Eucommia ulmoides leaves and the best PLS regression model was obtained with second derivative NIR spectra in the region between 4000–6000 cm^{-1} (R2, 0.95). Marinho *et al.*[5] studied the application of NIR spectroscopy for analyzing the natural *trans*- and *cis*- polyisoprenes from *Ficus elastica* (*cis*-1, 4-polyisoprene) and gutta-percha (*trans*-1, 4-polyisoprene) and mixtures of these polymers. Sirisomboon *et al.*, [6] applied the FT-NIR spectroscopy in the wavelength range of 1100-2500 nm in evaluation of dry rubber content of rubber latex and Sirisomboon *et al.*[7] used the short wave NIR spectroscopy in the wavelength range of 700-950 nm in evaluation of dry rubber content and total solids content. The work of Sirisomboon *et al.*[7] was tested to use in the concentrated latex factory. Therefore, the objective of our work was to study the ability of the short wave NIR spectroscopy and update the model developed by Sirisomboon *et al.* [7] for prediction of dry rubber content of both field latex and concentrated latex of Para rubber, which were the materials used in the process of latex production,

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to facilitate the quality and process control in the factory.

2. Material and methods

2.1 Samples

Samples of Para rubber field latex and concentrated latex for updating the model were collected in the factory of the Thai Rubber Latex Corporation (Thailand) Public Company Limited in the Nongyai district, Chonburi province, Thailand. The samples were immediately subjected to the experiment during 24-25 May, 19, 25, 29 June, 17 August, 7 September and 4 October 2012. The 159 field latex samples were obtained from the latex that the farmers in the Chonburi and nearby provinces sold to the factory. The 21 concentrated latex samples were obtained from the storage tanks of the factory. In total the adding samples were 180 samples. The experiment was conducted at 25±2°C room temperature.

2.2 NIR Scanning

The NIR scanning was conducted as in Sirisomboon *et al.* (2013). A latex sample without bubbles was scanned in a quartz cuvette with the size of 1×0.5 cm over the wavelength range of 350–1100 nm by a spectrometer (AVA-Spec-2048-USB2, Avantes, The Netherlands) in transmission mode. The scanning was done on a sample with two replicates and 5 scans per replicate, and the transmission spectra were transformed to be absorption spectra before analysis. The Teflon with the thickness of 1 cm was used for scanning as the reference material.

2.3 Dry Rubber Content (DRC) Measurement

The dry rubber content of rubber latex was measured following the standard method used by the factory which followed the ISO 126:2005 Natural rubber latex concentrate – Determination of dry rubber content [2]. The description of the dry rubber content measurement according to the ISO standard is in Sirisomboon et al.[6].

2.4 Model updating and data analysis

The new reference data of 180 samples for model updating were merged with the corresponding 700-950 nm NIR absorption spectra. They were combined to the old data of 280 samples of the original model. After sorting the added samples in ascending order of dry rubber content, the samples were divided into a calibration set and a prediction set in the ratio of 8:2. Then the updated model was developed by Partial least squares regression (PLSR), using the calibration set, with spectral mathematical pretreatment (17 point S. Golay smoothing and range normalization).

The updating of calibration model was done using Unscrambler 9.8 (Camo, Norway). The performance of the model was determined by the slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias.

3. Result and Discussion

Table 1 shows the statistical values of DRC of field latex and concentrated latex of the calibration and prediction sets. The PLS regression updated model was developed. The results show that the optimal number of factors of the model was 4 factors (PLS vectors), for which the slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias were 1.0126, -0.3729, 0.9931, 1.2654% and 0.1103%, respectively. Williams [8] suggested that with the r of 0.99 or more the model was excellent and usable in any application including quality assurance. Comparing with old model where the slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias were 1.0154, -0.6286, 0.9960, 1.190% and 0.0322%, respectively, it could be seen that the performance of the updated model was slighly lower than that of the old model. Therefore, there is the need to add more samples to the present model to make a new update to make a more accurate model. However, by those performance parameters obtained according to Williams [8] the model still can be used for the process control in a factory.

Table 1 Statistical values of dry rubber content (DRC) of field and concentrated lattices of Para rubber of calibration set and prediction set.

Data set	No	Mean	Max	Min	SD
Calibration Set	144	38.1514	63.9827	24.9845	10.8968
Prediction Set	36	38.3053	61.8063	27.5900	10.5542

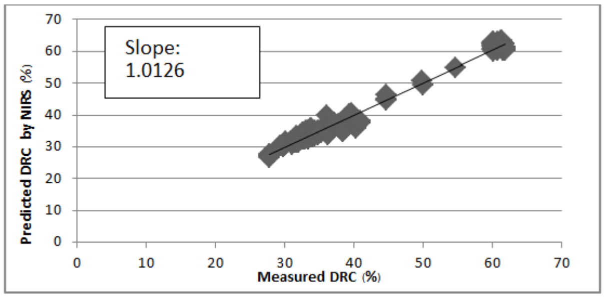

Figure 1 Linear correlation plots of measured versus predicted dry rubber content (DRC) of Para rubber of field latex and concentrated latex.

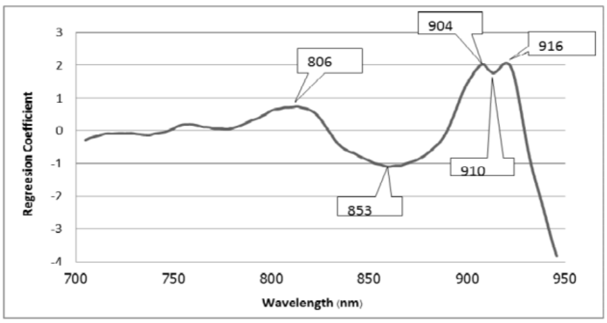

Figure 2 Regression coefficient plot of PLSR model for dry rubber content (DRC)of the latex.

Figure 1 shows the linear correlation plots of measured versus predicted DRC. Figure 2 shows the regression coefficient plots of PLSR model for DRC of the latex. The signal at about 904 and 916 nm appeared to have a strong effect on the model and 906 nm is the natural rubber band [7].

4. CONCLUSIONS

The near infrared spectroscopy technique developed for measuring the dry rubber content of field latex and concentrated latex using shortwave near infrared spectrometer shows its high performance and this could be done within 2-3 minutes per sample. With the short wave near infrared technology the investment cost may be high compare to the standard ISO method, but the return of investment is relatively fast as the operating cost per sample is very low and rapid. The technique now is tested for the real use in the concentrated latex factory in Thailand.

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