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# An Updated Model for Fast Total Solids Content Determination in Natural Rubber Latex Using Shortwave Near Infrared Spectroscopy

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## Abstract

The analysis of total solids content (TSC) 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 1.0084, -0.2332, 0.9940, 1.3611% and 0.1456%, respectively. The updated model was done by adding the 160 samples merged into the 280 original samples. The slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias were 0.9795, 0.7150, 0.9834, 1.6186% and -0.0802%, respectively. Therefore, the robust updated model by NIRS technique was more accurate and faster method for determining the TSC of Para rubber latex, for both field latex and concentrated latex.

Keywords: Natural rubber latex, Total solids content, Shortwave, Near infrared spectroscopy

## 1 Introduction

The total solids content (TSC) of a latex is defined as the percentage by mass of the whole which is non-volatile under specified conditions of drying in an open atmosphere at an elevated temperature (Blackley, 1997).

Natural rubber latex is the raw materials used for the manufacture of various latex products such as gloves (both examination and household), condoms, baby teats, catheters, foam products, latex thread for undergarments, adhesives for various applications and cast products like toys etc.

The TSC includes dry rubber content (DRC) and other solid matter called non-rubber solids content (NRC) in the latex. The non-rubber content is the indicator for the cleanliness of the latex. The lower the NRC, the cleaner the latex is. Thus, NRC can be calculated by the difference between the TSC and the DRC of the latex.

In addition, the TSC is an important parameter on which the various parameters are based on, namely, volatile fatty acid number (VFA number), Potassium Hydroxide number (KOH number), mechanical stability testing (MST) and Brookfield viscosity.

NIR spectroscopy uses the electromagnetic radiation absorption at wavelengths range of 780–2500 nm. NIR bands are generated from overlapping absorptions corresponding mainly to overtones and combinations of vibration of C–H, O–H, and N–H chemical bonds which are included in the biological materials. According to Huang et al. (Huang et al., 2008), in practice, the common modes are transmittance, interactance, transflectance, diffuse transmittance, and diffuse reflectance, with the last two being most frequently used. Diffuse transmittance measurements are suitable for samples of 1-2 cm thickness using shortwave near infrared radiation (780-1100 nm) while long wavelength (1100-2500 nm) could be applied to thinner samples. The diffuse reflectance measurement, where most of the incident radiation is reflected, is suitable for thicker samples. NIR spectroscopy is a rapid, accurate, non-destructive, less or no sample preparation, no chemical, enviromental friendly and can be applied off line, at line, in line or online for quality assurance and process control.

It is reported that various agro-industries such as flour milling (Miralbés et al., 2004), soybean meal factory (Haughey et al., 2013), bakery factory (Albanell et al., 2012), etc. use NIR spectroscopy. There are a few research reported the application of NIR spectroscopy in rubber latex factory (Sirisomboon et al., 2012, 2013a, 2013b) and there is still a need for further research for the real application in the factory. Therefore, the objective of our work was to update the shortwave near infrared spectroscopy model developed previously (Sirisomboon et al., 2013b) for fast total solids content determination in natural rubber latex production factory to facilitate the quality and process control.

## 2 *Materials and methods*

### *2.1 Samples*

Samples of Para rubber field latex and concentrated latex for updating the model were collected from the factory of the Thai Rubber Latex Corp. (Thailand) Public Company Limited in 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 131 field latex samples were obtained from the latex that the farmers in the Chonburi and near-by provinces sold to the factory. The 29 concentrated latex samples were obtained from the storage tanks of the factory. In total the samples were 160 samples. The experiment for NIR scanning was conducted at 25±2°C room temperature.

### *2.2 NIR Scanning*

The NIR scanning was conducted followed Sirisomboon et al. (2013b). A latex sample without bubbles was scanned in a quartz cuvette with the size of 1 cm×0.5 cm (width×thickness) 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 Total Solids Content (TSC) Measurement*

The total solids content of rubber latex was measured following the standard method used by the factory following the ISO 124:2011(E) Latex, rubber – Determination of total solids content (ISO, 2011). The description of the total solids content measurement by the ISO standard is in Sirisomboon et al. (2013b).

### *2.4 Model updating and data analysis*

The new reference data of 160 samples for model updating were merged with the corresponding 700-950 nm NIR absorption spectra. Then they were combined to the old data of 280 samples of the original model developed by Sirisomboon et al. (2013b). The 280 samples of field latex and concentrated latex were collected from the same factory between 3rd and 28th October 2011. 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 Results and discussion

Table 1 shows the statistical values of TSC of field latex and concentrated latex of the calibration, prediction sets. The PLS regression updated model was developed. The results showed that the optimal model required five factors (PLS vectors). The five factors were the slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias, of which the values were 0.9795, 0.7150, 0.9834, 1.6186% and -0.0802%, respectively.

Table 1 Statistical values of total solids content (TSC) of field and concentrated lattices of Para rubber of calibration set and prediction set.

| Data set | N | Mean | Max | Min | SD |
|---|---|---|---|---|---|
| Calibration | 32 | 38.816 | 64.385 | 27.695 | 9.603 |
| Set | 7 | 4 | 7 | 8 | 7 |
| Prediction | 11 | 39.605 | 64.203 | 30.609 | 9.550 |
| Set | 3 | 4 | 0 | 0 | 4 |

Williams (2010) suggested that with the r between 0.96-0.98 the model was usable in most application including quality assurance. Comparing with old model where the slope, offset, correlation coefficient (r), standard error of prediction (SEP) and bias were 1.0084, -0.2332, 0.9940, 1.3611% and 0.1456%, respectively, it could be seen that though the r value of the updated model was not higher than that of the old model but the bias was significantly lower by 0.2258%. These proved that the model can be used for the process control in a factory. By using shortwave near infrared spectrometer the fixed cost will be around 30,000 US$, while the traditional method using hot air oven and accessory needs a fixed cost of at least twice as much. With the NIR technique, the TSC measurement can be done in only a few seconds, while the traditional method needs 16 h.

Figure 1 shows the linear correlation plots of measured versus predicted TSC. Figure 2 shows the regression coefficient plots of PLSR model for TSC of the latex. The signal at about 905 and 918 nm appeared to have a strong effect on the model and 906 nm is the natural rubber band (Sirisomboon et al., 2013b).

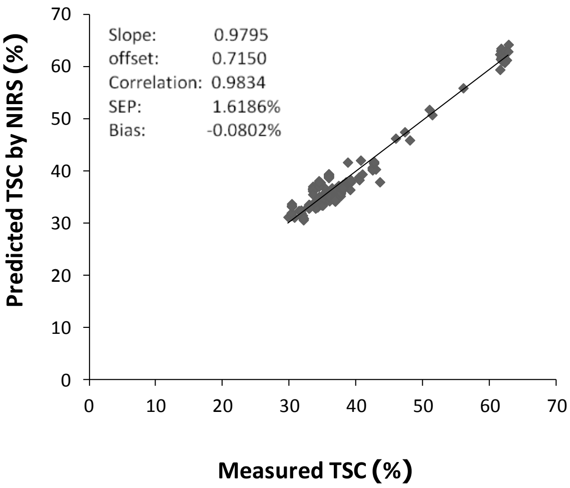


Figure 1 Linear correlation plots of measured versus predicted total solids content (TSC) of Para rubber of field latex and concentrated latex.

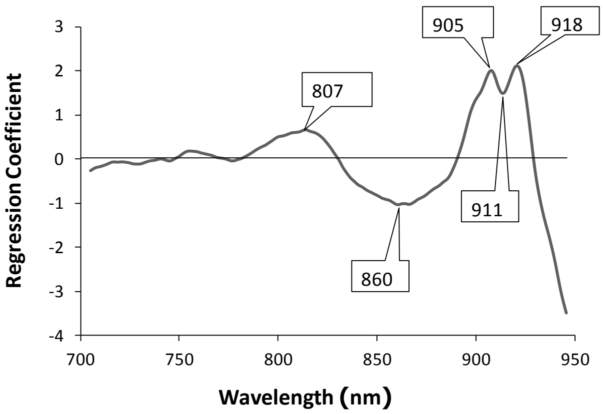


Figure 2 Regression coefficient plot of PLSR model for total solids content (TSC) of the latex.

## 4 Conclusions

The near infrared spectroscopy technique developed for measuring the total solids 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 and operating cost will be tremendously low compared to long wave technology. (approximately 30,000 US$ as compared to 100,000 US$) The technique now is tested for the real use in the concentrated latex factory in Thailand.

## 5 Acknowledgments

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## 6 Referrences

Albanell, E., Miñarro, B., Carrasco, N. 2012. Detection of low-level gluten content in flour and batter by near infrared reflectance spectroscopy (NIRS). Journal of Cereal Science 56(2), 490-495.

Blackley, D.C. 1997. Polymer Latices, Vol. 1, 2nd Edition, Chapman & Hall, London,

Haughey, S.A., Graham S.F., Cancouët, E., Elliott, C.T. 2013. The application of near-infrared reflectance spectroscopy (NIRS) to detect melamine adulteration of soya bean meal. Food Chemistry, 136(3–4), 1557-1561.

Huang, H., Yu, H., Xu, H., Ying, Y. 2008. Near infrared spectroscopy for on/in-line monitoring of quality in foods and beverages: A review. Journal of Food Engineering 87(3), 303-313.

ISO 124:2011(E) Latex, rubber – Determination of total solids content.

Miralbés, C. 2004. Quality control in the milling industry using near infrared transmittance spectroscopy. Food Chemistry 88(4), 621-628.

Sirisomboon P, Chowbankrang R, Williams P. 2012. Evaluation of apparent viscosity of Para rubber latex by diffuse reflection near-infrared spectroscopy. Applied Spectroscopy 66(5), 595-599.

Sirisomboon, P., Deeprommit, M., Suchaiboonsiri, W., Lertsri, W. 2013b. Shortwave near infrared spectroscopy for determination of dry rubber content and total solids content of Para rubber latex. Journal of Near Infrared Spectroscopy 2, 269–279.

Sirisomboon, P., Kaewkuptong, A., Williams, P. 2013a. Feasibility study on the evaluation of the dry rubber content of field and concentrated latex of Para rubber by diffuse reflectance near infrared spectroscopy. Journal of Near Infrared Spectroscopy 21, 81–88.

Williams, P. 2010. Near-infrared Technology – Getting the best out of light. A short course in the practical implementation of near-infrared spectroscopy for the user. 5.4. ed. PDK Grain, Nanaimo, Canada.