

Determination of Dry Rubber Content of *Hevea* Latex by Microwave Technique¹

KAIDA BIN KHALID

Jabatan Fizik, Fakulti Sains dan Pengajian Alam Sekitar, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia

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RINGKASAN

Pengukuran bagi berat getah kering lateks hevea dengan menggunakan teknik gelombang mikro adalah diterangkan. Dalam kaedah ini pengecilan gelombang mikro pada 10.7 GHz bagi lateks diukur dan ditentu ukur dengan kaedah makmal piawai. Dibandingkan dengan kaedah piawai, alat ini berkeupayaan memendekkan tempuh pengukuran dari 8 – 16 jam ke tiga minit. Pekali korelasi diantara berat getah kering yang diukur menggunakan alat ini dan kaedah makmal piawai adalah 0.998 dan sisihan lazim adalah kurang dari 0.7%.

Keterhasilan semula bagi kaedah ini adalah pada paras 0.8% unit berat getah kering.

SUMMARY

The measurement of the dry rubber content of the fresh hevea latex by microwave technique is described. In this technique the attenuation of microwave by latex is measured at 10.7 GHz and is then calibrated against the standard laboratory method. Compared with the standard method this instrument is able to reduce the measuring time 8 – 16 hours to three minutes. The correlation coefficient between the DRC determined using this instrument and the standard laboratory method is 0.998 and the standard deviation is less than 0.7%.

The reproducibility is at a level of 0.8% unit DRC.

INTRODUCTION

Hevea latex is a biological product of a complex composition. The basic components of a freshly tapped natural rubber latex, other than water which constitutes about 22 to 48%, are dry rubber (20 to 45%), proteinous substances (1.5%), resinous substances (2%), carbohydrates 1%, inorganic matter 0.5% and other (CHIN, 1979). Therefore transaction with the tappers depends on the dry rubber content (DRC) of the latex and the true DRC of the latex must be determined to ensure a fair price.

Many methods for the determination of the DRC of field latex have been developed and only three methods have been widely used. These are the standard laboratory method, the 'Chee'

method and the hydrometric method. The standard laboratory method is based on Malaysian standard MS 3:35 : 1975 (SIRIM, 1975) and this method is commonly used in research and quality control laboratories. This technique, however, is not suitable for field use because of high capital outlay. The whole operation makes more than 16 hours and requires skilful operators. The 'Chee' method is actually an over simplified version of the standard laboratory method. Although the capital outlay is small and the total error is approximately 1% compared to the standard method the operational procedure is still slow. The hydrometric method is widely used in the field because of its speed and operational simplicity. However this method has a coefficient of deviation of 11.7% in total error based on the standard laboratory method.

¹The technique described in this paper was judged the best entry in the international competition on DRC determination organised by the Malaysian Rubber Research and Development Board held recently.

Key to author's name: K. Kaida

An attempt is made to find an alternative method of determining the DRC of field latex which is accurate, and rapid, and the instrument is simple to operate, cheap and portable.

In this article, a measuring instrument based on a microwave technique is described.

Physical Principles

The principle of microwave technique is based on the fact that at microwave frequencies the loss tangent and dielectric constant of water are much higher than the non-water substances in the latex.

Normally at room temperature and at 10.7 GHz the value of the dielectric constant ϵ' of water is about 60 and the loss tangent $\tan \delta$ is about 0.54. The solid content of the latex has a dielectric constant in the range of 2.0 to 2.5 and the loss tangent is between 0.01 to 0.05.

This means that the attenuation due to water is large while that caused by dry rubber is small. Therefore, the higher the total solid content the lower the attenuation of the microwave power.

By assuming the proportional relationship between the total solid content and DRC, a correlation between the DRC and the attenuated microwave power can be derived.

Design of The DRC Meter

This technique is based on the same principle used for measuring moisture content. Instead of measuring the water content, we measure the solid content of the material. Figure 1 shows a block diagram of the microwave DRC meter. The meter consists of a Gunn diode oscillator, transmitting

and receiving horns, and a detector. A microwave signal at 10.7 GHz, 10 mW is generated by the Gunn diode which is located in a rectangular waveguide cavity. The detector is made up of a receiver horn, coaxial adapter, detector diode and an amplifier. In order to measure the attenuation the transmitter horn and receiver horn are set facing each other in a horizontal plane. The latex is filled in a perspex cell and placed in a horizontal position in the gap between these horns. The cell is placed in a horizontal position to ensure uniform density of the latex. The inner dimension of the perspex cell is 6.35 cm X 5.67 cm X 0.45 cm. The microwave power is measured by detector and displayed on the millivolt meter.

Figure 2 shows a photograph of the microwave DRC meter.

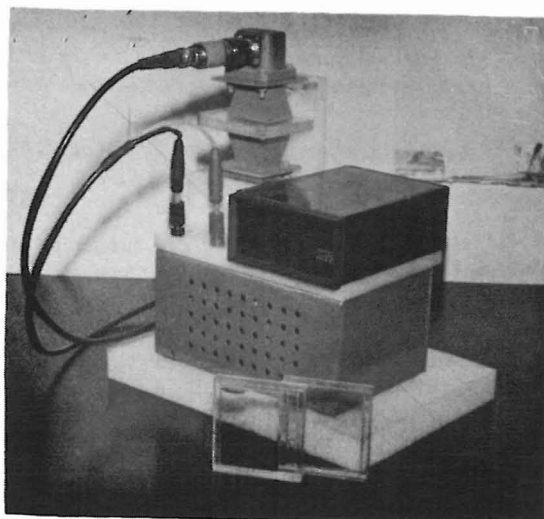


Fig. 2. The Microwave DRC meter.

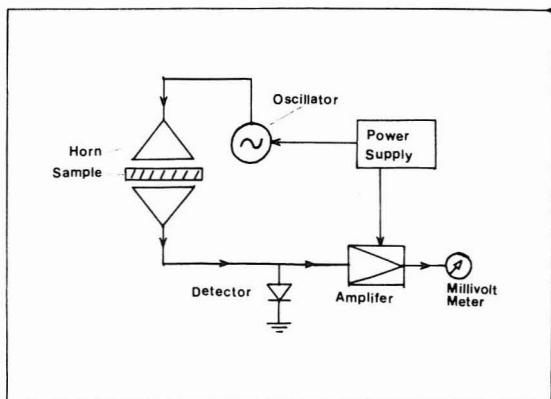


Fig. 1. Block diagram of the Microwave DRC meter.

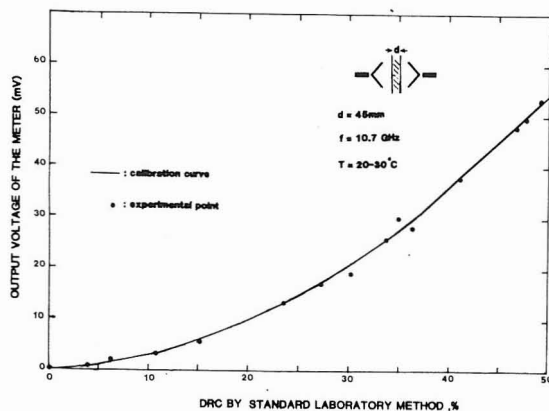


Fig. 3. Calibration of the Microwave DRC meter: Output voltage of the meter versus DRC by standard laboratory method.

Method of Measurement

To calibrate the meter, the correlation between the actual DRC (measured by Standard Laboratory Method, MS 3:35:1975) and the output voltage of the meter was obtained. Initially, the cell containing distilled water is placed in the gap between the horns and the amplifier and adjusted to give zero output. The distilled water is then replaced with the latex and the output voltage (representing the attenuation due to absorption) is recorded. For the measurement there should be no gas bubbles in the cell and the outer part of the cell should be dried. The DRC of the latex sample is then determined using the Standard Laboratory Method¹. A calibration curve of the microwave output voltage against the DRC is then plotted as shown in Figure 3. This calibration curve can subsequently be used with the instrument to ascertain the DRC of the latex. Apart from the DRC, the total solid content of the latex can also be calibrated.

Experimental Results

Various latex samples were taken from the University farm. Samples with lower DRC were prepared by diluting with distilled water. The results for the DRC ranging from 0% to 53% are shown in Figure 3. The temperature for these measurements ranges between 20° to 30°C.

Taking Y to be the value measured by the standard method and X to be the value measured using this instrument (in millivolt), the linear formula is $\log Y = \log 6.3 + 0.514 \log X$. This equation is obtained by using a least squares curve fitting. The sum of square errors is 6.3. This equation was used as a calibration curve.

PERFORMANCE OF THE INSTRUMENT

Accuracy and reproducibility

The present technique is able to reproduce duplicate results to a level of 0.8% unit DRC. The deviation of the test result is less than 0.7% compared to that obtain by the standard method and is quite satisfactory for practical use.

Figure 4 shows a relation between the DRC obtained by the microwave method and the Standard Laboratory Method for 29 samples of latex. The correlation coefficient between the results of the methods is 0.998. There is, however, a total error of 0.2% in the Standard Laboratory

Method. This deviation may be due to the differences in the chemical compounds of the latex, instability of the microwave power, detector sensitivity, moisture content of the air, room temperature and the dryness of the outer part of the cell.

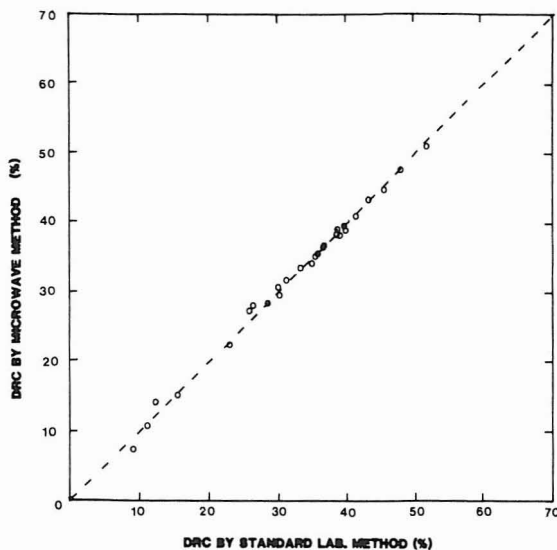


Fig. 4. DRC indicated by the microwave method versus DRC by the standard laboratory method.

Figure 5 shows the stability characteristics of a microwave signal with respect to time for five samples. The degree of stability increases as the

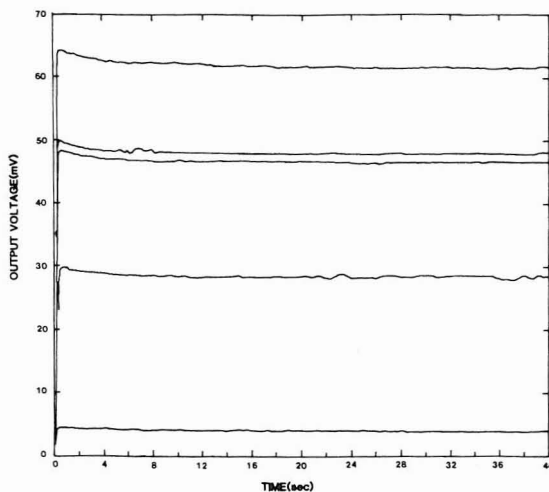


Fig. 5. Time dependence of the output voltage.

¹ Standard Laboratory Method : MS 3 : 35 : 1975 Briefly the method involves acid coagulating of a known weight of field latex and heated over a steam bath until a clear serum is obtained. The coagulum is thoroughly washed and placed in an oven at 70°C over night before reweighing.

time increases and the measurement can be taken after about 2 seconds.

Speed

This method is rapid and the whole operation takes less than three minutes. Table 1 shows the timing chart of the whole operation.

Possibly the error can be reduced by using the amplitude modulated signal so that a more stable microwave power can be obtained. Instead of looking at a variation of the attenuation with DRC we can also use the variation of phase shift with DRC. This aspect is currently undergoing investigation.

TABLE 1
Timing Chart

Operation	pouring the latex in dry cell	Washing drying the outer part of cell	Putting the cell in the gap	Taking the reading (+stabilizing time)	Calibration	Removing the cell	Total time
The time required (seconds)	10	60	5	30	15	10	130 sec.

Ease of the Operation

The method is easy to operate and does not require skilful operators. It is easier than the Hydrometric Method. No chemical reagents are needed for the test. The instrument is portable and operates on D.C.. Scale reading is easy especially when using the digital version. The tapper is able to witness the whole operation of the test on their latices and obtain the result after three minutes.

Capital Outlay

The cost of the instrument is about one thousand dollars (M\$1,000), which may be reduced to a range of M\$500 to M\$800 if mass produced.

Since there is no chemical reagent needed there will be no daily expenditure except for the changing of the batteries.

CONCLUSIONS

The microwave DRC meter overcomes the limitations of the Hydrometric method and 'Chee' method and enables efficient measurement, with ease of reading when the result is displayed digitally. This technique is able to reduce the measuring time from 16 hours to three minutes with a deviation less than 0.7% unit DRC.

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