RUBBER PROPERTIES OF SELECTED CLONES

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Abstract

The purpose of this study was to investigate the characteristics of rubber properties prepared from selected clones planted in Malaysia. The clones of RRIM 2001, RRIM 2002, RRIM 928, PB260, PB350 and RRIM 3001 were selected for this study and the properties of dry rubber were determined in accordance with Standard Malaysian Rubber (SMR) specifications. Cuplumps and latices from these clones were prepared and processed into SMR 10 and SMR CV60 respectively. Investigation of the Mooney viscosity ($V_R$) has found clones PB260 fulfils the specification for SMR CV60. Four clones were found to exceed the limit specified for SMR CV 60 whereas clone RRIM 928 was found to be lower. A correlation between $V_R$ and Wallace Plasticity Index (Po) values was also found. The increase in $V_R$ values was consistent with the increase in Po values. Interestingly all clones satisfied the Plasticity Retention Index (PRI) limit in the SMR CV grade and SMR 10. Examination of the samples from cuplumps has shown that all clones fulfil the specified parameters in the SMR 10 grade. It can be concluded that the clones chosen in this study could not satisfy the Mooney viscosity range specified in the stabilized rubber (CV) grade. However, high Mooney viscosity can be minimized through blending of latices from various clones. Interestingly there was no significant effect of individual clones on rubber properties. All clones comply the SMR 10 specifications.

Keywords: Standard Malaysian Rubber, rubber clones, rubber properties, mooney viscosity, Wallace Plasticity.

INTRODUCTION

There are numbers of rubber clones planted in Malaysia but among the most popular are RRIM 2001, RRIM 2002, RRIM 928, RRIM 3001, PB260 and PB350. They were selected in this study for examining the characteristics and properties in relation to the Standard Malaysian Rubber.

The variation in the quality of raw natural rubber causes serious problems associated with processing and grading with the quality of processed crop varying with changes in season, clonal origin and especially with the maturation time of the cuplump material (Roux et al., 2000). The approximately 6% classed as impurities contains many substances which are of vital importance in both vulcanization and oxidation properties (Bristow, 1990).
The selection of suitable rubber clones is important for the processor in achieving the desired SMR grade. On the other hand rubber growers would wish to select the clones that give high latex yield, and give high resistance to certain diseases.

Many studies have been carried out on clonal characteristics and their influence on rubber processing properties. It was reported (Bonfils et al, 2000) in previous studies that, the varying molecular weight of rubber clones play an important role in determining viscosity and initial Wallace plasticity. Other factors such as clonal origin, weather, type of soil, method of rubber processing will govern the rubber properties.

In practice, monoclonal latices are seldom used; instead, different latices are bulked together after collection. The mixing of clonal latices results in the viscosity of rubber being approximately equal to the average viscosity contributions of the individual clonal rubbers.

The purpose of this study was to understand the effect of individual NR clones on rubber properties according to SMR CV60, and SMR 10 specifications. The samples of SMR CV were prepared from latex while the samples of SMR 10 were prepared from cuplump. Standard Malaysian Rubber (SMR) is guided with various technical specifications. Among the properties specified in the SMR scheme are dirt content, ash content, volatile matter, nitrogen level, initial Wallace plasticity, plasticity retention index and, Mooney viscosity.

**MATERIALS AND METHODS**

The latices and cuplump from different rubber clones were collected from rubber trees planted in RRIM Experimental Station in Kota Tinggi, Malaysia. After tapping of all the selected clones, the latex was left to coagulate naturally and the cuplumps allowed to mature for 3 days in cups and then stored for 14 days for maturation in the laboratory before processing. The samples were passed through a creeper for 9 passes, washed and crumbled into smaller size. Rubber samples were then were dried at a temperature of 110°C for 3 ½ hours. The latex samples were preserved with 0.2% ammonia. 0.15% hydroxylamine neutral sulphate was added to the latex for the CV grade. The samples were coagulated with formic acid at pH 5. The coagula were then washed, creped, and dried at the temperature of 110°C for 3 ½ hour. The dry rubber samples were then tested for the dirt level, ash content, nitrogen level, Wallace...
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Plasticity (Po), Plasticity Retention Index (PRI), Mooney viscosity and colour using the standard test methods (Bulletin 7, 1991).

RESULTS AND DISCUSSION

Samples of dried rubber from individual clones were prepared from latex and cuplumps. They were regarded as latex grade and field grade respectively. The samples in this study were prepared and tested according to Standard Malaysian Rubber test methods and graded according to SMR specifications (Bulletin 11, 1991) in Table 1. The latex grade was measured against SMR CV 60 specifications and the field grade was measured against SMR 10 specifications.

Table 1. SMR Specifications for SMR CV60 and SMR 10.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SMR CV60</th>
<th>SMR10</th>
</tr>
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<tbody>
<tr>
<td>Dirt retained on 44u aperture (max. %wt)</td>
<td>0.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Ash Content (max, %wt)</td>
<td>0.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Nitrogen (max, %wt)</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Volatile Matter (max, %wt)</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Mooney Viscosity</td>
<td>60(-5, +5)</td>
<td>-</td>
</tr>
<tr>
<td>Wallace Plasticity (Po) (min)</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Plasticity Retention Index (PRI) (min)</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>

Mooney Viscosity (V_R)

Mooney viscosity is a measurement of hardness and is closely related to the rubber processability properties. It is understood that rubber with high Mooney viscosity requires long pre-mastication times whereas rubber with low Mooney viscosity requires less pre-mastication. From the 6 clones studied, the Mooney viscosity of 5 clones was found to exceed the limit specified for SMR CV. Only clone PB260 satisfied the Mooney viscosity range for SMR CV. RRIM 928 was found to have a low Mooney viscosity and out of range as required for SMR CV60 (see Figure 1). It is understood that the Mooney viscosity of rubber can sometimes change during storage and this is due to the fact that natural rubber often hardens, resulting in higher bulk viscosity (Yip, 1990). The increase in hardness on storage could be due to the presence of carbonyl groups in rubber (Yip, 1990). Obviously, latices with high Mooney rubber cannot be used for CV production. To overcome the high Mooney viscosity of rubber, it is necessary to blend clonal latices to obtain the required viscosity range for SMR CV (Sekhar, 1961). The main feature of viscosity stabilized rubber is the low and constant viscosity and this
allows the consumer to reduce or eliminate the pre-mastication step normally practiced in the manufacturing process lines. This in turn brings natural rubber another step closer to synthetic rubber\(^8\). The Mooney viscosity of the field grade samples however did not tested for this paper, as it was not specified for SMR 10.

Mooney viscosity and initial Wallace viscosity, are two parameters known to be related. This is illustrated in Figure 2 where a correlation between Mooney viscosity and Initial Wallace Plasticity Index (Po) values is found. The increase in Mooney viscosity values is consistent with the increasing in Po values. (Figure 2). Their relationship however is dependent on the history of the rubber samples involved since differences in processing, drying conditions and mastication could affect it. Nevertheless, in this study the samples were treated under the same conditions.
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Initial Wallace Plasticity

Initial Wallace Plasticity of dry rubber from field grade and latex grade were investigated and the results are shown in Figure 3. It shows that all individual clones fulfil the specified parameters for SMR 10. The Po values for the clonal rubbers were found to vary from 40 to 58, and were observed to be well above the minimum limit of 30. The Po value of latex grade was found to be lower than those samples from field grade. This suggested that the latex grade was softer compared to the field grade. Po is a method of measuring the hardness of NR and is influenced by molecular weight and gel content of the NR. For SMR field grade, a rubber is considered to be too soft if the Po value is below 30 units. On the other hand Po is not specified for SMR CV hence it was not further investigated.

![Figure 3. Initial Wallace Plasticity in field grade and latex grade](image)

Plasticity Retention Index. (PRI)

Plasticity Retention Index (PRI) of the samples are presented in Figure 4. It reflects the resistance of the rubber to molecular breakdown when it is heated in an oven at 140°C for 30 min. The level of degradation during heating is assessed using the Wallace plasticity value. PRI is calculated from the following equation:

\[
PRI (\%) = \frac{P_{30}}{Po} \times 100
\]

where \( P_{30} \) is the aged plasticity and Po is the plasticity before ageing in the oven.
The results show that all clonal rubbers satisfied the Plasticity Retention Index (PRI) limit in the SMR CV scheme. The PRI values of all the clones were 80% above the minimum limit of 60%. This suggests that all clones did not affect the PRI property. It was reported (Yip, 1990) in a previous study that there are reactions that occur during PRI test; degradation, crosslinking by free radicals and a certain amount of hardening due to the aldehyde groups and the aldehyde-condensing groups.

![Figure 4. Plasticity Retention Index of field grade and latex grade.](chart.png)

Examination of the samples of field grade shows that all clones fulfil the specified parameters in the SMR 10 scheme. The PRI values were found to be around 80% and this well above the limit parameters of 50% in the SMR 10 Scheme. The PRI of the field grade samples was slightly lower compared to those of the latex grade. This is consistent with the finding by L. Bateman et al. (1966).

**Nitrogen Content**

Nitrogen content is one of the parameters that determines the presence of protein in the rubber. Besides that, this parameters used to monitor the presence of skim rubber in technical specified rubber. Comparison of nitrogen content in samples prepared from latex and cuplump was made. It has revealed that the nitrogen content in both samples are comparable and fulfil the nitrogen limit specified in the latex grade and cuplump grades. Nitrogen content is not directly related to the clonal factor but it is influenced by the type of soil and fertilizer used. The results of nitrogen content of latex grade and field grade are shown in Figure 5. It was found that the samples of latex grade contained a higher
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nitrogen content than the field grade. As mentioned earlier, the latices were stabilised using ammonia. The presence of ammonia in the latex and lack of washing during processing could lead to the higher nitrogen content in the latex grade.

![Bar chart showing nitrogen content in field grade and latex grade](image)

**Figure 5.** Nitrogen content in field grade and latex grade.

**Dirt Content**

Dirt content is a measure of the contamination level of the rubber during the processing of latex into dry rubber. The results of dirt content are shown in Figure 6. The results show that the dirt content for both samples were well below the maximum limit for SMR CV (0.02%) and SMR 10 (0.08%) specifications. Normally, latex grades would have a much lower dirt content than field grade from cuplump. However, this study had shown that the dirt content in the latex grade and field grade is within the same range. It is suggested the clonal factor has nothing to do with the dirt content.
Ash Content

The ash component of natural rubber is derived from mineral constituents. In most cases, a high ash content is related to a high dirt content. However, there are cases where it is due to the presence of high calcium content of the lattices (Othman et al, 2001). As indicated in Figure 7, most of the clones showed an ash content in the latex grade from 0.2% - 0.3%, which is within the specification for SMR CV rubbers. The ash content of field grade samples were detected between 0.3% - 0.5%, slightly higher than those for the latex grade. This suggests that the ash content in the rubber does not relate to clonal type but it is very much influenced by the quality of raw material and the effectiveness of the processing line.
Degree Storage Hardening ($\Delta P$) of the rubber was investigated. Figure 8 shows the value of $\Delta P$ measured in the samples of latex grade. The $\Delta P$ is related to the amount of hydroxylamine neutral sulphate (HNS) used to stabilize the viscosity of the rubber. All samples of the rubbers were found to have $\Delta P$ values below 8 units, indicating that the amount of hydroxylamine added to the latex is sufficient to stop the storage hardening process. If the $\Delta P$ values close to the maximum limit, it suggests that more hydroxylamine might be required.

![Figure 8. Degree of storage hardening ($\Delta P$) in latex grade.](image)

**Volatile Matter**

Volatile matter is a measurement of the moisture content in rubber. The moisture content is related to the efficiency of shear rate, drying condition and the dryness of the raw rubber before processing. It has been reported that volatile matter content in the rubber is not related to the clonal characteristic of natural rubber (Ong and Lim, 1978). Figure 9 demonstrates volatile matter in the samples of both field and latex grade. In this study the volatile matter found in the field grade meets the specification for SMR 10. Low volatile matter was found in the field grade due to less moisture content in the cuplump before processing. Ideally, the cuplumps were kept for 14 day for maturation. During this period, moisture content can escape and this helps to reduce the volatile matter in the rubber. On the other hand, volatile matter found in latex grade samples was much higher than the limit allowed (8%) in SMR CV specifications. Almost all latex grade samples demonstrated higher
volatile and above the max limit of 0.8%. Obviously these results do not meet SMR CV specifications. High volatile matter in latex grade could be due to the highly ammoniated latex use in the present study. In addition, the variation of crumb size, inefficient shear during creeping and inconsistent drying process could result in poor moisture removal. This leads to higher volatile matter in the samples.

![Figure 9. Volatile matter in field grade and latex grade.](image)

**CONCLUSION**

Characterization of selected clonal rubbers shows that variation of characteristic between the clones was possible and this eventually would determine the final properties of the rubber. Among the parameters studied in this study, Mooney viscosity, Initial Wallace Index and Plasticity Retention Index were directly related to the clone. The intrinsic properties of the rubber are interrelated between these parameters. However, the clone did not influence other parameters such as dirt, ash, nitrogen content, and volatile matter but they were affected by other factors such as contamination, agricultural practices and processing condition. The increase in Mooney viscosity found in rubber was not a major issue in rubber processing in Malaysia. Mixing high Mooney viscosity lattices with low Mooney viscosity lattices is the effective solution in meeting SMR specifications.
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ACKNOWLEDGEMENT

The author wishes to thanks the Malaysian Rubber Board Management for their technical support and permission to publish this paper. The author also would like to dedicate an appreciation to supporting staff for their kind assistance in this study.

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