CHAPTER V

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

The aim of this thesis was investigated the influence of carbon black type and loading on reversion behavior and thermal aging properties of natural rubber (NR) compounds. In the first part, most attention was only paid to the cure characteristics, reversion behavior, and thermal aging properties of the gum or unfilled NR compound. Thereafter, how the presence of carbon black effected on those properties of NR compounds was focused regarding to carbon black type and carbon black loading. The results can be summarized as followed.

5.1.1 Cure Characteristics, Reversion Behavior and Thermal Aging Properties of Gum NR Compound

1. Cure characteristics of gum NR compound depended significantly on the curing temperature. The curing reaction was accelerated by increasing in the curing temperatures, thus leading to the lowering of both scorch time and cure times (tc_{90} and tc_{100}). The cure rate index increased significantly when the curing temperature was increased from 130 to 180°C.

2. The reversion behavior of the gum NR compound was initially observed at the curing temperature of 140°C. Increasing curing temperature caused more reversion at the prolonged cure. This could be indicated by the shorter plateau region and the faster reversion rate.

3. Thermal aging resistance of the gum NR vulcanizates cured with different curing times were not much different. However, the 90% cure time (tc_{90}) was proposed to be the optimal cure time. This was because the gum vulcanizate cured with tc_{90} gave the highest tensile strength no matter before or after aging.

5.1.2 Influence of Carbon Black on Cure Characteristics, Reversion Behavior and Thermal Aging Properties of NR Compounds

5.1.2.1 Cure characteristics of carbon black filled NR compounds

1. The effect of the increasing curing temperature on the cure characteristics of NR compounds seemed to be the similar trend for all types of carbon black and also similar to that of gum compound. Therefore, the increase in the curing temperature accelerated the curing reaction, thus lowering the scorch time (ts_2) and cure times (tc_{90} and tc_{100}) but increasing the cure rate index (CRI).

2. The changing of the scorch time and cure times (tc_{90} and tc_{100}) depended on carbon black type. In addition, The NR compound filled with N330 showed the faster cure rate compared to the NR compound with other types of carbon black.

3. No matter which carbon black, the presence of carbon black reduced the scorch time with increasing carbon black loading. However, the change in the 90% cure time depended on carbon black type and also the curing temperature. At 50 phr loading, for all curing temperature but 130°C, the addition of N330 and N550 decreased the 90% cure time. In the case of N776 and N990, the increasing of the 90% cure time was only observed at temperature above 170°C. Any change in the scorch time and the 90% cure time was amplified by the increasing carbon black loading.

4. The reduction of surface activity on N330 significantly decreased the influence of N330 on the cure characteristics

5.1.2.2 Reversion behavior of carbon black filled NR compounds

1. The presence of carbon black, even 10 phr, reduced the reversion activation energy. Therefore, the reversion of the carbon black

filled NR compounds (except N990) was observed at lower temperature which was 130°C when comparing to the gum one. In the case of N990, the reversion would be observed at 130°C when 20 phr of N990 was added.

2. The NR filled with N330 had the highest reversion rate, which clearly observed when curing temperature increased, followed by N550, N776 and N990.

3. For all types of carbon black used here, the increasing carbon black loading caused the higher reversion rate.

4. The reduction of surface activity of N330 significantly slower reversion rate when compared to the normal N330.

5.1.2.3 Thermal Aging Properties of Carbon Black Filled NR Compounds

1. Thermal aging resistance of the vulcanizate filled with N990 was greater than that of the ones filled with N774, N550 and N330. It was important to mention that although N330 had the highest reinforcing efficiency, it caused the highest thermal degradation.

2. Thermal aging resistance did not depend on the carbon black loading for all carbon black types. There were only the NR vulcanizates filled with N330 and N550 that their thermal aging resistance was carbon black loading dependent.

5.2 Recommendation

It was found here that for the DCBS-accelerated sulfur cure system, the highly reinforcing carbon black, N330, caused more reversion to NR compound and less thermal aging properties of the NR vulcanizates. To obtain a suitable rubber formula when compound is reinforced by N330, the effect of N330 on those properties when using different curing systems must be investigated.