

## CHAPTER V

### CONCLUSIONS AND SUGGESTION

#### 5.1 Conclusions

The *in situ* generated silica in NR-g-MMA was prepared by the sol-gel process of TEOS and  $\gamma$ -MPS as a silane coupling agent in the grafted rubber latex. The preparation was divided into 3 steps. Firstly MMA was grafted to the NR latex using CHPO/TEPA as a redox initiator. Secondly  $\gamma$ -MPS was sequentially grafted to the NR-g-MMA latex. Lastly TEOS was mixed into the NR-g-MMA- $\gamma$ -MPS latex, followed by heating the latex mixture to initiate the sol-gel process of added silanes as well as to dry the rubber composite.

The NR-g-MMA film was transparent, yellowish in color and stiffer than the ungrafted NR film. The grafting of MMA and  $\gamma$ -MPS were evidently confirmed by FT-IR spectroscopy and TEM analysis. In the case of NR-g-MMA- $\gamma$ -MPS-TEOS, the TEM clearly shows that PMMA and *in situ* silica nanoparticles reside in the shell layer of the NR core. It was also found that the silica particle size from  $\gamma$ -MPS/TEOS was smaller than that from TEOS alone. The conversion of  $\gamma$ -MPS/TEOS to silica in the composites was between 60 to 90%. The amount of *in situ* generated silica increased with increasing the TEOS amount added from 5 to 15 phr.

The  $T_g$  of NR grafted with MMA,  $\gamma$ -MPS, and these mixed with TEOS were found to be between -67.3 to -68.5°C. A possible evidence for interaction between the *in situ* silica particles and the rubber molecules was found as second  $T_g$ 's at -10.2 to -11.3°C. Finally, no enhancement in the thermo-oxidative degradation of silica-NR-g-MMA-  $\gamma$ -MPS composite was observed as compared to the NR alone, probably due to the low silica content.

## 5.2 Suggestions for future work

- New silane precursors that are more effective in improving the compatibility between the silica and rubber and suitable for water-based system such as vinyl triethoxysilane.
- Increase the amount of initiator in the 2<sup>nd</sup> time or add a 3<sup>rd</sup> portion of initiator for higher crosslink in the grafted NR.
- Analysis the mechanical property of the grafted NR/silica composites.