CHAPTER V

CONCLUSIONS AND FUTURE DIRECTION

5.1 Conclusions

The *in situ* modified silica was generated by a sol-gel process of 2 silane precursors: TEOS and TESPT. TESPT was added together with TEOS into the latex before the sol-gel step. The process was completed within 7 days at the temperature of 50°C, with %conversion of TEOS to silica was almost 100%. The *in situ* generated silica particles were well dispersed in the NR matrix, with the size of 123 nm for the composite without TESPT, and 37 nm for the composite with TESPT.

The influences of the amount of TEOS, TESPT and ammonia on the mechanical properties of the composites were investigated by a statistical analysis method, namely 'two-level factorial design.' It was found that tensile modulus at 300% elongation, tear strength and hardness of the composites were significantly affected by TEOS and TESPT content. The ammonia content showed an adverse effect. Therefore, for practical usage, a silica-NR vulcanizate having high mechanical properties can be obtained by adding a large amount of TEOS and TESPT contents without the need to add more ammonia into the concentrated NR latex which already contains 0.7% NH_3 for preservation purpose.

The addition of TESPT caused Δtorque (difference between the maximum and minimum torques) to increase but reduce both scorch time (ts_2) and optimum cure time (t_{90}). Therefore, it is evident that TESPT not only acts as a coupling agent but also a co-curing agent in the sulfur vulcanization process. Excessive use of TESPT can, however, cause the cure rate to decrease, possibly due to the plasticizing effect.

5.2 Future Direction

- Study in detail the effect of gelation time and the amount of TESPT on the size and dispersion of silica particles by TEM.
- Study new silane precursors that are more effective in improving the compatibility between the silica and rubber, giving rise to the increase mechanical properties of the NR-silica composite.
- Develop a protocol to produce NR-silica composite with sulfur-free vulcanization for use in biomedical applications.