# CHAPTER V
# CONCLUSIONS AND SUGGESTED WORK

Benzoxazine monomer was synthesized by using the Manich reaction where the molar ratio of phenol:p-formaldehyde:ethylenediamine was 2:4:1 and chloroform was used as a solvent. Characterization showed that the benzoxazine monomer has a melting temperature around 111°C and starts to degrade around 250°C. Barium titanate and barium strontium titanate were synthesized by using the sol-gel process, 2-step thermal decomposition and further sintered during ceramic pellets preparation at 1200°C and 1300°C. It was found that as the more Sr is added in $(Ba_{1-x}Sr_x)TiO_3$, the higher the temperatures are needed to obtain full crystallization of the perovskite phase. The suitable temperature for thermal decomposition of $(Ba_{0.7}Sr_{0.3})TiO_3$ and $(Ba_{0.5}Sr_{0.5})TiO_3$ in the sol-gel process is 1000°C to achieve full crystallization. The sintering temperature is 1330°C for both $(Ba_{0.7}Sr_{0.3})TiO_3$ and $(Ba_{0.5}Sr_{0.5})TiO_3$ which can be observed as fully crystallized by XRD and SEM. TEM imaging showed that the particle size of $(Ba_{0.7}Sr_{0.3})TiO_3$ is in the range of 50-100 nm.

A compression molding machine was employed to form the composites with ratios of ceramic to benzoxazine monomer at 1% and 5% by weight. The electrical measurements showed that $(Ba_{0.7}Sr_{0.3})TiO_3$ has a higher dielectric constant when compared to $(Ba_{0.5}Sr_{0.5})TiO_3$ because the ferroelectric transition takes place closer to room temperature. The dielectric constants of polybenzoxazine and the composites were relatively low. The dielectric constant also has a weak dependence on frequency and higher concentrations of ferroelectric filler lead to higher dielectric constant composites. Finally, the dielectric constant of composites strongly depend on the dielectric properties of the polymer matrix and dielectric losses of composites also depend on the polymer matrix.

**Suggested Work**

1. The thermal decomposition process should control the cool down rate. For example, if we can use rapid thermal annealing, then it will yield smaller particle sizes.
2. The compression molding method should be employed by using a smaller mold or thinner mold in order to obtain greater dispersion of fillers in the polymer matrix. Alternatively, other methods should be used.
3. The amount of ferroelectric filler could be increased to measure the effect on the dielectric properties.
4. Mechanical and piezoelectric properties should be further studied.