# CHAPTER VII
# CONCLUSION AND RECOMMENDATIONS

## 7.1 Conclusion

In this work, polycaprolactone (PCL) were studied for use as mouth guard material. Firstly, the different molecular weights of PCL were investigated for structure and mechanical properties. PCL was synthesized by solution ring-opening polymerization of ε-CL with different [ε-CL]/[$Sn(Oct)_2$] mole ratios to reach the different molecular weights from 17,000 to 95,800 g/mol. The synthesized PCL was confirmed by FTIR occuring the strong peak for carbonyl stretching mode at 1732 $cm^{-1}$ and 1169 $cm^{-1}$ for the symmetric C-O-C stretching modes of the ester group. The highest molecular weight PCL was compared to commercial one for XRD pattern and exhibited the same crystal structure. As results, the mechanical properties of PCL were affected by molecular weight. Higher molecular weight showed higher impact strength and higher %elongation at break for tensile properties. The storage modulus of PCL did not be affected by molecular weight but affected by molecular weight distribution by the decreasing of storage modulus when molecular weight distribution increased. Thermal properties did not be affected by molecular weight. The results of characterization of different molecular weight PCL could be concluded that high molecular weight PCL should be used for mouth guard materials.

After that high molecular weight PCL was further studied by two expected method, the addition of rigid part (organoclay) and soft part (Ethylene vinyl acetate). The addition of organoclay showed moderate compatibility between PCL and organoclay examined by XRD and SEM. Impact strength of PCL nanoclay nanocomposites decreased when organoclay content increased. Young's modulus and storage modulus between 20 and 50°C increased when organoclay content increased. The addition of organoclay did not affect the melting behavior of PCL nanoclay nanocomposites but it could enhance the thermal stability. As results, PCL nanoclay nanocomposites with 3 wt% content of organoclay was more appropiate than the other content of organoclay for use as mouth guard materials.

The addition of soft part was started by the grafting reaction of ethylene vinyl acetate and polycaprolactone. The success of graft copolymer was confirmed by FTIR of the characteristic –OH peak of PCL at 3529 $cm^{-1}$. DSC measurement showed the changes in both melting and crystallization temperature. Melting temperature of EVA-g-PCL shifted to lower temperature than pure PCL and modified EVA. The same result occurred for crystallization temperature at high PCL content as well. Thermal stability of PCL phase decreased after grafting of PCL on EVA backbone. Impact strength of PCL and EVA-g-PCL at 1:5 weight ratio showed the highest value by 115% increase from pure PCL. Dynamic mechanical properties showed the most compatibility of EVA-g-PCL at 1:5 weight ratio. From the result, EVA-g-PCL at weight ratio 1:5 could reach the point of mouth guard materials because it showed high increase of impact strength from the pure PCL meanwhile the modulus was also close to the pure one.

The structure and mechanical property relationship of PCL, its nanocomposites, and its graft copolymer could be concluded that high molecular weight PCL, the 3 wt% organoclay content of PCL nanoclay nanocomposites, and EVA-g-PCL at 1:5 weight ratio were appropiate for use as mouth guard materials. The ability of shaping will be studied later.

## 7.2 Recommendations

7.2.1 In many research of ring-opening polymerization of PCL by stannous octoate, they were often synthesized for $[\varepsilon\text{-CL}]/[Sn(Oct)_2]$ in the range of 2000 to 4000. As results, $[\varepsilon\text{-CL}]/[Sn(Oct)_2]$ which is lower than 2000 should be studied to examine that it can or cannot reach higher molecular weight than 95800 g/mol.

7.2.2 Other organoclays should be studied to compare with this PCL nanoclay nanocomposites about the compatibility between organoclay and PCL. The higher compatibility may improve the mechanical properties of PCL nanoclay nanocomposites. Other fillers should be studied to compare with this PCL nanoclay nanocomposites as well.

7.2.3 EVA-g-PCL at other weight ratio should be investigated to find more appropriate weight ratio and that ratio should be modified by mixing with organoclay or other fillers to improve the mechanical properties

7.2.4 Other cyclic monomers that can be synthesized through ring-opening polymerization such as L-lactide should be used to graft with EVA to compare with EVA-g-PCL.