CHAPTER 5

CONCLUSIONS

The objective of this study was to study the possibility of conversion of zinc hydrometallurgical waste into glass-ceramic materials. Thus properties of zinc waste, properties of obtained glasses and glass-ceramics were characterized. The conclusions have been drawn as follows:

1. The glass transition temperature (T_g) and crystallization temperature (T_c) of the twenty-five glasses were all between 550°C-630°C and 680°C-870°C respectively. DTA patterns of 25 glasses showed the exothermic peak which indicates that glasses would simply form glass-ceramics.

2. Most glass-ceramics showed the highest density and lowest water absorption at heat-treatment temperature around 750°C and 850°C (condition C)

3. Five major crystal phases and combination of these phases were found in glass-ceramics after heat-treatment, which were wollastonite-ferroan ($Ca_{2.87}FeO_{0.13}(SiO_3)_3$), pyroxene ($(Mg_{0.937}Fe_{0.063})(Ca_{0.75}1Na_{0.249}Fe_{0.018})(Si_2O_6)$, anorthite ($Ca(Al_2SiO_8)$, quartz ($SiO_2$), and cristobalite ($SiO_2$). The major factors that affected crystal phase formation were the compositions of each glass-ceramic and the heat-treatment temperatures.

4. The bending strength of twenty-five glass-ceramics heat-treated at condition B and C were varied depending on crystal phase formed and heat-treatment temperature. Glass-ceramics containing a single phase (pyroxene or wollastonite-ferroan) gave high values of bending strength, whereas glass-ceramics containing mixed phases gave low values. The bending strength of glass-ceramics containing single phases increased with the increasing of heat-treatment temperature, whereas those of mixed phases decreased. Of the twenty-five glass-ceramics, the bending strength of GC#2 (containing pyroxene phase) heat-treated at condition C was the highest at ~119.26 MPa.

The bending strength of GC#9 (contained mixed phases) heat-treated at condition C was lowest at ~22.96 MPa.

5. The leachability of Pb from glass-ceramics was examined by TCLP. The leached out concentration of Pb in glass-ceramics containing single pyroxene phase were all higher than the USA regulatory limit (5 ppm), whereas the leached out concentration of Pb in glass-ceramics containing single wollastonite and cristobalite phases were all lower than the limit.

6. The thermal expansion coefficients of glass-ceramics containing pyroxene phases were higher than the other single phase materials, whereas those of glass-ceramics containing mixed phases were mostly lower.

If one would like to choose the obtained glass-ceramics in this study for further application in the industries, the single phase of wollastonite glass-ceramics would be recommended, depending on the required applications. The general properties of GC#24 heat-treated at condition B and C, were considerably good, since it showed good physical properties. GC#24 contained a stable wollastonite-ferroan phase in both condition B and C. The bending strength was ~84.4 MPa at condition B and increased to ~105.5 MPa at condition C. The thermal expansion coefficient was ~13.7 $x10^{-6}$ /^{o}C in the range of 100-350^{o}C (condition C). The leached out concentration of Pb in GC#24 heat-treated at conditions B and C were only 2 ppm which is lower than the USA regulatory limit.