Chapter 7

SUMMARY AND FUTURE WORK

Summary

The present thesis deals with four different types of bioactive glasses. The first one is Sm_2O_3 (wt %) substituted bioactive glass and glass-ceramic and the second one is CeO_2 and La_2O_3 (wt %) substituted bioactive glass one by one and glass-ceramic, third one is CeO_2 and la_2O_3 (equal wt % upto 2%) substituted bioactive glass and glass-ceramic and last one is Al_2O_3 and la_2O_3 (equal wt % upto 2%) substituted bioactive glass and glass-ceramic. Samarium, Cerium, Lanthanum and Aluminum oxide were substituted to the glass composition for silica in different concentrations to yield a non-charge balanced series (NonCB) of bioactive glass, respectively based on its dual role in the glass. The other components of the bioactive glass were kept constant. During investigation, a comparative study was made on physical, mechanical and bioactive properties of REEs (Sm_2O_3, CeO_2 and La_2O_3) substituted 45S5 bioactive glasses and their ceramic derivatives. The following conclusions were obtained from this investigation.

- On the substitution of SiO_2 by Sm_2O_3 in 45S5 bioactive glass decreases its glass nucleation andcrystallization temperature as investigated through DTA/TGA.
- There is no significant effect has been observed on in-vitro bioactivity due to substitution of 2 % of SiO_2 (wt %) by CeO_2 and La_2O_3 in 45S5 bioactive glass but substitution of more than 2 % of SiO_2 for CeO_2 and La_2O_3 has led to decrease in vitro bioactivity.

- pH values of Sm_2O_3, CeO_2 and La_2O_3 substituted glasses increased for 4 days then decreased to suitable body temperature.
- Substitution of SiO_2 by Sm_2O_3, CeO_2, La_2O_3 and Al_2O_3 in 45S5 bioactive glass enhances its density in the order of CeLa4 > AlLa-4 > Sm4 > La2.
- Substitution of SiO_2 by Sm_2O_3, CeO_2, La_2O_3 and Al_2O_3 in 45S5 bioactive glass enhances its Young's modulus.
- Substitution of SiO_2 by REEs in 45S5 bioactive glass enhances its micro hardness.
- Incorporation of Sm_2O_3, CeO_2, La_2O_3 and Al_2O_3 in 45S5 bioactive glass enhances its flexural strength.
- Crystallization of bioactive glasses produces crystalline phases of sodium calcium silicate [$Na_2Ca_2Si_3O_9$ &$Ca(PO_3)_2$]. Crystallization of bioactive glasses decreases. It's in-vitro bioactivity. Crystallization of bioactive glasses increases their chemical stability, density, Young's, shear and bulk modulus, compressive strength, micro hardness and flexural strength while decreases their Possion' ratio.
- The cell culture studies have shown that the bioactive glass and its derivatives were non cytotoxic against mouse fibroblast, L929 cell lines. The cell proliferation rate was maximum in the sample no CeLa3 samples in 5 days which was found to match exactly with the result of cytotoxicity test.
- The hemolysis assay was also supported the compatability of bioactive glass and its derivatives towards the human RBCs.
- The florescence microscopy (apoptosis assay) was supported the biocompatibility, because there was no morphological changes in cells treated with RREs substituted bioactive glass.

Hence, the present investigation clearly concluded that Sm_2O_3, CeO_2, La_2O_3 and Al_2O_3 substituted bioactive glass and glass-ceramics with different batches would be potential biomaterials for biomedical application having good mechanical strength.

Future Work

- Using sol-gel processes to make bioactive glass and glass-ceramics.
- Detail in-vivo animal study can be undertaken for assessing its suitability for possible future clinical application.
- Preclinical trial needed for development for further clinical application.