Chapter V

Conclusion and Scope for the Future Work

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5.1 Conclusion

The aim of the present work was to synthesize pure leucite and kalsilite glass ceramics using mechanochemical synthesis route for PFM. The compositions which have maximum phase formation and better thermal, mechanical and microstructural properties were chosen for the bioactive glass ceramic composites. Furthermore, Al_2O_3 was added to the leucite-based bioactive glass-ceramic composite to further enhance the mechanical properties without affecting the biological and thermal response. Following conclusion has been drawn from this study.

- Micro fine crystalline leucite and kalsilite has been successfully synthesized using mechanochemical synthesis route and characterized.
- The addition of 2 wt. % of CaF_2 in the raw batch of leucite promotes the pure formation of leucite at low temperature.
- The addition of 2 wt. % of MgF_2 inhibits the formation of leucite phase and stabilizes the kalsilite meta-stable phase.
- CTE of the samples with the mixes of nanocrystalline leucite powders and LTF nearly matched with the coping material (nickel-chrome alloy).
- Flexural strength of the CaF_2 added leucite (MCL-C) sample is slightly higher than that of the without CaF_2 (MCL). This is due to the homogenous dispersion of leucite grains within the glassy matrix leads to its enhanced mechanical strength.

- SEM micrographs show the homogenous distribution of fine leucite particles throughout LTF matrix. There is no visible micro-crack appears during the phase transformation.
- Weibull modulus and nominal strength of the MCL-C samples are higher than that of the MCL samples. A high value of Weibull modulus confirms the reliability of these samples.
- All the MKL (kalsilite without MgF_2) and MKL-M (with MgF_2) samples are suitable for PFM as its CTE value in the range 14.0 to 14.8 × 10^{-6}/°C are close to that of the standard CTE of (14.5 × 10^{-6}/ °C) of dentine Vita VMK 95 Dentine 1M2.
- MKL-M samples have slightly higher flexural strength than that of the MKL samples.
- The micrographs show the homogenous distribution of hexagonal kalsilite throughout the LTF matrix. There is no visible micro-crack appears due to the phase transformation.
- Lowest leaching of the ions has been observed in the samples containing higher wt. % of leucite and kalsilite. This is due to the homogeneous distribution of microfine crystalline kalsilite and leucite throughout the LTF matrix.
- The bioactive leucite/kalsilite glass-ceramic composites have been successfully prepared by mixing mechanochemically derived leucite/kalsilite, LTF and bioactive glass in a fixed proportion and followed by heating at 960 ºC.
- The formation of calcium silicate ($2CaO.SiO_2$) and wollastonite ($CaO.SiO_2$) crystalline phases (after heat treatment) has been confirmed in the leucite-based composites using XRD.
- These phases have high strength consequently improves the flexural strength of the leucite-based composites.

- After heat treatment, a sodium orthosilicate ($2Na_2O.SiO_2$) crystalline phase has been found in the kalsilite based composites.
- Values of CTE of all the composites have been found in the range 14.5 to 15.9×10^{-6}/°C.
- These values are similar to values obtained for dentine (VITA VMK95 Dentin 1M2) and the substrate (VITA VMK95 opaque 1M2) as 14.5×10^{-6}/°C& 14.0×10^{-6} /°C respectively.
- Values of CTE for both the substrate and the composite coated materials are very close so that the applied heat treatment will not lead to peel off the coating.
- Leucite based bioactive composites have higher flexural strength than that of the kalsilite based composites and the values are nearly close to the commercial dentine.
- Formation of sodium orthosilicate phase in the kalsilite composites results in the low strength because this phase has less strength as compared to wollastonite and calcium silicate.
- The formation of hydroxyapatite layer on the whole surface of the composites has been confirmed using SEM and FTIR after immersion in SBF for 0, 7 and 14 days.
- Leucite and kalsilite glass–ceramic composites are observed to be cytocompatible and relatively nontoxic to buccal epithelial cells.
- SCC-25 cells have been cultured on the leucite and kalsilite glass–ceramic composites to demonstrate both the cytocompatibility and biocompatibility of the compounds in the case of clinical application.
- It has been observed that leucite and kalsilite based glass–ceramic composites are tolerant to the growth of the SCC-25 cells. The results suggest that the prepared

composite materials perform better compared to the standard materials and allow growth of the cells efficiently over its surface.

- Alumina added leucite glass ceramic composites show high flexural strength than that of the leucite-based glass ceramic composite and the commercial dentine.
- A uniform attachment of SSC-25 cells after 10 days of culture on the surface of the composites has been observed.
- It is concluded that addition of alumina to the leucite glass ceramic composite is a successful approach to the improve its mechanical and biological properties.
- Among the series of the samples, COMP-1 & COMP-2 show the best thermal, mechanical and bioactive behavior as compared to the commercial dentine (VITA VMK95 Dentin 1M2). It is, therefore a potential candidate for dental restoration and use of them will reduce the cost also as compared to the commercial product.
- Use of this material will enhance the bioactivity, decrease the marginal gap and will reduce the secondary caries formation.
- Permission for clinical trial of the prepared material is needed to prepare the domestic product and to file a patent.

5.2 Scope of the future work

- In-vivo testing of the prepared materials will be useful for their practical application.
- Ion leachability test of the composite materials using AAS to confirm their chemical durability.
- Study of the addition of fine Al_2O_3 to the kalsilite based glass ceramic composites on the mechanical, thermal and biological properties.