Preface

The present thesis has been written in seven chapters based on the investigations carried out on systematization of development of chosen new ceramic materials and their analysis concerning the structural, dielectric and ferroelectric properties of BaBi$_2$Nb$_2$O$_9$; LiTi$_2$(PO$_4$)$_3$, LiV$_3$O$_8$ & Li$_2$TiO$_3$ ceramic powders. Such materials have been considered to be more important for their use as ferroelectric and electrode materials.

Chapter-I, presents a brief introduction on ceramic materials relating to ferroelectric and electrode materials and necessary basic theory concerning ceramic powder materials.

Chapter-II, describes the preparation of ferroelectric BaBi$_2$Nb$_2$O$_9$ ceramic powder and LiTi$_2$(PO$_4$)$_3$, LiV$_3$O$_8$ & Li$_2$TiO$_3$ electrode ceramic powders using a solid state reaction method. These developed ceramic materials have been characterized by carrying out studied on thermal analysis (TG-DTA), structural (XRD, FTIR and Raman) morphological (SEM) and elemental analysis (EDS) as a primary task in this thesis. The dielectric properties ($\varepsilon'$ & $\tan\delta$) and conductivities ($\sigma_{ac}$ & $\sigma_{dc}$) have been measured in the frequency range from 500 Hz to 1M Hz. The Polarization-Electric field (P-E) hysteresis loop measurements have also been carried out at the room temperature.

Chapter-III, documents the results concerning the thermal, structural, dielectric and ferroelectric properties of BaBi$_2$Nb$_2$O$_9$ ceramic powders. The XRD profiles have shown that the sample sintered at 1000 °C (ad optimized temperature) has displayed well defined features and hence their structure being in orthorhombic space group $A21am$ (36). From the TG-DTA analysis, it is found that the crystallization temperature has been at (750 °C) based on the constant weight % in TG profile and corresponding exothermic peak present at 747 °C in DTA profile.
Morphological analysis has been carried out from the SEM images and elemental analysis from the EDS profile. For the temperature optimized sample, both Raman and FTIR spectral profiles have been studied. It is interesting to report that we could notice ferroelectric to paraelectric phase change based on the analysis of the dielectric properties as function of temperature (30-350 °C) in the frequency range (1k Hz - 1M Hz). Ferroelectric nature of the sample has been confirmed from the measurement of its hysteresis loop at the room temperature. The results of this chapter have earlier been published in a journal:

i. *Structural and dielectric properties of BaBi$_2$Nb$_2$O$_9$ ferroelectric ceramic powders by a solid state reaction method*
   R. Ramaraghavulu and S. Buddhudu
   *Ferroelectrics (Taylor & Francis, USA) 460 (2014) 57-67.*

ii. *Structural and dielectric properties of BaBi$_2$Nb$_2$O$_9$ ferroelectric ceramic powders by a solid state reaction method*
   R. Ramaraghavulu and S. Buddhudu

**Chapter-IV**, presents the results on the thermal, structural, dielectric and conductivities (ac & dc) properties of LiTi$_2$(PO$_4$)$_3$ ceramic powders. The XRD profiles have shown that the sample sintered at 1100 °C (optimized) has displayed well defined features. XRD peaks are in good agreement with the JCPDS Card No. 35-0754 confirming a *rhombohedral* structure in a space group of R 3c. The SEM image of this sample has been examined. EDAX and Raman spectra have been obtained for the LiTi$_2$(PO$_4$)$_3$ ceramic powders sintered at 1100 °C for analysis. Thermal properties of as prepared precursor LiTi$_2$(PO$_4$)$_3$ sample, has been studied from the measurement of the TG-DTA profiles. Besides this, dielectric constant, dielectric loss and conductivities (σ$_{ac}$ and σ$_{dc}$) have also been carried out for the LiTi$_2$(PO$_4$)$_3$ ceramic powders. The results of this chapter have earlier been published in a journal and also in a national conference as detailed here:

i. *Analysis of structural, thermal and dielectric properties of LiTi$_2$(PO$_4$)$_3$ ceramic powders*
   R. Ramaraghavulu and S. Buddhudu
ii. *Analysis of structural thermal and dielectric properties of LiTi$_2$(PO$_4$)$_3$ ceramic powders*
R. Ramaraghavulu and S. Buddhudu  
*Nat. Conf. on Advanced Materials and Applications (NCAMA-2013)*, 
NIT Tiruchirapalli, Tamilanadu, during April 4-5, 2013.

Chapter-V, deals with the results pertaining to the thermal, structural, dielectric and conductivities (ac & dc) properties of LiV$_3$O$_8$ ceramic powders. The X-ray diffraction profiles of these samples show that the ceramic powders sintered at 600 °C (optimized) has shown a well defined *monoclinic* structure in a space group of P2$_1$/m (11) with lattice parameters, a = 6.68 Å, b = 3.6 Å, c = 12.03 Å and α = γ = 90° and β = 107° and it is found to be in good agreement with the JCPDS Card No. 72-1193. The SEM image of this ceramic powder shows the distributions of grains are in cylindrical rods form. Thermal (TG) property of as prepared precursor LiV$_3$O$_8$ chemicals has been investigated. Raman and FTIR spectra of the temperature optimized (600 °C) ceramic powder have been carried out. Besides this, its dielectric constant ($\varepsilon'$) and tangent loss as a function of frequency (100 Hz – 1 MHz) and conductivities ($\sigma_{ac}$ and $\sigma_{dc}$) have also been understood in evaluating its potentialities for different applications. The results of this chapter have earlier been published in a journal:

i. *Structural and dielectric properties of LiV$_3$O$_8$ ceramic powders*
R. Ramaraghavulu, K. Sivaiah and S. Buddhudu  
*Ferroelectrics (Taylor & Francis, USA)* 43 (2012) 55-64.

ii. *A detailed study on the conductivity properties of LiV$_3$O$_8$ ceramic powder for its use as a battery material*
R. Ramaraghavulu and S. Buddhudu  
*AP Science Congress 2013*
Univ. of Hyd., Hyderabad, during Nov. 14-16, 2013.

Chapter-VI, gives the results on the thermal, structural, dielectric and conductivities of Li$_2$TiO$_3$ ceramic powders. The sample sintered at 800° C (optimized) has shown a good crystallinity from its XRD peaks and the sample is found to be in *monoclinic* structure which is in accordance with the reported data of JCPDS 33-0831. The SEM image for sample sintered at 800 °C, shows the distribution of grains in spherical form.
FTIR and Raman spectral profiles have been measured for the temperature optimized (800 °C) sample for understanding the structural details of Li$_2$TiO$_3$ ceramic powders. Besides these, dielectric constant, dielectric loss and ac conductivities have been measured for the temperature optimized sample. In respect of the thermal properties, only for the as synthesized (precursor) sample, simultaneous measurement of TG-DTA profiles has been carried out for analysis. The results of this chapter have earlier been published in a journal:

i. *Analysis of structural and thermal properties of Li$_2$TiO$_3$ ceramic powders*  
R. Ramaraghavulu, S. Buddhudu and G. Bhaskar Kumar  

ii. *Analysis of structural and thermal properties of Li$_2$TiO$_3$ ceramic powders*  
R. Ramaraghavulu, and S. Buddhudu  
*Int. Conf. on Nanomaterials and Nanotechnology (NANO-2010)*  

Chapter-VII, presents a comprehensive summary on important results given in thesis on two types of ceramic powders: ferroelectric natured (BaBi$_2$Nb$_2$O$_9$) ceramic powders and (LiTi$_2$(PO$_4$)$_3$, LiV$_3$O$_8$ & Li$_2$TiO$_3$) electrode ceramic powders. The thermal, structural, ferroelectric dielectric and conductivity properties of BaBi$_2$Nb$_2$O$_9$ and LiTi$_2$(PO$_4$)$_3$, LiV$_3$O$_8$ & Li$_2$TiO$_3$ ceramic powders, have been investigated using tools like TG-DTA, XRD, SEM, Raman, FTIR and dielectric study. Entire thesis results have earlier been presented in a National Workshop:

i. *Synthesis and dielectric analysis of certain ceramic powders*  
R. Ramaraghavulu, B. Chandra Babu and S. Buddhudu  
*Advanced Materials Characterization Techniques (AMCT-2013)*  
Dept of Physics, Sri Venkateswara University, Tirupati, March 23, 2013.

ii. *Synthesis and characterisation of BaBi$_2$Nb$_2$O$_9$ and LiTi$_2$(PO$_4$)$_3$, LiV$_3$O$_8$ & Li$_2$TiO$_3$ ceramic powders*  
R. Ramaraghavulu, B. V. Rao, G. B. Kumar & S. Buddhudu  
*National Seminar on Recent Trends in Advanced Material (NSRTA)*  
Dept. of Materials Science & Nanotechnology, Yogi Veman University, Kadapa, March 1, 2014.