PREFACE

Development of advanced ceramic materials is an emerging area with an ever-growing list of material compositions and broad base of current and potential applications. Needs and opportunities for ceramics in the future are particularly evident in areas such as computing, communications, defence, medicine, pollution abatement and transportation. A great deal of research has gone into the production of materials having superior structural and mechanical properties. However, high cost of raw materials and difficulty in manufacturing complex shaped ceramic components limit their use. Kaolinite, an inexpensive natural raw material with good processability can be a promising candidate for the preparation of materials for special applications. The focus of the present work is on the preparation of kaolin based ceramic materials viz., spodumene, cordierite, fiber reinforced ceramic composites, cermets and mullite-silicon carbide composites by adopting appropriate fabrication methodologies and controlled high temperature sintering.

Chapter 1 presents a brief summary of the major developments in ceramics in the last few decades followed by structure and properties of kaolinite (the basic raw material used for the present study) and the importance of the present work in the area of engineering ceramics.

Chapter 2 titled “Raw material characterization and experimental techniques” describes the major experimental techniques employed for the distinct property evaluation. The techniques include X-ray diffraction (XRD), thermogravimetric and differential thermal analysis (TG-DTA), particle size analysis, laser photoflash technique, impedance analysis and scanning electron microscopy (SEM).

Chapter 3 deals with Mullite-β-spodumene composites from aluminosilicates. Sintering studies of kaolin, metakaolin, and zeolite 4A, synthetic mixes of Al₂O₃ and SiO₂ (in the stoichiometric ratio of kaolinite Al/Si =1) in the presence of Li₂CO₃ and LiCl as fluxing agents are carried out at temperatures 1223-1623 K with a soaking period of three hours. The physical, mechanical, thermal, electrical and morphological characteristics of the samples are also discussed.

Chapter 4 describes the synthesis of cordierite by conventional and sol-gel routes. A comparative study of the properties of cordierite formed under different methods has been presented. Conventional sintering of stoichiometric composition of kaolin, talc and MgO gave rise to cordierite formation at 1623 K. Since cordierite has low coefficient of thermal expansion and better thermal and chemical stability, possibility of its use as substrate material for catalytic converters has been discussed. A working model of the catalytic
converter with pellet type and honeycomb catalyst carriers have been developed and their efficiency in pollution monitoring are briefly described.

Chapter 5 deals with “Kaolin based fiber reinforced ceramic composites”. Fiber reinforced ceramics are a special and sophisticated class of composite materials having potentially high structural efficiencies. In the present work, kaolin, metakaolin, spodumene and cordierite are used as the matrix materials while aluminosilicate, silicon carbide (nicalon) and refractory grade zirconia fibers as reinforcements. The samples are sintered at temperatures 1623-1823 K with a soaking period of three hours. Phase identification was carried out by X-ray diffractograms. The physical, mechanical and thermal properties have been discussed. Interface relations are explained in terms of scanning electron microscopy. The application of these fiber reinforced ceramic materials for the fabrication of complex shaped engineering materials has been carried out.

Chapter 6 describes the preparation of kaolin based ceramic-metal composites (cermets). Different weight percentages (1-30) of metallic powders such as Al and Zn are incorporated in the metakaolin matrix and sintered at temperatures 1523-1823 K with a soaking period of three hours in order to prepare Al and Zn based cermets. Phases formed during sintering were monitored by X-ray analysis. The physical, mechanical, thermal, electrical and microstructural properties of the cermets are also presented.

Chapter 7 deals with the synthesis of mullite-silicon carbide composites by carbothermal reduction of metakaolin and zeolite 4A. Carbothermal reduction of aluminosilicate minerals has great technological value since they use natural raw materials to achieve advanced ceramic powders. In the present work, reactions of zeolite/mineral-carbon mixtures were carried out at temperatures 1173-1773 K in N₂ atmosphere. The phase identification and morphological characteristics of the samples are discussed.

Chapter 8 summarizes the important results of the work described in previous chapters and also presents the future perspectives.