PREFACE

The present research work reports the development and a systematic study of structural and other properties of pure and doped $AlO(OH)\cdot xH_2O$ and derivatives of mesoporous Al_2O_3 in different polymorphs, Cr^{3+}:Al_2O_3 nanoceramics, and Co:Al_2O_3 nanocermets. A novel chemical method using a controlled surface hydrolysis of Al-metal with nascent surfaces in water at room temperature is developed and explored to derive a mesoporous $AlO(OH)\cdot xH_2O$ and its controlled molecular decomposition to mesoporous Al_2O_3 powders in different polymorphs. The method is extended to obtain a precursor mixture to synthesize a mesoporous Al_2O_3 composite with Cr_2O_3 metal oxide or Co-metal of nanoparticles. Mechanical attrition is used to promote a homogeneous distribution of Cr^{3+} in $AlO(OH)\cdot xH_2O$ as a precursor. Cr^{3+}:Al_2O_3 nanoceramics appear on heating the precursor in air at 800 to 1500 K of temperature. A controlled thermal decomposition and co-reduction of Co^{2+}:$AlO(OH)\cdot xH_2O$ gives a Co:Al_2O_3 nanocermet on heating in H_2 gas at 975 to 1125 K. The formation of the samples in different polymorphs and the structural and other properties are studied with X-ray diffraction, thermal analysis, microstructure, XPS analysis, BET studies, and IR & Raman, optical absorption, emission and EPR spectra. Microhardness and dielectric properties are studied for α-Al_2O_3. The total surface and Gibbs free energies are used to analyze and model thermodynamic stabilities and phase transformations in Al_2O_3 and Co:Al_2O_3 in nanoparticles.

The results and the data analysis are presented with discussion in seven chapters. Chapter-I gives a general introduction about the subject with the statement of the problem, reviews of the chemical methods in synthesis of fine ceramics or metals, important polymorphs of Al_2O_3 and Co-metal in nanoparticles, their typical physical properties and applications. A mesoporous composite structure and the role of pores in novel properties and applications are briefed. Chapter-II describes experimental methods followed in this study and the X-ray diffraction, microstructure, and other analytical techniques applied to characterize the samples. Analysis and modeling of the results are discussed in subsequent Chapters of III to VII. A summary of the work with important implications achieved in this work is reproduced in the last Chapter-VIII.

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