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Topic of research: "Investigation of cost-effective Novel Ionic conductor for moderate temperature Solid Oxide Fuel Cells (SOFCs)".

Findings

The research has provided significant insights into the synthesis and characterization of alkali metal-doped trimeric strontium metasilicates and hexagonal perovskite-related $Ba_3MoNbO_{8.5}$ materials as promising solid electrolytes for IT-SOFC applications. Two classes of materials i.e. strontium metasilicate and its derivatives, and $Ba_3MoNbO_{8.5}$ hexagonal perovskite system, both have been synthesised via solid state reaction route synthesis. Comprehensive characterization techniques, including X-ray diffraction (XRD), Raman spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), UV-Visible Spectroscopy, Thermogravimetric Analysis (TGA), Scanning Electron Microscopy(SEM) with Energy Dispersive X-ray Spectroscopy (EDS) and Electrochemical Impedance Spectroscopy (EIS) for detailed investigations.

Chapter 1 introduces the fundamental concepts of fuel cells with an emphasis on Solid Oxide Fuel Cells (SOFCs), detailing their components and characteristics. It includes a detailed review of existing electrolyte materials and outlines the objectives of the present research work.

Chapter 2 covers in depth explanation of solid state reaction route synthesis technique and various techniques for characterization such as XRD, FTIR, XPS, UV-Visible Spectroscopy, TGA, SEM, EDS, EIS for in depth structural, morphological, optical, and electrochemical investigation of synthesised materials.

Chapter 3 explores Na^+-substituted trimeric strontium silicate ($Sr_{3-3x}Na_{3x}Si_3O_{9-\delta}$, $0.00 \leq x \leq 0.20$) compositions, synthesised via solid state reaction route. The compositions exhibited crystalline phase in C12/c1space group in monoclinic phase. SEM and EDX analyses revealed increased grain size and a secondary glassy phase with sodium doping. AC conductivity and impedance studies showed improved ionic conductivity with Na^+ content.

Chapter 4 investigates K^+-substituted trimeric strontium silicate $Sr_{3-3x}K_{3x}Si_3O_9$ ($0.0 \leq x \leq 0.2$). Predominant monoclinic phase, with secondary peaks suggesting the presence of amorphous phases resulting from potassium doping. Doping enhanced grain density and lowered porosity. Conductivity investigations revealed substantial increment in conductivity correlated with elevated potassium levels, associated toward the potassium rich amorphous phase at the grain boundaries.

Chapter 5 analyses germanium bi-substituted trimeric strontium silicate ($Sr_{3-3x}Na_{3x}Si_{3-3y}Ge_{3y}O_{9}$-$\delta$; $0 < x < 0.20$, $y = 0.1$) as a prospective solid electrolyte. Doping was seen to stabilize the monoclinic phase (space group C12/c1), with small amorphous impurity phases emerging at higher dopant concentrations. Sodium doping substantially enhanced electrical conductivity.

Chapter 6 covers potassium and germanium co-doped strontium silicate ($Sr_{3-3x}K_{3x}Si_{3-3y}Ge_{3y}O_{9}$-$\delta$; $0 \leq x \leq 0.20$, $y = 0.1$). Stabilization of a monoclinic phase through potassium doping was observed. Potassium-enriched glassy phase at the grain boundaries were reported in elevated doping concentrations. Electrical impedance spectroscopy demonstrated improved ionic conductivity.

Chapter 7 briefly investigates the $Ba_3MoNbO_{8.5}$ (BNM) hexagonal perovskite. BNM crystallises in hexagonal structure with an R3m space group. UV-Vis analyses established a high energy band gap. BNM exhibited a dense morphology. Elevated ionic conductivity and two-dimensional oxide-ion migration was observed.

Chapter 8 encapsulates the key conclusions and findings of this thesis and enumerates several ideas for future research aimed at optimizing solid electrolyte within intermediate temperature region.