Impedance spectroscopic analysis of green phase Y_2BaCuO_5 ceramics

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Abstract

In the present work, the polycrystalline Y_2BaCuO_5 powder was successfully synthesized via solid state reaction route using Y_2O_3, $BaCO_3$ and CuO as precursor chemicals (AR grade). Y_2BaCuO_5 (Y211) is easily identifiable and is often referred as 'green phase' due to its green colouration. To investigate its structural, morphological and electrical properties, a range of characterization techniques were employed. From the XRD data of the prepared Y_2BaCuO_5 sample, a single orthorhombic crystal phase was confirmed containing Pnma space group. From the SEM image it was observed that the sample was slightly porous in nature with well-defined grain growth. From the Impedance Spectroscopy data analysis, it was observed that the magnitude of Z′ (real Z) decreases with the increase in both frequency as well as temperature indicating an increase in ac conductivity with the rise in temperature and frequency. From the Nyquist plot, it was also observed that with the increase in temperature, the slope of the lines decreases and their curve bends towards real Z-axis, and thus tracing a semicircle. The centre of the semi-circular arc shifts towards the origin on increasing temperature which indicated that the conductivity of the samples increases with increase in temperature. The result in details will be presented and discussed.

Keywords: Green phase, XRD, SEM, EDS, Impedance Spectroscopy, Nyquist plot.

Synthesis Method

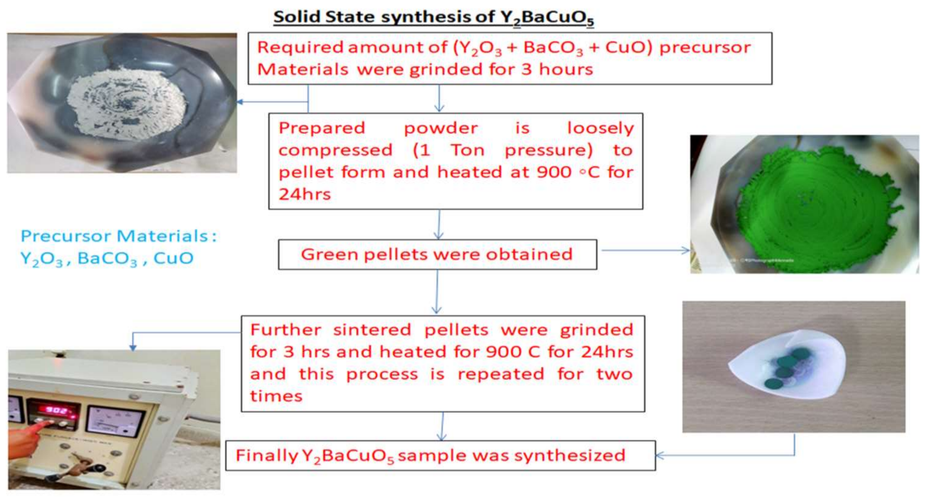

Fig.1

Introduction

- The ever growing demand for energy urges researchers to look for new materials and processes to develop highly improved energy storage devices.
- Although global production of sustainable energy is increasing, its intermittent nature requires effective energy storage. Among several options available electrochemical energy storage has several advantages. More specific Li-ion rechargeable batteries are interesting candidates to fulfil the need due to their high energy and power density.
- Also known as Ultra capacitor Energy storage device having similarities with both batteries and conventional capacitors.
- Unlike batteries SCs store electrical energy not chemical energy.
- Unlike capacitors, supercapacitors contains moving ions.
- Having capacitance value much higher than other capacitors
- It typically stores 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries, and tolerates many more charge and discharge cycles than rechargeable batteries.

Motivation/Objective

- Conventional Li-ion batteries use an organic polymer electrolyte which exhibits several safety issues like:
  - Leakage
  - Flammable
  - Poor chemically stable
- In liquid electrolytes Li ions and anions are mobile causing severe concentration gradient of the conducting salts during the current flow, thus limiting the cell current.
- To overcome these defects, there is a need for solid electrolytes as it can operate at high voltage thus producing high power density.
- Preparation and characterization of transition metal oxide material for better solid electrolyte applications to be used in supercapacitors.
- Have high energy storage capacity, compared to electrolytic capacitors and batteries because of the use of activated carbon which increases the capacitance value.
- Long shelf life as compared to batteries.
- In batteries, the energy is stored and released via a chemical reaction inside electrode material which causes degradation.
- Supercapacitors can recharge in short time, and supply high and frequent power demand peaks.
- Supercapacitors have high power density and can provide large power burst for short duration.

Need for Y_2BaCuO_5

- insulator phase of $YBa_2Cu_3O_{7-x}$ high-temperature superconductors
- reported as a new material for a microwave dielectric resonator
- high electrochemical stability,
- catalytic activity
- low electric resistivity,
- low thermal conductivity

Results

XRD

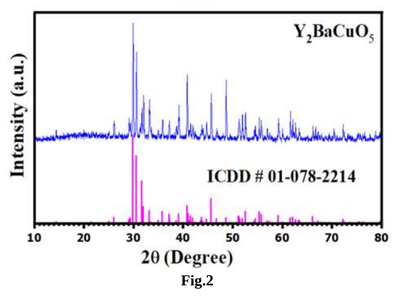

Fig.2

SEM

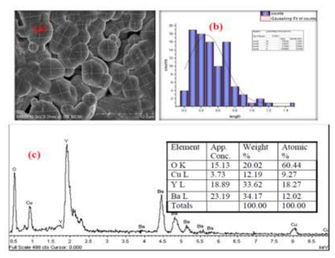

Fig.3

Impedance Analysis

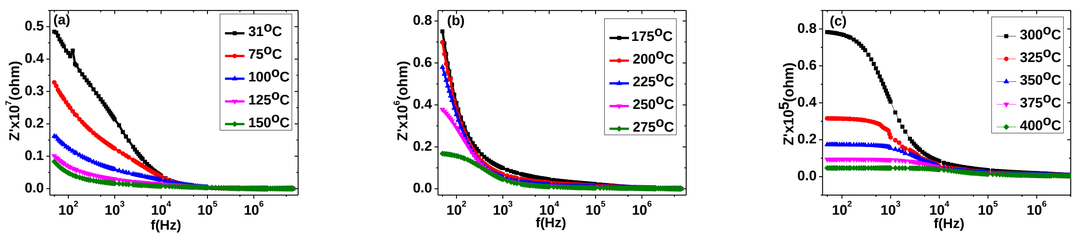

Fig.4

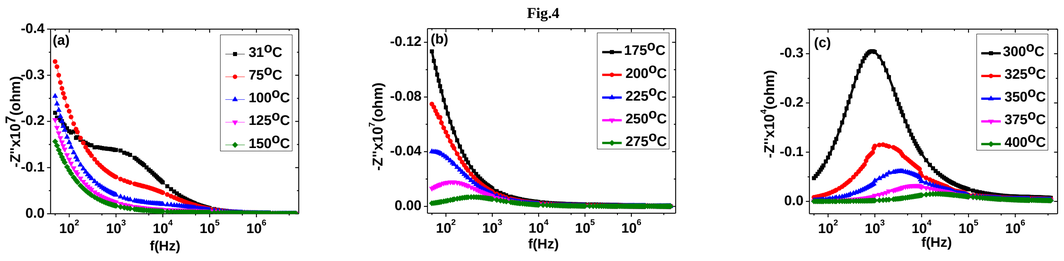

Fig.5

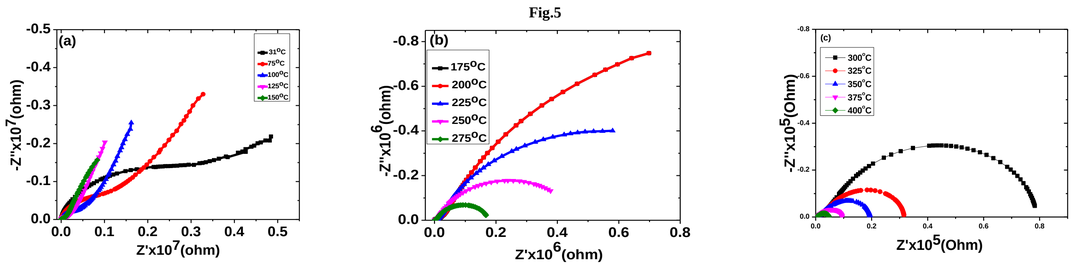

Fig.6

Conclusions

- The XRD data confirms the formation of single orthorhombic crystal phase with Pnma space group of the prepared Y_2BaCuO_5 sample.
- From the SEM images it is observed that the prepared sample is slightly porous in nature with well defined micron size grain growth occuring due to the crystallization of the sintered Y_2BaCuO_5 sample pellet.
- EDS spectra showed the existence of Y, Ba, Cu and O elements in the prepared Y_2BaCuO_5 sample pellet.
- Impedance data analysis indicates that the ionic conductivity of the samples increases with increasing temperature.

References

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