American Journal of Engineering and Applied Sciences

Original Research Paper

Electrical Properties of Cobalt Oxide/Silica Nanocomposites Obtained by Sol-Gel Technique

[1,2]Gomaa A.M. Ali, [3]Osama A. Fouad and [4,5]Salah A. Makhlouf

[1]*Department of Chemsitry, Faculty of Science, Al-Azhar University, Assiut, Egypt*
[2]*Faculty of Industrial Sciences and Technology, University Malaysia Pahang, Kuantan, Malaysia*
[3]*Central Metallurgical Research and Development Institute, CMRDI, Helwan, Egypt*
[4]*Department of Physics, Faculty of Science, Assiut University, Assiut, Egypt*
[5]*Deanship of Scientific Research, Al Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia*

Article history
Received: 17-10-2015
Revised: 21-10-2015
Accepted: 14-11-2015

Corresponding Author:
Salah A. Makhlouf
Department of Physics, Faculty of Science, Assiut University, Assiut, Egypt and
Deanship of Scientific Research, Al Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia

Email: smakhlouf@gmail.com

Abstract: This work is an extension of our previous studies on cobalt oxide nanoparticles impeded in a silica matrix. Here we study the preparation and characterization of high cobalt content materials (60-90 wt%). In addition, the DC electrical conductivity of the prepared materials in a wide temperature range (350-673 K) was measured and discussed. The activation energy has been obtained according to Mott's Small-Polaron Hopping (SPH) and Mott's and Greaves Variable Range Hopping (VRH) models.

Keywords: Sol-Gel, Cobalt Oxide/Silica, Nanocomposites, Electrical Conductivity

Introduction

Different preparation methods were reported for cobalt oxide nanoparticles embedded in a silica matrix such as sol-gel (Santos *et al*., 2012; Cantalini *et al*., 2005), hydrothermal (Kogelbauer *et al*., 1995; Bhoware and Singh, 2007), grafting, immobilization (Bhoware and Singh, 2007) and direct solution impregnation (Ming and Baker, 1995) methods. Among all of these techniques, sol-gel is considered as the most effective one producing mesoporous structures and fine particles (Cantalini *et al*., 2005; Fouad *et al*., 2011; Santos *et al*., 2012). Cobalt silica composite materials have been widely studied for many technological applications such as catalysis (Ming and Baker, 1995), humidity and gas sensing (Fouad *et al*., 2012; Cantalini *et al*., 2005), super capacitance (Ali *et al*., 2014). Cobalt oxide is an active material having multi oxidation states and silica has a porous structure, so the composite of cobalt oxide and silica would pocess interesting properties. Silica was found to be an excellent host material which offers homogenous distribution of the guest particles and prevents particle's growth and leading to the formation of highly dispersed nanocomposite materials.

Two main models have been reported to study the conductivity in transition metal oxide: Small-Polaron Hopping (SPH) and Variable Range Hopping (VRH) models at high and low temperatures, respectively (Ali *et al*., 2013; Hazra *et al*., 1995; Yildiz *et al*., 2009). Where, the electrical conduction takes place by the hopping movement of small polarons between two different oxidation states of the transition metal ions at high temperatures.

This study aims to prepare materials with high content of cobalt oxide dispersed in a silica matrix and study their electrical properties. The conduction mechanisms at high and low temperature ranges are to be discussed.

Materials and Methods

The materials for this study have been prepared by sol-gel method. Alcoholic solutions of cobalt nitrate and TEOS were used as cobalt and silica source, respectively. The detailed experimental procedure has been reported in our previous reports (Ali *et al*., 2013; Fouad *et al*., 2012; 2011) and is described schematically in Fig. 1.