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Gas phase synthesis of metallic and bimetallic catalyst nanoparticles by rod-to-tube type spark discharge generator

Saeed Ahmad, Patrik Laiho, Qiang Zhang, Hua Jiang, Aqeel Hussain, Yongping Liao, Er-Xiong Ding, Nan Wei, Esko I. Kauppinen*

Department of Applied Physics, Aalto University School of Science, P.O. Box 15100, FI-00076 Aalto, Finland

*Corresponding author: E-mail address: esko.kauppinen@aalto.fi

Abstract

We report a novel design of spark discharge generator which consists of rod and tube electrodes for the gas phase synthesis of catalyst nanoparticles. We synthesized monometallic catalyst particles (Fe, Ni, Cu) and bimetallic particles (Co-Fe, Co-Ni) with the rod-to-tube type spark discharge generator (R-T SDG). Time stability and size distribution of the particles were studied by a scanning mobility particle sizer with an electrometer. We found that R-T SDG maintains a constant size distribution of the nanoparticles for 24 hours. These nanoparticles have a geometric mean mobility diameter of 5.17, 5.46, 4.54, 4.90, and 4.72 nm of Fe, Ni, Cu, Co-Fe and Co-Ni, respectively. A high-resolution transmission electron microscope (HRTEM) equipped with X-rays energy dispersive spectrometer (EDS) was used to obtain morphology, composition and structure of the nanoparticles. From HRTEM micrographs, we found separated nanoparticles and small agglomerates (< 8 nm), whereas EDS showed highly pure metallic and bimetallic nanoparticles. As an application of the aerosol produced catalyst nanoparticles, single-walled carbon nanotubes were synthesized using floating catalyst chemical vapor deposition technique with R-T SDG produced iron particles as a catalyst.

Keywords: Mobility diameter; Bimetallic nanoparticles; Carrier gas; Axial flow; SWCNTs

1. Introduction

Research on synthesis of nanoparticles has attracted considerable interest in the last few decades due to their widespread applications in the field of nanoelectronics (Millstone et al., 2010), biomedicine (Colombo et al., 2012), biotechnology (Chatterjee, Sarkar, Jagajjanani Rao, & Paria, 2014), solar technology (Abdin et al., 2013), sensor technology (El-Ansary & Faddah, 2010), optoelectronics (Tanabe, 2007), nano magnetism (Fernández-Pacheco et al., 2017), and catalysis (Moisala, Nasibulin, & Kauppinen, 2003). Because of their size-dependent catalytic activity and high surface area, they have shown unique properties in the field of catalysis

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