Materials Chemistry and Physics 114 (2009) 902–907

Contents lists available at ScienceDirect

Materials Chemistry and Physics

journal homepage: www.elsevier.com/locate/matchemphys

The synthesis of nickel nanoparticles with controlled morphology and SiO_2/Ni core-shell structures

Z. Libor, Q. Zhang*

Department of Advanced Materials, Cranfield University, Cranfield, Bedfordshire MK43 0AL, UK

ARTICLE INFO

Article history:
Received 26 August 2008
Received in revised form 1 October 2008
Accepted 27 October 2008

Keywords:
Spherical nickel nanoparticles
Star-shape nickel
Flower shape nickel
Magnetic materials
Zetapotential
Core-shell structure
SiO_2/Ni composite

ABSTRACT

The magnetic nanopowders can be potentially applied in wide range of fields such as magnetic storage, magnetic fluid, medical diagnosis, conducting paints, rechargeable batteries, optoelectronics, magnetic recording media, drug delivery system and catalysis. They have attracted interest in the past decade and have also been studied extensively because of their size- and shape-dependent physical-chemical and magnetic properties for applications in various useful technologies. In this work, we present our experimental results on the preparation of nanosized Ni nanoparticles with different shapes by using a wet chemical solution route. Ni nanoparticles were prepared by reducing a Ni-complex formed between nickel-acetate and hydrazine solution under basic condition. Then through the control of reaction temperature and ageing time, nanosized Ni particles with different morphologies could be formed. The morphology and sizes of synthesized nanostructures were studied by scanning electron microscopy (SEM). Structural properties of nanoparticles were examined by X-ray diffraction. We also report the core-shell structures of micro-composites of silica-nickel (SiO_2/Ni). The composite core-shell structures were formed by the control of the surface charges of particles in aqueous solutions. A specific composite (SiO_2/Ni) can be produced by controlling the surface charge, the pH and the molar ratio of the components. Core-shell structures are stable at room temperature.

1. Introduction

Nanomaterials have attracted interest in the past decade and have been studied extensively because of their size- and shape-dependent physical-chemical and magnetic properties for applications in various useful technologies. In recent years, with growing interest in building advanced materials using nanoscale particles, there is a need for general approaches to controlling the size and shape of nanocrystals [1,2]. Nanoscale metal materials have attracted much attention owing to their promising potential in magnetic storage, magnetic fluid, medical diagnosis and catalysis. Small metal particle arrays have been used to build single-electron devices [2–4]. More attention has been attracted on nanoscale magnetic transition metal-based materials, including Ni, Co and Fe duo to their magnetic properties and application potential. For such crystallites, the physical and chemical properties depend sensitively on particle size and shape [2–11]. In the last few years, nickel nanomaterials with the following shapes have been synthesized: nanotubes, nanorods, hollow spheres, nanobelts, nanoprisms, and hexagonal flakes [2–6]. Magnetic nanoparticles are being widely used in rechargeable batteries [7], optoelectronics [8], chemical catalysts [9], conducting paints [10], magnetic recording media, ferro-fluids, magnetic resonance imaging contrast enhancement, drug delivery [11] and magnetic hyperthermia [12,13]. Several methods have been developed to synthesize particles with controlled size and shape. These methods include photolytic reduction [14], radiolytic reduction [15], sonochemical method [16], solvent extraction reduction [17], microemulsion technique [18], polyol process [19], and chemical route [20]. Chemical control over the size and shape of nanocrystals presents a challenge to this field. Li et al. [21] have reported the synthesis of pure black powder Ni through reduction of aqueous $NiSO_4$ with hydrazine. Ni et al. [22] have synthesized distinct flowery shapes of Ni nanocrystals using a hydrothermal chemical reduction containing a mixture of $Ni(N_2H_4)_3^{2+}$ and $Ni(dmg)_2$ (nickel dimethylglyoximate) as the nickel source. In this paper, we report our experimental results on the preparation of nanosized Ni nanoparticles with different shapes by using a modified version of the wet chemical solution route used by Li et al. [21]. Through the control of reaction temperature and ageing time, nanosized Ni particles with different morphologies were prepared. We also report a core-shell structure of SiO_2/Ni composite synthesized by an electrophoretic method.

* Corresponding author. Fax: +44 1234751346.
E-mail address: q.zhang@cranfield.ac.uk (Q. Zhang).

0254-0584/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.matchemphys.2008.10.068

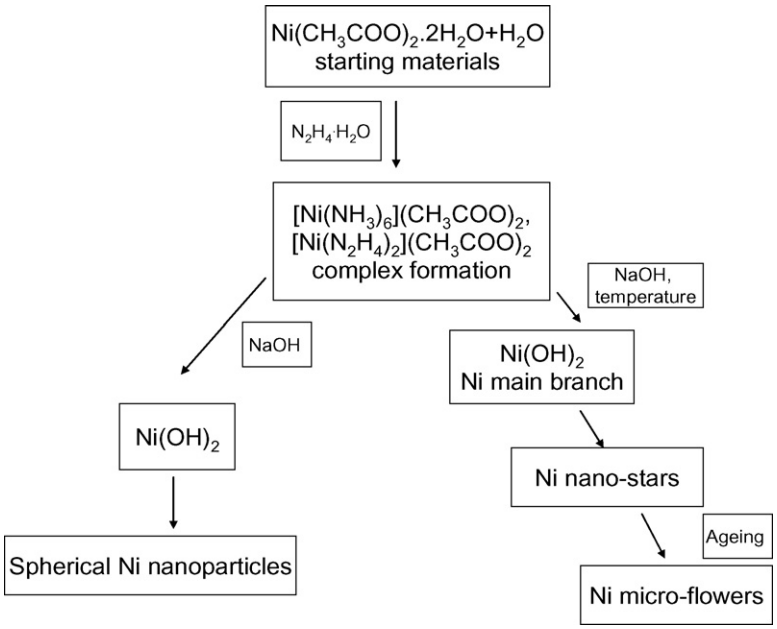

Fig. 1. Schematic illustration of the possible formation process of the spherical nickel nanoparticles and Ni nanostars- and microflower-structures.

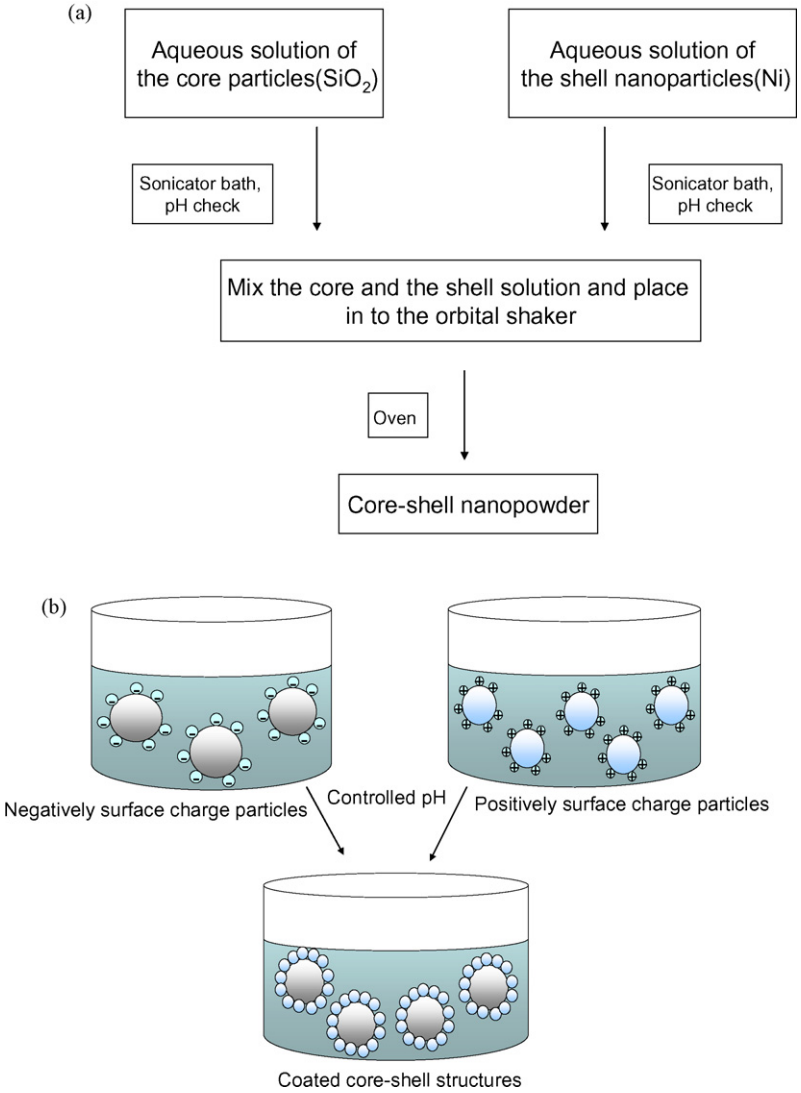

Fig. 2. (a) Synthesis route of core-shell particles; (b) schematic diagram of the formation of core-shell particles.