Chemical Engineering Journal 210 (2012) 157–165

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Role of polymeric surfactants on the growth of manganese ferrite nanoparticles

Tahereh Rohani Bastami [a,b], Mohammad H. Entezari [b,*], Qiu Hong Hu [a], Sandy Budi Hartono [a], Shi Zhang Qiao [a,*]

[a] ARC Centre of Excellence for Functional Nanomaterials, Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, QLD 4072, Australia
[b] Department of Chemistry, Ferdowsi University of Mashhad, 91775 Mashhad, Iran

HIGHLIGHTS

- The effect of polymeric surfactants was studied on the growth of manganese ferrite nanoparticles.
- Nanoparticles were formed by attachment and growth of primary building blocks.
- Particle size was dependent to the kind of surfactant and the time and temperature of the reaction.
- Nanoparticles were collapsed after reaching a critical size.
- More collapses between primary building blocks were observed by using PEG_{10000}.

ARTICLE INFO

Article history:
Received 13 May 2012
Received in revised form 2 August 2012
Accepted 9 August 2012
Available online 29 August 2012

Keywords:
Manganese ferrite
Growth kinetics
Polyethylene glycol
Ostwald ripening

ABSTRACT

The growth kinetics of manganese ferrite ($MnFe_2O_4$) nanoparticles was studied by solvothermal reaction of iron and manganese salts in ethylene glycol as a solvent. To explore the mechanism of the nanoparticle formation and development, polyethylene glycol (PEG) with different molecular weights and polyvinyl pyrrolidone (PVP) were used as polymeric surfactants to investigate their effects on the formation of $MnFe_2O_4$ nanoparticles. The size evolution and the size distribution not only dependent on the kind of surfactant but also on the time and temperature of reaction process. In the presence of low molecular weight PEG (PEG_{300}), nanoparticles with diameter of 180 nm and narrow size distribution could be produced at 160 °C during 12 h of reaction while the nanoparticles with average size of 330 nm were formed by using PEG_{300} at 200 °C and 48 h. Therefore, by increasing the temperature and the time of reaction, the size of nanoparticles was increased and finally reached a critical size and then collapsed. When a large molecular weight surfactant PEG_{10000} was used, the nanoparticles with average size of 230 nm were formed at 180 °C and 60 h. In the case of PEG_{300} and PEG_{10000} as lower and higher molecular weights, the separation between building blocks occurred after 60 h and 48 h for 180 °C and 200 °C, respectively. However, more collapses between primary building blocks were observed by using PEG_{10000}. The nanoparticles were composed of small building blocks and exhibited a spherical mesocrystal structure which was demonstrated from the TEM and scanning electron microscope (SEM) results. The investigation on the growth mechanism of the nanoparticles indicated that the formation of manganese ferrite was followed by the attachment and growth of primary building blocks and their Ostwald ripening process.

1. Introduction

Magnetic nanoparticles have attracted great interests [1–6]. One of the most important groups of magnetic nanoparticles is ferrite which has a very high magnetization value at room temperature [7]. Manganese ferrite ($MnFe_2O_4$) as a superparamagnetic nanoparticle has a very high magnetization capacity owing to its large magnetic spin magnitude [8]. It has been widely used in electronic [9,10], contrast-enhancement agents in MRI technology [11–13] and recording media [14]. However, magnetic properties of the nanoparticles and its application are strongly dependent on the size, shape, morphology and crystallinity of the nanoparticles [15–19]. Manganese ferrite nanoparticles with different sizes and morphologies have been synthesized by different methods. Some of these methods include ball milling [20], co-precipitation of Mn^{2+} and Fe^{3+} in aqueous solution [21], reverse micelle [22,23], thermal decomposition [24–27], and solvothermal method [19]. The last method offers many advantages over the others such as its simplicity, high crystallinity of the products, capability to

* Corresponding authors. Tel.: +98 511 8797928 304; fax: +98 511 8795457 (M.H. Entezari), tel.: +61 7 33463815; fax: +61 7 22463973 (S.Z. Qiao).
E-mail addresses: moh_entezari@yahoo.com (M.H. Entezari), s.qiao@uq.edu.au (S.Z. Qiao).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.08.031