FePt NANOPARTICLES WITH A NARROW COMPOSITION DISTRIBUTION SYNTHESIZED VIA PYROLYSIS OF IRON(III) ETHOXIDE AND PLATINUM(II) ACETYLACETONATE

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Among many kinds of magnetic materials, $L1_0$-phase FePt shows almost the highest magnetic anisotropy resulting in high coercivity [1]. Thus, FePt has been intensively studied as material for magnetic recording media with a storage capacity of Tbit/in^2 [2]. After the IBM group reported the synthesis of FePt nanoparticles (NPs) in liquid phase using iron pentacarbonyl [$Fe(CO)_5$] and platinum(II) acetylacetonate [$Pt(acac)_2$] as precursors [3], a lot of groups investigated advanced synthetic methods and applications of FePt NPs. FePt shows a high maximum energy product (BH)max of 13 MGOe [4]. Therefore, FePt NPs are also attractive materials for medical [5] or nanocomposite [6] applications. Additionally, FePt is a promising material as catalyst for fuel cells [7].

For the above-mentioned applications, there are several requirements for FePt NPs. First of all, although a smaller size is better, the diameter of NPs should be larger than the superparamagnetic limit, ca. 3.3 nm, if one wants FePt NPs to be ferromagnetic [8]. Secondly, the size distribution of NPs should be narrow enough for the application. Thirdly, undesirable sintering between each NP, that takes place when NPs are annealed in order to transform the crystalline structure from the chemically disordered fcc to the chemically ordered fct ($L1_0$ phase), should be avoided. Finally, the Fe_xPt_{100-x} NPs should be within the composition of $40<x<60$ to be transformed into the $L1_0$ structure according to the phase diagram [9].

Although various synthetic methods have been proposed to fulfill some of these requirements, to the best of our knowledge, to date, none of them succeeded to meet all the requirements simultaneously. For example, in the case of the most popular synthetic method in which $Fe(CO)_5$ is used as a precursor, besides the drawbacks of high toxicity and high flammability, the atomic composition distribution of FePt NPs (mean diameter 3 nm) is extremely broad and the fraction of Fe_xPt_{100-x} NPs which are within a composition of $40<x<60$ was reported to be less than 30 % [10].

Here, we report the synthesis of FePt NPs using iron(III) ethoxide [$Fe(OEt)_3$] and platinum(II) acetylacetonate [$Pt(acac)_2$] as precursors without any reducing agent. By using $Fe(OEt)_3$ and $Pt(acac)_2$ as precursors, monodispersed equiatomic colloidal FePt NPs of 4.5 nm mean diameter were chemically synthesized without reducing agent (Fig. 1). TEM-EDX analysis of single NPs revealed that the composition distribution among NPs was much narrower than that of NPs synthesized via a conventional method using $Fe(CO)_5$ as a Fe precursor. The fraction of Fe_xPt_{100-x} NPs, which were within an appropriate composition range to be transformed into the $L1_0$ phase, was found to be over 70 % (Fig. 2). The reason why such narrowed composition distribution was obtained might be related to synchronization between thermal decomposition of $Fe(OEt)_3$ and reduction of $Pt(acac)_2$. By annealing FePt NPs at 600 °C for 30 min, as-synthesized fcc-phase FePt NPs were transformed into $L1_0$-phase and showed coercivity of 11.2 kOe. The synthetic route proposed in this study is easy and robust

enough in view of a composition control compared with other existing methods. Moreover, the precursor is less toxic and easy-to-handle.

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Figures:

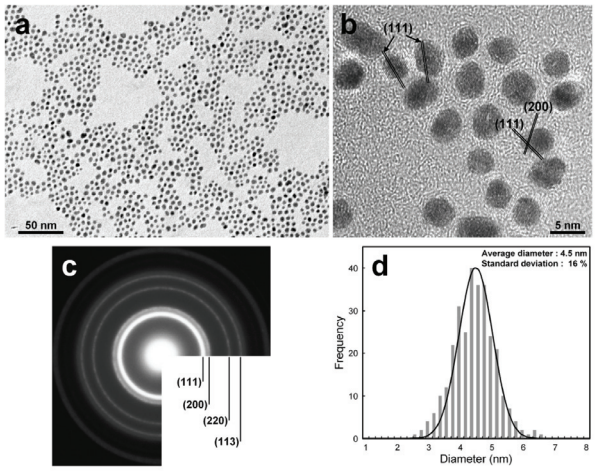

Fig. 1. (a) Low and (b) high magnification TEM micrographs of as-synthesized FePt NPs. (c) SAED pattern and (d) size distribution of as-synthesized fcc-FePt NPs.

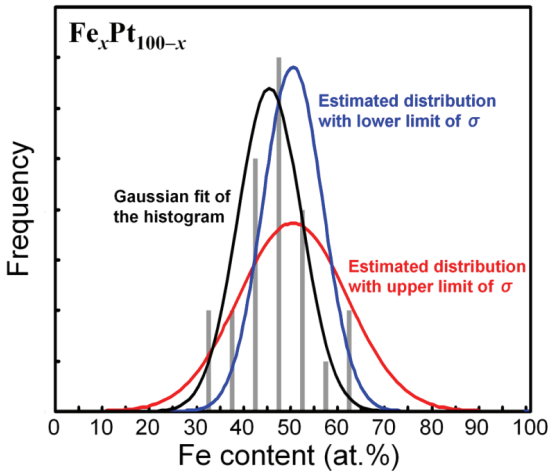

Fig. 2. Composition distribution obtained from 23 NPs individually analyzed by TEM-EDX. Black curve is the Gaussian fit of the histogram. Red and blue curves respectively represent the estimated broadest and narrowest distributions of the parent population with 95 % confidence level. Note that these two curves are normalized in order that the area equates to that of the Gaussian fit of the histogram (black curve).