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Research articles

Effect of corrosion methods on morphology of superparamagnetic and flexible iron oxide nanobrushes

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ABSTRACT

Superparamagnetic iron oxide nanobrushes with different morphologies prepared using an anodic aluminum oxide Template (AAO) template. Flexible polymers and the precursor iron oxide nanoparticles coated with polyacrylic acid (PAA) were assembled into iron oxide nanobrushes. The iron oxide nanobrushes with different morphologies were obtained by etching the alumina template with different degrees. The morphologies of the iron oxide nanobrush arrays were characterized with field emission scanning electron microscope (FESEM). The hysteresis loops of the iron oxide nanobrush arrays were measured using vibrating sample magnetometry (VSM), where the coercivity and remanence are almost zero, to achieve a typical superparamagnetism. The contact angle test shows that the iron oxide nanobrushes have hydrophilicity. These superparamagnetic and flexible iron oxide nanobrushes might be used in self-cleaning surfaces and sensors driven by a magnetic field.

1. Introduction

In the past few years, magnetic nanowires have been developed for a wide range of applications, including sensors [1–3], microfluidics [4,5], biomedical materials [6,7] and photonics [8]. Compared with traditional materials, nanomaterials have smaller sizes and larger specific surface areas, which endow them with many novel properties, including optical, electrical, thermal and magnetic properties. Nanowires, made from materials such as iron oxide, have received significant attention as useful candidates for many fields because of their biocompatibility and magnetic properties. Iron oxide nanowires prepared by Kumeria et al. [9] can efficiently act as drug carriers with triggered payload release and magnetothermal heating features for potential anticancer therapeutics applications. Iron oxide nanowires made by Hong et al. [10] could be used as a high capacity anode for lithium-ion batteries.

Many methods have been used to fabricate iron oxide nanowires, including hydrothermal methods [11–14], electrospinning [15] and sol-gel methods [16]. However, the length and diameter of the iron oxide nanowires prepared by these methods are hard to control. We used a novel method combined with electrostatic assembly [17,18] and the anodic aluminum oxide (AAO) for the preparation of superparamagnetic iron oxide nanowires, with either positive or negative charges on their surface. The ordered iron oxide nanowire arrays we fabricated is not only have highly persistent superparamagnetic, but also have tunable diameters and lengths. Our previous study [19] found that the formation and morphology of iron oxide nanowire arrays was affected by four factors, namely, the concentration of iron oxide nanoparticles, the pore diameter of the AAO template, the charge ratio of iron oxide nanoparticles and PDADMAC, and the molecular weight of polyacrylic acid. However, there have been few discussions regarding about the effects of different corrosion conditions on the morphology of nanobrushes.

In this work, we demonstrate a low cost method to fabricate iron oxide nanobrushes with superparamagnetic and hydrophilic. We obtain the iron oxide nanobrushes by growing in an AAO Template via the chemical corrosion method. Meanwhile, we study found the influence of some factors on the morphology of the iron oxide nanobrushes, including etching solution and corrosion time.

2. Fabrication

In this study, we report a novel and effective approach for the formation of iron oxide nanowires. The process of iron oxide nanoparticle and polymer assembly into iron oxide nanowires is shown in Fig. 1. To improve their stability, the iron oxide nanoparticles were coated with poly(acrylic acid) using the precipitation dispersion technique. Salt solutions of iron oxide nanoparticles and polymers were prepared

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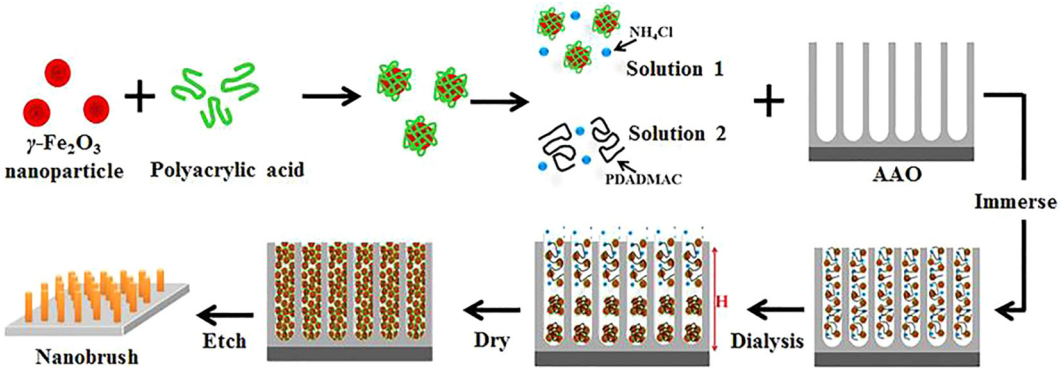

Fig. 1. Fabrication process of iron oxide nanobrushes.

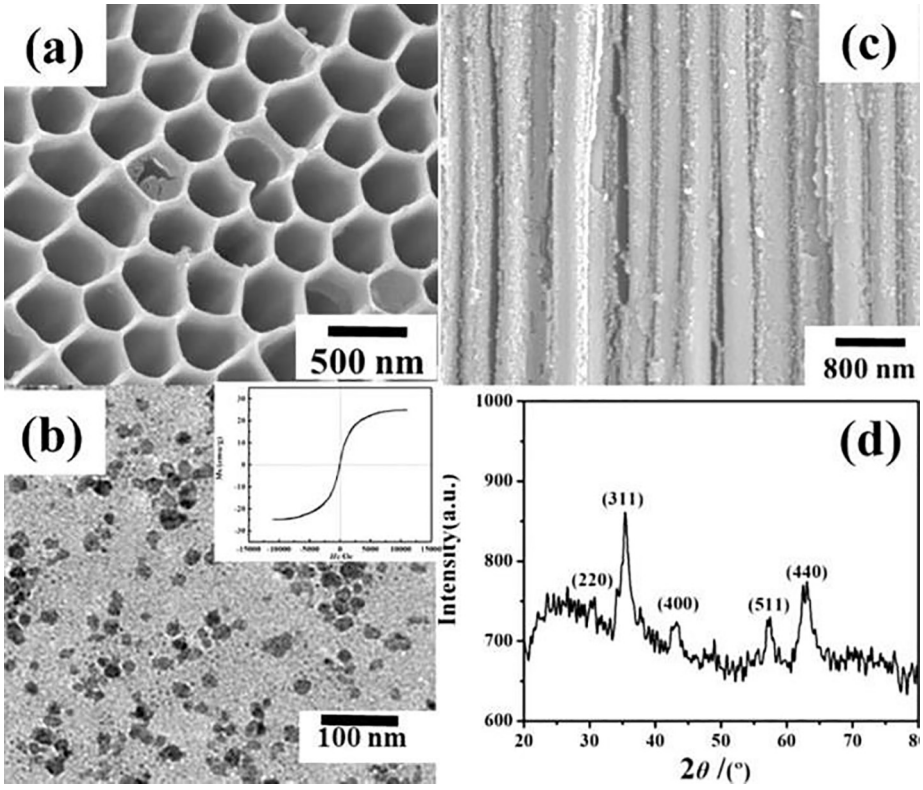

Fig. 2. (a) Micrographs of AAO template with a diameter of ~400 nm. (b) The transmission electron microscopy image of iron oxide nanoparticles. (c) Typical FE-SEM images of iron oxide nanowires assembled with iron oxide nanoparticles and PDADMAC with an AAO template pore diameter of 400 nm. (d) XRD pattern of iron oxide nanoparticles without coating.

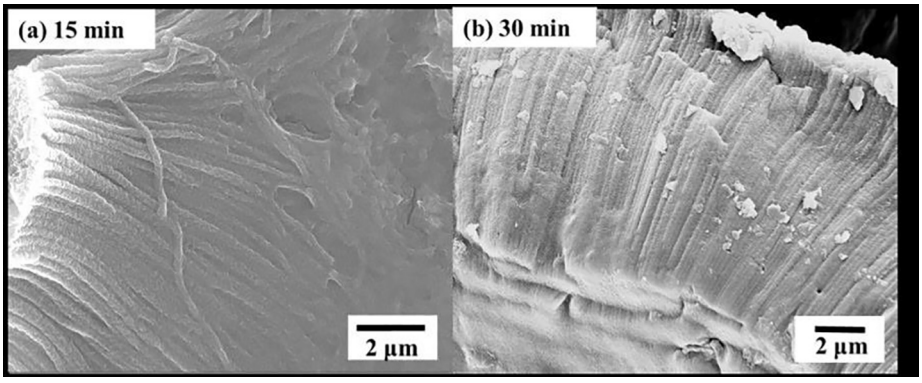

Fig. 3. SEM images of morphology of nanowires etched with 0.05 wt% sodium hydroxide solutions at different times.

respectively. Afterwards, a solution was made using a mixture of the foregoing two solutions under a certain charge ratio Z with quick stirring throughout the process. The AAO template prepared by improved Hard Anodization [20] or commercially available is soaked into the solution to ensure the iron oxide nanoparticles and polymer are adequately filled with AAO template holes. After that, it was placed in ultra-pure water to dialysis for a period of time with a 0.5 T magnetic field throughout the whole process. In the dialysis process, ordered iron