Green electrochemical template synthesis of CoPt nanoparticles with tunable size, composition and magnetism from microemulsions using ionic liquids

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Abstract

In the last decades, the use of nanomaterials has become a burgeoning topic since given their extraordinary and unusual physical and chemical properties numerous potential applications in catalysis, biological labeling, photonics, optoelectronics, and information storage, among others fields are continuously emerging. It is well known that the composition, crystal phase, size and size distribution of the nanoparticles are key factors that determine their properties [1, 2]. However, thermal treatments at high temperatures are often necessary in order to obtain specific crystal phases in nanoalloys. These post-synthesis treatments often affect the particle size, structural properties and particle distribution sizes [3]. Therefore, the synthesis of nanoparticles of customized size, composition and shape has long been a scientific and technological challenge.

In this work, a new versatile, environmentally friendly, simple, inexpensive, easily scalable synthesis pathway is presented which combines the potential of the electrodeposition techniques with the possibility of using ionic liquid microemulsions as micro/nanoreactors (Figure 1). Notably, microemulsions are a well-established synthesis procedure to prepare homogeneous and monodisperse small nanoparticles of metals, metal oxides and other inorganic materials [4]. Therefore, electrodeposition in combination with microemulsions offers both economic and environmental benefits because it is simple, easily scalable; it implies a low setup cost and avoids the use of aggressive chemical reducing agents [5].

The proposed method allows producing alloyed nanoparticles with sizes ranging from less than 10 nm to over 120 nm and excellent size distribution using different aqueous solution/ionic liquid/surfactant W/IL/S (CoPt aqueous solution/ bmimPF_6/ Triton X-100) microemulsions. Importantly, the stoichiometry of the nanoparticles can be directly controlled by the Co/Pt ratio in the nanoreactors. In contrast with water-in-oil microemulsion systems, the higher conductivity of the ionic liquid compared to oil substantially increases the deposition rate when used electrochemically, hence, making the process more attractive for production. We have demonstrated that the magnetic properties of the nanoparticles can be tuned in a straight forward way by adjusting the synthesis conditions. Figure 2 shows that the magnetic response ranges from superparamagnetism (smaller nanoparticles) to hard magnetic (H_C = 4100 Oe). Remarkably, these appealing magnetic properties are obtained in the as-grown state (i.e., without post-annealing) as opposed to many other hard magnetic materials.

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Figures

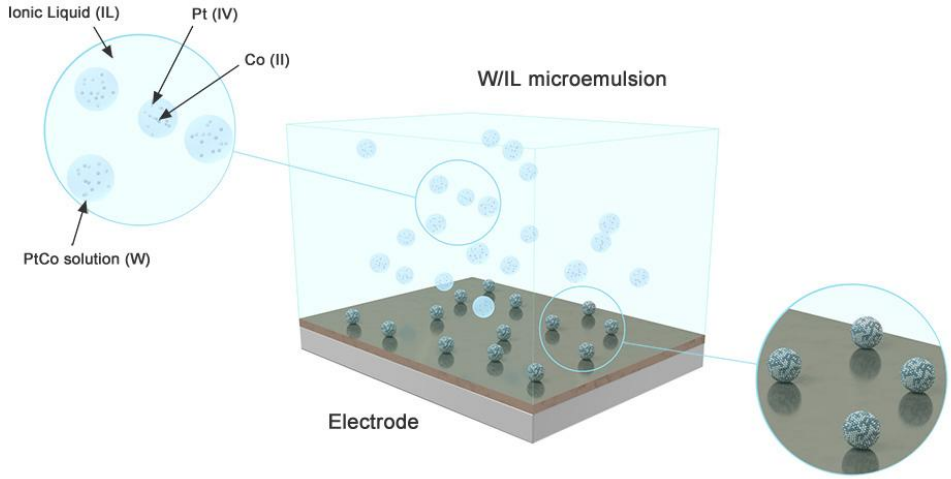

Figure 1: Schematic representation of electrochemical synthesis of magnetic CoPt nanoparticles in W/IL microemulsions.

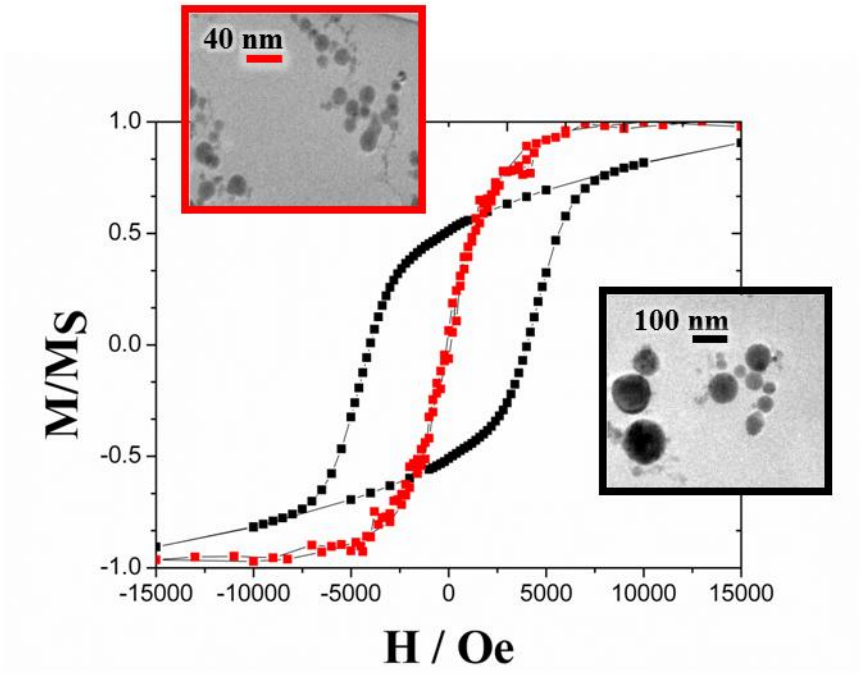

Figure 2: Magnetic behavior of CoPt alloyed nanoparticles.