Synthesis of highly anisotropic metal nanomaterials by the tuning of solvent circumstances

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Abstract:

The present thesis is concerned with synthesis of highly anisotropic metal nanomaterials by the tuning of solvent circumstances. Three parts of works are listed as follows:

1D self-assembly of gold nanoparticles induced by interactions between triphenylene ligands

Inducing nanoparticles into well-ordered one-dimensional (1D) arrangement has received significant attention in recent years owing to their unique transport properties. In present research, I first synthesized a series of gold nanoparticles stabilized by triphenylene (TP) as a discotic liquid crystal molecule (AuTP). The self-assembly structure of AuTPs could be controlled between the 1D striped and *hcp* arrangements by the tuning of the π-π interaction among the adjacent TP ligands on a particle surface. In particular, the following 2 points were essential for the 1D arrangement of AuTP: 1) the sufficient free space around the TP moieties, which easily allows the TP ligands on the adjacent Au nanoparticles to intercalate, 2) the adjustment of the solvent hydrophilicity ratio between methanol and toluene to promote strong π electronic, *inter*molecular *full*-stacking interaction of TP moieties among AuTPs. This free space around the TP moieties was controlled by the metal core size and the alkyl chain length of TP ligands. AuTP*8*-2.4 and AuTP*12*-2.8 formed highly ordered 1D arrangements. I demonstrated definite evidence by FL spectra and NMR that the conditions for TP ligands decide the self-assembly structure of metal cores. This concept is essential and applicable to a wide variety of nanoparticle systems.

A convenient method to synthesize single-crystalline Pt nanowires

The preparation of highly-controlled Pt nanostructures have attracted intense interest because of their novel physical and chemical properties for a new generation of catalysts, electronics, and photonics. Especially, selective preparation of Pt nanowires with small diameter, high aspect ratio, and uniform orientation is hard to achieve, and still a challenging subject in the field of nanomaterials. Here, I first synthesize single-crystalline Pt nanowires with high aspect ratio of ca. 2nm diameter at room temperature in less than 3 hours. I have controlled key steps such as stabilization of Pt(0) nuclei, as well as sophisticated growth into nanowires. I tune the solvent polarity and amount of $NaBH_4$ to prevent Pt(0) nuclei from aggregation in alkaline conditions. Single-crystalline Pt anowires are produced after removing capping $NaBH_4$ by air oxidation with the aid of plausible adsorption of DMF on Pt{111} facetes. This method provides a clue for preparing a wide variety of shape-controlled metal nanocrystals, which may be useful in various fields, such as nanowire network electrodes, supracurrent devices, waveguides, hydrogen storage systems, nanosensors, biotransporters, etc.

New gold nanodisks prepared by UV irradiation in chloroform

Metal (specifically Au and Ag) nanodisks are being intensely studied since a few years ago, devoted to nanodisks are mainly motivated by their extremely interesting optical properties. In this work, I used one convenient method to synthesize gold nanodisks. Three critical strategies in the present preparation procedures are as follows. One is to stabilized Au particles by triphenylene moieties, which can harvest photons by aromatic rings and accelerate the change of shape. Second is to put the nanoparticles into Chloroform. Chloroform can have a chemical reaction with Au nanoparticles. Third, is to irradiate AuTP solution by UV light. This is the first report to synthesize nanodisks by UV irradiation of metal nanoparticle stabilized by discotic liquid crystals.