

## A facile one-pot solution-phase route to synthesizing a novel composite hierarchical hollow structure: W18O49/WO2 Hollow Nanourchins

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To date, nanostructured tungsten oxides with a variety of stoichiometries, such as WO<sub>3</sub>, WO<sub>2.9</sub>, W<sub>18</sub>O<sub>49</sub>, and WO<sub>2</sub>, have been prepared, because they are promising candidates for applications such as gas sensors, photocatalysts, electrochromic devices, and field emission devices. Among them, W<sub>18</sub>O<sub>49</sub> and WO<sub>2</sub> have been widely studied due to their outstanding chemical sensing, catalytic, and electron emissive properties. Here we report, for the first time, a one-pot solution-phase route to synthesizing a novel composite hierarchical hollow structure without adding catalysts, surfactants, or templates. The products, consisting of a WO<sub>2</sub> hollow core sphere surrounded by a W<sub>18</sub>O<sub>49</sub> nanorod shell (yielding a sea urchin-like structure), were generated as discrete structures via Ostwald ripening. To our knowledge, this type of composite hierarchical core/shell structure has not been reported previously. The morphological evolution and the detailed growth mechanism were carefully studied. We also demonstrate that the size of the hollow urchins is readily tunable by controlling the reactant concentrations. Interestingly, although bulk tungsten oxides are weakly paramagnetic or diamagnetic, the as-prepared products show unusual ferromagnetic behavior at room temperature. The urchin structures also show a very high Brunauer-Emmett-Teller (BET) surface area, suggesting that they may potentially be applied to chemical sensor or effective catalyst technologies.

**Keywords:** tungsten oxide, nanomaterial, hierarchical structure

## Surface modification for block copolymer nanolithography on gold surface

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Block copolymer lithography has attracted great attention for emerging nanolithography since nanoscale periodic patterns can be easily obtained through self-assembly process without conventional top-down patterning process. Since the morphologies of self-assembled block copolymer patterns are strongly dependent on surface energy of a substrate, suitable surface modification is required. Until now, the surface modification has been studied by using random copolymer or self-assembled monolayers (SAMs). However, the research on surface modifications has been limited within several substrates such as Si-based materials. In present study, we investigated the formation of block copolymer on Au substrate by O<sub>2</sub> plasma treatment with the SAM of 3-(p-methoxy-phenyl)propyltrichloro-silane [MPTS, CH<sub>3</sub>OPh(CH<sub>2</sub>)<sub>3</sub>SiCl<sub>3</sub>]. After O<sub>2</sub> plasma treatment, the chemical bonding states of the surface were analyzed by X-ray photoelectron spectroscopy (XPS). The static contact angle measurement was performed to study the effects of O<sub>2</sub> plasma treatment on the formation of MPTS monolayer. The block copolymer nanotemplates formed on Au surface were analyzed by scanning electron microscopy. The results showed that the ordering of self-assembled block copolymer pattern and the formation of cylindrical nanohole arrays were enhanced dramatically by oxygen plasma treatment. Thus, the oxidation of gold surface by O<sub>2</sub> plasma treatment enables the MPTS to form the monolayer assembly leading to surface neutralization of gold substrates.

**Keywords:** block copolymer, lithography, gold