

Supporting Information

Chemical Functionalization of Magnetic Carbon-Encapsulated Nanoparticles Based on Acid Oxidation

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The functionalization effect on the Ni(C) nanocapsules was roughly assessed by dispersion experiments. For each case, about 5 mg sample was used. The raw, oxidized and ODA-grafted Ni(C) nanocapsules were ultrasonically dispersed in 10 mL of hexane/water (1/1 v/v) for 20 min respectively. After 5 min setting, the dispersion is shown in Figure S1. It's seen that the raw Ni(C) nanocapsules stayed in hexane (oil phase) at the hexane/water interface (Figure S1a-I), the oxidized ones dispersed in water (Figure S1a-II), while the ODA-grafted ones could generate a homogeneous dispersion in hexane (Figure S1a-III), even after 1 h setting. After 5 h setting, as seen from Figure S1b, the raw Ni(C) nanocapsules kept unchanged (Figure S1b-I), and large part of the oxidized ones settled at bottom (Figure S1b-II), while the ODA-grafted ones settled at the hexane/water interface (Figure S1b-III). The precipitated ODA-grafted Ni(C) nanocapsules could be easily redispersed under sonication. These results indicate that ODA-grafting could effectively improve the dispersion of the Ni(C) nanocapsules. The eventual precipitation of the functionalized Ni(C) nanocapsules should result from the thin thickness of the outer carbon shell or the relative large ratio of the inside Ni particles to the outer carbon shells for the raw Ni(C) nanocapsules we used (see Fig. 1c,d in the text). Due to the large density of nickel ($\sim 8.9\text{g/cm}^3$), the precipitation could not completely overcome by the ODA-grafting in our case. The soluble product might be obtained by using the Ni(C) nanocapsules with smaller ratio of Ni to carbon, i.e., with smaller inside Ni particles or thicker carbon shell. Actually, the carbon-encapsulated Ce_2C nanoparticles with high portion of carbon are stable in acidic solution for more than one month (Ref. 4c in manuscript), and ODA-grafted carbon nanotubes could generate a stable dispersion in many solutions (Ref. 23 in manuscript).

These experimental results also show that the raw Ni(C) nanocapsules could be regulated from hydrophobicity to hydrophilicity by acid oxidation due to the formation of hydrophilic functional group on surface, e.g. $-\text{COOH}$, then back to hydrophobicity by ODA-grafting for the hydrophobic alkyl group of ODA.

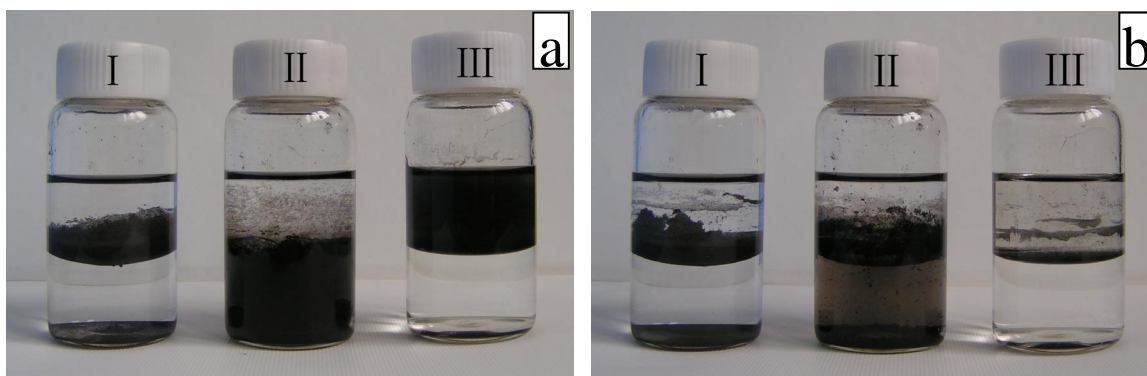


Figure S1 Dispersions of the raw (I), oxidized (II) and ODA-grafted (III) Ni(C) nanocapsules in hexane/water solution. Setting for 5 min (a) and 5 h (b) respectively. The upper part is hexane.

The functionalization on the outer carbon shell should not affect the inside Ni nanoparticles. The intuitionistic ferromagnetism of Ni(C) nanocapsules before and after functionalization was examined by the magnet attraction observation, as shown in Figure S2. It' seen that all the three samples could be effectively attracted by magnet, suggesting that the ferromagnetism of the inside Ni nanoparticles didn't change a lot, i.e., the inside Ni nanoparticles could be well protected. In principle, the influence of the surface functionalization on the magnetism of the inside magnetic particles could be evaluated by the comparison of the saturation magnetizations (M_z). Specifically, since the species from the functionalization are nonmagnetic, the reduced M_z due to the mass increase from such species, which is experimentally obtainable, could be quantitatively estimated. The deviation of this evaluated M_z from the measured M_z could be used to test the "well-protection" of the CENCs in future work.

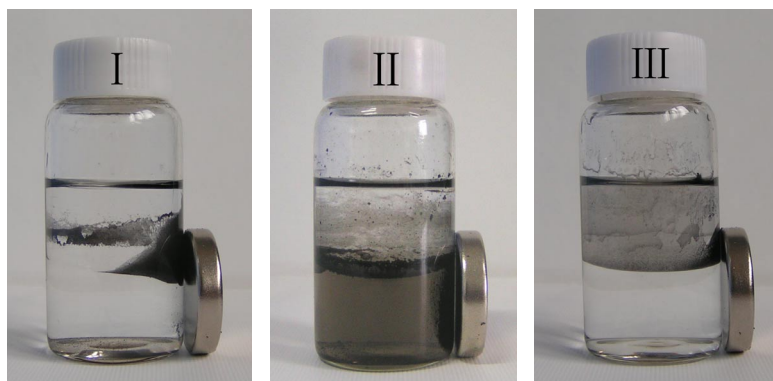


Figure S2 Magnet attraction observation of the raw (I), oxidized (II) and ODA-grafted (III) Ni(C) nanocapsules in hexane/water solution.