Tailoring of carbon-based nanomaterials by a dc arc discharge method: controlled synthesis and applications for environmental managements

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1. Introduction

Carbon-based nanomaterials have been emerging as promising candidates for the applications ranging from microwave absorbent, Li-ion batteries, catalyst support, drug/gene/RNA delivery carriers and wastewater treatment due to their remarkable physicochemical properties [1]. Up to date, different strategies have been developed to fabricate carbon-based nanomaterials, such as laser ablation, arc discharge plasma, chemical vapor deposition, hydrothermal process, radio-frequency thermal plasma and chemical reduction. Arc discharge is one of the most efficient approaches to fabricate carbon-based nanomaterials [2,3]. However, given the ultra-fast synthetic procedure, the understanding of the precise controllability of morphology and quality has been a long standing challenge. To better comprehend the tailoring mechanism of the nanomaterial growth in arc plasma, a series of synthetic parameters were investigated systematically in this study. The specific application of carbon-based nanomaterials in environmental managements was also investigated.

2. Experimental section

Carbon-based nanomaterials were prepared by using a one-step direct current arc discharge method. The anode was molded with metallic powder and graphite powder, and the cathode was a pointed graphite rod (50 mm×Ø10 mm, purity 99.9%). All system has been evacuated to several Pa and a gas mixture of He/CH_4 was flown to the chamber until the pressure reached given values. The arc discharge was generated by applying a high current of 120 A at 20 V between the two electrodes.

3. Results and discussion

Hollow carbon nanospheres (HCNSs, Figure 1) with controlled shell morphologies and qualities were successfully synthesized via a one-step copper-graphite arc discharge method by alternating the CH_4 concentration in the reactant gas mixture and the collecting zones with different distances from the arc center. Tailoring of graphite-encapsulated magnetic nanoparticles (GEMNPs, Figure 2) with controlled surface morphologies was also achieved via iron oxide-graphite arc discharge process by changing the synthetic parameters (i.e., the CH_4 concentration, collected zone and working gas pressure).

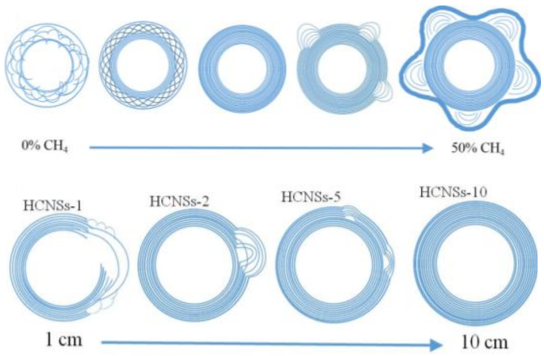

Figure 1. The schematic diagram of morphological evolution of HCNSs.

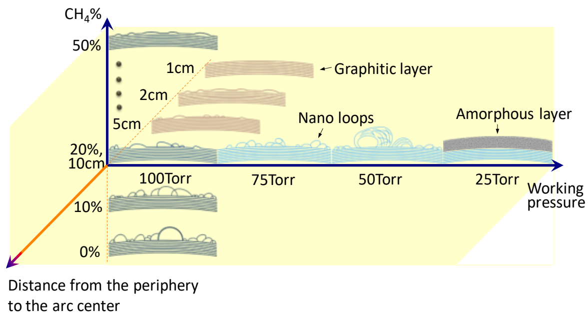

Figure 2. The schematic diagram of morphological evolution of coating graphite shells.

These results would bring a fundamental comprehension of the controllable fabrication of carbon-based nanomaterials. Very promisingly, this arc discharge strategy probably can be extended to the synthesis of other nanomaterials with controllable surface morphologies and properties. The adsorption performances of HCNSs and GEMNPs towards heavy metal ions and organic pollutants in the aqueous solutions for environmental managements were also evaluated in this study.

References

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