Electronic Supplementary Material (ESI) for Nanoscale.
This journal is © The Royal Society of Chemistry 2016

Supporting Information

Tunable Construction of Multishelled Hollow Carbonate Nanospheres and Its Potential Applications

Xiaoming Ma[a]*, Xiaoting Zhang[a], Lin Yang[a]*, Ge Wang[a], Kai Jiang[a], Geoffrey Wu[b], Weigang Cui[c], and Zipeng Wei[a]

a.Collaborative Innovation Center of Henan Province for Green Manufacturing of Fine Chemicals, Key Laboratory of Green Chemical Media and Reactions, Ministry of Education, School of Chemistry and Chemical Engineering, Henan Normal University, Xinxiang, Henan 453007, P. R. China

b. Center for Drug Evaluation and Research, Food and Drug Administration, 10903 New Hampshire Avenue, Silver Spring, MD 20993, USA

c. Department of human anatomy, Xinxiang Medical University, Henan 453003, P. R. China

* To whom correspondence should be addressed. Tel: +86-373-3326335; Fax: +86-373-3328507. E-mail: sunshinyma@hotmail.com

Table S1. Specific surface area, pore volume and average pores size of the hierarchically porous multi-shelled hollow $CaCO_3$ spheres.

Samples	BET Surface Area (m^2/g)	Pore Volume (cm^3/g)	Pore Size (nm)
SHCN	97.7	0.3	3.73, 14.21 and 65.54
DHCN	102.8	0.3	3.46, 14.28 and 60.34
THCN	135.2	0.5	3.91, 14.28 and 58.17

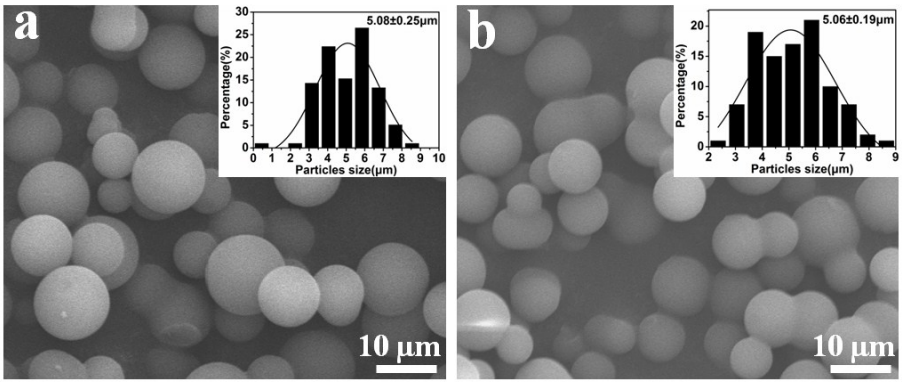

Fig. S1 SEM images of the CMSs (a) and T-CMSs (b). Insets show the particles size distribution of each condition.

Table S2. BET surface area and pore volume of the CMSs and T-CMSs.

Carbonaceous Nanospheres	BET Surface Area(m^2/g)	Pore Volume(cm^3/g)
As-prepared (CMSs)	1.87	0.0045
HCl-EtOH Treated (T-CMSs)	5.65	0.0048

Table S3. Amount of acetate calcium adsorbed into CMSs or T-CMSs under different conditions.

Samples	Adsorbing temperature (℃)	Amount of acetate calcium adsorbed (%)
CMSs	25	2.60
T-CMSs	25	4.48
T-CMSs	30	6.93

The amount of the precursor material calcium acetate adsorbed could be purposely modulated through different strategies: the diffusion rate of precursor ions and the adsorption ability of CMSs. The diffusion rate could be easily adjusted according to Arrhenius equation and could be achieved by regulating the adsorption temperature. Otherwise, to enhance the adsorption capacity of the CMSs, we modified the CMSs by immersing them in ethanol solution of 3 M HCl for 2 days (denoted as T-CMSs). Compared with the untreated CMSs, the morphology and size of T-CMSs nearly kept the same, while the specific surface area could be enhanced by 41.7 % (Figure S1 and Table S2). The amount of calcium ions adsorbed in each condition was analyzed using ICP-MS measurement after calcination of the CMSs-Ca^{2+} or T-CMSs-Ca^{2+} and dissolving the residue in 5 % HNO_3 solution (Table S3). The variation of calcium acetate incorporated in the CMSs directly played key roles in the formation of different-shelled porous hollow $CaCO_3$ spheres.

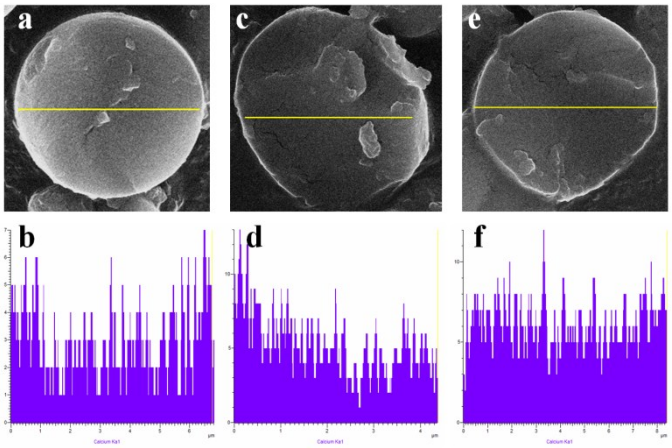

Fig. S2 FE-SEM and EDS line scanning of (a and b) the CMSs hemisphere adsorbed with acetate calcium at 25 ℃, (c and d) the T-CMSs hemisphere adsorbed with acetate calcium at 25 ℃ and (e and f) the T-CMSs hemisphere adsorbed with acetate calcium at 30 ℃.

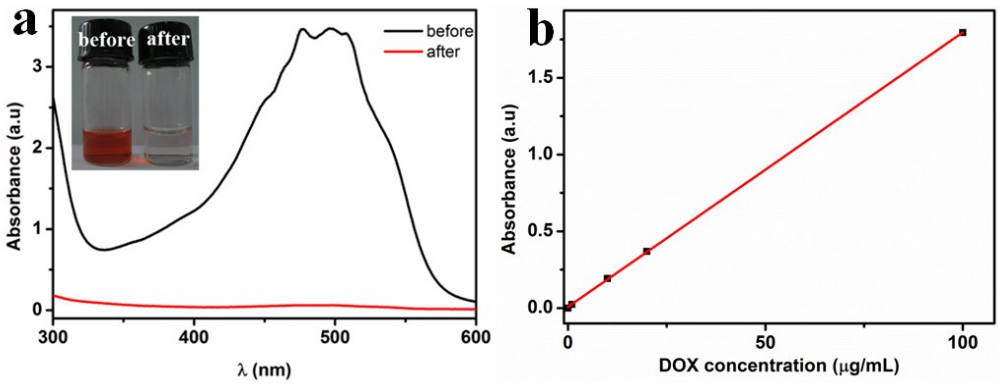

Fig. S3 (a) UV-Visible spectra of DOX solution before and after loading into the THCN (5 mg sample added into 5 mL DOX solution with a concentration of 250 μg/mL). Inset was the digital image of the corresponding solution. (b) Absorbance at 480 nm vs. free DOX concentration (optical path = 1 cm). Solid line is the liner fit using the analysis tool in Origin software and the R^2 = 0.9999.

Table S4. Amount of DOX adsorbed into single-, double- and triple-shelled hollow nanospheres under the same condition.

Samples	Amount of DOX adsorbed (μg/mg)
SHCN	110.26
DHCN	188.48
THCN	245.33

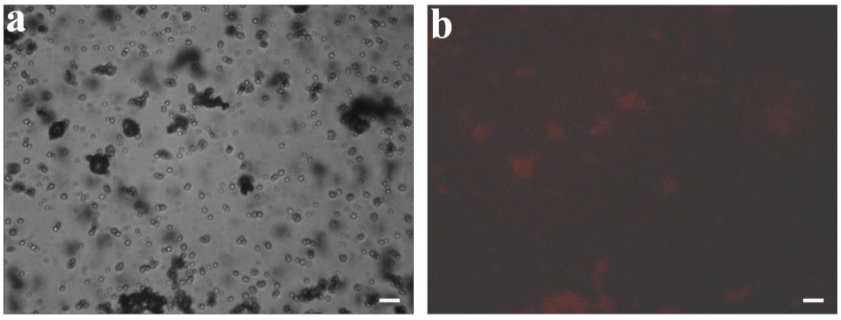

Fig. S4 CLSM images for the triple-shelled porous hollow $CaCO_3$ spheres loaded with DOX under visible light (a) and UV light (b), respectively (Scale bar: 1 μm).

The DOX loaded in the triple-shelled porous hollow $CaCO_3$ spheres was visualized by confocal laser scanning microscopy. Compared to the image under the visible light (Figure S4a), the image under UV light showed that the hollow $CaCO_3$ spheres exhibit strong fluorescence, indicating that

the DOX should be adsorbed inside the THCN (Figure S4b).

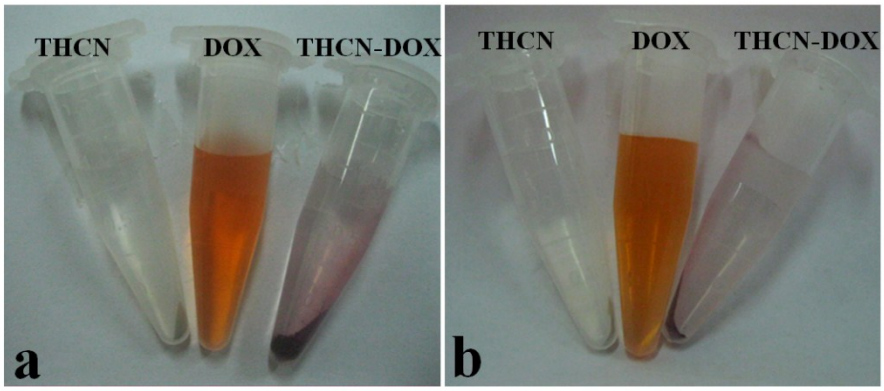

Fig. S5 Digital images of THCN, free DOX and THCN-DOX under centrifugation at the speed of 10000 r/min for 10 min. (a) was taken immediately after DOX loading experiment and (b) was obtained after storage for 10 days. No obvious DOX release was observed after storage for 10 days, indicating the stability of the THCN-DOX.

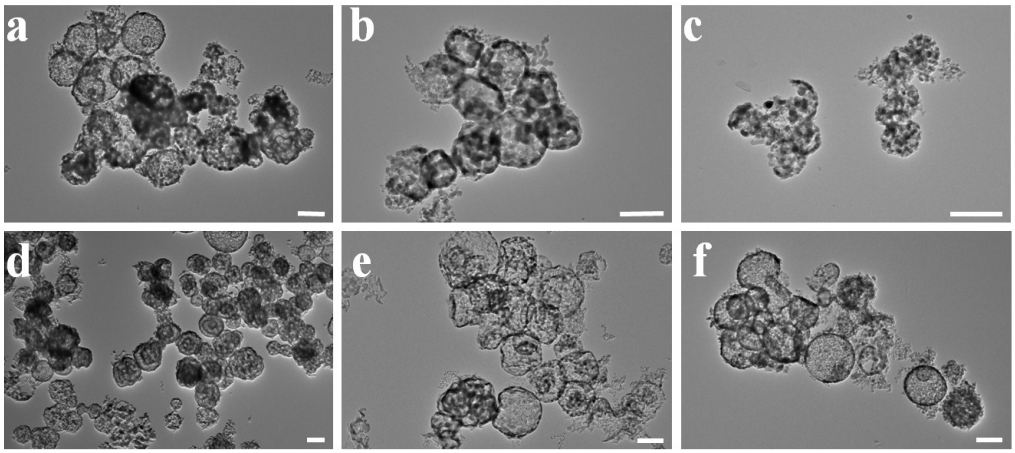

Fig. S6 TEM images of the THCN collected in the pH 4.5 (a, b and c) and 6.0 (d, e and f) environments at the point of release 5 h, 10 h and 20 h of DOX test at 37 °C, respectively. (Scale bar: 200 nm). The typical time-dependent TEM analyses show intuitively the decomposition process of the THCN at the acid environment.