Carbon coating for nano-rattle Sn@C composite anode material for alkali metal ion batteries

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Tin based alloy anode material undergoes huge volume expansion upon lithium ion insertion (up to 360%) which causes cracking of the active material, consequently leading to capacity fading. This greatly hinders the practical application of Sn as anode material in lithium ion batteries[1]. 'Nano-rattle' type Sn nanoparticles (NPs) encapsulated in a carbon shell are proposed here as they feature a buffer volume (void) to cope with the volume expansion problem.

Carbon coating: A reverse micelle micro emulsion technique has been adopted to form SiO_2 NPs in the first step[2], followed by hydrothermal carbonization to form carbon coating on silica NPs. The nano-rattle morphology is however difficult to obtain if the intermediate hydrothermal carbonization step does not yield a uniform carbon coating on the silica surface. This is why this study emphasizes on the variation of the pH, the concentration and the respective surface polarity values which influence the wettability, adsorption and aggregation properties[3].

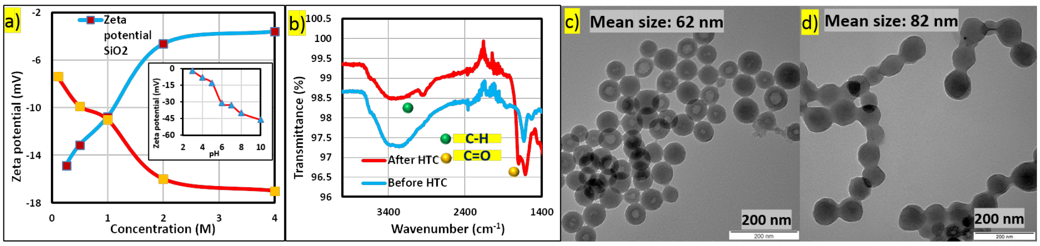

Figure 1: Graphs showing Zeta potential analysis (a) and FTIR (b), TEM images showing SiO2 NPs before (c) and after (d) hydrothermal carbonization Figure 1a shows the zeta potential measurements as a function of the concentration of silica and sucrose, which was used as carbon source. The inset graph shows that the silica suspension is more stable at high pH. The FTIR graph in figure 1b shows the presence of C=O and C-H bands after coating of sucrose on the surface of silica. The TEM images 1c and 1d show the as-formed silica NPs before and after hydrothermal carbonization, respectively. The particle size increased after the hydrothermal process, probably due to formation of a porous, spongy carbon shell.

Conclusion and perspectives: A thin and homogeneous carbon coating on the surface of single silica sphere can be formed by controlling silica surface and a well-dispersed suspension. Further steps are on-going to obtain Sn@C nano-rattles after the substrate etching process and Sn impregnation process. Finally, the electrochemical properties of the nano-rattle Sn@C composite electrode will be analysed by cycling at different C-rates.

[1] Besenhard, J. O.; Yang, J.; Winter, M.,*Journal of Power Sources* **1997**, *68* (1), 87-90.
[2]Priebe, M.; Fromm, K. M., *Particle & Particle Systems Characterization* **2014**, *31* (6), 645-651.
[3]Yu, L.; Falco, C.; Weber, J.; White, R. J.; Howe, J. Y.; Titirici, M.-M., *Langmuir* **2012,** *28* (33), 12373-12383.