# Mesoporous Tin Phosphates: Novel Anode Materials for Li Rechargeable Batteries

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Surfactants have been shown to organize silica into a variety of mesopore forms via the interaction with ionic species. This approach to mesostructured materials has been extended into other oxides and phosphates (with Al, Sn, Ti, etc.) which have applications with electronic or magnetic interactions. However, except for $AlPO_4$, other phosphates have not received much attention due to difficulty in forming the mesopores. Recently, Serre *et al.*[1] and Mal *et al.*[2] have reported hexagonal and cubic mesoporous tin phosphates with pore diameters less than ~4 nm using cethyl-trimethyl-ammonium bromide (CTAB). Although tin phosphate is one of promising candidates for anode materials for Li secondary battery, larger volume change from tin aggregation during lithium alloying/dealloying led to dramatic decrease in the Li-storage ability.

In this study, we drastically improved both the capacity and capacity retention of the conventional tin phosphate anode by introducing hexagonal and cubic mesopores with 2-10 nm pore size using surfactants as a structure-directing agent (Fig. 1). These mesopores play an important role in reducing aggregation of Sn particles into larger aggregates and acts as "buffer zone" accommodating the volume change of the tin during Li alloying/dealloying (Fig. 2).

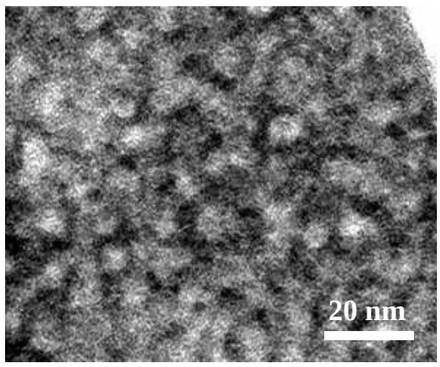


Fig. 1. TEM image of the annealed mesoporous tin phosphate.

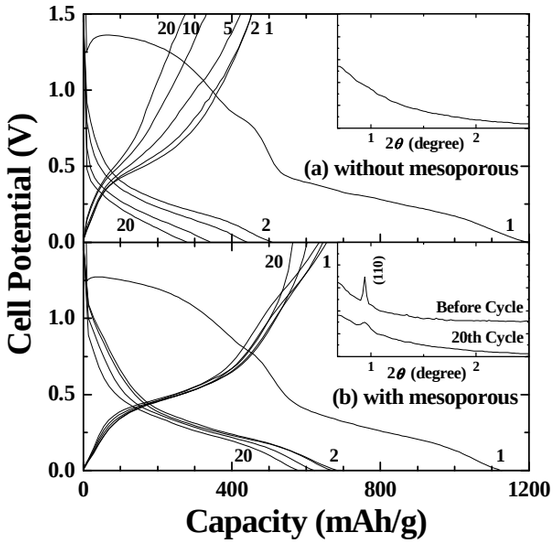


Fig. 2. Voltage profiles of (a) crystalline tin phosphate without meso-periodicity, and (b) mesoporous tin phosphate anode, in coin-type half cells during the 1st, 2nd, 5th, 10th, and 20th cycles between 1.5 and 0 V. The inset shows small-angle x-ray diffraction peaks before cycling and after the 20th cycling.

## References

1. Serre, C.; Auroux, A.; Gervasini, A.; Hervieu, M. ; Ferey, G. ; *Angew. Chem. Int. Ed.* 2002, **41**, 1594-1597.
2. N. K. Mal, S. Ichikawa, M. Fujiwara.; *Chem. Commun.* 2002, **112-113**.

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