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Project “New materials for future batteries”

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Events

Meng Li & Prof. Hyung Gyu Park introduce their NRP 70-relevant research achievement at SCCER Heat & Electricity Storage, 2nd Symposium: “Improved Energy Storage Density of Carbon-Nanotube-based Supercapacitors by a Pseudocapacitive Coating” on May 5, 2015, Villigen.

Opportunities and Risks of nano-LiMnPO₄:
 ionic diffusivity and life cycle assessments

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Olivine structure (LiMPO₄, M=transition metal): Excellent structural stability
 safe, performance, durability, low cost (requirements of advanced Li-ion battery)

Olivine Cathode material	Theo. capacity (mAh g ⁻¹)	Voltage (V vs. Li ⁺ /Li)	Theo. energy density (Wh kg ⁻¹)	Remark
LiFePO ₄	170	3.6	578	Facil synthesis, sub-micron particles
LiMnPO ₄	171	4.1	701	Difficult to synthesize, Reduce 20 % of cells

LiMnPO₄ nanoparticles **Carbon**

Opportunities of battery nanomaterials:
 Nanocomposite structure of nano-LiMnPO₄ and carbon
 Enhanced conductivity of Li⁺ and e⁻

Risks of battery nanomaterials:
 Life Cycle assessments in terms of environment

Opportunities of battery nanomaterial: nano-LiMnPO₄

1) Various shapes and sizes of LiMnPO₄ nanomaterials

2) Tap densities of nano and micron sized materials

	Micro-LiMnPO ₄		Nano-LiMnPO ₄			Nanocomposite	
	Cubic	Nano-rod	Elongated	Needle	Mixed	Compact	
Tap density (g/ml)	1.75	0.77	0.97	1.07	0.54	0.27	0.77
SSA (m ² /g)	0.92	14.2	26.8	28	67	30	6.28

2) Electrochemistry of LiMnPO₄ electrodes

i. Li⁺ ion diffusion in LiMnPO₄

LiMnPO ₄ particle shape	Surface area (cm ² /g)	Size (nm)	D ₀ (cm ² /s)	Li ⁺ diffusion direction
21.4	14	1.6 × 10 ⁴		
28.0	62	1.3 × 10 ⁴		
26.8	85	2.0 × 10 ⁴		
14.2	122	9.2 × 10 ⁴		

ii. Rate capabilities

Risks of battery nanomaterial: Life Cycle Assessment (LCA)

Environmental impact of LiMnPO₄

global warming (GWP), fossil depletion (FDP), freshwater acidity (FEP), freshwater eutrophication (FEP), human toxicity (HTP), marine acidity (MEP), marine eutrophication (MEP), metal depletion (MDP), ozone depletion (ODP), particulate matter formation (PMF), terrestrial acidification (TAP), terrestrial eutrophication (TEP), toxicity.

Summary

- The shape and size of LiMnPO₄ nanoparticles are controlled.
- The nanocomposite became 3 times denser than the mixed nanomaterials after the compact process.
- Li⁺ ion diffusion depends on the shape of LiMnPO₄. It occurred in a shorter length of a single nanoparticle.
- The full capacity of nanocomposite C-LiMnPO₄ is reached at C/20.

Acknowledgement

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Mengmeng Deng, Meng Li and Prof. Hyung Gyu Park participate in the 1st update collaboration meeting with Prof. Fromm's group on August 26, 2015, in Zurich.