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Prussian blue analogues as battery materials for energy science

Yutaka Moritomo

University of Tsukuba, Japan

Prussian blue analogues (PBAs: $\text{Na}_x\text{M}[\text{Fe}(\text{CN})_6]_y$, where M is a transition metal) have three-dimensional (3D) jungle-gym-type host framework and cubic nanopores, 0.5 nm at the edge. PBAs are promising cathode materials for lithium ion (LIBs) and sodium ion (SIBs) secondary batteries, [1-3] reflecting their nanoporous host framework. Actually, thin film of $\text{Na}_x\text{Co}[\text{Fe}(\text{CN})_6]_{0.90}$ shows high capacity of 135 mAh/g, [3] which is comparable to the value (= 140mAh/g) of actually-used LiCoO_2 . The thin film electrode exhibits a high capacity of 121 mAh/g (90 % of the OCV value) even at 60 C. The discharge curve exhibits two plateaus at 3.8 and 3.4 V. By means of ex situ X-ray diffraction and absorption measurements, we have ascribed them the redox processes of Fe and Co. [3]

The thin film battery electrode is a nice platform for energy science, because the electrode is free from carbon-based conducting material and polymer-based binder. With use of an optical battery cell and microscopy, we clarified the structural dynamics in the charge process (Li intercalation process) of $\text{Li}_x\text{Co}[\text{Fe}(\text{CN})_6]_{0.90}$. [4] We clearly observed phase separation into the Li-rich and Li-poor domains of order of 10,000 nm. With use of the inelastic X-ray scattering technique, we clarified that local structures around CO^{2+} and Co^{3+} in $\text{Na}_x\text{Co}[\text{Fe}(\text{CN})_6]_{0.90}$.

- [1] T. Matsuda and Y. Moritomo, Appl. Phys. Express 4 (2011) 047101
- [2] T. Matsuda, M. Takachi and Y. Moritomo, Chem. Comm. 49 (2013) 2721.
- [3] M. Takachi, T. Matsuda, and Y. Moritomo, Jpn. J. Appl. Phys. 52 (2013) 090202.
- [4] M. Takachi and Y. Moritomo, Sci. Rep. in press.

Biography

Yutaka Moritomo has completed his PhD in physics at the age of 27 years from University of Tokyo and postdoctoral studies from University of Tokyo. Now, he is the director of division of materials for energy storage and conversion, Center for Integrated Research in Fundamental Science and Engineering (CiRfSE), University of Tsukuba. He has published more than 300 papers (total citation is more than 20,000).

moritomo.yutaka.gf@u.tsukuba.ac.jp

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