Electrochemical Performance of K_xCoO_2 in Non-Aqueous K Cell

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Reversible potassium insertion into graphite has been reported for a negative electrode material of potassium-ion batteries in 2015, and our group has demonstrated that the potassium half-cell delivers reversible capacity of ca. 250 mAh g^{-1} and exhibits an enormously high rate performance.[1] The findings have opened the door for realizing high-voltage potassium-ion batteries. However, further developments of the positive electrode materials are required. Electrochemical studies on Li-ion and Na-ion batteries started with $LiCoO_2$ and $NaCoO_2$, respectively, and potassium-containing layered cobalt oxides, K_xCoO_2 have been already reported by Delmas in 1975,[2] the electrode performance has been never reported to our knowledge. In this study, reversible potassium intercalation into the K_xCoO_2 and its phase evolution were investigated in potassium cells for the first time.

$K_{0.31}CoO_2$ with P2-type structure was prepared by a conventional solid-state reaction with starting materials of KOH and Co_3O_4. The structure and composition were confirmed using X-ray diffraction (XRD) and inductively coupled plasma-optical emission spectrometry (ICP-OES). Figure 1 shows charge/discharge curves and rate capability of $K_{0.31}CoO_2$ electrodes tested in aprotic K cells at room temperature. Reversible K extraction/insertion from/into $K_{0.31}CoO_2$ are observed in the voltage range of 2.0-3.9 V and the cell delivers reversible capacity of 57 mAh g^{-1} and good rate performance with stepwise voltage profile, which would be related to K/vacancy ordering. Phase transition will be presented and discussed with *operando* XRD and electrochemical data.

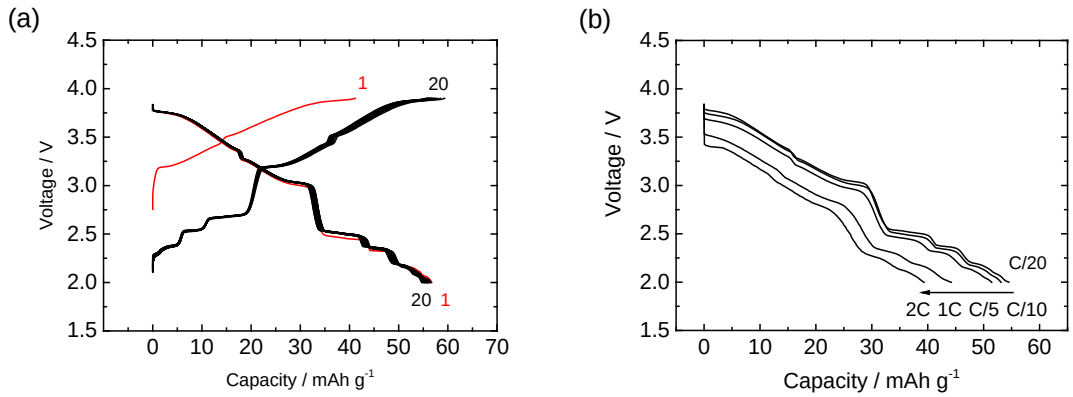

Figure 1. (a) Charge/discharge curves of K//$K_{0.31}CoO_2$ cell with 1 M KFSI EC:DEC at a current rate of 10.3mA g^{-1} in the voltage range of 2.0 – 3.9 V and (b) discharge curves at various C-rate of C/20 – 2C (1C = 236 mA g^{-1}).

References

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[2] C. Delmas, C. Fouassier, and P. Hagenmuller, *J. Solid State Chem.*, **13**, 165 (1975).