SBR-based Binders for High-voltage Positive Electrodes of Lithium-ion Batteries

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1. Introduction

Much attention are paid to aqueous binders because of the lower cost and organic solvent-free process compared to conventional PVdF binder. Styrene-butadiene rubber (SBR) latex binder, for example, is already used for negative electrodes of lithium-ion batteries in commercial production. We have taken advantage of SBR/sodium carboxymethyl cellulose (CMC) binders for $LiCoO_2$ electrodes to enhance cycle performance in high voltage [1]. In this study, we have applied SBR binders modified with different degree of cross-linkage or –CN group to LNMO electrodes and investigated the effect of SBR on electrochemical behavior.

2. Experimental

Positive electrode active material $LiNi_{0.5}Mn_{1.5}O_4$ (LNMO) was synthesized through solid state process [2]. Three kinds of SBR-based binders were used in this study: standard SBR (SBR_{std}), low cross-linked SBR (SBR_{low}), and SBR modified with -CN group (SBR_{CN}). PVdF or SBR/CMC binder, LNMO, and conductive agent (AB) were mixed into a slurry, which was coated on a Al foil substrate to form positive electrodes and dried for 24 h under vacuum. These electrodes were tested using 2032 coin cells with Li metal negative electrodes and 1 mol dm^{-3} $LiPF_6$/EC: DMC (1:1, v/v) by charge-discharge cycling between 3.5 and 5.0 V in CC mode.

3. Results and Discussion

Figure 1 shows 45 ^{o}C charge-discharge cycle performance of Li cells with LNMO positive electrodes containing SBR-based binders or PVdF. All cells with SBR-based binders retained more than 80% of the initial capacities after 50 cycles, which is superior to the cell with PVdF. Especially, the cell with SBR_{CN} containing -CN group shows the best retention. Soft X-ray photoelectron spectroscopy (SOXPES) and hard X-ray photoelectron spectroscopy (HAXPES) were applied to the electrodes sampled after 50 cycles. All of SOXPES O 1s spectra demonstrate apparent signals by the decomposition products of electrolyte solution between 534.1 and 532.5 eV of binding energy, while no signals by lattice oxygen from LNMO were observed at 530.1 eV. HAXPES O 1s spectra demonstrate clear signals by lattice oxygen in all spectra. However, the intensity for the signal in the SBR_{CN} electrode is very weak in comparison with that of the electrolyte decompositions. These result suggest that thick decomposition layer formed on LNMO in the SBR_{CN} cell is a excellent passivation layer with good diffusion rate of lithium ions and supports high-temperature durability. Further data will be shown and discussed in the poster.

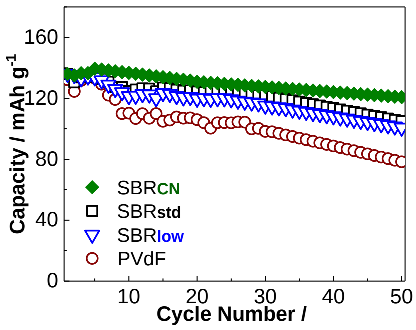

Fig. 1. Cycleability of LNMO electrodes with different binders at 45 ^{o}C.

References:

[1] N. Yabuuchi, S. Komaba *et al.*, *J. Electrochem. Soc*., 162 (4) (2015) A538-A544 .

[2] S. Patoux, S. Martinet *et al.*, *J. Power Sources*, 189 (2009) 344-352.