RE-SYNTHESIS OF $LiCoO_2$ EXTRACTED FROM DISCARDED BATTERIES WITH LOW AND HIGH STATE OF HEALTH

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1. Introduction

To avoid ambient contamination and for sustainability reasons, discarded lithium-ion batteries (LIBs) should be recycled. Although several recycling processes are already known, no consider the effect of the battery state of health (SOH) on them. $LiCoO_2$ compounds extracted from cathodes of discarded LIBs with low (L) and high (H) SOH were re-synthesized and its structural and electrochemical properties are discussed.

2. Experimental

The batteries' SOH were measured from charge-discharge cycles performed in the 4.2-3.6 V. Crystalline phases and the lattice parameters of the $LiCoO_2$ were identified from Rietveld x-ray refinements. The as-extracted $LiCoO_2$ compounds were thermally decomposed at 700 ^oC in O_2 atmosphere, whose products were submitted to a solid-state reaction with Li_2CoO_3 at 750 ^oC in O_2 atmosphere. Galvanostatic charge-discharge cycles in a re-synthesized $LiCoO_2$/Li cell furnished its charge capacity and voltage profile.

3. Results and Discussions

The compounds extracted from the L and H batteries were identified respectively as $Li_{0.73}CoO_2$ and $Li_{0.96}CoO_2$, that after thermal decomposition resulted in the Li_1CoO_2 and Co_3O_4 compounds, as reaction products. Co_3O_4 concentrations equal to 33.5% and 11.8% in wt were measured for L and H decomposed cathodes, respectively [1]. The solid-state re-synthesis reaction transformed Co_3O_4 into the stoichiometric Li_1CoO_2 compound.

The $LiCoO_2$ lattice parameters as a function of processing temperatures are shown in Figure 1. The *c* parameter, higher for $Li_{0.73}CoO_2$ than for $Li_{0.96}CoO_2$ as-extracted compounds, and the inverse behavior for the *a* parameter is an effect of electrostatic repulsion between the O-Co-O layers, upon Li removal [2]. A Li_1CoO_2 single phase with c=14.0496(5) Å and a=b=2.81412(5) Å was identified after the $LiCoO_2$ re-synthesized. The c/a = 4.99 and the x-ray peak intensity ratio I(003)/I(104) > 2.6 indicates a well ordered Li_1CoO_2 layered structure, with few or none cationic exchange.

The voltage profiles as a function of the specific discharge capacity is shown in Figure 2a shows for the re-synthesized Li_1CoO_2 electrodes. Higher specific charge capacities were measured for the electrode re-synthesized from the L cathode, Figure 2b. Specific charge capacities of 130.0 and 125.0 mAh g^{-1} were measured in the twentieth cycle for the re-synthesized L and H cathodes, respectively. We argue that the small size of the re-synthesized particles from the L cathode (as observed from SEM images) can explain the best performance of the corresponding Li_1CoO_2/Li cell, due the higher specific surface area of this electrode.

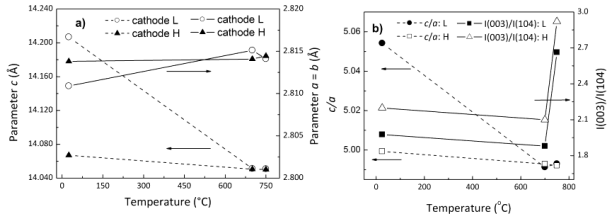

Fig. 1. *Lattice parameters for the as-extracted (25 ^oC), thermal decomposed (700 ^oC) and re-synthesized (750 ^oC) $LiCoO_2$ compound from the L and H cathodes (a), the corresponding c/a and x-ray intensity $I_{(003)}/I_{(104)}$ ratios (b).*

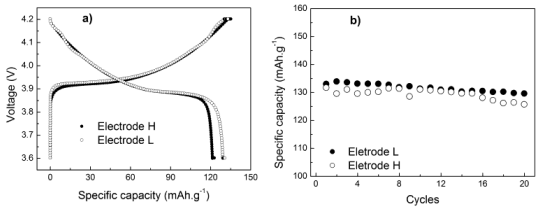

Fig. 2. *Voltage profiles as a function of specific charge capacity for the L and H re-synthesized $LiCoO_2$ cathodes (a), cycling discharge capacities measured at 0.2C rate for the re-synthesized L and H cathodes.*

4. References

[1]- R. Floriano, A. O. dos Santos, A. Urbano, L. P. Cardoso, J. Scarminio, IJRRAS, **17**, 158-166, (2013).
[2]- S. Laubach at al., Phys. Chem. Chem. Phys., **11**, 3278–3289, (2009).

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