**$Li_2RuO_3$ as an Additive to $LiCoO_2$ in Li-ion Batteries**

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We are studying composite $LiCoO_2/Li_2RuO_3$ electrodes because of their possible benefits in lithium ion batteries. $Li_2RuO_3$ is of interest because it is an electrochemically active material with low capacity fade and high theoretical capacity, but its practical voltage plateau is lower than that of $LiCoO_2$ (e.g., 3.5 vs 3.7 V, see Fig 1). $Li_2RuO_3$ had been found previously to play a stabilization role and contribute electrochemically to the layered insertion material $LiNiO_2$ [1]. $Li_2RuO_3$ has also demonstrated reversibility in lithium cells [2] and delithiated forms had been found to have lower resistivity [3].

The cycling performance of $Li_2RuO_3/LiCoO_2$ composites are studied with physical mixtures of $Li_2RuO_3$ and $LiCoO_2$ (45:55 w/w) by comparison to isolated $LiCoO_2$ and $Li_2RuO_3$ electrodes. The electrodes are tested as half cells vs. Li metal and in full batteries vs. carbonaceous anodes. Their losses, capacity fade, and cycling capacity are studied at C/5, 1C, and 2C rates.

Composite cathodes of $Li_2RuO_3$ and $LiCoO_2$ (45:55 w/w) have a significantly higher capacity when discharged between 4.3 and 2 V vs. the electrodes with only $Li_2RuO_3$ or $LiCoO_2$ at 1 C and C/5 rates. Fig. 1 shows the profile for a 1 C discharge from 4.3 to 2 V, and the majority of the capacity increase is observed from 3 to 2 V.

A significant increase in capacity is also observed in the first discharge of the electrodes with 7:1 w/w $LiCoO_2$ and $Li_2RuO_3$ vs. the $LiCoO_2$ and $Li_2RuO_3$ electrodes as shown in Fig. 2 for a 2 C rate. After continued cycling at 2 C, this trend changes, and the $Li_2RuO_3$ electrodes has a higher capacity than the $LiCoO_2$ and mixed electrodes (Fig. 3) and all electrodes have similar capacity fades.

This presentation will highlight progress in battery performance of the $Li_2RuO_3/LiCoO_2$ cathode composite.

**Acknowledgments**

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**References**

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[2] H. Kobayashi, R. Kanno, Y. Kamamoto, M. Tabuchi and O. Nakamura, *Solid State Ionics*, **82**, 25 (1995).
[3] H. Kobayashi, R. Kanno, Y. Kamamoto, M. Tabuchi and O. Nakamura, *Solid State Ionics*, **86-88**, 859 (1996).

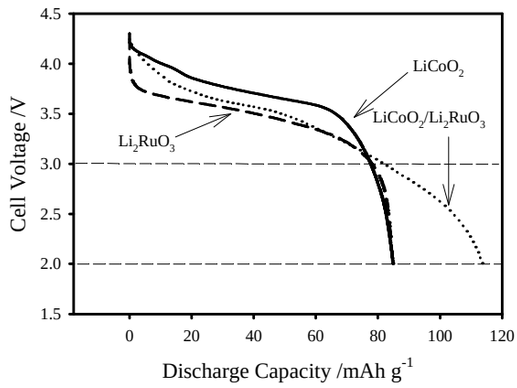


**Figure 1**. Initial discharge of $LiCoO_2$, $Li_2RuO_3$, and $LiCoO_2/Li_2RuO_3$ (55:45 w/w) electrodes at a 1 C rate from 4.3 to 2 V.

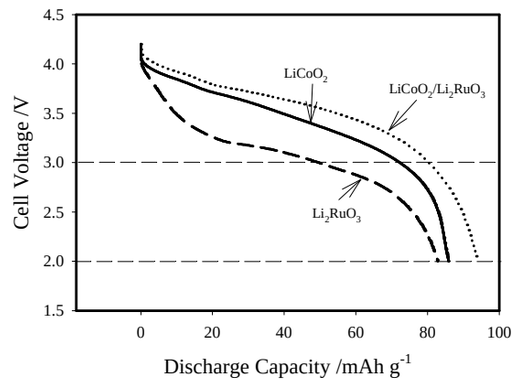


**Figure 2.** Initial discharge of $LiCoO_2$, $Li_2RuO_3$, and $LiCoO_2$/ $Li_2RuO_3$ (7:1 w/w) electrodes at a 2 C rate between 4.2 and 2 V.

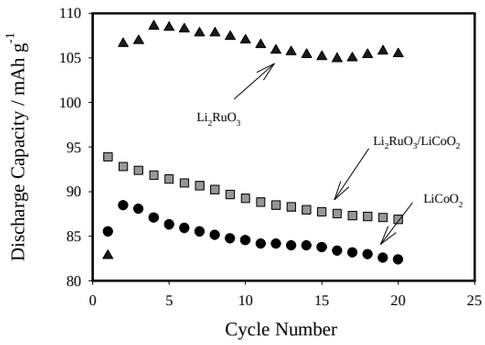


**Figure 3**. Comparison of capacity as a function of cycle number at 2C rates for $LiCoO_2$, $Li_2RuO_3$, and $LiCoO_2$/ $Li_2RuO_3$ (7:1 w/w) electrodes.