Electrochemical Noise Investigation of Lithium Anode During Charging Process and Early Detection of Dendrite Formation

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Electrochemical noise analysis is a widely utilized technique in corrosion research, enabling the identification of corrosion modes and differentiation between localized and uniform corrosion types when combined with post-mortem investigations. With the growing prominence of lithium-ion batteries, there is an increasing demand for faster, easier, and more cost-effective testing methods that are non-destructive and non-disruptive. While some studies have explored electrochemical noise measurements in batteries, the existing literature on this topic remains scarce and questionable. By employing electrochemical noise analysis on lithium batteries, it is possible to non-invasively assess battery health. [1] Our previous research has demonstrated an increase in voltage noise in non-rechargeable Li/MnO2 batteries following exposure to short circuits, indicating morphological changes in metallic lithium. This approach offers a potential non-invasive diagnostic tool. [2]

Lithium metal-based chemistries possess significantly higher capacities compared to rechargeable alternatives due to the use of metallic lithium at the anode, instead of lithium-aluminum alloys. Charging lithium metal electrodes can lead to the formation of dendrites, which pose a risk of short circuits, battery combustion, or even explosions by compromising the separator that separates the anode and cathode. Detecting potential dendrite formation beforehand is of great academic and industrial importance. Initial investigations have shown a significant increase in noise levels after charging, accompanied by severe deterioration in the anode as observed through scanning electron microscopy (SEM). Electrochemical noise measurements have shown significant noise level increases during the charging and discharging cycles of lithium batteries, as evidenced by preliminary studies (Figure 1). This observation parallels the noise measurements conducted on non-rechargeable lithium chemistry batteries exposed to short circuits, underscoring the importance of studying noise variations during these cycles in dendrite-prone lithium batteries. Additional preliminary noise measurements on the lithium anode further confirm the rise in noise levels after charge and discharge cycles.

This conference presentation provides an overview of electrochemical noise measurements and explores the underlying causes behind the noise level increases specifically in the lithium anode. To establish correlations between noisy features in the noise measurements and the formation of mossy and dendritic structures during the charge and discharge processes, we will present findings from optical and electron microscopy analyses.

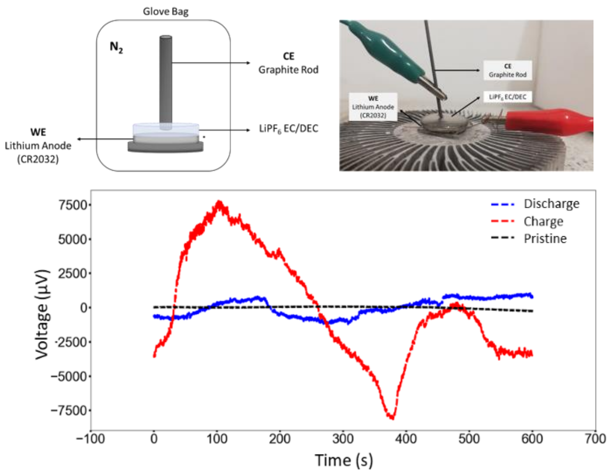
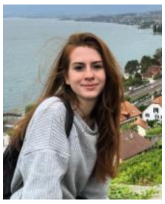


Figure 1. The noise measurement of pristine CR2032 (black) and the noise measurement of CR2032 after charged (red), and discharged (blue)

References

[1] Uzundal CB; Ulgut B; "A New Method for Voltage Noise Measurement and Its Application to Abused Primary Batteries" Journal of the Electrochemical Society,2018 volume 165, issue 11, A2557-A2562
[2] Karaoglu G; Uzundal CB; Ulgut B; "Uneven Discharge of Metallic Lithium Causes Increased Voltage Noise in Li/MnO2 Primary Batteries upon Shorting, Journal of The Electrochemical Society, 167(13), 130534.



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