Analysis of the Separator Porosity on the Performance of Lithium-ion Batteries

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Overview

- The objective of this work is to investigate the effects of the porosity of the separator on the electrochemical performance of lithium-ion batteries.
- In the recent years intensive efforts have been made to improve the performance of lithium-ion batteries. Separators are important component of lithium-ion batteries since it isolates the electrodes and prevent from short-circuit issues. Electrochemical performance are highly dependent on the materials, structure and the separators used.
- Separators are not involved directly in the reactions, but the physical properties plays an important role in determining the performance of the battery including energy density, power density and safety.

Method

- Four different separators from Celgard were used for this analysis. Two monolayer (PP2075, 2400) made with polypropylene (PP) material and two trilayer separators (H2512, H2013) made with polypropylene/polyethylene/ polypropylene (PP/PE/PP) materials were used with the cells for testing.
- Separatos were doubled for all the samples for the experiments to avoid short circuit issues and to provide stability and to obtain consistent comparison.
- Half cells were fabricated with LFP as cathode (both calendered and uncalendered electrode samples) and Lithium metal as anode. Cells were fabricated with the electrode of same thickness. Charge discharge tests were performed at 1C rate, SEM and EIS results were also analyzed.

Results

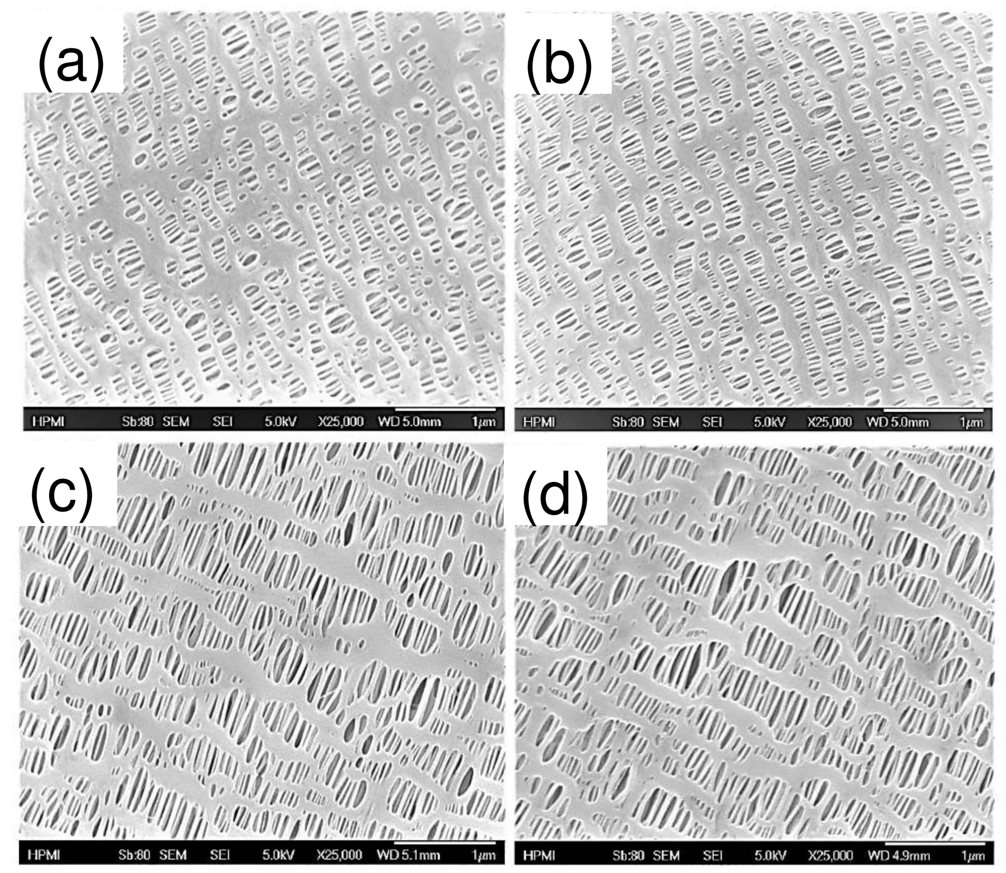


Figure 1: SEM images of the Celgard commercial separators trilayers (a) H2013 (Porosity 45%, thickness 20µm), (b) H2512 (Porosity 50%, thickness 25 µm), monolayers (c) 2400 (Porosity 41%, thickness 25 µm) (d) PP2075 (Porosity 48%, thickness 20 µm)

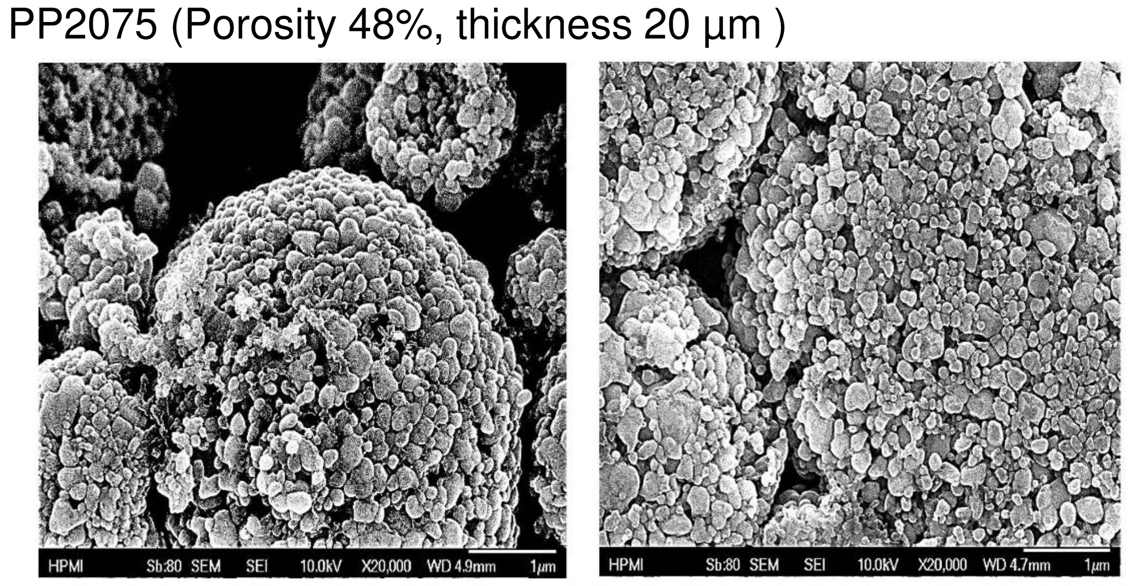


Figure 2: SEM Images of LFP electrode (a) Uncalendered electrode, (b) Calendered electrode

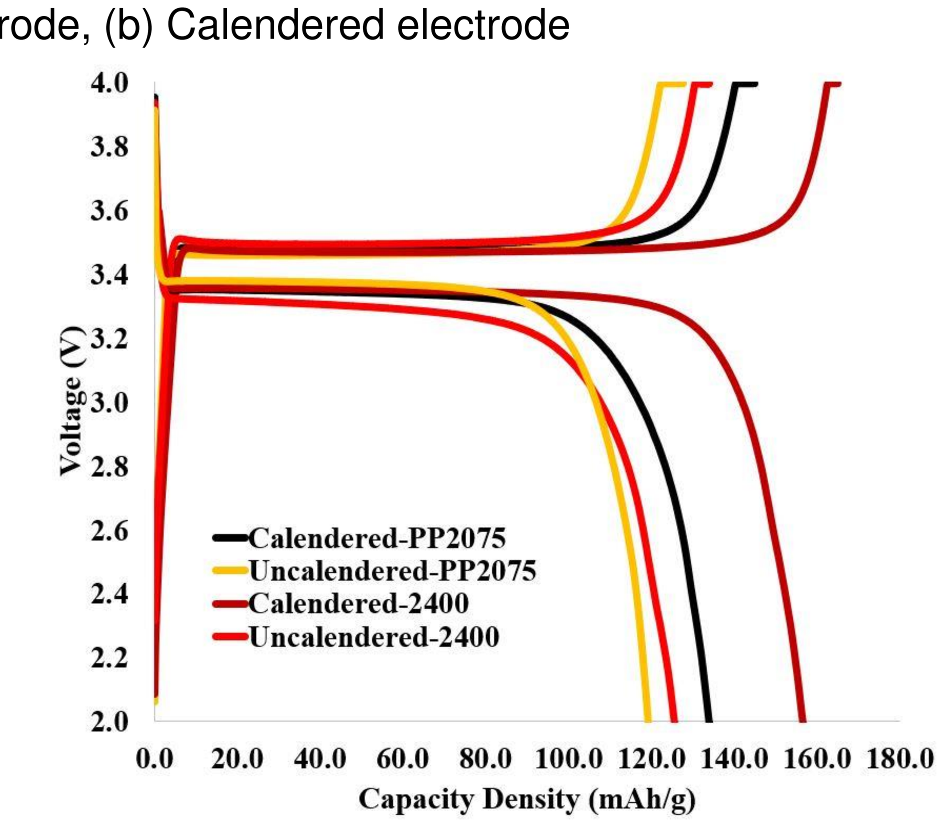


Figure 3: Charge and Discharge performance of LFP batteries assembled with monolayer separators PP2075 and 2400

Results (Continued)

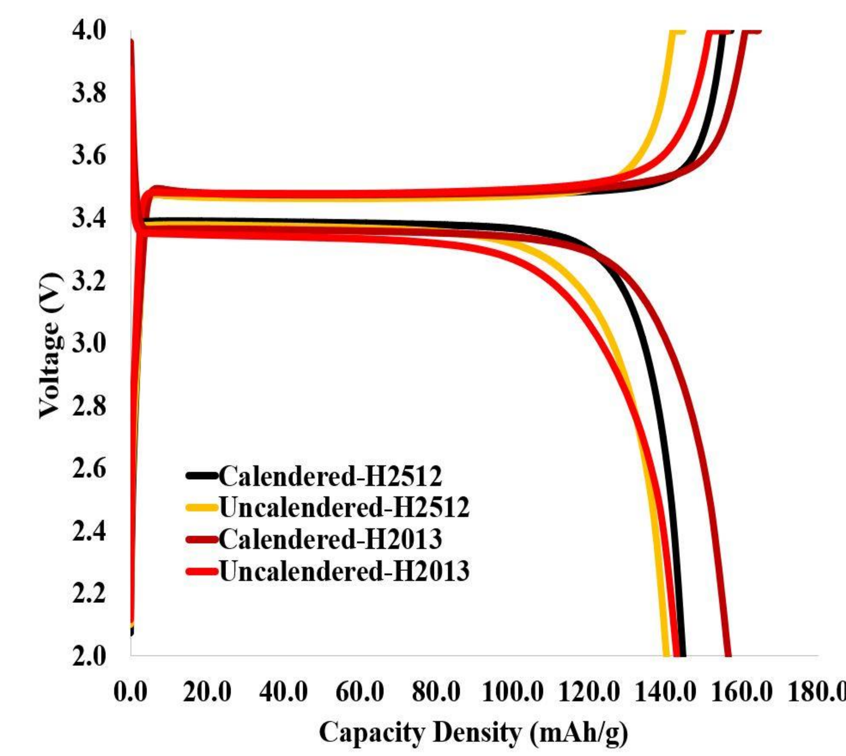


Figure 4: Charge and Discharge performance of LFP batteries assembled with trilayer separators H2512 and H2013

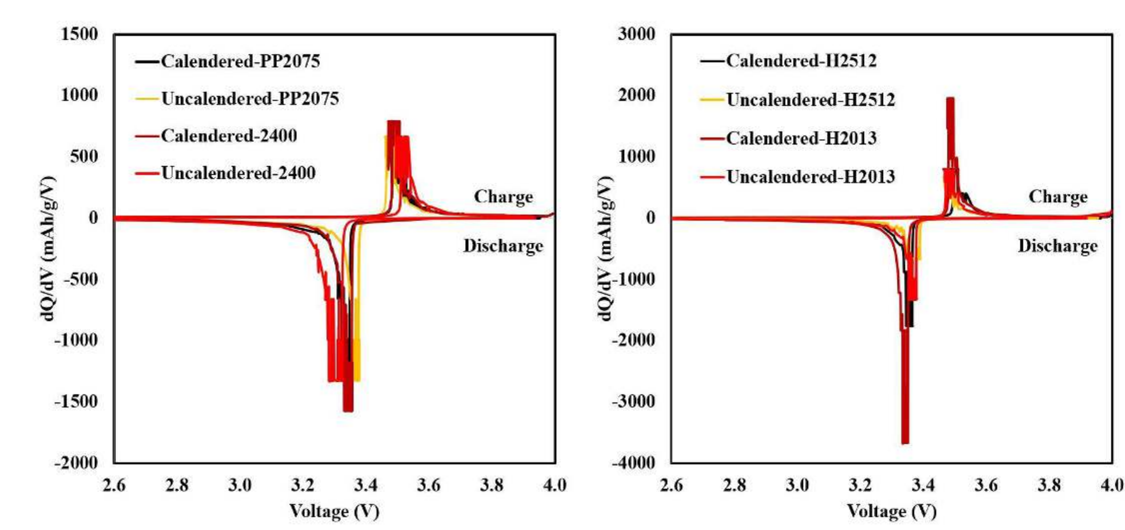


Figure 5: dQ/dV vs. Voltage curve of both charge and discharge data of (a) monolayer separators and (b) trilayer separators

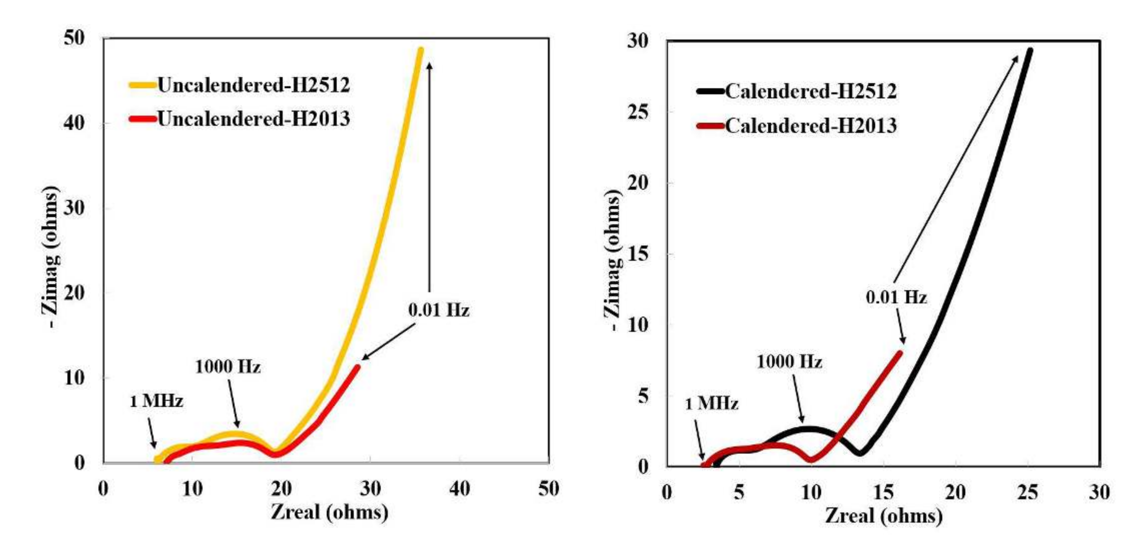


Figure 6: Measured EIS data for calendered and uncalendered electrodes with trilayer separators
(a) Uncalendered electrodes using H2512 and H2013 separators, (b) Calendered electrodes using H2512 and H2013 separators

Results (Continued)

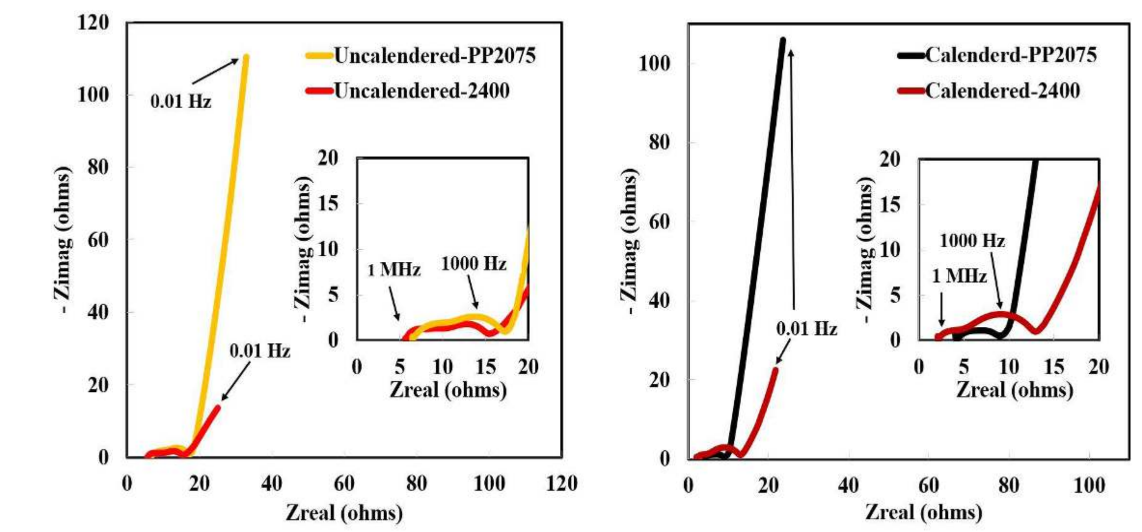


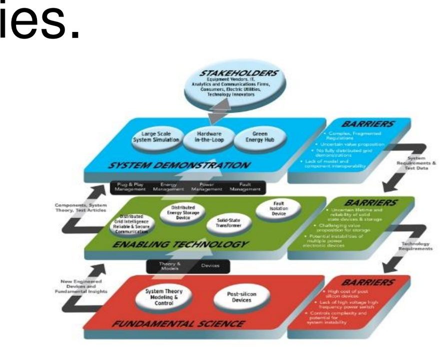
Figure 7: Measured EIS data for calendered and uncalendered electrodes for monolayer separators (a) Uncalendered electrodes using 2400 and PP2075 separators, (b) Calendered electrodes using 2400 and PP2075 separators

Conclusions

- Porosity of the separator plays an important role in the cell operation, and best performances were observed at 45% (trilayer) and 41% (monolayer) separator porosities.
- Cells with higher porosity separators exhibited lower specific capacity and higher ohmic and charge transfer resistances.

Future Work

- Analysis of separators with different porosities and thickness and to obtain a more comprehensive result on the performance of the batteries.



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