INTRODUCTION
Since their 1990 market debut by Sony, Li-ion batteries (LIBs) have become a popular energy storage platform in portable electronics. Electric vehicles powered by LIBs have also experienced recent commercial success, but they are currently limited to short range commutes due to the low capacity of present-day electrodes (e.g., the graphite used as the anode material). Silicon is a promising candidate for next generation LIB anodes due to its high theoretical capacity (3,576 mAh/g), which is an order of magnitude greater than that of graphite (372 mAh/g). The use of Si anodes has been hindered by complications arising from Si volume changes (~400%) during battery charging and discharging. These severe volumetric swings ultimately lead to electronic isolation of Si particles, an unstable solid-electrolyte interface, and poor capacity retention.

OBJECTIVES
Characterize the effectiveness of different polymer binders in Si based anodes for Li-ion batteries.

Investigate polymer crosslinking as an approach to maintain intimate contact between Si nanoparticles and the polymer binder.

Structures of polymer binders investigated in this study.

Slurries containing Si nanoparticles (20 nm), carbon black, and a polymer binder were cast onto copper foil. All anodes contained 60 wt% Si, 20 wt % C, and 20 wt% binder and were characterized in CR2032 Li-ion half cells.

CR2032 Construction and Characterization
Anode: Si based slurry on copper foil
Counter electrode: Li metal
Electrolyte: 1:1 LiPF6 in EC/DEC/DMC (ethylene carbonate/ diethyl carbonate/dimethyl carbonate) by volume with a 5 wt% vinylene carbonate additive
Voltage Range: 0.015 - 1.5V
Constant Current: 0.1C

ELECTROCHEMICAL PERFORMANCE

POLYMER CROSSLINKING

Crosslinking was confirmed through polymer swelling experiments.
- Polymer films (without Si or C) were soaked at room temperature for 3 hours in water (PAA, CMC) or methanol (PAA, PVBAA).
- Individual polymers fully dissolved in solvent.
- Crosslinked polymer films exhibited limited swelling, which indicates successful crosslinking.
- Increased PAA content decreased the crosslinking effectiveness.

FUTURE WORK
The findings of this study will be used as reference data for future work with electrospun Si/C/polymer nanofiber electrodes. This future investigation will determine how electrode morphology affects anode stability.

CONCLUSIONS
PAA/CMC and PAA/PVBAA systems were successfully crosslinked.
- PAA and CMC are promising binders for Si based anodes
  - Low swelling in propylene carbonate (~2%) and high initial capacity (>1,000 mAh/g total) and moderate capacity retention
- PVBAA and PVDF are poor binders for Si based anodes
  - Very low capacities (<300 mAh/g total) and poor capacity retention
- Thermally crosslinked binders did not enhance anode stability
- Limited electrolyte absorption may limit the effectiveness of crosslinks

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