BATTLE OF THE ANODES: HOW CAN WE IMPROVE FULL CELL PERFORMANCE?

Investigating the role of graphite anodes in full-cell optimization

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ABSTRACT

Full-cells are shown to be more commercially relevant than their half-cell counterparts [1] but with extra factors affecting overall performance. This project looks specifically at how anodes are affected by the full-cell arrangement.
We compared variations of graphite anode by observing differences between; a commercially bought CES graphite and inhouse graphite of varying thickness and processing methods.

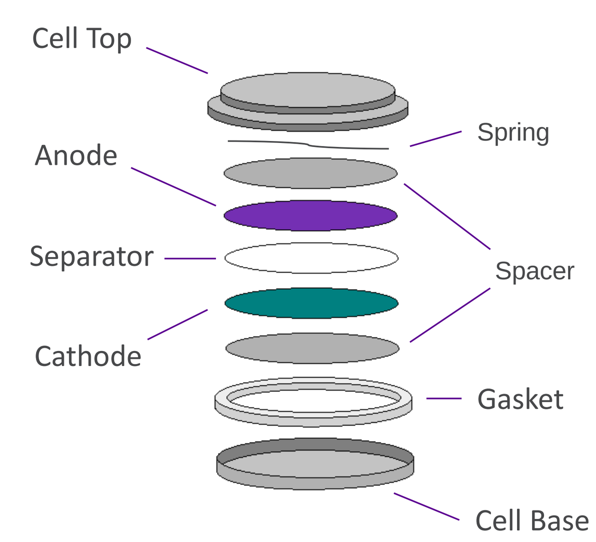
Seeing if we can produce graphite to a commercial standard or better in a full-cell arrangement will help make all future research more repeatable and aid in overall understanding of full-cells that will continue to be looked at.

MOTIVATIONS

Coin cells come in two variations, half/full-cell. Half-cells test a single electrode against a lithium chip while a full-cell is a complete cell with both electrodes [2].

Benefits of Full-Cells

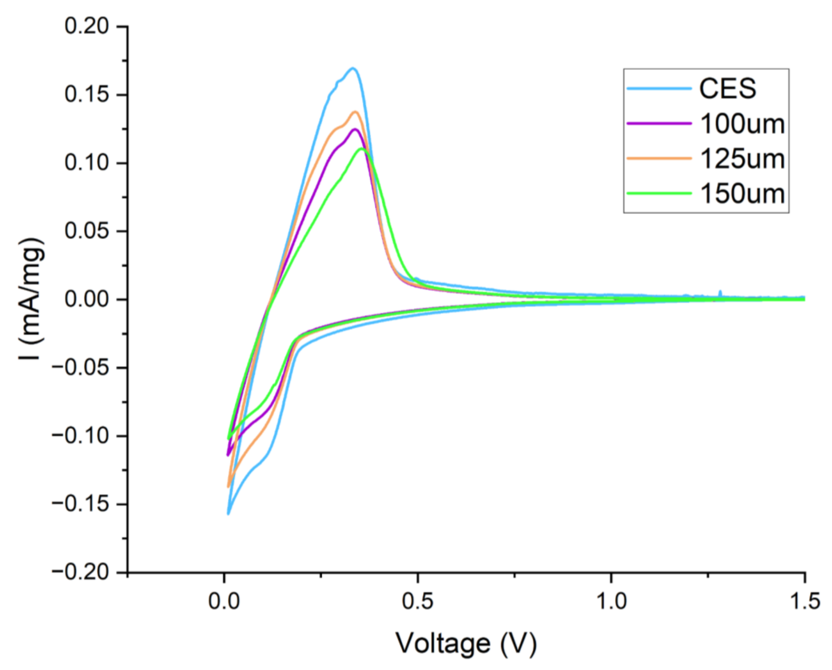
- **More commercially relevant results.**
- **Shows better long-term cathode performance.**
- **Side reactions aren't masked by large lithium reserve.**



OPTIMIZATION

- Ideal **N/P ratio** of around **1.1 - 1.2**,[3] controlled by electrode **mass loadings**.
- **Anode** should be **slightly larger** than cathode [2] for **best electrode alignment**.
- Must have good **pressure** in the cell to **improve cycle life** and **reduce resistance**.
- Allow **long** enough **rest** [3] time for **complete wetting**.

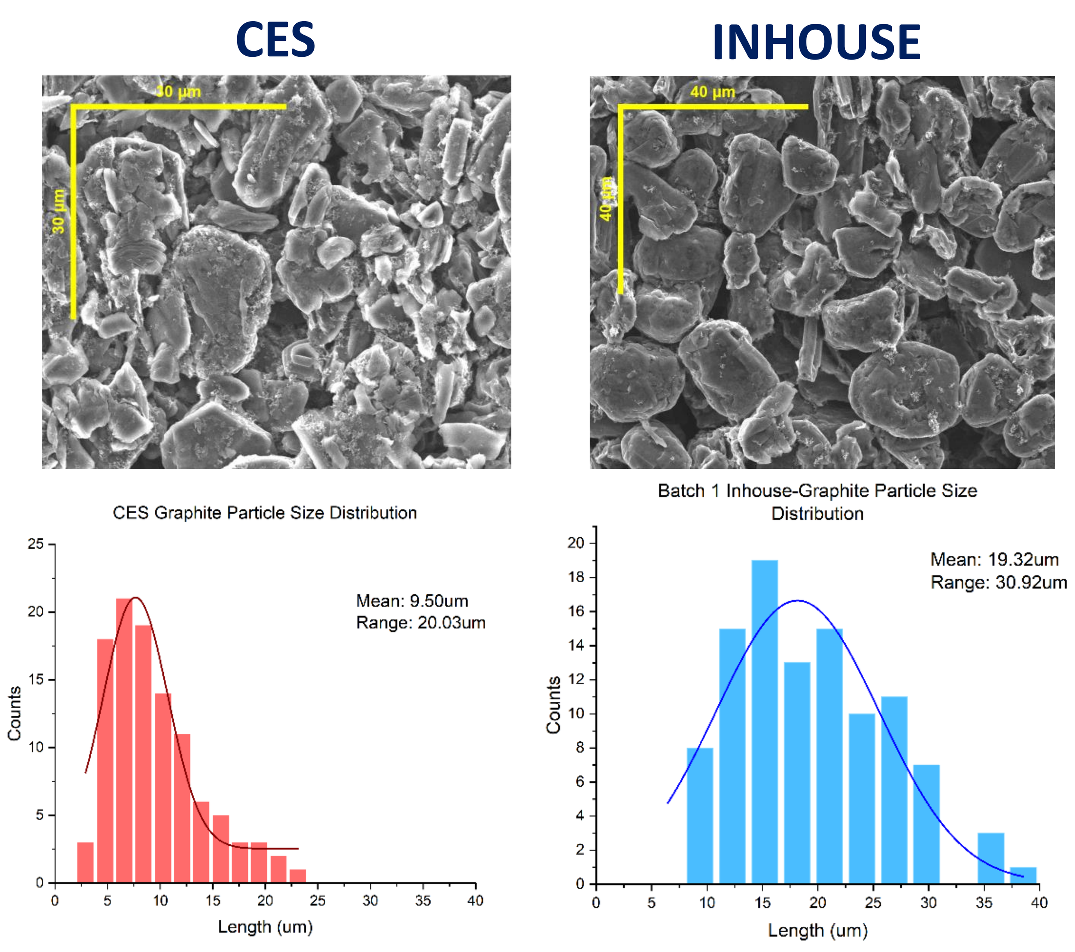
10TH CYCLE CV HALF-CELL COMPARISONS



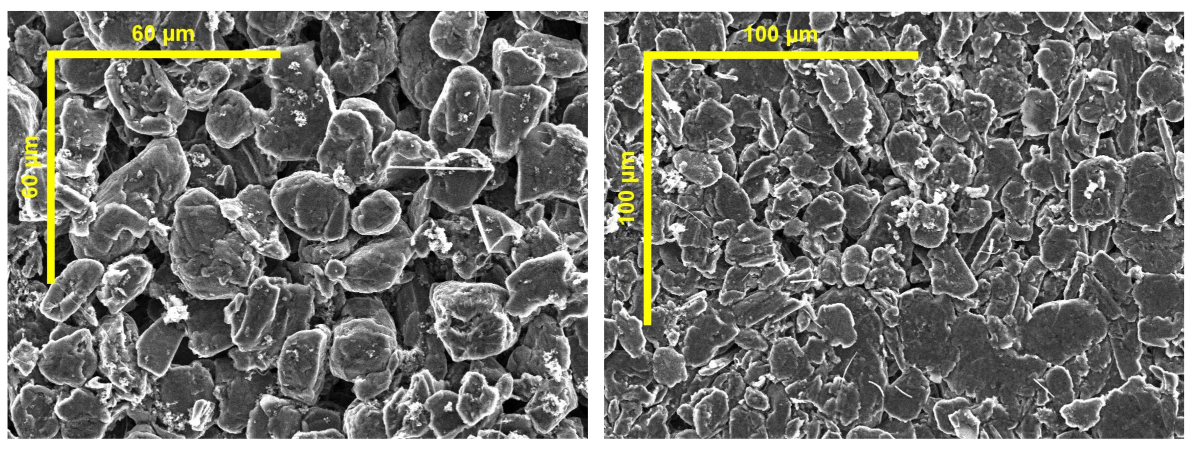
- Commercial **CES graphite** peaks at higher current, suggesting a **slightly lower resistance**.[4]
- **Increased thickness** of electrode likely **increased resistance** in inhouse graphite.
- Overall **CES** proved to be slightly **more reversible**.

Graphite//Li
Voltage Range: 0.01 - 2V

- **CES** graphite has **smaller** average **particle size** than in-house graphite.
- Integrating the charging part of the CV curve gives **power density**.
- **CES** showed **highest** power density at **55.7 W/g/m^2** at 10th cycle.



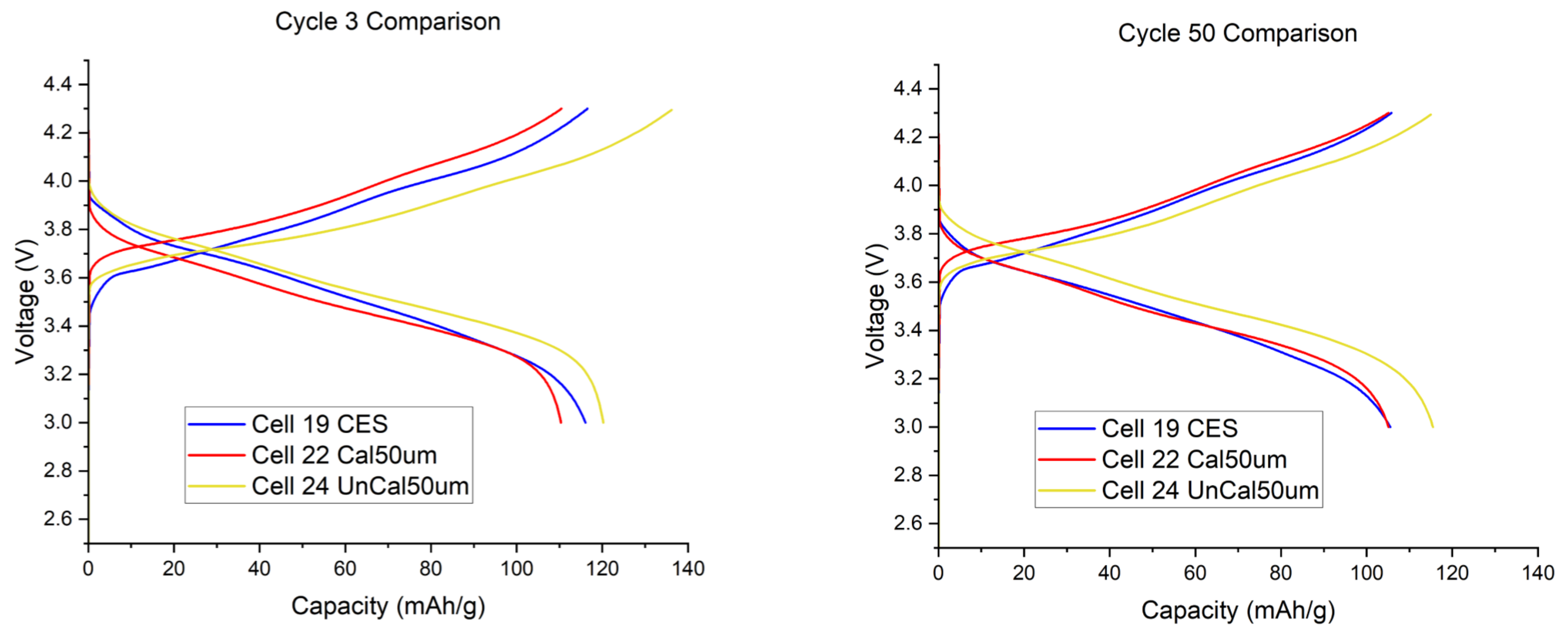
UNCALENDERED VS CALENDERED SEM



Calendered at **80°C**, **decreased thickness** of **20um**.

Overall **decrease in porosity** visible.

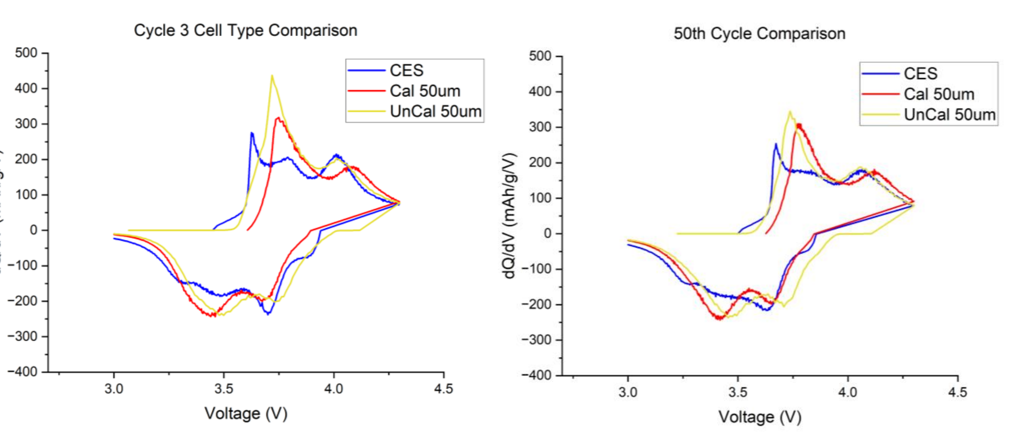
FULL-CELL CYCLING: 3RD AND 50TH CYCLE COMPARISON



- **Both** CES and inhouse have 3rd cycle discharge **capacities** around **110 - 120 mAh/g**.
- **CES graphite** has the **worst capacity retention**, **drop-off of** around **20 mAh/g** on discharge cycles.
- **Uncalendered** showed slightly **higher capacities** than **calendered graphite**.

Graphite//SC_LiNiO2
Voltage Range: 3 - 4.3V
2 Cycles at C/20
48 Cycles at 1C

FULL CELL CYCLING DQ/DV'S: 3RD AND 50TH CYCLES



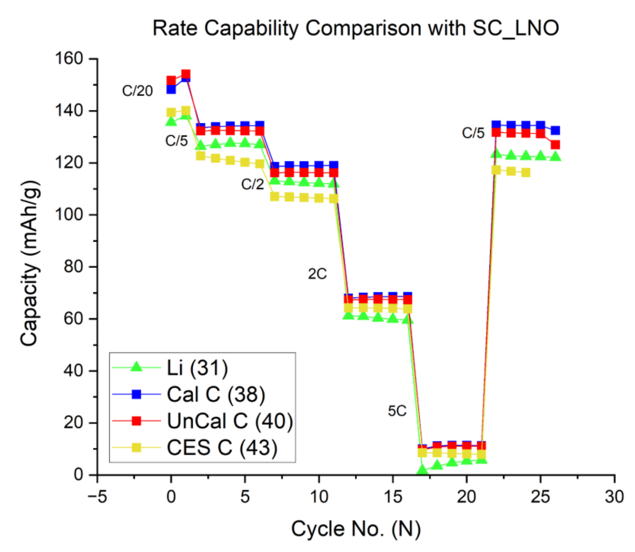
Inhouse graphite **peaks** are **shifted right** of CES peaks.

Possibly because inhouse has **larger particles** so **smaller surface area**, encouraging **more solid-state diffusion** and **increasing resistance**.

Graphite//SC_LiNiO2
Voltage Range: 3 - 4.3V

CES has **more peak shift** from 3rd to 50th cycle.

RATE CAPABILITY TESTS



- **All graphite's** appear to **cycle better than Li** at **higher rates**.
- **Inhouse** seems to **outperform CES** for **rate capability**.
- There is **similar capacity drop-off in all** graphite types between first C/5 and second C/5 cycling.

CONCLUSIONS

- Initial **CV comparisons** with **half-cell** arrangements **show little differences** between graphite types.
- **SEM** showed **CES graphite** to have **smaller particle size** and **higher power density**.
- **Full-cell cycling** showed greater **capacity drop-off** in **CES** compared to inhouse graphite.
- **Inhouse** appears to have **higher internal resistances** than CES graphite.
- The **dQ/dV's peak shift** from 3rd cycle to 50th cycle of **CES full-cell** suggests **more surface damage** has occurred **comparatively** to inhouse graphite.
- **Rate capability** shows **inhouse graphite** performs **best** and all graphite **full-cells cycle better at higher rates** than Li half-cells.

REFERENCES

INTERN BIO

Clarice Doyle is a 3rd year undergraduate student studying Materials Science and Engineering MEng at the University of Sheffield. She completed her internship in the Corr-Cussen Group at the University of Sheffield.

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