Cyclic Voltammetry results

The forward scan peaks correspond to delithiation of cathode, and reverse peaks to lithiation of cathode

Observation → Hypothesis

Pristine CVs
- Dual peaks $a_1$ and $b_1$ → two step de/lithiation process
- Peak-to-peak separation increases with scan rate → quasi reversible process
- Graph of current/(scan rate)$^{1/2}$ → linear → diffusion is rate limiting step

Aged CVs
- All peaks show decreasing current → capacity loss
- Ratio of $I_{a1}/I_{b1}$ decreases with ageing → degradation at anode
- Graph of current/(scan rate) → reaction is surface controlled
- Change from diffusion control to surface control may suggest active surface area of anode is decreasing

DCIR results

- Resistance at 0% SOC is high but drops quickly with charging
- Stays low up to 100% SOC

Possible explanation
- Near 0% SOC, most $Li^+$ should be in cathode, but $Li^+$ ions can build up around cathode as intercalation is not instant. Diffusion gradient becomes unfavourable, increasing resistance.
- There are also few spaces for incoming $Li^+$ to occupy, so resistance is high.
- Capacity of anode is typically higher than cathode, which could explain lack of resistance increase at 100% SOC.

Conclusions
- Both techniques indicate the main cause of capacity loss is degradation at the anode.
- Cyclic voltammograms also suggest a reduction in the active surface area of the anode.
- A possible cause of both is lithium plating at the anode.
- Instead of intercalating into the graphite electrode, lithium ions are reduced and metal gets deposited on the surface.
- This reduces the active surface area for lithium deposition and the capacity of the battery.
- Can also develop into dendrite formation, which introduces safety concerns due to short circuiting.
- Especially significant for fast charging, where more $Li^+$ ions are moved to the anode in a short time, and plating is more likely.

Impact / Next Steps
- Post-mortem analysis and cell disassembly could help confirm if lithium plating is occurring and offer a qualitative assessment of the extent.
- Having an idea of the degradation mechanism allows for more relevant testing and development of mitigation techniques.
- Repeat the experiments with faster charge/discharge cycles to identify the effects of fast charging.
- Alter the charge/discharge protocols (i.e., cycle with fast charge and slow discharge) to mimic real life applications.