

Alternative Cathode Substrates for the Na-Air Battery

Goward Group

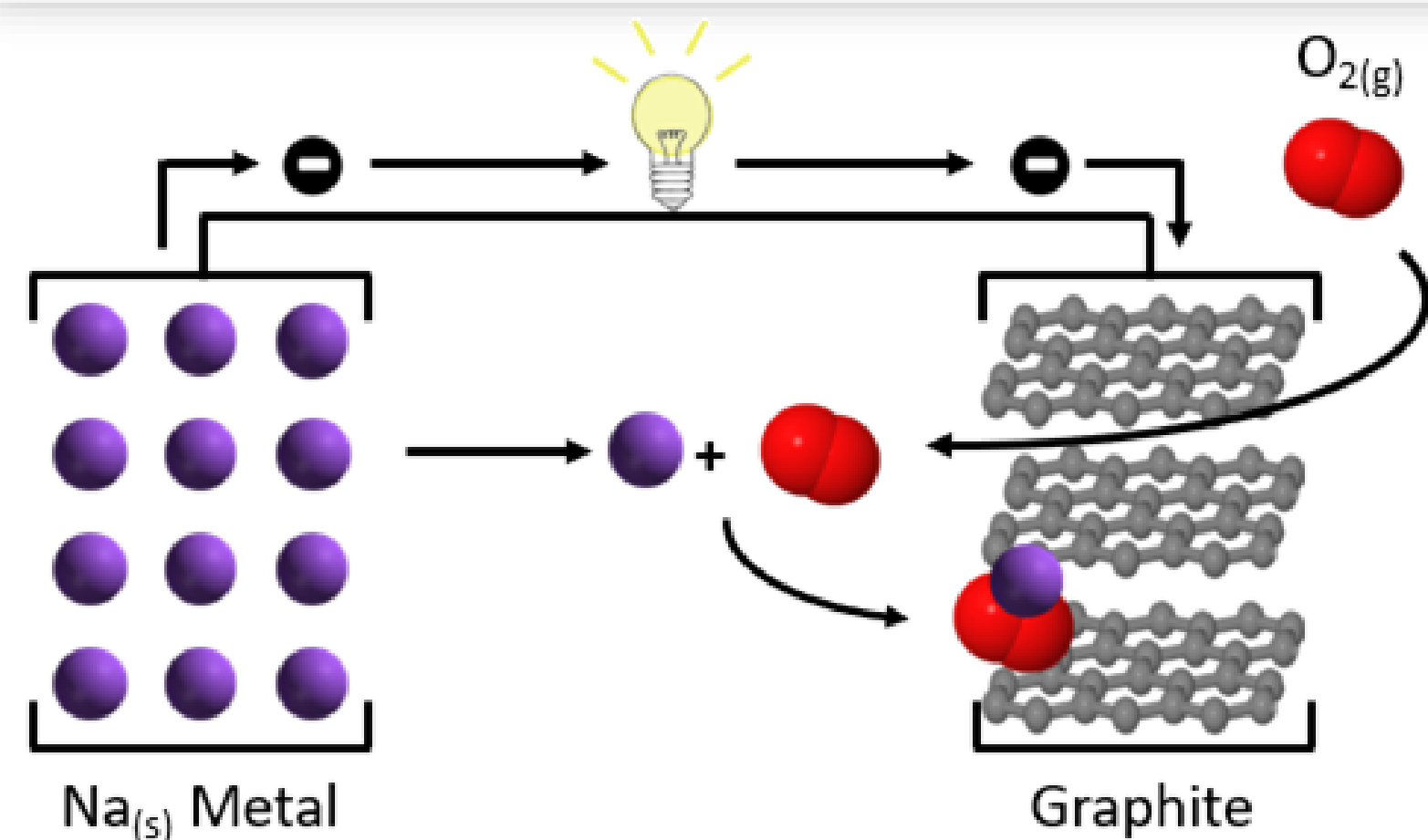
Department of Chemistry, Faculty of Science

Christopher Franko, Hossein Yadegari, Andy Sun, Gillian Goward*

EECOMOBILITY (ORF) &

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The Na-Air Battery



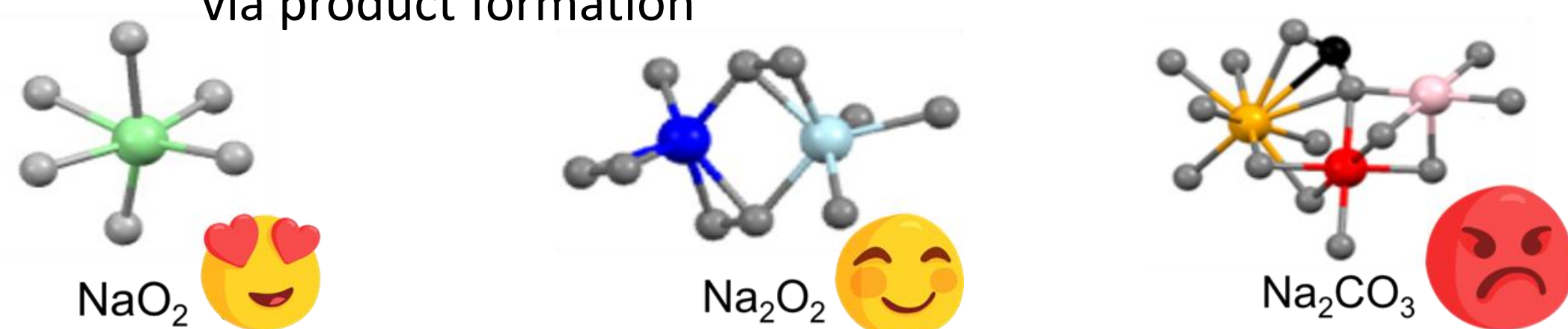
Possible Electrochemical Discharge Products:

NaO_2 = High Energy Density & Coulombic Efficiency

Na_2O_2 = High Energy Density & Low Coulombic Efficiency

Na_2CO_3 = Parasitic, can not "recharge" if formed

Reacts Na and $\text{O}_{2(g)}$ to release energy via product formation

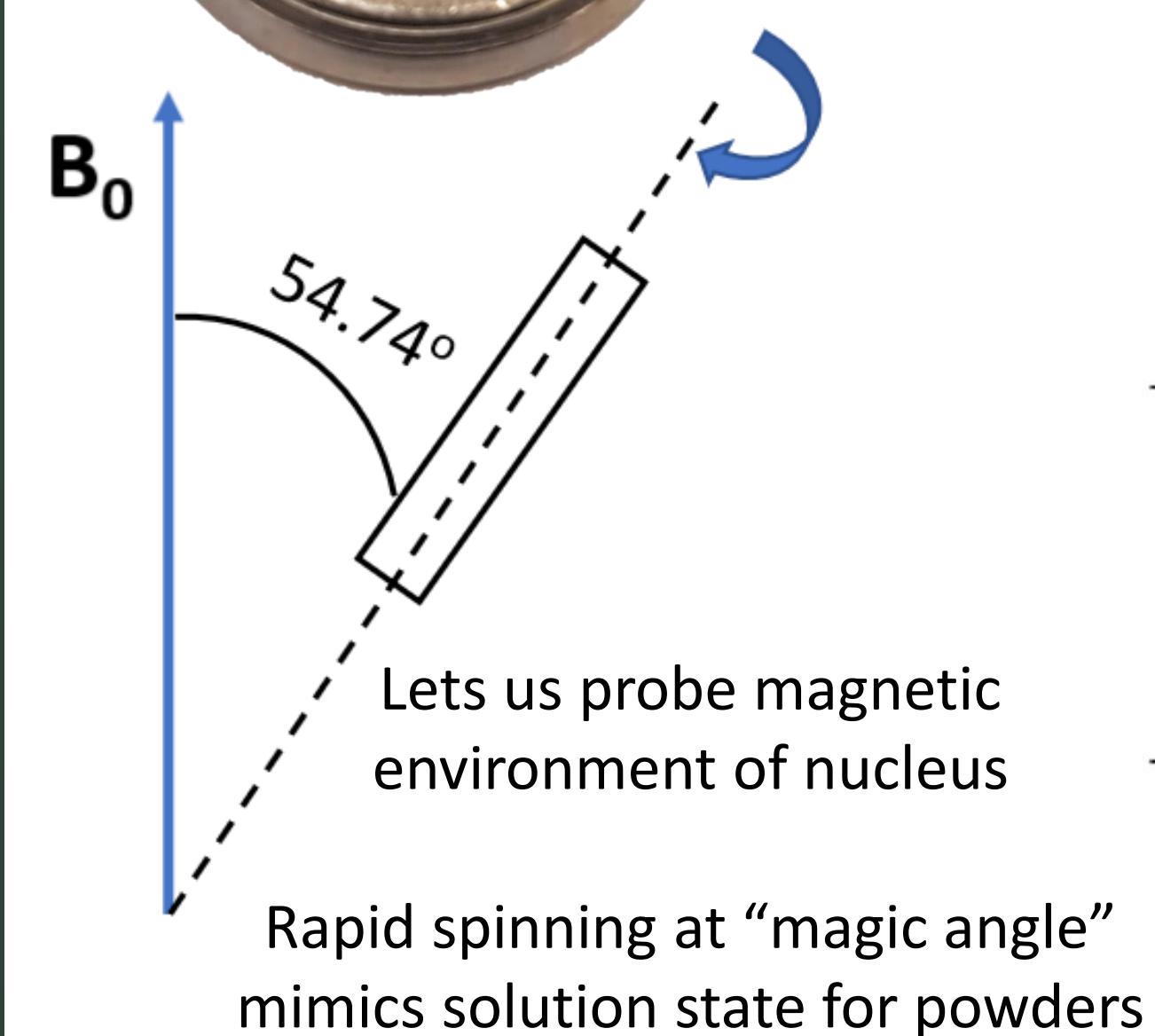


Solid State NMR Spectroscopy

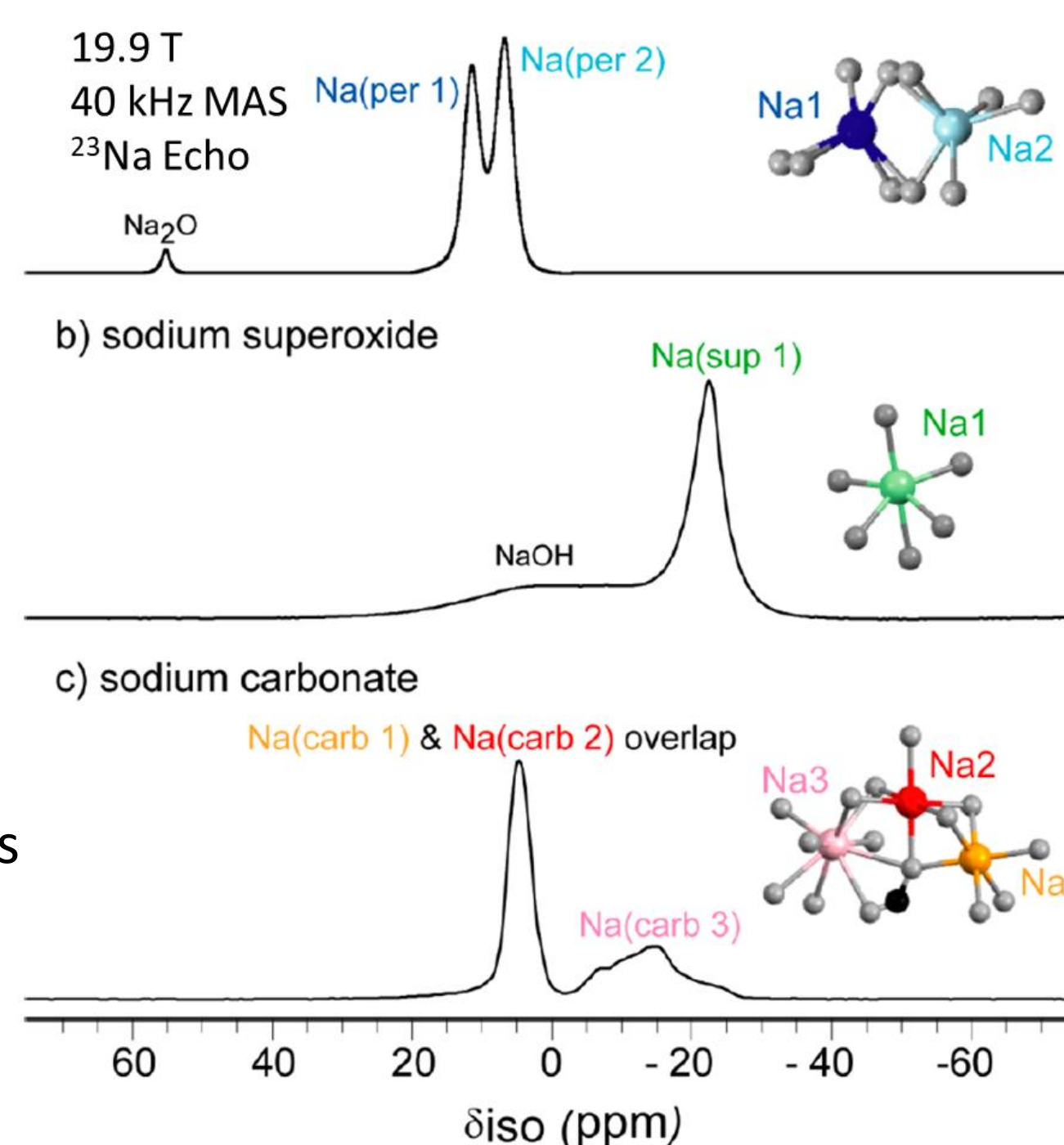


Na-Air coin cells made and sealed in chamber filled with O_2 gas for cycling

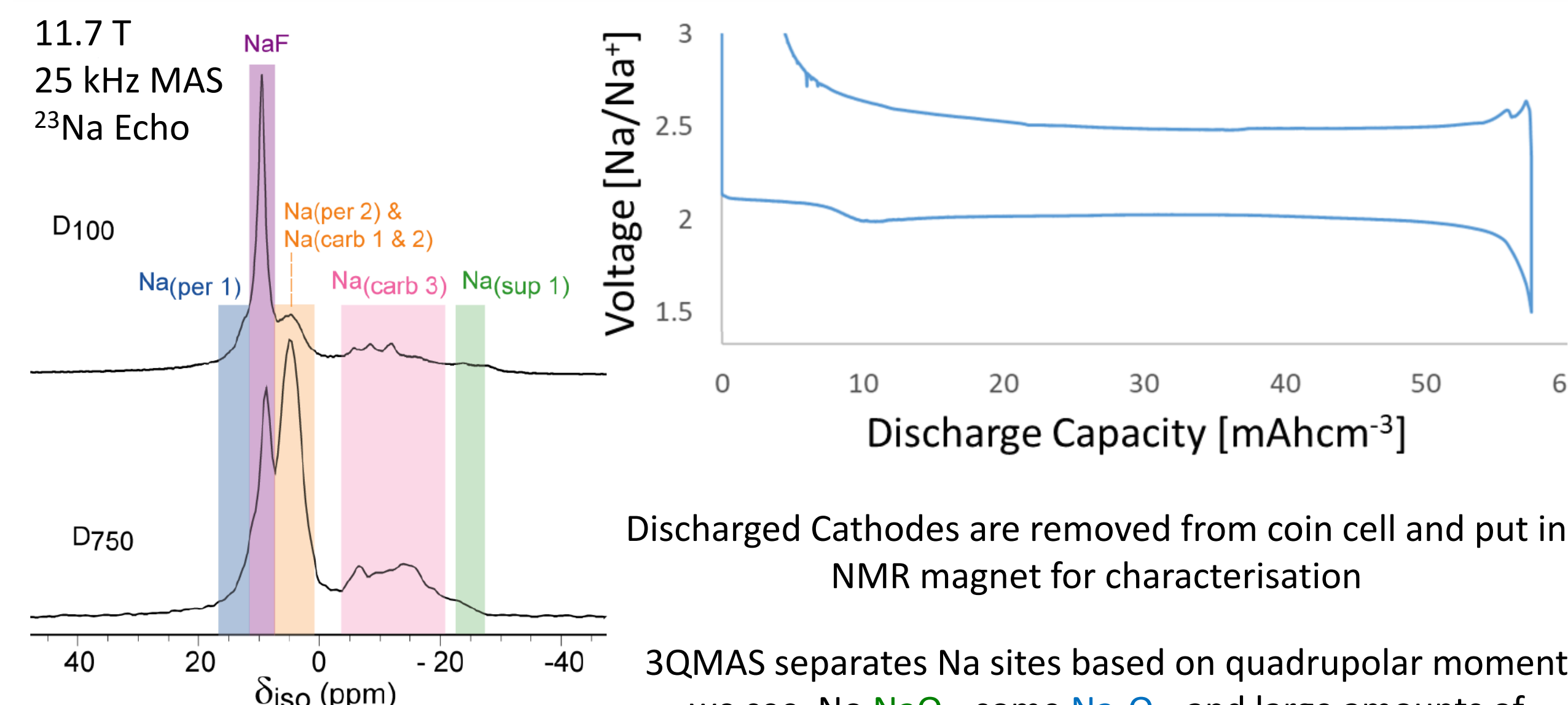
We need a method to study the parasitic reactions happening within the cell



Each of the main discharge products has a unique spectrum



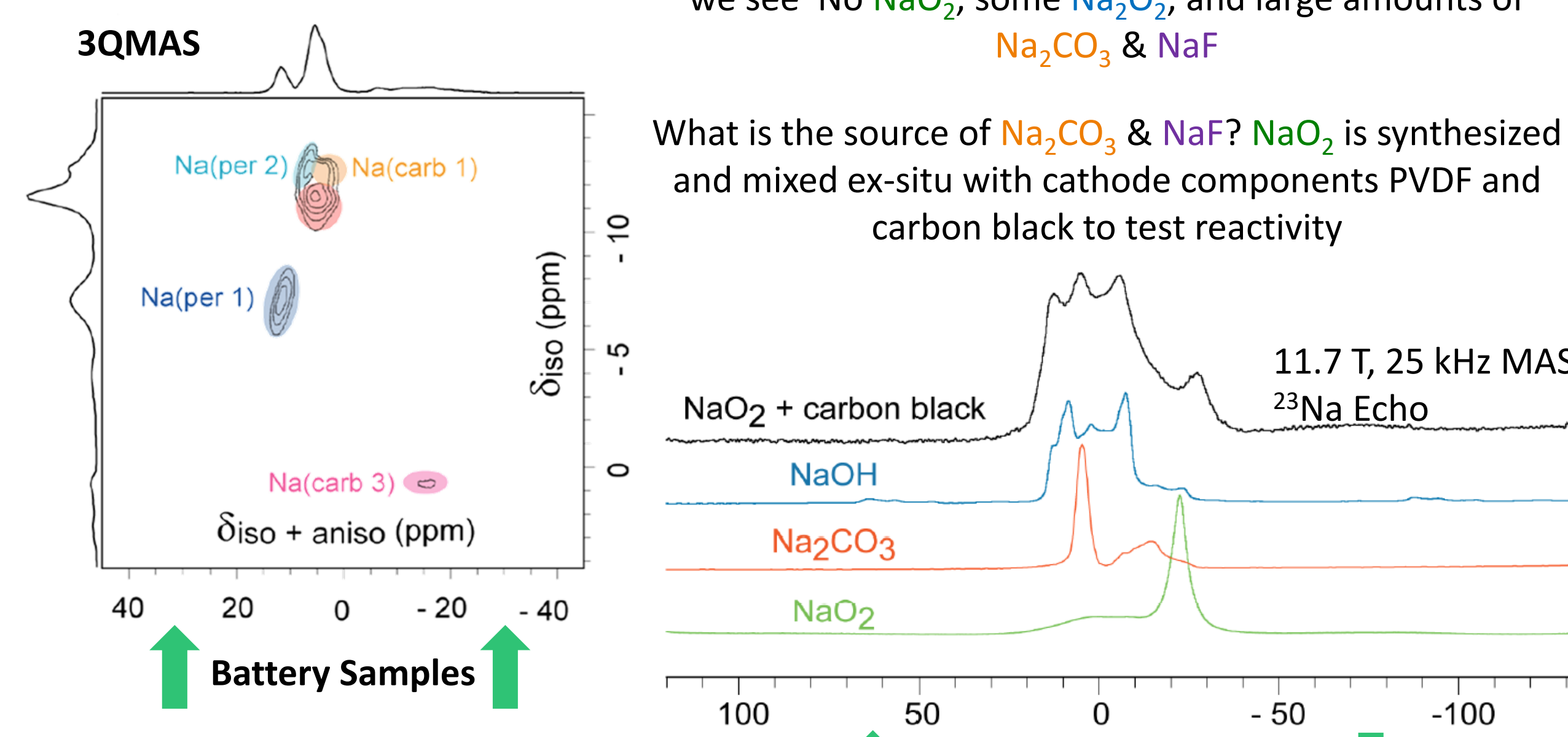
^{23}Na NMR of Discharged Cathodes



Discharged Cathodes are removed from coin cell and put in NMR magnet for characterisation

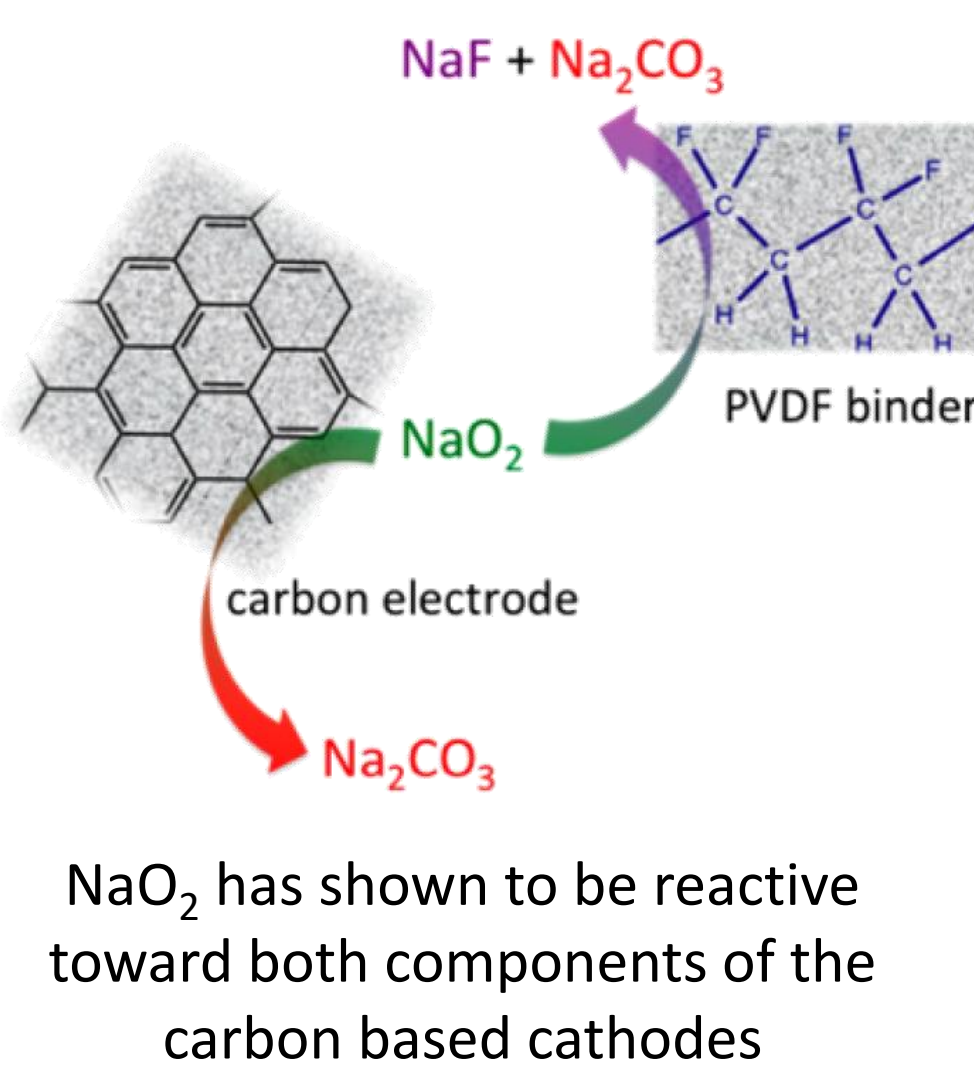
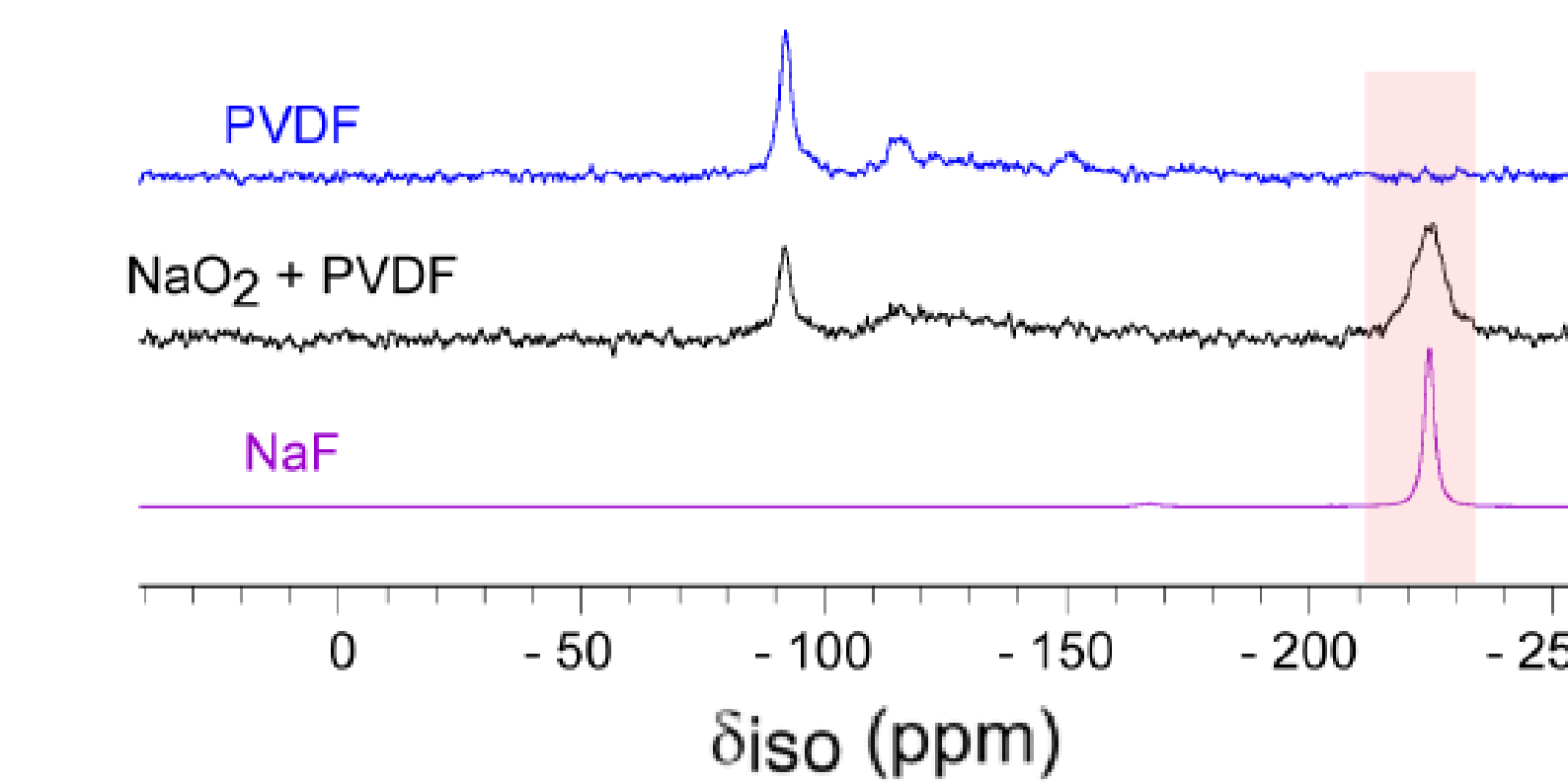
3QMAS separates Na sites based on quadrupolar moment we see No NaO_2 , some Na_2O_2 , and large amounts of Na_2CO_3 & NaF

What is the source of Na_2CO_3 & NaF? NaO_2 is synthesized and mixed ex-situ with cathode components PVDF and carbon black to test reactivity



NMR shows NaO_2 reacting with graphitic carbon, which was previously thought to be stable (above)

Synthesised NaO_2 also reacting with PVDF, the main bonding material used in Na-Air cathodes to make NaF



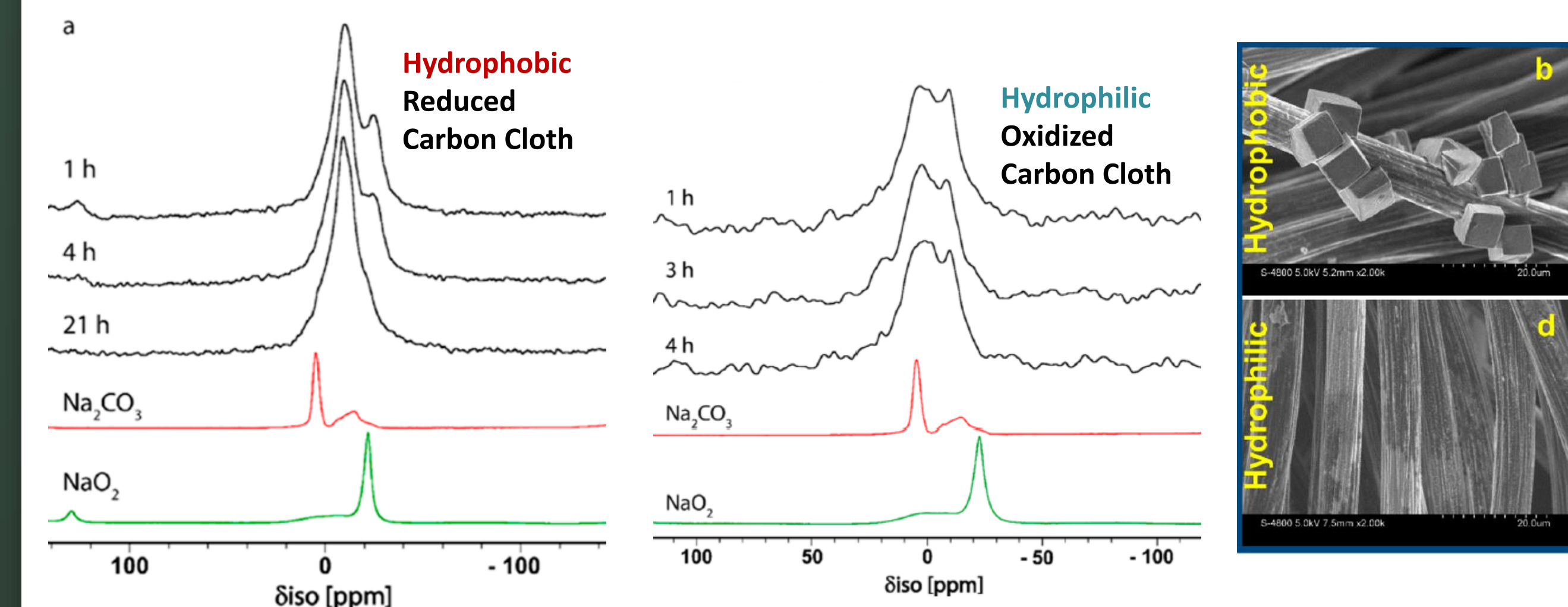
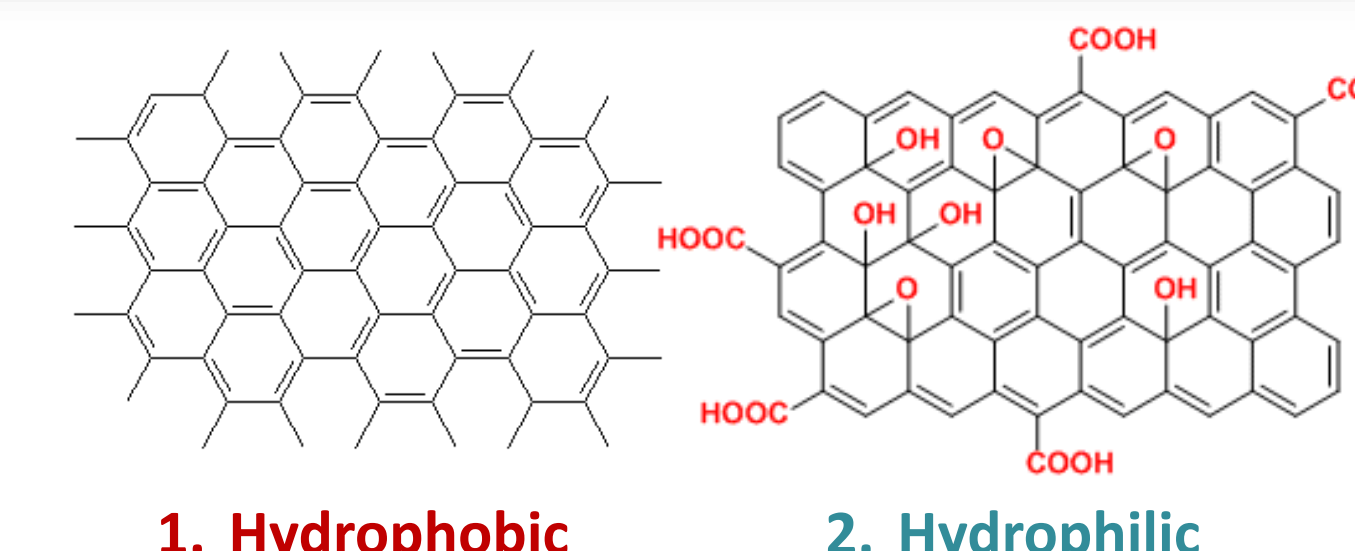
NaO_2 has shown to be reactive toward both components of the carbon based cathodes

Are we able to stabilise the carbon cathodes through chemical functionalization?

Functionalized Carbon Cloth Cathodes

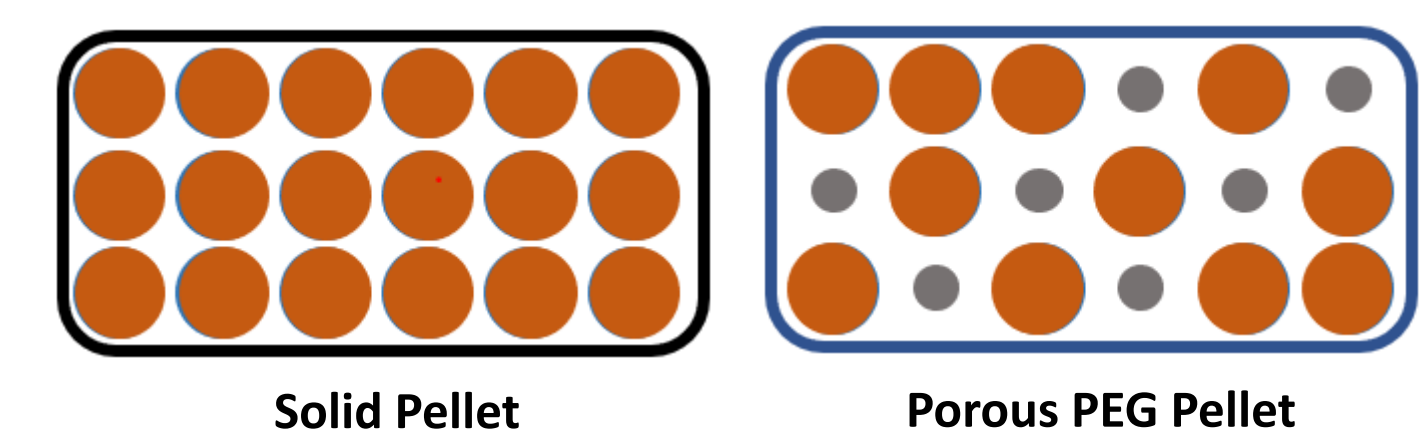
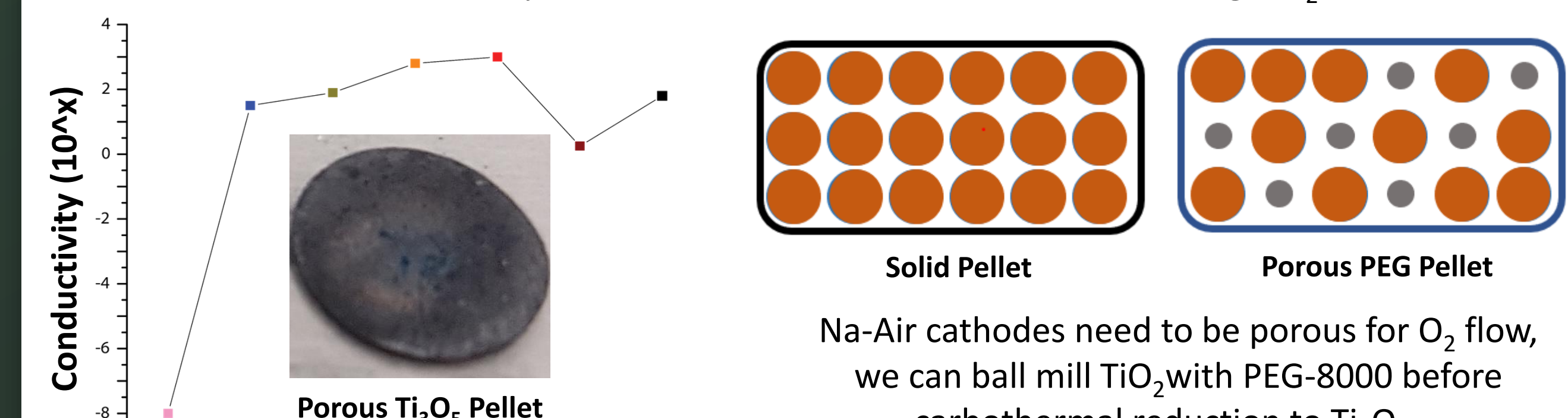
Binder-free carbon cloths are reduced via H_2 flow and oxidized via Hummer method to test affect on stability

Hydrophobic shows greater affinity to NaO_2 crystallite production, while hydrophilic cloth forms a passivating layer of Na_2CO_3



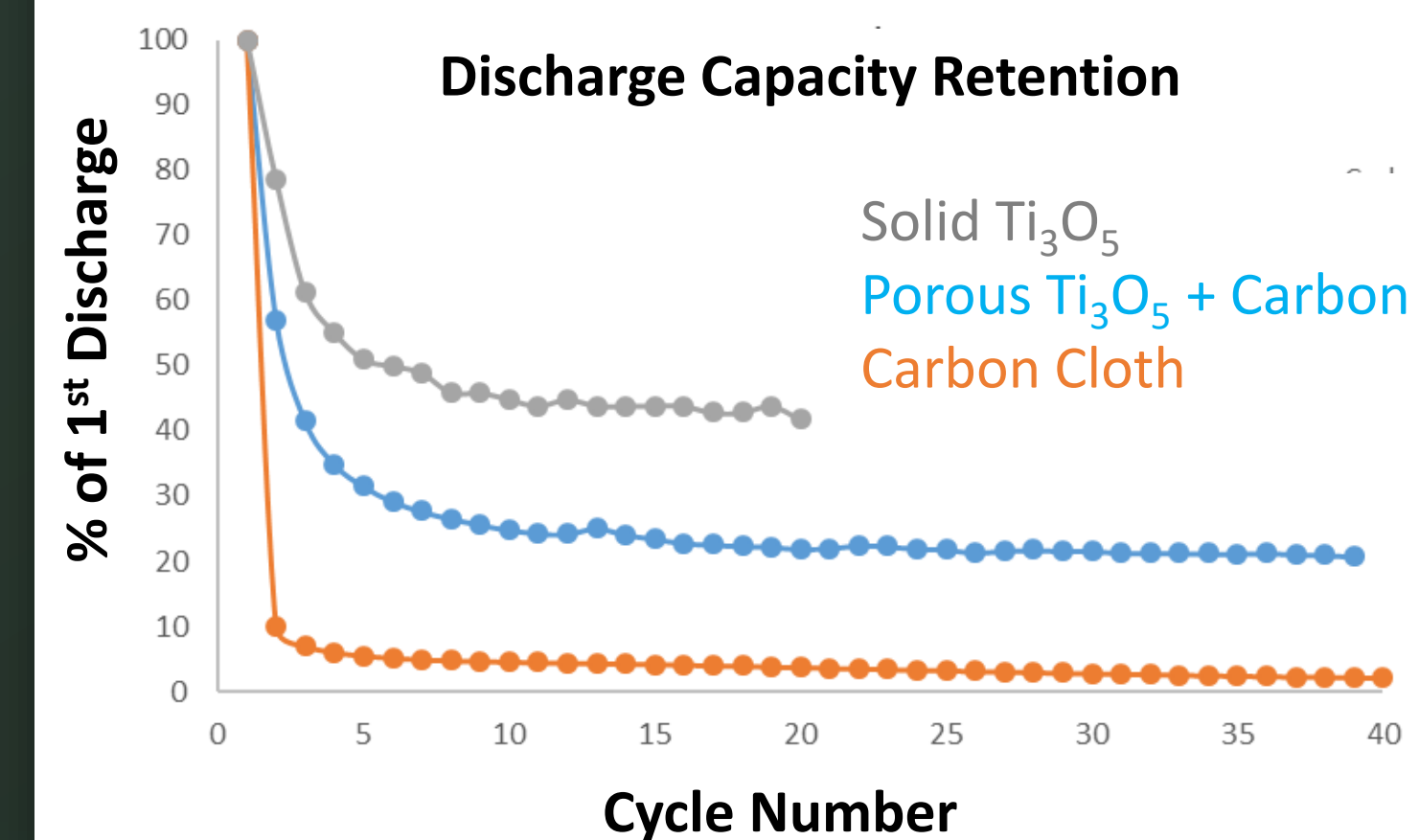
Options For Carbon-Free Cathodes?

Magneli phase $\text{Ti}_n\text{O}_{2n-1}$ has been shown to be stable toward the superoxide anion in the fuel cell community, and is much more conductive than insulating TiO_2



Na-Air cathodes need to be porous for O_2 flow, we can ball mill TiO_2 with PEG-8000 before carbothermal reduction to $\text{Ti}_n\text{O}_{2n-1}$

PEG will degrade with heat, leaving decreased volume carbon black pores



Capacity retention is much improved in the porous cathodes, and even more so in the carbonless solid pellets

$\text{Ti}_n\text{O}_{2n-1}$ is a promising electrode material, discharge products need to be characterized via NMR to see the reactions happening

Alternative synthesis methods for porous pellets need to be explored