Alternative Cathode Substrates for the Na-Air Battery

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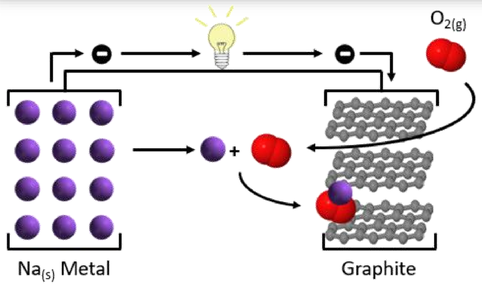
EECOMOBILITY (ORF) & HEVPD&D CREATE

The Na-Air Battery



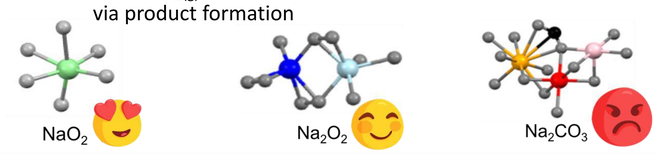
Possible Electrochemical Discharge Products:

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

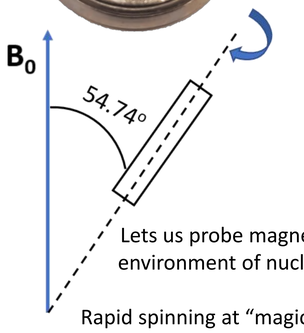
Reacts Na and $O_{2(g)}$ to release energy via product formation



Solid State NMR Spectroscopy

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

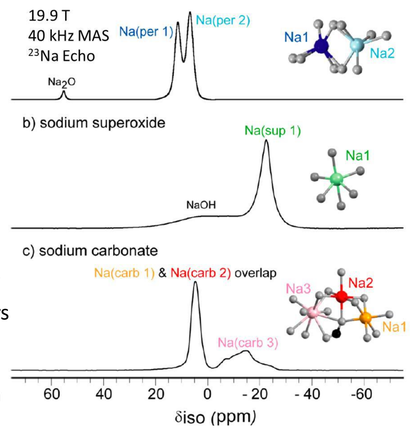
We need a method to study the parasitic reactions happening within the cell



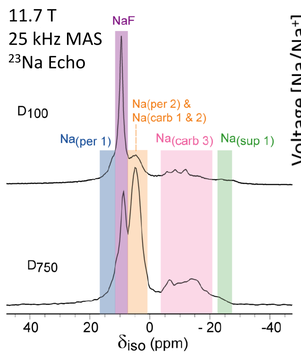
Lets us probe magnetic environment of nucleus

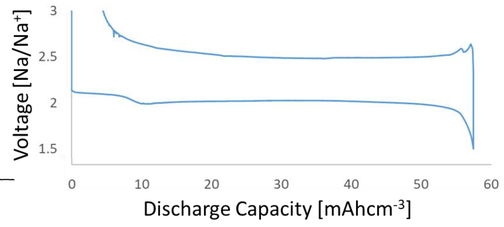
Rapid spinning at "magic angle" mimics solution state for powders

Each of the main discharge products has a unique spectrum



^{23}Na NMR of Discharged Cathodes

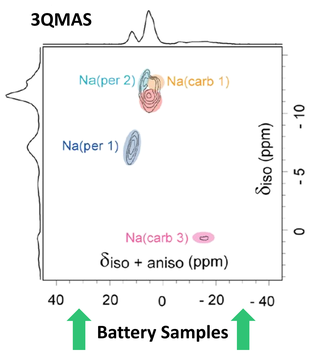


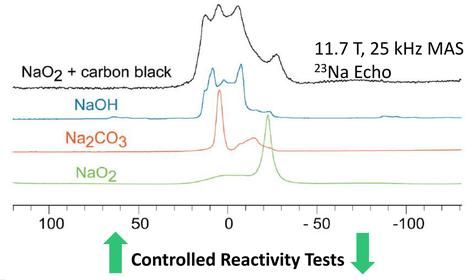


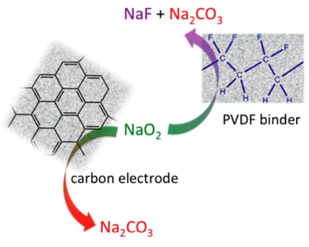
Discharged Cathodes are removed from coin cell and put in NMR magnet for characterisation

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





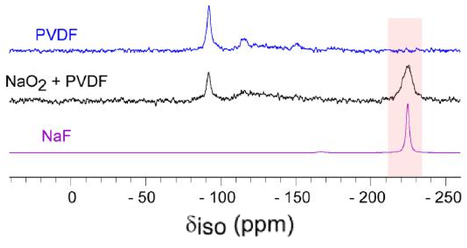


NaO_2 has shown to be reactive toward both components of the carbon based cathodes

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

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

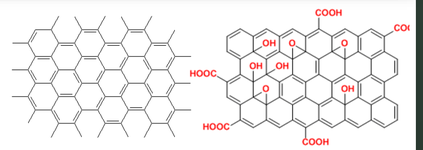
Synthesised NaO_2 also reacting with PVDF, the main bonding material used in Na-Air cathodes to make NaF

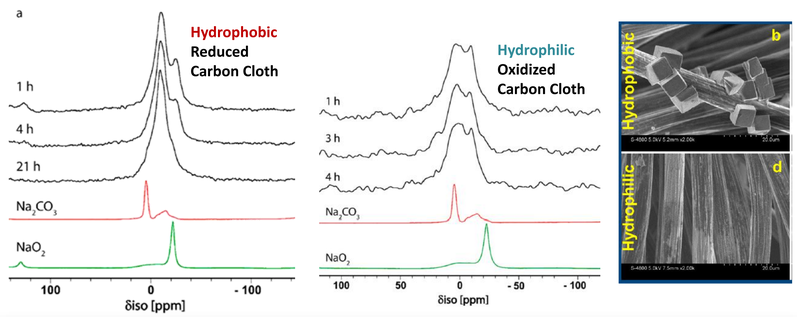


Functionalized Carbon Cloth Cathodes

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

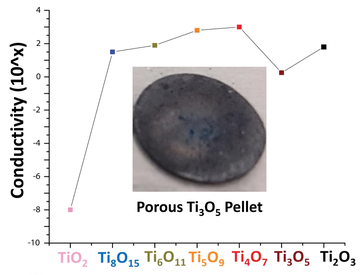
Hydrophobic shows greater affinity to NaO_2 crystallite production, while hydrophilic cloth forms a passivating layer of Na_2CO_3

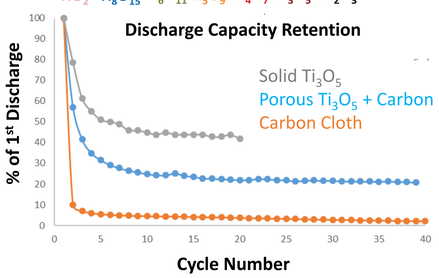


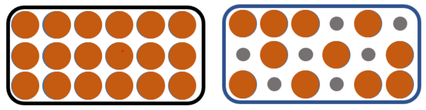


Options For Carbon-Free Cathodes?

Magneli phase Ti_nO_{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 Ti_nO_{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

Ti_nO_{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

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