Alternative Cathode Substrates for the Na-Air Battery

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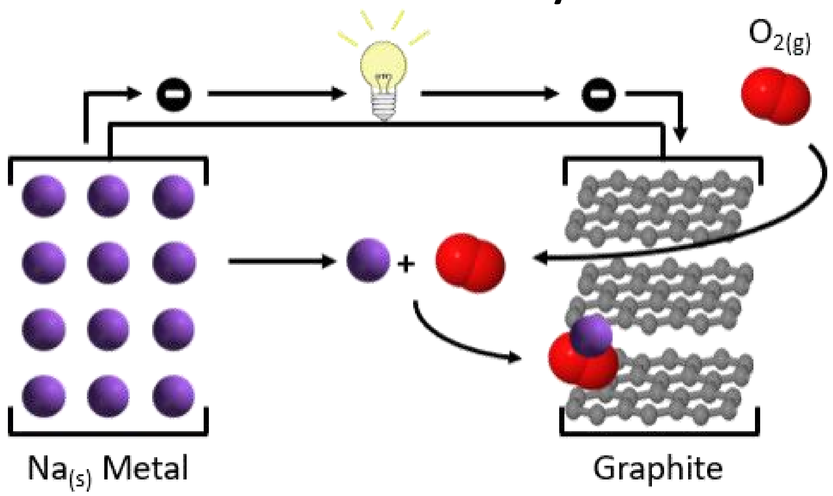
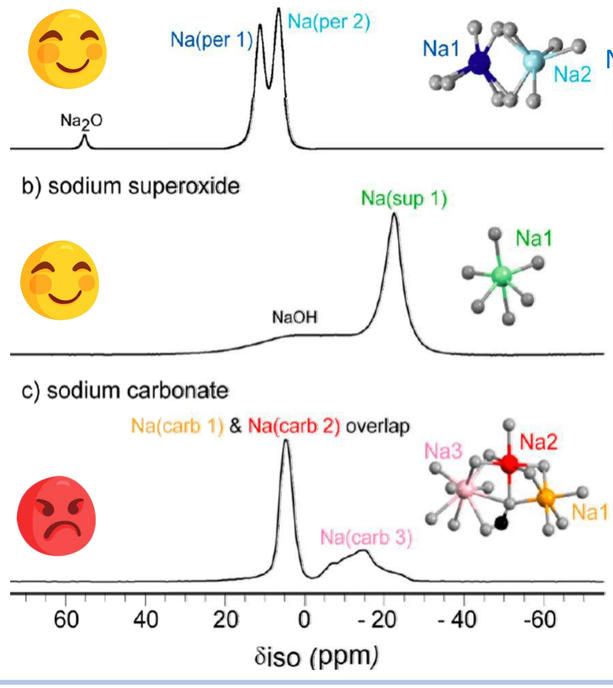
EECOMOBILITY (ORF) & HEVPD&D CREATE

The Na-Air Battery



Reacts Na and $O_{2(g)}$ to release energy and form oxides on discharge. Oxides are broken down into Na and O_2 on charging cycle

Solid state ^{23}Na magic angle spinning NMR can be used to distinguish electrochemical products on cycled cathodes



Na_2O_2 = Formed via two-electron ORR Higher Energy Density but Low Coulombic Efficiency

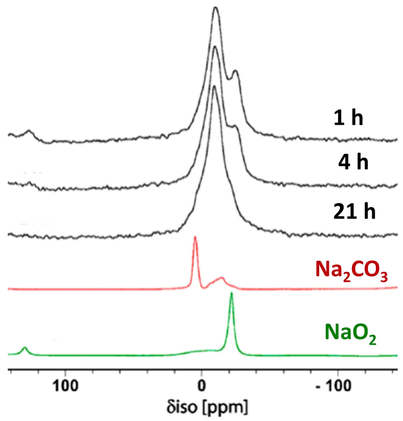
NaO_2 = Formed via single electron ORR High Energy Density & Coulombic Efficiency

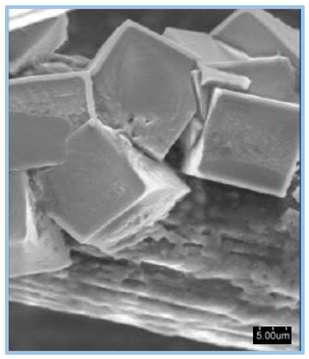
Na_2CO_3 = Formed via parasitic side reactions Can not "recharge" if formed, lost capacity

Tailoring Discharge Chemistry at the Cathode

Na-Air coin cells with both hydrophobic and hydrophilic carbon cathodes were discharged in an oxygen environment

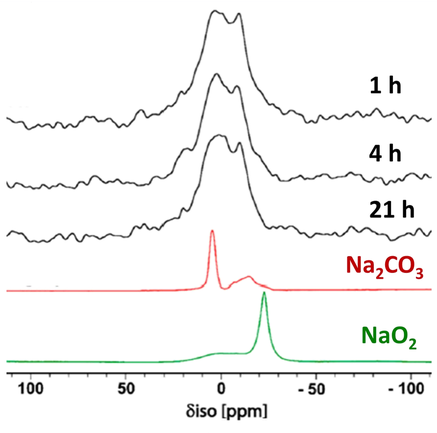
Hydrophobic and hydrophilic carbon cathodes are made via H_2 reduction and Hummers method respectively

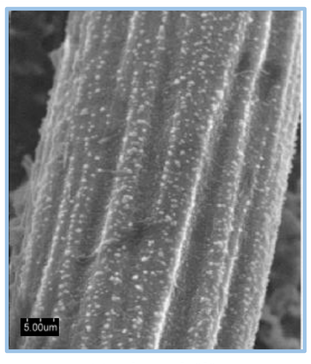




Hydrophobic

The hydrophobic surface promotes O_2^- solvation, producing NaO_2 crystals in a solution based mechanism, but NaO_2 degrades quickly





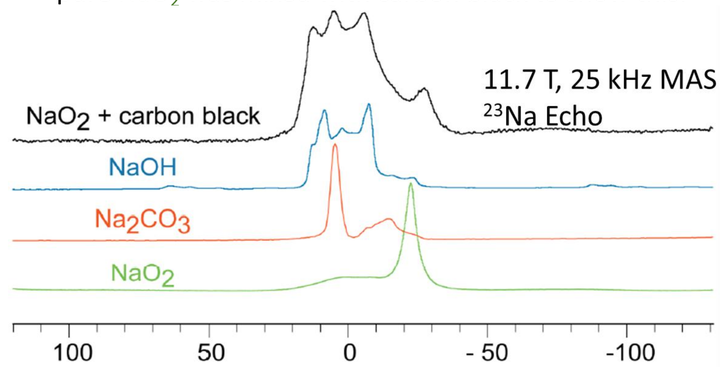
Hydrophilic

The hydrophilic surface promotes O_2^- adsorption, producing $Na_2O_2{\cdot}2H_2O$ and Na_2CO_3 in a surface mediated reaction, products are more stable but the mixture is more amorphous and complex

Hydrophobic environments promote solution formation, via $1e^-$ ORR
Hydrophilic environments promote surface mediation, via $2e^-$ ORR

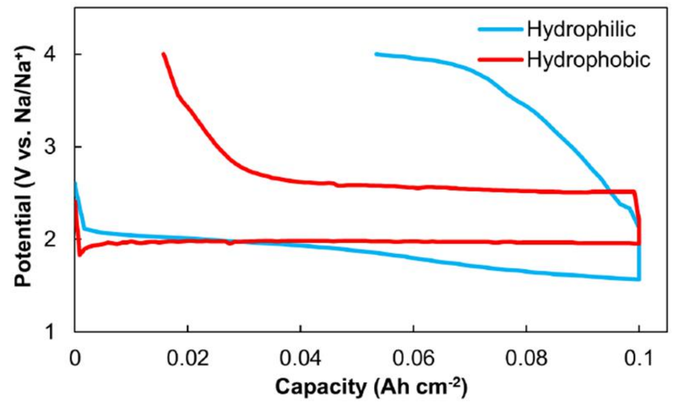
The Na_nO_2 Problem

The instability of NaO_2 extends to all forms of carbon in general, pure NaO_2 was mixed with carbon black to show this:



To Summarize: We can selectively form NaO_2, but it is not stable long term. Na_2O_2 is more stable, but is not easy to form selectively

Further, Na_2O_2 based products have higher charging overpotentials, and high charging voltages degrade the cell electrolyte and cathode:



1. More stable, non-carbon, cathodes that can be oxidatively stable toward NaO_2 or Na_2O_2's high potentials need to be explored
2. Higher voltage electrolytes need to be tested to withstand the high voltages needed to recharge Na_2O_2 based cells

Current projects in the Goward group are investigating each of these

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