

Alternative Cathode Substrates for the Na-Air Battery

Goward Group

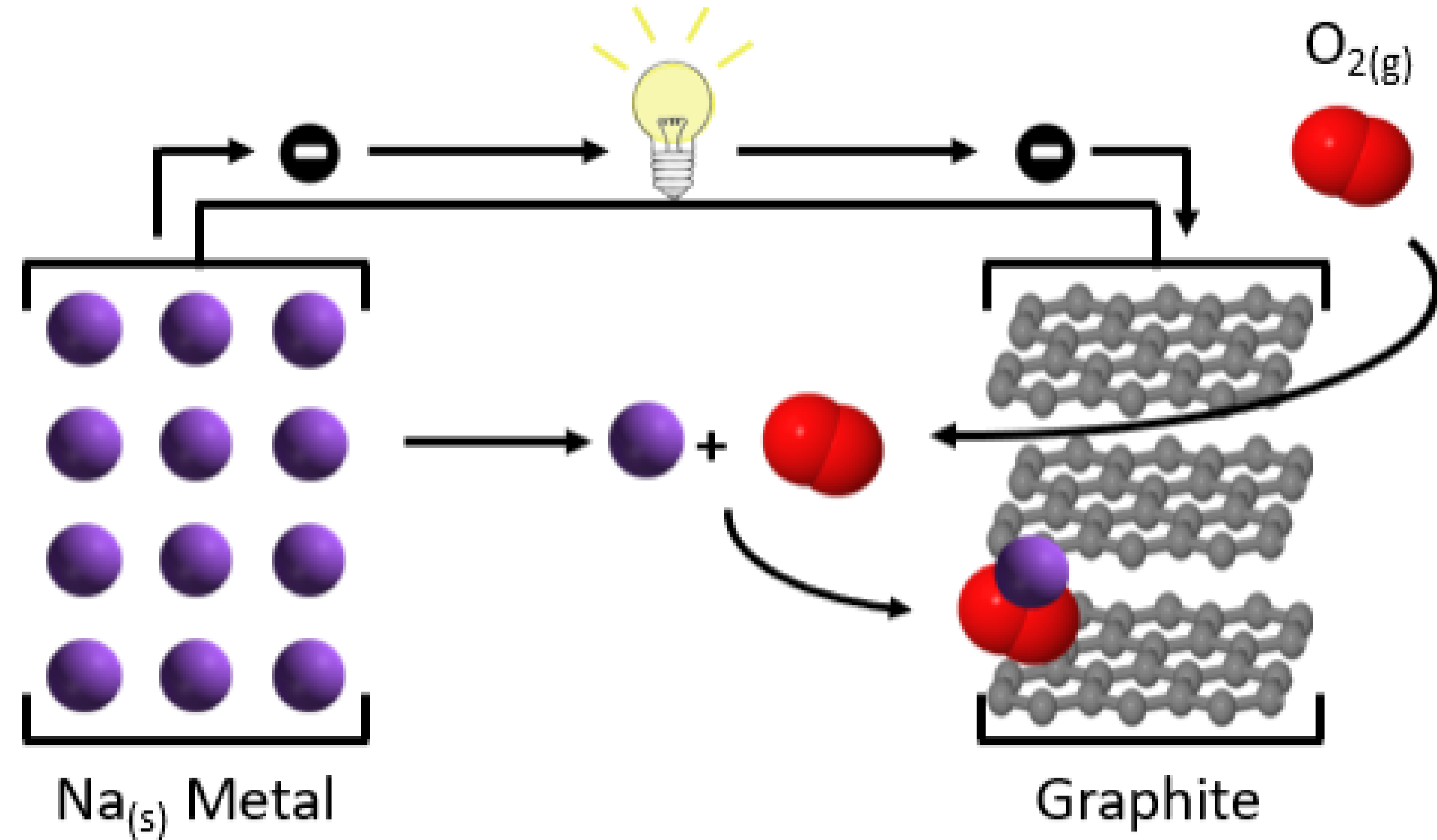
Department of Chemistry, Faculty of Science

Christopher Franko, Hossein Yadegari, Andy Sun, Yaser Abu-Lebdeh, Gillian Goward*



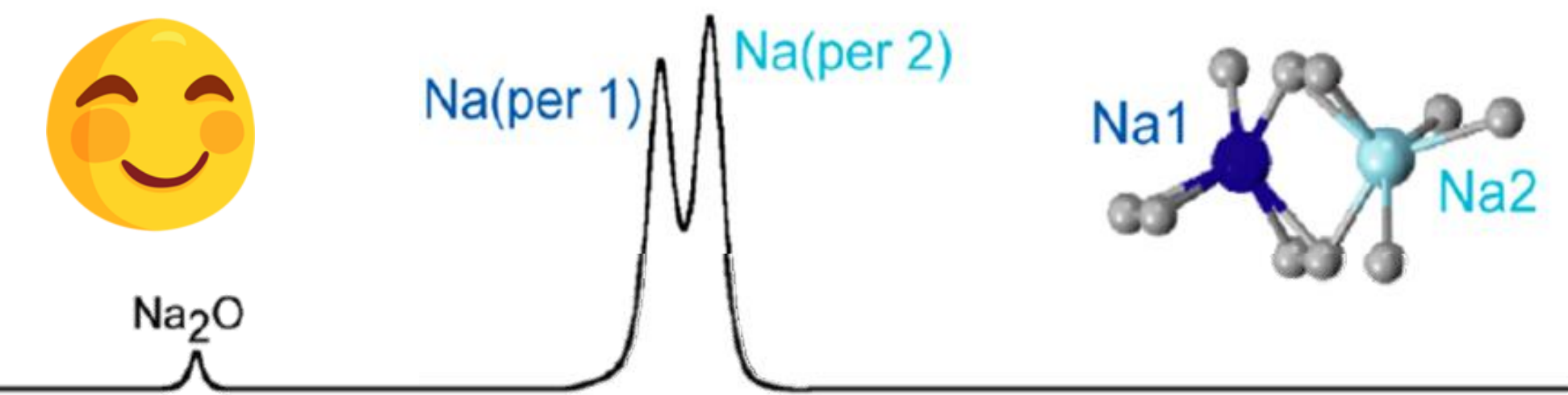
EECOMOBILITY (ORF) & HEVPD&D CREATE

The Na-Air Battery

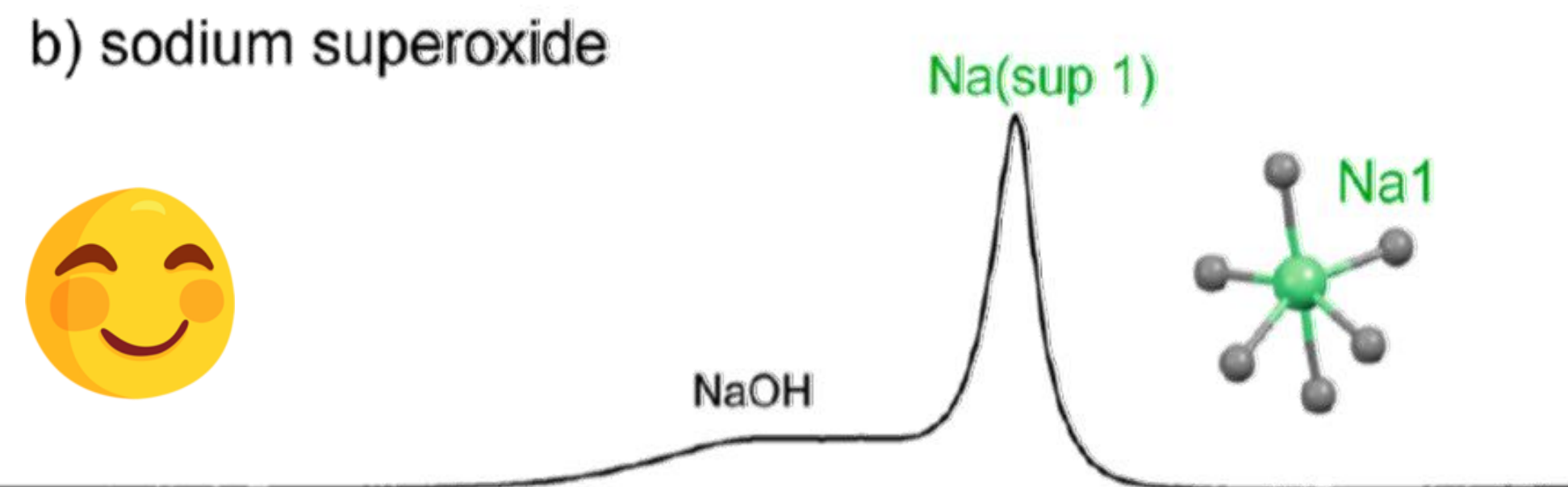


Reacts Na and $O_{2(g)}$ to release energy and form oxides on discharge. Oxides are broken down into Na and O_2 on charging cycle

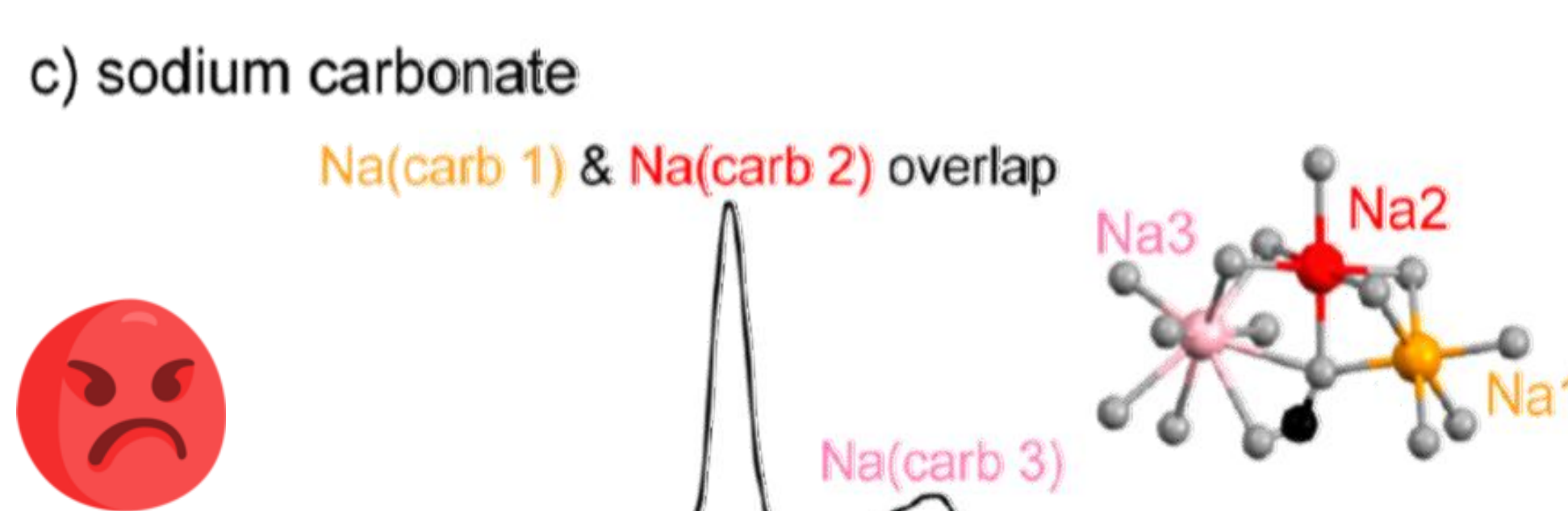
Solid state ^{23}Na magic angle spinning NMR can be used to distinguish electrochemical products on cycled cathodes



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

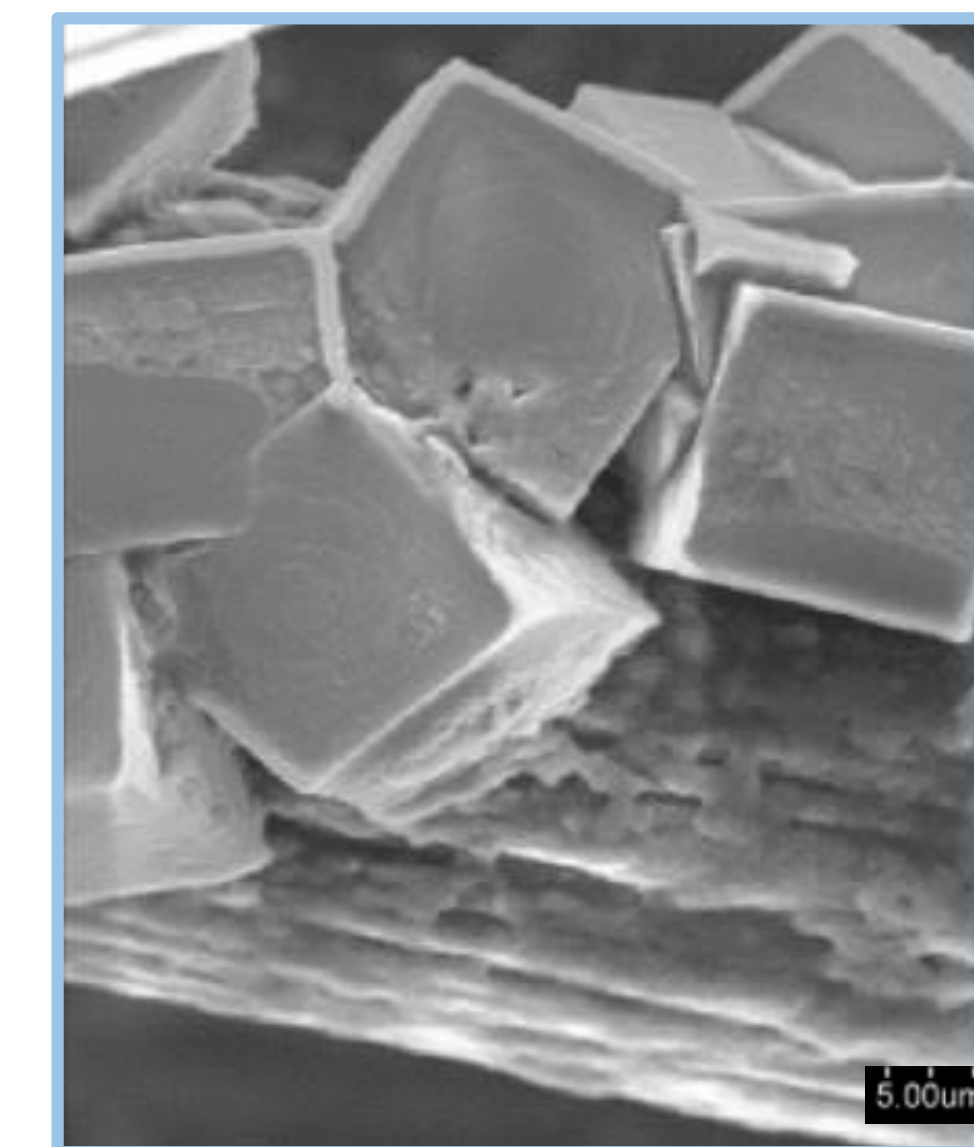
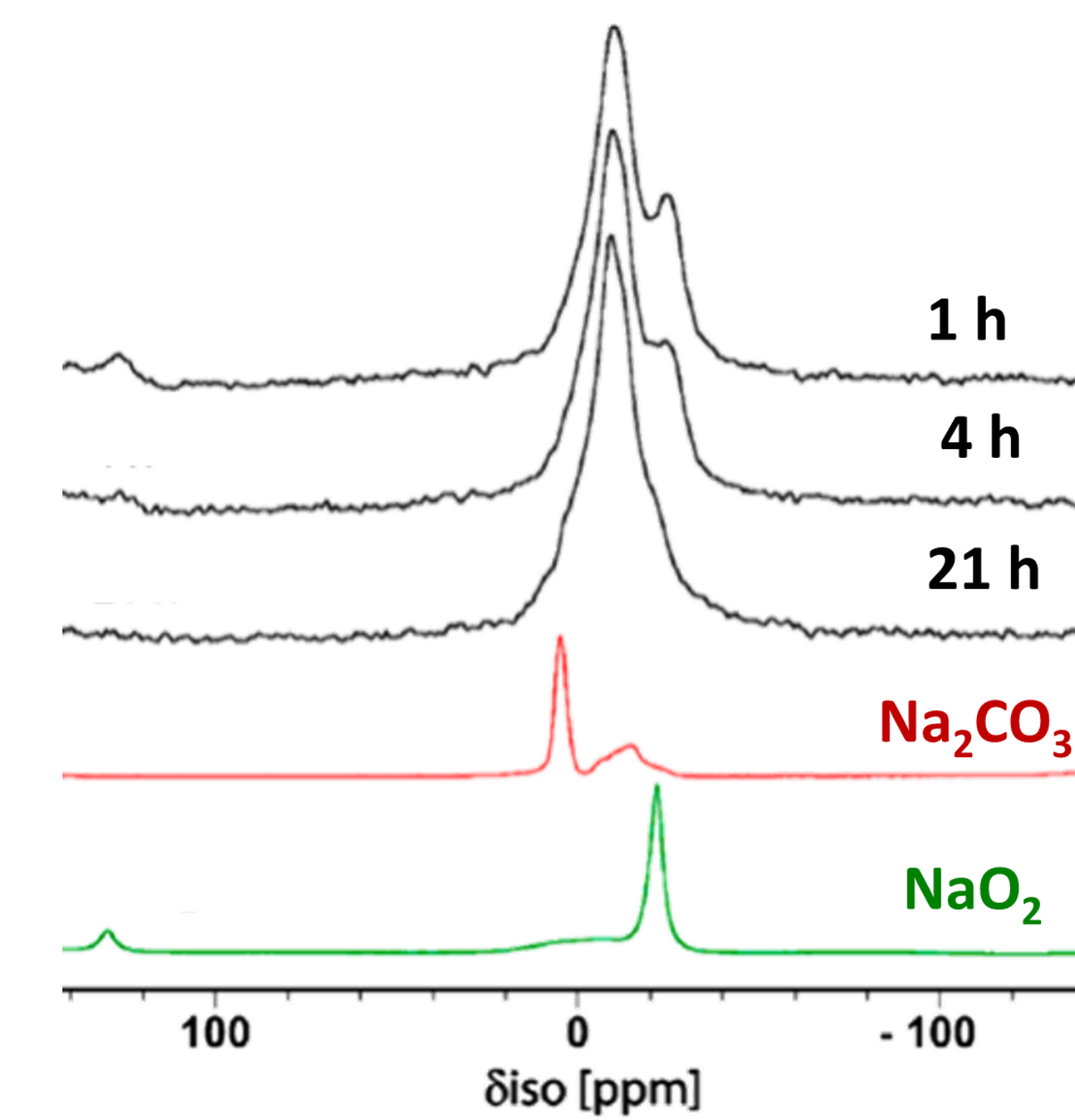
Tailoring Discharge Chemistry at the Cathode



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

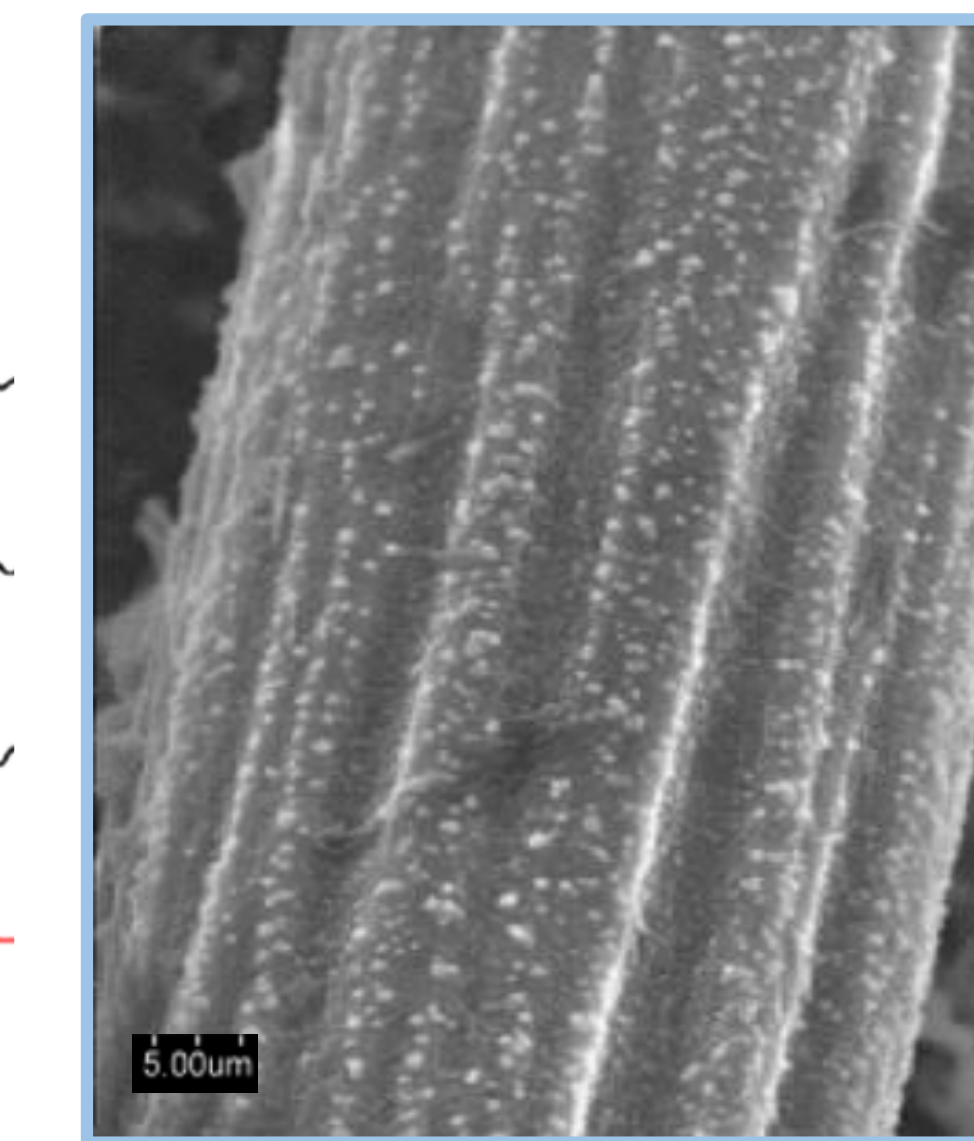
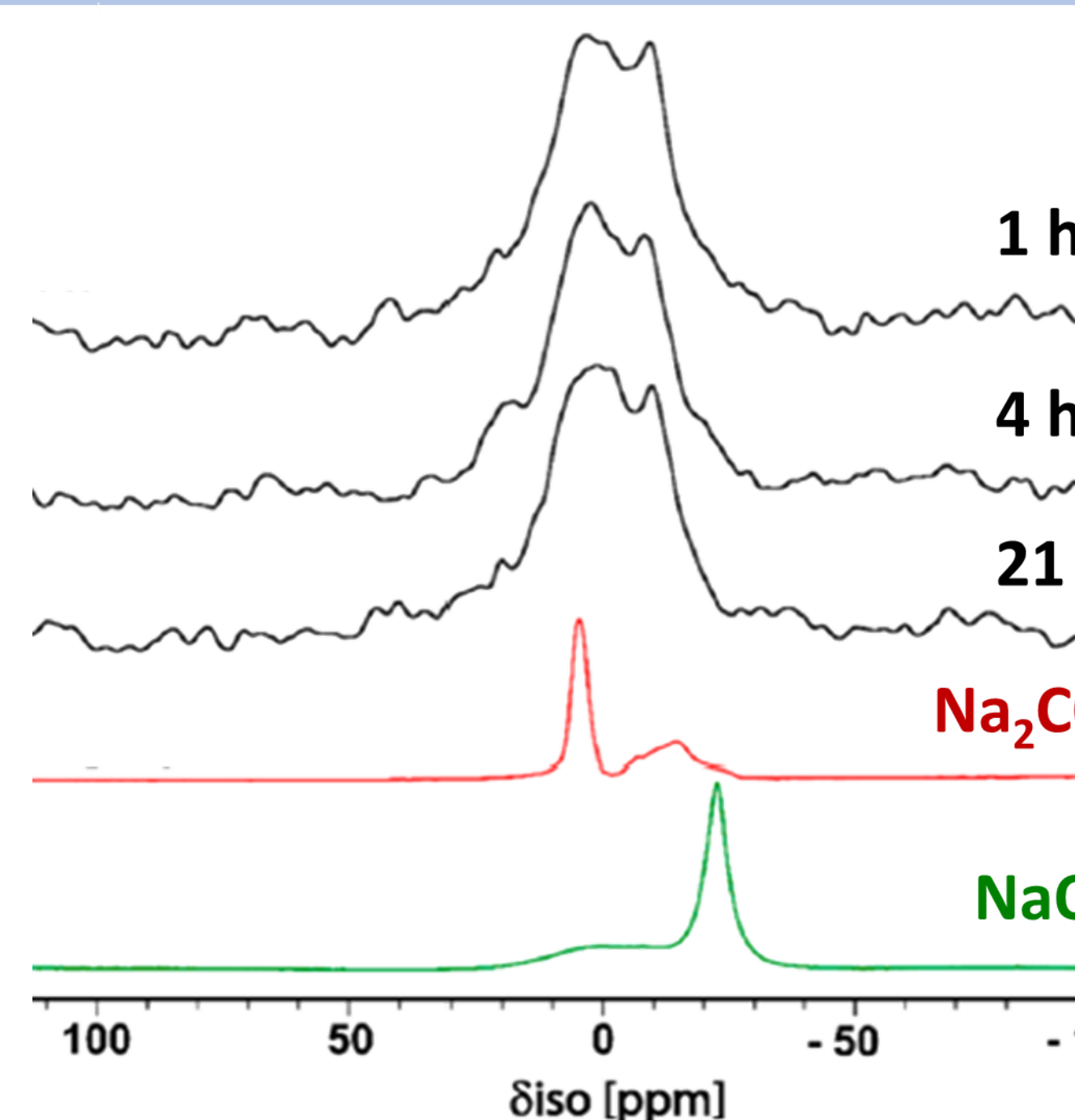


Hydrophobic and hydrophilic carbon cathodes are made via H_2 reduction and Hummers method respectively



Hydrophobic

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



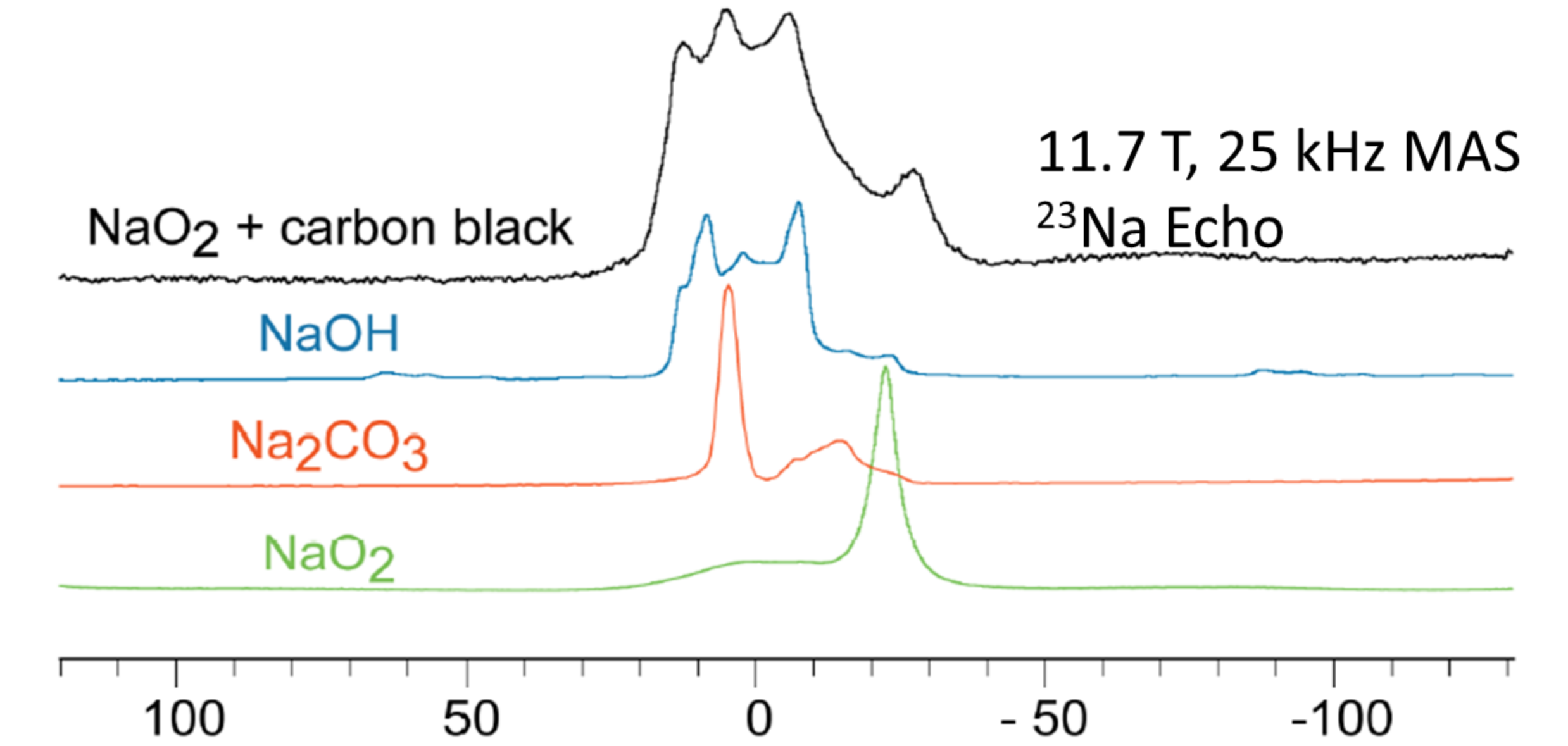
Hydrophilic

The hydrophilic surface promotes O_2^- adsorption, producing $\text{Na}_2\text{O}_2 \cdot 2\text{H}_2\text{O}$ 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

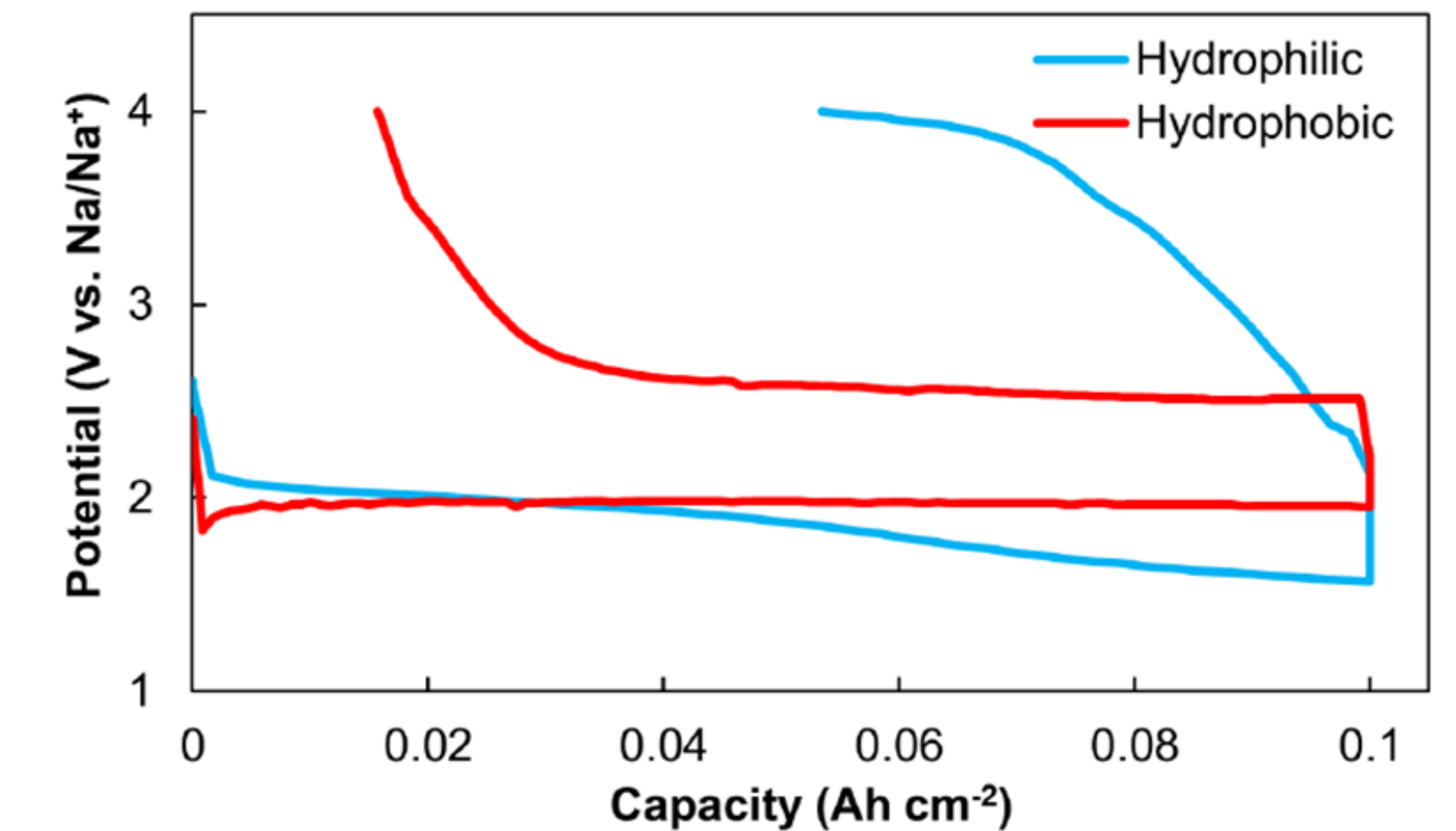
The Na_nO_2 Problem

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