To access the manuscript:

Impact of surfactants on Carbon Black Slurries used in Flow Battery Application

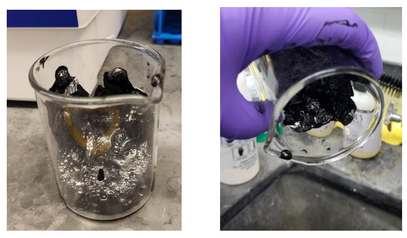
KangJin Lee, Mohan Das, and Christopher L. Wirth

Department of Chemical and Biomolecular Engineering, Case Western Reserve University

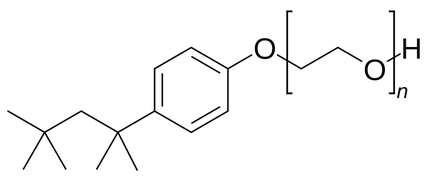
Introduction

Along with many advantages of using carbon black slurry as a flowing electrode, challenges such as clogging and sedimentation has been observed. Understanding the behavior of slurry electrodes are crucial in improving battery performance.

Non-ionic surfactants have been observed to be good dispersants for carbon black particles.[1] Here, we investigated the impact of non-ionic surfactant (Triton X-100) on carbon black slurry stability and performance by studying its gravitational settling and capacity/conductivity.



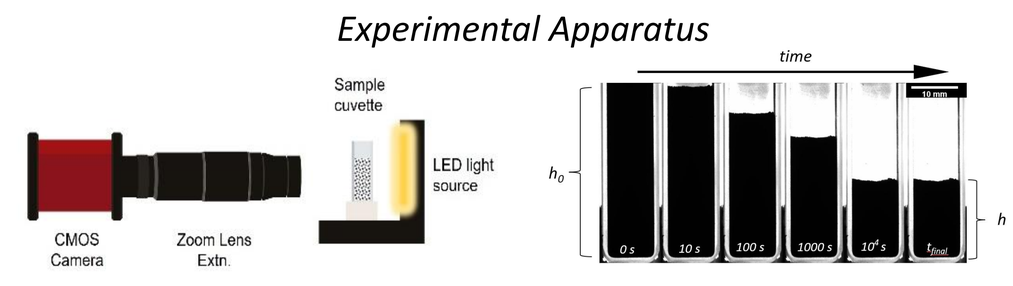
"Clogged" CB slurry



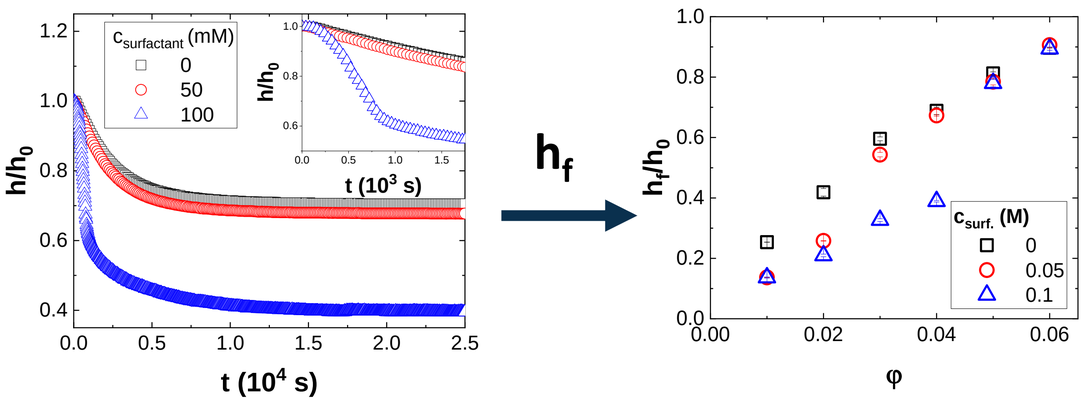
Triton X-100 (n = 9-10)

Slurry Stability - Sedimentation

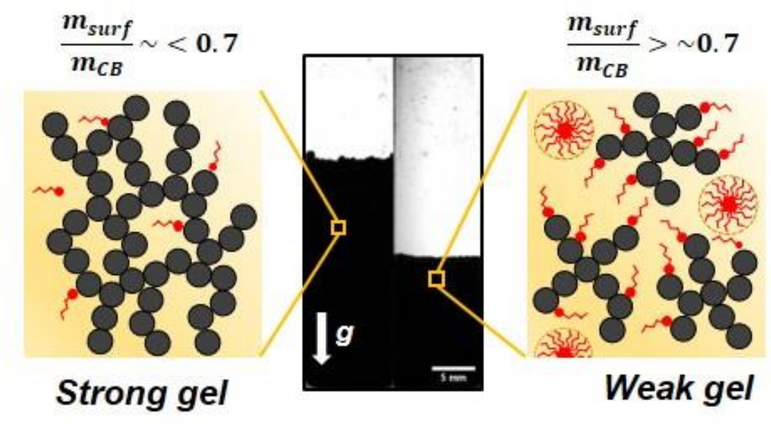
Experimental Apparatus



- Observed sedimentation dynamics of carbon black loading at 2-12g/100mL
- Fits an exponential decay model suggested by Manley *et al.*[2] of a gel collapse



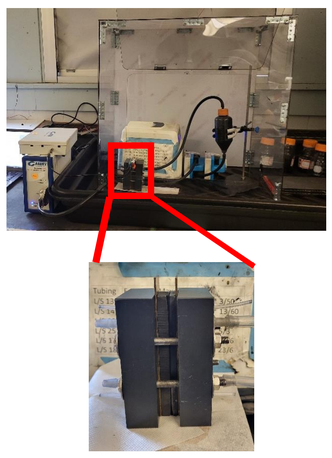
Catastrophic collapse is observed at higher surfactant concentrations where $\boldsymbol{\alpha}$ $(\frac{m_{surf.}}{m_{CB}}) > \mathbf{0.7}$ due to weak gel formation



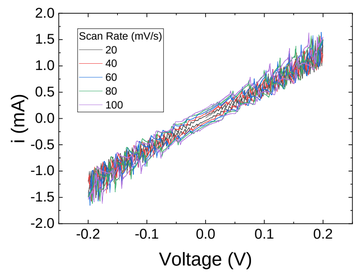
[1] Porcher, W., *et al*. *Journal of Power Sources,* **2010**, 195, 2835-2843
[2] Manley S., *et al*. *Physical Review Letters*, **2005**, 94(21).

Flow Battery Apparatus

Flow battery set-up

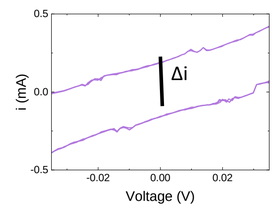


CV-scan at different scan rates from -0.2 to 0.2 V



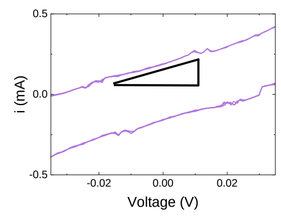
$\frac{\Delta i}{2} = \dot{V} C_{tot}$

Capacity



$\frac{\partial A}{\partial V} = \kappa$

Conductivity



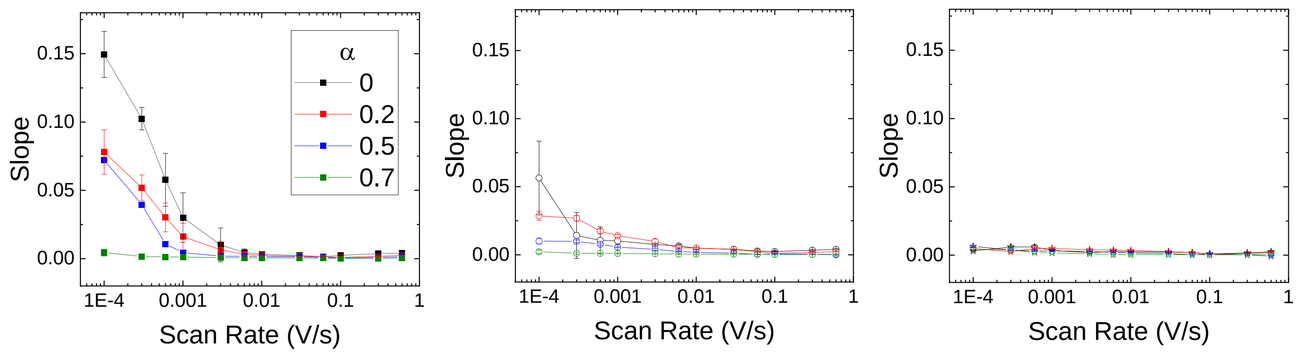
Slurry Performance - Conductivity & Capacity

To evaluate slurry performance, slurry conductivity and capacity based on:

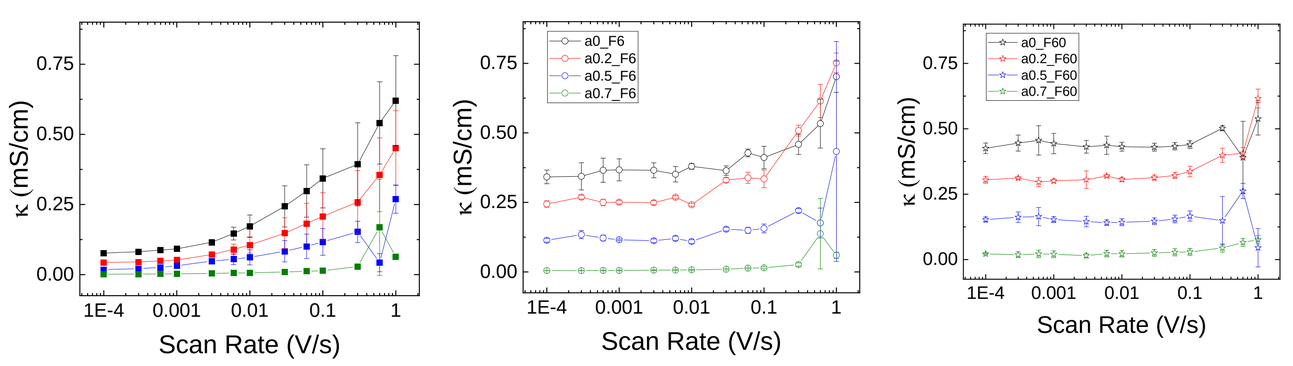
- **Slurry flowrate** – structure and residence time of particles
- **Scan rate** – effective surface area measured
- **Surfactant concentration (α)** – available surface area of CB particles

Low flowrate → **High flowrate**

Capacity



Conductivity



With increasing:	Capacity	Conductivity
Flowrate	Decrease	Increase
Scan rate	Decrease	Increase
$\alpha = \frac{m_{surf.}}{m_{CB}}$	Decrease	Decrease

Conclusion

- Carbon black slurry shows gel collapse behavior
- $\boldsymbol{\alpha} > 0.7$ weakens the particle interaction, leading to a weak gel formation and catastrophic gel collapse
- Conductivity and capacity decreases with addition of surfactants due to decrease in effective surface area covered by surfactant adsorption

Acknowledgement

This work was funded through the U. S. Department of Energy, Office of Electricity, Pacific Northwest National Lab Contract #540358.

The authors would like to gratefully acknowledge Dr. Imre Gyuk, Director of Energy Storage Research in the Office of Electricity, for financial support, and Dr. Akolkar, Dr. Savinell, and Dr. Wainright for their input in the project.