Electrochemical Energy Storage
Approach to Renewable Energy

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Dyes do this...

What if...they could do this?
… or this?
Brief Electrochemistry Overview

- Involves electron (charge) transfer across interfaces; in this case, an electrode and a solution
- A potentiostat applies a voltage to the electrode thus controlling the energy of electrons
- Data ($i$ vs $E$) collected from cyclic voltammetry (CV) allows for an analysis of electron transfer

Experimental Set Up

- **Working electrode**: Pt
- **Reference electrode**: Ag/AgCl(aq)
- **Counter electrode**: Pt

**Experimental Setup Diagram**

- **Porous glass frit**
- **0.1 M TBAP in ACN**
- **~5 mM dye**
- **0.1 M TBAP in ACN**
- **Ar**

**Chemicals**
- GC: Glassy carbon
- TBAP: Tetrabutylammonium perchlorate
- ACN: Acetonitrile
CVs for Solvent Blue 59

![Graph showing cyclic voltammograms for Solvent Blue 59 with different scan rates: 20, 50, 100, and 200 mV/s. The x-axis represents potential (V vs. Ag/AgCl(aq)) and the y-axis represents current (μA).]

![Structural formula of Solvent Blue 59 with labeled atoms.

![Image of Solvent Blue 59 and Sudan Blue II in test tubes.]}
Diffusion Coefficient for Solvent Blue 59

- Calculated diffusion coefficients
  - $9.3 \times 10^{-7}$ cm$^2$/s
  - $2.0 \times 10^{-7}$ cm$^2$/s
  - $6.1 \times 10^{-7}$ cm$^2$/s
  - $6.2 \times 10^{-7}$ cm$^2$/s
  - $2.1 \times 10^{-7}$ cm$^2$/s
  - $9.7 \times 10^{-7}$ cm$^2$/s

- Randles-Sevcik Equation
  
  $$i_p = 0.4463nFAC \left( \frac{nFvD}{RT} \right)^{1/2}$$
Solvent Blue 59 UV/vis

Absorbance

<table>
<thead>
<tr>
<th>Concentration of Saturated Solution (mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{638\text{nm}} = 0.20686$</td>
</tr>
<tr>
<td>3.59</td>
</tr>
<tr>
<td>$A_{593\text{nm}} = 0.17917$</td>
</tr>
<tr>
<td>3.60</td>
</tr>
</tbody>
</table>
CVs for Sudan Blue II

- Background
- 20 mV/s
- 50 mV/s
- 100 mV/s

Potential (V vs. Ag/AgCl(aq))

Current (μA)
Diffusion Coefficient for Sudan Blue II

- Calculated diffusion coefficients
  - $5.5 \times 10^{-6} \text{ cm}^2/\text{s}$
  - $6.5 \times 10^{-7} \text{ cm}^2/\text{s}$
  - $2.9 \times 10^{-6} \text{ cm}^2/\text{s}$
  - $1.1 \times 10^{-6} \text{ cm}^2/\text{s}$
  - $2.2 \times 10^{-6} \text{ cm}^2/\text{s}$
  - $4.2 \times 10^{-6} \text{ cm}^2/\text{s}$
  - $9.2 \times 10^{-7} \text{ cm}^2/\text{s}$
  - $4.7 \times 10^{-6} \text{ cm}^2/\text{s}$

- Randles-Sevcik Equation
  
  $i_p = 0.4463nFAC\left(\frac{nFvD}{RT}\right)^{\frac{1}{2}}$
### Sudan Blue II UV/vis

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Absorbance</th>
<th>Concentration (mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>640 nm</td>
<td>$y = 0.59095x - 0.00016$</td>
<td></td>
</tr>
<tr>
<td>594 nm</td>
<td>$y = 0.50405x - 0.00184$</td>
<td></td>
</tr>
<tr>
<td>$A_{640\text{nm}}$</td>
<td>0.91207</td>
<td>12.35</td>
</tr>
<tr>
<td>$A_{594\text{nm}}$</td>
<td>0.78619</td>
<td>12.51</td>
</tr>
</tbody>
</table>
Conclusions:

- Our results indicate that from the dyes studied, Sudan Blue II represents the most promising energy storage material
  - Sudan Blue II has 4 reversible redox couples while Solvent Blue 59 has 3 reversible redox couples
  - Sudan Blue II has higher diffusion coefficient values than Solvent Blue 59
  - Sudan Blue II has a higher saturated concentration which means there is more active material in a set volume
Future Experiments

- Analyze different anthraquinone dyes
- Purification of dyes
- Use of different working electrodes
- Measure kinetics of electron transfer using rotating disk electrode (RDE)
Acknowledgements

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  - Dr. Héctor D. Abruña

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  - Jeesoo Seok

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