

Catalyst Characterization for Sulfur Dioxide Depolarized Electrolyzer

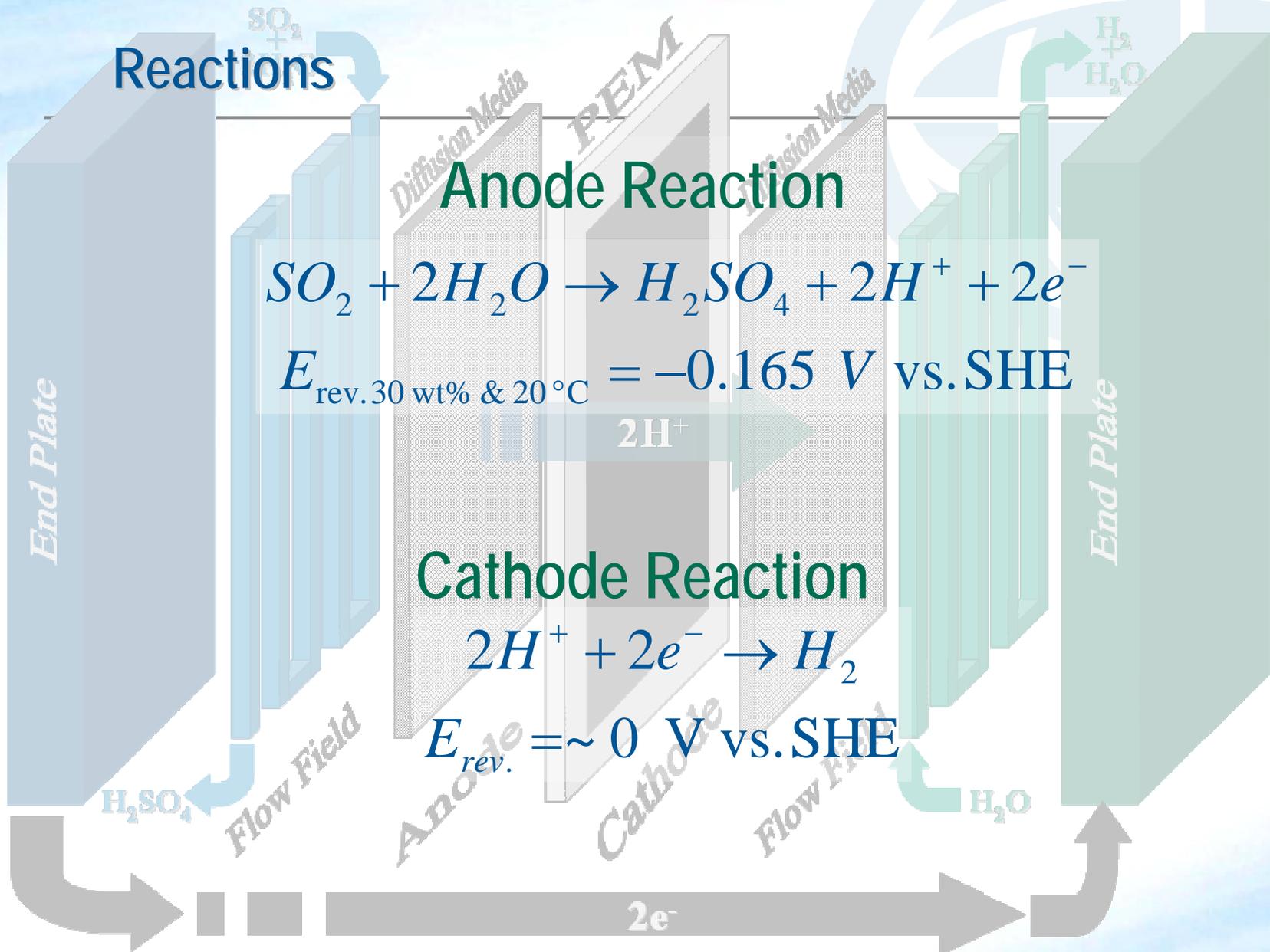
Héctor R. Colón-Mercado, Mark C. Elvington and

David T. Hobbs

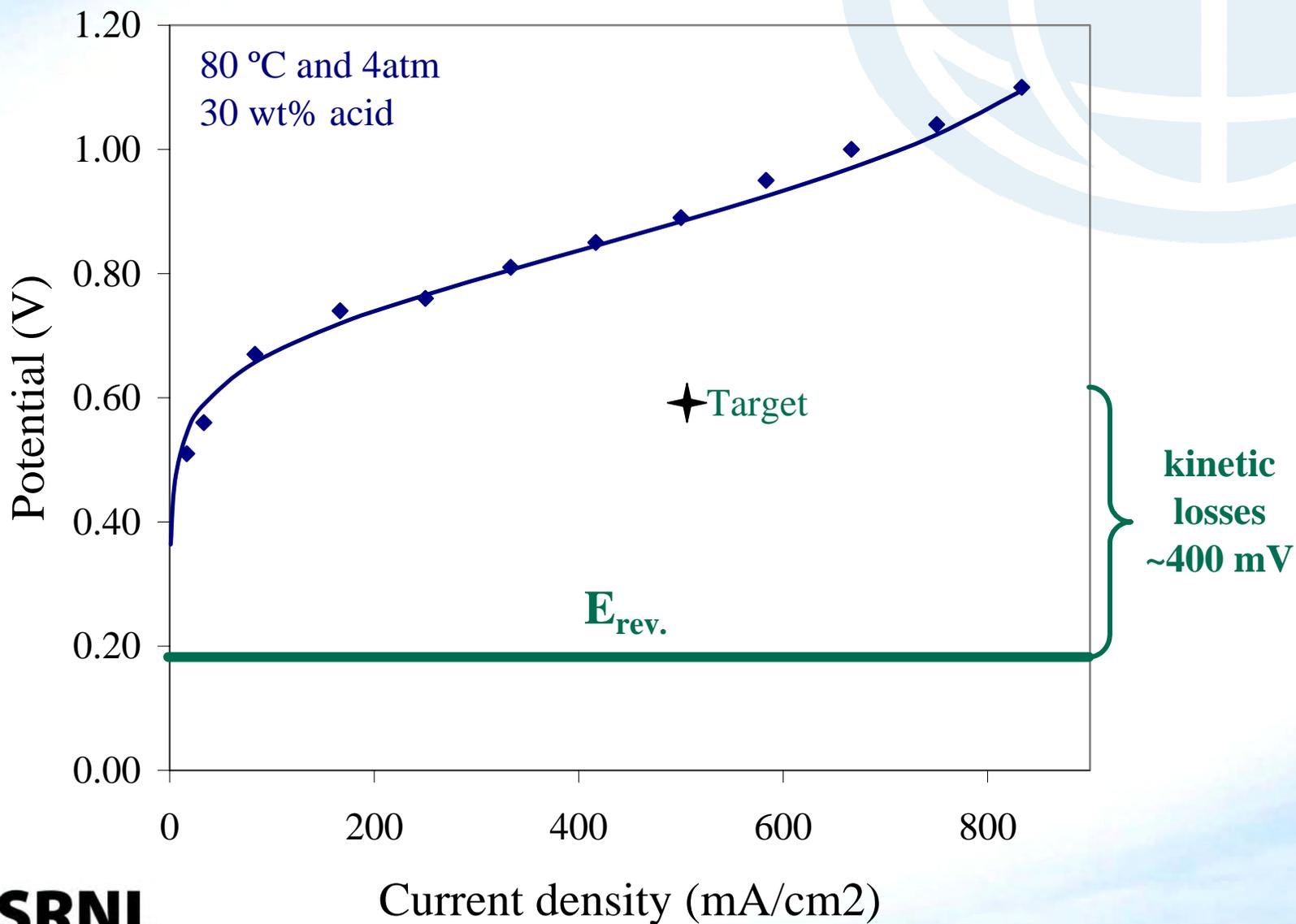
April 21 2009



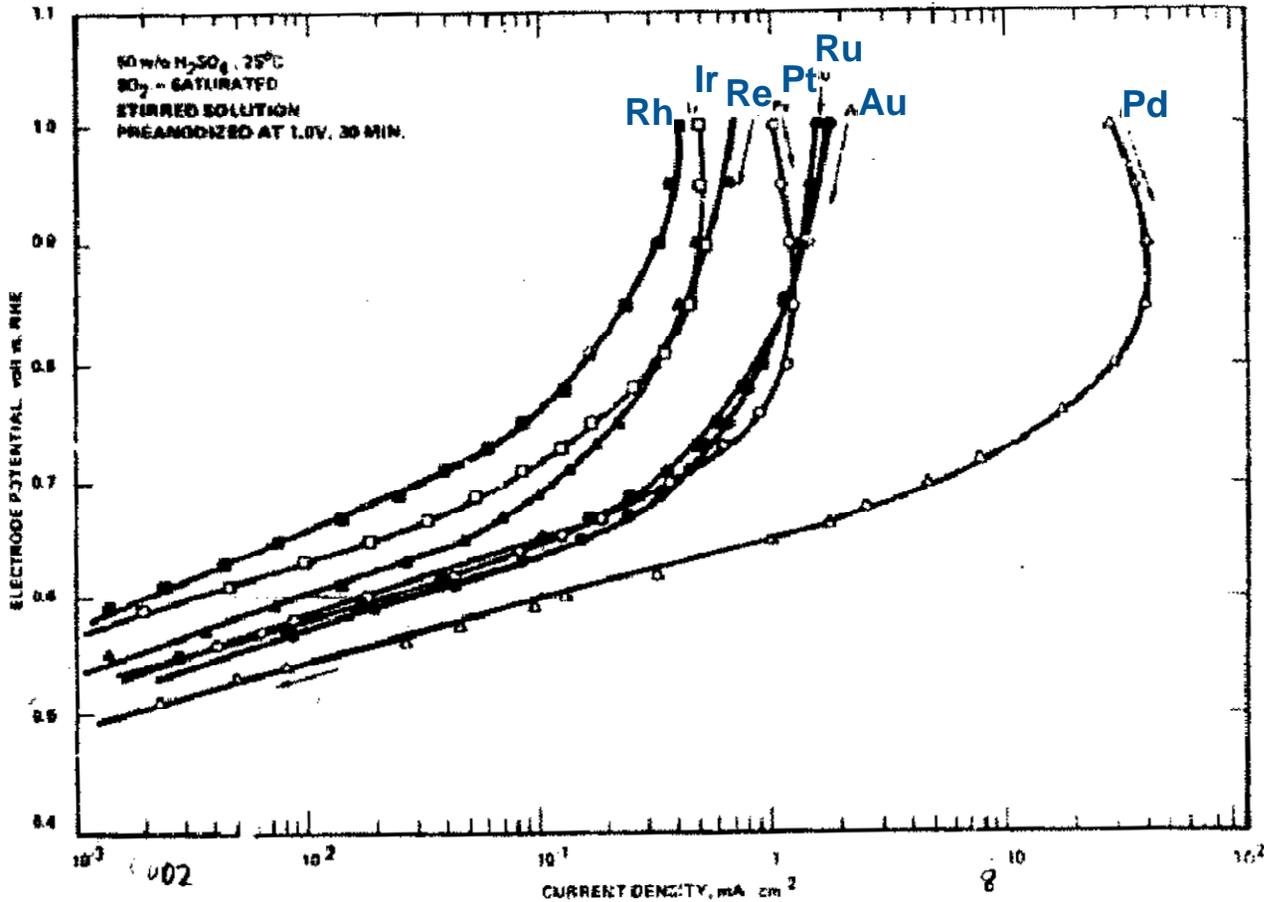
Hybrid Sulfur Electrolyzer Workshop



Electrolyzer Needs



Previous Work (Westinghouse Electric Corporation)



Experiments on smooth electrodes

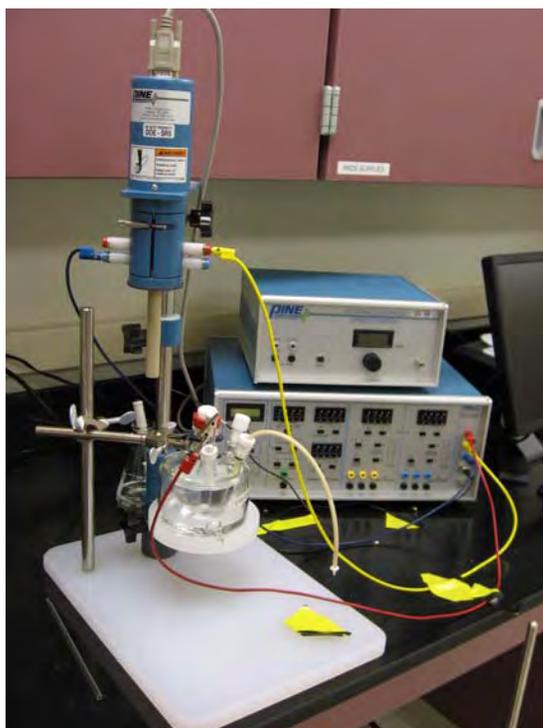
Pd shows highest activity followed by:
Au/Ru/Pt > Re > Ir > Rh

P. W. Lu and R. L. Ammon, J. Electrochem. Soc., 127 (1980) pp.2610-2616

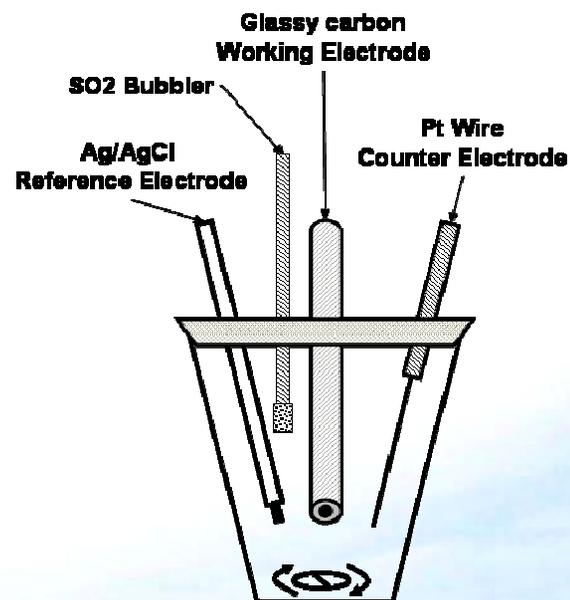
Electrocatalyst Testing

Materials tested:

Pt, Pd, Pt/transition metal alloys
(all supported on carbon black)

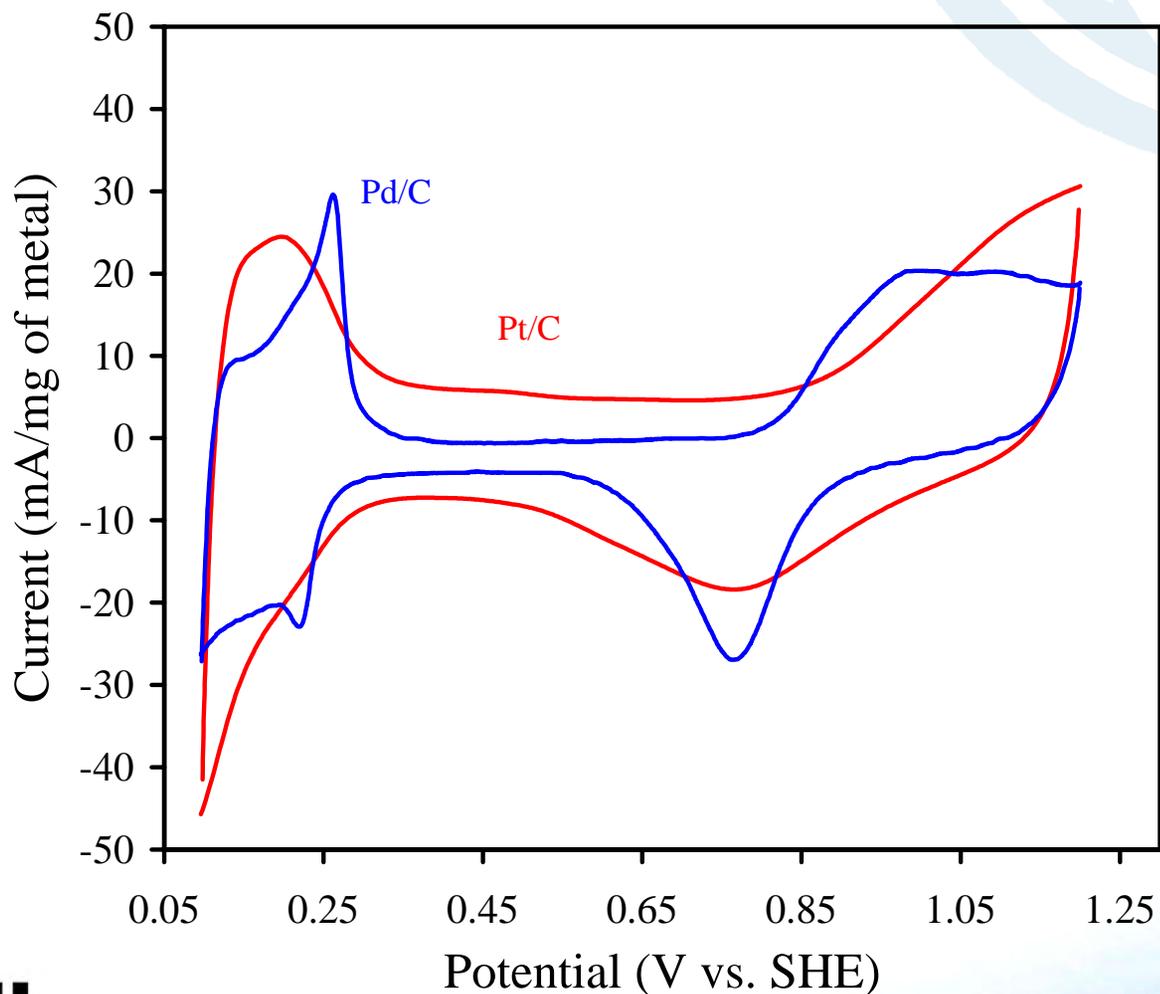


- Cyclic Voltammetry (50 mV/s)
 - Stability test
 - Surface Reactions
- Linear Sweep Voltammetry (5mV/s)
 - SO₂ oxidation kinetics



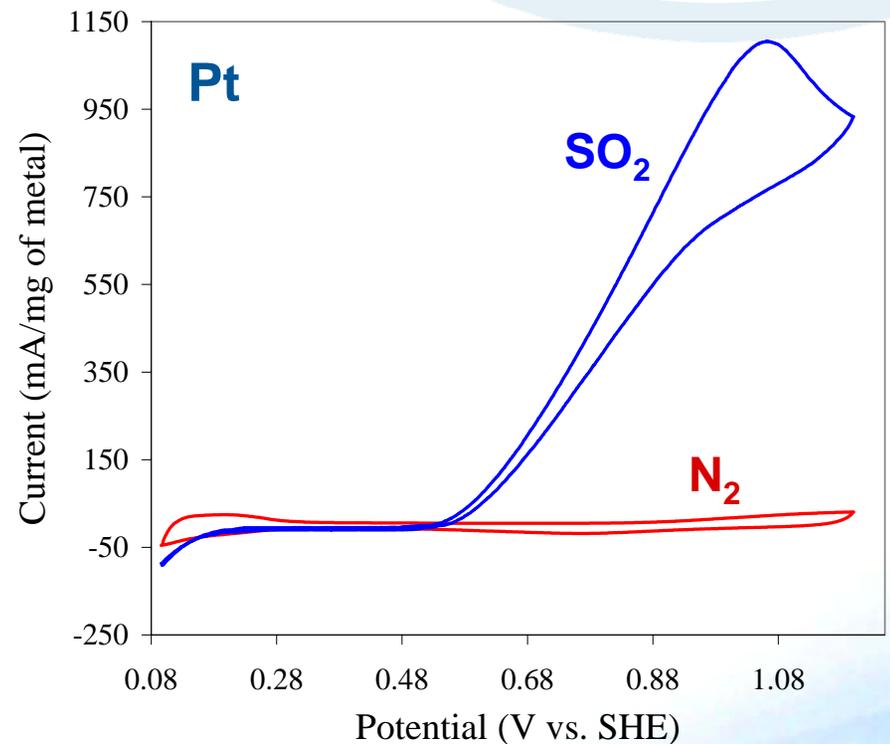
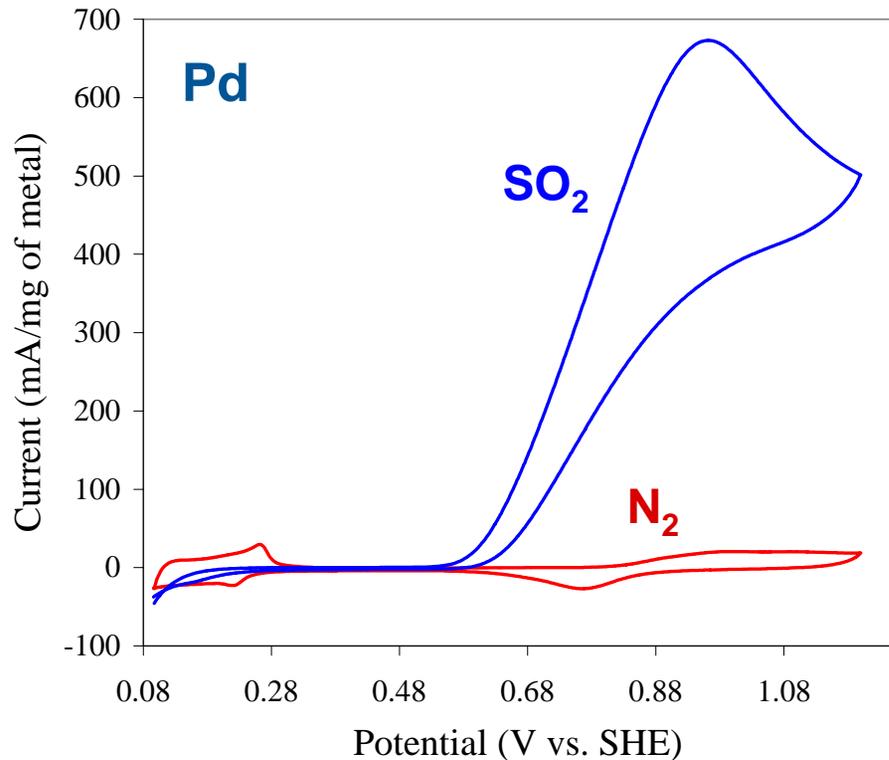
Catalyst Testing: Cyclic Voltammograms with N₂

Cyclic Voltammetry of Pt/C and Pd/C exhibit similar behavior



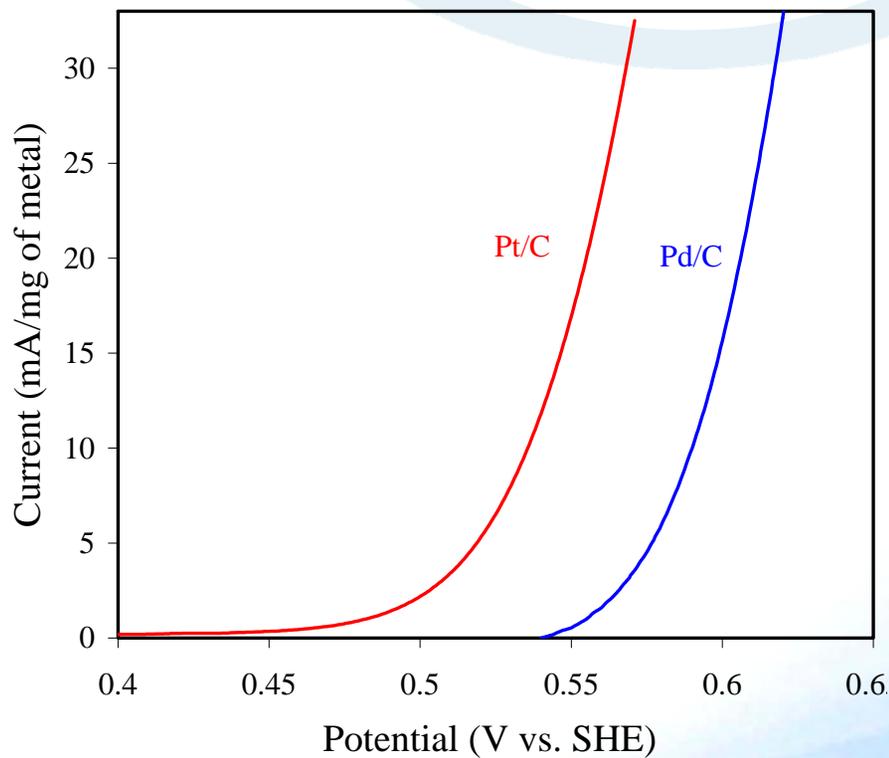
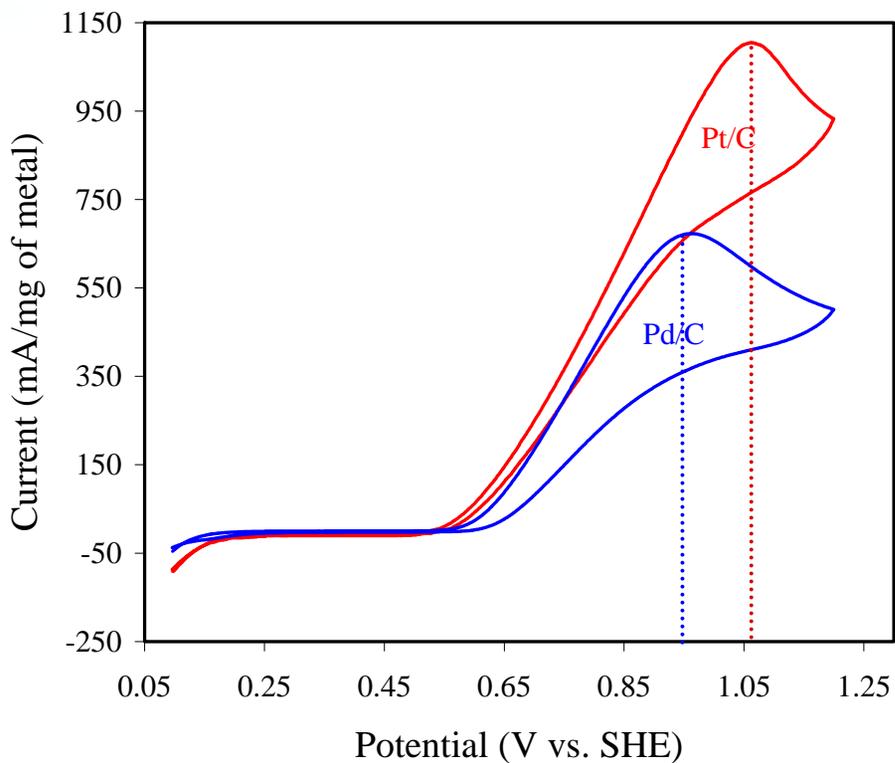
Catalyst Testing: Cyclic Voltammograms with SO₂

- The introduction of SO₂ in solution contaminates the electrode surface and the H adsorption-desorption peak disappears.
- A SO₂ oxidation peak appears



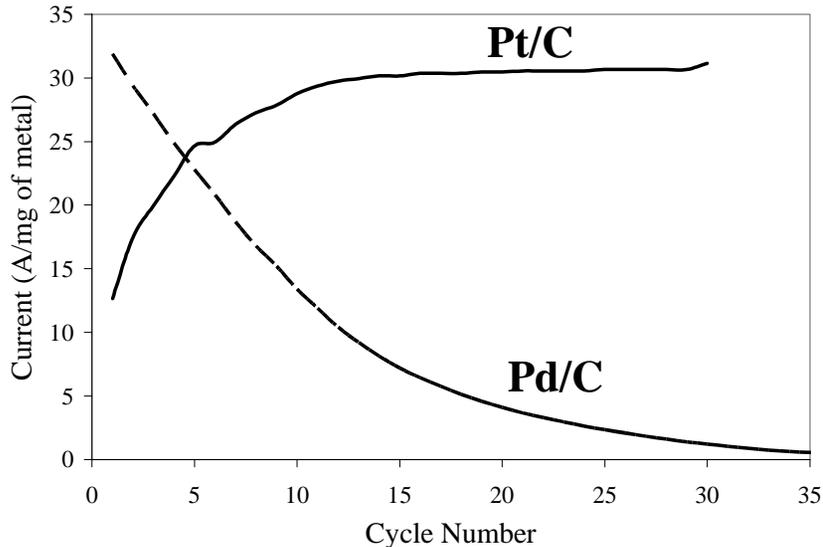
Catalyst Testing: SO₂ Activity

Pt/C exhibits greater activity than Pd/C

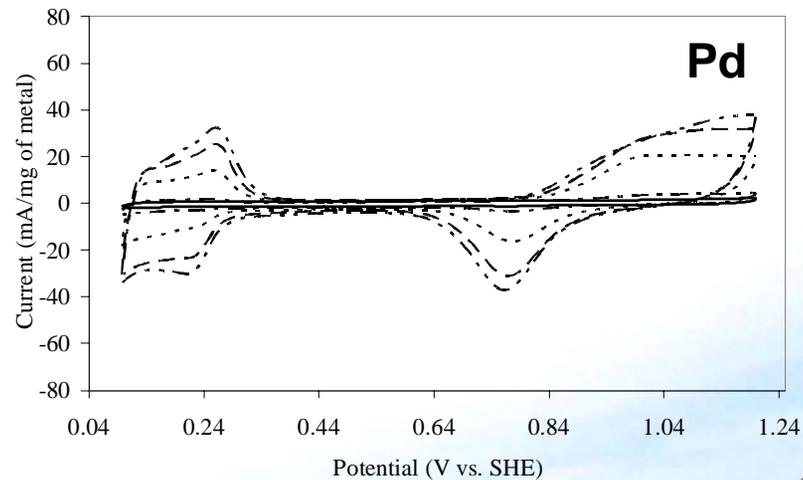
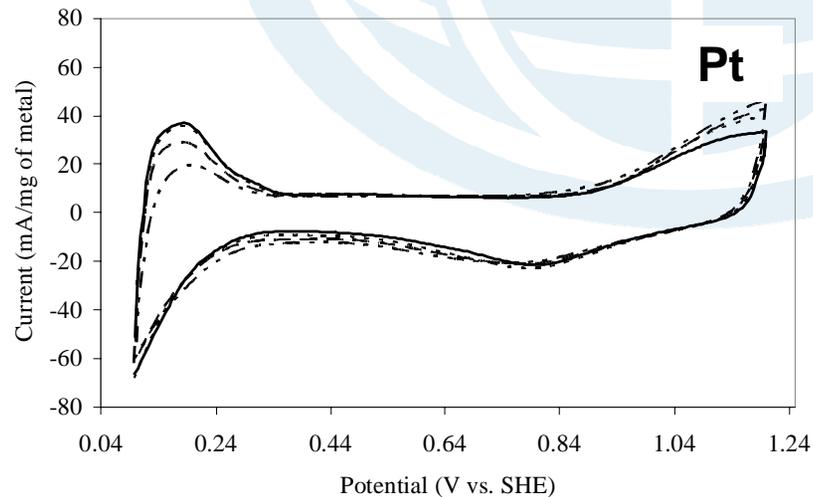


Catalyst Testing: Stability

Pt/C exhibits greater stability than Pd/C after multiple cyclic voltammetry scans



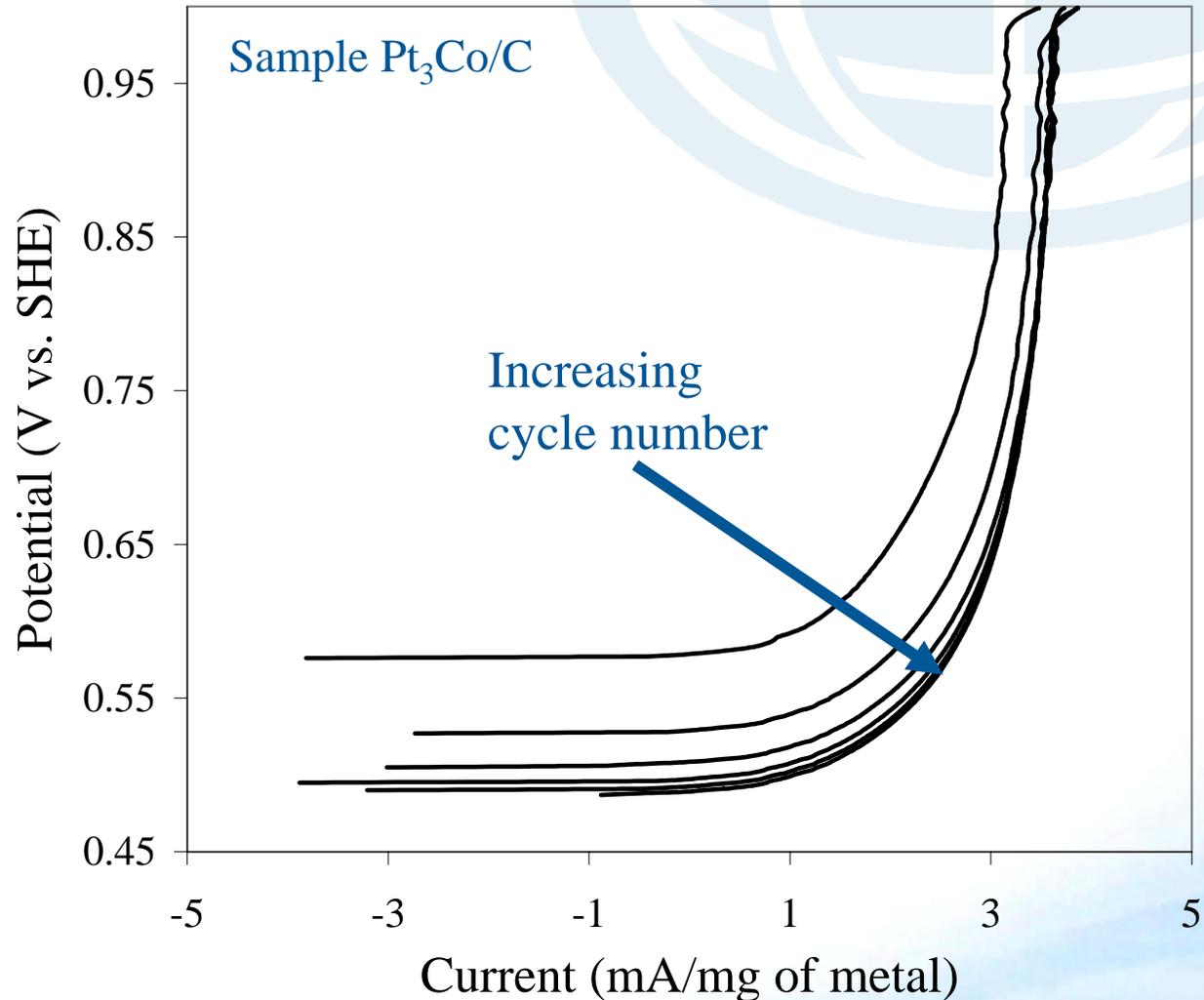
H. R. Colón-Mercado and D. T. Hobbs, "Catalyst evaluation for a sulfur dioxide-depolarized electrolyzer", *Electrochemistry Communications*, **2007** 9, 2649-2653



Catalyst Testing: Catalysts Activation

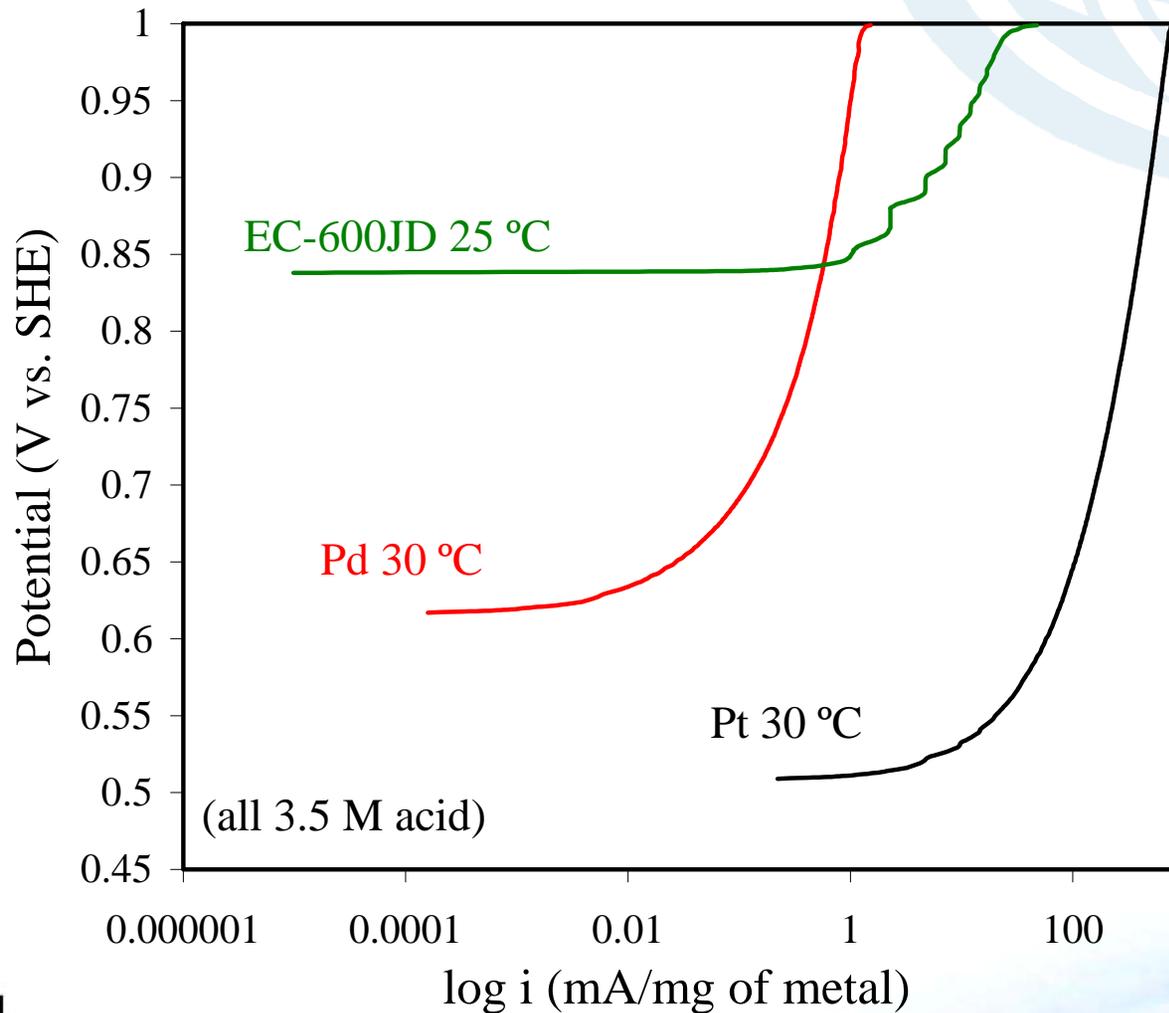
The catalyst performance increases as a function of cycle

It is speculated that anodization of the catalyst surface improves the activity for SO₂ oxidation



Catalyst Testing: SO₂ Oxidation Activity

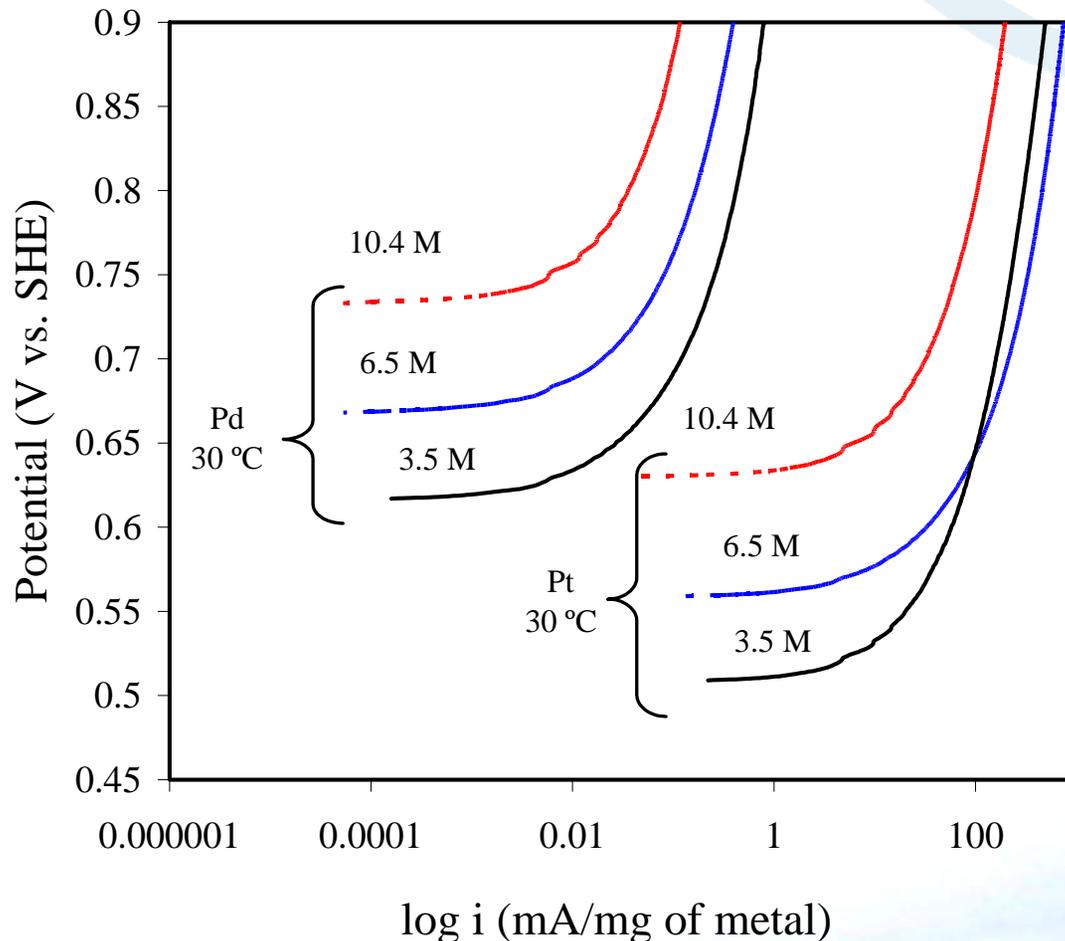
Comparison of Pt/C, Pd/C and Carbon Support



Catalyst Testing: SO₂ Oxidation Activity

Kinetic activity decreases as the acid strength increases

Pt exhibits approximately 100 mV better performance than Pd



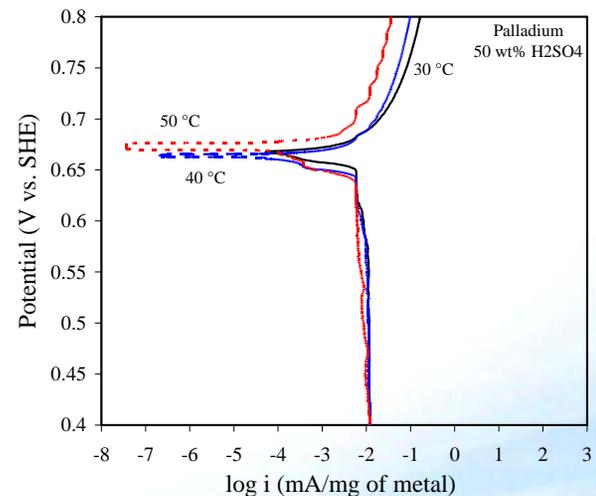
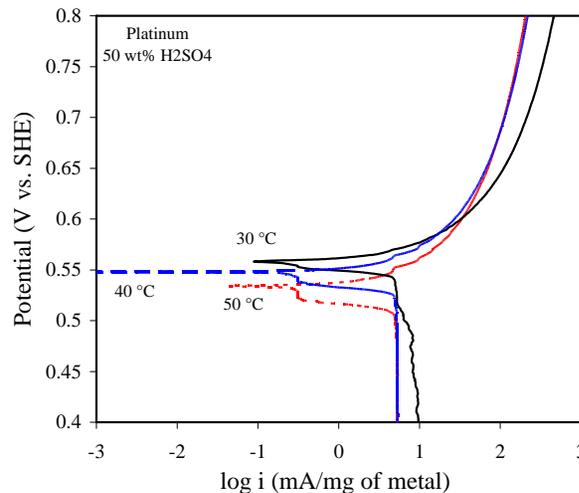
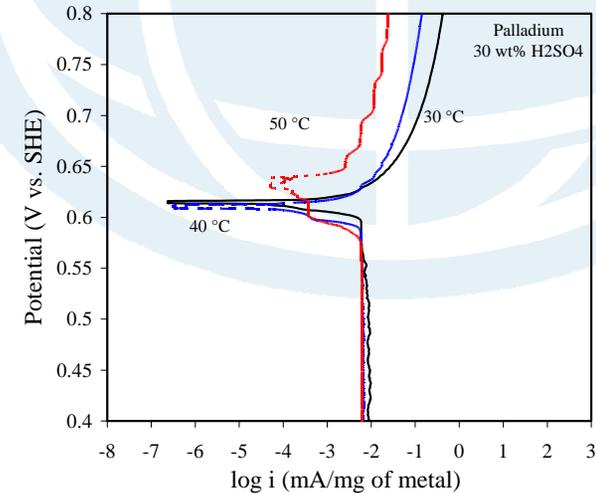
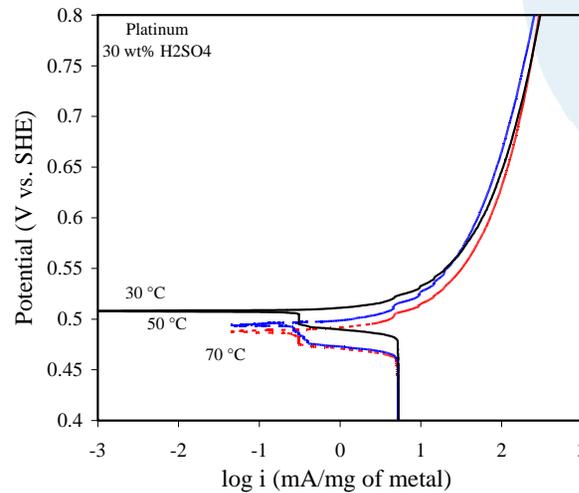
Catalyst Testing: SO₂ Oxidation Activity

Increasing sulfuric acid concentration increases anode potential

Pt/C exhibits higher catalytic activity than Pd/C

- higher current
- lower potential

H. R. Colón-Mercado and D. T. Hobbs, "Catalyst evaluation for a sulfur dioxide-depolarized electrolyzer", *Electrochemistry Communications*, **2007** 9, 2649-2653

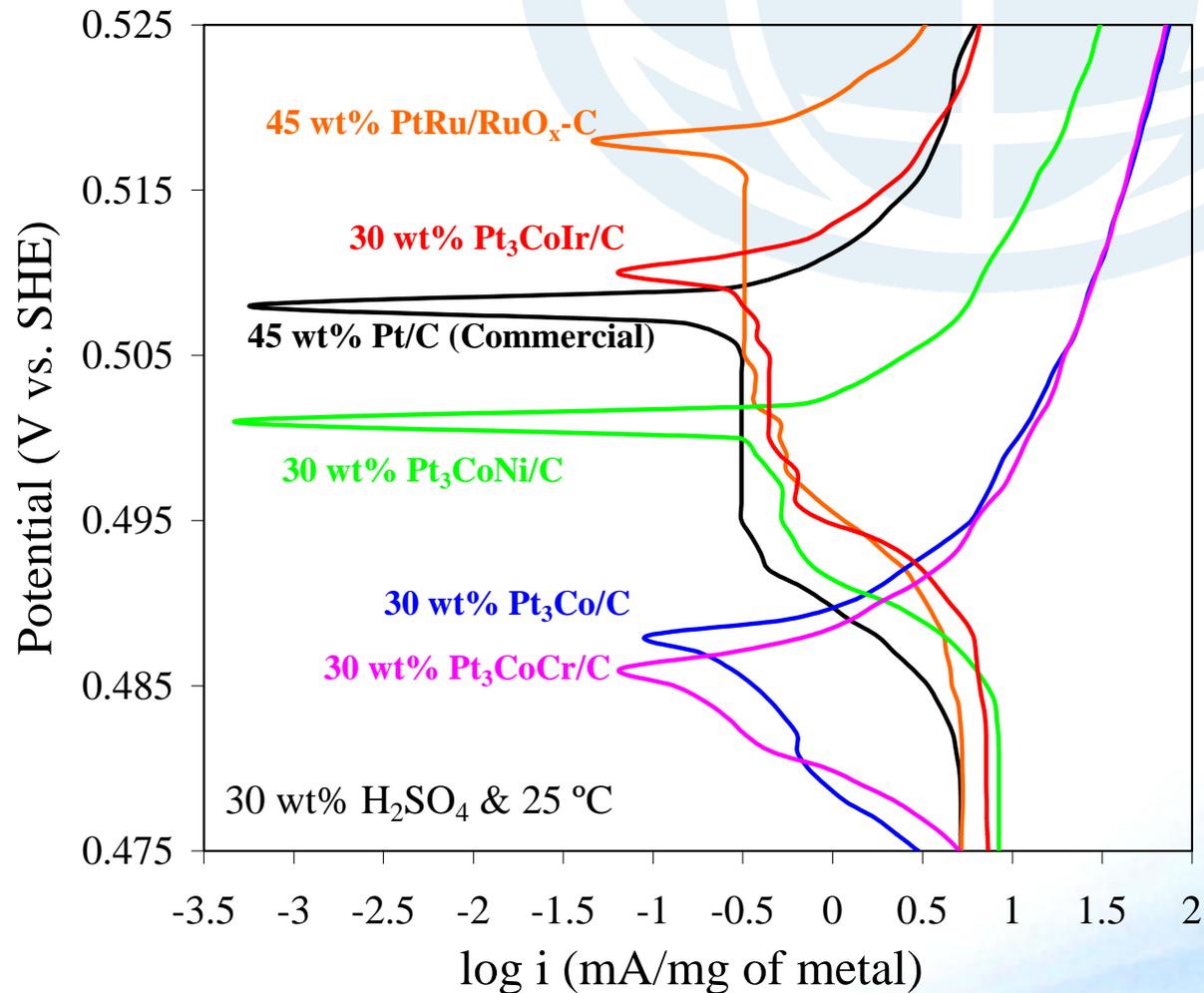


Electrocatalyst Testing

Pt/Co, Pt/Co/Ni and Pt/Co/Cr alloy catalysts exhibited 5 – 25 mV lower oxidation potential compared to commercial Pt/C material

All catalysts exhibit good stability after multiple CV cycles

Pt alloys with Ir and Ru show lower activity



Pt/Co/Ni/Cr/Ir alloys provided by Columbian Chemical Company
Pt/Ru provided by Prof. Lukehart (Vanderbilt University)

Conclusions

- **Pd catalyst shows degradation**
- **Activation of the catalyst surface is needed for optimum oxidation kinetics**
- **Pt shows higher catalytic activity than Pd**
- **Higher temperatures increases catalyst activity**
- **Higher acid concentrations decrease catalyst activity**
- **Pt-transition metal alloys show improved activity**

Current/Future Activities

- **Test new catalysts**
 - anode
 - cathode
- **Perform extensive testing to determine mechanism of SO₂ oxidation/reduction at anode and cathode**
- **Down select and prepare MEAs for electrolyzer testing**

Acknowledgements

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