High Pressure Plasma Electrolysis Experiments

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Plasma Electrolysis

• First experiments by Ohmuri and Mizuno\(^{(1)}\).
• Reproduced by several laboratories including Fauvarque and Clauzon\(^{(2)}\).
• On the internet, many demonstrations without accurate measurements.


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Objective

• Pressure and temperature effect,
• Reactivity increases with temperature,
• Plasma density increases with pressure,

Design a cell in order to study reactions at high temperature and high pressure.
Calorimetry Principles

• The electrical input is measured with a Wattmeter, sampling frequency: 70kHz
• The heat energy is measured by the loss of water measured by the weight loss.
## Pressure vs. Temperature

<table>
<thead>
<tr>
<th>Pressure (bar)</th>
<th>Heat of vaporization (J/g)</th>
<th>Boiling Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2258</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>2202</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>2163</td>
<td>134</td>
</tr>
<tr>
<td>4</td>
<td>2133</td>
<td>144</td>
</tr>
<tr>
<td>5</td>
<td>2107</td>
<td>152</td>
</tr>
</tbody>
</table>
Cell specifications

- All Teflon chamber
- Capable of standing up to 10 bar and 177°C
- Total weight is less than 6kg, due to existing equipment limitations
- Relief valve
- Pressure gauge
- Resistor (300 W) for calibration.
Cell Schematic

Anode (Stainless Steel)
Cathode (W: 15x2 mm)
Resistance Heater
Mechanical Pressure Gauge 1-16 bar
Adjustable Relief Valve
Vapor Exhaust
PTFE (Teflon)
Alumina Tube
Stainless Steel

Designed to stand 10 bar, tested at 7.5 bar, operated at 5 bar

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Cell : Inside

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Complete Cell on the Scale
Cathode details

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Calibration

- With resistance heater losses varies with pressure:

<table>
<thead>
<tr>
<th>Pressure (bar)</th>
<th>Loss (Watt)</th>
<th>Power (Watt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75 +/- 5</td>
<td>250/300</td>
</tr>
<tr>
<td>2</td>
<td>95 +/- 5</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>102 +/- 5</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>111 +/- 5</td>
<td>300</td>
</tr>
<tr>
<td>5</td>
<td>117 +/- 5</td>
<td>250/300</td>
</tr>
</tbody>
</table>
Experimental Conditions

- Electrolyte: H₂O and K₂CO₃ 0.03/0.06 mol/liter
- Quantity: 1.3 liter
- Electrode: W + 2% Th rod 15mm x 2mm
Parameters

- Cathode material
- Cathode dimensions
- Electrolyte composition: nature / concentration
- Pressure / Temperature
- Voltage / Current
- Pulsing voltage
Preliminary Results

Conditions:
- Constant Voltage: max = 360 Volt
- Current max: 2 Amp
- Pressure 5 bar / 152° C

Results:
- Average Power In: 404 Watt
- Average XSH: 21 Watt
- COP: 1.05
- Duration 56 minute
Precision of the measurements

• Power in : measured with a Wattmeter sampling frequency 70 kHz, at constant voltage.
• Power out : measured with a 6 kg / 0.2 mg scale.
• Dry water vapor coming out.
Dry vapor
Conclusion

Advantages:
• This type of calorimetry operates at constant temperature.
• Very short time constant.
• Variable temperature and pressure.
• Potentially high COP.
• Excellent for demonstration purposes.
• Possible measurement of deuterium formation if any.

Disadvantages:
• Destruction of the cathode during operation.
• Total duration is time limited with this design.