Impedance Studies of Composite Electrolyte with Mixed Ion Conductivity

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Main disadvantages:
- Water dilutes the fuel
- Decreases electrode catalytic activity
- Impossible to use metallic materials

Main disadvantages:
- Water dilutes the oxidizing gas
- Decreases electrode catalytic activity
- High corrosive media

Adisadvantages:
- The fuel is not diluted
- Hydrogen, oxygen and water are located in three independent chambers
- Every element of the cell plays a single role and can be optimized
- The water produced in the central membrane can be re-used for hydrogen production
Central membrane

Requirements:

- high proton and oxide ion conductivity
- porosity
- termochemical and mechanical stability
Central membrane

Electrolyte supported symmetrical half cell:  Me = Ag; Pt

BCY15  YDC15

$\text{BaCe}_{0.85}\text{Y}_{0.15}\text{O}_{2.925}$  $\text{Ce}_{0.85}\text{Y}_{0.15}\text{O}_{1.925}$

proton conductor  oxide ion conductor

Conditions

50 % vol BCY15 + 50 % vol YDC15
Poreformer: starch/graphite (2, 5, 7%)
Sintering T: 1300-1350°C
Impedance studies

Measurement conditions:

- Frequency Response Analyser Solartron 1260
  - Frequency range from 10 MHz - 0.1 Hz with 5 p/decade
  - Amplitude: 200 mV and 50 mV (potentiostatic)
    5-20 mA (galvanostatic)

- Atmosphere
  - Hydrogen
  - Oxygen

- Temperature range 100 – 800°C
Results

SEM observations:

- **No pore former**
  - Grain size: 1-2 μm

- **2% graphite**
  - Grain size: 1-5 μm

- **5% starch**
  - Grain size: 1-3 μm

- **7% starch**
  - Grain size: 1-3 μm
Conductivity studies:

- **O₂**
  - 42 % porosity
  - 35% porosity
  - 28 % porosity

- **H₂**
Conductivity studies:

\[ \lg(\rho / \Omega \text{cm}) = 1000 T^{-1} / K^{-1} \]

- \( E_a = 0.69 \text{ eV} \) for \( \text{O}_2 \)
- \( E_a = 0.73 \text{ eV} \) for \( \text{H}_2 \)
Conductivity studies:

**Results**

PoC sample /Proof of the Concept/

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Advantages of monolithic CM:

- replacement of the triple phase boundary with two phase boundary (BCY/pore),
- decrease of the CM resistance,
- fasciliation of the technology,
- improvement of the thermo chemical and thermo mechanical stability.
Results

Conductivity studies:

H₂O(gas) + Vₒ²⁺ + Oₒ⁻ → 2OHₒ⁻

Arrhenius plots of monolithic BCY15 central membrane in:

- (●) dry oxygen and (■) wet hydrogen.
Conductivity studies:

Results

\[ E_a = 0.73 \text{ eV in } H_2 \]
\[ E_a = 0.68 \text{ eV in } O_2 \]
\[ E_a = 0.65 \text{ eV in } O_2 \]
Conclusions
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The samples were fabricated by ARMINES.

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Thank you for the attention
• BCY has good protonic conductivity

• Proton conducting mechanism:

\[ \text{H}_2\text{O}(g) + \text{V}^{-}_\text{O} + \text{O}^\text{y}_\text{O} \rightarrow 2\text{OH}^\cdot_\text{O} \]

• Hypothesis: oxygen vacancies leads to oxide ion conductivity
calibration measurement at short circuit
measurement of the cell with the sample
complex plain impedance diagram of the sample after the correction
zoomed high frequency part
Conclusions

\[ P = 5 \, \text{mW/cm}^2 \]

700°C

\[ i = 75.6 \, \text{mW/cm}^2 \]

monolithic CM

PoC

\[ i = 5 \, \text{mA/cm}^2 \]
Conductivity studies:

**Results**


\[\lg\left(\frac{\rho}{\Omega \text{cm}}\right) = 0.8 + 0.29 \frac{T}{K}\]

\[\lg\left(\frac{\rho}{\Omega \text{cm}}\right) = 1.2 + 0.34 \frac{T}{K}\]

\[\frac{E_a}{eV} = 0.29\]

\[\frac{E_a}{eV} = 0.34\]