



ENGINEERING CHEMISTRY

Lata Pasupulety

Department of Science and Humanities

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Module 5- Energy storage devices – Fuel cells



Class content:

- ***Types of Fuel cells***

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Types of Fuel cells (based on electrolyte):

- Alkaline fuel cell
- Phosphoric acid fuel cell
- Molten carbonate fuel cell
- Polymer electrolyte fuel cell
- Solid oxide fuel cell

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Alkaline fuel cell

- Aqueous solution of **KOH** is used as electrolyte
- **Low temperature** fuel cell (operates at 100°C)
- Oxygen reduction is **more rapid** in alkaline electrolytes than in acid electrolytes
- Use of **non noble metal electro-catalyst** is feasible
- **Carbon containing fuels cannot be used** as CO_2 is formed as product which reacts with the electrolyte, KOH, to form K_2CO_3 which reduces efficiency of the cell



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Phosphoric acid fuel cell

- Concentrated phosphoric acid is used as electrolyte
- Intermediate **temperature** fuel cell (operates between 160 – 220°C)
- Platinum is used as **electro-catalyst**
- Use **only H₂** as fuel
- H₂ used as fuel must be very pure as sulphur compounds and CO poison the Pt catalyst

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Molten carbonate fuel cell

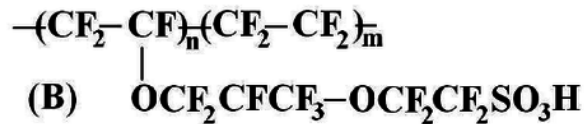
- Molten carbonates (mixture of $\text{LiAlO}_2 + \text{K}_2\text{CO}_3 + \text{Li}_2\text{CO}_3$) used as electrolyte
- High **temperature** fuel cell (operates between $600 - 650^\circ\text{C}$)
- Catalyst is not required since it operates at high temperature
- **H_2 or CO** can be used as fuel

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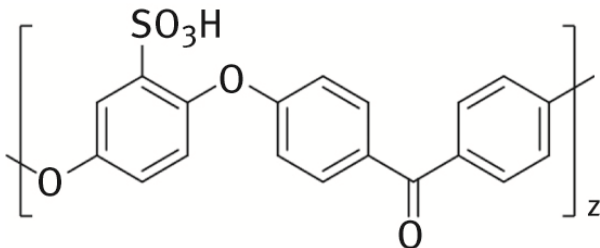
Polymer electrolyte membrane fuel cell

- Known as **proton exchange membrane fuel cell**
- **Polymer membrane** or proton exchange membrane is used as electrolyte
- Fluorocarbon backbone ($-\text{CF}_2-\text{CF}_2-$) similar to Teflon to which **sulphonic acid groups ($-\text{SO}_3\text{H}$)** are attached. The **protons on sulphonic acid group** are free to migrate through the hydrated membrane. e.g., (A) **Aquivion** and (B) **Nafion**



Source: https://www.researchgate.net/figure/Chemical-structures-of-A-AquivionR-or-Hyflon-and-B-NafionR_fig1_234842575

- New membranes are being used especially when CH_3OH is used as fuel - **Poly electrolyte membranes** e.g., **SPEEK** - sulphonated poly(ether ether ketone)



Source: <https://www.degruyter.com/view/journals/psr/2/8/article-20170018.xml?language=en>

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Polymer electrolyte membrane fuel cell(contd.)

- **Low temperature fuel cell** (60- 90 °C)
- Polymer membrane **must remain hydrated** to maintain H^+ conductivity
- Water produced from the reaction must be removed from the cathode
 - **High temperatures** may dehydrate the polymer so H^+ conductivity cannot take place and the polymer may degrade and crack resulting in short circuit
 - **Low temperatures** will result in flooding of the cell thereby reducing efficiency of the cell and a higher catalyst loading will be required
- Low weight and volume
- **High energy density**
- **Noble metal catalyst** usually Pt is used
- **CO, if present poisons the catalyst** , so pure fuel and oxidant should be used

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Solid oxide fuel cell

- **Ceramic oxide** capable of conducting oxide ions is used as electrolyte, e.g. ZrO_2 doped with Y_2O_3
- **Very high temperature** fuel cell (operates at $650 - 1000^\circ\text{C}$)
- Due to high temperature , **expensive catalyst need not be used**
- **CO** can also be used as a fuel
- **Slow** start - up



THANK YOU

Lata Pasupulety

Department of Science and Humanities

latapasupulety@pes.edu

+91 80 6666 3333 Extn 759