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ENGINEERING CHEMISTRY

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Hydrogen Energy Production and Storage



Class content:

- *Hydrogen Energy*
- *Hydrogen Production methods*
 - *Steam Reforming*
 - *Electrolysis of water*

Hydrogen Energy Production and Storage

Hydrogen Energy

- The Hydrogen energy has been identified as one of **potential sources of fuel** in the state-of-art technological era
- Hydrogen production, storage and transportation has become **the focus** of science and technology
- Sustainable **production** of Hydrogen from **renewable feedstocks** and **electrolysis of water** has taken a lead role in technology development
- **Hydrogen economy** is a vision of an **energy delivery infrastructure based on hydrogen** as a **carbon-free energy carrier**

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Advantages

- Abundant availability in earth crust
- Compatibility of hydrogen with fuel cell
- Higher efficiency (65%) than diesel (45%) and gasoline (22%)

Disadvantages

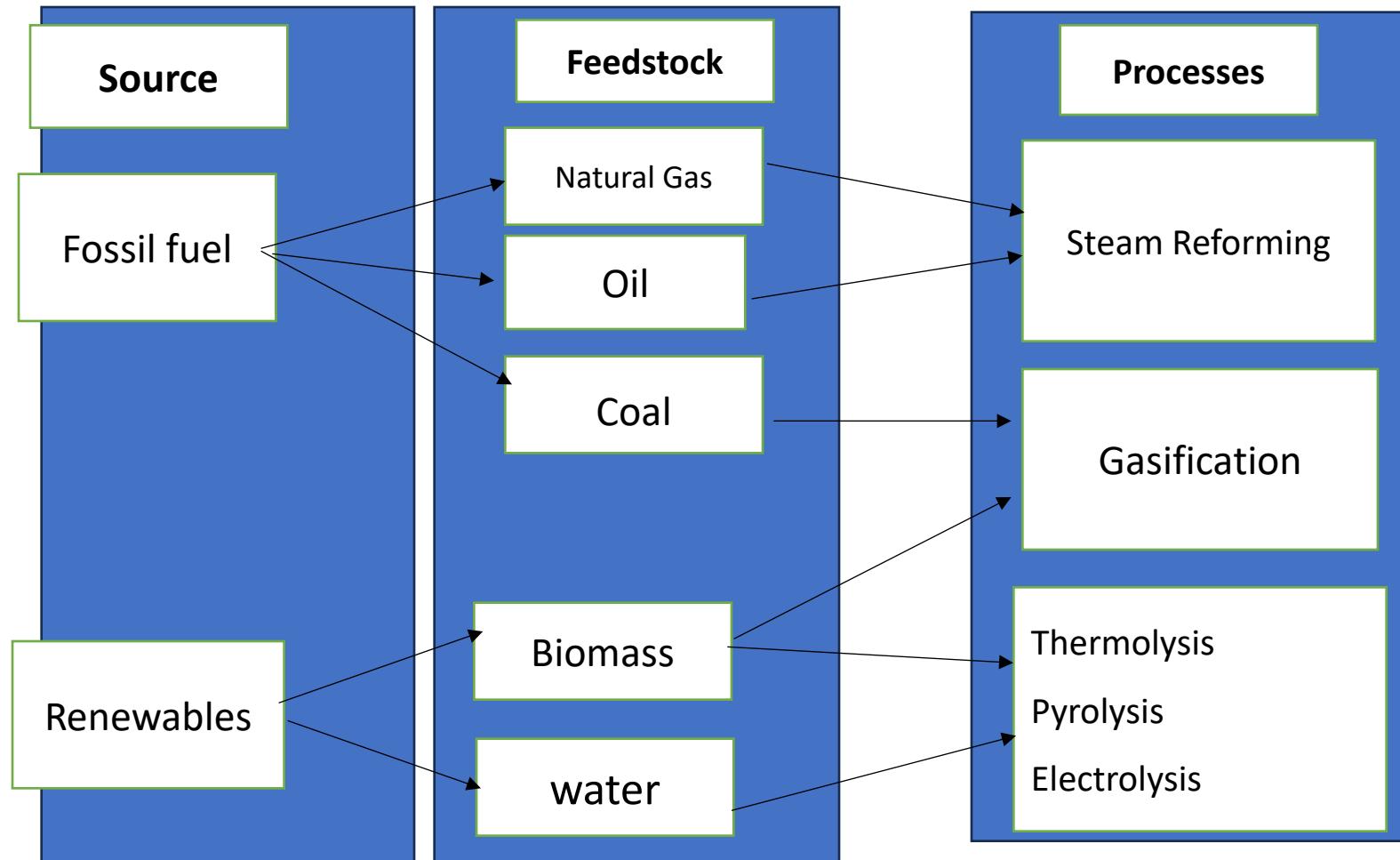
- High cost
- Highly flammable
- It is still dependent on fossil fuels

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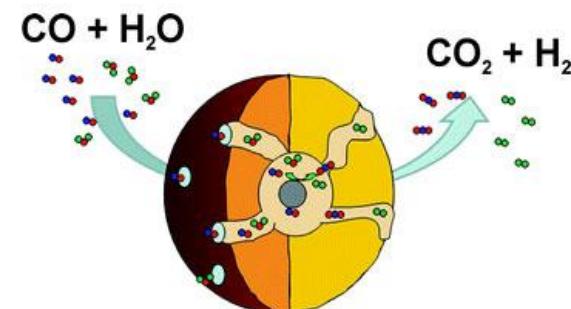


Strategic Hydrogen production methods



Hydrogen Production methods

- **Steam reforming** (steam methane reforming –Grey Hydrogen)
 - Natural gas is used to produce Hydrogen
 - Most widespread process for generation of hydrogen
- **Gasification process** (Black Hydrogen)
 - Hydrogen is produced from coal by gasification process
 - Coal is converted into CO_2 and subjected to gasification process to produce Carbon monoxide which is subjected to water gas shift process to produce mixture of CO_2 and H_2 is purified to get pure H_2
- **Thermolysis** (Green Hydrogen)
 - involves thermochemical water splitting at high temperature $500^\circ\text{C} - 2000^\circ\text{C}$ to produce hydrogen
 - carried in a closed system-the chemical used in the process are reused within each cycle consumed only water and produces hydrogen and oxygen



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• Photolysis

- Processes use light energy to split water into hydrogen and oxygen
- One of the potential for sustainable hydrogen production
- Low environmental impact
- Yet in early stage of research

• Electrolysis

- uses electricity to split water into hydrogen and oxygen
- Electrolysis reaction takes place in a unit called an **electrolyzer**
- Method is promising option for carbon-free hydrogen production from renewable and nuclear resources.

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Steam reforming (Steam methane reforming)

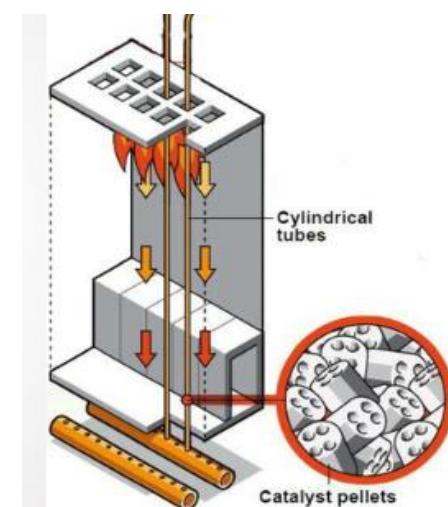
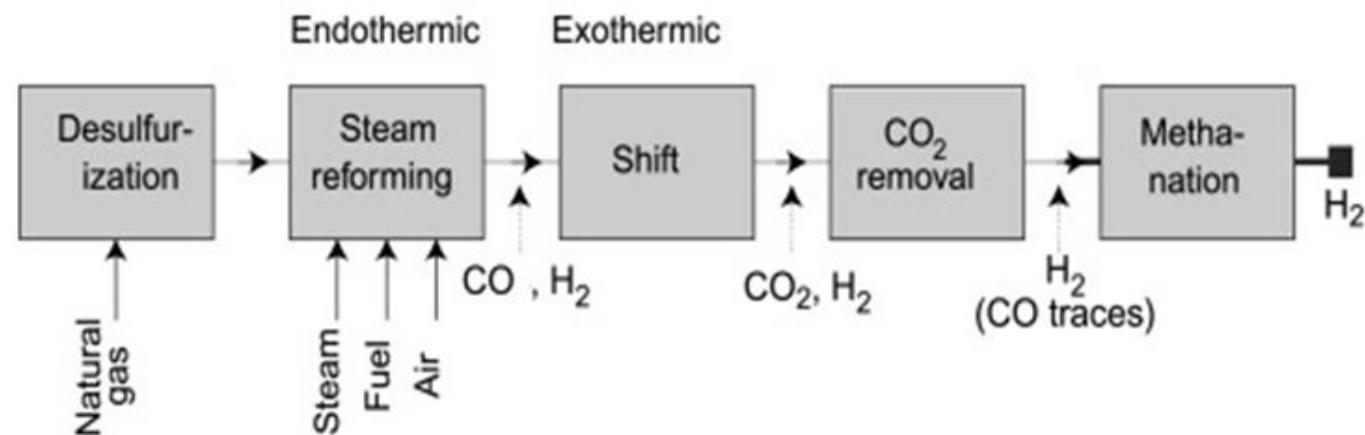
- Process involves four important steps

• Desulphurization

- removal of sulphur from the feedstocks
- Sulphur tends to poison catalysts used in the steam reforming

• Steam reforming

- Steam, fuel and air in the reform chamber in presence of catalyst form syngas
- $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3 \text{ H}_2$
- 850-900°C
- Ni catalyst
- Endothermic reaction ($\Delta H^\circ = +206 \text{ KJ/mole}$)
- High temperature and low pressure is favoured



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- Shift reforming (Water Gas shift reactions)



- Catalyst: $\text{Fe}_3\text{O}_4/\text{Cr}_2\text{O}_3$
- Exothermic reaction ($\Delta H^\circ = -41.0 \text{ KJ/mole}$)
- Favoured at low temperature (350°C)
- H_2 produced will have traces of Carbon monoxide as impurities

- Purification

- CO_2 is removed to produce pure Hydrogen
- Traces of CO is removed by **methanation** ($350 - 450^\circ\text{C}$)



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Green Hydrogen production

Green Hydrogen refers to **production of Hydrogen gas from renewable resources, through Electrolysis** producing clean energy

Hydrogen production by electrolysis can be achieved by three methods.

1. Alkaline Electrolysis
2. Acid Electrolysis

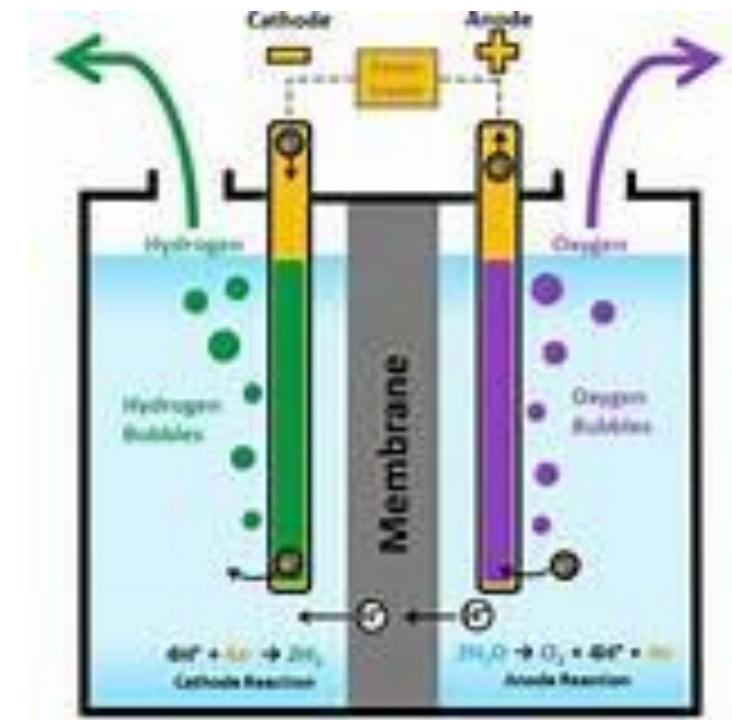
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- In Alkaline electrolyte process

Construction

- Anodic materials: Ni and its alloys
- Cathodic materials: Cu, Pt
- Electrolyte : KOH, NaOH (20-40 wt %)
- Catalyst: Ni-Co-Au, RuO₂
- Operation temperatures are between 343 – 363 K
- Operating pressure up to 3 Mpa



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Working Principle:

- Pure water is the very poor conductor of electricity because splitting of **water is very less**, hence acid (H_2SO_4 in acid electrolyzer) or base (KOH or NaOH in Alkaline electrolyzer) is used to improve the conductivity

Reactions:

- Anode: $2\text{OH}^- \rightarrow \frac{1}{2}\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^-$
- Cathode: $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$
- Overall Reaction:
$$2\text{H}_2\text{O}_{(\text{liquid})} + \text{Energy} \rightarrow 2\text{H}_2(\text{gas}) + \text{O}_2(\text{gas})$$



THANK YOU
