THE FINAL WORD

The official e-newsletter
of
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M. Sc. Industrial Chemistry

1. Final year students have joined Industry via campus placement

At Lupin .Ltd, Ankleswar

Dixitkumar Barot

Henilkumar Patel

Harikrushna Bhatt

At Astral Adhesive .Ltd, Santej, Ahmedabad

(From left to Right) Yash Patel, Vishal Patel, Dhrumil Soliya, Yash Parekh, Maulik Suthar , Karan Ray

At JDM Scientific Research Organisation Pvt.Ltd, Vadodara

Jayani Patel

Article

2. Era of online Learning

The covid-19 has resulted in schools/colleges shut all across the world. Students are out of classroom. As a result, education system has changed dramatically with distinctive rise of E-learning whereby teaching is undertaken on digital platforms.

There are, however challenges to overcome. Some students without reliable internet access struggle to participate in digital learning. For those who do have access to the right technology, there is evidence that learning online can be more effective in number of ways.

In online learning, we learn through presentations, videos and of course live sessions going on and something called E-learning material that are organized rather than simply recorded. This is getting a lot of popularity in the current pandemic days.There are some advantages and disadvantages of online learning.

Advantages :

- If you look at the online learning, one of the biggest advantage you have got is access anywhere, anytime. You don't have to be physically present at particular place.
- This gives freedom from a geographic location.
- It minimizes travelling.
- Forget about attending classes for hours sitting in an uncomfortable chair and suffering from back pain.
- You'll not be bound to physical class sessions when you opt for online education.
- All lectures and needed material are provided via online platforms, so you'll easily access them from the comfort of your home.
- You don't need to get up early and get dressed.
- Online education will look good on your resume showing potential employers that you're committed to learning and you're eager to obtain more knowledge.

These are the positives of online learning and it is gaining lot of ground in the current days senerio. But there are always negatives because we have been used to the kind of classroom learning since decades.

Disadvantages :

- The key negative point that you face is lots of fun is missing.
- Online learning reduces the interaction with teachers.
- At younger age we have been used to giving respect to elders and then your body language when 10 different people sitting in classroom, your sitting position, your attention, where your eyes are looking.... That kind of thing is missing because here in online classes you can sit in any position, your body language may be something different.
- DOUBTS? it's a biggest thing. Can you get your doubt immediately resolved? It may not be their. So in online learning you have to be dependent on something unless the class is a live online session.
- Most importantly, character imbibing is the key factor. You learn a lot from your teachers such as the human behaviours. It's not just a lesson alone.

- Most importantly, *character imbibing* is the key factor. You learn a lot from your teachers such as the human behaviours. It's not just a lesson alone. Your body language, kindness, noble tendencies, the way you interact with people, the way you give respect…those characters imbibing can definetly missing from the online lectures.

But we can say that online learning is very good when it comes to gaining knowledge and not very good when it comes to soft factors.So if you want to build character, online learning is not that good.

- Aayushi Patel (19IC02)

3. Hydrogen Production Technology

Energy is one of the most important needs for the human life. Hydrogen energy became the most significant energy as the current demand gradually starts to increase. Hydrogen energy is an important key solution to tackle the global temperature rise as it evolved only water vapour upon burning unlike other fossil fuels. Also hydrogen is backbone for fertilizer industry. It is most prominent energy source for future also for fuel cell based technologies. Also hydrogen has high energy content compared to the fossil fuels, Table 1 is shown the energy content of different fuel resources.

Fuel	Energy content (Mj/kg)
Hydrogen	120
Natural Gas	54.4
Propane	49.6
Petrol	46.4
Diesel	45.6
Wood	16.2

Table 1 : Energy content of diffrent fuels

International Energy Agency report is predicted that the global energy demand will increase to 50% by 2030. The world has been started to convert energy from one energy form to another form. The transition of solids to liquids to gases has been illustrated in Figure 1. Where clearly shown that hydrogen will be driving force to meet future energy demand.

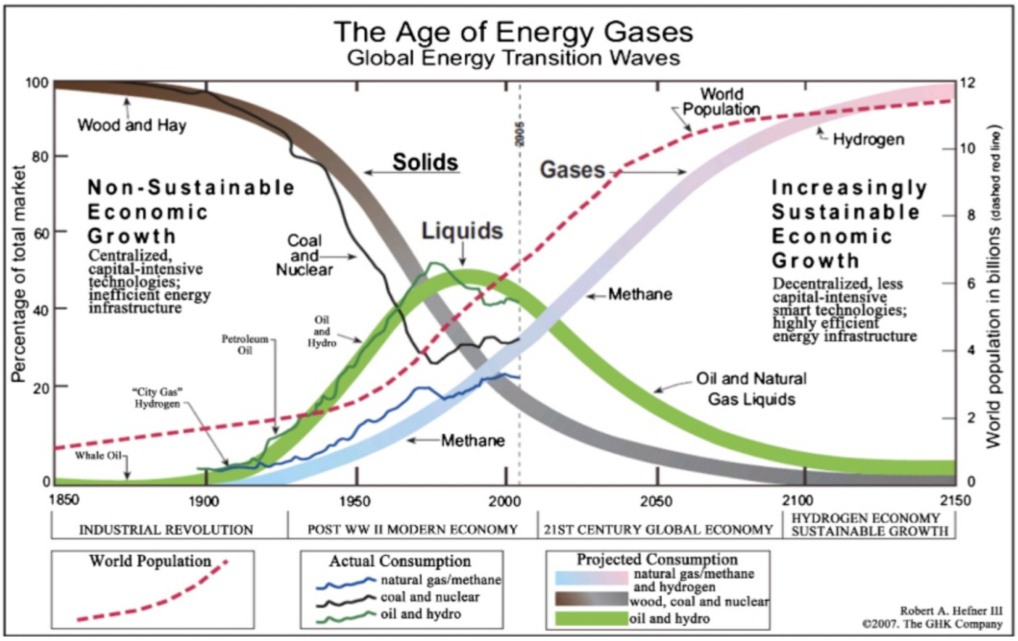
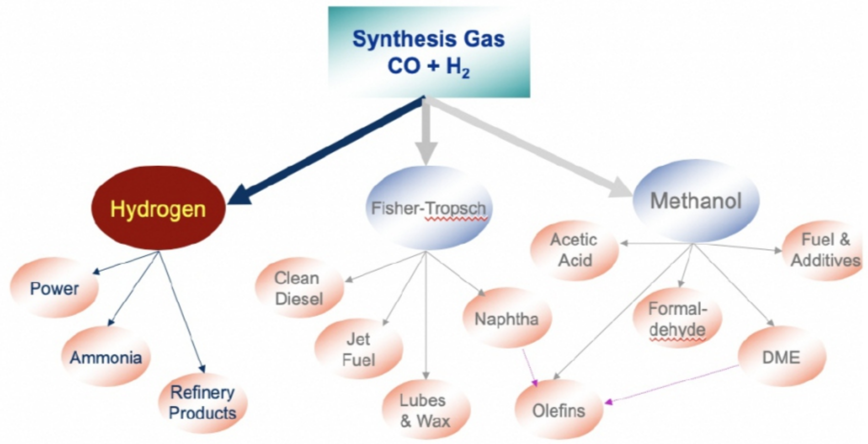
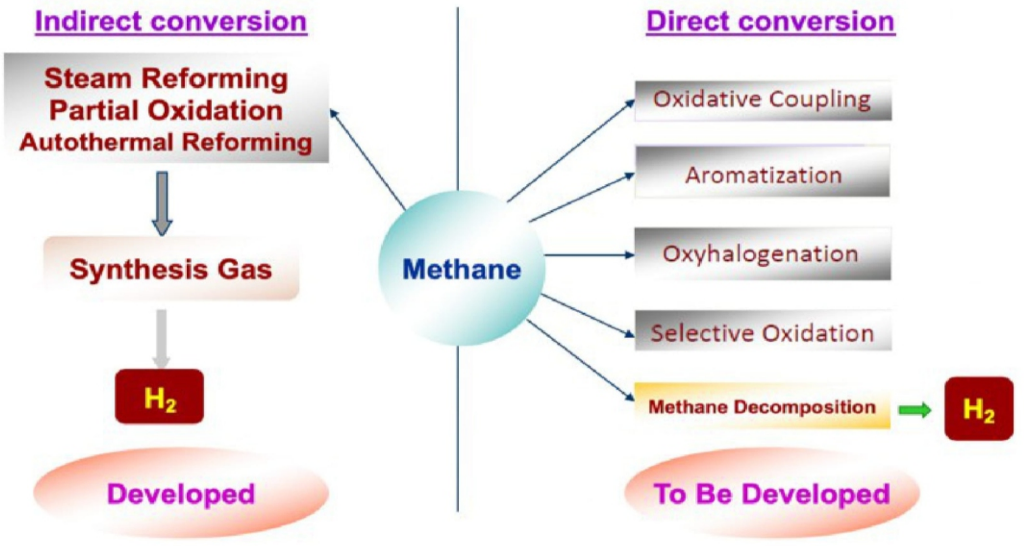


Fig 1: Global energy system transition from 1850 to 2150

As of 2019, 70 million tons of hydrogen is produced every year. Majority hydrogen is consumed in fertilizer industry (54%) to produce ammonia as ammonia is used as raw material for urea and other ammonical fertilizers. Chemical industries and refineries (35%) use it majorly for hydrogenation, desulfurization and as a component of synthesis gas to make various chemicals mainly for Fisher-Tropsch products and methanol.

Hydrogen can be produced via variety of sources via variety of different routes. But preference remains on economy and availability of sources. Figure 2. However, all the routes are not practiced commercially due to economy or lack of technological advancement.





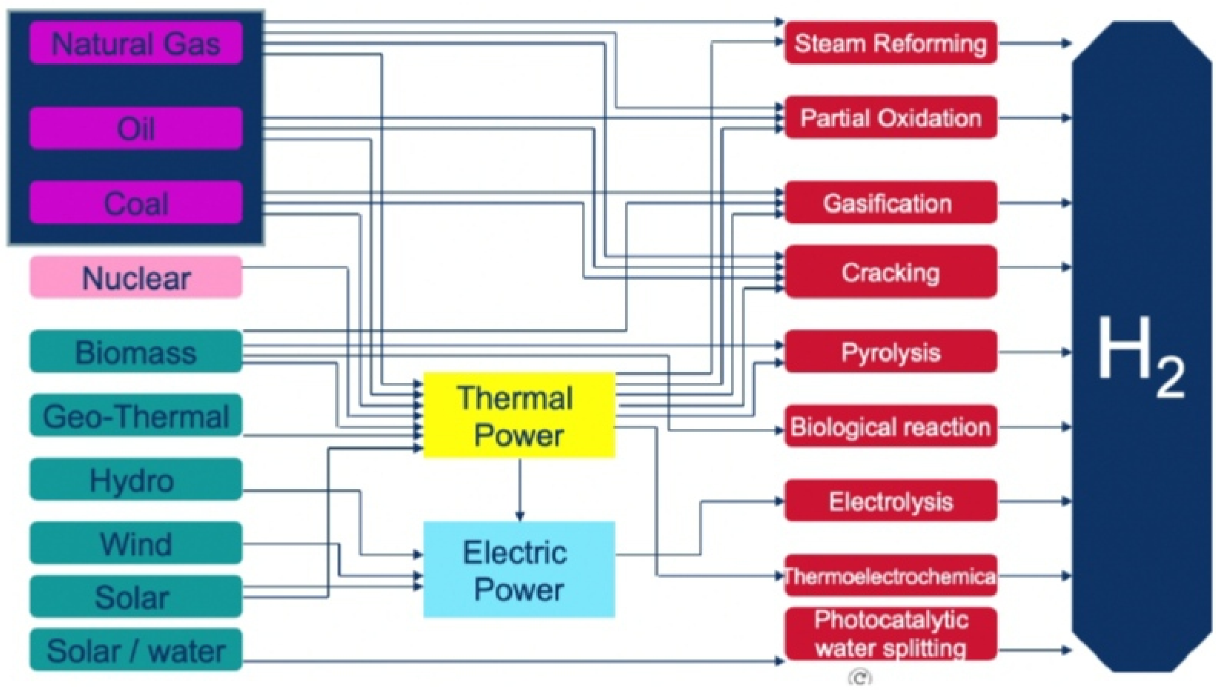


Fig 2: Major applications of synthesis gas (left), methane to hydrogen

Hydrogen production technologies are commercially available, while some of these technologies are still under development. Currently, the maximum hydrogen fuel produced by steam reforming. Mostly hydrogen is produced via natural gas, as abundant availability and minimum by-products. Figure 2 is showing already developed and commercialized indirect routes via synthesis gas ($CO+H_2$) vs future direct routes of hydrogen production.

Current research trend towards direct routes like oxidative coupling of methane and oxygen to produce ethylene and hydrogen, methane aromatization to produce benzene and hydrogen, oxychlorination of methane with HCl and O_2 to produce chlorinated methane and hydrogen, direct methane thermal decomposition to make coke and hydrogen etc remains route of interest of researchers. But none of these routes are close to commercialization. High activation energy to activate methane molecule remains major challenge, as the temperature required to activate methane, formed products decompose to stable products like CO_2 and Water. So indirect routes via synthesis gas remains choice of refiners for hydrogen production.

Steam reforming is most common method and have highest efficiency among all 3 synthesis gas production routes mentioned in Figure 2 . Hydrocarbon (mainly methane and in some cases oil, coke or biomass) and steam is used as feed to produce synthesis gas.

Chemical reactions involved in steam reforming are explained in Figure 3. Feed contains organic sulfur is major impurity. Also it is common poison for reforming catalyst. So feed gas purification is required. For sulfur removal, feed is hydrogenated to convert organic sulfur to H_2S. Then feed is reacted with ZnO adsorbent to convert in ZnS at around 350 C temperature (Reaction A). Also some minor amount of ethylene present in feed is hydrogenated to ethane, as ethylene polymerize on catalyst resulting reduced catalyst life.

A FEED GAS PURIFICATION

$$RSH + H_2 = H_2S + RH$$

$$C_2H_2 + 2H_2 = C_2H_6$$

$$H_2S + ZnO = ZnS + H_2O$$

B STEAM REFORMING

$$CH_4 + H_2O = CO + 3H_2$$

$$CO + H_2O = CO_2 + H_2$$

C HIGH TEMPERATURE & LOW TEMPERATURE SHIFT REACTIONS

$$CO + H_2O = CO_2 + H_2$$

D (i) CO_2 Removal : Chemical

(with Benfield solution)

$$K_2CO_3 + CO_2 + H_2O \rightleftharpoons 2KHCO_3$$

(with monomethanolamine)

$$(CH_2CH_2OH)NH_2 + CO_2 + H_2O = (CH_2CH_2OH)NH_3^+ + HCO_3^-$$

(ii) CO_2 Removal : Physical

Pressure Swing Adsorption

Fig 3: Chemical reaction involved in steam reforming and commercial Ni/Al_2O_3 catalyst

Steam reforming reaction (Reaction B) converts methane and steam to CO and H_2 at 800-1000 C and 22-25 bar pressure. Nickel on alumina is used as catalyst. Catalyst shape is shown in Figure 3. Catalyst pellets have several holes to reduce pressure drop in reactor tube. Catalyst pellets are filled in reactor tubes. Reforming reaction has positive enthalpy, hence it is endothermic and highly energy intensive. CO and H_2 are produced in reformer in close to 1:3 mole ratio. This ratio of synthesis gas can be used directly for Fisher-Tropsch synthesis and Methanol production which also makes huge value chain of products as shown in Figure 2.

But when hydrogen production is main purpose, water-gas shift reaction is used to convert formed CO and water to CO_2 and H_2 using Iron oxide catalyst promoted with chromia. (Reaction C).

Formed CO_2 is removed from hydrogen and via 2 routes as shown in reaction D. In modern plants, Pressure Swing Adsorption is preferred due to lower operating cost and no by-product like chemical process and also produce high purity hydrogen up to 99.9%.

In steam reforming, 9 tons of CO_2 is produced every ton of hydrogen. However, in urea production, CO_2 is consumed as raw material too. Rest of CO_2 is captured to produced various chemicals and also used in food and beverages after purification.

Till date, steam reforming remains preferred process for refiners. Many efforts are going on for partial oxidation process development, but control of over oxidation of formed CO and H_2 to CO_2 and H_2O respectively remains major challenge. Hydrogen production is still expensive. So far, main challenges are:

- Identify more durable reforming catalyst
- Develop advanced purification technology
- Find less energy intensive efficient process for hydrogen production
- Search for renewable source of hydrogen
- Reduce cost of carbon capture convert it to value added products
- Capture and storage of hydrogen

- Jayen Barochia (IC 04-'06)

(Jayen Barochia is former technology development leader at SABIC and having 13 years of international research experience and 12 international patents.)