



# **Disruptive Science and Technology**

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**INTERNATIONAL CONFERENCE ON GREEN HYDROGEN 2023, New Delhi**

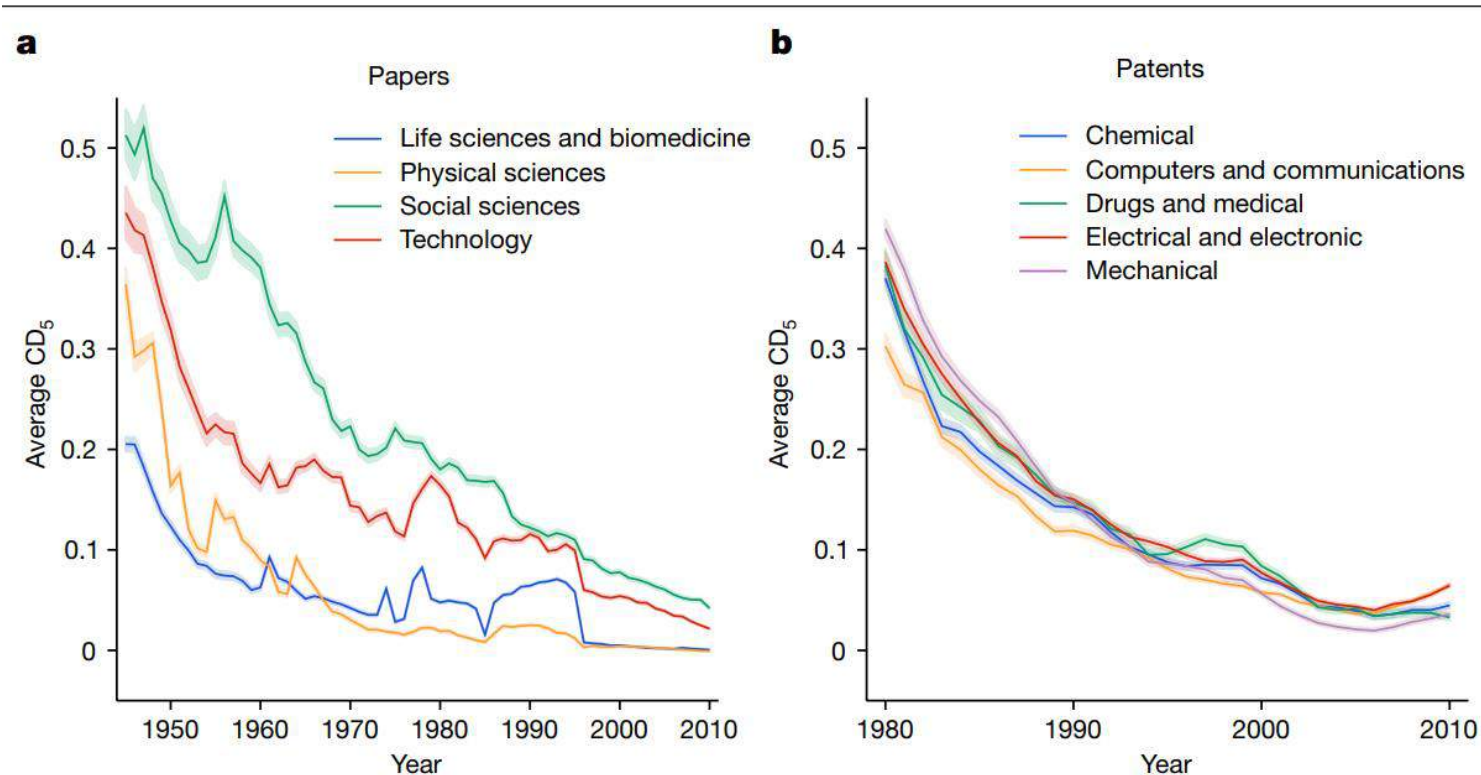
# Papers and patents are becoming less disruptive over time

## 'DISRUPTIVE' SCIENCE HAS DECLINED — EVEN AS PAPERS PROLIFERATE

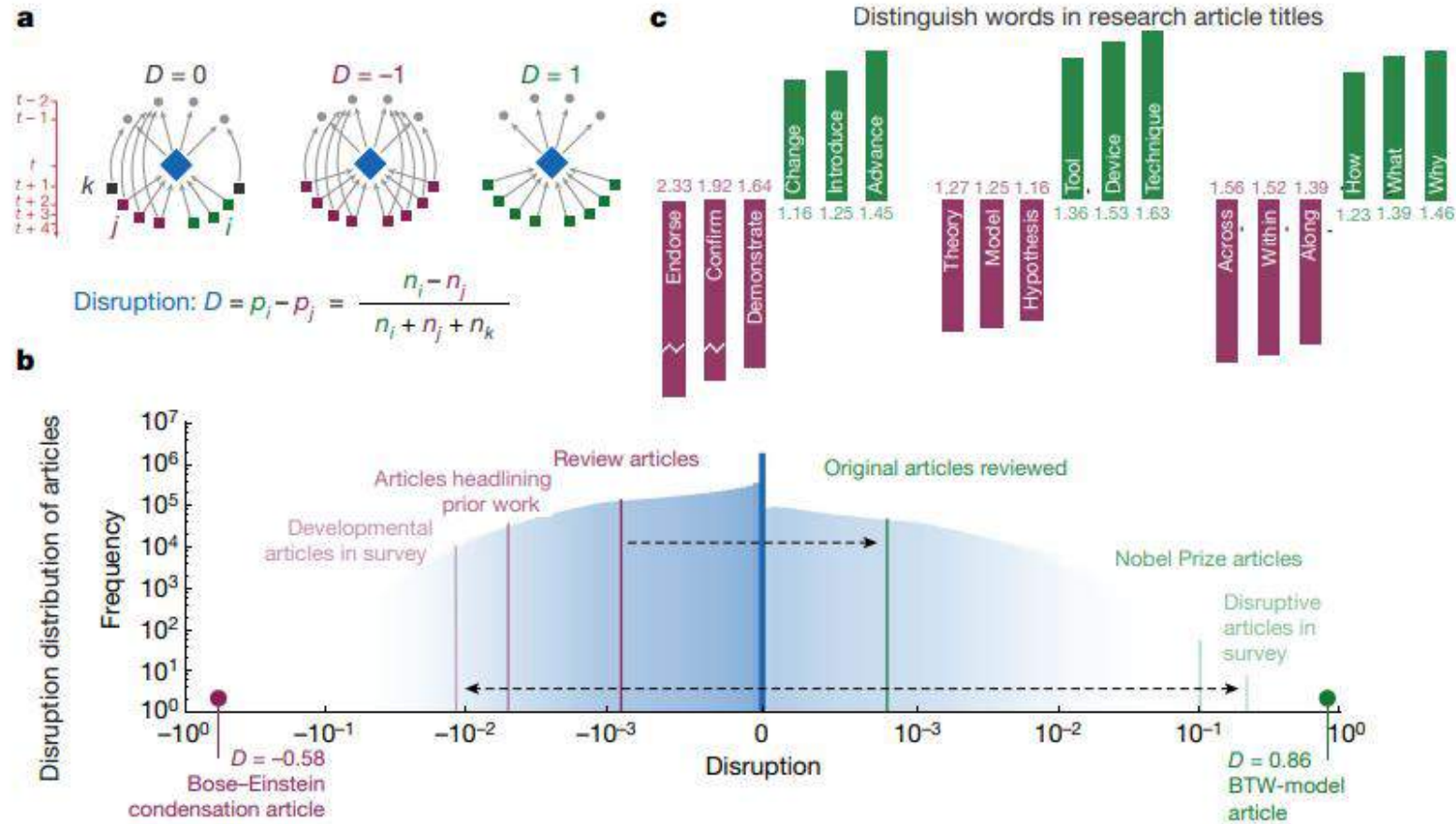
### DISRUPTIVE SCIENCE DWINDLES

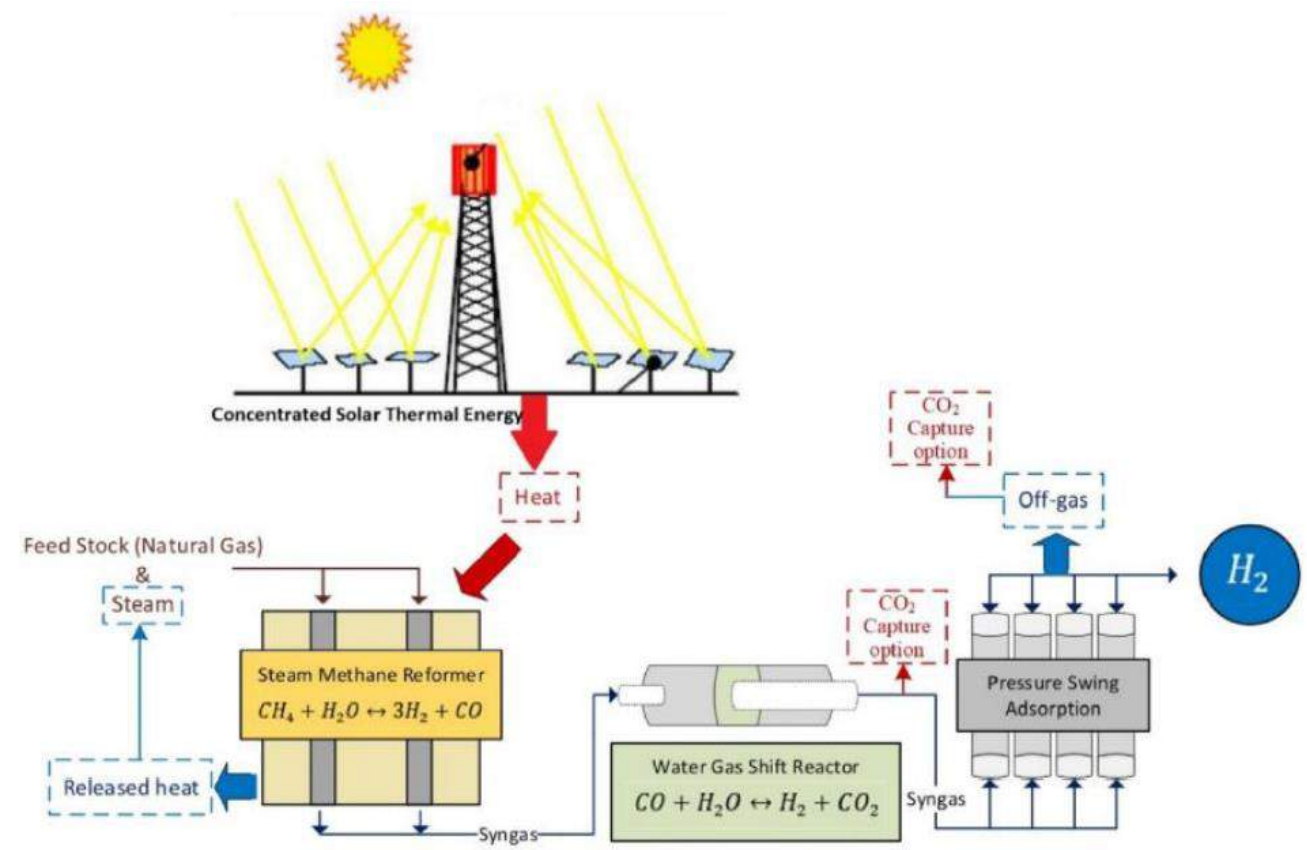
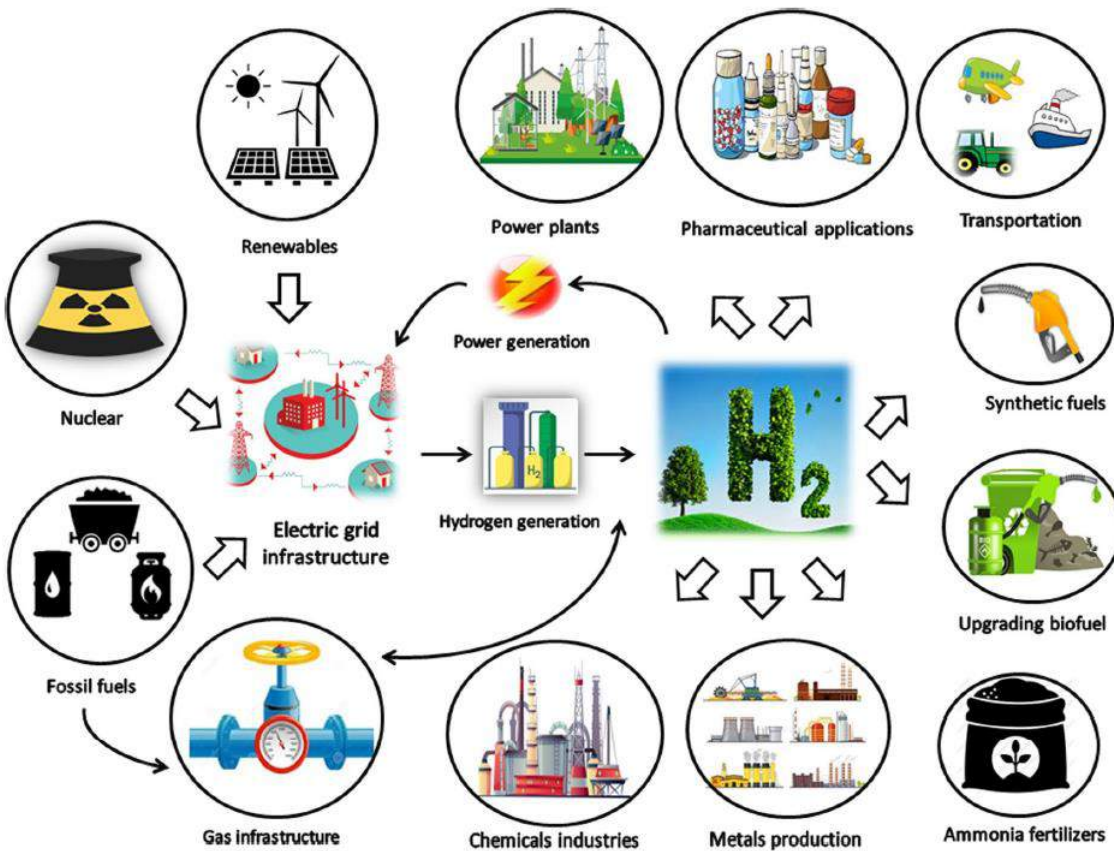
To quantify how much a paper shakes up a field, researchers used a metric called a CD index, which ranges from 1 for the most disruptive papers to -1 for the least disruptive. Analysis of millions of papers shows that disruptiveness has fallen over time in all analysed fields.

The proportion of publications that send a field in a new direction has plummeted since the 1940s.



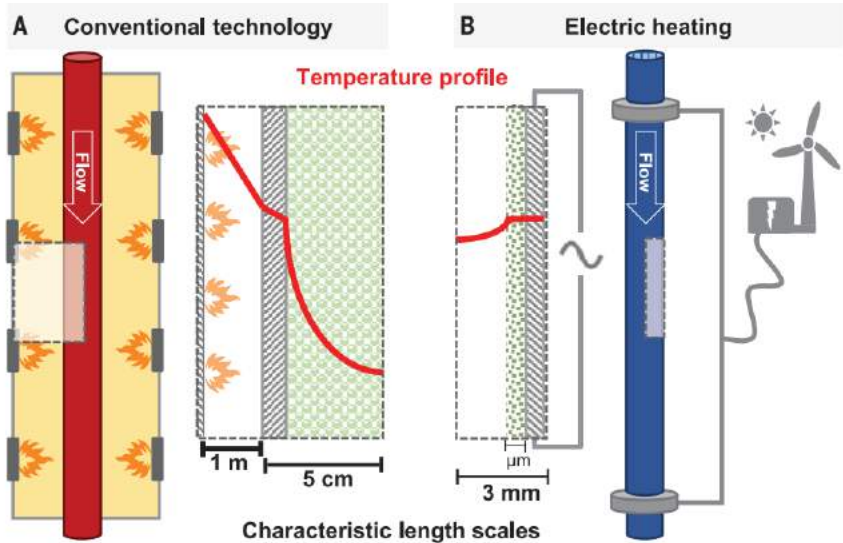
# Large teams develop and small teams disrupt science and technology





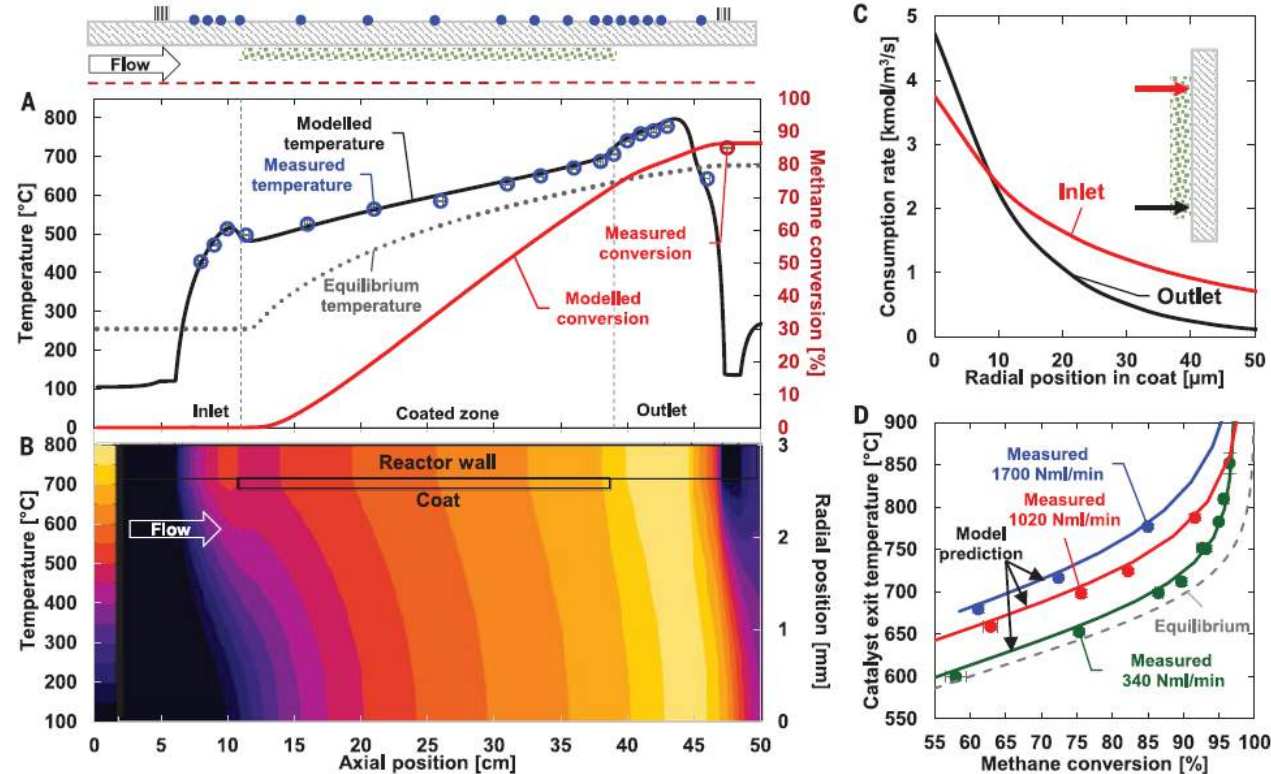
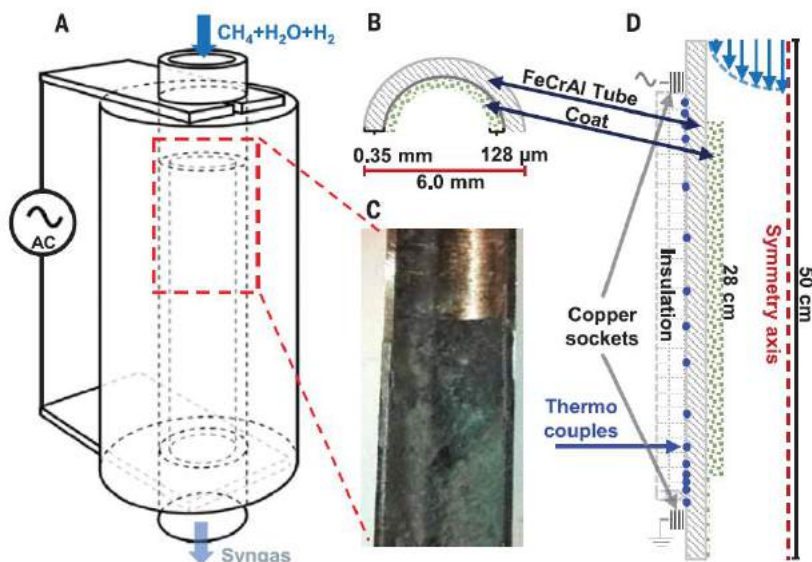
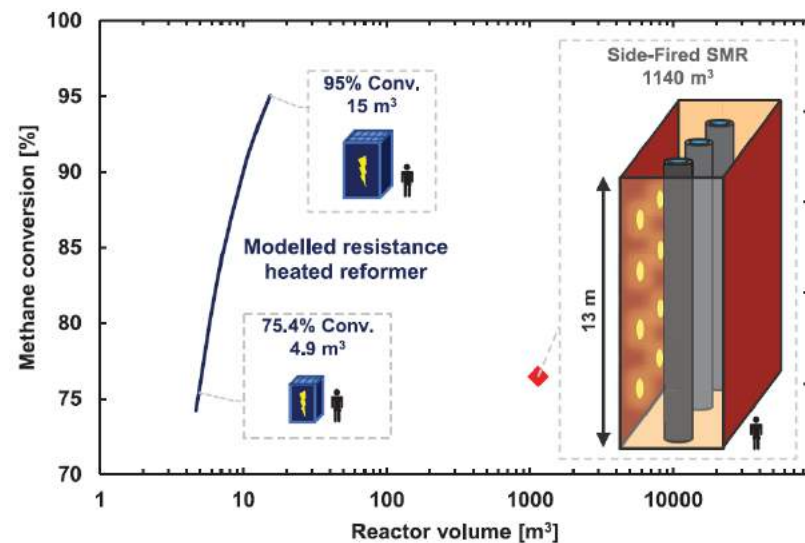
# Hydrogen to the rescue

Large-scale, environmentally friendly hydrogen production will rely on steam methane reforming coupled with carbon capture and electrolysis, but solar fuels could have a disruptive role to play.

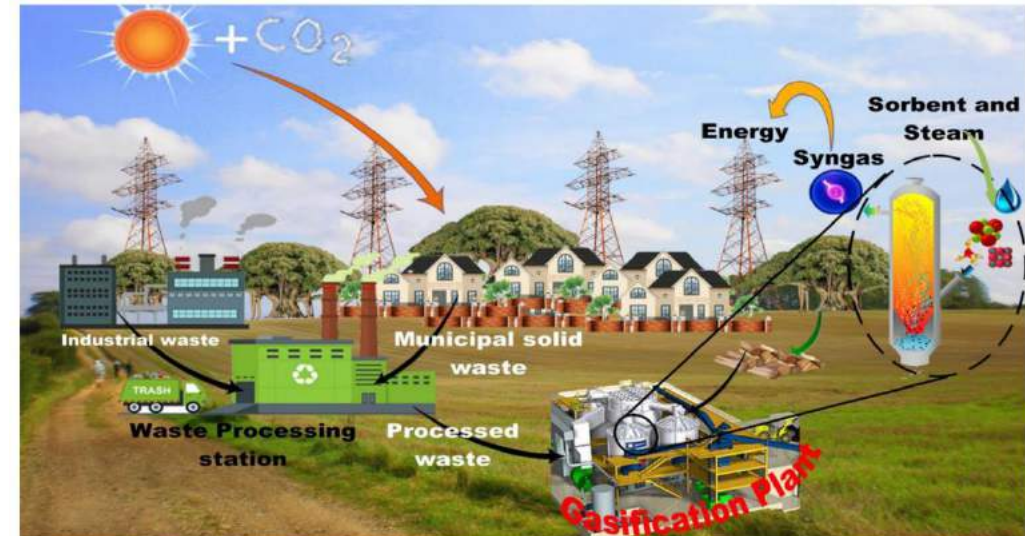
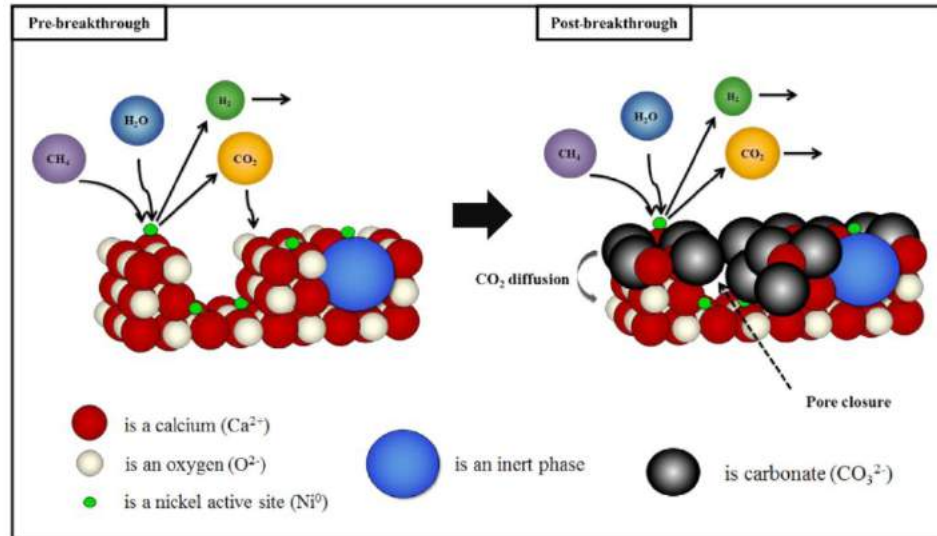
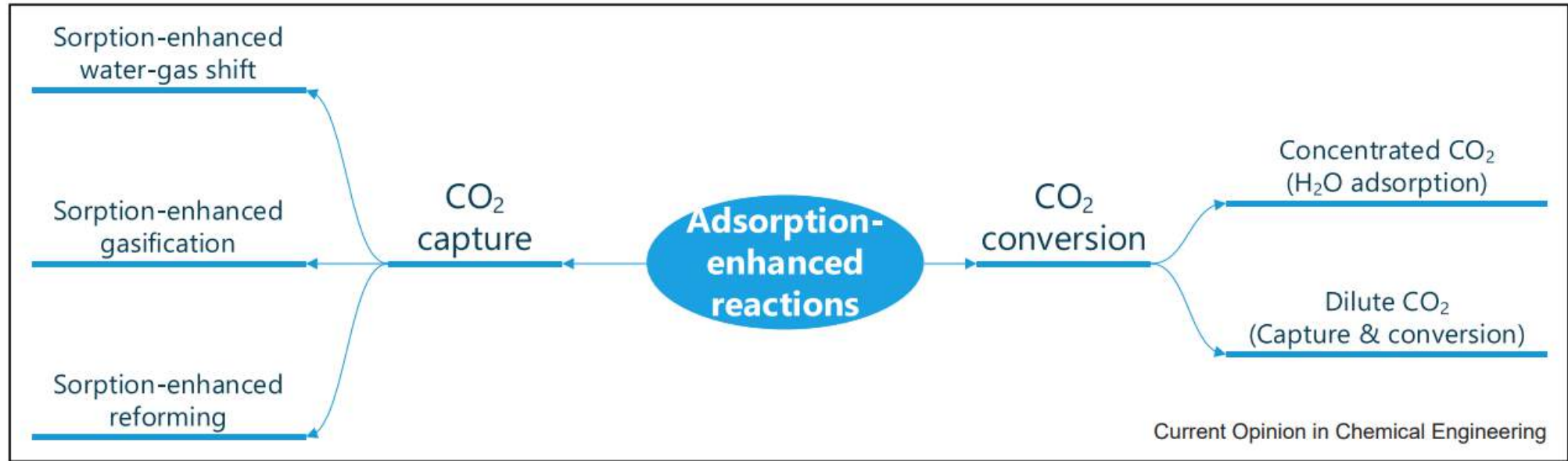


# Electrified methane reforming: A compact approach to greener industrial hydrogen production

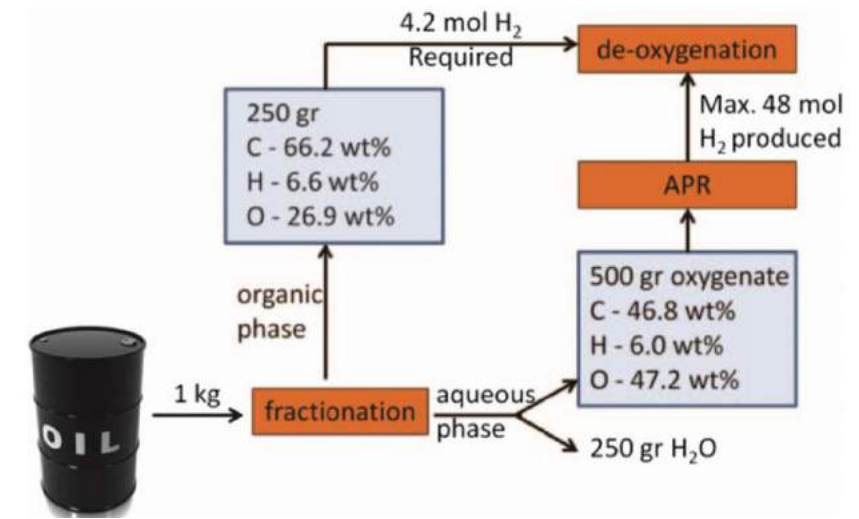
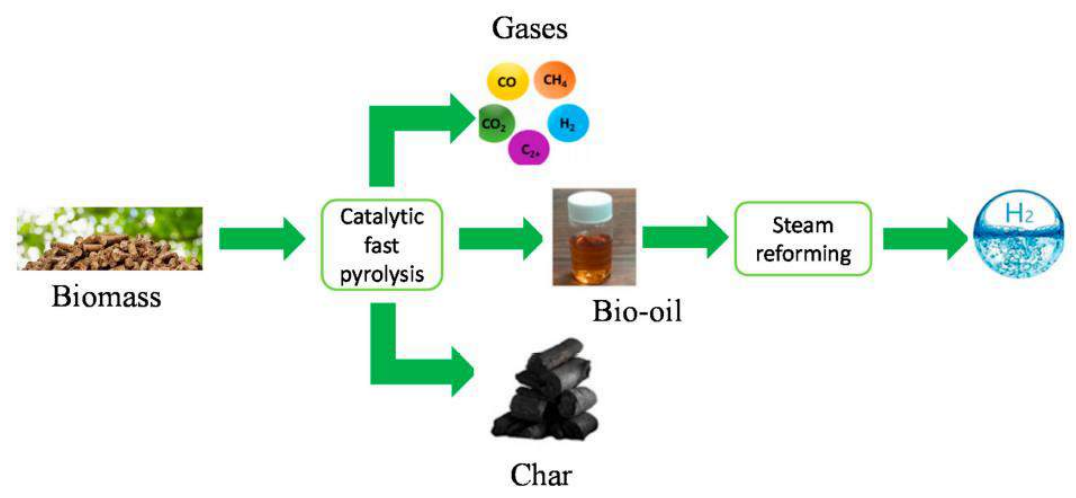
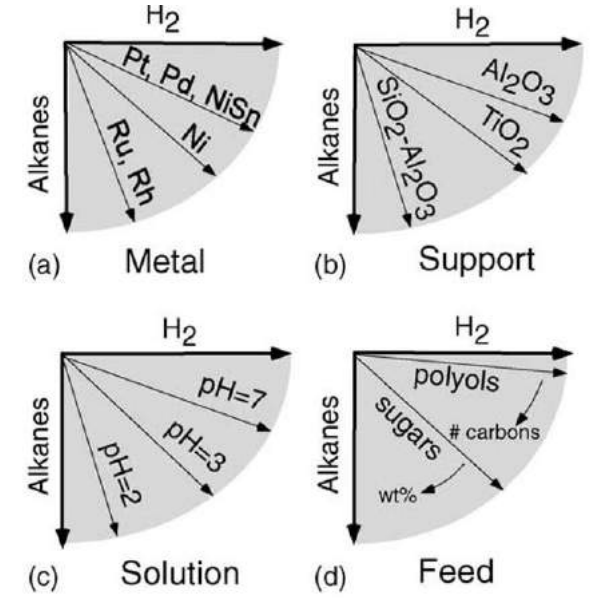
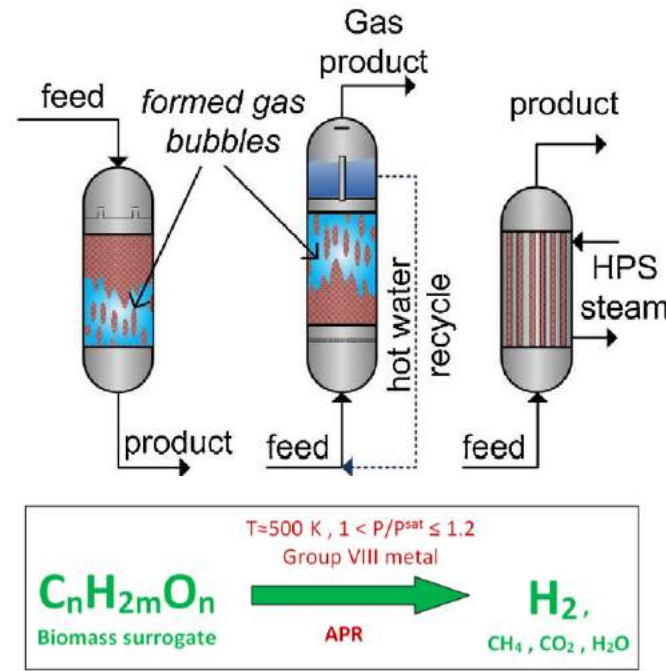
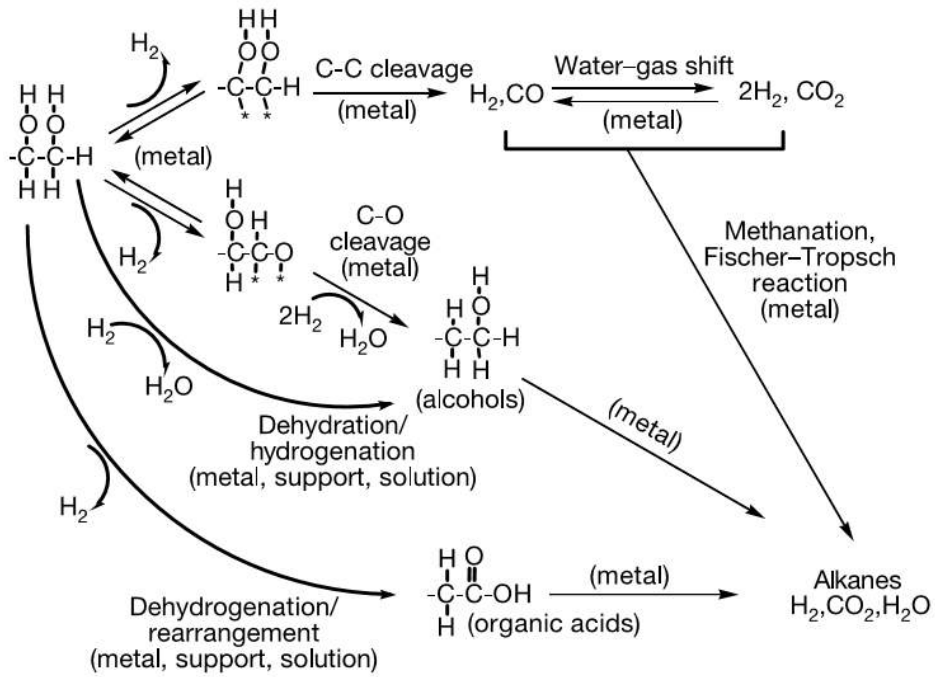
Wismann *et al.*, *Science* **364**, 756-759 (2019)



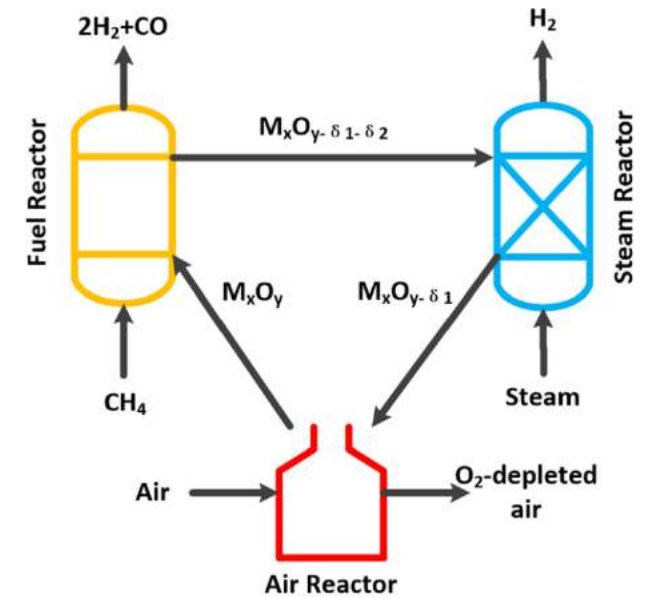
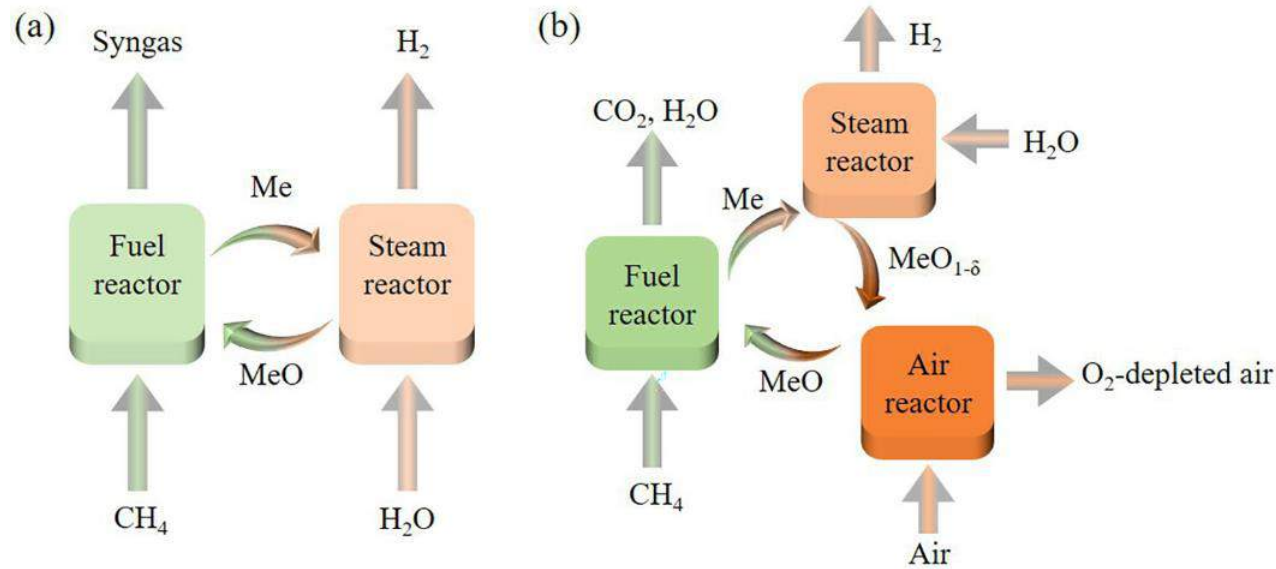
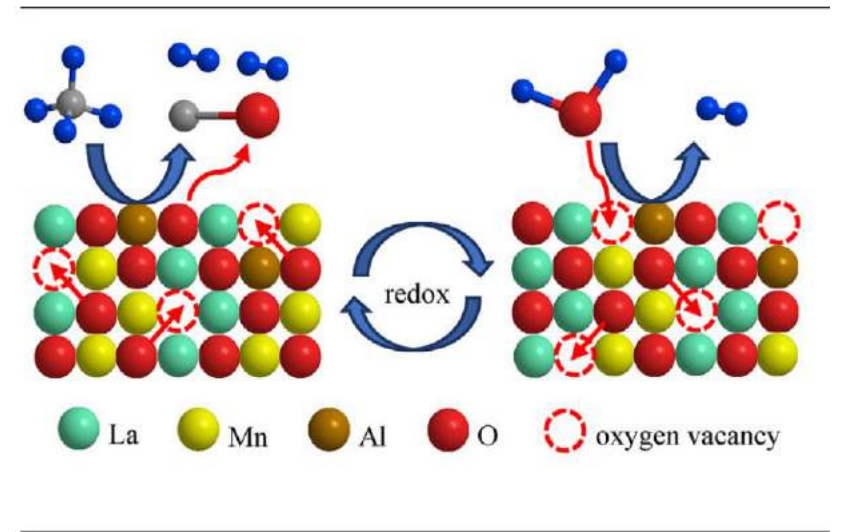
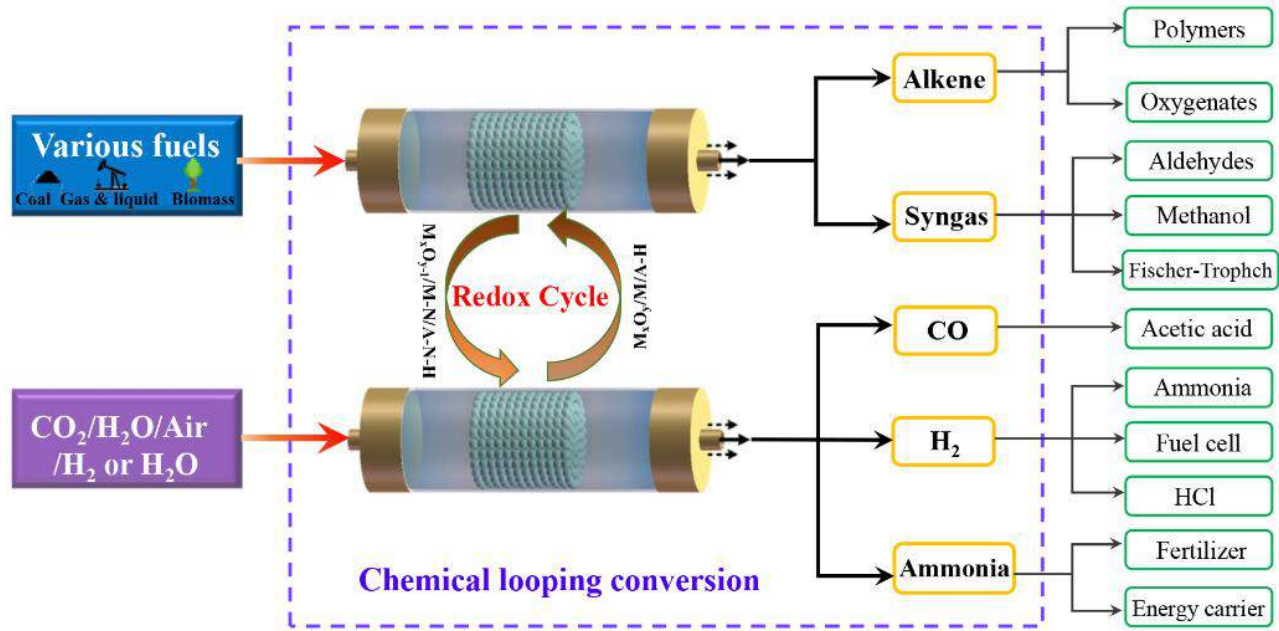
# In-situ CO<sub>2</sub> sorption for enhanced hydrogen production



# Hydrogen from aqueous-phase reforming of bio-feeds

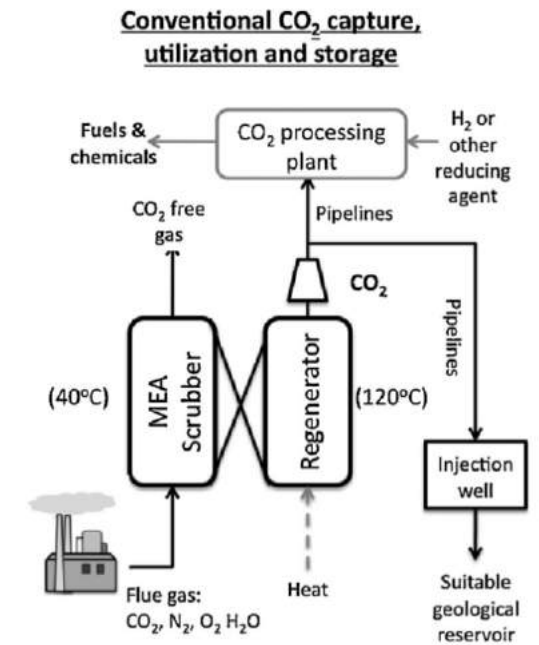
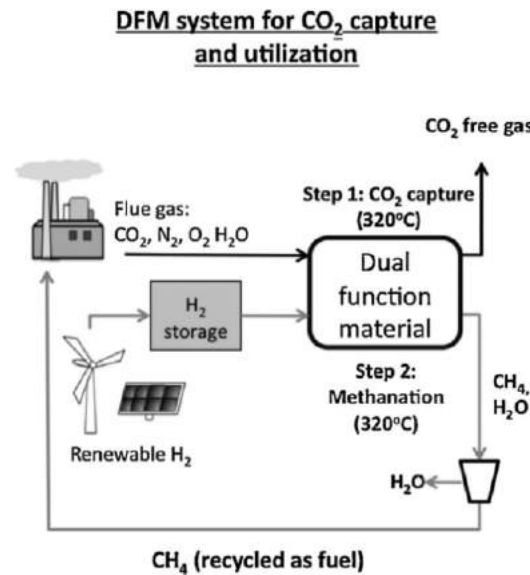
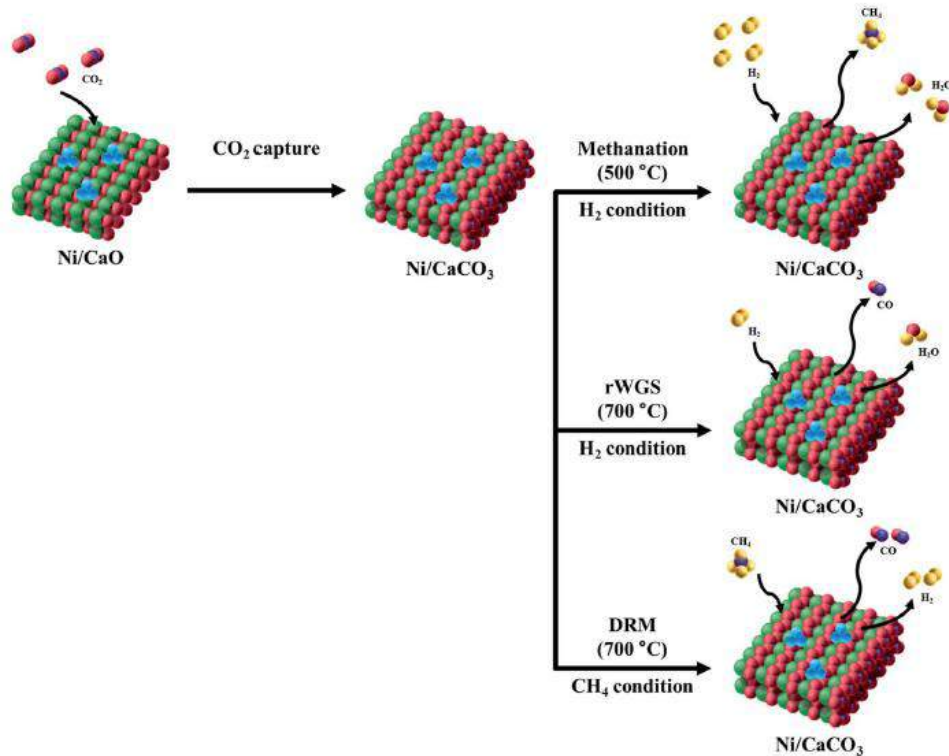
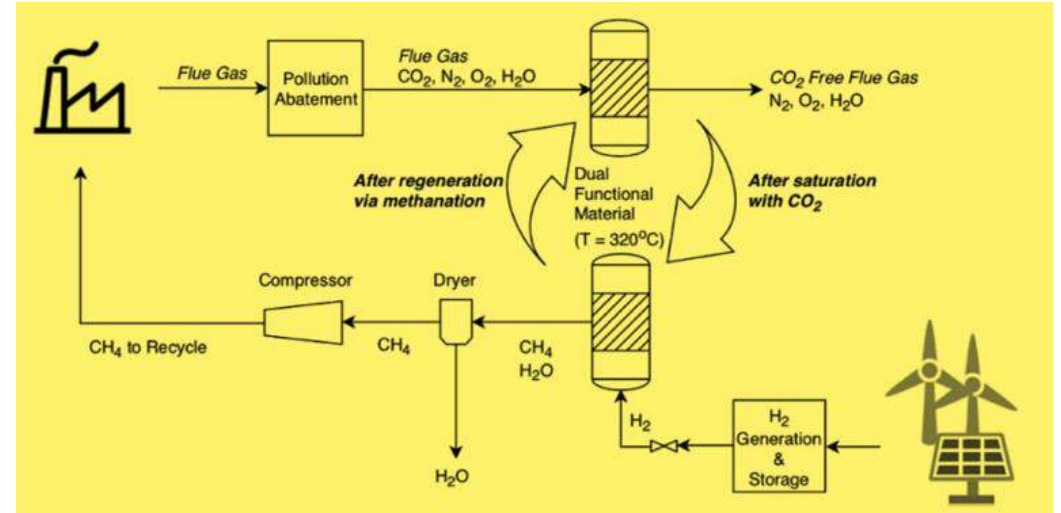
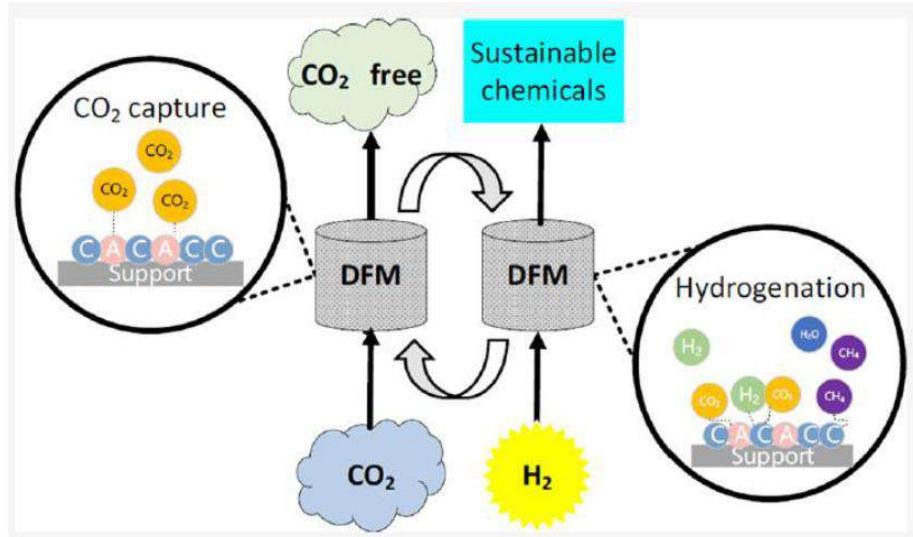


# Hydrogen from chemical looping steam reforming

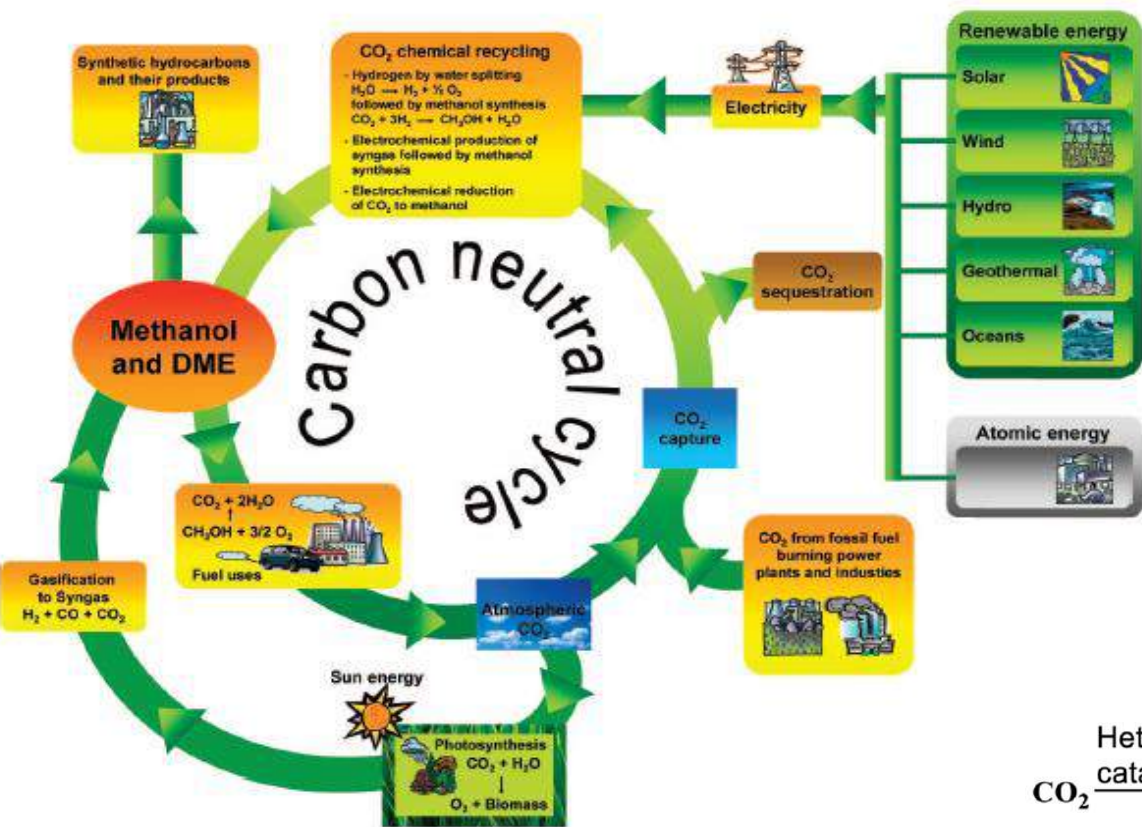




# Using hydrogen for ICCU (e.g., ICCU-Methanation)



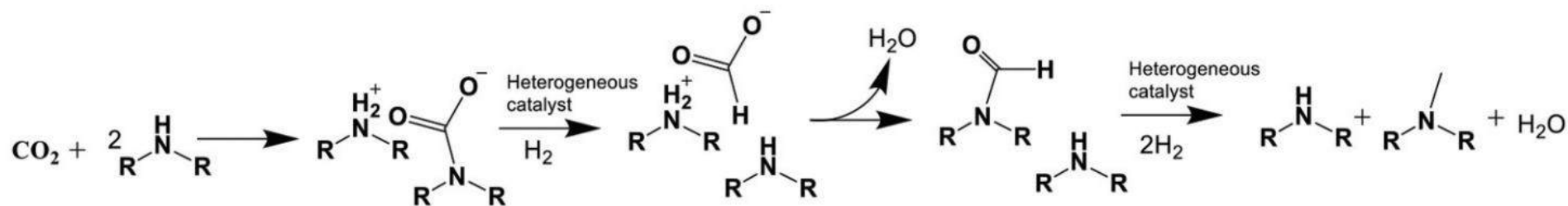
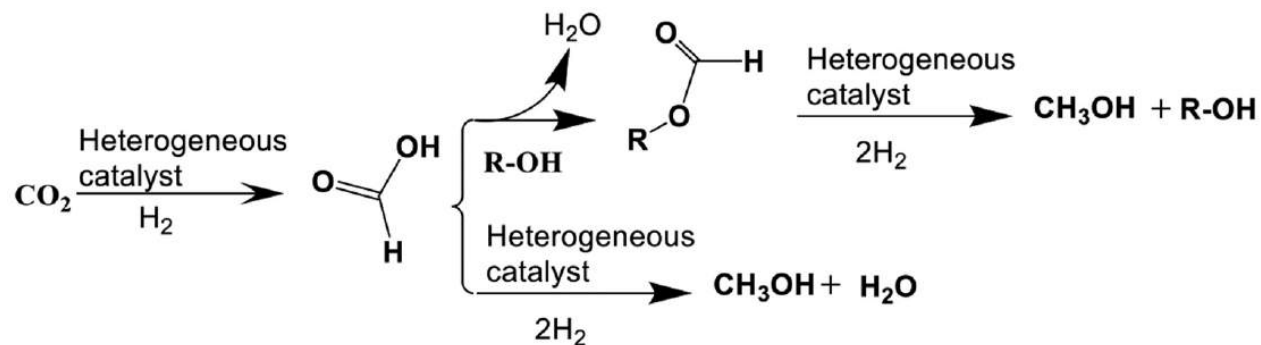
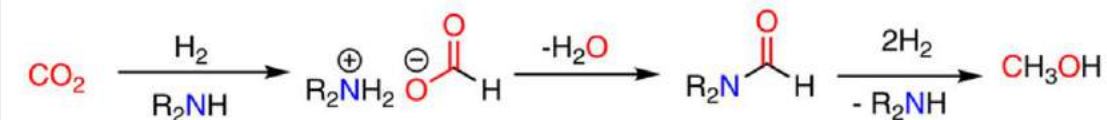
# Using hydrogen for **tandem amine-based CO<sub>2</sub> capture and hydrogenation to methanol**



## A. CO<sub>2</sub> capture using amines



## B. Amine assisted CO<sub>2</sub> hydrogenation to CH<sub>3</sub>OH



THANK YOU