Process for upgrading industrial exhaust gases into low-carbon fuels and chemicals

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Context

Reducing greenhouse gas emissions (GHG) is currently a major global issue. Following the COP21 conference in Paris in 2015, several countries, including Canada (and Quebec) have made ambitious commitments to reduce their GHG emissions.The government of Canada is currently implementing, for example, the "Clean Fuel Standard", which is an strict regulation that will limit the use of fossil fuels (liquids, gases and solids) in the next few years. Hence, industries of all sectors are invited to find ways of reducing their GHG emissions. Our invention addresses this concern and offers a way to produce low-carbon energy products by using CO_2 as feedstock to produce syngas (a building block for the production of a wide range of chemicals, such as methanol, diesel, jet fuel, etc).

The invention arrives in a very favorable market trend and our environmentally-friendly approach will be very disruptive compared to conventional syngas production processes (such as Steam Methane Reforming (SMR) since our invention uses GHG as raw material instead of using crude oil and natural gas.

Description

The main invention is a new process that uses CO_2 (one of the GHG) from industrial exhaust, water (H_2O) and renewable electricity to produce syngas (H_2/CO). The latter can be used for the production of energy, chemicals and advanced fuels. The process uses a simple and low cost catalyst for the conversion and is comparable to photosynthesis whereby plants and microorganisms use CO_2 and water to produce metabolites. The process can produce syngas with different H_2/CO ratios accordingly to the desired final product. Moreover, renewable electricity can be used to provide energy to the reaction. Hence, chemical storage of renewable electricity is also possible with this process.

The process uses a low-cost iron-based catalyst that allows optimal conversion of CO_2 and water.

Applications

Industrial sector (CO_2 capture and use)

- **Carbon capture** : the novel approach can utilize CO_2 generated by the various industrial processes to produce low-carbon fuels and chemicals
- **Industries with high GHG emissions**, see the % of each CO_2 contributor below (in Quebec 2020) :
    - **Transportation 42,6 %** : cars, trucks, ships, trains, and planes
    - **Industry 32.3 %** : cement factories, mining, pulp and paper companies
    - **Agriculture 10.4 %**
    - **Commercial and Residential 9.1 %** : fossil fuels burned for heat
    - **Residual materials 5.2%**
    - **Electricity and heat 0.5%**
- **Storage of renewable electricity:** in stable and easy to transport Finish Products

Commercial Advantages

- **Additionnal revenues** : by extracting the untapped value of GHG (CO_2) and commercializing resultant Final Products (low-carbon fuels and chemicals)
- **Cost-effective :** lower implementation cost compared to other CO_2 valorization technologies
- **Environmentrally friendly and Carbon-reduction technology :** open-up to carbon tax reduction

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Technical Advantages

- High process performance
  - **CO_2 Conversion ratio** : up to 70%
  - **High purity syngas with a mouldable H_2/CO ratio accordingly to the desired Final Product**

- **Low acquisition and operating cost versus conventional process**
  - **Low CAPEX:** elimination of process steps (ie: the Capture and Purification of CO_2 and H_2 Production steps)
  - **Low OPEX**
    - Simple and low-cost Catalyst
    - Mild reaction temperature is used (compared to classical processes, such as SMR)

Intellectual Property

Patent submission PCT WO2023077243A1

Bench scale proof-of-concept experiments have been performed

Scale-up is being design

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ANNEX

Figure 1 – Process that transforms CO_2 into low-carbon fuels and bioproducts

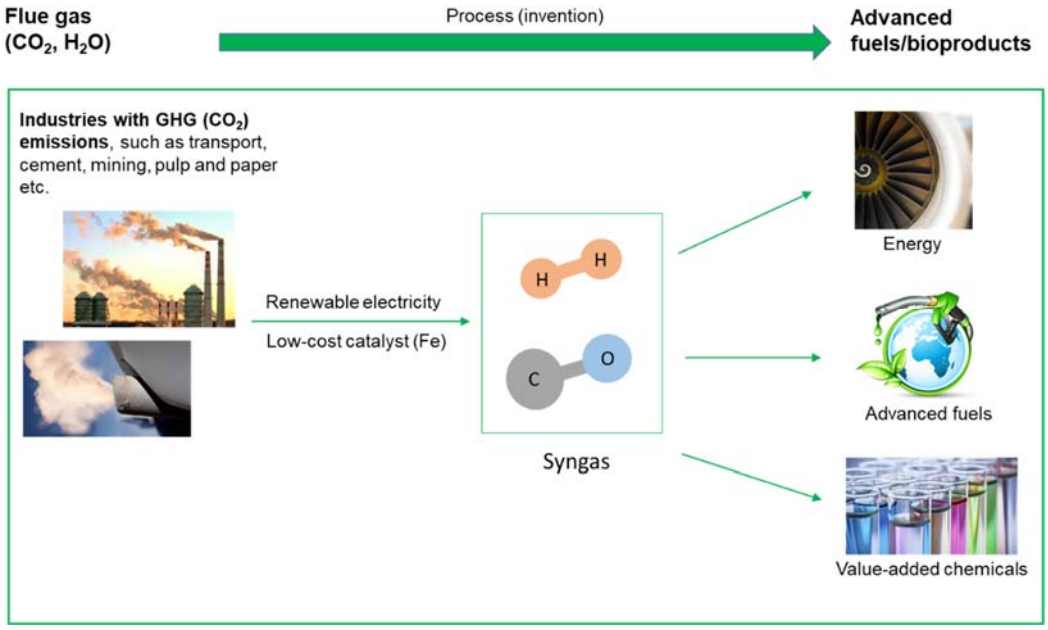
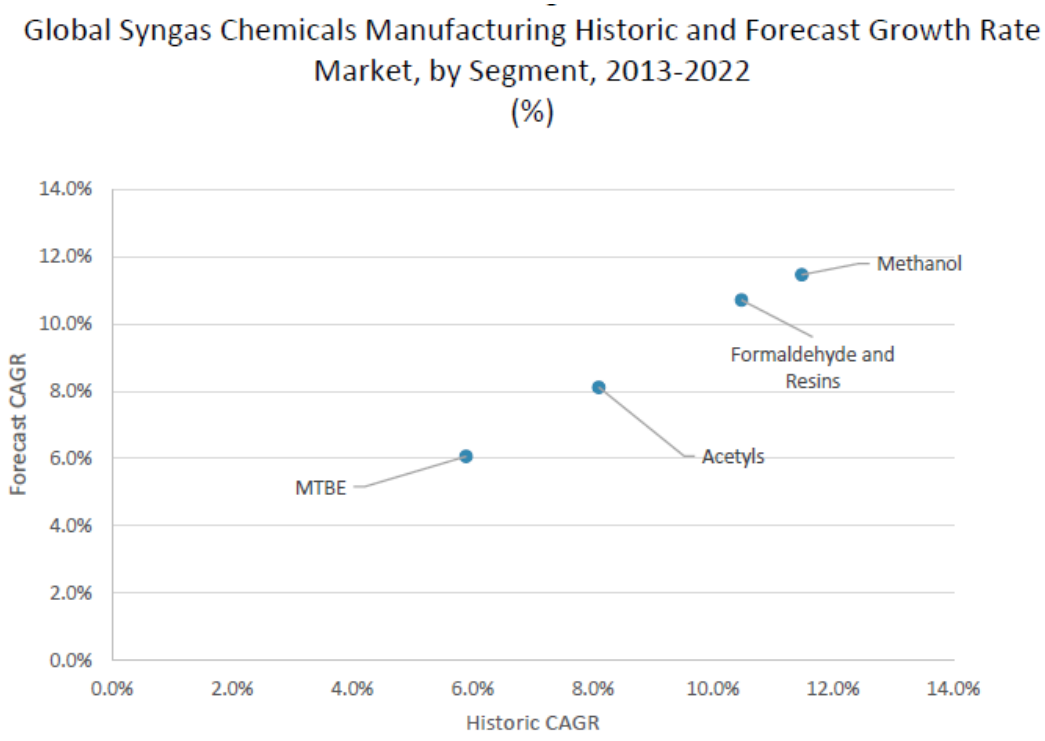


Figure 2 – Increasing demand for Syngas Chemicals (CAGR 9.1%)



Source: BCC Research, GSTC, IHS, IMF, National Statistics Offices