Source : www.thehindu.com Date : 2018-09-09

FUEL FROM AIR AND WATER

Relevant for: Environment & Disaster Management | Topic: Environmental Conservation, Sustainable Development & EIA

Carbonate veins that formed when water containing dissolved carbon dioxide flowed through rocks. | Photo Credit: VINCENT FOURNIER

As we have kept on burning more and more of organic fuel, such as coal and crude oil, over the last century across the world, the amount of the oxidation product, carbon dioxide (CO_2), in the atmosphere has reached alarming levels, causing global warming and climate change.

Given this scenario, why not capture the CO_2 from the atmosphere and convert it into something inescapable, such as solid carbonate rocks? Such direct air capture (abbreviated as DAC) of the gas and converting it from the biosphere (obtained from biological sources such as burning fuel by us) to the geosphere (as rocks and minerals) has been done by a company in Switzerland, called Climeworks. They have put up a plant in Iceland, where they bury CO_2 (or sequester it) into solid calcium carbonate ($CaCO_3$) rocks, just as basalt; they also sell the CO_2 to greenhouses and beverage makers.

An even better method would be to convert it back into hydrocarbon fuel through a reverse reaction, a process termed as air to fuel or A2F. And a group of scientists led by Dr David Keith of Harvard have put together a company called “Carbon Engineering”, with such a conversion of DAC into A2F. They have published their latest paper in the journal *Joule* last month (see Keith D, et al., A Process for Capturing CO_2 from the Atmosphere, *Joule,* DOI: 10.1016/j.joule.2018.05.006). Incidentally, the name of the journal is apt since a unit of energy in the international system of units is a joule, named after the English physicist James P. Joule).

The team has been working for the last several years on this problem. What is being done is to capture the undesirable product CO_2, run it through a reactor in an efficient manner and use it to combine with hydrogen (obtained through electrolysis of water) and generate the hydrocarbon fuel. The whole process is what is termed as ‘carbon-neutral-fuel production’ by them.

Capturing CO_2 from ambient air itself is not new. As the authors point out, this was attempted as early as the 1950s, as a pre-treatment of air; and in the 1960s, it was attempted to use as feedstock for the production of hydrocarbon fuels in mobile nuclear power plants. What Carbon Engineering has done is to describe the nuts and bolts of the process, the engineering steps, and the cost-benefit analysis. Their claim is that it should be possible to make the process as viable as anywhere between US $50-100 per ton of CO_2 captured by DAC.

As Tracy Staedter summarises it in her “Inscience” column of June 2018, “ambient air is sucked in, passed over a thin plastic surface that has a solution of potassium hydroxide (KOH). The potassium carbonate (K_2CO_3) so obtained is piped into a reactor containing calcium hydroxide ($Ca(OH)_2$), to make pellets of calcium carbonate ($CaCO_3$). The KOH released in this reaction is re-circulated for use. Now the pellets are heated, releasing CO_2 which can be sequestered (as Climeworks have done), or can be mixed with hydrogen (H_2, obtained separately through electrolysis of water), to make a hydrocarbon fuel. The company should be able to make fuels for vehicles, using their approach”.

Dr. David Roberts, in his analysis of this A2F project, in his website (vox.com) also considers the approach of Carbon Engineering to become viable in the near future. And Dr. Jeff Tollefson writes about A2F in the 7 June 2018 issue of *Nature* that DAC is cheaper than what scientists had thought. It used to be thought that it would cost anywhere between $50 to $1000 per ton of CO_2. Now it appears to be anywhere between $94 and $234. And 1 million tons of CO_2 can be converted to about 30 million gallons of jet fuel, diesel or gas.

The interesting points to note in the above chemical reaction cycle are: CO_2 is pumped in step1 and comes out in step 3, where it can be captured and stored for making fuel by reacting with hydrogen in a separate reactor. Water which is a reagent in step 4 is a product in step 2. And $Ca(OH)_2$, a reagent in step 2 is released in step 4. Thus the whole process is not just carbon-neutral but appears to be inorganic-chemical-neutral as well. It is estimated that 1 million tons of CO_2 can be converted to 30 million gallons of jet fuel diesel, or gas.

This is reverse engineering at its most hopeful. Or as the wag said: whatever goes up should come down!

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