Rise of the gaseous (carbon dioxide) feedstock in circular bioeconomy

Voluminous release of carbon dioxide into the atmosphere due to incessant combustion of hydrocarbon based fuel is causing grave environmental effects and irreversible climate changes globally. With the dawn of 20th century industrialization ~9.1 gigatons of CO_2 is generated annually. Understanding the consequences, the world leaders have agreed to reduce the carbon dioxide emissions below the critical level and maintain the temperature rise below 2^0C at COP21 held in Paris. This calls for carbon capture and sequestration (CCS) technologies more intensively. The current CCS methods follow the principle of capturing the emission at the source, transporting it to a remote location and storing it deep underground or at ocean beds, trying to keep it away from the atmosphere. These technologies are relocating CO_2 from entering into the atmosphere to a presumably safer location, which however doesn't solve the problem in totality. The CCS mechanisms require expensive high energy installations to capture CO_2 at site and carbon based fuel for transportation to the storage location, considering the overall equation the technologies currently deployed have substantial room for process enhancement. Also, the storage locations being within the earth and continuously getting added, could cause other harmful effects, moreover, there are possibilities of the storage mechanism reverting which would release the complete CO_2 which paints an unmanageable circumstance.

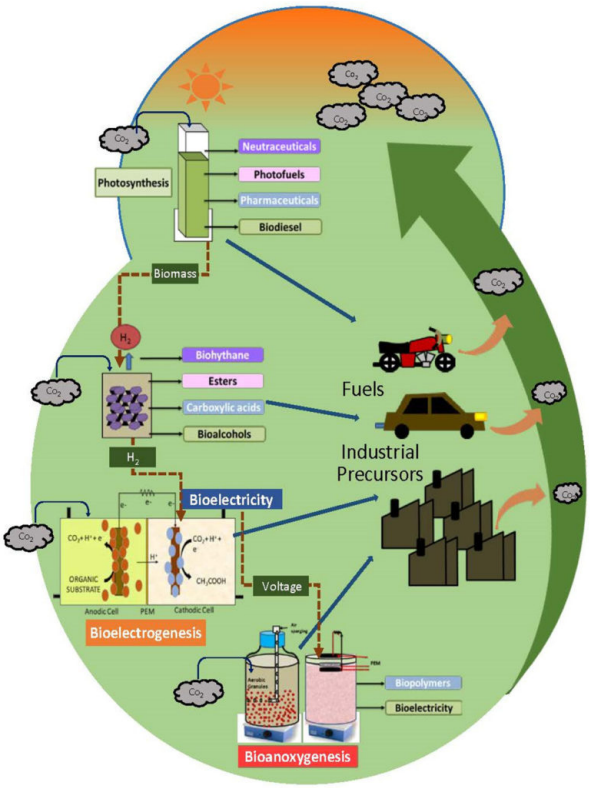

Fig. 1. CO2 as feedstock for producing biobased products and biofuels in a biorefinery approach,

collinear to the petroleum refinery.

Can there be a green sustainable process that doesn't cause any form of pollution? For which we need to find an answer. With the world pivoting towards renewable and sustainable energy, CO_2 qualifies as the new found feedstock and in abundant quantities for the foreseeable future. Mimicking nature's processes like photosynthesis, chemoautotrophism, etc., to convert CO_2 into valuable products provides a solution and it is the current research focus all over the globe. The proposed photosynthetic model comprises of microalgae, photobacteria and azolla which sequesters CO_2 and provide O_2 the sole life giver. These are also rich sources of biodiesel, neutraceuticals, pharmaceuticals, edible oils, antioxidants, cosmetics, etc. Apart from these, natural CO_2 sequesters chemoautotrophs possess the inherent machinery to utilize CO_2 as the carbon source for their metabolism. The proposed chemoautotrophic model comprises of acidogenic and bioelectrogenic (Chemoelectroautotrophs) bacteria which are able to sequester CO_2 under some input energy unlike the photoautotrophs. Chemoautotrophs convers CO_2 to products like carboxylic acids, alcohols, biogas, biofuels, biopolymers, etc. These models function in a carbon-negative mode enabling the recycle of CO_2 and abating the climatic concerns. Individually, the proposed models are potential CO_2 sequesters but, when integrated the overall process efficiency can be increased with multitude of products synthesis. Integrating multiple bioprocesses in a sequential closed loop can be considered as the sustainable strategy that will have positive repercussions on the present state of economy and environment.

Expeditious scientific developments are able to transform the detrimental causative into a beneficial solution. Though the scale of operation and efficiency are not comparable at present, proposed models provide a sustainable and viable solution in the coming days. Numerous startups and big companies alike are rigorously working in this domain. These models have the capability to overwrite the caveats our planet is facing and establish a sustainable bioeconomy platform in a biorefinery approach.

S. Venkata Mohan, J. A.Modestra, K. Amulya, Sai Kishore Butti, G. Velvizhi
Bioengineering and Environmental Sciences (BEES),
CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad, India

Publication

A Circular Bioeconomy with Biobased Products from CO2 Sequestration.
Venkata Mohan S, Modestra JA, Amulya K, Butti SK, Velvizhi G
Trends Biotechnol. 2016 Jun