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Editorial

Capture and Fixation of CO_2 Emissions: An Opportunity in Disguise

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Carbon dioxide, CO_2 and water, H_2O molecules are used by plants in the presence of sunlight in order to make starch by photosynthesis. Human respiration involves inhalation of oxygen, O_2 molecules and exhalation of CO_2 molecules. In the year, 2005, Environmental Protection Agency, EPA estimates in the year 2005, the rate of emissions of CO_2 to the atmosphere was 2.7 billion tons per year. By the year 2011 the CO_2 emissions have reduced to 2.1Gt/year. EPA sees the connection between natural disasters such as drought, floods, forest fires and global warming with CO_2 emissions. The CO_2 emissions arise from 2100 power plants that use fossil fuel such as coal and oil, steel mills, ceramic kilns and glass melting.

Kyoto protocol signed in December, 1997 at Kyoto, Japan laid down CO_2, methane, nitrous oxide, PFCs, perfluorocarbons, HFCs, hydro fluorocarbons, SF_6 sulfur hexafluoride as pollutants. My master's thesis paper discussed a novel method to extract substantial portions of a West Virginia, high ash, bituminous coal using N-Methyl-2-Pyrrolidone as super solvent under mild conditions. My research advisor and the investigator team flew me and another investigator to Maastricht, Netherlands from Morgantown, WV in order to present a paper at the International Coal Science Conference in October, 1987. The clean coal extract contains 0.01% ash and virtually no pyritic sulfur. The extraction yield was 70% on a mineral and ash free basis [1]. Since then Prof. J.W. Zondlo and other investigators have made progress and dehydrogenated the coal extract into solvent extract carbon. These can be used as electrodes in a direct carbon fuel cell to give higher open circuit voltages compared with hydrogen fuel cell [2, 3]. When used as power plants these would have zero carbon emissions. SOFC, solid oxide fuel cells can be used to construct mini power plants with zero carbon emissions according to K. R. Sridhar, CEO of Bloom Energy, Sunnyvale, CA. Nuclear power plants, windmills, solar power plants either photovoltaic or concentrated solar power are examples of obtaining electrical energy without carbon emissions.

CO_2 emissions can be reduced by either fixation or by capture. Chemical, electrochemical and biological methods can be employed for reduction of CO_2 emissions. Biological methods include the use of aquatic plant, microalgae, microphytes and sea weeds and sea pores. President B. Obama and EPA announced the Clean Power Plan on an August day in 2015 [4]. This is an opportunity in disguise. This is an example of how federal government is not the problem and can do more to make our lives peaceful and prosperous. Under this plan the President has called for:

1. 32% reduction of CO_2 emissions by 2030.
2. 17 % cut in CO_2 emissions by 2020.
3. 25-28% reduction of CO_2 emissions by 2025. The President is in favor of hammering out global climate change treaty.

Enzyme catalytic reactions can be performed under dense CO_2 surroundings. Commercial quantities of biodiesel from cellulosic biomass, r-s propanediol from d, l lactic acid using enzyme catalysis are now in vogue. Under the presence of supercritical CO_2 polymers can be synthesized and fluoropolymers can be prepared. CO_2 can be fixed using processes encountered within organisms such as the Calvin- Benson-Bassham, CBB cycle in leaf carbon metabolism, Krebs cycle, Wood- Ljungdahl pathway etc. CO_2 and water combine with 3 ribulose 1, 5-biphosphate in order to form glyceraldehydes. The enzyme that serves as a catalyst is ribulose diphosphate carboxylase. The ATP cycle offers the necessary energy.

CO_2 goes into preparation of Na_2CO_3 laundry detergent, carbonated beverage, fire extinguishers, chemical lasers, bread dough, lead paint pigment and dish washing compounds. The capture of CO_2 can be accomplished by:

1. Absorption towers with either monoethanolamine, MEA solvent or alkali carbonate based solvents such as hot K_2CO_3, potassium carbonate [5].
2. Adsorption beds with molecule sieves [6] with 5 nm diameter made from serpentinitite (Magnesium silicate hydroxide) with surface area, 2500 m^2/gm.

The sequestered CO_2 after regeneration of the solvent can be stored underground at 14 MPa pressure. Storage of CO_2 can be made robust by use of hydro phase liquid phase sintering, HCPS. Separation of MEA from MEA-CO2 adduct can be bettered by using serpentine reactions. In the Solvay process to manufacture Na_2CO_3, 2 moles of CO_2 along with brine and ammonium hydroxide are taken in and along with Na_2CO_3, ammonium chloride and one mole of CO_2 and H_2O are produced. CO_2 gets fixed. Limestone can be the starting material in order to manufacture Na_2CO_3. CO_2 is recovered and utilized by dry reforming of methane. LNG, liquefied natural gas comprises of 65-70% methane and 30-35% CO_2. The carbon monoxide formed during reformation process can be noxious and have to be reacted away in large measure.

A direct route in order to prepare methanol from CO_2 by hydrogenation has been patented in Japan in the RITE process. Cu-Zn, copper-zinc can be used as catalyst and $La_2Zr_2O_7$ as promoter in the synthesis of methanol from CO_2. Advances made genome sequencing using microarray analysis and dynamic programming may lead to genetically modified crops that can be tailored to consume CO_2 at higher volumes. Third generation bio fuels are expected to stem from microalgae. In 2009, Exxon Mobil has pledged $600 million for research in photosynthetic algae-biofuels. The CO_2 species undergoes mass transfer from the atmosphere to microalgae. Here microalgae biomass is formed. Bio ethanol can be produced. Formic acid, formaldehyde, methanol, methane are some organic compounds that can be produced from CO_2 and H_2O. Ethylene oxide can be combined with CO_2 to make epoxides. Cement formulations can use CO_2. Capture of CO_2 may be performed in a fluidized bed. Flue gas from power plant can be carbonated in a fast fluidized bed. The solvent is then regenerated. 110 million tons per year of CO_2 is used as raw material for the production of urea, methanol, acetic acid, polycarbonates, cyclic carbonates, salicylic acid carbonates.

Polyformaldehyde has oxygen and carbon in its backbone. CO, carbon monoxide can be polymerized to form polyketone. In 2000 polymerization of acetylene to conducting polymers lead to the award of Nobel Prize to A. J. Heeger, H. Shirakawa and A. Mc Diarrmid. The polymer science of CO needs to be better understood. Boudard reaction can be used to make CO, from CO_2. Oxycarbons in an alternating fashion in the polymer backbone may not be stable [7]. But ketone density in polymers can be increased.

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