CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT THROUGH CARBON DIOXIDE UTILIZATION

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Abstract : As early as 1896, the Swedish scientist Svante Arrhenius had predicted that human activities would interfere with the way the sun interacts with the earth, resulting in global warming and climate change. His prediction has become true and climate change is now disrupting global environmental stability. The last few decades have seen many treaties, conventions, and protocols for the cause of global environmental protection and reduction in Green House Gas particularly CO_2. Few examples for the environmental issues of global significance are ozone layer depletion, global warming and loss of biodiversity. One of the most important characteristics of this environmental degradation is that it affects all mankind on a global scale without regard to any particular country, region, or race. The whole world is a stakeholder and this raises issues on who should do what to combat environmental degradation. Climate change is impacting the natural ecosystems and is expected to have substantial adverse effects in India. This paper presents an overall review about climate change, possible ways of reducing these Green House Gases through Chemical and Biochemical path ways for sustainable development of World.

Key Words: Climate change, Sustainable development, Global warming, Green House Gas, Ecosystems.

INTRODUCTION

Climate change is one of the complex problems facing mankind today. The overriding complexity of the problem is attributed to its deeper global ramifications on a vast range of issues impacting the very survival of life on Earth. Climate change is not an isolated issue. It has several aspects and inter-linkages namely, science and technology, economy and trade, diplomacy and politics - that makes it not just another issue in this complicated world of proliferating issues, but the mother of all issues. In the face of much diversity that characterizes human society, climate change provides a potent reminder of one thing that we share in common - the planet Earth. All nations and all people share the same atmosphere. And, we only have one. Addressing the climate chaos by all the countries, both individually and collectively, will be critical to the human well-being and prosperity of the present as well as the future generations.

The key environmental challenges have become sharper in the past two decades. The 2009 State of the Environment Report by the Ministry of Environment and Forests (MOEF) clubs the issues under five key challenges faced by India and world, which are climate change, food security, water security, energy security, and managing urbanization. Climate change is impacting the natural ecosystems and is expected to have substantial adverse effects on World, mainly on agriculture on which around 58 per cent of the population depends for livelihood, water storage, groundwater recharge, sea-level rise, and threats to a long coastline and habitations. Climate change will also cause increased frequency of extreme events such as storms, floods, and droughts. These in turn will impact world's food & water security problems.

World's Green-House Gas Emissions and Research on CO_2

According to the findings of the report *Trends in global CO_2 emissions*, global carbon dioxide (CO2), emission increased by 3% in 2011. The three percent increase in CO_2 took the total amount of CO_2 in air at an all-time high of 34 billion tonnes. The report was released by the European Commission's Joint Research Centre (JRC) and the Netherlands Environmental Assessment Agency (PBL).The United States with 17.3 tones per capita remains one of the top CO2 emitters, while, China, the world's most populous country, average CO2 emissions increased by nine percent to 7.2 tonnes per capita. The 27-nation European Union emitted 7.5 tonnes of CO_2 per person. Fossil fuel emissions in World continue to result largely from Petroleum and coal. The approximately 115 million metric tons of CO_2 used annually by the global chemical industry really doesn't compare to the approximately 24 billion metric tons of annual anthropogenic CO_2 emissions. Doing the math makes it obvious that CO_2 capture and sequestration will be necessary, regardless of how much CO_2 industry ends up using as a feedstock. Potentially, however, there are better ways to deal with CO_2, a growing number of researchers are saying.

1. Christopher M. Rayner of the University of Leeds and colleagues from across the U.K. are working on involves

catalytic processes for reducing CO_2 to formic acid (HCO_2H). Formic acid has potential to power fuel cells for electricity generation and automobiles and as a precursor for other fuels and commodity chemicals, including polymers. Hydrogen will be needed for the conversion and would have to be sourced from elsewhere, Rayner explained. "But compared with using hydrogen alone or methanol, they believe formic acid has much greater potential". Lots of opportunities exist, Rayner believes. "Chemists are uniquely positioned to make fundamentally important contributions to climate change and reduction of CO_2 levels," he said. "But an enormous challenge lies ahead."

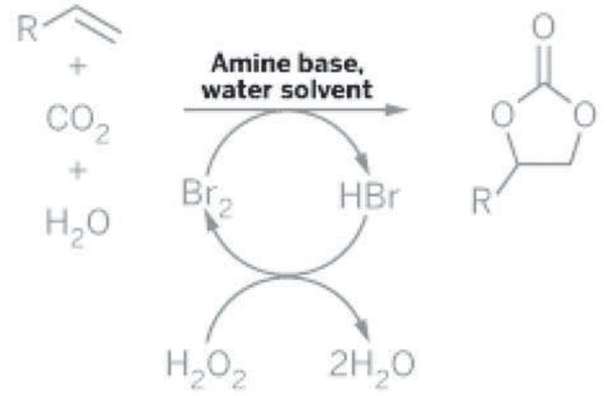

Figure 1 CO_2 Splitting Mechanism

2. One strategy Chao-Jun Li of McGill University, Montreal envisions as having some potential in this arena is CO_2 chemistry in which water is the solvent. In Chicago, Li described a project by Nicolas Eghbali in his group to convert CO_2 and olefins into cyclic carbonates in water (*Green Chem.* **2007**, 9, 213). This oxidative carboxylation of olefins is not exactly a new approach, but there are few references to it in the chemical literature, and they all report low efficiencies.

3) Greener Carbonates Eghbali and Li fashioned a direct route to cyclic carbonates from an olefin and CO_2 that bypasses the extra step of making an epoxide starting material. Carbonates are useful and often greener substitutes for toxic phosgene ($COCl_2$) and Dimethyl sulfate in a host of chemical reactions. They also serve well as solvents, especially in medicines and cosmetics, and they are electrolytes of choice in lithium-ion batteries.

4) In Chicago, David C. Grills of Brookhaven National Laboratory described research in collaboration with Brookhaven chemist Etsuko Fujita to improve the efficiency of homogeneous rhenium catalysts that photo chemically reduce CO_2 to CO. Fujita has worked for several years exploring the mechanisms and kinetics of CO_2-to-CO reduction using a variety of metal catalysts. With these artificial photo systems, she has identified reaction intermediates by using transient and conventional spectroscopic techniques.

5) Attempting to chase after Mother Nature's methods of capturing CO_2, organometallic chemist Daniel L. Dubois of the Institute for Interfacial Catalysis at Pacific Northwest National Laboratory spoke about CO_2 reduction in electrochemical cells. Like that of other groups, DuBois' idea is to develop a catalyst capable of reducing CO_2 to useful fuels. In the case of methanol, the six electrons for the conversion could be supplied by a solar photovoltaic device and the six hydrogen ions could come from water.

If catalytic systems were designed to make these conversions during periods of excess energy production from solar, wind, or nuclear energy, chemical fuels could serve as a form of large-scale energy storage," DuBois observed. "In non-fossil-based systems of the future, it will be necessary to reversibly interconvert between these various types of fuels and electricity as needed using inexpensive catalysts."

6) Chemists have shown that it is possible to use solar energy, paired with the right catalyst, to convert carbon dioxide into a raw material for making a wide range of products, including plastics and gasoline. Researchers at the University of California, San Diego (UCSD), recently demonstrated that light absorbed and converted into electricity by a silicon electrode can help drive a reaction that converts carbon dioxide into carbon monoxide and oxygen. Carbon monoxide is a valuable commodity chemical that is widely used to make plastics and other products. It is also a key ingredient in a process for making synthetic fuels, including syngas (a mixture largely of carbon monoxide and hydrogen), methanol, and gasoline.

Uses of CO_2

"Industrial processes can in principle be developed to have a positive influence on atmospheric CO_2—we don't have to bury it all to have an impact". "But the products would have to be in high demand." Otherwise, large piles of unwanted polycarbonates or "pretty white mountains" of calcium carbonate akin to the White Cliffs of Dover might dot the globe.

Bulk chemicals already produced routinely from CO_2 include urea to make nitrogen fertilizers, salicylic acid as a pharmaceutical ingredient, and polycarbonate-based plastics. Carbon dioxide also could be used more widely as a solvent. For example, supercritical CO_2 (the state existing at 31.0 °C and 72.8 atm) offers advantages in terms of stereo chemical control, product purification, and environmental issues for synthesizing fine chemicals and pharmaceuticals. Other avenues for usage of CO_2 include oil and gas recovery, enhanced agricultural production, and ponds of genetically modified algae that can convert power-plant CO_2 into biodiesel. Globally, about 110 megatons are currently consumed in this way each year.

"Using CO_2 as a raw material probably is never going to reduce atmospheric CO_2 levels or lessen the effects of CO_2 on climate change The numbers just don't add up," cautioned chemical engineer Eric J. Beckman of the University of Pittsburgh. "But there are places where using CO_2 as a raw material could create needed products. A bonus will be if such products could be made in a green and economically feasible fashion."

Progress to that end has been slow and not terribly creative so far. "Typically what we have seen is people making things that they are able to make, rather than making things that are truly useful". While much of this research is worthy of publication in top journals, it's not yet fully addressing real problems and challenges. "For example, most of these attempts make no mention of carbon—would more CO_2 be generated in the process than is consumed?"

In the 1980s, there was a rush to develop supercritical fluid technologies following the success with using supercritical CO_2 to extract caffeine from coffee. But this turned out to be "a solution in search of a problem". The "feeble" power of supercritical CO_2 to solubilize polar and high-molecular-weight compounds made it suitable only for niche applications. Since the early 1990s, the use of surfactants and co solvents has empowered supercritical CO_2. For example, it is now used in DuPont's polymerization of fluorinated monomers and in dry cleaning, as an alternative to halocarbon solvents. But using CO_2 as a solvent, "seems to have hit a wall". "Beyond traditional food processing, we haven't been seeing much in the way of large-scale applications coming out, and funding for such work is down a ton." But there's still potential for large-scale applications to emerge.

Biomass, methane, and carbon dioxide are huge renewable carbon resources for organic synthesis," commented chemistry professor Chao-Jun Li of McGill University, Montreal. "But using a renewable feedstock alone doesn't mean a process is green." A number of factors still need to be met, including reducing organic solvent use, reducing the number of reactants and reaction steps, reducing energy consumption, and reducing waste.

When it's exposed to the elements, the surface of copper turns green as it reacts with oxygen. But now scientists have discovered a copper-based material with a surprising property: it reacts with carbon dioxide in air rather than oxygen. Though the reaction is not a practical way to remove large quantities of carbon dioxide from the atmosphere, it does provide an alternative new route, using a cheap, non-petroleum feedstock, to make useful chemicals.

Some major reasons for producing chemicals from CO_2 are:

- can replace toxic chemical feed stocks (e.g. phosgene)
- will soon be stored for use in large feedstock reservoirs
- could possibly be used to make totally new materials (e.g. new polymers)
- Could provide more efficient and economical routes to existing chemicals.

Whatever chemistry we do with CO_2, it will make a small impact, and with potentially high product value, and significant positive impact on the global carbon balance. The road to determining the future of CO_2 clearly is still under construction. And chemists are planning a number of other workshops and conferences to help speed up the progress and perhaps redraw the map.

Usages of CO_2:

CO_2 as a Raw Material in Chemical Processes

- Entire molecule incorporated in the product
  - Urea & derivatives
  - Organic carbonates (DMC)
  - Salicylic acid & derivatives
  - Polymers
  - Organic intermediates
  - Fine chemicals
  - Inorganic carbonates
- CO_2 in reduction process → C_n molecule
  - Richer in Energy producing bulk chemicals
  - Methanol, CO, CH_4
  - other C_n molecules

Possible ways to Reduce CO2 and/or Green House gases

Global Warming

- Global Reproduction Plan
  - Field investigation
  - Development
  - Model
- CO_2 Separation & Collection Technology
  - Absorption
  - Adsorption
  - Membrane
  - Other related items
- CO2 Capture Technology
  - Bacteria
  - Algae
  - Other related items
- CO_2 Utilization Technology
  - Methanol
  - Manure-feed oil
  - Formic acid
  - Hydrocarbons
- CO_2 Disposal Technology
  - Land disposal
  - Ocean disposal
  - other related items
- Environ-mental Productive Technology
  - Hydrogen
  - Catalyst
  - other related items

CO_2 as a Resource in Technological Processes:

- Addition to beverages and drinks
- Food packaging and Freezing
- Manuring substitutes in horticulture
- Industrial Extraction, Foaming agents
- Enhanced oil recovery
- Waste water treatment
- Inert atmosphere
- Cold welding & Molding processes
- Dry ice cooling foodstuffs
- Cleansing processes and Lasers
- Calibration gas, Smoke effects
- Metal production
- Anaesthetize agents for pigs.

CONCLUSIONS

Climate change is the defining issue of our times. It is perhaps, the greatest challenge to sustainable development. It should be addressed by all countries with a shared perspective, free from narrow and myopic considerations. Simple and complex efforts can make this GHG's like CO_2 can turn to produce high value product which has diverse applications like feed stock for hydrocarbons, fuel for thermal applications, power generation. The following conclusions can be drawn from the study

- Cheaper input of the one of the raw material
- Process will be less complex than Gasification
- Substantial reduction of green house gas emissions into atmosphere
- Can be adoptable near high emission areas.

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