The Mother of All Problems

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Recently our Prime Minister received the 'Champions of earth' award from United Nations. International Solar Alliance was initiated by India around 2015. The Paris Agreement was signed on 12th April 2016. Have we ever thought why this hullaballoo over climate, environment and alternate fuel sources? Worldwide people are splitting their hairs to find the answer to one big problem, the mother of all problems. The problem of finding a viable, alternative, clean and renewable energy source to help us fight the menace of Global Warming.

Let's have a look at the Mother of all problems:

Fossil fuel reserves are exhausting very quickly.

Years of fossil fuel burning has polluted the environment badly.

Due to emission of greenhouse gases, Global Warming is increasing.

Rapid deforestation is adding to our woes.

Polar ice caps are melting, ecological balance is getting disturbed.

And our energy demands are ever increasing.

Now, standing at such a point, looking at problems of such magnitude, we can conclude only one thing, the world is heading for destruction slowly. Now we as scientists have a scientific social responsibility to do something about itAt times of such need we can't stay calm and play our violins like King Nero did, while his Rome was burning.

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Thinking alternatively:

Carbon Dioxide (CO_2, a greenhouse gas) generation from fossil fuel burning is a big problem which leads to global warming. What if we can turn this problem into an advantage? What if we can turn CO_2 into some chemicals which can act as alternative sources of energy? Then with ~~by~~ one master stroke we can kill two birds global warming along with global energy crisis. We also have to find an alternate and environmentally benign source of energy, right? Nature has the solution, the lightest solution. Well, Hydrogen gas is the answer. We can use Hydrogen gas, the lightest gas in nature as an alternate source of energy.

Learn from Nature:

Whenever in problem, dial Nature for help. Mother Nature has all the solutions to our problems and we just need to take one good look at her to find inspiration. Plants and other organisms use photosynthesis to remove CO_2 from atmosphere and incorporate it into biomass. In our blood we have Myoglobin, Haemoglobin. These macromolecules have a common basic structural unit called Porphyrin. This Porphyrin contains iron metal in the core. Myoglobin and hemoglobin are known for oxygen storage and oxygen transport in the body respectively. Scientists have made synthetic mimics of those iron porphyrins and explored oxygen reactivity . Oxygen binds to the iron centre of the iron porphyrin at a state where Iron normally exists inside our body called Iron(II) state while CO_2 also binds with Iron but at a state called Iron(0) state where iron is saturated with more electrons. Nature has also created a class of enzymes (macromolecular biological catalyst, which acts upon some chemicals namely substrate and convert those chemicals into some other chemicals called product) called "Hydrogenases". These enzymes are known for the inter conversion of protons (hydrogen atom sans electron) to hydrogen. Hydrogenases are classified into three different types based on active site (a portion of a macromolecule where the actual chemical reaction takes place) and metal content viz. nickel-iron , iron-iron and iron hydrogenase.

Our endeavour

Getting inspired by nature, we jumped at the first opportunity to find a solution to the Mother l problems. In our laboratory we are working with several structural and functional mimic of nickel iron and iron-iron hydrogenases. These bimetallic catalysts (a substance that takes part in a chemical reaction and increases the rate of the reaction but at the end itself remains a spectator) can convert proton to hydrogen efficiently. In our laboratory we have prepared several iron-porphyrin catalysts which can reduce CO_2 to Carbon monoxide(CO) at a commendable rate. A mixture of CO and H_2 can be converted into hydrocarbons by an industrial process named "Fisher-Tropsch". To look into more detail about these processes we need to take several snapshots of the systems during the course of the chemical reaction. These snapshots will tell us what is actually happening in the molecular level. This is called the investigation of the reaction mechanism. We all have our childhood memories captured digitally and also we have our recent remembrances in the

form of selfies in our smart phones. If we arrange those photographs chronologically then we can see our evolution from a child to a complete adult. Human evolution is a slow process. We can easily see it but those proton reduction and CO_2 reduction reactions are very fast. To visualize the advancement of the chemical reactions we need more sophisticated camera. Infrared spectrometer, cyclic voltameter, nuclear magnetic resonance (NMR) spectrometer,Raman spectrometer are the cameras for us. Light being an electromagnetic radiation interacts with the molecule and this leads to some changes in the molecules and that change is studied by the detector. For infrared spectroscopy infrared light source is used and for Raman spectroscopy we use LASER light. In NMR spectroscopy a strong magnetic field interacts with the molecule and gives the signature of the system. Cyclic voltammetry is a technique where electrical pulse which is equivalent to a burst of electrons is given to a molecule via the electrodes and the molecule takes up electrons and gets reduced. Finally the machine gives us a current vs potential diagram as output. From these experiments we can have some idea about the intermediate stages of a chemical conversion. Every person has a unique fingerprint and identity card. Similarly every molecule or species has its own distinct features. We have to identify them seeing those identification marks.

Now one can ask why do we need to see the progress of a chemical reaction at the molecular level? The answer lies within the human life. Many of us have regrets about the past. We think that if we had not made that mistake, life would have been different. So if we don't look properly at the intermediate stages of a chemical reaction we can never improve on that. So far we have successfully converted proton to hydrogen and CO_2 to CO with synthetic molecules. Our next goal is to convert CO_2 to methane (simplest hydrocarbon which can act as a fuel). To achieve this target we need to focus on the mechanism of the reaction and by the knowledge of the intermediate states involved in the reaction we can tune our catalytic system to make it much more efficient, cheaper and capable of producing hydrocarbon from CO_2 at industrial scale. Fortunately we got methane from CO_2 using bimetallic Nickel-iron catalyst in acidic medium in an aqueous environment. This is called heterogeneous catalysis where the catalyst is insoluble in the solvent phase and it is deposited on a surface of a material called edge plane graphite (EPG) surface. Without the presence of acid, CO_2 can't be reduced so aqueous acid solution is used in the experiment. We have detected methane via gas chromatography analysis, a technique by which the presence of a gaseous species in the reaction mixture can be detected. But there occurs a competitive hydrogen evolution reaction which is predominant. Now like Sherlock Holmes, we have to solve the mystery behind this chemistry. We need to investigate the reaction mechanism of the methane and hydrogen formation using the above mentioned techniques and try to tune the catalytic system so that we can get methane as the major product of the reaction and also at an appreciable rate**.**

The way forward:

Following the natural stride we have found a pathway to fight the scarcity of global energy demand. But only scientists can't do everything. Scientists, technocrats, government and above all the common people should come together in this journey to save the Environment. We all have to take

an oath murmuring the Bettie Wilson's song "let's work on the solutions So our children can play in pure clean water in blue sky above, it's not a fantasy we'll make it our reality , we've got to all come together and start planning the seeds, mother nature needs us".