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Photochemistry

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1. Novel Directions

1.1. Solar Energy Pumped Lasers (SEPL)

It is now possible, with solar energy concentrators, to supply a solar furnace with sufficient photons to heat it up to at least 1375 °C. With this kind of photon density, it is also possible to pump lasers. The lasers can then be used in the synthesis of expensive pure material by wavelength-selective destruction of small amounts of impurities in precious solids or in surface modification of highly technical devices by controlled photochemical deposition.

It is recommended that this kind of laser pumping be incorporated as part of a solar energy chemical factory (solar furnace). In such an arrangement, the laser pumping may use a narrow frequency band of the total solar energy spectrum, leaving the (broad band) rest of the concentrated solar energy to heat up the solar furnace. It is also possible to place the laser cavity in the focus of the concentrator when needed and remove it when it is not needed.

1.2. Proton Gradients and Proton Pumps

The two photosynthetic systems in nature are chlorophyll (green plant) and bacteriorhodopsin. The first one absorbs solar energy and pumps electrons while the second system uses solar energy to pump protons across its membrane. This creates proton gradients whose electric fields are used to convert ADP into ATP (the fuel of life). Interestingly enough, even the electron pump system of chlorophyll reduces the quinone, which is used in subsequent chemical reactions, to create proton gradients used for the making of ATP. Furthermore, bioenergy conversion in biological systems frequently involves the use of proton gradients in the conversion of energy into chemicals. In spite of this, most of the theoretical and experimental research efforts in solar energy have been spent to understand or develop energy converters using electron transfer reactions and only minor effort on proton transfer reactions. Of course if electric current is what is needed, electrons are more preferable due to their high mobilities. However, if the

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conversion of solar energy into chemical energy is the aim, proton pumping is preferable since the proton gradients produced are stable for the sufficiently long time required for the completion of many chemical reactions.

Chemical research is needed to find the appropriate membrane across which proton gradients can be created by the absorption of solar energy. The latter should involve a reversible process to make the device renewable. We can learn a great deal from nature by understanding the interesting mechanism used by bacteriorhodopsin.

The interesting aspect of proton pumping is that the proton donor systems can pump protons upon the absorption of photons even in the infrared region of radiation.

1.3. Self-Assembled (Self-Repairing) Solar Energy Devices

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It would be beneficial if solar energy converters can be devised which are self-repairing, as. e.g., in biological systems. Such devices would have more reliability and longer lifetimes for future space exploration.

2. Solar-Chemical Industry

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Solar energy has been used by man for a long time both as a source of energy (e.g., in burning wood) and as a source of chemicals (in food for both animals and humans). Both types make use of biomass and agricultural chemistry.

In addition agriculturally based industry has developed e.g. the dairy industry, meat industry, wine industry, etc. All these industries have made use of solar energy conversion into chemicals and not of direct conversion of solar energy to other types of energy. Of course, there is now a minor industry based on solar water heaters in developing countries and a minor photovoltaic industry in developed nations. We should thus think more in the direction of solar energy conversion into chemicals instead of trying to go for the big fight of changing the fuel used by the utilities at this time.

Due to the low solar density, concentrators are needed. Thus the volume of material produced is also reduced. For this reason, precious chemicals and materials used in high-volume or high-tech industries need to be made either by solar thermochemistry, solar linear and non-linear photochemistry, or by high-temperature linear and non-linear, high light intensity photochemistry. For the more delicate surface modification now being developed using lasers, solar pumped lasers might be used. In these industries, it is not important to run production day and night. However, the design of the solar reactor and its laser component should be such that it runs at a constant light and/or temperature. Computer control of energy and material flows can keep these parameters constant.

It is important to realize that solar energy will be used not in network form at the moment but on dispersed locations and not only as a source of energy (as in photovoltaic) but also as a source of precious chemicals.

It should also be mentioned that once the developed nations develop solar reactor technology, they can sell it to the developing countries whose solar power is much more useful. Again, the developed nations gain economic competitiveness. We might be able to sell oil-rich countries solar reactors to pay for part of the oil until we develop the solar energy technology.

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