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# CHEMICAL STORAGE OF SOLAR ENERGY

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The absolute magnitude of the energy available from the sun offers encouragement for its development as a much needed resource. Presently the inability to store solar energy for longer than a few days hampers its otherwise attractive features. A promising solution to this problem involves the use of sunlight induced photochemical reactions to generate storable products of high energy content reconvertible at will to the original material. Thus in the thermodynamically unfavorable energy storage step (1),

$$R + \text{light} \longrightarrow P \qquad (1)$$

a portion of the incident photon energy is converted to and stored as the increased chemical potential energy of the photoproduct. Reversion of the system to the starting material (2)

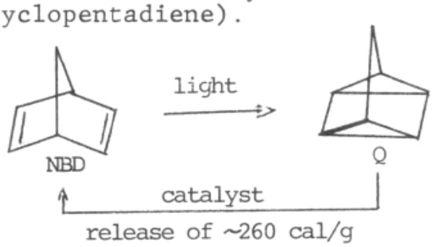
$$P \longrightarrow R + \text{heat} \qquad (2)$$

occurs with the release of this excess energy, considered here in the form of heat. Ideally, the reverse step is negligibly slow at ambient temperature but proceeds rapidly and cleanly upon the addition of an appropriate catalyst. This feature ensures that energy may be stored indefinitely and is only released upon demand.

Steps 1 and 2 constitute the rudiments of a cycle whereby sunlight is ultimately converted to a more usable form (heat) with no net consumption of limited resources. In an ideal system the recyclable storage medium should possess the following characteristics:

(i) significant absorption of incident solar radiation
(ii) high specific energy storage capacity (heat stored per gram of photoproduct formed)
(iii) absence of destructive side reactions
(iv) ease of handling (can be readily cycled in a storage device)
(v) synthesis from readily available and inexpensive starting materials.

Because of these stringent requirements the number of currently known photochemical reactions which possess any promise for use in a cyclical energy storage system is understandable small. Perhaps the most attractive candidate is the norbornadiene (NBD)-quadricyclene(Q) interconversion (3). Both compounds are liquids with boiling points and densities similar to water. Although NBD itself does not absorb light in the wavelength region of available solar radiation, the photoreaction does occur in the presence of an appropriate spectral sensitizer with an overall efficiency of Q production approaching 100% in optimal cases. The photoproduct, while containing some 260 cal/g excess energy over NBD, is stable toward thermal reversal. Exposure to certain transition metal catalysts, however, allows for the clean and rapid conversion of Q to NBD with the release of the excess energy. NBD is an attractive sotrage medium from a cost standpoint, since it is prepared from readily available chemicals (acetylene and cyclopentadiene).




(3)

The Solar Energy Storage Program at the University of Georgia is directed toward the development of this promising system. To date, considerable progress has been achieved in several areas:

(1) Development of Sensitizers and Catalysts
New and more effective sensitizers and catalysts have been discovered and conditions found where single cycles of the photochemical step and catalytic reversion step appear to be quantitative.

(2) Polymeric Anchoring of Sensitizer and Catalyst
The need to physically constrain the catalyst for the heat-releasing reaction to the catalytic chamber is obvious. Similar confinement of the photosensitizer to the irradiation chamber reduces the required amount of this component by several orders of magnitude. Polymer immobilization also precludes undesirable interactions between the catalyst and sensitizer and facilitates their replacement in an actual device.

(3) Long Term Stability Studies
The requirement that a practical solar energy storage system based on the NBD-Q interconversion can be repeatedly cycled without degradation of the key components (sensitizer,

catalyst, storage medium) is quite stringent. For this reason, the ability of the system to be recycled is currently being examined.

Some readily apparent applications of a NBD-Q based energy storage system are the heating, cooling, and hot water production in buildings. Roughly 20% of all energy (primarily from fossil fuels) currently consumed in the United States is used for these purposes.