CHEMISTRY

Semiconductors: Ain't misbehavin'

If the prevailing theory on a certain type of semiconductor is correct, then the devices are misbehaving: Results of recent experiments with these semiconductors just don't seem to conform to theoretical expectations. The other possibility, of course, is that the prevailing theory needs revision, and that is what Mark S. Wrighton of Massachusetts Institute of Technology and his colleagues believe.

Wrighton and colleagues, in a series of three papers in the JOURNAL OF THE AMERICAN CHEMICAL SOCIETY (Vol. 102, No. 11), propose a new theory for the behavior of light-activated, liquid junction semiconductors, or semiconductors immersed in a solution of ions. (The "liquid junction" refers to the interface between the solid and solution.) Such semiconductors can absorb light and produce an electric current. Prevailing theory states that the voltage of this current depends on the chemical makeup of the solution; Wrighton and colleagues say photovoltage is independent of what is in the solution and instead may depend on the surface property of the semiconductor.

Wrighton and colleagues explain that their theory involves the concept of fermi level pinning. The term "fermi level pinning" more commonly refers to other semiconductors — those with metal/semiconductor interfaces, rather than liquid junctions. In these semiconductors, researchers observed that the photovoltage output is independent of the metal-interface type. This phenomenon was termed "fermi level pinning," to indicate that the voltage potential is pinned to, or depends on, the fermi surface — the highest occupied energy bond of the semiconductor filled with electrons.

If fermi level pinning explains the behavior of liquid junction semiconductors, says Wrighton, then the efficiency of those semiconductors is limited by their surface properties, not by the composition of the solution. "So a lot of effort should go into changing the surface properties," Wrighton says.

Another important implication," Wrighton says, "is that now you can do many electrochemical reactions that you did not think would be possible." According to the conventional theory, certain solution reactions are considered impossible because the expected energy output is too low to drive these reactions. But Wrighton and colleagues have observed semiconductors drive such "impossible" reactions, and they attribute the behavior to the concept of fermi level pinning.

If the new model proves to be correct, Wrighton and colleagues will bring semiconductor technology one step closer to the design of efficient solar energy conversion devices. A system of reactions that previous models predicted would not go could be set up to efficiently use sunlight to split water — the sought after reaction of green plants.

But the new model already has been criticized by other researchers attempting to explain why certain liquid-junction semiconductors are not following model theories. While Wrighton admits that there probably is a range of explanations for the experimentally observed behavior of all liquid-junction semiconductors, he maintains that those with good solar response exhibit fermi level pinning. And, he says, those are "all the important ones."

Hydrogel: More than meets the eye

A polymeric material has safely replaced portions of eye fluid in preliminary animal tests. The material — polyvinyl alcohol hydrogel — seems to merge well with the vitreous body of albino rabbits, report researchers from three Japanese institutions, including the Nara Prefectural Medical School. The gel ultimately may alleviate the vitreous-replacement problems associated with certain eye diseases and delicate eye operations.

ASTRONOMY

Dietrick E. Thomsen reports from Tucson, Ariz., at the meeting of the Astronomical Society of the Pacific

Cool dwarfs and the age of the galaxy

One of the reasons that white dwarf stars are interesting is that they are the end of evolution for a very large proportion of stars. A star is born, develops dynamically and nucleosynthetically according to the plan appropriate to its size and mass, and then in many cases enters old age as a white dwarf.

Old age is not a hot time for most stars. White dwarfs tend to cool off as they age further. From the time that the galaxy was formed, stars have been made and gone through this scheme of development. So, as James Liebert of the University of Arizona points out, a study of the coolest white dwarfs, which are the oldest, and a comparison of their numbers and distribution with those of younger stars could give some indication of the age of the disk of the Milky Way galaxy.

Liebert and co-workers started a search for really cool white dwarfs. He reports that they don't seem to be there. That could lead to one of two conclusions: Either the theory of how the white dwarfs cool is wrong, or the rate of white dwarf production has not been constant. There are two ways to assume that the cooling theory is wrong, Liebert says. These stars go through a "crystallization" phase: The ions in them become rigidly bound to one another. Exactly how this happens, in waves coming out from the core or all at once, affects the energy balance and may retard or advance cooling. Or the star may find some other energy source "that keeps it suspended at a moderately high level of energy." Gravitational energy generated by the separation of heavy elements from light ones might do it.

After the researchers have adjusted the "cooling curve" to take account of these possibilities in the way they think most plausible, the ineresting thing is to find out whether there are a few cool white dwarfs of magnitude fainter than 17 or none at all. That could tell something about the white dwarf production rate and hence the age of the galactic disk.

Blown away, but how?

There are a fair number of binary star systems in which the two stars that revolve around each other are so close together that the gravitational pull of one of them draws matter from the other. This "accreting matter" runs in a steady stream and constantly falls onto the star that draws it.

Except that in some cases it seems to miss or almost miss, says Ronald S. Polidan of Princeton University. It is as if something is deflecting the accreting stream from its target. That something could be a stellar wind blowing off the accreting star. A stellar wind — the sun's has been famous for decades — is matter flowing off the surface of the star in all directions. The problem is that theorists had said that the accreting stars were just the sort of stars that for astrophysical reasons should not develop a stellar wind.

Theorists to the contrary, observation shows it's there, says Polidan. Spectroscopic observation of several such systems with the ultraviolet observing Copernicus satellite shows evidence for matter coming away from the accreting star in stellar wind fashion. That, however, raises another mystery.

A study of the comparative rates of flow of the accreting streams and the stellar winds in these cases shows a strange reversal of what might be expected by ordinary dynamics. To give one example (HR 2142) the accreting stream flows at a rate of a millionth of the sun's mass per year. The stellar wind from the accreting star flows at about a thousandth of that rate, a billionth of the sun's mass per year. You would not expect the thinner stream to push the thicker one aside. Nevertheless, in this case it blows it away. Polidan and his collaborators are going to use the International Ultraviolet Explorer satellite to try to find out why.