The glow of "sooty sand" could open new era of environmentally friendly fluorescence

June 19, 1997

HOLD FOR SCIENCE EMBARGO: 4 p.m., Eastern Time, Thursday, June 19, 1997 Media Contact: Warren R. Froelich, (619) 534-8564, wfroelic@ucsd.edu

A class of chemicals that's virtually identical to sooty sand found on most beaches may one day provide the basis for a new generation of efficient and environmentally friendly fluorescent lighting for homes, computer laptop displays and television sets.

In the current issue of the journal Science, chemists from the University of California, San Diego report that these so-called photoluminescent silicates not only are easy to make, they will retain their capacity to glow for as long as it takes sand to degrade.

"These substances are incredibly stable," said Michael Sailor, professor of chemistry and biochemistry UCSD, and principal investigator of the study. "We've never seen them decompose. They're about as indestructible as sand."

Sailor added that it's amazing that the special luminescent qualities of these phosphors-- chemicals that can be made to glow under the influence of ultraviolet light--were not discovered till now.

"Somebody in the 1950s should have discovered this stuff gives off a really bright light, but nobody did," he said.

Also participating in the study were UCSD graduate student Will H. Green, along with undergraduate students Khoa P. Le, Jonathan Grey and Tiffany T. Au.

Currently, fluorescent tubes or lamps are made to glow when phosphors that coat the insides of glass tubes are excited by ultraviolet light generated when electron beams shoot through an atmosphere of mercury vapor.

Though generally considered an advance over incandescent lighting, the technology is not without its social and economic costs.

Environmentally, not only is mercury highly toxic--creating pollution problems when fluorescent tubes come to their final resting place in landfills--but the phosphors themselves contain toxic metals as well.

Also, to generate enough energy for current phosphors to glow requires about 4.5 electron volts, even though the visible light emitted is about 2 electron volts. The rest of the energy is thrown away as heat.

"People have been looking around for something, some gas that you could fill the tube with, that would give you a lower energy excitation source," said Sailor. "If you had a good phosphor that could absorb that and still give off visible light, then you'd be in great shape."

The discovery of the new class of phosphors came during experiments on porous silicon, which is capable of emitting light when stimulated by a laser. In the course of one study, graduate student Green noticed a white powder residue which, when energized by ultraviolet light, glowed even whiter and brighter than porous silicon. Further analysis revealed the material to be an essential ingredient in the formation of a silicate.

Sailor recognized that the same class of chemicals could be easily produced in the laboratory using a well-known procedure called a "sol-gel" reaction. In this reaction, when alcohol and water by-products are removed from a chemical called tetraalkoxysilane, a rigid porous silicate network is left behind, which now is being used for a variety of optical and optoelectronic applications.

Curiously, the material is similar in composition to non-toxic, water-generated "magic rocks" available in many toy stores.

The researchers further discovered that if this silicate material were mixed with a strong dose of an organic acid called carboxylic acid--vinegar is the simplest form--and then heated in an oven, the resulting silicate would emit a strong white glow under the influence of a low-energy ultraviolet light source.

"In effect, you could probably do this reaction in somebody's kitchen, if you take these magic rocks and mix them with a really strong vinegar and heat it up," said Sailor.

Additional tinkering in Sailor's lab produced a variety of phosphors, some that emitted different colors, and some that were water soluble--meaning they could coat the inside of glass tubes or be sculpted into any shape, including fibers.

"What's really neat is this stuff, if you analyze it, looks like a handful of sand off the beach with a lot of carbon in it," said Sailor. "The key is how the carbon atoms are stitched together that's important."

In theory, even glass (whose chemical structure is silicon dioxide) can be made to glow if enough energy were applied to break the bonds tying silicon with oxygen. Fluorescence results when the now broken chemical bond re-forms, giving off energy in the form of light. Typically, a great deal of energy is required to break the silicon-oxygen bond. However, it's believed that when carbon is added as a substitute for silicon in the structure's lattice, it creates a weakness that makes it easier to cleave this bond, thus requiring less energy.

According to Sailor's laboratory test results, the new material can be made to glow when exposed to less than 3.5 electron volts of energy, a significant improvement in energy efficiency over current fluorescent tubes. This means that toxic mercury vapor would not be required as an energy source, Sailor said.

Increasing the efficiency of fluorescence tubes would be particularly important in battery- powered devices, including laptop computers whose displays rely on fluorescent backlights. If display lights require less energy to glow, the lifetime of batteries used to power the laptops suddenly would increase.

"The key breakthrough is that this material can be excited at a fairly low energy compared to the amount of energy it gives off," he said. "So the potential is there to make the process much more efficient. In addition, the material is a lot cheaper than most conventional phosphor materials."

(June 19, 1997