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# Rare earth metal enhances phosphate glass

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(PhysOrg.com) -- Adding cerium oxide to phosphate glass rather than the commonly used silicate glass may make glasses that block ultraviolet light and have increased radiation damage resistance while remaining colorless, according to Penn State researchers. These cerium-containing phosphate glasses have many commercial applications for use in windows, sunglasses and solar cells.

"We wanted to get larger amounts of cerium into glass, because of its beneficial properties, and then investigate the properties of the glasses," said Jen Rygel, graduate student in materials science and engineering.

Cerium exists in two states in glasses -- cerium (III) and cerium (IV) -- both states strongly absorb ultraviolet light. For years cerium has been added to silicate glass to enhance its ultraviolet absorbing capacity. The problem has always been that silicate glass can only dissolve so much cerium before it becomes saturated and can hold no more. Also, with high concentrations of cerium, silicate glass begins to turn yellow -- an undesirable characteristic for such things as windows or sunglasses.

Phosphate glasses have a more flexible structure then silicate glasses, which allow higher percentages of cerium to be incorporated before it begins to color. Rygel, working with Carlo Pantano, distinguished professor of materials science and engineering, and director of Penn State's Materials Research Institute, synthesized and compared 11 glasses with varying concentrations of cerium, aluminum, phosphorus and silica.

They found that they could make phosphate glasses with 16 times more cerium oxide than silicate glasses while maintaining the same coloration and ability to absorb ultraviolet light. They published their work in today's (Dec. 15) issue of *Non-Crystalline Solids*.

"We were able to get a lot more cerium into our phosphate glass without sacrificing the optical transmission -- they both still looked clear," said Rygel.

The researchers could get more cerium into phosphate glass compared to silicate because of the different bonding networks silica and phosphorus form when made into glasses.

One explanation for why phosphate glass can incorporate more cerium than silicate glass without yellowing may be that the absorbing ranges for the two cerium states -- cerium (III) and cerium (IV) -- are shifted to absorb less blue light in phosphate glasses.

"A good example is in solar cells," said Rygel. "The wavelengths that solar cells use aren't ultraviolet, and actually ultraviolet radiation can cause damage to the electronics of a solar cell. If you add cerium to the glass you can prevent the ultraviolet from getting down to the photovoltaic cells, potentially increasing their lifetime."

To synthesize their glasses the researchers used a procedure called open-crucible melting. Raw materials such as phosphorus pentoxide, aluminum phosphate, cerium phosphate and silicon dioxide were combined in a crucible and heated in a high-temperature furnace to a temperature of 3000 degrees Fahrenheit melting the contents to a liquid.

"After it's all melted, we pull it out of the furnace and pour it into a graphite mold," said Rygel. "The glass is then cooled down slowly so it doesn't break due to thermal stress."

Cerium additions do not just block ultraviolet light. Increasing a glass' cerium concentration can also increase its resistance to radiation damage from x-rays and gamma rays by capturing freed electrons.

"Radiation can kick electrons free from atoms," said Rygel. "You can see this by looking at what happens to a Coke bottle over time. It darkens because of radiation exposure."

The proposed mechanisms for cerium's ability to block radiation are all based on cerium's two states and their ratio within the glass. Because of these implications Rygel wanted to know what percentages of each existed within her glasses.

Using X-ray photoelectron spectroscopy Rygel could determine whether the cerium in the glass was mostly in the cerium (III) or cerium (IV) oxidation state, or a ratio of the two. She found that all of her glasses contained approximately 95 percent cerium (III).

Provided by Penn State

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