Researchers seek new roles for two common materials

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(PhysOrg.com) -- With more study, alumina could ease kidney dialysis, while magnesium could lead the way to lighter, more fuel-efficient cars.

As materials go, aluminum-oxide (Al_2O_3), commonly known as alumina, is one of the world's most versatile ceramics.

Alumina is hard, it is a good conductor of heat, and it is resistant to corrosion and abrasion. It is a precursor of metallic aluminum and it is found in sparkplugs and cutting tools, hip replacements and water filters, toothpaste and pre-finished wood flooring, and a variety of other applications.

Now, researchers in Lehigh's Institute of Metal Forming (IMF) are using the university's electron microscopy labs in an attempt to equip one type of alumina for a new medical role—the production of a more-efficient kidney dialysis filter.

Alejandro Toro and Wojciech Misiolek, along with M. Kylan McQuaig, are studying the structure of anodic alumina with an aberration-corrected transmission electron microscope (TEM) that resolves specimens to 0.1 nanometer, or about half the width of an atom. The instrument helps scientists locate and identify individual atoms in crystalline materials.

The researchers are also performing diffraction analyses with conventional TEM to identify the different ways in which groups of atoms within the material are arranged in space, forming what is known as the crystal structure.

Using heat to improve pore distribution

Alumina is amorphous in the samples fabricated by the anodization process in the IMF lab, but under proper heat treatment it becomes crystalline and acquires an orderly structure. But the crystalline phases formed from anodic alumina are not as well understood as those of conventional alumina.

Toro and Misiolek are using TEM to determine how heat treatment affects the chemical structure and crystallography of anodic alumina. Their goal is to improve the strength and mechanical stability of the ceramic, and to promote the orderly distribution of pores on its surface.

The project is an outgrowth to the development by Misiolek and William Van Geertruyden ’04 Ph.D., another IMF researcher, of a ceramic dialysis filter whose pores measure nanometers in diameter. The filter’s tiny pores correspond more closely with the nano-sized toxins in the body’s blood than do the larger pores found in conventional polymeric dialysis filters. This quality gives it the potential to remove toxins more quickly and efficiently from the blood during dialysis and thus shorten the length of a treatment session, say the inventors.

Misiolek is IMF director and Loewy Chair of materials forming and processing at Lehigh. Toro, a professor of materials science and engineering at the National University of Colombia in Medellin, Colombia, is concluding a six-month stay at Lehigh as Loewy visiting professor. Van Geertruyden is general manager of EMV Technologies LLC in Bethlehem, and McQuaig, the university’s first Loewy Graduate Fellow, received an M.S. in May.

An automotive application for lightweight magnesium

In another project, Misiolek and Toro are using TEM to gain a better understanding of the strength and mechanical stability of magnesium, which has been the object of years of study by automakers.

“Magnesium is even lighter than aluminum, which manufacturers are planning to use in newer cars,” says Misiolek. “The hope is that it will make cars lighter, more fuel-efficient, cleaner and with superior handling due to more even load distribution between front and rear axis.”

In collaboration with General Motors, Misiolek and Toro are studying a magnesium alloy containing zinc and cesium. Zinc improves magnesium’s strength, while cesium improves its ability to deform, or change shape.

“Magnesium is not easy to deform because it cracks and can break,” says Misiolek. “This alloy improves magnesium’s ability to deform without compromising its strength and its ability to bear loads.

“This is especially important to auto manufacturers. The parts of a car are geometrically complex and require a material that can deform to create the right shape and thickness.”

Misiolek and Toro are studying the structure of the alloy to determine the distribution of the cesium and zinc, as well as the properties of the alloy, at the atomic scale.

Provided by Lehigh University