Scientists develop life-saving chrome

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British scientists have developed a safer and more versatile alternative to chrome electroplating, the coating found on vintage car bumpers, steel camshafts, and fixtures such as door furniture and light fittings.

Chrome electroplating protects from corrosion and adds an aesthetically pleasing sheen, but chromium comes with serious health risks and chromium compounds have been shown to cause cancer.

Speaking at an Institute of Physics conference in Chester , Professor Robert Akid warns that workers are being exposed to chromium compounds that are potentially cancer-causing and says that a safer alternative is much needed . He told the conference, Novel Applications of Surface Modification, organized by the Applied Physics and Technology Division of the Institute of Physics, that he and his colleagues are developing an alternative that will not only be safer but cuts down on costs by reducing the numerous processing stages associated with conventional electroplating.

Professor Akid, who is Head of the Structural Materials & Integrity Research Centre at Sheffield Hallam University , is developing a so-called “sol-gel technology” which is a colloid with nanoparticles in a solvent that can form a gel. A metal object is sprayed with or dipped into the sol-gel system and it quickly forms a gel-like layer on the object's surface. The solvent is then removed by evaporation and the coating cured, or hardened. Akid says that the sol-gel approach can be used to coat a wider range of metals than electroplating methods.

Professor Akid said: “These inorganic-organic hybrid coatings have the potential to become an effective method of producing an alternative low-cost anti-corrosion or functional coating. The technology can be formulated and cured to give highly corrosion resistant, ceramic-based coatings. The method uses a range of cure temperatures and coatings are cured rapidly. The chemistry of the formulations has also been developed to provide sol-gel solutions that have a good shelf life.”

There are technical issues yet to be addressed by the Sheffied team, however. For instance, a pre-requisite for such anticorrosion coatings on metals, such as aluminium and other metal surfaces, including zinc, stainless steel, and magnesium, is that they should be sufficiently thick, to give adequate lifetime and hard enough to be protected from scratching and abrasion.

Until now, sol-gel derived layers can be formed only up to two or three hundred nanometers in thickness with a single-dip. Akid explains that double dipping to produce multiple coatings is possible but this has the potential drawback of a reduction in coating properties.

Akid said: “The new type of protective coatings not only have high corrosion resistance and don't easily release their constituent ions into the environment, but are also non-toxic." Akid and his colleagues have used sol-gel mixtures that produce aluminium oxide and silicon oxide coatings with a chemical component that allows them to bind to the metal component's surface.

The team's preliminary corrosion tests, including so-called potentiodynamic polarisation in which an electric current is used to induce corrosion showed that the coating possesses excellent corrosion resistance properties compared with uncoated samples and other pre-treatments. The researchers have also carried out mechanical tests and have shown with a simple scratch and bend tests that the coatings exhibit very good adhesion to the substrate.

As a further test of the durability of the coating, the researchers also immersed coated components in an exfoliation solution consisting of nitric acid and chloride with very high acidity, pH1. This simulates the kind of corrosion that aluminium alloy aerospace components might experience, albeit an accelerated test. Akid explained that their test results compared well with similar tests on bare and chromic acid anodised samples. The sol-gel hybrid coating showed little attack even after almost 200 hours immersion. The chromic acid anodised components were pitted after this time and so failed the test, while the bare simple was extremely corroded. The team used scanning electron microscopy (SEM) to identify the nature of the attack, general or localised corrosion.

Source: Institute of Physics