



Materials & Coatings

Nano-Ceramic Coated Plastics

Adding this non-stick coating to cookware can create easy-to-clean plastic containers.

John H. Glenn Research Center, Cleveland, Ohio

Plastic products, due to their durability, safety, and low manufacturing cost, are now rapidly replacing cookware items traditionally made of glass and ceramics. Despite this trend, some still prefer relatively expensive and more fragile ceramic/glassware because plastics can deteriorate over time after exposure to foods, which can generate odors, bad appearance, and/or color change. Nano-ceramic coatings can eliminate these drawbacks while still retaining the advantages of the plastic, since the coating only alters the surface of the plastic. The surface coating adds functionality to the plastics such as self-cleaning and disinfectant capabilities that result from a photocatalytic effect of certain ceramic systems. These ceramic coatings can also provide non-stick surfaces and higher temperature capabilities for the base plastics without resorting to ceramic or glass materials.

Titanium dioxide (TiO_2) and zinc oxide (ZnO) are the candidates for a nano-ceramic coating to deposit on the plastics or plastic films used in cook-

ware and kitchenware. Both are wide-bandgap semiconductors (3.0 to 3.2 eV for TiO_2 and 3.2 to 3.3 eV for ZnO), so they exhibit a photocatalytic property under ultraviolet (UV) light. This will lead to decomposition of organic compounds. Decomposed products can be easily washed off by water, so the use of detergents will be minimal. High-crystalline film with large surface area for the reaction is essential to guarantee good photocatalytic performance of these oxides. Low-temperature processing ($<100^\circ\text{C}$) is also a key to generating these ceramic coatings on the plastics.

One possible way of processing nano-ceramic coatings at low temperatures ($<90^\circ\text{C}$) is to take advantage of *in-situ* precipitated nanoparticles and nanostructures grown from aqueous solution. These nanostructures can be tailored to ceramic film formation and the subsequent microstructure development. In addition, the process provides environment-friendly processing because of the aqueous solution. Low-temperature processing has also shown versatility to generate various nanostructures. The

growth of low-dimensional nanostructures (0-D, 1-D) provides a means of enhancing the crystallinity of the solution-prepared films that is of importance for photocatalytic performance.

This technology can generate durable, fully functional nano-ceramic coatings (TiO_2 , ZnO) on plastic materials (silicone, Teflon, PET, etc.) that can possess both photocatalytic oxide properties and flexible plastic properties. Processing cost is low and it does not require any expensive equipment investment. Processing can be scalable to current manufacturing infrastructure.

This work was done by Junghyun Cho of Binghamton University for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-19005-1.

Preparation of a Bimetal Using Mechanical Alloying for Environmental or Industrial Use

This technology could be of use for catalyst production or environmental applications.

John F. Kennedy Space Center, Florida

Following the 1976 Toxic Substances Control Act ban on their manufacture, PCBs remain an environmental threat. PCBs are known to bio-accumulate and concentrate in fatty tissues. Further complications arise from the potential for contamination of commercial mixtures with other more toxic chlorinated compounds such as polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Until recently, only one option was available for the treatment of PCB-contaminated materials: incineration. This may prove

to be more detrimental to the environment than the PCBs themselves due to the potential for formation of PCDDs.

Metals have been used for the past ten years for the remediation of halogenated solvents and other contaminants in the environment; however, zero-valent metals alone do not possess the activity required to dehalogenate PCBs. Palladium has been shown to act as an excellent catalyst for the dechlorination of PCBs with active metals. This invention is a method for the production of a palladium/magnesium

bimetal capable of dechlorinating PCBs using mechanical milling/mechanical alloying. Other base metals and catalysts may also be alloyed together (e.g., nickel or zinc) to create a similarly functioning catalyst system. Several bimetal catalyst systems currently can be used for processes such as hydrogen peroxide synthesis, oxidation of ethane, selective oxidation, hydrogenation, and production of syngas for further conversion to clean fuels. The processes for making these bimetal catalysts often involve vapor deposition.

This technology provides an alternative to vapor deposition that may provide equally active catalysts.

A hydrogenation catalyst including a base material coated with a catalytic metal is made using mechanical milling techniques. The hydrogenation catalysts are used as an excellent catalyst for the dehalogenation of contaminated compounds and the remediation of other industrial compounds. The mechanical milling technique is simpler and cheaper than previously used methods for producing hydrogenation catalysts.

Preferably, the hydrogenation catalyst is a bimetallic particle formed from a zero-valent iron or zero-valent magnesium particle coated with palladium that

is impregnated onto a high-surface-area graphite support. The zero-valent metal particles should be microscale or nanoscale zero-valent magnesium or zero-valent iron particles. Other zero-valent metal particles and combinations may be used. Additionally, the base material may be selected from a variety of minerals including, but not limited to, alumina and zeolites. The catalytic metal is preferably selected from the group consisting of noble metals and transition metals, preferably palladium.

The mechanical milling process includes milling the base material with a catalytic metal impregnated into a high-surface-area support to form the hydrogenation catalyst. In a preferred me-

chanical milling process, a zero-valent metal particle is provided as the base material, preferably having a particle size of less than about 10 microns, preferably 0.1 to 10 microns or smaller, prior to milling. The catalytic metal is supported on a conductive carbon support structure prior to milling. For example, palladium may be impregnated on a graphite support. Other support structures such as semiconductive metal oxides may also be used.

This work was done by Jacqueline Quinn of Kennedy Space Center and Cherie Geiger and Christian Clausen of the University of Central Florida. For more information, contact the KSC Technology Transfer Office at (321) 867-5033. KSC-12978

Phase Change Material for Temperature Control of Imager or Sounder on GOES Type Satellites in GEO

Goddard Space Flight Center, Greenbelt, Maryland

An imager or sounder on satellites, such as the Geostationary Operational Environmental Satellite (GOES), in geostationary orbit (GEO) has a scan mirror and motor in the scan cavity. The GEO orbit is 24 hours long. During part of the orbit, direct sunlight enters the scan aperture and adds heat to components in the scan cavity. Solar heating also increases the scan motor temperature. Overheating of the scan motor could reduce its reliability. For GOES-N to P, a radiator with a thermal louver rejects the solar heat absorbed to keep the scan cavity cool. A sunshield shields the radiator/louver from the Sun. This innovation uses phase change material (PCM) in the scan cavity

to maintain the temperature stability of the scan mirror and motor.

When sunlight enters the scan aperture, solar heating causes the PCM to melt. When sunlight stops entering the scan aperture, the PCM releases the thermal energy stored to keep the components in the scan cavity warm. It reduces the heater power required to make up the heat lost by radiation to space through the aperture. This is a major advantage when compared to a radiator/louver. PCM is compact because it has a high solid-to-liquid enthalpy. Also, it could be spread out in the scan cavity. This is another advantage. Paraffin wax is a good PCM candidate, with

high solid-to-liquid enthalpy, which is about 225 kJ/kg.

For GOES-N to P, a radiator with a louver rejects the solar heat that enters the aperture to keep the scan cavity cool. For the remainder of the orbit, sunlight does not enter the scan aperture. However, the radiator/louver continues radiating heat to space because the louver effective emittance is about 0.12, even if the louver is fully closed. This requires makeup heater power to maintain the temperature within the stability range.

This work was done by Michael Choi of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16546-1