Nanostructured Superhydrophobic Coatings

Large-scale Implementation of Nanostructured Superhydrophobic (SH) Powders for Breakthrough Energy Savings

Nanostructured superhydrophobic (SH) powders cause water to bead off of surfaces, resulting in surfaces that are non-wetting and water-repelling. Oak Ridge National Laboratory (ORNL) has developed a set of SH powders that are more water repellent and more durable than anything found in nature.

Based on the extreme water repellency of uniform glass cone array surfaces, researchers at ORNL developed these oxide-based powders so that each powder grain is both porous and nanotextured. These characteristics enable the grains to trap a layer of air on the coating's surface, making the powders remarkably water repellent.

Because the nanostructured SH powders substantially reduce the frictional forces between water and a given substrate surface, their use could potentially result in major energy savings. In addition to increasing energy savings, ORNL's SH powder coatings can also help reduce rusting in steel and even have the potential to impede the growth of algae on the surfaces of water transportation systems, potentially decreasing maintenance costs.

Although these powders have not yet reached the marketplace, they are very amenable for large-scale use in industrial, transportation, and consumer products. The nanostructured SH powders can be applied to very large surface areas using conventional spray coating and painting techniques. Additionally, one of the powders is based on a commonly available, inexpensive, and easily mined material known as diatomaceous earth, which is presently used in a number of agricultural and food-based products. Industrial implementation of these powders could lead to breakthrough energy savings and related carbon, economic, and environmental benefits.

Benefits for Our Industry and Our Nation

The project is developing and producing in quantity nanostructured powders that can, for example, reduce ice formation on power and communication lines. Large energy savings can result from different applications of the SH powder coatings, for example reduced energy consumption to pump water through pipes coated with SH technology on their interior.

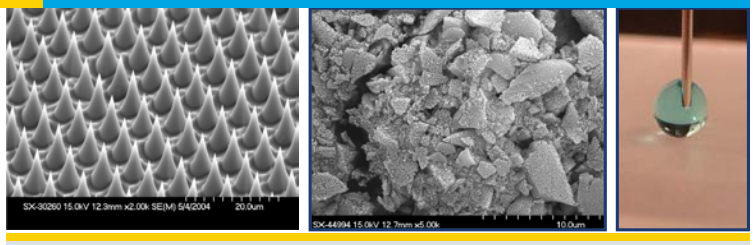

Figure 1. Left: Glass cone array. Center: Highly water-repellent nanotextured superhydrohobic (SH) particles. Right: A water drop sitting on an Oak Ridge National Laboratory–developed SH powder-coated surface demonstrates the dramatic coating contact angle.

Illustration courtesy of Oak Ridge National Laboratory.

Applications in Our Nation's Industry

Possible application areas for this technology include the following:

(1) Corrosion resistance for applications such as structural steels and vehicle bodies.

(2) Resistance to wetting and ice formation: telephone and high voltage power cable lines.

Project Description

This project deals with the nanostructured superhydrophobic (SH) powders developed at ORNL. The SH technology is patented and currently licensed to VeloxFlow. This project seeks to (1) improve powder quality; (2) identify binders for plastics, fiberglass, metal (steel being the first priority), wood, and other products such as rubber and shingles; (3) test the coated product for coating quality and durability under operating conditions; and (4) application testing and production of powders in quantity.

Barriers

- Successful scale-up process for large-scale production of nanostructured SH powder at an economical cost
- Incorporation of these powders into components and systems with modification of currently used commercial manufacturing practices

Pathways

The project initially focused on correlating powder size with SH performance to help select the optimum powder for various applications. The project then identified approaches for binding or incorporating SH powders to surfaces of PVC, plastics,

fiberglass, metal, wood, rubber, and concrete. In addition, research was expanded to include exploration of nanostructured SH materials to copper nanowires. Galvanic corrosion performance tests were conducted on metal samples with and without the SH coating to determine performance enhancement. In addition, an ice adhesion tester was devised to test the adhesion properties of ice on SH surfaces. The exact physical properties were measured, with appropriate modeling also performed. Finally, application testing is being conducted to define markets, explore additional applications, and calculate energy/cost savings for each application.

Milestones

This project started in September 2008.

- Finalized SH powder size and binder for PVC, characterization of coating quality, and testing of the prototype under application conditions (Completed)
- Finalized binder system for steel and fiberglass, characterization of coating quality, and beginning of initial application testing in pump impellers and boat motors (Completed)
- Measurement of prototype test data through long-term testing of binder and coating stability under operating conditions

Commercialization

VeloxFlow is currently focusing on product applications, manufacturing, and the marketing strategy. VeloxFlow, which holds the license to the patented nanostructured SH technology, is focused on the continued development of bonding techniques for super hydrophobic diatomaceous earth (SHDE), water flow applications, related technology market insertion, and the production of SHDE powder. ORNL is complementing the efforts of VeloxFlow by focusing on applications, customer identification, and technical sales. The new technology is first being utilized to coat the inside of pipes for reduced energy consumption in water flow. VeloxFlow will work with ORNL to establish new markets for the application of the SH technology.

Project Partners

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