Low-Cost, Sustainable Multifunctional Coatings

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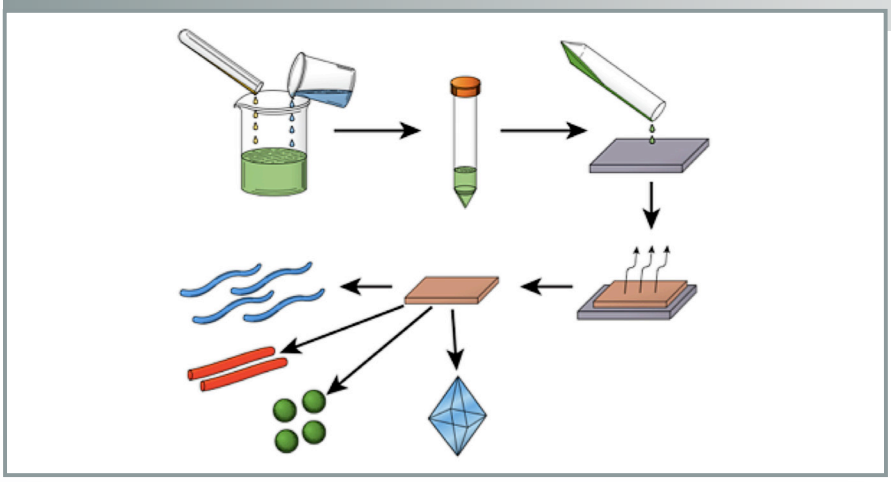

Technology Summary

Nanomaterials and nanotechnology have attracted a great deal of attention over the last 20 years because of their perceived potential. However, in many cases the processes to produce nanomaterials are highly complex, not readily scalable, and expensive; worse, some nanomaterial manufacturing processes produce harmful wastes. Researchers at ORNL are working to address these issues and ensure a greener, more sustainable future through development of a suite of new products and processes based on renewable natural materials such as nanocellulose, a low-cost, renewable material with interesting optical and strength properties.

In one example, researchers are using cellulose nanofibrils (CNFs) as sacrificial templates in the production of metal oxide particles with controllable, well-defined morphologies. The truly unique feature of the technique is the ability to make industrial size quantities in a matter of hours at significantly lower costs than the competing technologies currently available, such as atomic layer deposition. In the ORNL process, metal oxide precursors are dissolved in water and then added to a CNF suspension, leading to the formation of metal-ion-conjugated CNFs. The resulting fibers are collected by centrifugation to remove unbound metal ions, redispersed in water, cast onto a substrate, and dried to form a CNF film conjugated with the metal oxide precursors. The film is then annealed at high temperature to remove the nanocellulose, leaving behind the metal oxide nanoparticles. Morphology and other physical characteristics of the resulting particles are highly correlated with the ratio of CNFs to the precursors. The process is simple, scalable, inexpensive, and sustainable.

In a related example, researchers are taking advantage of the optical properties of nanocellulose to make infrared (IR)-blocking hybrid composites that can substitute for glass in traditional and not-so-traditional applications. In this case, the starting material is a nanocellulose aerogel template in which IR-blocking particles are dispersed and chemically bonded to the nanofibrils. In subsequent steps, the nanofibrils are cross-linked to improve mechanical properties and stability and compacted, resulting in a hybrid organic-inorganic composite that while transparent also blocks infrared radiation. Thin films and IR-blocking materials developed from the process can be used in thermally insulating coatings or replace glass in traditional applications where they will not only provide insulation, but also greater shatter protection than traditional glass.

Advantages

- Low-cost, renewable feedstocks
- Durable, safe alternatives to conventional products
- Design flexibility
- Environmentally friendly products and processes
- Cost and time competitive processes

Potential Applications

- Low-cost, transparent electronics and coatings for electronics
- Coatings for defrosting windshields
- Window pane glazes
- Energy-efficient (infrared-blocking) windows
- Solar cells
- Sensors
- Porous electrodes
- Lithium ion batteries
- High-density magnetic memory devices

Patent

Soydan Ozcan and Yuan Lu. *Method of Making Controlled Morphology Metal-Oxides,* US Patent Application 14/551,460, filed November 24, 2014.

Soydan Ozcan and Amit Naskar. *Infrared-Blocking Nanocellulose Aerogel Windows,* US Patent Application 62/132,178, filed March 12, 2015.

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