Nanotechnology

EDITORIAL

Ensuring sustainability with green nanotechnology

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Ensuring sustainability with green nanotechnology

Stanislaus Wong
University of New York at Stony Brook, NY, USA
sswong@bnl.gov

Barbara Karn
National Science Foundation, VA, USA
bkarn@nsf.edu

Nanotechnology offers immense promise for developing new technologies that are more sustainable than current technologies. All major industrial sectors have felt nanotechnology's impact, mainly from the incorporation of nanomaterials into their products. For example, nanotechnology has improved the design and performance of products in areas as diverse as electronics, medicine and medical devices, food and agriculture, cosmetics, chemicals, materials, coatings, energy, as well as many others. Moreover, the revenues from nanotechnology-enabled products are not trivial. For instance, Lux Research maintains that commercial sales in both Europe and the USA will attain revenues of over $1 trillion from nano-enabled products by 2015.

The manufacturing of the nanomaterials for these products uses many processes equivalent to chemical manufacturing processes. As a result, manufacturing nanomaterials can produce either harmful pollutants or adverse environmental impacts similar to those from chemical manufacturing. Unlike the chemical industry, however, those same processes are not ingrained in the manufacturing of nanomaterials, and the opportunity exists at the initial design stage to purposely account for and mitigate out potentially harmful environmental impacts. While prevention has not been a priority in current industries, it can become a main concern for the new and future industries that manufacture nanomaterials on a bulk commercial scale. This is where green nanotechnology comes in.

Green nanotechnology involves deliberate efforts aimed at developing meaningful and reasonable protocols for generating products and their associated production processes in a benign fashion. The goal is a conscious minimization of risks associated with the products of nanoscience. The green products of nanotechnology are those that are used in either direct or indirect environmental applications. Direct environmental applications provide benefits such as monitoring using nano-enabled sensors, remediation of hazardous waste sites with nanomaterials, or treatment of wastewater and drinking water with nanomaterials. Indirect environmental applications include, for example, the saved energy associated with either lighter nanocomposite materials in transport vehicles or reduced waste from smaller products.

The production and process aspects of green nanotechnology involve both making nanomaterials in a more environmentally benign fashion and using nanomaterials to make current chemical processes more environmentally acceptable. Examples of producing nanomaterials in a 'greener manner' could involve but are not limited to the use of supercritical CO_2, water, or ionic liquids to replace a volatile organic solvent. Either self-assembly or templating might also be used to eliminate waste in manufacturing. Renewables could be utilized as replacements for either nonrenewable and/or toxic starting materials. Microwave techniques might potentially help to conserve energy, as could both facile thermal and hydrothermal processes. Catalytic and photocatalytic reactions could also increase efficiency and decrease the formation of harmful byproducts. In addition, engineered nanomaterials themselves can be used as catalysts in current chemical processes and as separation membranes to aid in the efficiency of these operations. Furthermore, in order to be truly green, these products and processes must be considered within a lifecycle framework.

The papers in this special issue are but a small sampling of the myriad of possibilities that green nanotechnology holds. In the nascent nanotechnology industry, green nanotechnology offers the opportunity to get it right in the first place. It is not too late to take Ben Franklin's words to heart, 'an ounce of prevention is worth a pound of cure'.