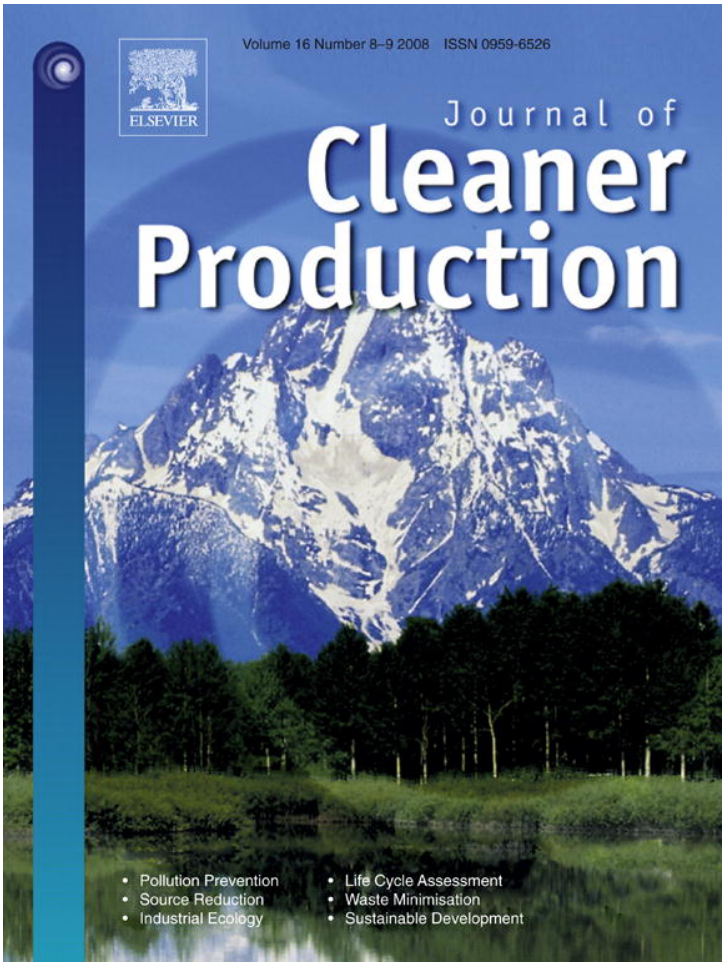

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Note from the field

Nanotechnology field observations: scouting the new industrial west

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Abstract

Public awareness and governmental involvement in overseeing the responsible development of nanotechnologies is lagging far behind the rapid pace of nanotechnology development and commercialization. Numerous products containing nanomaterials are already on the market and many more complex products are sure to follow. This paper highlights some of the recent work conducted by the Project on Emerging Nanotechnologies, a partnership between the Woodrow Wilson International Center for Scholars and The Pew Charitable Trusts. The paper summarizes the Project's research and findings regarding nanotech oversight, public awareness and attitudes, and work to develop a more strategic approach to addressing the potential risks associated with nanotech-based materials and products. We present these observations as a set of field notes from the rapidly changing ''nanofrontier.''

Keywords: Nanotechnology; Environment; Sustainability; Policy; Public awareness; Public involvement

When Thomas Jefferson sent Meriwether Lewis and William Clark to map the American West in 1804, he said, ''The work we are now doing is, I trust, done for posterity—in such a way that they need not repeat it…. Those who come afterwards will fill up the canvas—we begin.'' Nanotechnology may, as some maintain, be the next industrial revolution, the new West. If we develop this technology astutely, posterity will fill the canvas with new innovations that hopefully place our society on a more sustainable path. But the map is not clear at this point in time. As we explore this new technological frontier we have two basic choices: (a) ensuring the safety of nanoengineered materials and products across their life cycle, while also capitalizing on the environmental, social, and economic benefits of this technology—or (b) producing nanomaterials and products rapidly *without* sufficient consideration and prevention of potential adverse effects. Past experiences with the introduction of new technologies and materials (e.g., asbestos, lead, genetically-modified foods, DDT) should convince government and industry that much can go wrong if we misread the social or scientific compass at this early phase of our journey. Following in the footsteps of other explorers, here there are some preliminary notes from the field, observations of an emerging landscape and ecosystem where nanotechnologies are and will continue to be developed and deployed.

Nanotechnology field observations. *Postmarked: May 2007. Sender: Project on Emerging Nanotechnologies, Washington, DC, USA.*[1]

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[1] The Project on Emerging Nanotechnologies was established in April 2005 as a partnership between the Woodrow Wilson International Center for Scholars and The Pew Charitable Trusts. The Project is dedicated to helping ensure that as nanotechnologies advance, possible risks are minimized, public and consumer engagement remains strong, and the potential benefits of these new technologies are realized. Website: www.nanotechproject.org.

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1. The public and the marketplace

Nanotechnology is penetrating the marketplace at a rapidly increasing pace. Lux Research estimates that nanotechnology was ''incorporated into [US]$30 billion in manufactured goods in 2005'' and will reach US$2.6 trillion by 2014 [1]. As of May 2007, our project's online inventory of nanotechnology-based consumer products contains nearly 500 products from 20 nations (a doubling of products in 14 months) [2].[2] These products use many types of engineered nanomaterials, with nano-scale silver being the most prevalent, followed by carbon-based materials such as fullerenes and nanotubes. A large percentage of these products fall into categories such as cosmetics and dietary supplements, where oversight is weak or virtually non-existent in the United States and in many other countries.

Despite the flow of a wide variety of products containing nanomaterials into the consumer marketplace, the American public remains largely uninformed about nanotechnology. In September 2006, we released the results of a national telephone survey, conducted by Hart Research, of over 1000 adults on their opinions of nanotechnology. Almost 70 percent of those surveyed had heard ''nothing'' or ''very little'' about nanotechnology. When presented with information on the potential benefits (applications) and risks (implications) of nanotechnology, almost one-half of the participants in the survey expressed concern that the potential risks would outweigh the benefits. This was especially true of females (in particular, those over age 50), a demographic that will likely purchase many of the nanotech-based products on the market, such as cosmetics. When it comes to trust, Americans demonstrated greater confidence in government agencies and independent organizations than in businesses to maximize benefits and minimize risks associated with scientific and technological advances [3].

2. U.S. governmental efforts reviewed

According to analyses done by the Project on Emerging Nanotechnologies, the U.S. government has allotted a mere one percent of its total nanotechnology research and development budget for targeted research that addresses environmental, health, and safety (EH&S) implications of nanotechnologies [4]. Furthermore, the U.S. government has failed to provide a full, public, and transparent accounting of exactly what EH&S research it is funding. Groups outside of the government have advocated for increases in risk-related research to levels of 5–10 percent of the total annual research and development budget (this would equal around US$50–$100 million per year) [5].

As more products flow into the marketplace and the potential exposure of workers and consumers to nanomaterials increases, it is imperative to have in place in the United States, and elsewhere, a comprehensive, coordinated risk research strategy that prioritizes pressing research needs and assigns them to the responsible government agencies. The U.S. government has not produced such a strategy, despite over one and a half years of work by the Administration's interagency Nanotechnology Environmental and Health Implications (NEHI) working group.[3] In addition, we need to go beyond national strategies to avoid research duplication and ensure optimal use of limited funds. A global EH&S strategy is needed, which is informed through a comprehensive, project-by-project, online inventory of existing and planned research [4].

Existing environmental laws may not be adequate to handle nanotechnology's complexities. An environmental policy analysis, undertaken by J. Clarence Davies and released by our project in January 2006, concluded that a new law may be needed to deal with unique aspects of nanotechnology and shortcomings in existing laws [6]. The U.S. Environmental Protection Agency (EPA) has held public meetings to prepare itself for a voluntary *Nanoscale Materials Stewardship Program*, but has been slow to take concrete action toward implementing this program and in carrying out coordinated risk research efforts on nanomaterials. The EPA is beginning to review certain nanomaterials as new chemicals or uses under the Toxic Substances Control Act and Federal Insecticide, Fungicide, and Rodenticide Act, and as new fuel additives under the Clean Air Act; however, this is contingent upon companies submitting this information to the agency. In November 2006, the EPA announced its plans to regulate products (e.g., washing machines, food storage containers, socks) containing nanosilver that claim to use the nanosilver as an antimicrobial pesticide to kill germs. This decision reverses the agency's previous decision to approve these products as devices [7].

How the oversight system evolves at this early stage will have significant impacts on industry structure, the competitive strategies of firms, and approaches to intellectual property. It can ultimately define who can play or not, especially if the costs of testing and data submissions are high. These impacts have not received the attention they deserve, but need to be addressed as soon as possible. In a recent paper, Mark Greenwood explored competitive implications of potential nanotechnology

[2] The inventory contains only products that manufacturers have declared as based on nanotechnology. A similar inventory developed in Japan, contains over 200 nano-based consumer products.

[3] On September 21, 2006, the U.S. House of Representatives Committee on Science held a hearing on ''Research on Environmental and Safety Impacts of Nanotechnology: What are the Federal Agencies Doing?'' In his opening statement, Chairman Sherwood Boehlert stated: ''The government needs to establish and implement a clear, prioritized research agenda and fund it adequately. The problem is that we still haven't done that, and 'time's a wasting.''' He continued: ''I'm pleased that the long-delayed interagency report on research needs is finally being released at – and dare I say, because of – our hearing today. But as that document itself states, it is only a first step, and it doesn't fully set priorities, never mind assign them.'' Three months later (January 2007), the agency workgroup held a public meeting to seek input on environmental, health, and safety research needs and prioritization criteria—something that many groups (including Environmental Defense, Lux Research, Natural Resources Defense Council, ICF International, our project, among others) had already considered and reported on.

regulation and argued for the need to look beyond the laws and statutes for innovative solutions [8].

Another U.S. regulatory institution, the Food and Drug Administration (FDA) is not ''nano ready.'' An extensive analysis completed in September 2006 by our project and written by former FDA official Michael Taylor indicated that significant weaknesses and gaps existed in the FDA's oversight capacity, especially in the areas of cosmetics and dietary supplements [9]. The limitations are not just legal in nature, but have to do with a lack of adequate resources and expertise, a problem that has plagued the FDA for years in many fields, but will be compounded by nanotechnology.[4] On October 10, 2006, the FDA held its first public meeting on nanotechnology to gather and evaluate information on nanomaterials in FDA-regulated products. FDA's initial findings and recommendations from this meeting are not expected until late summer 2007 [10,11].

3. Outlook

The majority of nanotechnology development in the United States is not guided by the principles of sustainability.[5] The word ''sustainability'' has been largely banned from the federal lexicon for the past six years putting it into the category of a rare species. Small pockets of researchers remain committed to following a more ''green'' path for nanotechnology development—designing nanomaterials using clean practices (e.g., reducing solvents and toxic inputs, minimizing energy needs, preventing waste) or producing renewable or more sustainable technologies using nanomaterials (e.g., nanocrystals that create more efficient solar cells, nanocomposites that lower vehicle greenhouse gas emissions, and iron oxide nanoparticles that separate heavy metals from drinking water)[6]; however, funds for research in this area are scarce and the United States has no comprehensive research strategy linking nanotechnologies to sustainability goals.

As companies begin to put in place new production infrastructures to develop nanomaterials or nanoproducts, a window of opportunity exists to design and engineer risks out of production processes and products, or achieve significant risk mitigation. Before manufacturers become rooted in processes that may present risks to workers and consumers, incur damage to the environment, or deplete limited resources, industry and government should take advantage of this window and focus more attention and funding on getting this emerging technology on a path toward sustainability.

Managing the introduction of nanotechnologies by both industry and government is becoming more complex as more parties have vested interests in the economic, social, and environmental outcomes. In addition, nanotechnology species diversity is growing, though an awareness of the diversity and its implications lags far behind. An increasing number of environmental organizations (including Environmental Defense, the Natural Resources Defense Council, Friends of the Earth, ETC Group) are focusing on nanotechnology along with the press and consumer groups, such as the Consumers Union [12].[7] This evolving stakeholder ecosystem will re-define risks and opportunities on a constant basis and require that organizations continually assess both cooperation and competition strategies as well as the timing of their actions, such as the introduction of new products or oversight regimes [13]. The time horizons for decision-making will shrink as the rate of production ramps up and the speed of market introduction for nanoengineered applications increases.

In January 2006, a Canadian scientist stated that: ''It will be several years before nanotechnology will be used in everyday products,'' [14]. Yet, there are already hundreds of products in use (of which we are aware) *today*. A tsunami of nano-based products will wash over the marketplace in the next two to three years, a function of billions of dollars of applied research done by both governments and industry at a global scale. As a society, we continually underestimate the pace of technological advance and under-invest in social innovations that will better prepare us to use technologies safely and advantageously. Thomas Jefferson had estimated that it would take our nation one hundred generations to fill up the land he had sent Lewis and Clark to explore. Americans did it in less than five. We do not have a long time to prepare government and the public for the introduction of nanotechnologies. It will not be enough to simply ask the right questions; they must be asked early enough to be tackled in an astute manner. If we want to develop nanotechnology in light of sustainability, the next five years are critical.

[4] FDA's budget should be about 50 percent higher than it is today for it to be handling all that it was doing in 1996 and additional jobs FDA has been mandated over the last 10 years.

[5] The Brundtland Report, the result of the UN Conference on the Human Environment, defined sustainable development as development that ''meets the needs of the present generation without compromising the ability of future generations to meet their own needs.'' In the nanotechnology context, sustainability may mean taking care that (a) we design our production processes and distribution systems for nanomaterials and nanoproducts today in ways that use resources (materials, energy) wisely (both in quantity and type), minimize waste and emissions, and prevent adverse impacts on human health and the environment; and (b) we design nanomaterials and nanoproducts with beneficial properties for the environment, human health, and society.

[6] Over the past year, the Project on Emerging Nanotechnologies has held a number of policy forums and one symposium on Green Nano focusing on the development of clean technologies to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new nanoproducts that are more environmentally friendly throughout their life cycle. See: www.nanotechproject.org/41. The Project released its first *Green Nano* report in April 2007.

[7] In his letter to subscribers, Consumers Union President Jim Guest recommends: ''Before these [nanotechnology] products show up en masse in stores and doctors' offices, a worldwide effort is needed to understand what nanoparticles can do to our health and to the environment. Nanotech products need to be labeled so that consumers can choose whether to accept their current unknowns.''

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