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CIELAP Brief on Nanotechnology and Metals
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About Nanotechnology

Nanotechnology is the rapidly advancing ability of humans to manipulate and use materials at the nanoscale, essentially at the scale of molecules and atoms. Since its beginnings in the 1980s and 1990s nanotechnology has developed quickly, with more than 800 manufacturer-identified nanotechnology-based consumer products currently on the market[1] and many more poised for development.

Nanotechnology is of significant interest because materials at this scale can exhibit novel properties that are different from the same substance's properties at the macro or even micro scales. For instance nanoscale silver has antibacterial properties and is currently being used in consumer products such as socks, washing machines, and bandages. Nanotechnology is already having a profound effect on a wide range of different sectors and applications, from medicine to packaging to environmental sensors and remediation.

Impacts of Nanotechnology on the Metals Industry

Nanotechnology has spurred many changes for the metals industries in recent years, both in existing and new markets including applications for the chemicals, automotive, biomedical, energy, electronics, and other sectors. Advances in nanotechnology and metals are impacting each another in a number of ways including the following:

- The miniaturization of electronics has created demand for smaller and less expensive components, including circuits, sensors, optics, and other devices, that make use of precious metals. Nanotechnology allows for less use of these metals, which reduces production costs. This increased affordability is expected to increase demand for metals and preserve their use in electronic products rather than requiring manufacturers to seek alternatives.[2]
- Nanotechnology is also providing alternatives to precious metals in electronics, however. Scientists have experimented with the use of carbon nanotubes and suggest that the nanotubes can minimize heat loss, reduce damage to metal conductors, improve conductivity and mitigate other challenges that come from miniaturizing metals for electrical and electronic use. Some expect that these nanomaterials, which can be many times stronger than metals, will some day replace

[1] The Project on Emerging Nanotechnologies – Inventory of Consumer Products, http://www.nanotechproject.org/inventories/consumer/

[2] Meridian Institute, Nanotechnology, Commodities & Development, a Background Paper for the International Workshop on Nanotechnology, Commodities & Development, 29 – 31 May, 2007, http://www.merid.org/nano/commoditiesworkshop/files/Comm_Dev_and_Nano_FINAL.pdf.

metals in a broad range of electronics applications.[3] There is some concern that such advancements will result in losses in demand for copper.[4]

- Metal nanoparticles, particularly precious metals including gold, platinum and palladium, are increasingly being used as catalysts in various industrial and environmental applications. Metal nanocatalysts are being used in automobile emission control systems and in other pollution control and treatment applications, to facilitate petroleum extraction and production, and to produce chemicals and chemical products. It is expected that the increased affordability of the use of precious metals in these applications, due to the minute amount needed for each process, will increase overall demand for these metals.[5]
- Global demand for nanoscale oxides of metals such as titanium, zinc, iron and aluminum has been increasing rapidly. Such oxides are being used extensively in applications such as toothpaste, sunscreens and other personal care products; in water treatment and environmental remediation; and to produce green energy.[6] Advances in nanoscale metal oxides are expected to increase demand for metals.
- Metal nanoparticles also present opportunities for medical applications. For instance gold nanoparticles are being applied to targeted drug delivery. Nanosilver is used in wound dressings, bandages and surgical instruments because of its antibacterial properties.[7]
- Advances have been made regarding the production of metal nanoparticles. For example, phytomining is a process whereby plants are planted near gold deposits. Plants take up the gold, which can then be recovered from the plants.[8]
- Nanotechnology is being used for remediation to clean up heavy metal contamination including the removal of lead, zinc, copper, cadmium, nickel, manganese, cobalt, and arsenic from water and soil. One commercial application suggests the potential for remediation of tailings ponds, industrial wastewater and agricultural fields, battery recycling operations, and treatment of acid mine leaching.[9]

Environment and Health Risks of Developments in this Area

The environmental and health effects of exposure to nanomaterials have only recently begun to be studied and remain largely unknown. Nanoparticles have a much larger surface area to volume than materials in bulk form and a number of studies have found them to be substantially more toxic and biologically reactive than larger particles of the same material. One recent study, for instance, suggests that cells may allow metal-containing nanoparticles to permeate membranes that would typically protect the cell against metal salts. Once

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[3] Nanowerk, *Carbon nanotubes are superior to metals for electronics*, March 20 2009, http://www.nanowerk.com/news/newsid=9723.php.

[4] Meridian Institute, *Nanotechnology, Commodities & Development, a Background Paper for the International Workshop on Nanotechnology, Commodities & Development, 29 – 31 May, 2007*, http://www.merid.org/nano/commoditiesworkshop/files/Comm_Dev_and_Nano_FINAL.pdf at 27.

[5] *Ibid* at 26.

[6] *Ibid* at 27.

[7] *Ibid* at 27.

[8] *Ibid* at 28.

[9] AzoNano, *Cleaning Up Heavy Metals Pollution With Nanotechnology*, June 13 2008, http://www.azonano.com/news.asp?newsID=6570.

inside, metal ions may leach from the nanoparticles and act as toxins.[10] Given the reactivity and suspected toxicity of nanoparticles, many stakeholders have expressed concern about the risks they present for people's health, including the health and safety of workers and consumers exposed to the materials, and the environment.

Metals are involved in nearly every industry and it is difficult to know how applications involving metal nanoparticles will be used in the future. Given such uncertainty about the risks, it may be useful to weigh the potential benefits vs. the potential risks of specific applications in determining how to move forward with research and development. Developments in areas that have significant potential to cause harm with few benefits (e.g. cosmetics, which are applied to and absorbed by the skin) could be restricted while applications with strong potential benefits including applications for medicine and remediation could be encouraged as long as significant oversight is put in place.

Current Federal Government Activities

Environment Canada and Health Canada are the Federal government departments that have responsibility for nanotechnology regulation and policy. In June 2007, Environment Canada notified manufacturers or importers of nanomaterials that the New Substances Regulations under the *Canadian Environmental Protection Act* (CEPA) would apply to materials with "unique structures or molecular arrangements."[11] This would include carbon fullerenes or nanotubes, but not other nanomaterials such as titanium dioxide, because they have the same molecular arrangement as at the macro scale. In January 2009, a spokesperson for the Canadian government stated that it would soon use its powers under s. 71 of CEPA to require companies to report their use of nanotechnology and the quantities and toxicity of nanomaterials used.[12] Environment Canada also introduced a Proposed Regulatory Framework for Nanomaterials in September 2007.[13]

Further Regulation Needed

It is generally stated that nanotechnology is a "platform" technology in that it will profoundly affect virtually every sector of society. The development of nanotechnology is also expected to be very important to Canada's future economic success. Despite the potential and significance of nanotechnologies, however, Canada presently has no formal regulatory or public policy framework for managing their risks and benefits, nor for informing and consulting the public about the issues related to them.

In 2008 CIELAP released a second discussion paper on a framework for Canadian nanotechnology policy to update its 2007 paper on the theme. We can reiterate the priorities we identified then, specifically that the Canadian government should prioritize:

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[10] Ludwig K. Limbach, Peter Wick, Pius Manser, Robert N. Grass, Arie Bruinink, and Wendelin J. Stark, Exposure of Engineered Nanoparticles to Human Lung Epithelial Cells: Influence of Chemical Composition and Catalytic Activity on Oxidative Stress, *Environ. Sci. Technol.*, 2007, 41 (11), pp 4158–4163.

[11] Environment Canada, New Substances Program Advisory Note 2007-06: *Requirements for nanomaterials under the New Substances Notification Regulations (Chemicals and Polymers)*, June 2007, http://www.ec.gc.ca/substances/nsb/eng/a200706_e.shtml.

[12] P. Menyasz, "Canada to Require Companies to Report Quantity, Usage, Toxicity of Nanomaterials," *Bureau of National Affairs' Daily Environment Report*, January 26, 2009.

[13] Government of Canada, Proposed Regulatory Framework for Nanomaterials under the *Canadian Environmental Protection Act, 1999*, September 10 2007, http://www.ec.gc.ca/substances/nsb/eng/nanoproposition_e.shtml.

Institutional Developments for Nanotechnology Governance and Leadership including:

- establishing a broad purpose statement for a nanotechnology policy framework that incorporates sustainable development and its values;
- developing a public engagement strategy with new institutional arrangements and resources for public involvement;
- identifying a lead government agency that would ensure that all priorities are attended to and gaps are addressed; and
- developing further regulatory approaches to oversee nanotechnology and the next generations of medical and nano-bio devices.

Knowledge and Information Needs including:

- developing a publicly available Canadian inventory of nanotechnology activities and commercial products;
- continued involvement with and support for resolving technical questions at the international level;
- support for further science and research; and
- addressing worker safety and public health in existing research laboratories, other facilities, and industries using nano materials.

Addressing Social, Commercial and Economic Concerns including:

- developing a public education and engagement strategy;
- requiring the labeling of nanomaterials in consumer products;
- reviewing whether particular nanotechnology applications are targeted for development because of their social or economic benefits in Canada; and
- understanding the use and threats of nanotechnology in military applications and determining ways to prepare for and avoid these threats.

This brief is one of seven policy briefs prepared by CIELAP in the spring of 2009. CIELAP's other briefs and publications can be found on the CIELAP website at www.cielap.org.