Nanotechnology in Automotive and Industrial Materials Manufacturing in Canada

Executive Summary

Chemicals

11 April 2006

Prepared Under Contract # 5016569 for:
Christopher Morris
Industry Development—Nanotechnology
Industry Canada—Automotive and Industrial Materials Branch
235 Queen Street
Ottawa, ON K1A 0H5

Prepared by:
David J. Roughley, Strategic Technology Consulting (Vancouver, BC)
E-mail: davidroughley@shaw.ca
Tele: 604 990 1246

Project Team:
Dennis Senik and Associates Inc. (Ottawa, ON)
Victor Jones, CAST Ventures Corporation (Vancouver, BC)
Jeffrey Doyle, Doyletech Corporation (Ottawa, ON)
Glenn McDougall, Doyletech Corporation (Ottawa, ON)

Executive Summary

The Canadian chemical manufacturing sector is a $40 billion industry with diverse activities. Not surprisingly, nanotechnology (NT) awareness and exploitation is also diverse. Some sub sectors exhibit good NT awareness and have adequate resources to explore/exploit NT, whilst others are at a much earlier stage of exploration. Despite industry claims of long-term NT exploitation ("old nanotechnology"), modern NT approaches have only recently appeared on the horizon for many small and medium-sized players in Canada. While larger companies (often foreign-owned) have adequate mechanisms to explore new materials, technologies and processes, the same may not be true for smaller players. In the latter case, Canadian federal research centers and universities will play an important supporting role. But even in the leader group of companies, much NT research activity is driven from offshore locations, (though some have established R&D facilities in Canada). As a result, awareness/activity levels at operations sites in Canada are often relatively modest.

The chemical industry is a material supplier for a vast range of applications. Globally, a variety of automotive applications use—or will soon use—NT advances. Examples include polymer nanocomposites for body panels, NT-enabled paints and coatings, and nanoparticle lubricant additives. Adhesive and abrasive products (both industrial and consumer grade) are also available that utilize NT materials and intermediates. Toners (for printing), and catalyst supports (for fuel cells) are a few other examples identified in this project. Electronics (including displays), industrial coatings, and glass coatings all exploit thick and thin film technology that achieves performance enhancements based on control of the film material at the nanocrystalline or nanostructured level.

Among basic chemicals and petrochemicals companies in Canada, the evaluation of NT potential appears to be at an early stage. For example, in the lubricants area, NT could help solve a number of challenges, but its role is expected to be relatively modest. A more significant area is in fuel additives, where overseas developers are enabling efficiency improvements and emission reductions through NT solutions. Much of this technology will likely appear as foreign companies import developed products or processes into their Canadian branch plants. In specialty and other chemicals sub sectors, NT has already appeared in the supply chain. For example, 3M has identified NT as impacting all its identified high-growth market spaces. NT will likely be used to improve higher-valued products, rather than attempting to differentiate commodity products with minimal margin. In the resins and synthetic rubber sub sectors, NT awareness appears limited beyond the global competitor group. Paint, coatings and adhesives sub sectors are already adopting or commercially exploiting NT-based or NT-enhanced products and processes. From nanoparticles in paint, to ultra thin (nanoscale) optical, electrical, mechanical, thermal (and other performance-modifying) films, this industry sector is an established NT adopter. Impact is already significant and can be expected to increase. Other applications of NT in the chemicals industries feature in the upgrade of chemical plant processes and installations to achieve greater energy efficiency, better environmental performance, or for cost reduction. Federal programs such as TPC are already supporting such aims in Canada. Also, in the area of process improvement, some Canadian efforts in membrane separation materials and technologies show near-term promise.

As part of the general field of nanotechnology, a class of specialist materials and intermediates suppliers has begun to emerge. Inorganic nanopowders, precursors, nanoparticles, and carbon nanomaterials (nanotubes, fullerenes, and other variants) are all at various stages of commercial development. Some are becoming available from Canadian-based developers. Intermediates include nanocomposites, nanodispersions, nanomembranes, nanofoam, nanorings, nanomesh and a variety of other structures—many of which are under development industrially and at academic establishments and federal laboratories. Nanomaterials developers can—at one level—be considered a new category of chemical supplier, though many have core business activities outside of NT. The picture for this emerging group of companies is very dynamic at present.

When thinking about NT and the chemical industry one has to recognize the “slow-industry-cycle” nature of the business, and its relative maturity. The structure of the chemical industry varies according to the sub sector, but the increasing trend for SME or middle-tier specialist companies to find fertile ground in the chemicals industry may well lead to some fast-moving market niches within the overall (more pedestrian) markets, some driven or enabled by NT. The view of the leader group companies is that NT will change the nature of the business, shifting industrial structure and creating new markets. The current outlook might be considered revolutionary in a less mature industry. But capital cost and plant introduction/upgrade cycles will moderate this potential to a more evolutionary introduction path, providing improvements for existing products and processes. The further introduction of NT will likely be on a case-by-case basis driven principally by cost reduction, performance enhancement, and environmental compliance issues.

Project Background

Nanotechnology (NT) encompasses the design, characterization, production and application of very small structures to exploit their unique physical, chemical and biological properties. Size dependent properties of nanomaterials, usually in the 1 to 100-nanometer (nm) range, include chemical, biological, electronic, photonic, magnetic, rheological, structural and mechanical effects. Nano-enabled products are those that gain value-added attributes from their manipulation of nanostructure, utilization of nanomaterials, inclusion of nanodevices within the product, or have nanocoatings or treatments that confer performance benefits. Nano-enabled processes utilize nanotechnology to produce products more efficiently, often with sustainable development benefits. Importantly, a general NT definition includes some activities and processes that have been known for decades in addition to the exploitation of nanomaterials (such as carbon nanotubes and even nanoparticles of traditional materials) that have appeared more recently. The range of applications is large, and growing[1]. The global market for nanotechnology is widely expected to reach US $1 trillion by 2012. Of this, US $340 billion will be for performance materials, US $310 billion for electronics and information technology and US $100 billion for pharmaceuticals. Canada's industrial base has sufficient receptor capacity for nanotechnology to warrant serious consideration as a future source of economic growth. At a stage where many applications of nanotechnology are still emerging, Canada has an opportunity to benefit from its world-class research and development foundations. However, the industrial uptake of nanotechnology in Canada is at a preliminary stage and to date has not been systematically reviewed.

In 2004 Industry Canada's Policy Sector recommended that the Prime Minister's Advisory Council on Science and Technology (PMACST) be tasked with undertaking a nanotechnology review. This review was approved and a series of background studies were commissioned through 2005[2]. The PMACST intends to make recommendations to Cabinet along with input from the National Science Advisor (NSA) on strategy options in early 2006. The Automotive and Industrial Materials Branch (AIMB) through the Industrial Materials Directorate (IMD) is also working in partnership with PMACST Secretariat to deliver on this review by commissioning specific reports and studies focused on industrial implementation of nanotechnology.

In this study a project team led by David J. Roughley, Strategic Technology Consulting (Vancouver) was commissioned to investigate the AIMB's principle industrial sectors' status with respect to nanotechnology-derived innovations. AIMB's area comprises 6 sectors, which are subdivided for statistical purposes into 35 sub sectors. Through a review of existing reports, public materials, and targeted discussions with known experts and industry leaders the project aimed to assess current status and future impact of nanotechnology by reviewing a sample selection of the 35 sub sectors. The reports are collected under four materials sectors from the perspective of the existing North American Industry Classification System (NAICS). This report focuses on the chemicals sector. The other three sector reports included in this project are plastics and rubber, primary metals, and automotive manufacturing.

[1] See for example at the Woodrow Wilson International Center for Scholars *A Nanotechnology Consumer Products Inventory*: http://www.nanotechproject.org/index.php?id=44&action=view

[2] The PMACST web site contains a number of documents that issued from the review process and provide useful background information for these reports: see http://acst-ccst.gc.ca/back/home_e.html