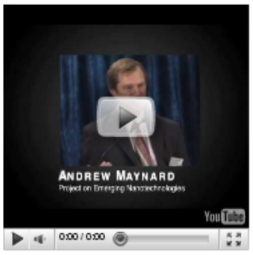
California Department of Toxic Substances Control

Nanotechnology

DTSC and Nanotechnology

Nanotechnology is a science that promises breakthroughs in all kinds of areas. We are already seeing it in stain resistant clothes, stronger materials and even in makeup. DTSC is working to make sure that Nanotechnology is safe for our health and the environment, that industry and government build strong partnerships, that the consumers get product information and that the benefits of Green chemistry will be incorporated.



Watch the video to learn more
View the text here

What is nanotechnology?

Nanotechnology is the design, characterization, production, and application of structures, devices, and systems by controlling the shape and size at the nanometer scale. A nanometer (nm) is one billionth of a meter. For comparison, a single human hair is about 80,000 nm wide, a red blood cell is approximately 7,000 nm wide and a water molecule is almost 0.3 nm across. The nanoscale generally is defined in nanotechnology to be from 100 nm down to the size of atoms (approximately 0.2 nm). Understanding and controlling matter at the nanoscale interests researchers in the sciences, medicine, agriculture, and industry because a material's properties at the nanoscale can be very different from those at a larger scale. As reports of new discoveries and applications for nanotechnology emerged, governmental, industrial, and public stakeholders recognized the need to develop a standard nanotechnology terminology to facilitate communication among the various communities.

Flower Bouquet, a 3-dimensional nanostructure grown by controlled nucleation of silicon carbide nanowires on gallium catalyst particles. As the growth proceeds, individual nanowires 'knit' together to form 3-dimensional structures. Photo: ©Ghim Wei Ho and Prof. Mark Welland, Nanostructure Center, University of Cambridge

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Why is nanotechnology of interest?

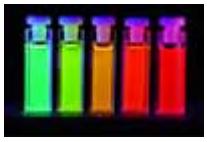


Photo: *Phillips*

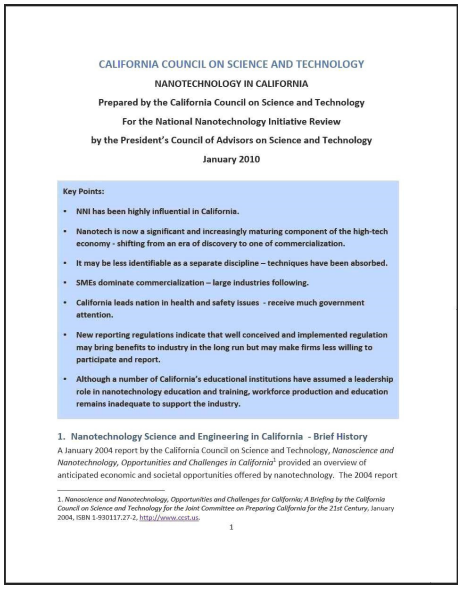
The unique physical, chemical, and biological properties of materials at the nanoscale enable novel applications and functions with the potential to promote enormous societal and economic benefits. Some current innovative applications of nanotechnology include the use of nanomaterials in liquid filtration and water purification, as catalysts in petroleum refining and catalytic converters, and in nanoscale biological imaging. In the near future of two to five years, nanotechnology will be integrated into advanced drug delivery systems, real-time medical diagnostic tools, sensors for airborne chemicals or other toxins, and photovoltaics (solar cells), fuel cells and portable power to provide inexpensive, clean energy.

The properties of materials at the nanoscale are attributed to two main factors. First, nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form. This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties. Second, quantum effects can begin to dominate the behavior of matter at the nanoscale - particularly at the lower end of the scale affecting the optical, electrical and magnetic behavior of materials. The photo above shows an example of quantum dots. Particles of inorganic semiconducting crystals with nanometer scale dimensions ("quantum dots") exhibit size-dependent optical properties. In other words, the color of a cadmium-selenium (CdSE) quantum dot will vary depending on the quantum dot's size, even though the chemical composition of the dot has not changed. Companies are investigating quantum dots to develop composite materials such as those used as light-emitting diodes (LEDs) where the color is determined by the size of the quantum dots. The superior optical properties of quantum dots are being studied for use in diode lasers, optical amplifiers and switches, biological sensors, and solid-state quantum computing.

The unique properties exhibited by nanomaterials for commercial applications also raise concerns regarding potential environmental and human impact of these materials. Scientists, regulators, and the public are asking the question: What do we know about the safety of nanotechnology and nanomaterials?

Why is DTSC interested in nanotechnology?

DTSC sees nanotechnology as the new "plastic" because it will show up in many industrial applications and consumer products. Materials and devices designed at the nanoscale level are being used or considered for use in applications as diverse as cancer treatment to scratch-resistance automotive coatings. Because of the unique properties of nanomaterials, DTSC is gathering information on nanotechnology and monitoring the efforts of other regulatory agencies about this emerging technology. DTSC sees a need to understand this industrial sector and its products. DTSC also wants to work with this emerging industrial sector to incorporate the benefits of "green chemistry" approaches, pollution prevention techniques, and sustainable manufacturing strategies to prevent potential adverse public health and environmental consequences. "High technologies" such as nuclear power, genetically modified organisms, and ever-smaller consumer electronics have begun to leave their legacy. The benefits of nuclear power in preventing global warming and genetically modified organisms in increased food production are obscured by public fear of perceived consequences. Consumer electronics, while providing entertainment and ease today, at the



CALIFORNIA COUNCIL ON SCIENCE AND TECHNOLOGY

NANOTECHNOLOGY IN CALIFORNIA

Prepared by the California Council on Science and Technology

For the National Nanotechnology Initiative Review

by the President's Council of Advisors on Science and Technology

January 2010

Key Points:

- NNI has been highly influential in California.
- Nanotech is now a significant and increasingly maturing component of the high-tech economy - shifting from an era of discovery to one of commercialization.
- It may be less identifiable as a separate discipline – techniques have been absorbed.
- SMEs dominate commercialization – large industries following.
- California leads nation in health and safety issues - receive much government attention.
- New reporting regulations indicate that well conceived and implemented regulation may bring benefits to industry in the long run but may make firms less willing to participate and report.
- Although a number of California's educational institutions have assumed a leadership role in nanotechnology education and training, workforce production and education remains inadequate to support the industry.

1. Nanotechnology Science and Engineering in California - Brief History

A January 2004 report by the California Council on Science and Technology, *Nanoscience and Nanotechnology, Opportunities and Challenges in California*[1] provided an overview of anticipated economic and societal opportunities offered by nanotechnology. The 2004 report

1. *Nanoscience and Nanotechnology, Opportunities and Challenges for California; A Briefing by the California Council on Science and Technology for the Joint Committee on Preparing California for the 21st Century*, January 2004, ISBN 1-930117.27-2, http://www.ccst.us.

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(enlarge image)

end of their service life produce an increasing burden of "e-waste" the heavy metals of which can cause harm in many ways. Nanotechnologies are diverse in form, substance, function, and promise. DTSC is working toward a partnership with this industrial sector to develop an industrial ecology of manufacturing to product stewardship approach that will protect public health and the environment. DTSC will also continue to explore the merits of pro-active industrial initiatives and traditional governmental regulatory approaches.

California Council on Science and Technology, January 2010 Report, *Nanotechnology in California*

As a starting point in this process, DTSC reviewed the December 2004 report issued by the Blue Ribbon Task Force on Nanotechnology addressed major areas of concern in promoting nanotechnology research and development, commercialization, facilities and infrastructure, policies and ethics, and education. Recently, the California Council on science and Technology (CCST) issued a report in January 2010 outlining the status of nanotechnology in California. The report refers to DTSC's efforts to collect information on certain nanomaterials as part of the Chemical Information Call-in.

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What are its current applications in industry?

Some examples of nanotechnology used in clothing are stain-resistant pants and shorts with built-in sunscreen.

Examples of agrifood research include developing bacterial pathogen detectors from nanochemicals for use post-harvest.

Some examples of nanotechnology used in clothing are stain-resistant pants and shorts with built-in sunscreen. Examples of agrifood research include developing bacterial pathogen detectors from nanochemicals for use post-harvest. Most science and technology experts consider nanotechnology to be an industrial revolution on the horizon that will have an enormous social and economic impact. However, currently the applied use of nanomaterials and nanotechnology is limited, except in the electronics and information technology industries, where semiconductor devices with a certain minimum feature size have been at the nanoscale for several decades. Companies have introduced nanotechnology in several consumer products such as cosmetics, food and clothing. The Woodrow Wilson International Center for Scholars developed searchable databases listing the uses of nanotechnology in consumer products and the research being conducted on agrifood (e.g., food, agriculture, forestry, and agroecosystems). Other applications include new detection systems, filtration media, and electronic chip design.

Additional information

Nanotechnology Related Web Site Links

Nanotechnology Events Calendar (non-DTSC events are provided only for the reader's information).

General

- ASTM, E2456-06, Terminology for Nanotechnology, December 2006
- Bergeson & Campbell, P.C., Memorandum regarding EPA Announces Availability of Final Nanotechnology White Paper, February 20, 2007
- Blue Ribbon Task Force on Nanotechnology, Thinking Big About Thinking Small An Action Agenda for California, December 2005
- California Environmental Protection Agency (Cal/EPA) Library (search the CIWMB/DTSC Catalog using the keyword "nano")
- Center on Nanotechnology and Society, Faces of Risk: Nanopolicy and the Agenda for Safety and Society
- City of Berkeley, Manufactured Nanoscale Material Health & Safety Disclosure, August 2007
- Environmental Defense and DuPont Nano Partnership, The Nano Risk Framework, June 2007
- Feder, B., Engineering Food at Level of Molecules, New York Times, October 10, 2006
- Lin, Patrick, Ethics for Technologies that Converge at the Nanoscale, Nanoethics, Number 2, pgs. 105-122, August 2007
- Reynolds, Glen Harlan, Nanotechnology and Regulatory Policy: Three Futures, Harvard Journal of Law & Technology, Volume 17, Number 1, Fall 2003
- TASwiss, Information Brochure, Know Your Nano!, publifocus "Nanotechnology, Health and the Environment", August 2006
- The Royal Society & the Royal Academy of Engineering, Nanoscience and nanotechnologies: opportunities and uncertainties, July 2004
- U.S. EPA, Final Nanotechnology White Paper, February 2007
- U.S. EPA, Nanoscale Materials Stewardship Program (NMSP)

Environmental Cleanup

- Nanoforum, Nano and the Environment, December 2005
- Tratynek, P.,etal., Nanotechnologies for environmental clean-up, Nanotoday, May 2006, Vol.1, Number 2, pages 44-48
- U.S. EPA, Pollution Prevention Through Nanotechnology, September 2007
- U.S. EPA, Nanotechnology and OSWER: New Opportunities and Challenges, July 2006
- U.S. EPA, U.S. EPA Workshop on Nanotechnology for Site Remediation, October 2005
- U.S. Navy, Nanoscale Zerovalent Iron Tool, January 2005

Research

- U.S. EPA, Nanotechnology: Research Projects

- National Research Council, A Matter of Size: Triennial Review of the National Nanotechnology Initiative, 2006 (abstract only. Purchase required for full article)
- Woodrow Wilson International Center for Scholars, Nanotechnology: A Research Strategy for Addressing Risk, July 2006

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Questions, Comments, and Suggestions

If you have any comments or suggestions regarding this web page or questions related to nanotechnology and the environment, please send them to nanotechnology@dtsc.ca.gov. If you would like to receive updates on DTSC related activities regarding nanotechnology, please subscribe to the DTSC Nanotechnology listserv.

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