California's Efforts to Safe and Responsible Nanotechnologies: Information Call-in from Manufacturers of Nanometals and Oxides

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ABSTRACT

While nanomaterials are found in a growing number of applications, there are large knowledge gaps. The potential risks of nanomaterials are not well known. A safe and responsible approach for nanotechnology is necessary. As the first step to understanding these potential risks, the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) requested information from manufacturers of carbon nanotubes in 2009. DTSC will expand the information call-in to include nanometal oxides and nanometals in 2010. DTSC will request the information regarding analytical test methods, fate and transport in the environment and other relevant information from manufacturers.

Keywords: nanomaterials, data gap, information call-in, environment, potential risks.

1 INTRODUCTION

Nanotechnology is a rapidly emerging technology with vast potential to create new materials with unique properties and to produce new and improved products for numerous applications. Because of their unique properties such as optical, physicochemical, thermal, and electrical properties, many nanotechnology-based products are already available in the marketplace [1].

However, there are large knowledge gaps in properties of nanomaterials. For example, the characterization of nanomaterial (surface area, size, and shape), toxicity, and fate and transport as well as the development of test methods are needed more knowledge for better understanding the characteristics of nanomaterials. Due to their unique properties, nanomaterials might have the potential to adversely effects to human health and the environment. The potential risks of nanomaterials are not well known, thus a safe and responsible approach for nanotechnology is necessary.

Although the quantity of nanomaterials is small, the particles size are much smaller enough even to pass through skin or even the blood-brain barrier. Large proportion of atoms in nanoparticles lies on the surface and could be highly reactive [2]. The estimated production capacity of nanomaterials is very much smaller than conventional commercial materials. But because of their small size, the surface area is much larger and so they are very reactive. This implies nanomaterials might have very big effects to human health and the environment. To data, the potential environment effects of engineered nanoparticles, in any quantity, are largely unknown

It is necessary to develop and collect information to figure out the impacts from nanotechnology. Information call-in by DTSC will be the trigger for the safe nanotechnology and also sustain development of the nanomaterial sector. DTSC is exercising its authority under California's Health and Safety Code, Chapter 699 (Assembly Bill 289).

2 CALIFORNIA AND NANOINDUSTRY

2.1 Practices of California nanoindustry

The State of California is a leader in nanotechnology with more than 20% of the U.S.-based micro and nano companies located in California. The largest nanotechnology industrial sector in California is the materials industry. The ten campuses of the University of California system, private universities, national research laboratories, and private research centers provide excellent resources and support for nanotechnology-related research and development. These resources and high tech infrastructure uniquely position California to become a leader in nanotechnology. Having been a leader and center for the high-tech industry, California has an excellent infrastructure in place for development of this new and highly promising industry.

2.2 Concerns about nanomaterials

There are concerns that the unique properties of nanomaterials might pose substantial risks to both human health and the environment. Data on ecotoxicity or adverse effects of nanomaterials are very limited but it is reported that toxicological behavior of nanomaterials depends on properties such as surface area, quantity, solubility, and shape [3]. Several possible adverse effects of nanomaterials, such as oxidative stress by TiO_2, penetration of zinc oxide (ZnO) particles into animal skin, and structural resemblance of carbon nanotubes to asbestos, have been reported [4, 5]. Additionally, the end-of-life impacts of nanomaterials to human and the environment are largely unknown.

The study of the fate and transport of nanoparticles is concerned with determining how their properties and behavior change over time, particularly after released into the environment. Information on the fate and transport of nanoparticles in the aqueous matrices indicated that the behaviors of nanoparticles show differences in different media [6]. At present, little is known about nanomaterials' fate and transportation in the environment.

3 ADDRESSING THE DATA GAPS BY FEDERAL GOVERNMENT

On October, 2008, the U.S. EPA issued a Federal Register notice regarding carbon nanotubes (CNTs). The notice reminds manufacturers and importers that they must notify EPA 90 days prior to the manufacture or import of new chemical CNTs for commercial purposes, in accordance with TSCA Section 5 regulations for new chemicals at 40 C.F.R. 720.22. This voluntary 2 years program is intended to help inform eventual regulatory decisions about nanomaterials [7, 8].

4 CALIFORNIA DTSC APPROACHES FOR SAFE NANO

DTSC's information call-in is a mandatory program different from that mentioned above and include both commercial and research entities. DTSC will continue to select materials of interest for call-in and start the next official call-in by end of 2010. The selected materials are interest to DTSC because they are currently used in many available commercial products, and DTSC believed the market place should have data on analytical methods, toxicity, physicochemical properties, and fate and transport.

4.1 Process for information call-in by DTSC

DTSC has identified manufacturers throughout the world who produce or import nanometal oxides and nanometals of interest in California, and will cooperate with manufacturers to develop an equitable and resource-efficient approach to filling key information gaps. DTSC will also collaborate with manufacturers throughout the process to identify and prioritize information gaps, and develop strategies to address those gaps. Also, DTSC will collaborate with other organizations to promote better information gathering and share a useful data or ideas.

4.2 What information will be requested?

DTSC will send an official information request letter to manufacturers who produce or import nanometal oxides or nanometals in California or who may export nanometal oxides or nanometals into the State. The letter will has six topics of questions to manufactures regarding analytical test methods, fate and transport and other information on nanometal oxides and nanometals. Six sample questions are:

1. What is the value chain for your company? For example, in what products are your nanometal oxides or nanometals used by others? In what quantities? Who are your major customers?
2. What sampling, detection and measurement methods are you using to monitor (detect and measure) the presence of your chemical in the workplace and the environment? Provide a full description of all required sampling, detection, measurement and verification methodologies.
3. What is your knowledge about the current and projected presence of your chemical in the environment that results from manufacturing, distribution, use, and end-of-life disposal?
4. What is your knowledge about the safety of your chemical in terms of occupational safety, public health and the environment?
5. What methods are you using to protect workers in the research, development and manufacturing environment?
6. When released, does your material constitute a hazardous waste under California Health &Safety Code provisions? Are discarded off-spec materials a hazardous waste? Once discarded are the nanomaterials you produce a hazardous waste? What are your waste handling practices for the nanomaterials?

It is obvious from Question #1 that the value chain of nanometal oxides or nanometals is of interest to DTSC. Who make nanometal oxides or nanometals, what is the production capacity and who use the nanomaterials and where are they located are all important questions. It is critical to understanding the general the value chain of nanomaterial. The application areas should also be identified. It is expected that applications will increase with innovations in technology.

Questions #2 and #5 are about environmental health and safety for workers. Although there are existing protocols for monitoring and testing of particles, and personal protection equipment, they are based on the existing particles, i.e. at least micron scale and not proven effective for nanoscale particles.

Questions #3 and #4 are about the material's properties. The properties of nanomaterials, such as toxicity, reactivity, and physical forms are different from their bulk materials. Nanomaterials' behaviors in air, water, and soil are critical to understand safety and health for ecosystem. Proper disposal or treatment of nanomaterials or nano-containing products in every life cycle stage is necessary to prevent adverse effects from improper handlings.

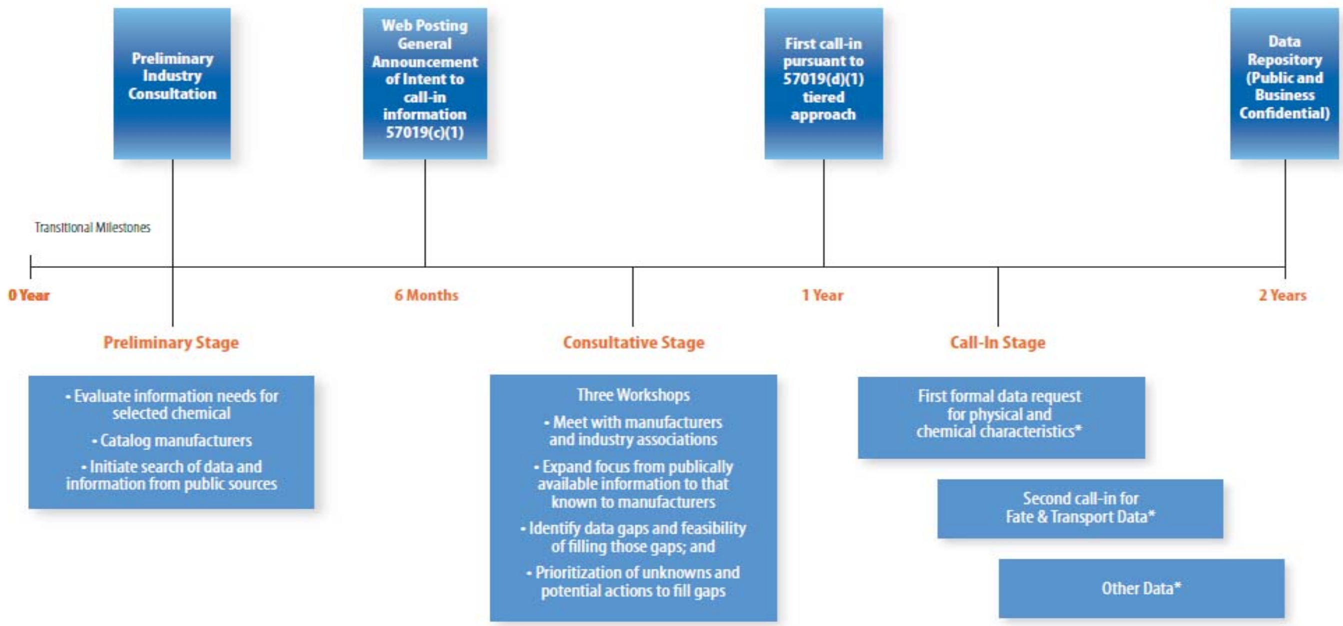

Figure 1: The proposed time line for chemical information call-in.

Question #6 is about the nanomaterials waste handling methods. Nanomaterials are not categorized as hazardous waste but because of the lack of clarity in regard to their toxicity to human and the environment, their proper disposal is considered prudent.

Through these questions, DTSC will understand the nanomaterials flow in industry and basic information about handling practices in manufacturers. This is the first step for filling out information gaps about nano safety and health.

Companies with small size may not have enough ability to cover these issues but it is important to know about current status of nanomaterial that they are handling. Moreover, for those small companies DTSC can provide basic information and it is one of the goals for this information call-in.

4.3 Time line for information call-in

Figure 1 shows the proposed time line for chemical information call-in. Information call-in process will take 2 years of framework. For the first year, DTSC has been met manufacturers and importers of nanomaterials in California and discussed with them for information call-in. And DTSC will send official letter requesting for physical and chemical characteristics of chemical, and fate and transport data to manufacturers and importers in California.

After receiving the formal letter, manufacturers and importers have to reply within 365 days to DTSC. DTSC will post all information on the web site.

5 CONSEQUENCES OF INFORMATION CALL-IN BY DTSC

5.1 What does DTSC expect from chemical information call-in?

Understanding the nature of these materials and their fate and transport in the environment, and how to guard public health, the workforce and the environment from adverse impact is critical to success of the industry. The information call-in will help develop the body of knowledge on nanomaterials and identify gaps in the existing understanding.

5.2 Benefits of industry from information call-in

Evaluating the potential environmental impacts of engineered nanomaterials prior to their mass production is essential to address environmental and human health concern and to develop sustainable nanotechnology.

With recognition of potential risks of nanomaterials, if industry can develop safe nanomaterials industry can avoid unnecessary liability and furthermore contribute for the safe environment.

DISCLAMER: The ideas and opinions expressed herein are those of the author and do not necessarily reflect the official position of the California Department of Toxic Substances Control.

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