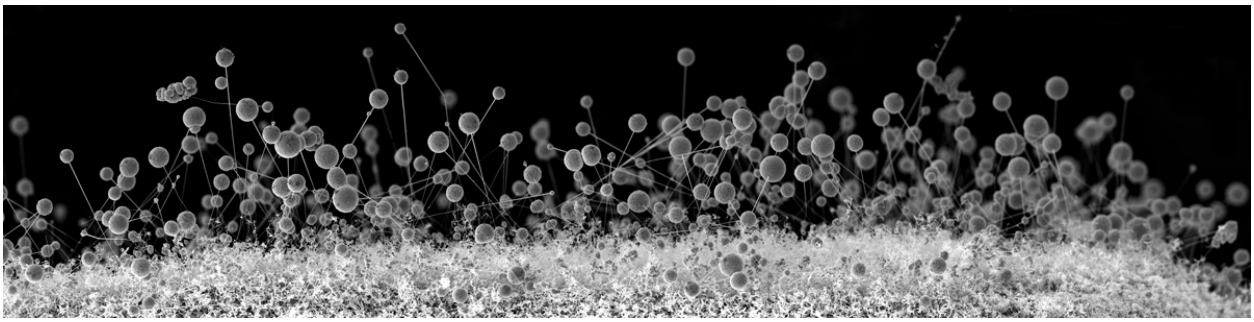
NANOSCALE MATERIALS STEWARDSHIP PROGRAM

Interim Report

January 2009



U.S. Environmental Protection Agency
Office of Pollution Prevention and Toxics

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Cover Photo:
The balls in this picture are germanium and the wires are zinc oxide. They were fabricated inside a tube furnace system at temperature of 900-1000 Celsius degree. The source materials for this synthesis are zinc oxide powder, germanium powder and graphite powder. At the reaction temperature, zinc oxide and germanium oxide powders were reduced by graphite through a reduction reaction, providing zinc and germanium sources for zinc oxide nanowires and germanium balls growth, respectively. In this growth, the germanium balls act as the catalyst which direct the zinc oxide nanowires growth to finally sitting on the top of the nanowires. The diameter of the germanium balls is in the range of 1 to 5 micrometers and the diameter of the zinc oxide nanowires is in the range of 100 to 200 nanometers.

Concept for Image by UGA Fine Art Associate Professor Michael Oliveri
FEI scans taken and assembled by Michael Oliveri
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Nano structures created by UGA Physics and Engineering Assistant Professor Dr. Zhengwei Pan, along with his Post-Doctoral research associates Dr. Zhanjun Gu and Dr. Feng Liu. Credits: Michael Oliveri, Innerspace 4

1 Executive Summary

The Nanoscale Materials Stewardship Program (NMSP) was developed to help provide a firmer scientific foundation for regulatory decisions by encouraging submission and development of information for nanoscale materials. The NMSP comprised two sub-programs, the Basic Program and the In-Depth Program. When the NMSP was initiated, EPA committed to issue this interim report after one year. The Agency welcomes comments on this interim report EPA will issue a more detailed final report and program evaluation at the conclusion of the NMSP in early 2010.

Under the Basic Program, EPA invited participants to voluntarily report available information by July 29, 2008 on the engineered nanoscale materials they manufacture, import, process or use. By that date, the Agency received submissions from 16 companies and trade associations covering 91 different nanoscale materials. As of December 8, 2008, twenty-nine companies or associations submitted information to EPA covering 123 nanoscale materials and a further seven companies have outstanding commitments to the Basic Program. EPA also invited participants to submit new data that became available for nanoscale materials already reported or to identify additional nanoscale materials to report under the Basic Program. EPA is evaluating the information submitted under the Basic Program through a process similar to that of a new chemical review.

Under the In-Depth Program, EPA invited participants to work with the Agency and others on a plan for the development of data on representative nanoscale materials over a longer time frame. By the 6-month mark, one company had agreed to participate in the In-Depth Program; by December 8, 2008, 4 companies have agreed to participate.

Based on the current interim results, the NMSP can be considered successful. However, a number of the environmental health and safety data gaps the Agency hoped to fill through the NMSP still exist. EPA is considering how to best use testing and information gathering authorities under the Toxic Substances Control Act to help address those gaps.

EPA will continue to review new chemical nanoscale materials submitted under the Toxic Substances Control Act sections 5(a) and 5(h)(4) and apply, as appropriate, testing requirements and exposure controls under section 5(e) and Significant New Use Rules (SNURs) under section 5(a)(2).

EPA continues to welcome new participants and information submissions for the NMSP, which will continue until January 2010. The Agency will also continue to explore the best ways to gather the information needed to provide a firmer scientific foundation for regulatory decisions on nanoscale materials.

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2 Introduction

There are unanswered questions about the potential risks of nanoscale materials to human health and the environment. Under the Toxic Substances Control Act (TSCA), EPA has the obligation to ensure that potential risks are adequately understood and controlled to protect human health and the environment. The same special properties that make nanoscale materials useful are also properties that may cause some nanoscale materials to pose potential risks to humans and the environment, under specific conditions. At this point not enough information exists to fully assess these risks. This information is important because EPA will need a sound scientific basis for assessing and managing any unforeseen future impacts resulting from the introduction of nanoscale materials into the environment. A challenge for environmental protection is to help fully realize the societal benefits of nanotechnology while identifying and minimizing any adverse impacts to humans or ecosystems from exposure to nanoscale materials.

The growing diversity and complexity of the types and uses of nanoscale materials available and being developed presents challenges in evaluating risks associated with the manufacture and use of these materials. A risk assessment combines an evaluation of exposure to a given substance with information on the toxicity of the substance to assess or predict the probability, nature, and magnitude of the adverse effects that may occur. Understanding the following key aspects of risk assessment as they relate to nanoscale materials will be necessary for EPA to evaluate and manage any potential risks: chemical identification and physical properties characterization, environmental fate, environmental detection and analysis, human and environmental exposure, human health effects, and ecological effects. In addition, EPA needs to understand how to best apply nanotechnology for pollution prevention in current manufacturing processes and in the manufacture of new nanoscale materials, as well as in environmental detection, monitoring, and clean-up.

This understanding will come from scientific information generated by environmental research and development activities within government agencies, academia, and the private sector. Specific academic examples are the Centers for the Environmental Implications of Nanotechnology (CEIN) and EPA's Science to Achieve Results (STAR) grants on nanotechnology. The National Nanotechnology Initiative will sponsor some of this research. Individual agencies such as the National Institute for Occupational Safety and Health (NIOSH) and EPA are currently conducting this type of research. The Organization for Economic Co-operation and Development (OECD) will spur further research through its Sponsorship Program for Safety Testing a Representative Set of Manufactured Nanomaterials. Manufacturers and users of nanoscale materials will also develop this information. TSCA clearly states in section 2(b)(1) that it is the responsibility of manufacturers to develop such information for chemical substances they manufacture.

3 Development of the Nanoscale Materials Stewardship Program (NMSP)

EPA developed the Nanoscale Materials Stewardship Program ("NMSP" or "the program") to complement and support its regulatory activities on nanoscale materials. The program was designed to help the Agency gather existing data and information from manufacturers, importers, processors, and users of nanoscale materials; to build EPA's knowledge base in this area; and to identify and encourage use of risk management practices in developing and commercializing nanoscale materials. EPA decided to initiate the NMSP to quickly learn about commercially available nanoscale materials, while identifying and encouraging risk management practices. Data developed for and obtained from the NSMP will help EPA to address some of the recommendations identified in the February 2007 EPA Nanotechnology White Paper (http://www.epa.gov/osa/pdfs/nanotech/epa-nanotechnology-whitepaper-0207.pdf). The data will also help to determine next steps in development of environmental health and safety data and appropriate regulatory actions under TSCA. EPA believes that participation in the NMSP will encourage responsible development of nanoscale materials and will benefit all stakeholders. EPA views the data development efforts under the NMSP to be an important integral component of EPA's commitment to national and international efforts to understand exposures, hazards, and risks of nanoscale materials.

3.1 Early Steps

The Agency held an initial public meeting in June 2005 on the TSCA and Nanotechnology (70 FR 24574) to discuss a potential voluntary pilot program for certain nanoscale materials and the information needed to adequately inform the conduct of the pilot program. During the period July through November 2005, EPA worked with a federal advisory committee, the National Pollution Prevention and Toxics Advisory Committee (NPPTAC), to develop further understanding on TSCA and nanotechnology issues. A NPPTAC Interim Ad-hoc Workgroup on Nanoscale Materials was formed and developed an Overview Document that discussed several aspects of TSCA and nanoscale materials, including possible elements of an EPA voluntary program for existing chemical nanoscale materials (http://www.epa.gov/oppt/npptac/pubs/nanowgoverviewdocument20051125.pdf). The document was submitted by the NPPTAC to EPA for its consideration in November 2005.

The Overview Document stated that the degree to which a voluntary program is meeting or has achieved its overall goal and other objectives would depend on the following:

- The rate of participation;
- The amount and quality of information generated by the program participants;
- The adequacy and potential effectiveness of existing risk management practices; and
- The lessons and conclusions that can be drawn from the program experience, for example:
    - Characteristics of nanoscale substances that should be considered in risk assessment and risk management;

- Which, if any, regulatory changes are needed to address nanoscale materials; and
- Risk management practices appropriate to nanoscale substances.

The Overview Document stated that a voluntary stewardship program was an important early step in assisting EPA to assess and address potential risks of engineered nanoscale materials and that a high level of participation and cooperation will provide the public with greater assurance that engineered nanoscale materials will be managed in a responsible and accountable manner. A key outcome of the proposed voluntary program would be to "provide the information and experience necessary to develop an overall approach to the treatment of nanoscale chemical substances under TSCA…"

3.2 Development of the NMSP

EPA subsequently undertook to develop a voluntary stewardship program for nanoscale materials generally following the approach suggested by the NPPTAC document. EPA conducted a scientific public peer consultation on risk management practices for nanoscale materials in October 2006, (http://www.epa.gov/opptintr/nano/nanopublicmeetingsummaryfinaloct2006.pdf). In a discussion paper prepared for the meeting, EPA presented the results of a literature search and asked for input on risk management practices. EPA identified the NIOSH document "Approaches to Safe Nanotechnology: an Information Exchange with NIOSH**"** as a primary resource. Attendees and panelists offered additional comments and resources on risk management practices. One point of general agreement was that EPA should continue to work closely with NIOSH regarding risk management practices for nanoscale materials. EPA continues to consult with NIOSH, especially regarding risk management practices for new chemical nanoscale materials.

In July 2007 (http://www.epa.gov/fedrgstr/EPA-TOX/2007/July/Day-12/t13558.htm), the Agency announced the availability of three draft documents pertaining to the NMSP:

- A Concept Paper for the Nanoscale Materials Stewardship Program;
- TSCA Inventory Status of Nanoscale Materials - General Approach; and
- An Information Collection Request for the NMSP that included a proposed optional reporting form.

EPA held a public meeting in August 2007 to solicit input on the draft documents and the design of the NMSP (http://epa.gov/oppt/nano/mtgsummary080207.pdf).

In September 2007, the Agency held a second scientific public peer consultation. This second consultation focused on material characterization of nanoscale materials (http://www.epa.gov/oppt/nano/mc09072007-mtgsummary.pdf). EPA prepared a document for the meeting which provided background information and contained a series of questions on discussion topics for the material characterization of nanoscale materials. Discussions surrounding those questions informed EPA of data elements that are important for material characterization. Several panel members specifically mentioned surface modification as a potentially important data element. Multiple panelists discussed their view that virtually all

properties have some importance. Some panelists commented that because there is a lack of information regarding potential effects associated with exposure to nanoscale materials, EPA should attempt to acquire as much information as possible rather than limiting the effort to investigate certain properties. Other panelists acknowledged that all properties could potentially result in an impact; however, they felt it would be more appropriate to prioritize efforts and focus on properties that are most likely to result in an impact. They acknowledged that the costs associated with testing may have an impact on which tests should be performed, if only limited useful information would be produced.

EPA finalized its approach under the NMSP based on written public comments, comments received at the public meeting, and the two scientific peer consultations. Subsequently, on January 28, 2008, the Agency announced the final design and format of the NMSP in the Federal Register (http://www.epa.gov/fedrgstr/EPA-TOX/2008/January/Day-28/t1411.htm) and invited interested parties to participate in the program.

The NMSP has two components, a Basic Program and an In-Depth Program:

- Under the Basic Program, EPA asked manufacturers, processors, importers, and users of chemical nanoscale materials to submit existing information on their nanoscale materials, i.e., physical and chemical properties, hazard, exposure, use, and risk management practices or plans, during the first six months of the program. The Agency also invited researchers who develop or study engineered nanoscale materials to participate.

- Under the In-Depth Program, EPA invited participants to sponsor the development of test data for representative nanoscale materials and to work with the Agency to devise a data development plan. A particular sponsor may choose to implement one or more aspects of the plan; or a consortium of sponsors and other stakeholders may work together to implement aspects of the plan. At its completion, EPA and sponsors will review the information gathered; consider input from stakeholders; conduct final assessments; and consider further action. Efforts under the In-Depth Program are relevant to the work being done under the OECD Working Party on Manufactured Nanomaterials (WPMN) (see Section 7.1.3 for further description of the WPMN).

EPA conducted an extensive outreach campaign to educate and encourage participation in the NMSP. In addition to the Federal Register notices, public meeting, and two peer consultations discussed above, the Agency reached out to over 150 individual companies and 11 trade associations through letters, phone calls, and meetings. EPA senior managers and staff presented on the NMSP at over 30 international, national, and regional meetings. EPA also discussed the NMSP with other federal agencies to get their input and to encourage federal and non-federal researchers to participate in the program.

4 Summary of Data Received under the Basic Program

Under the Basic Program, EPA invited participants to voluntarily report available information by July 28, 2008 on the engineered nanoscale materials they manufacture, import, process or use. By that date, the Agency received submissions from 16 companies and trade associations covering 91 different nanoscale materials based on 47 different chemicals[1]. The comparative work in this report is based only on submissions received by September 1, 2008[2] and includes submissions from 21 companies and trade associations and on 106 nanoscale materials based on 52 different chemicals. A listing of participating companies and trade associations and the nanoscale materials they have reported is attached as Annex C. A more up-to-date listing is also available on EPA's NMSP website (http://www.epa.gov/oppt/nano/stewardship.htm) which is updated whenever EPA receives additional information. EPA has posted copies of all non-confidential submissions and, when supplied by NMSP participants, sanitized versions of confidential submissions on the website. The information and results presented in this section are preliminary and may change as the Agency receives more information and finalizes its assessment of the NMSP submissions.

Thus far, the program has considerably increased the Agency's understanding of the types of nanoscale materials in commerce. Most submissions included information on physical and chemical properties, commercial use (realized or projected), basic manufacturing and processes as well as risk management practices. However, very few submissions provided either toxicity or fate studies. Because many submitters claimed some information as confidential business information, the Agency is limited in the details of what it can report for any particular submission.

In reviewing the submissions, the Agency recognized that many materials are currently produced only for research and development (R&D) purposes. This information is important to the Agency for several reasons, including:

- Providing a baseline assessment of the relative commercialization of different nanoscale materials;
- Allowing the Agency to identify nanoscale materials near commercialization and prioritizing future research and regulatory efforts; and
- Informing Agency staff on various nanoscale material issues including environmental fate, toxicity, and physical-chemical properties in comparison to the bulk scale. The Agency anticipates drawing upon this in-house experience in future nanoscale material regulatory and research work, including the New Chemicals Program.

[1] As of December 8, 2008, twenty-nine companies and trade associations have submitted information to EPA covering 123 nanoscale materials based on 58 different chemicals. Another seven companies have committed to submit information.

[2] Technical challenges with repeating the comparison as new submissions continue to be received prevents on-they-fly updates.

Figure 1 illustrates the number of nanoscale materials and chemicals used for R&D purposes as well as commercial activities submitted to the NMSP. It is important to note that EPA maintains a distinction between "chemical substances" and "nanoscale materials" throughout this report. "Chemical substances", as defined under TSCA, are distinguished by unique molecular identities, and, in this report, are referred to as chemicals. This issue is discussed in more detail in the EPA paper on the TSCA Inventory Status of Nanoscale Substances – General Approach (http://www.epa.gov/oppt/nano/nmsp-inventorypaper2008.pdf). From submissions to the NMSP as well as other information sources used in the comparison discussed in Section 5, it is not always possible to determine the exact molecular identities of the nanoscale materials provided. Information in some submissions was such that only a portion of the molecular identity was reported, e.g. this might be the case for a substance that was coated with another unidentified substance or for a substance for which the crystal structure was not provided. For the purposes of this report, these materials with incomplete or unidentifiable molecular identities are grouped based on the available information regarding the primary composition of the core substance (as opposed to a surface coating). As part of the follow-up work, EPA will work to clarify the molecular identities of the submissions.

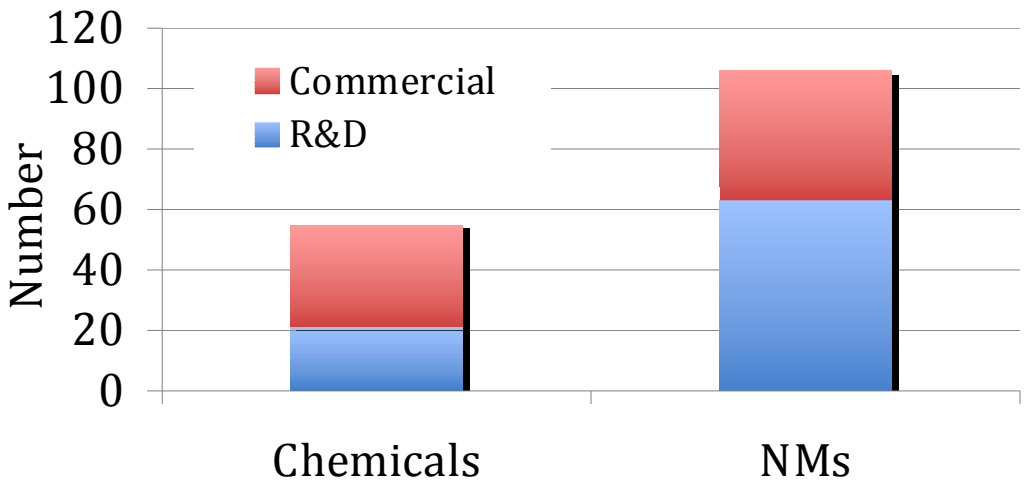

Figure 1 Many nanoscale materials (NMs) in the NMSP are for R&D purposes only. However, when those submissions are grouped into chemical substances, Agency received at least one commercial nanoscale material submission for the majority of cases.

For this NMSP interim report, the Agency considered each substance submitted to the Basic Program to be a unique "nanoscale material". Nanoscale materials include research, pre-commercial, and commercial nanoscale substances and may be different chemicals (e.g. anatase titanium dioxide and rutile titanium dioxide) or that are different physical forms of the same chemical (e.g. 10 nm rutile titanium dioxide and 20 nm rutile titanium dioxide). Some submitters reported "nanostructured" materials, i.e. a material whose overall material size was greater than 100 nanometers (nm) but which contained active structures within the materials of less than 100 nm. The Agency would find it helpful to continue to receive more information on each of the commercial nanoscale materials being produced.

Although not being able to identify the specific molecular identity of all nanoscale materials provided, the Agency has identified 18 nanoscale materials in the NMSP submissions as potentially being "new" chemicals under TSCA; these, include nanoscale materials that are at the research and development stages. As the molecular identities of many submissions are incomplete, any designations of a chemical or nanoscale material as "new" or "existing" in this report is based solely on the best available information and is not a determination for regulatory purposes.

For initial comparative purposes, Figures 2 and 3 group the NMSP nanoscale materials by general chemical category and general physical shape, respectively, noting the breakdown of commercial versus R&D as in Figure 1.

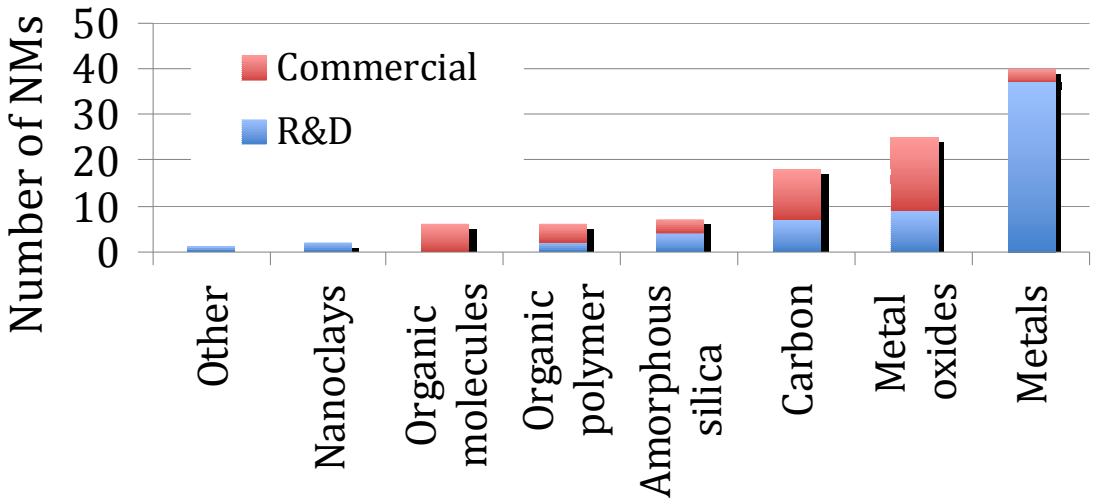

Figure 2 Submissions of the nanoscale materials (NMs) in the NMSP grouped by chemical category.

Figure 4 illustrates data elements reported as a percentage of NMSP submissions; most of the reported data elements in the NMSP were for use, material characterization, and risk management practices. Relatively little environmental health and safety data was reported. For this interim report, EPA did not analyze the utility or completeness of the data elements of the submissions; this analysis will be provided in the final report of the NMSP.

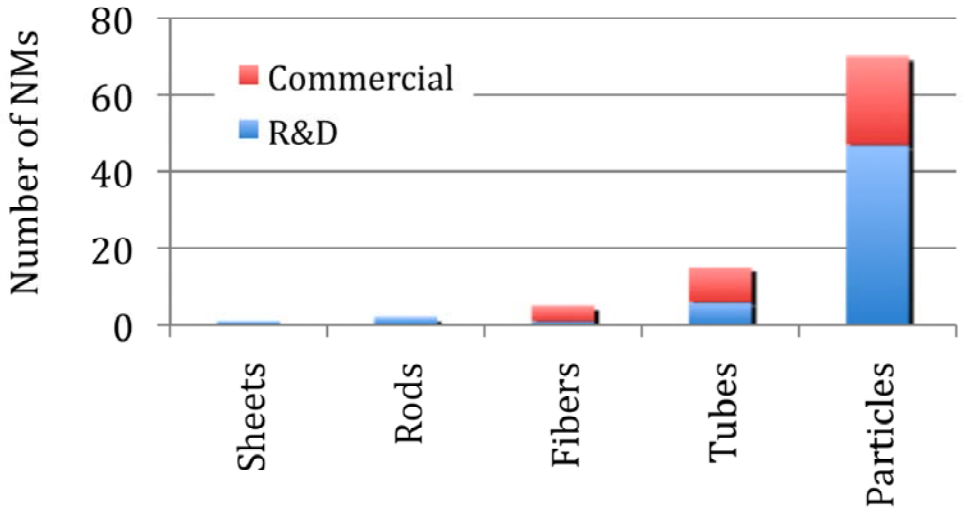

Figure 3 Submissions of the nanoscale materials (NMs) in the NMSP grouped by physical shape

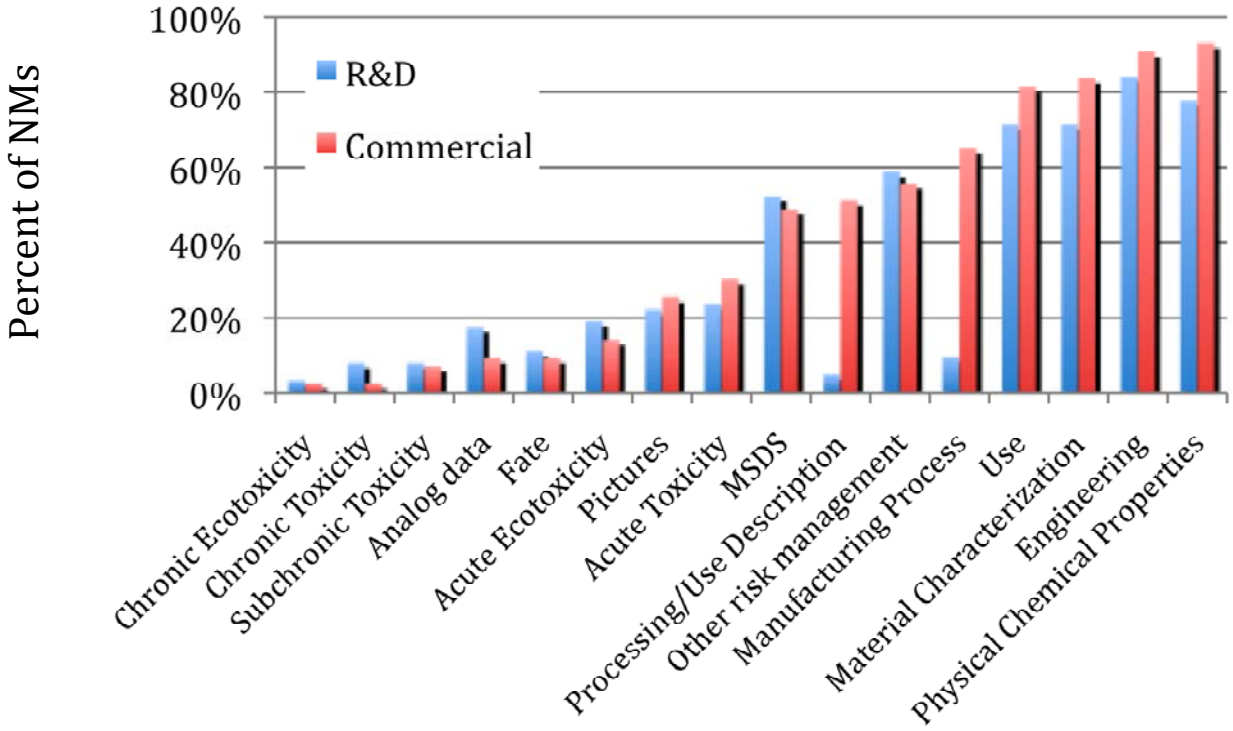

Figure 4 Submissions of nanoscale material (NMs) to the NMSP by inclusion of data for a particular element

5 Comparison of Data Received in the Basic Program with Available Information on Commercial Nanoscale Materials

As far as EPA is aware, there is no comprehensive database of nanoscale materials, which is a critical need for better understanding the universe of commercially available nanoscale materials. Consequently, over the past several months, EPA developed a baseline of the nanoscale materials that are apparently commercially-relevant in the United States. In developing this baseline, EPA evaluated two well-recognized data sources[3] for nanoscale materials, the Nanowerk Nanomaterials Database and the Wilson Center Project on Emerging Nanotechnologies (PEN) Inventory of Nanomaterials in Consumer Products, and compared the information in these data sources with information received in the NMSP submissions. The Agency welcomes further views on expanding and refining this comparison. The information and results presented in this section are preliminary and may change as the Agency receives more information and finalizes its assessment of the NMSP submissions and the underlying datasets.

5.1 Limitations of the Comparison

In utilizing this data, the Agency acknowledges there are limitations with both the Nanowerk and Wilson Center databases; neither were designed to answer questions regarding any specific company's production or use of a particular nanoscale material. These databases had other limitations that are described below.

Nanowerk LLC collects, catalogs, and publishes information on nanoscale materials that are available for commercial and research sale. The Nanowerk database does not, for example: distinguish between research and commercial use; regularly update the availability of the listed nanoscale materials from the companies listed; or verify the characterization data provided by the companies. Furthermore, not every material that the Agency has identified from its review of the literature as being produced in the nanoscale form is included in the Nanowerk database (e.g., non-carbon nanotubes and caged structures analogous to carbon fullerenes, nanoclays, and dendrimers).

The Wilson Center PEN collects, catalogs, and publishes information on commercial products for which the manufacturer makes a reasonable claim or appears to make a claim that the product contains nanoscale materials. The PEN database does not verify whether a particular product actually does contain nanoscale materials nor does it always provide the specific molecular identity and form of a particular nanoscale material for verification. Commercial

[3] Further data sources under consideration by EPA for its ongoing analyses include: Environmental Working Group Survey of Nano-Scale Ingredients in Cosmetics, the National Nanotechnology Initiative and EPA reports on nanoscale materials, results of similar initiatives in other countries reported through the OECD WPMN, and from searching scientific literature and company promotional websites.

products that are not advertised by manufacturers to contain nanoscale materials are not likely included in the database.

It is important to note that many of the products and materials included in the PEN and Nanowerk databases may be excluded from or exempted under TSCA regulation (cosmetics, pesticides, R&D chemicals, etc.). Additionally, some substances or products may be manufactured outside the U.S., but for this report, EPA assumes that they may be available for importation. These databases also do not include every supplier or every commercial form of a nanoscale material that may be available for sale.

5.2 Comparison Results

At the Agency's request, the Nanowerk data were graciously provided by Nanowerk LLC as of July 15, 2008, with some data removed to protect intellectual property. The Agency did not remove non-US companies from the comparison because the substances may be available for import into the US. As part of the comparison, the Agency merged equivalent fields from disparate tables to create a single table describing 2,084 potential nanoscale materials. Excluding materials not of interest to EPA for the NMSP and materials that would be considered "new" chemicals under TSCA (such as carbon nanotubes and fullerenes)[4], and by grouping together entries that had the same molecular identity, EPA identified 1332 nanoscale material submissions based on 199 unique existing chemicals. For the purposes of this report and as a starting point for discussion, EPA considered evidence of 5 commercial product forms (as described as in Section 4 of this report) of a chemical substance in the Nanowerk database to indicate commercial relevance.[5] Using this threshold, EPA identified 55 commercially-relevant chemicals in the Nanowerk database.

EPA utilized the PEN data from the February 22, 2008 update of the database for this comparison. As with the Nanowerk database, the Agency merged equivalent fields from this table with a master table of nanoscale materials from the other sources. Of the 606 products in the database, EPA was able to identify or make a reasonable estimate of at least the partial molecular identity in 467 products (77%) for a total of 566 nanoscale materials (some products appeared to contain multiple nanoscale materials)[6]. The Agency considered the likely presence

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[4] For the purposes of this report, "new" chemicals include those that would have been reported to the Agency as a new chemical in commerce since January 1st, 2005, as well as chemicals that have not yet been reported. "Materials not of interest" to the NMSP are based on the 2008 NMSP Concept paper, Annex A, Section 3.2 available at: http://www.epa.gov/oppt/nano/nmsp-conceptpaper.pdf, but these exclusions are applied only to the PEN and Nanowerk datasets for comparison purposes.

[5] The Agency selected the threshold of 5 commercial product forms for this interim report largely because, in reviewing individual nanoscale materials it became clear that a high proportion were likely to be "made to order" and/or available only for R&D, particularly when only one or a few forms were listed. EPA would like to better refine this baseline approach for the final report, and would welcome comments on the selected methodology.

[6] EPA was not able to identify any nanoscale material in 66 of the products and made a reasonable estimate for the identity of a nanoscale material in 63 products, based on available

of a nanoscale material in a single commercial product to be sufficient for meeting the threshold of commercial-relevance. Using this threshold, EPA identified 48 commercially-relevant chemicals in the PEN database.

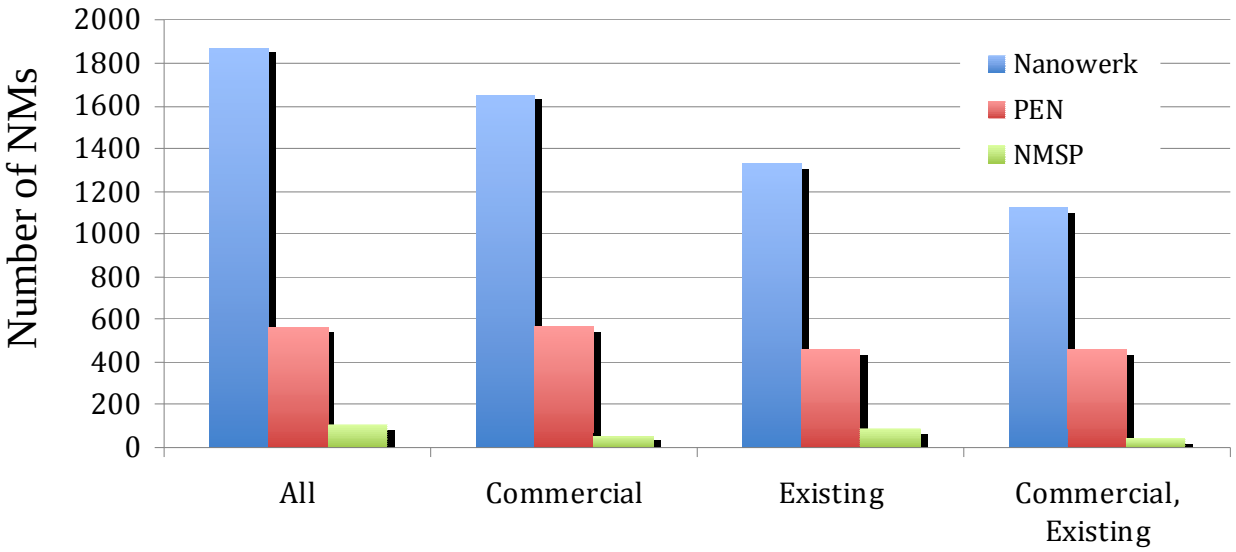

Figure 5 Comparison of Nanowerk, PEN, and NMSP nanoscale materials. Only nanoscale materials with a molecular identity of interest to EPA under the NMSP are counted, and 'existing' refers to nanoscale materials that have a molecular identity corresponding to an existing chemical on the TSCA Inventory.

Figure 5 compares the number of distinct nanoscale materials in the three datasets using the three different data sources. **Figure 6** compares the number of distinct chemicals in the three datasets. Both figures consider the likely commercial status and whether the nanoscale material is on the TSCA Inventory (i.e., "existing"). Comparing either the Nanowerk or PEN datasets to the submissions received under the NMSP demonstrates the potential for significant gaps between existing chemicals that may already be commercialized and those submitted under the NMSP.

Figure 7 and Figure 8 examine the overlap between the different datasets of existing chemicals and existing commercially-relevant ones, respectively. EPA found a total of 234 unique existing chemicals with Nanowerk having 199, PEN with 48, and the NMSP with 34. The diagrams indicate that each dataset contains a significant number of chemicals at the

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information. The Agency suspected that 78 of the products might contain a nanoscale material, but was not able to ascertain the molecular identity. EPA identified 48 existing chemicals of interest and four categories of nanoscale materials (such as nanoclays or polymers) for which a specific molecular identity could not be ascertained. For the cases where only chemical category could be determined, we counted each instance as a unique chemical. Fluorinated polymers in the PEN database are counted as a single chemical although they may ultimately have different chemical identities as they originate from a single company and brand.

nanoscale exclusive to that dataset: 85% in Nanowerk, 46% in PEN, and 26% in the NMSP. EPA found a total of 91 unique commercially-relevant existing chemicals with Nanowerk having 54, PEN with 48, and the NMSP with 15. The diagrams indicate that each dataset contains a significant number of chemicals at the nanoscale exclusive to that dataset: 63% in Nanowerk, 58% in PEN, and 29% in the NMSP. A significant challenge and follow-up activity is to determine the uniqueness of substances for which only limited molecular identity information is available. For example, each incomplete polymeric substance is counted as unique because of the tremendous variety of polymers available today. While each dataset has a significant proportion of chemicals unique to that dataset, the overlap of the datasets is remarkably consistent with the OECD testing efforts (described in Section 7.1.3) on a representative group of 14 commercial nanoscale materials. Seven of the twelve substances common to all three datasets of existing chemicals (Figure 8) are targeted for testing. Only four substances are missing from all three datasets: nanoclays, dendrimers, polystyrene, and iron. Twelve of the fourteen OECD representative substances are covered by the NMSP; only iron and dendrimers are missing.

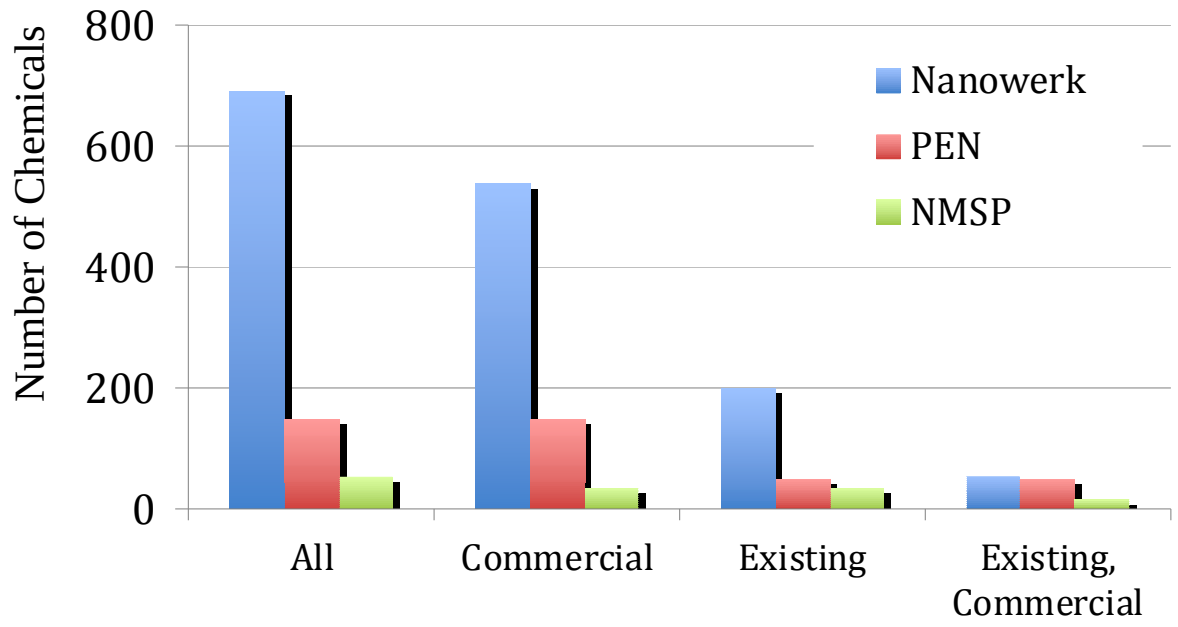

Figure 6 Comparison of Nanowerk, PEN, and NMSP chemicals. Only NMs with a molecular identity of interest to EPA under the NMSP are counted, and 'existing' refers to NMs that have a molecular identity corresponding to an existing chemical on the TSCA Inventory.

Note: For counting purposes in this report, each carbon nanotube in the datasets is counted as a unique chemical (over 400 in Nanowerk) because the Agency has not yet set a policy for distinguishing or grouping carbon nanotubes for TSCA Inventory purposes. Hence, chemical counts are significantly increased. They are treated as 'new' chemicals, however, and therefore are not included in the existing chemicals analysis.

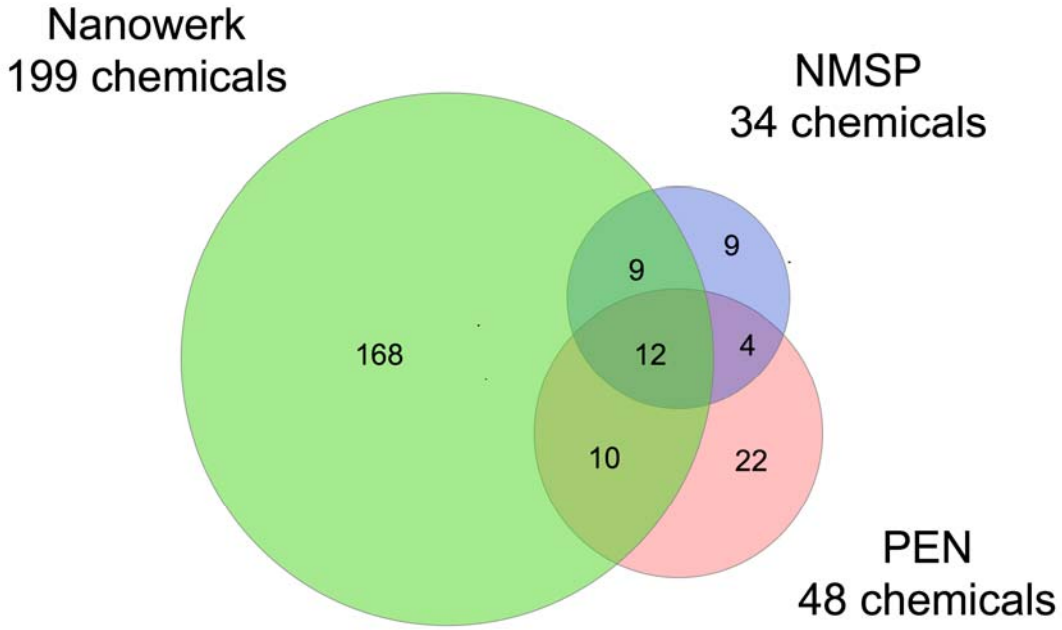

Figure 7 Overlap of existing chemicals between the Nanowerk, PEN, and NMSP datasets. EPA found a total of 234 unique existing chemicals. The counts refer to the chemicals in each category of overlap. In addition to the 34 existing chemicals, the NMSP contained 18 new or likely to be considered new chemicals.

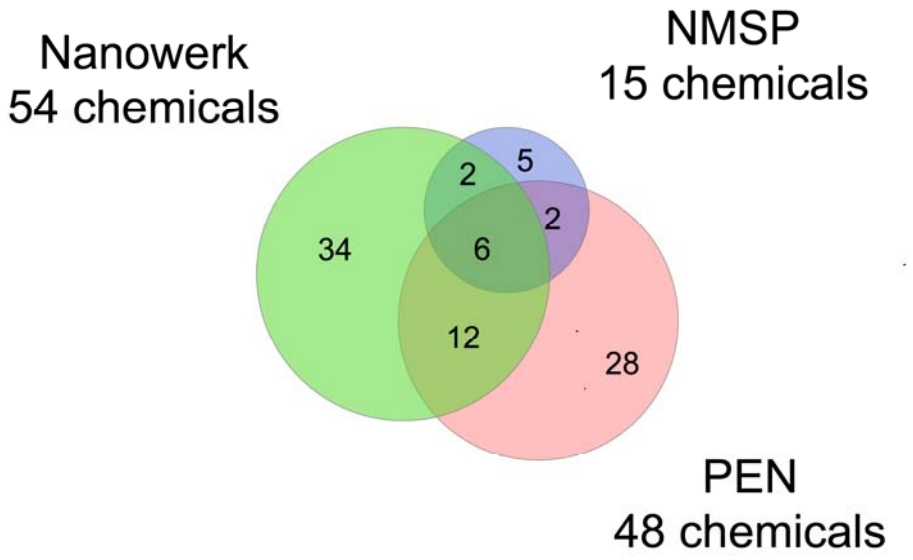

Figure 8 Overlap of existing commercially-relevant chemicals between the Nanowerk, PEN, and NMSP datasets. EPA found a total of 91 unique chemicals. The counts refer to the chemicals in each category of overlap. Beyond the 15 chemicals

5.3 Summary and Next Steps of the Comparison

Combining all three datasets, EPA identified over 200 existing chemicals that are produced at the nanoscale for commercial and R&D purposes, of which 91 are likely to be manufactured for commercial purposes. Of these, 28 chemicals are included in the NMSP submissions under the Basic Program. However, only 15 of these 28 commercially-relevant, existing chemicals in the NMSP had submissions indicating commercial production – the rest were R&D submissions. The NMSP also included four submissions on existing commercial chemicals that were not in the Nanowerk or PEN datasets. While the comparison is not complete, it illustrates a potential gap between the approximately 91 different chemicals from which commercially-relevant nanoscale materials may be produced and the submissions under the NMSP. However, through the NMSP and the TSCA New Chemicals programs, as well as as other programs described in Section 7 (in particular, the OECD testing priorities discussed in Section 7.1.3), the Agency has identified additional commercially available nanoscale materials that would not meet the likely commercial production thresholds from the Nanowerk and PEN datasets alone. The Agency will continue to consider other sources of data and tools for identifying commercial production of nanoscale materials.

This interim comparison provides a framework that supports the Agency's evaluations and decision-making. EPA is, for example, considering the comparison as an additional source of information to possibly refine the chemical categories of nanoscale materials proposed in the material characterization public meeting held in September 2007 (http://www.epa.gov/oppt/nano/mc09072007-mtgsummary.pdf). Because the differences between bulk and nanoscale materials are poorly understood, developing categories of relevant chemicals with similar properties may assist the Agency in developing models to predict relevant physical-chemical and other properties as they apply to nanoscale materials. Additionally, the Agency has already used the datasets to identify and reach out to potential stakeholders and will continue these outreach activities.

6 Report on the In-Depth Program Participation

Under the In-Depth Program, EPA invited participants to work with the Agency and others on a plan for the development of data on representative nanoscale materials over a longer time frame. As December 8, 2008 four companies have committed to participate thus far; SouthWest NanoTechnologies, Inc., Swan Chemicals Inc., Unidym, and Selah Technologies. The nanoscale materials covered are carbon nanotubes and a carbon nanoparticle.

In early 2009, EPA plans to initiate an appropriate procedure to further discussions with these companies towards the design and implementation of an In-Depth testing program.

In addition, the American Chemistry Council (ACC) has expressed an interest in working with EPA towards a research program that may help develop a better understanding of the risks of nanoscale materials.

7 Other Relevant Activities in the US Government and Internationally

EPA is providing leadership regarding the development and implementation of regulatory oversight on nanoscale materials that are regulated under TSCA. These efforts have involved a variety of activities for nanoscale materials as described in this report to develop data, engage nationally and internationally with other regulatory entities, undertake extensive outreach activities, and regulate new chemical nanoscale materials. The NMSP exists in the context of these ongoing data development (research and testing) and regulatory programs. At the Agency, overarching research goals were outlined in the February 2007 EPA Nanotechnology White Paper.

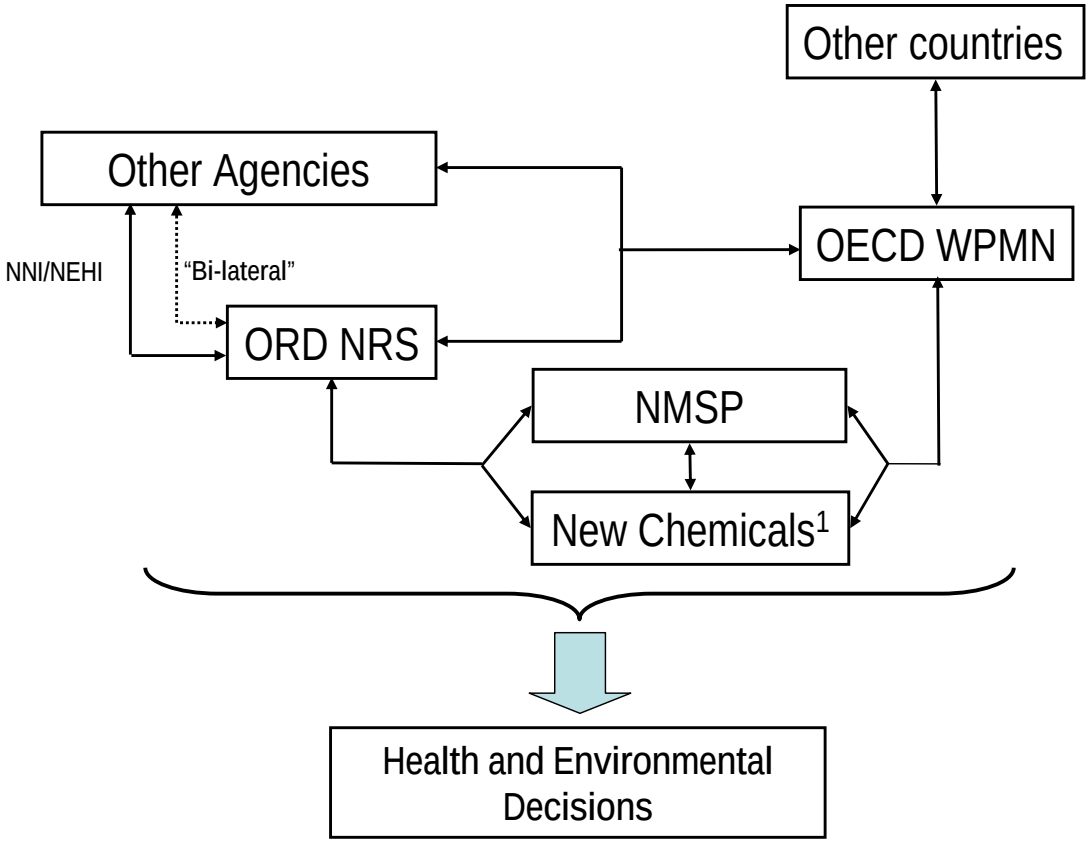

Figure 9 The NMSP in the context of other research and regulatory programs. The Office of Research and Development (ORD) has developed a Nanomaterial Research Strategy (NRS) that is discussed in Section 7.1.1. The National Nanotechnology Initiative (NNI) has established the Nanotechnology Environmental and Health Implications (NEHI) working group to coordinate federal research on environmental health and safety studies (Section 7.1.2). At the international level, the Organization for Economic Co-operation and Development (OECD) has established the Working Party on Manufactured Nanomaterials (WPMN), which is discussed in Section 7.1.3.

[1]The NMSP directly interacts with EPA's regulatory efforts on new chemical nanoscale materials, which is addressed in Section 7.2.1.

7.1 Data and Standards Development (Research and Testing)

7.1.1 ORD's Nanomaterial Research Strategy (NRS)

The purpose of the Nanomaterial Research Strategy is to guide the EPA's Office of Research and Development's program in nanomaterial research. The strategy builds on and is consistent with the foundation of scientific needs identified by the Nanotechnology Environmental and Health Implications Working Group (http://www.nano.gov/NNI_EHS_Research_Strategy.pdf), and in the EPA's *Nanotechnology White Paper* (http://www.epa.gov/osa/pdfs/nanotech/epa-nanotechnology-whitepaper-0207.pdf)). The purpose of EPA's nanotechnology research program is to conduct focused research to inform decisions related to nanomaterial implications and applications that may be made under the various environmental statutes for which the EPA is responsible. EPA recognizes that the information generated through its research program likely will have use in areas beyond the Agency's purview. EPA is collaborating across the government, industry, and the international community to implement this strategy. EPA's in-house research program has the capability to leverage results from EPA grant programs, as well as to collaborate with grantees to address the many challenging research issues outlined in this strategy. EPA's strategy focuses on four areas that take advantage of EPA's scientific expertise as well as fill gaps not addressed by other organizations. The four research themes are:

- Identifying sources, fate, transport, and exposure
- Understanding human health and ecological effects to inform risk assessments and test methods
- Developing risk assessment approaches
- Preventing and mitigating risks

Annex A provides a fuller description of the NRS.

7.1.2 NNI/NEHI

The 21st Century Nanotechnology Research and Development Act resulted in the implementation of The National Nanotechnology Initiative (NNI). The NNI created a framework for a comprehensive nanotechnology R&D program by establishing shared goals, priorities, and strategies (http://www.nano.gov/html/about/home_about.html). The NNI consists of the individual and cooperative nanotechnology-related activities of 25 Federal agencies with a range of research and regulatory roles and responsibilities. The NNI does not itself fund research. Rather, it informs and influences the Federal budget and planning processes through NNI's individual member agencies, each of which conducts its own nanotechnology activities, including research, in a manner consistent with its mission. EPA coordinates its nanotechnology research activities with other federal agencies through the NNI. The Nanoscale Science, Engineering and Technology (NSET) Subcommittee coordinates many of the NNI activities that provide channels for the exchange of information and the formulation of research strategies that accelerate progress towards understanding the risks and benefits of nanotechnology. The Nanotechnology Environmental and Health Implications (NEHI) Working Group of the NSET coordinates research relevant to and practices that protect human health and safety as well as the environment (http://www.nano.gov/html/society/NEHI.html). The NSET Subcommittee and

NEHI Working Group provide leadership in establishing the national nanotechnology environmental, health, and safety research agenda and in communicating data and information related to environmental and health aspects of nanotechnology between NNI agencies and with the public.

7.1.3 OECD

The OECD Council established the Working Party on Manufactured Nanomaterials (WPMN) as a subsidiary body of the Chemicals Committee in September 2006. The Program of Work of the WPMN can be found at: http://appli1.oecd.org/olis/2008doc.nsf/linkto/env-jm-mono(2008)2. EPA participates in and chairs the WPMN. The WPMN is engaged in a variety of projects to further the understanding of the properties and potential risks of nanoscale materials. (See Annex B for further description) One project involves a *Sponsorship Program for Safety Testing a Representative Set of Manufactured Nanomaterials*. The program is designed to have sponsors develop a set of testing endpoints for a representative group of 14 commercially-relevant nanoscale materials. For more information on the endpoints and the list of manufactured nanoscale materials see http://appli1.oecd.org/olis/2008doc.nsf/linkto/env-jm-mono(2008)13-rev. EPA is sponsoring environmental effects and fate testing of fullerenes, single walled carbon nanotubes, multiwalled carbon nanotubes, silver nanoparticles and cerium oxide as part of the OECD program. Annex D lists the 14 representative nanoscale materials and contains a summary of sponsors as of October 13, 2008.

7.1.4 International Organization for Standardization Technical Committee 229 (ISO/TC229)

The International Organization for Standardization (ISO) has established a technical committee to develop international standards for nanotechnology. This technical committee, ISO/TC229, is working to develop standards for terminology and nomenclature, metrology and instrumentation, including specifications for reference materials, test methodologies, modeling and simulation, and science-based health, safety and environmental practices. EPA actively participates and contributes to ISO working groups.

7.2 Regulatory and Policy Development

7.2.1 Regulatory Efforts on New Chemical Nanoscale Materials

Under TSCA section 5, notices for chemical substances that have a molecular identity different from those listed on the TSCA Chemical Substances Inventory are required to be submitted to EPA for review prior to commercial manufacture or import. In January, 2008, EPA published a paper on the "TSCA Inventory Status of Nanoscale Substances – General Approach." This paper reiterated the Agency's long-standing application of the definition of "chemical substance" under TSCA Section 3(2)A that chemical substances that may be available in different physical forms but that have the same molecular identity constitute a single chemical substance for purposes of the TSCA Inventory and new chemical reporting[7].

[7] Available at: http://www.epa.gov/oppt/nano/nmsp-inventorypaper2008.pdf.

Although the General Approach paper dealt with the case of allotropes of a material as being new chemicals if not listed on the Inventory, the Agency found some confusion among manufacturers particularly with respect to carbon nanotubes (CNTs). EPA subsequently published a Federal Register notice (73 FR 64946) on October 31, 2008 explicitly stating that CNTs are considered distinct chemical substances from graphite or other allotropes of carbon listed on the TSCA Inventory. Since January 2005, EPA has received and reviewed more than fifty new chemical notices under TSCA for nanoscale materials including carbon nanotubes and fullerenes. In some cases, new chemical notices were submitted on nanoscale materials following a bona fide intent to manufacture query from a manufacturer to determine the TSCA Inventory status of the substance in question.

Where necessary, the Agency has taken steps to control or limit exposures to nanoscale materials submitted for TSCA new chemical review, including:

- limiting the uses of the nanoscale materials;
- requiring the use of personal protective equipment, such as impervious gloves and NIOSH approved respirators; and
- limiting environmental releases.

The Agency has also required testing to generate health and environmental effects data where appropriate. EPA has permitted limited manufacture of new chemical nanoscale materials by using administrative orders under section 5(e) of TSCA and/or Significant New Use Rules under section 5(a)(2) of TSCA. The Agency has also allowed limited manufacture of new chemical nanoscale materials under the terms of certain regulatory exemptions (fewer than 10 through November 2008), but only in circumstances where exposures were tightly controlled to protect against unreasonable risks (using, for example, specific protective equipment and stringent environmental release limitations).

The Agency believes the NMSP and other initiatives described in the previous paragraphs will ultimately provide strong support for activities conducted under EPA's New Chemicals program. Each submission in the NMSP is undergoing a review similar to that of a new chemical. At the current time, EPA has utilized the existing framework of the new chemicals review process with some additional questions specifically designed to deal with nanoscale materials. As part of the review process, EPA is identifying additional issues and questions. A full analysis of experience and reviews under the new chemicals program will be included in the final report on the NMSP.

7.2.2 Nanotechnology Policy Coordination Group (NPCG)

Recognizing the need for policy coordination, EPA proposed and contributed to the establishment of the Federal Nanotechnology Policy Coordination Group (NPCG). The NPCG identifies, coordinates, and addresses policy questions associated with nanotechnology issues that affect multiple federal agencies with diverse goals and missions and is co-chaired by Office of Science and Technology Policy and the Council on Environmental Quality. The NPCG has

contributed to the development and elaboration of a coordinated federal policy approach, including development of a document entitled "Principles for Nanotechnology Environmental, Health, and Safety Oversight". This document outlined generally applicable principles relevant to oversight for nanotechnology by the Federal government and was issued on November 8, 2007. (http://www.ostp.gov/galleries/default-file/Nano%20EHS%20Principles%20Memo_OSTP-CEQ_FINAL.pdf)

7.2.3 Other

There are other offices or federal agencies engaged in regulatory or policy development efforts applicable to nanoscale materials. For example, EPA regulates products intended to control pests under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The Food and Drug Administration uses its authority under the Federal Food, Drug, and Cosmetic Act (FFDCA) to ensure that drugs, drug delivery systems, cosmetics, medical devices, vaccines, and food products reaching the marketplace are safe and effective. Regulation of exposure to chemicals in the workplace falls under the Occupational Safety and Health Administration's general industry standards. The National Institute for Occupational Safety and Health (NIOSH) is responsible for research on and development of recommended occupational exposure levels and work practices. EPA's implementation of the NMSP gives due consideration to the important roles of these agencies in evaluating and addressing the potential risks of nanoscale materials. In addition, EPA is sharing information and experience gained through the NMSP with these agencies.

7.2.4 International Policy Coordination Efforts

The OECD WPMN project on Cooperation on Voluntary Schemes and Regulatory Programs illustrates the benefits of sharing experiences with other governments. EPA was able to share internationally the information available through its NPPTAC overview document, peer consultations and other experiences in developing the NMSP. EPA has also learned from the experience of other countries in developing and implementing voluntary reporting programs of the necessity for confidentiality, outreach, and deadlines to make such programs more successful. EPA has also exchanged information with other governments regarding application of regulations to nanoscale materials.

Other countries' national chemical programs have also begun to address nanoscale materials. For example, the United Kingdom's Department of Environment, Food, and Rural Affairs established a voluntary reporting program similar to the NMSP in September 2006. To date they have received 11 submissions – 9 from industry, 2 from academia[8]. Australia has published a voluntary call for information regarding the volumes, types and data holdings of nanoscale materials that are being used within Australia as industrial chemicals in the 2008 calendar year. The voluntary call for information is directed to industry and researchers. Canada is developing a mandatory information gathering survey for nanoscale materials under the authority of the Canadian Environmental Protection Act of 1999. The European Commission has determined that nanoscale materials are covered under the REACH (Registration, Evaluation,

[8] Defra, 2008. "The UK Voluntary Reporting Scheme for Engineered Nanoscale materials: Seventh Quarterly Update." Accessed on December 12, 2008 at: http://defra.gov.uk/environment/nanotech/pdf/vrs-sevetnh-progress-report.pdf.

Authorization and Restriction of Chemicals) legislation and will consider if there is a need for specific REACH regulations as they pertain to nanoscale materials.

8 Conclusions

EPA has received a significant amount of data through NMSP submissions and believes that the NMSP has contributed to a considerably stronger and better informed understanding of the issues and commercial status of nanoscale materials in the United States. The Agency is still analyzing those data and expects to receive additional submissions from companies that have committed to participate. Midway through the program, the Agency considers the NMSP successful for a number of reasons:

- The participating companies and associations have demonstrated solid commitment to the NMSP's Basic Program and provided EPA with considerable amounts of valuable data (e.g., material characterization, uses, etc.) the Agency would not have otherwise obtained in less than a year, including enhancing EPA's understanding of:
    - the risk management practices currently employed by companies for nanoscale materials; and
    - nanoscale materials used in research and development, which has contributed to EPA's Nanomaterial Research Strategy.

- The development and implementation of the NMSP has informed EPA's regulatory understanding of nanoscale materials, including:
    - how to structure and effectively report information on nanoscale materials, including the development and elaboration on policy guidance which can be used in future regulatory or additional voluntary efforts on nanoscale materials;
    - information related to reviews under the TSCA new chemicals program which has helped the Agency identify and follow up with several companies that needed to file bona fide intent to manufacture notices or pre-manufacture notices under TSCA for their carbon nanotubes and fullerenes; and
    - policy issues relating to possible approaches and strategies for effectively structuring any needed regulatory requirements.

- The NMSP has better informed the US Government's participation in the OECD WPMN:
    - the experience gained in the NMSP, given the number and variety of submissions, has been a valuable input into the WPMN's deliberations; and
    - the fact that 12 of the 14 major nanoscale materials in the OECD WPMN sponsorship program were reported under the NMSP has demonstrated the relevance of the OECD's sponsorship program as a vehicle for speeding the collaborative development of needed test data and helps confirm that the NMSP Basic Program has captured nanoscale materials of global significance.

- Four companies have committed to support further testing of nanoscale materials in the NMSP In-Depth program which should help to accelerate the development of needed understanding for carbon nanotubes and carbon nanoparticles; and

- In the aggregate, the NMSP has sufficiently advanced EPA's knowledge and understanding to enable the Agency to take further steps towards evaluating and, where appropriate, mitigating potential risks to health and the environment.

The progress made under the NMSP should be tempered against a number of considerations:

- It appears that nearly two-thirds of the chemical substances from which commercially available nanoscale materials are based were not reported under the Basic Program.

- It appears that approximately 90% of the different nanoscale materials that are likely to be commercially available were not reported under the Basic Program.

- There is some uncertainty regarding whether each NMSP participant reported all of the nanoscale materials it manufactures and there may be gaps in the data reported by each participant. Review of NMSP submissions reveal a number of instances where the details of the manufacturing, processing, and use of nanoscale materials were not reported.

- A number of the NMSP submissions did not contain exposure or hazard-related data. Exposure and hazard data are two of the major categories of information EPA identified in its concept paper for the NMSP that are needed to inform risk assessment and risk management of nanoscale materials.

- The low rate of engagement in the In-Depth Program suggests that most companies are not inclined to voluntarily test their nanoscale materials.

- The need for additional progress towards addressing NPPTAC's considerations discussed in Section 3.1 of this report. For example:
  - A higher rate of participation;
  - An increased amount of information from program participants, where applicable;
  - Understanding the adequacy and potential effectiveness of existing risk management practices; and
  - Developing additional lessons and conclusions from the program experience, including:
    - What are the characteristics of nanoscale substances that should be considered in risk assessment and risk management;
    - Which, if any, regulatory changes may be needed to address nanoscale materials; and
    - What further risk management practices are appropriate for nanoscale substances?

9 Next Steps

The NMSP is scheduled to run until January 2010. EPA welcomes new participants and will continue its outreach to nanoscale materials manufacturers and importers through regional, national, and international conferences, meetings and calls. The Agency will continue to identify and inform companies of their obligations under TSCA for new chemical nanoscale materials.

EPA will initiate discussions with In-Depth participants. The Agency strongly encourages others to participate in the program as it develops. EPA will review the data gaps revealed by the NMSP in the context of other national and international data development initiatives, to inform the design and development of the In-Depth program.

EPA will continue to evaluate the Basic Program submissions, including information on risk management practices, to identify characteristics of nanoscale materials that should be considered in risk assessment as well as approaches for risk management. EPA will continue developing the comparison of commercially-relevant nanoscale materials and refining categories of nanoscale materials based on molecular identity and physical properties in order to better understand their behavior and help prioritize research and regulatory efforts. The Agency will ultimately incorporate this information into its new and existing chemical review process.

EPA will consider how to best apply regulatory approaches under TSCA section 8(a) to address the data gaps on existing chemical nanoscale material production, uses and exposures that were identified through this analysis of the Basic Program information. Due to the limited participation in the In-Depth Program, EPA will also consider how best to apply rulemaking under TSCA section 4 to develop needed environmental, health, and safety data. Such rulemaking would give due consideration to testing planned or underway in other forums, e.g. OECD and In-Depth program, and ORD and NNI research.

EPA may adjust or decide next steps for the NMSP as experience or test data warrant. This includes:

- The Agency will take any necessary action to prevent unreasonable risks to human health and the environment. EPA has not yet identified any NMSP submissions that would warrant those types of actions.
- The Agency will issue a more detailed report on the NMSP in January 2010 and decide on any additional NMSP activities as appropriate.

The Agency welcomes comments on this interim report, and will use those comments, as appropriate, in further refining the NMSP and in the development of the final NMSP report.

10 Annex A - Summary of EPA Nanomaterial Research Strategy

The Nanomaterial Research Strategy (NRS) describes the Environmental Protection Agency's (EPA) strategy for conducting and supporting research to understand the potential human health and ecological (henceforth referred to jointly as "environmental") implications from exposure to manufactured nanomaterials, and how nanotechnology can be used in environmental protection applications. EPA has written this document with three main purposes: (1) to guide its own researchers and managers as they conduct EPA's research program, (2) to assist scientists in other organizations as they plan their own research programs, and (3) to inform the public of how EPA intends to generate scientific information to guide environmental decisions related to nanomaterials.

The purpose of EPA's research program in support of the National Nanotechnology Initiative is to conduct focused research to address risk assessment and risk management needs for nanomaterials in support of the various environmental statutes for which the EPA is responsible. This program will be coordinated with research conducted by other federal agencies, where the EPA will lead selected research areas and rely on research products under the leadership of its federal research partners in other research areas. Collaboration is encouraged among researchers across the government, industry, and the international community. EPA's in-house research program has the capability to leverage results from EPA grant programs, as well as to collaborate with grantees to address the many challenging research issues outlined in this strategy.

The NRS focuses on developing scientific information for nanomaterial decision support. However, because other entities also conduct research related to nanomaterials and the environment, EPA is focusing on four areas that take advantage of EPA's scientific expertise as well as fill gaps not addressed by other organizations. The four research themes are:

- Identifying sources, fate, transport, and exposure
- Understanding human health and ecological effects to inform risk assessments and test methods
- Developing risk assessment approaches
- Preventing and mitigating risks

EPA believes that its research should advance two key objectives: (1) the development of approaches for identifying and addressing any hazardous properties, while maintaining beneficial properties, before a nanomaterial enters the environment; and (2) identifying whether, once a nanomaterial enters the environment, it presents environmental risks. EPA will pursue these objectives from a life-cycle perspective—i.e., by understanding where environmental impacts may occur, and where benefits may be attained, throughout a nanomaterial's existence: from its production, through its use in products, and as it is disposed of or recycled.

ORD is focusing its initial in-house research on seven manufactured nanomaterials: single-walled carbon nanotubes, multi-walled carbon nanotubes, fullerenes, cerium oxide, silver, titanium dioxide, zero-valent iron. Ultimately, ORD has as a goal the development of predictive

models and tools that will enable testing across these material classes, since testing the many potential variations of materials within each of these seven classes would be very resource intensive.

ORD selected these seven material types based on the materials' current use in products, the near-term needs of EPA's program and regional offices, research underway at other federal agencies, and the materials selected for testing in the OECD's Working Party on Manufactured Nanomaterials. Over time, ORD expects to extend its efforts to other material types.

ORD evaluated several key issues and activities to identify priorities for the research program. The program will be problem-driven and focused on addressing EPA's needs. Also research recommendations from the EPA *Nanotechnology White Paper* and research coordination leadership in the NNI Strategy (2008) were important considerations. Defining questions are:

- Does the research support EPA's mission to protect human health and the environment?
- Is the research important to support EPA regulatory decisions on nanomaterials?
- What is the role EPA played in leading/coordinating this research topic under the NNI EHS strategy (2008)?
- Is the research part of an international agreement to collaborate and leverage research activities?
- What research themes are important to support Agency risk assessment and management activities?
- How do partnerships with federal, academic, and industry researchers enhance research activities?

Having considered these questions within the context of resource constraints and research being conducted by other organizations, ORD has focused its nanotechnology research program on the four research themes described above. The EPA research program will address key science questions.

Theme 1: Sources, Fate, Transport, and Exposure

- What technologies exist, can be modified, or must be developed to detect and quantify manufactured nanomaterials in environmental media and biological samples?
- What are the major processes and/or properties that govern the environmental fate, transport, and transformation of manufactured nanomaterials, and how are these related to the physical and chemical properties of those materials?
- What are the exposures that will result from releases of manufactured nanomaterials?

Theme 2: Human Health and Ecological Research to Inform Risk Assessment and Test Methods

- What are the effects of manufactured nanomaterials and their applications on human health, and how can these effects be best quantified and predicted?
- What are the effects of manufactured nanomaterials and their applications on ecological receptors, and how can these effects be best quantified and predicted?

Theme 3: Risk Assessment Methods and Case Studies.

- In what ways, if at all, do risk assessment approaches need to be amended to incorporate special characteristics of manufactured nanomaterials?

Theme 4: Preventing and Managing Risks

- Which manufactured nanomaterials have a high potential for release from a life-cycle perspective and what practices can be applied to minimize the risks of nanomaterials throughout their life cycle?
- How can manufactured nanomaterials be applied for treatment and remediation of contaminants, and what decision-making methods need to be developed for risk management of nanomaterials?

The research described in the NRS will be implemented through multi-year plans (MYP). The Office of Research and Development's research multi-year plans present the long-term strategic vision of the EPA's research programs. The MYPs serve as a planning and communication tool to describe the scope of research addressing EPA's priority science questions. The MYPs are also used to help (1) demonstrate how ORD's research programs contribute to Agency outcomes and strategic goals; (2) provide information to aid in and support decisions during budget formulation; and (3) assist in managing performance and accountability reporting, including the OMB Program Assessment Rating Tool (PART) review.

11 Annex B - Description of OECD Working Party on Manufactured Nanomaterials

In 2006, OECD's Chemicals Committee agreed to a Program of Work on Manufactured Nanomaterials. This Program of Work is addressing human health and environmental safety aspects of manufactured nanomaterials. The Chemicals Committee also established a Working Party on Manufactured Nanomaterials (WPMN) to implement its Program of Work. The objective of the WPMN is to promote international cooperation in human health and environmental safety related aspects of manufactured nanomaterials (MN), in order to assist in the development of rigorous safety evaluation of nanomaterials. The work is being implemented through eight projects listed below:

- Development of a Database on Human Health and Environmental Safety Research;
- Research Strategies on Manufactured Nanomaterials;
- Safety Testing of a Representative Set of Manufactured Nanomaterials;
- Manufactured Nanomaterials and Test Guidelines;
- Cooperation on Voluntary Schemes and Regulatory Programs;
- Cooperation on Risk Assessment;
- The Role of Alternative Methods in Nanotoxicology; and
- Exposure Measurement and Exposure Mitigation

These eight projects are being managed by eight steering groups which are implementing their "operational plans", each with their specific objectives and timelines. These steering groups (which average around 20 participants) are being led/ chaired by members of the WPMN, with support from the OECD Secretariat. Much of the work has been (and is being) undertaken through teleconferences and electronic means. At the same time, there are close linkages among the projects, and for this reason, "face-to-face" meetings of steering groups are organized as the need arise. Results of each project are then evaluated and endorsed by the entire WPMN.

12 Annex C - Current NMSP Participants (as of December 8, 2008)

Table 1

Company Name	Chemical Name
Ahwanee	multi-walled carbon nanotubes (MWCNT)
Altairnano	lithium titanate
Arkema	MWCNT
BASF Corporation	1. butyl acrylate polymer 2. butadiene styrene copolymer 3. polymer 4. titanium dioxide 5. confidential business information (CBI) 6. CBI 7. CBI
Bayer Material Science	CBI
Dow Chemical	1. CBI 2. CBI 3. CBI
DuPont	1. titanium dioxide 2. poly-(ethylene terephthalate) resin with sepiolite clay
Evonik/Degussa	1. titanium oxide 2. aluminum oxide
General Electric	1. antimony pentoxide 2. dimethyl siloxide, reaction product with silica 3. silanamine, 1,1,1-thrimethyl-n-(thrimethylsilyl) hydrolysis product with silica 4. silver
International Carbon Black Association	carbon black
Nano-C	fullerenes (4 chemicals)
Nanofilm	acrylic coating
Nanophase Technologies Corporation	1. iron oxide 2. aluminum oxide 3. cerium oxide
Nantero	CBI
Office ZPI	cluster diamonds
PPG Industries	1. amorphous silica 2. CBI

Company Name	Chemical Name
Pressure Chemical	1. CBI 2. CBI 3. CBI
Quantum Sphere	manganese/manganese oxide
Sabic Plastic Innovations	CBI CBI
Sasol North America	aluminum oxide hydroxide (3 materials)
Selah Technologies, Inc.	carbon nanoparticles
Showa Denko KK	MWCNT
SouthWest Nano Technologies, Inc.	carbon nanotube (CNT)
Strem Chemicals	aluminum oxide magnesium oxide calcium oxide calcium oxide(high surface area) cerium (IV) oxide copper (II) oxide magnesium oxide magnesium oxide (high surface area) titanium (IV) oxide zinc oxide MWCNT (5 chemicals) Single-walled carbon nanotubes (SWCNT) gold nanochain (AuNP) AuNP embedded sticky gold nanoparticles sugar-coated gold nanoparticles (4 materials) gold nanorods gold triangles, hexagons, polygons, and rods (3 materials) water-soluble gold particles (4 materials) AuNP 30-40nm (starch) water soluble gold nanoparticles citrates, (4 materials) AuNP 11-20nm (gelatin) Palladium nanoparticles, 1-5nm, PdNP (starch) PdNP, 2-3 (gelatin) PdNP, 2-4nm (gum arabic) platinum nanoparticles, PtNP (gum arabic) AgNP,10-15 nm, starch AgNP, 5-10 (gum Arabic) AgNP, 5-10 nm (gelatin) platinum, 2-5nm cobalt nanoparticles gold/tetra-n-octylammonium chloride colloid rhodium/tetra-n-octylammonium chloride

Company Name	Chemical Name
Strem Chemicals, cont.	colloid purified (70-75% Rh) cobalt magnetic fluid in kerosenes with AOT (sodium dioctylsulfosuccinate) and LP4 (a fatty acid condensation polymer) platinum-rhutenium/tetra-n-octylammonium chloride colloid rhodium colloid (polyethyleneglycol-dodecylether, hydrosol) iron-cobalt nanoparticles (surfaced modified with L-cysteine ethyl ester)(wet with ethanol) platinum-ruthenium colloid (polyethyleneglycol-dodecylether,hydrosol) nickel/tetra-n-octylammonium chloride colloid, purified (65-70%) iron-cobalt magnetic fluid in toluene stabilized with cashew nut liquid platinum/tetra-n-octylammonium chloride colloid purified (70-85 Pt) cobalt nanoparticles (surfaced modified with L-cysteine ethyl ester)(wet with ethanol) platinum colloid (polyethyleneglycol-dodecylether,hydrosol) cobalt nanoparticles, toluene wet titanium cluster, tetrahydofuran adduct (30-35% Ti) diphenyl(m-sulfonatophenyl)phosphine-gold nanocluster (water soluble) (1-3 nm) platinum, min.90%, (5-13 nm) cobalt nanoparticles coated with AOT (sodium dioctylsulfosuccinate) 10-12 nm titanium cluster, tetrahydofuran adduct (20-25% Ti)
Swan Chemicals	MWCNT SWCNT
Synthetic Amorphous Silica and Silicate Industry Association	Synthetic Amorphous Silica
Unidym	CNT
CBI Company 1	CBI
CBI Company 2	CBI

13 Annex D - OECD Sponsorship Program for the Testing of Manufactured Nanomaterials (MN)

Current Sponsors (as of 13 October 2008[i])

Representative Set of MN[ii]	Lead sponsor(s)[iii]	Co-sponsor(s)[iv]	Contributors[v]
Fullerenes(C60)	Japan United States		Denmark China
SWCNTs	Japan United States		Canada France Germany EC China BIAC
MWCNTs	Japan United States	Korea BIAC	Canada Germany France EC China BIAC
Silver nanoparticles	Korea United States	Canada Germany Nordic Council of Ministers	Australia France EC China
Iron nanoparticles	China	BIAC	Canada US Nordic Council of Ministers

Representative Set of MN[vi]	Lead sponsor(s)[vii]	Co-sponsor(s)[viii]	Contributors[ix]
Carbon black			Denmark Germany US
Titanium dioxide	Germany	Canada Korea Spain United States BIAC	Denmark China
Aluminum oxide			Germany United States
Cerium oxide	United States United Kingdom/BIAC	The Netherlands	Australia Germany EC
Zinc oxide	United Kingdom/BIAC	United States BIAC	Australia Canada
Silicon dioxide	EC	Korea BIAC	Denmark France
Polystyrene			Korea
Dendrimers		Spain	United States
Nanoclays			Denmark United States

[i] The sponsors arrangement is under development there the table of current sponsors will be revised as new information becomes available.

[ii] The phrase "representative nanomaterials" was intended to mean those manufactured nanomaterials (MNs) now or soon to enter into commerce. *See LIST OF MANUFACTURED NANOMATERIALS AND LIST OF ENDPOINTS FOR PHASE ONE OF THE OECD TESTING PROGRAMME* [ENV/JM/MONO(2008)13/REV]

[iii] **Lead Sponsor(s)** assume responsibility for conducting or coordinating all of the testing determined to be appropriate and feasible to address the endpoints of Phase 1 for a listed nanomaterial. In some cases, "joint lead" arrangements may be developed where appropriate and considering the degree of participation committed toward addressing endpoints.

[iv] **Co- Sponsor(s)** conduct some of the testing determined to be appropriate and feasible to address the endpoints of Phase 1 for a specific listed nanomaterial.

[v] A **Contributor** provides test data, reference or testing materials or other relevant information to the lead and co-sponsors.

[vi] The phrase "representative nanomaterials" was intended to mean those manufactured nanomaterials (MNs) now or soon to enter into commerce. See *LIST OF MANUFACTURED NANOMATERIALS AND LIST OF ENDPOINTS FOR PHASE ONE OF THE OECD TESTING PROGRAMME* [ENV/JM/MONO(2008)13/REV]

[vii] **Lead Sponsor(s)** assume responsibility for conducting or coordinating all of the testing determined to be appropriate and feasible to address the endpoints of Phase 1 for a listed nanomaterial. In some cases, "joint lead" arrangements may be developed where appropriate and considering the degree of participation committed toward addressing endpoints.

[viii] **Co- Sponsor(s)** conduct some of the testing determined to be appropriate and feasible to address the endpoints of Phase 1 for a specific listed nanomaterial.

[ix] A **Contributor** provides test data, reference or testing materials or other relevant information to the lead and co-sponsors.