TRANSPORT IN NANOTECHNOLOGY

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ABSTRACT

Nanotechnology is the science concerned with the design ,construction and utilization of functional structure with at least one characteristics measured in nanometers .Compared to typical transportation engineering structures the two field thus operate on hugely divergent dimensional scales. Traditionally , nanotechnology has been concerned with developments in the fields of microelectronics , medicine and material science. However the potential for application of many of the developments in the nanotechnology field in the area of transportation engineering is growing.

Ongoing research in this area focus on the development of improved material for construction of transportation facility and knowledge developed in the broader transportation engineering field to understand and characterize processes in nanotechnology.

In this paper a broad overview of the potential application of various nanotechnology development in the transportation engineering field is discussed. The focus is on the potential effects that the technology may have on aspects like safety, durability, economics and sustainability of the transportation infrastructure.

I INTRODUCTION

Nanotechnology is a field that is dominated by developments in basic physics and chemistry research where phenomena on atomic and molecular level are used to provide materials and structures that perform tasks that are not possible using materials in their typical macroscopical form. Transportation engineering is the field that is on a macro level concerned with the movement of people and goods over macro scale distance to ensure that the economy can function.

There are two overall approaches to building things at the nanoscale .The first is to chisel, etch or sculpt such features into an existing, big structure using techniques such as tunneling, scanning or atomic force microscopic various form of lithiography.Nano-size gears and smaller integrated circuits are just some of the objects being fabricated using this approach, which is sometime referred to as “top-down". The second method is the “bottom-up “approach: building things up from the atoms and molecules themselves. One new breakthrough resulting from bottom-up assembly is the single electron transistor.

Nan scaled filters such as sooty particles are applied in car tyres, in printer ink and paints. The nanometer sized dimensions of electronic components and functional layers in read heads allow a drastic improvement in performance of hard drives. Catalysts and air filters system cause clean air inside and outside of the car. Optical layers for reflection reduction on dashboard or hydrophobic and dirt-repellent "easy to clean "surfaces on car mirrors are further examples of application of nanotechnologies in automobiles.Nowadays,profit amounting to billions are being generated using such high end products.Nanotechnologies are thereby incorporated as components into the product or into the production engineering.

In this paper a short introduction is provided on the background to nanotechnology and transportation engineering. Based on a definition of broad objectives of transportation engineering, the potential areas where nanotechnology can benefit transportation engineering are defined and discussed.

II BACKGROUND ON NANOTECHNOLOGY AND TRANSPORTATION

2.1 Nanotechnology Background

Commercial interest in nanotechnology is growing exponentially across a range of industries. Many latent new users have little or no experience of handling nano materials, which can have very distinct physical and chemical properties from conventional chemicals. Small and medium enterprises who wish to use nanotechnology may not have extensive Health Safety and Environment (HS&E) resources available in house. Separate but related to the above, there is a high level of interest in nanotechnology in both the popular and scientific press. The general tenor is that technology offers major potential benefits but there is a lot we do not yet know from a human and environmental safety standpoints. In net it is very important that those wishing to deploy nanotechnology develop HS&E capability before moving ahead. not only do they need to develop capability to ensure worker and environmental safety ,they also need to be able to demonstrate capability to internal and external stakeholders considering workers, shareholders and public interest groups. This is an important aspect of product stewardship and miss-steps by a few companies could jeopardize the wider community`s right to practice.

Nanotechnology is the term used to cover the design, construction and utilization of useful structures with atleast one characteristic dimension measured in nanometers. The field of nanotechnology was developed in major leaps during the past 10 years.Nanoscale science can be divided into three broad areas: nanostructures, nanofabrication and Nano characterization with typical application in Nano electronics, Nano materials, life sciences and energy.

There are typical 12 types of nanostructure (Table 1),10 types of fabrication method and 10 types of characterization method that can be defined. It is important to realize that these type of structure, fabrication methods and characterization methods are continually developing and also that these focus on the nanotechnology field directly, and that as such these structure can not directly be scaled up to typical transportation engineering dimensions. Many of these properties of these materials depend on the material being available on the nanoscale,and therefore a leading part of the research into developing transportation applications is focused on the dimensional chasm that exists between nanoscale and the micro scale worlds.

Table 1 Types Of Nanostructures, Fabrication Methods and Characterization Methods (Nanopolis, 2005)

NANOSTRUCTURES	FABRICATION METHODS	CHARACTERISATION METHODS
Aero gels Carbon nanotubes Dendrimers Magnetic molecules Metallic nanoparticles Nanoclays Photonic crystals Quantum corrals Self-assembled monolayers Nanowires Semiconductor quantum dots Fluorescent semiconductor	Electron-beam deposition Focused ion beams Pulsed laser deposition Sputtering deposition lithography Nano-imprint lithography Chemical vapour Molecular self-assembly Hydrothermal synthesis Molecular beam epitaxy Electron spinning	Atomic Force Microscopy (AFM) Electrostatic force microscopy Magnetic force microscopy Scanning Electron Microscopy (SEM) Scanning near-field optical microscopy Scanning tunneling microscopy Transmission electron microscopy Infrared spectroscopy Nuclear magnetic resonance Optical tweezers Mass spectrometry

III RESEARCH AND APPLICATION

The specific area within transportation engineering infrastructure where application of nanotechnology may have an influence can be defined in various ways. The potential part of the supply of a durable transportation infrastructure facility in terms of improving the internal material properties.

3.1 Environmental Application Research

The agency should continue to undertake, cooperate on, and support research to better understand and apply information regarding environmental application of nonmaterial.

3.2 Risk Assesement Research

The agency should continue to undertake, cooperate on, and support research to better understand and apply information regarding nanomaterial.

- Chemical and physical identification and characterization

- Environmental fate
- Environmental detection and analysis
- Latent releases and human exposures
- Human health effects assessment
- Ecological effects assessment

To ensure that research supports Agency decision making, EPA should conduct case studies to further identify unique risk assessment considerations for nonmaterials.

3.3 Pollution, Prevention Stewardship And Sustainability

The Agency should engage resources and expertise to support, and develop approaches that promote pollution, prevention, sustainable resource use and good stewardship in the production, use and terminate of life management. Of nanomaterials.The Agency should force on new, "succeeding generation "nanotechnologies to identify ways to support environmentally beneficial approaches such as green energy, green create, green chemistry and green manufacturing.

In terms of the latent effect of nanotechnology on transport infrastructure the center in terms of sustainability would thus again lies in the realm of modification of existing materials that may be harmful to the environment, either through their application in the infrastructure, or through their production or extracting them from the environment in the first place.Further,the focus can be on the efficient re-use of existing material either reworking them and changing the structure to ensure that the properties of the materials are improved to provide a longer life. Materials can be modified enable construction at lower energy for the construction process. Prevention of health and safety effects through the modification of existing materials to enable an inert material that does not cause damage to environment.

3.4 Collaboration and Leadership

The agency should continue and expand its collaborations regarding nanomaterials applications and potential human health and environmental implications.

3.5 Intra -Agengy Workgroup

The agency should convence a standing intra-agency group to foster information sharing on nanotechnology science and policy issues.

3.6 Training

The agency should continue and expand its nanotechnology training activities for scientists and manager.

IV CHALLENGES

As with the most developing technologies, a major number of challenges exist during the initiation of the technology in the beginning. It is important to be realistic and identify and plan for the limitations and challenges inherent in this process. In this section a short summary of selected challenges and limitations affecting application of nanotechnology in transportation engineering are provided. The following main challenges and limitations can be defined:

- Dimensional chasm;
- Up scaling of fabrication;
- Costs

4.1 Dimensional chasm

The unique environment of the transportation engineer who works with large volumes of material should always be appreciated when evaluating potential applications of nanotechnology. The effects on manufacturing capacity and performance of the nanomaterials when combined with bulk aggregates and binders should be evaluated to ensure that the beneficial properties of the nanomaterials are still applicable and cost –and energy-efficient at these scales.

4.2 Up scaling of fabrication

Current efforts in the field of nanotechnology are focused on the fabrication, characterization and use of these materials on a nanoscale (or at best on a micro scale).

This leads to most of the development work focusing on very small quantities of material that is typically far removed from the type of quantities required for typical transportation infrastructure. One of the potential solutions to this is to focus on the nanomaterials to act as catalyser, thereby reducing the amount of nano materials required substantially. Another viewpoint is that for many applications, the material does not necessarily have to be used on a nano scale to obtain a major improvement in benefits. This would be the case with reduction of the dimensions of cement, where a substantial improvement in strength can already be obtained through the large scale milling of the cement to a finer form than the traditional form. Although the cement may not be purely a nanomaterial as yet (having at least one dimension of less than 100nm),the benefits obtained would already be substantial (Garcia –Luna and Bernal, 2005).

4.3 Costs

The costs of the most nanotechnology materials and equipments are very high. This is due to the complexity of the equipment used for preparation and characterization of material. However costs have been showed to decreased over time and the expectations are that, as manufacturing technologies improve, these costs may further decrease. Current opinion is that in special cases, the materials will enable unique solutions to complicated problems that cause them to be cost effective, which will lead to large scale applications of these specific technologies. It is the challenge to the transportation engineer to solve real world transportation infrastructure problems.

V CONCLUSIONS AND RECOMMENDATIONS

Based on the information discussed in this paper, the following conclusions and recommendations are drawn:

- Nanotechnology is rapidly expanding area of research where novel properties of materials manufactured on the nanoscale can be utilized for the benefit of transportation infrastructure
- A number of promising developments exists that can potentially change the service life and life cycle cost of transport infrastructure.
- Focused research into the timeous and directed research into nanotechnology for transport infrastructure should be pursued to ensure that the potential benefits of this technology can be obtained to provide longer life and more economical transport infrastructure.

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