DONALD BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT
UNIVERSITY OF CALIFORNIA, SANTA BARBARA

A Condensed Environmental Health & Safety Reference for Nanotechnology Startups (CERNS)

Group Project Brief

Project Members
Adeyemi Adeleye
Daniel Huang
Zoë Layton
[redacted]
Jessica Twining

Project Advisor
Patricia Holden

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Introduction

The nanotechnology industry is rapidly growing worldwide. A Lux Research (*1*) estimates that by 2014, engineered nanomaterials (ENMs) will be in 15% of the global output of manufactured goods, with revenue estimates of up to $2.6 trillion. Many ENMs are valuable because exhibit novel properties and their extremely small size allow them to be easily integrated into a wide range of manufactured goods. Current applications of nanotechnology include the use of nanomaterials in car tires, toothpaste, sunscreen, shirts, socks, bathtubs, toilets, and so on. They are also found in products that could benefit the environment, including water purification systems, solar panels, and lighter cars that require less fuel. A few examples of these products are shown in Figures 1–3.

Figure 1: Scratch-resistant nano-lenses
(**Source:** http://nanogloss.com/tag/nanotechnology-research/)

As with the advent of most technologies, there is a dearth of information about the physicochemical properties of nanomaterials as well as their potential impacts on humans and the environment. The pace of growth is exceeding our preparedness for any adverse effects.

Figure 2: Garment coated with smog-busting nanomaterials
(Source:http://news.thomasnet.com/IMT/archives/2007/11/fashionably_functional_garments_clothing_materials_fabric_science_high-tech.html)

Problem Statement and Goals

Despite the widespread optimism that nanotechnology will vastly improve quality of life, several studies have shown that exposure to certain nanomaterials may cause severe environmental problems and harm humans (*2*). The innovative properties that create the useful potential of nanomaterials may also generate new risks to workers, consumers of nanomaterials products, the public, and the environment.

Unfortunately, there are currently no specific regulations for the manufacturing and handling of nanomaterials and the management of nanomaterials waste streams. As such, the practice of nano-specific Environmental Health & Safety (EH&S) is completely voluntary and the industry depends on available guidance documents and literatures for this. This is still problematic because available documentation ranges from general documentation published by universities and government agencies to documents that are specific but only in one or a few areas of nano-specific EH&S. Additionally, organizations are devising sets of recommendations worldwide, but they have not been cross-compared for the sake of thoroughness, credibility, common agreement, and best practices.

Our goal was to provide companies with a condensation of all currently available nano-specific recommendations from all the guidance documents to help the industry implement nano-specific EH&S.

Figure 3: A racquet made with nanomaterials
(Source: http://www.polyfibre.com.au/products/racquets/nanotech-graduate.html)

Project Significance

Many guidance documents have been published from diverse sources to encourage the nanotechnology industry to implement a nano-specific EH&S program. Different sectors, including academia, government, industry, and non-profit, have independently published their own documents in support of nano-specific EH&S. Despite widespread availability, there are two main issues we identified through review of current guidance documents:

- A cross-comparison of specific recommendations that are contained in the guidance documents has not been performed.
- The multitude of guidance documents available could potentially be overwhelming to a company that wants to start a nano-specific EH&S program.

In this group project, we extracted specific recommendations from 27 guidance documents to reveal what exactly is being recommended. This was the first cross-comparison of its kind to be performed. The comparison was useful for identifying weaknesses and/or discrepancies of recommendations contained in guidance documents, as well as where further research is needed.

The cross-comparison allowed us to note the most frequent recommendations and provide a condensed guide of those recommendations, allowing companies to quickly review what is currently available to them. The product was titled: **A Condensed EH&S Reference for Nanotechnology Startups (CERNS)**. CERNS would decrease the amount of time companies would have to spend researching nano-specific guidance and further encourage them to implement a nano-specific EH&S program.

Methodology

Recommendations and Background Information

Our client, the UCLA group of the UC-CEIN, compiled 27 of the most internationally referenced nano-specific guidance documents. The guidance documents included 14 from academic institutions, 11 from various government agencies in the US and the European Union (EU), 1 from a nanotechnology company and 1 from a nonprofit. We selected the most comprehensive of all the guidance documents as the baseline for comparing all other documents. We then compared all the recommendations from the baseline documents with specific recommendations from all other documents one after the other. Also, whenever we found a recommendation in the other documents that was not mentioned by the baseline document, we extracted such recommendations. The comprehensive spreadsheet matrix, which has 945 rows and 38 columns, obtained at the end of this comparison-cum-consolidation was translated into the recommendations contained in CERNS.

Economic Implication

We made a comprehensive list of all the equipment and materials that were recommended by all the guidance documents. We then obtained the current pricing of these items from specific suppliers, mainly via their websites (when listed) or by getting a quote (when not available online). We then categorized all the equipment and materials into the various control measures of the traditional hierarchy of control system and determined the total cost of implementing each measure by aggregating the total cost of all the equipment and material categorized under them.

Results

CERNS was created by first outlining the important factors driving nano-specific EH&S, followed by an extensive summary of the recommendations found in our review of the available guidance. The recommendations section was divided into sub-categories (Fire and Explosion Control; Workplace Monitoring; Wet and Dry Spill Management; Waste Management; Control of Airborne Exposures; Control of Dermal Exposures; Laboratory Labeling and Storage; Consumer Product Labeling), which is how recommendations are typically presented in most guidance documents. Each of the recommendations sections in CERNS lists out specific guidelines and suggestions, based primarily from guidance documents that are the most compressive on the particular topic. Every recommendations section is then concluded with a guide on where to find additional information on the matter.

In developing CERNS, we were also interested in the consistency of the recommendations across the various guidance documents. Using our comprehensive spreadsheet matrix, we analyzed the frequency of overlap for specific recommendations. We found that 64.2% of all specific recommendations were contained in only between 1 to 10% of all documents (Fig. 5). That indicates how most recommendations are "rare" and not repeated in most of the documents. Similarly, only 2.3% of reviewed recommendations occurred in 40% or more of the reviewed documents (Fig. 5).

Discussion

The level of overlap in recommendations between the various guidance documents is generally very low. A likely explanation for this trend is that many of the reviewed guidance documents have different focuses, resulting in varying levels of specificity in their recommendations.

Figure 4: Some of the guidance documents that were accessed and consolidated

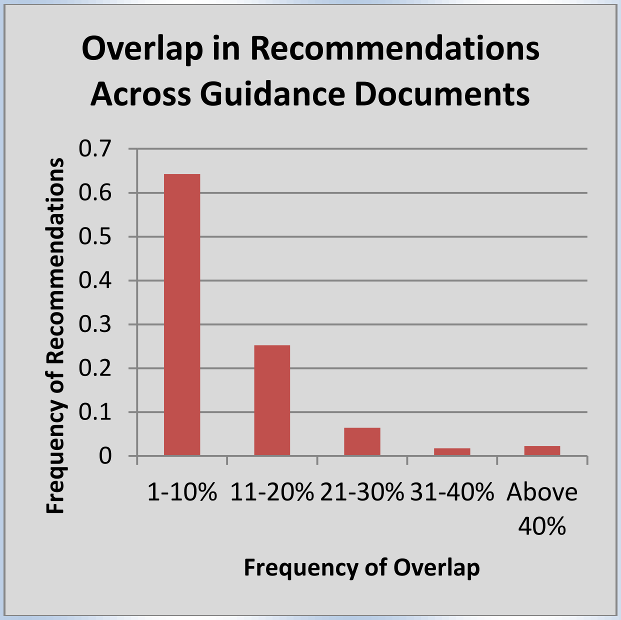

Figure 5: Frequency of overlap on specific recommendations across the 27 reviewed guidance documents.

For example, the lengths of guidance documents varied from quite a few pages, like those issued by several academic institutions, to extensive documents with almost exhaustive lists of guidelines, such as those by Ellenbecker and Tsai (2009) (*4*), the Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail (IRRSST) (*5*) in Montreal, and the British Standards Institute (BSI) (*3*). Therefore, the level of overlap for a particular recommendation across the guidance documents does not necessarily correspond to its relative importance or effectiveness in mitigating exposure risks during manufacturing and/or handling of nanomaterials. The relatively low level of overlap for most of the compiled specific recommendations though does highlight the importance of compiling and assessing such a large number of documents, because individual guidance documents do not provide a comprehensive overview of the current best practices for handling nanomaterials. . It is also important to note that more recommendations does not necessary translate into better management of nanomaterials exposure risks; although it is important for those handling nanomaterials to have a more complete perspective on the best available information for the matter.

Conclusions and Findings

The vast differences in scope and recommendations between individual guidance documents likely makes it very difficult for nanotechnology firms to discern the current best practices for nanomaterials safe handling. The development of CERNS should help to make this task less daunting and thereby encouraging more firms to voluntarily incorporate the current best practices into their own EH&S programs. It is important that firms realize though that EH&S programs need to be tailored specifically to their particular procedures and activities in order to minimize occupational exposure risks from nanomaterials. Likewise, it is crucial for firms to continue to keep up to date on the latest advancements in nano-specific EH&S, because the field is still nascent will likely evolve and shift in response to future technological improvements in monitoring and protective equipment, as well as ongoing research on the impact of nanomaterials exposure on humans and the environment.

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