Project Summary

A study on Exposure Scenarios and Engineering Controls for Carbon Nanotube Manufacturing Workplace

1. Background

At an industrial scale, nanomaterials can be produced and used in high volumes with relatively uniform composition and characteristics in a given occupational environment. Nanotechnology has the ability to transform many industries, from medicine to manufacturing, and the products they produce. An estimated two million new workers will be exposed to engineered nanomaterials (ENMs) in occupational environments over the next 15 years. The most significant exposures and risks will likely be in the occupational arena. The important thing to protect workers' health is to minimize exposures to hazardous substances in the workplace.

Controlling exposures to occupational hazards is the important for protecting workers. Engineering controls are likely the most effective control strategy for nanomaterials. Air cleaning and filtration method prevent the dispersion of nano-sized particles generated in a working place and to reduce the exposure of the toxic substance in nano size to the worker. However little has been studied on carbon nanotube exposure controls in the production and use of nanomaterials. There is no guideline of the adoption of engineering control systems according to the tasks or work processes for

the carbon nanotube or other nanomaterials workplace.

2. Objectives

This document discusses approaches and strategies to protect workers from potentially harmful exposures during nanomaterial manufacturing, use, and handling processes. We tried to suggest a guideline of the adoption of engineering control systems according to the task or work processes for the carbon nanotube workplace. The specific objectives of this study are as follows:

- to summarize the specific CNT data of all the scientific papers reporting performed measurement campaigns in workplaces involved in the production and/or manipulation of carbon nanotube from a WHO report
- to investigate documented exposure evidences for carbon nanotube given specific task(s) and control measure
- to investigate the current status of engineering control system for the four carbon nanotube manufacturers and one metal nanoparticle manufacture
- to find the effective air cleaning and filtration method to prevent the dispersion of nano-sized particles generated in a working place and to reduce the exposure of the toxic substance in nano size to the worker
- to investigate the cost .vs. effect of the engineering control systems of medium grade filter, HEPA grade filter and high efficiency ESP system by comparing between nanoparticle reduction efficiency and energy consumptions
- to carry out the experimental performance test to investigate the fractional efficiencies of a cyclone, a medium filter, a HEPA filter, and

filter media for two grades of facepiece respirators for the NaCl used conventionally as test aerosols, silver nanoparticlesgenerated by evaporation and condensation method, and MWCNTsprayed by an atomizer specially designed for airborne MWCNT

- to suggest a guideline of the adoption of engineering control systems according to the tasks or work processes for the carbon nanotube workplace

Because little has been published on carbon nanotube exposure controls in the production and use of nanomaterials, this study focuses on summarizing of the current status for the engineering control technologies currently used in other industries.

3. Methods

Carbon nanotube scenarios and exposure studies reported in the literature were collected and analyzed for the investigation on the exposure characteristics for the manufactured nanomaterials, especially carbon nanotube manufacturing workplace. We summarized the specific CNT data of the scientific papers reporting performed measurement campaigns in workplaces involved in the production and/or manipulation of carbon nanotube from a WHO report. The current status of engineering control system was summarized from NIOSH report and we checked questionnaires for the four carbon nanotube manufacturers and one metal nanoparticle manufacturer in Korea.

The cost-effectiveness was analyzed through the CFD simulations. The

operating cost, the clean air delivery rate, and the nano-sized particle removal rate were used to compare the cost-effectiveness for various air cleaning conditions.

Experimental performance test were carried out to investigate the fractional efficiencies of a cyclone, a medium filter, a HEPA filter, and filter media for two grades of facepiece respirators for the test NaCl particles, silver nanoparticles and MWCNT.

From the investigations we suggest a guideline of the adoption of engineering control systems according to the tasks or work processes for the carbon nanotube workplace.

4. Key findings

1) We summarized the specific CNT data of the scientific papers reporting performed measurement campaigns in workplaces involved in the production and/or manipulation of carbon nanotube from a WHO report and domestic researches. From the data, engineering control system was effective to reduce the inhalable nanoparticles in the workplace. This study focuses on summarizing of the current status for the engineering control technologies currently used in other industries.

2) We investigated the current status of engineering control system for the four carbon nanotube manufacturers and one metal nanoparticle manufacture. From the survey, canopy hood and general ventilation hood were mainly used in the nanomaterial manufacturing workplace. Personal protective equipment (PPE) and workplace cleaning were employed in addition to the

hood systems.

3) The use of the clean bench or booth was an effective method to minimize the dispersion of nanoparticles generated in the working place. From the analysis of the cost-effectiveness, the electrostatic precipitator having a performance of MERV15 was thought to be the effective filtration system for reducing nanoparticles generated inside the working place.

4) For HEPA filter, the fractional efficiency of NaCl, silver nanoparticle and MWCNT was higher than 99.99%. For media of respirator filter with two grades, the penetration of NaCl particles was less than 5% and the most penetrating particle size occurred at 40 nm. For silver nanoparticles, the most penetrating particle size was 20nm with higher efficiency than those of NaCl particles. The fractional efficiency of MWCNT was similar with those of NaCl particles.

5) From the investigations, we suggest a guideline of the adoption of engineering control systems according to the tasks or work processes for the carbon nanotube workplace. However, additional studies are required to complete a practical guideline.