Popular science summary

How long are you planning to work? The answer to this question can be determined by the conditions of your occupational environment. Your work may be physically strenuous or require that you be highly focused in stressful situations. Or you just may be affected by something so basic as the air you breathe.

Air is mainly comprised by nitrogen and oxygen gases, but it also contains airborne particles. When you walk along the beach you inhale salt particles from the sea. And when you walk on a well-trafficked road you inhale soot particles from car exhaust. You can choose where you take your walks, but you can't as easily choose your occupational environment. And regardless of where you are, you can never choose not to breathe. When introducing new products into occupational environments, airborne particles and gases other than nitrogen and oxygen can be generated. Together, they are called *aerosols*, and they can affect your health negatively. You spend about one third of your life at work and the introduction of new products should thus be assessed in terms of the risks. This needs to be done in order to ensure that you will not fall ill as a result of your occupational environment.

Two groups with challenging occupational environments are cleaning workers and workers in the nanotechnology industry. The research presented in this thesis has investigated the occupational environments of these groups, with a specific focus on the introduction of new products. In the cleaning occupation, high physical workloads and extensive use of cleaning chemicals have been problems for a long time. In recent years, the use of sprays has been introduced to facilitate the work, but with the negative consequence of creating a problem due to the nature of the aerosols that are generated. In the nanotechnology industry, the problems are rather the uncertainty about the types of exposures that are present, the types of new materials that are being used, and how dangerous these really are if inhaled.

To determine the actual extent of cleaning spray usage in the Swedish cleaning occupation, we conducted a survey of 225 professional cleaning workers. It showed that 77% of the workers use cleaning sprays at work, and that almost half of them experience some type of airway or eye symptoms in the process. The survey also showed that increased use of cleaning sprays increased the experience of the symptoms. To study the aerosol generation when using cleaning sprays, we conducted a few different aerosol measurements. To start with, we showed that the use of cleaning sprays greatly increases the airborne concentration of chemicals, but that it can also vary a lot between products. The measurements showed that between 3 and 30% of the chemicals sprayed from the bottles remain airborne, depending on the type of product that is used, and can continue to be inhaled by the workers.

We also conducted a laboratory study where a group of volunteer professional cleaning workers and a group of non-cleaning workers were recruited to investigate health effects during the use of different cleaning methods, both with and without chemicals. The results showed that both self-assessed symptoms from the nose and eyes and the measured effects on the nose and eyes were observed during spray use. We showed, however, that it is possible to decrease both the aerosol concentration in the air and the health effects on the user by making several easy changes. The first recommendation would be, of course, to clean without any chemicals at all. This is already a practice in several places today where only premoistened microfiber cloths are used. If chemicals are necessary, we recommend the use of application methods other than spray. In our studies, the use of foaming nozzles was shown to be effective in reducing both the aerosol concentration and the negative health effects.

In the nanotechnology industry, a selection of processes or handling tasks have previously been investigated to find possible exposure situations. Knowledge, however, is still lacking, especially in terms of nanofiber materials. The risk with these materials is that they are similar to asbestos fibers, which means that they can have severe health effects resulting, for example, in lung cancer. We conducted several workplace measurements at different companies to investigate the exposure situations of different fiber-shaped nanomaterials in the Swedish nanotechnology industry. With these measurements we could show that all types of fiber-shaped nanomaterials that were handled at the companies could be detected and identified in the air. A number of measurement methods were used and evaluated. We showed that a combination of filter samples followed by chemical analysis, and direct

reading measurements of different particle properties are crucial to getting the complete picture of the exposure situations, even though this can be expensive and time consuming. However, for some materials – for example carbon-containing materials such as graphene – faster and cheaper methods are available and were proven to work well in our studies.

To be able to assess how different nanomaterials should be handled, we need more knowledge about how dangerous it is to be exposed to these materials. Since the occupational exposure levels have not been completely determined, and due to the great uncertainty that exists about how dangerous the materials are, it would be unethical to conduct studies with human volunteers. Animals are often used instead to study the effects exposures can have. However, to reduce the unnecessary use of animals, and to investigate the underlying toxicological mechanisms behind the effects, experiments using cell cultures are performed. Traditionally, this is done by adding nanoparticles to cells covered with a growth liquid. But this does not resemble the actual exposure situation in our lungs where the nanoparticles are airborne when they come into contact with the cell surface of the lungs.

This is why cells with an air-liquid interface have been introduced for these types of studies. But to be able to expose cells at the air-liquid interface, special systems that can handle aerosols are needed. In our research, we used the Nano Aerosol Chamber for *In Vitro* Toxicity (NACIVT) system and compared it to traditional systems to investigate the differences in the effects on the cells. We showed that the NACIVT system was more sensitive to low doses of nanoparticle exposure than the traditional systems. Further on, it will be crucial to use more physiologically realistic systems such as this one to evaluate the hazards of airborne nanomaterials.

The new knowledge generated through the research presented in this thesis can be used to promote safe working environments. Information about different exposure situations and potential health effects can be used to provide improved risk assessments. Comparisons and evaluations of different measurement techniques can be used to come up with recommendations for occupational hygienists or for continued research in the area. The identification of processes that cause exposures can be used by companies to implement suitable control systems. All this can be done to ensure healthier workplaces!