Observation of nanoaerosol release from a hand dryer

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Abstract. Consumer exposure is one of exposures in the life cycle perspective to risk assessment. Many nanoproducts have been commercialized in the fields of health, electronics, home, food etc. Hand dryers are widely used at public rest rooms. In this study, we selected the hand dryer having a filter coated with silver nanoparticles as a popular electronic nanoproduct. A test chamber system was developed to detect nanoaerosols released from the test nanoproduct during the operation. The particle number concentration of the chamber background was confirmed to be <1 particles/cm$^3$ by using a condensation particle counter with a detection limit of 10 nm. When the hand dryer was turn on for 1 min, the particle number concentration in the chamber was almost linearly increased up to the peak concentration (<20 particles/cm$^3$). It was slowly decreased after the hand dryer was turn off. When the operation was extended to 10 min, similar release pattern of nanoaerosols was observed. Therefore, it was concluded that the nanoaerosols was emitted from the hand dryer during the operation. However, the amount of released nanoaerosols was negligible, compared to indoor nanoaerosol concentration (~10,000 particles/cm$^3$). Also, the released nanoaerosols could not be analyzed by filter sampling due to small quantity of mass.

1. Introduction
As nanotechnology is developed, new nanoproducts using nanomaterials are commercialized. Due to the dramatic increase of surface area, the nanomaterials are of concern in adverse human health effect, compared to well-known particulate matter of PM$_{10}$ or PM$_{2.5}$. Health risks are considered in the three aspects such as worker exposure, consumer exposure, and human population and ecological exposure. To assess worker exposure, many field studies have been conducted at workplaces. In the workplace, local exhaust ventilation systems or personal protection equipments could be applied to protect exposure of nanomaterials to workers [1-3]. However, a few investigations on consumer exposure were reported [4, 5]. In addition, proper measures are not available to protect nanomaterial exposure to consumers who use nanoproducts. To avoid consumer exposure to significant amount of nanomaterials, extensive studies on nanomaterial emission from nanoproducts are urgently needed. Accumulation of emission test data could make a standard emission test method, which enables to certify safe nanoproducts according to the emission level.

In this study, we investigated nanoaerosol release pattern of an electronic nanoproduct. The commercial hand dryer having a filter coated with silver nanoparticles was selected as a test nanoproduct and the experiment was carried out in a test chamber.

2. Experimental
To quantify the amount of nanoaerosol release, a test chamber system was designed as shown in figure 1. It consisted of a cube-shape chamber, a pure air generator, and a real-time aerosol monitoring instruments. The volume of the chamber was 93 L (41 × 35 × 65 cm) and it was enough to install a full-scale test product such as a hand dryer. The chamber was made of stainless steel except a small acrylic window for monitoring by eyes. An electric power socket attached on the wall was used to operate the electronic nanoproduct under the test.

Figure 1. Experimental schematic for testing the release of nanoaerosols from a hand dryer.

The total particle number concentration inside the chamber was monitored every second by using a condensation particle counter (CPC, TSI model 3010) with a detection limit of 10 nm. As shown in figure 1, a hand dryer was selected as a test product. It had a filter coated with silver nanoparticles for antibacterial function.

The test was conducted as follows. First, a test product was set in the test chamber. Prior to main test, the chamber was purged with a particle-free pure air of 10 L/min under no operation of the hand dryer to minimize a background particle concentration. Initial particle concentration in the chamber was higher than 3,000 particles/cm$^3$ and the background level of <1 particles/cm$^3$ was achieved after 90-min purging. After purging, the air flow rate of the pure air was reduced to 5 L/min for the main test.

The release experiment was carried out twice. At the first test, the hand dryer was turned on for 1 min and then turned off for 30 min four times cyclically. In the case of second test, the operation of the hand dryer lasted 10 min to investigate the effect of operating time on the release of nanoaerosols.

3. Results

3.1. Background level of nanoaerosols in the test chamber

As shown in figure 2, the initial particle number concentrations in the chamber ranged 4,000–11,000 particles/cm$^3$ because indoor aerosols entered during installation of the hand dryer. As soon as purging air was supplied at 0 min, the particle number concentration started to decrease linearly in its logarithm plot versus time because of constant air exchanging effect. The particle number concentrations became below 10 particles/cm$^3$ after 60-min purging, and then the background level of <1 particles/cm$^3$ was achieved after 90-min purging regardless of initial concentrations. Based on this background level measurement, it was possible to start the main release test after 90-min purging with 10 L/min of pure air under the indoor contaminant conditions of this study.
3.2. Release of nanoaerosols from a hand dryer

When the test hand dryer was turned on at 0 min after purging, the particle number concentration abruptly increased up to a peak value as shown in figure 3. And then it exponentially decreased down to the background level after its operation stopped. The peak particle concentrations ranged 10-20 and 150-200 particles/cm$^3$ for the 1-min and 10-min operation, respectively, which are significantly lower than that in indoor environment (~5,000 to 10,000 particles/cm$^3$). The almost linear increasing pattern of the particle number concentrations was observed for each 10-min operation period, which implies that nanoaerosols were released continuously at a similar pattern. Repetition of operation of the test electronic hand dryer showed a periodic particle release, implying that the test hand dryer generates a small amount of nanoaerosols during the use period. It is not confirmed to be silver nanoparticles due to low quantity of emission.

4. Conclusions

The release of nanoaerosols from the commercial hand dryer having a filter coated with silver nanoparticles was evaluated during the operation using the test chamber equipped with a CPC. The particle number concentration in the chamber started to almost linearly increase from <1 particles/cm$^3$ as a background level up to 20 and 200 particles/cm$^3$ for 1-min and 10-min operations, respectively. The particle number concentration exponentially decreased just after the hand dryer was turned off because of air exchange. Based on the similar increasing patterns of the particle number concentration during each operation, it is concluded that a small amount of nanoaerosols was released from the hand dryer. The chemical composition of the released nanoaerosols was not identified yet, because the amount of released nanoaerosols was negligible. More tests during the longer operation of the hand dryer are necessary for obtaining more information such as particle size distribution and chemical composition of the released nanoaerosols.

Further studies are needed to establish the standard test method for evaluating the exposure level to consumers of nanomaterials released from nanoproducts.
Figure 3. Variation of particle number concentration during the cyclic operation of the hand dryer.

References
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