Nanoaerosol Release Characteristics of Wallpaper Coated with TiO_2 Nanoparticles in an Air-jet Simulated Test Chamber

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ABSTRACT

Various colored wallpapers are popularly used as interior construction material of housings in Korea. Among them the TiO_2 coated wallpaers are sold in the market. In this work, we investigated nanoaerosol release characteristics of the wallpaper coated with TiO_2 nanoparticles. Prior to release test, the specimen was deteriorated by varing UV exposure time. A pulsed air jet was enforced to the specimen in the test chamber. The released aerosol amount was in order of wallpaper coated with TiO_2 nanoparticles by consumer > common wallpaper > wallpaer coated with TiO_2 particles by manufacturer. After 10-hours exposure, change in the released aerosol amount was negligible.

Keywords: nanoaerosol, release, nanoproduct, wallpaper, TiO_2

1 INTRODUCTION

As the commercialization of nanoproducts is increasing, the safety issue of nanomaterials is dealt in the view point of whole life cycle. Particularly, consumer nanoproducts are more interested in public health aspects.

Various release scenarios for nanoproducts were suggested in the point of professional user, consumer, environment, and recycling [1]. Released potential was summarized for material characteristics of MWCNT-polymer system [2]. Also, release mechanisms of mixing/sonication, sanding, grinding, drilling, cutting/sawing, UV weathering, UV + wet weathering, and abrasion were suggested for MWCNTs in polymer matrices [3]. Some of quantitative release test were reported for specimen [4] or a full-size product [5].

CNT-containing nanoproducts are widely needed in applications of electronics & data storage, defence, aerospace, energy, sporting goods, automotive, printing & packaging, textiles, healthcare & life sciences, environment, construction, and personal care [2].

In Koea, wallpaer is a popular interior construction material of housing. Wallpaper is well known to emit various volatile organic compounds and carbonyl compounds. Some wallpaer are coated with TiO_2 nanoparticles for photocatalytic effect.

In this work, we investigated nanoaerosol release characteristics of wallpaper coated with TiO_2 nanoparticles. Three test specimen including common wallpaer and wallpapers coated with TiO_2 nanoparticles by manufacturer or consumer were used to compare the amount of nanoaerosol release. We also considered degradation effect of wallpaper coated with TiO_2 nanoparticles by varying UV exposure time.

2 EXPERIMENTAL

Three kind of wallpapers were selected as test specimen: common wallpaper as a control, wallpaper coated with TiO_2 nanoparticles by manufacturer, and wallpaper coated with TiO_2 nanoparticles by consumer. 10×10 cm of wallpaper specimen were prepared.

Nanoaerosol release test for wallpapers was conducted by two steps. To simulate degradation effect, test specimen were exposed to UV light (351 nm wavelength, 8 W, Sankyo, Japan) in the closed UV exposure chamber as shown in Fig. 1. For wallpaper coated by consumer, the test specimen was set in the UV exposure chamber two hours later after TiO_2 spray coating. TiO_2 spray solution (>5 wt%, Nano-green Tech, Japan) was used. The chamber was divided by four rooms to control exposure time of each specimen independently. UV exposure time was set at 30 min, 120 min, 10 hours, and 48 hours.

After then, nanoaerosol release pattern was observed in an air-jet simulated test chamber. To measure the amount of nanoaerosol release, a test chamber system was designed as shown in Fig. 2. It consisted of a cube-shape chamber, a pure air generator, and a real-time aerosol monitoring instruments. The volume of the chamber was 27 L ($30\times30\times30$ cm). The chamber was made of stainless steel except a small acrylic window for monitoring by eyes.

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 [5].

The test was conducted as follows. First, a test specimen was set in the test chamber as shown in Fig. 3 (b). Here, the distance between air-jet nozzle and the test specimen was fixed at 1 cm. Prior to main test, the chamber was purged with a particle-free air of 10 L/min 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 as shown in Fig. 4. After purging, the air flow rate of the pure air was reduced to 5 L/min for the main test. The test lasted for 120 min.

Figure 1: UV light exposure chamber

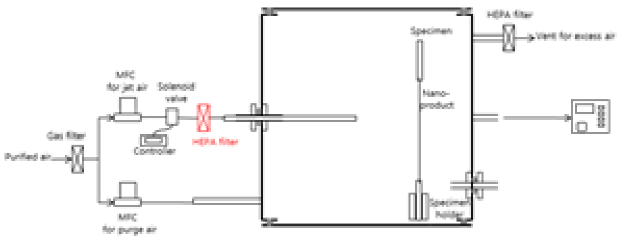
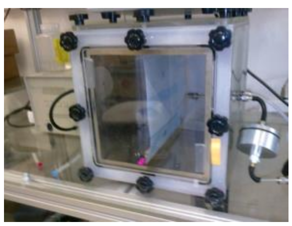


Figure 2: Nanoaerosol release test chamber system



(a) (b)

Figure 3: Wallpaper. (a) Commercial wallpaper, (b) Test specimen of wallpaper installed in the chamber

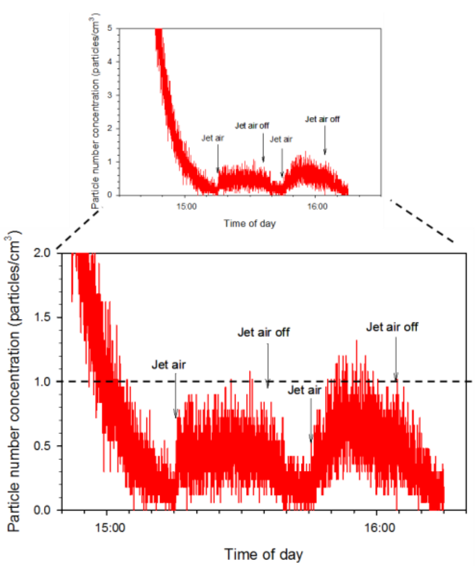
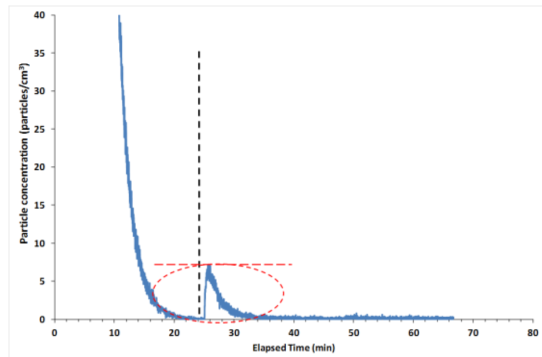


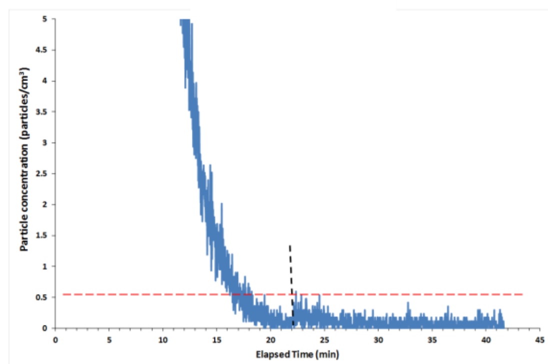
Figure 4: Decay pattern of particle concentration in the test chamber during the purging period

3 RESULTS

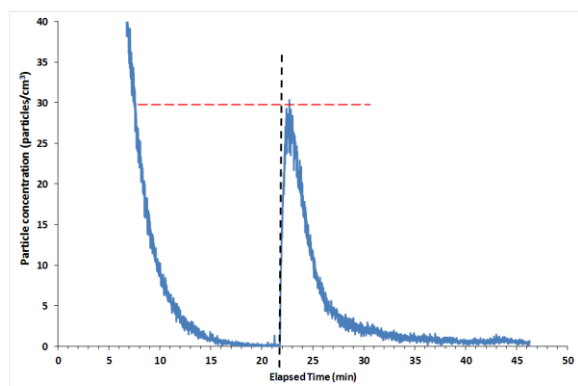
Nanoaerosol release patterns of three specimen not exposed to UV light are compared in Fig. 5. When pulsed air jet was applied, the particle concentration reached shortly peak level for common wallpaper and wallpaper coated with TiO_2 nanoparticles by consumer. Thereafter, it decreased slowly. Peak concentrations are 7 and 30 particles/cm^3, respectively. However, distinct release pattern was not observed for wallpaper coated with TiO_2 nanoparticles by manufacturer.



(a)

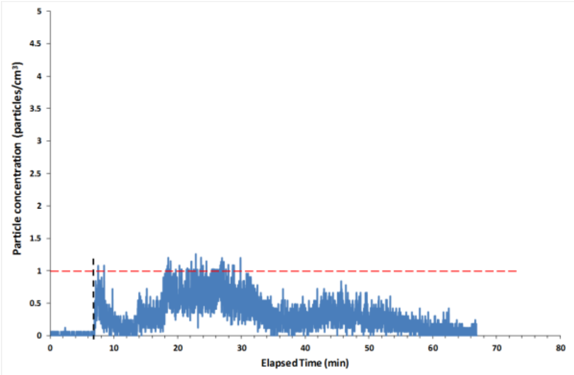


(b)

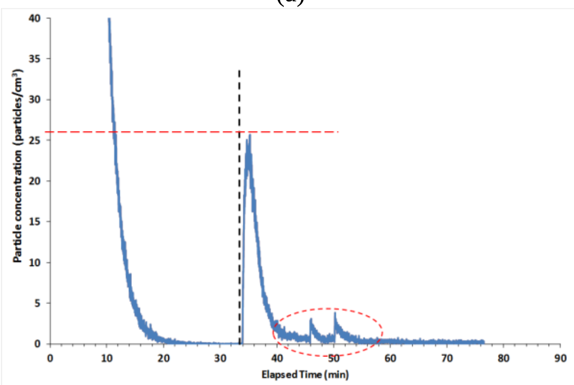


(c)

Figure 5: Initial nanoaerosol release patterns. (a) Common wallpaper, (b) Wallpaper coated with TiO_2 nanoparticles by manufacturer, and (c) Wallpaper coated with TiO_2 nanoparticles by consumer



(a)



(b)

Figure 6: Nanoaerosol release patterns after 10 hours UV exposure. (a) Wallpaper coated with TiO_2 nanoparticles by manufacturer and (b) Wallpaper coated with TiO_2 nanoparticles by consumer

Degradation effect is compared in Fig. 6 after 10 hours UV light exposure. For wallpaer coated with TiO_2 nanoparticles by manufacturer, although the amount of nanoaerosol release was slightly increased after 10-hours UV exposure, particle concentrations are still <1 particles/cm^3. For wallpaer coated with TiO_2 nanoparticles by consumer, the nanoaerosol release pattern is similar to that of unexposed case shown in Fig. 5 (c).

4 SUMMARY

TiO_2 nanoparticles are known to show photocatalytic effects. Wallpapers coated with TiO_2 nanoparticles are sold in Korea. In this study, UV degradation and airflow enforcement effects were simulated for three kinds of wallpapers: common wallpaper as a control, wallpaper coated with TiO_2 nanoparticles by manufactures, and wallpaper coated with TiO_2 nanoparticles by consumer. Among them wallpaper coated with TiO_2 nanoparticles by consumer shows the highest release of nanoaerosols. However, peak concentration was insignificant under 30 particles/cm^3. In this case, we would like to point out that TiO_2 nanoparticles may be heavily exposed to consumer during the TiO_2 coating period.

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