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Science for Environment Policy

Nanocoating on buildings releases potentially toxic particles to the air

Weathering and abrasion are reported to cause titanium dioxide nanoparticles to escape from a self-cleaning coating for buildings. These particles may be toxic to humans and wildlife. The researchers have developed three indicators from the test results to help predict levels of nanoparticle release from these coatings.

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Source: Shandilya, N., Le Bihan, O., Bressot, C. & Morgeneyer, M. (2015). Emission of Titanium Dioxide Nanoparticles from Building Materials to the Environment by Wear and Weather. *Environmental Science & Technology* 49(4): 2163–2170. DOI:10.1021/es504710p.

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Photocatalytic coatings containing nano-sized particles of titanium dioxide are increasingly applied to the outside of buildings for their antibacterial and self-cleaning properties. Weathering and wear can cause them to disintegrate and there are concerns about the subsequent release of nanoparticles into the environment. Various studies have found that some types of titanium dioxide nanoparticles have damaging effects on humans and animals. For example, experiments have shown that they can damage DNA.

This study investigated weathering and wear's effects on a photocatalytic nanocoating to help predict levels of nanoparticle release into water and air. The coating was comprised of 1.1% titanium dioxide particles by volume, which were around 8 nanometres in size.

Over a seven-month period, the researchers exposed a brick painted with the coating to UV light and water to recreate the effects of weather. At four intervals — two, four, six and seven months — they measured titanium levels in the runoff water. Titanium was measured as it is not possible to measure the relative number or percentage of titanium dioxide nanoparticles specifically. However, the coating's nanoparticles were the only type of titanium in the experiments.

At each of the four intervals, the brick was placed in a test chamber and rubbed with an abrasion technology commonly used in the paint industry to test products. The technology recreates friction levels found in a typical domestic environment, i.e. the same stress levels that being walked on or knocked, for example, would cause. The researchers then analysed the chamber's air for particles.

Weathering changed the coating's surface, which became increasingly cracked and lumpy over the seven months. Weathering alone did not appear to release nanoparticles into water; titanium was not seen above a detection threshold of 0.5 micrograms (µg) per litre of water at any stage. However, a longer period of weathering may produce different results.

Combined with weathering, abrasion did release titanium into the air, however. There was a big jump in release rates between four and seven months. Around 500 particles (including particles from the coating's polymer and the brick itself, as well as titanium particles) were recorded per cm^3 of air throughout the study. At four months, around 7% of all particles were titanium, but the figure was 55% at seven months.

Significantly, most of the titanium particles were 'free' (90% by mass). This means that they are no longer bound in a material, but are loose and could pose a health or ecological risk. This is particularly important, the researchers say, as many previous studies have suggested that particles remain bound, even if to smaller pieces of the main material.

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From these results, the researchers developed three indicators to help predict the release of nanoparticles from coatings:

1. **Emission Transition Pace (ETP)**: the rate of change in particle concentrations in relation to weathering duration. The ETP in this study accelerated after four months of weathering, for example.
2. **Stable Emission Duration (SED)**: this is a score which indicates the coating's lifetime; the higher the score, the longer the lifetime. The coating in this study fell from an initial score of 320 to 110 after 4 months, and to 0 after 6 months. A score of '0' suggests that the coating will disappear as soon as abrasion starts.
3. **Stable Emission Level (SEL)**: the concentration of particles for a corresponding SED score. It increased with weathering duration in this study. For example, at the start of the study the SEL was around 75 particles per cm^3 of air when the SED was 320. It rose to around 200 particles per cm^3 of air after 4 months when the SED was 110.

The researchers therefore consider four months of accelerated weathering to be this coating's 'nanosafe lifetime' — a form of 'best-before date'. The findings of this study can be extended to other forms of nanocoatings, to help inform safe design.

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