Study finds evidence nanoparticles may increase plant DNA damage

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Graphic showing that increasing exposure to cupric oxide bulk particles (BPs) and nanoparticles (NPs) by radish plants also increases the impact on growth with NPs showing the largest impact. From left to right, the exposure concentrations are 0; 100 parts per million (ppm) BPs; 1,000 ppm BPs; 100 ppm NPs; and 1,000 ppm NPs (showing a severely stunted plant). Credit: H. Wang, U.S. Environmental Protection Agency

(Phys.org) -- Researchers at the National Institute of Standards and Technology (NIST) and the University of Massachusetts Amherst (UMass) have provided the first evidence that engineered nanoparticles are able to accumulate within plants and damage their DNA. In a recent paper, the team led by NIST chemist Bryant C. Nelson showed that under laboratory conditions, cupric oxide nanoparticles have the capacity to enter plant root cells and generate many mutagenic DNA base lesions.

The team tested the man-made, ultrafine particles between 1 and 100 nanometers in size on a human food crop, the radish, and two species of common groundcovers used by grazing animals, perennial and annual ryegrass. This research is part of NIST's work to help characterize the potential environmental, health and safety (EHS) risks of nanomaterials, and develop methods for identifying and measuring them.

Cupric oxide (also known as copper (II) oxide or CuO) is a compound that has been used for many years as a pigment for coloring glass and ceramics, as a polish for optics, and as a catalyst in the manufacture of rayon. Cupric oxide also is a strong conductor of electric current, a property enhanced at the nanoscale level, which makes the nanoparticle form useful to semiconductor manufacturers.

Because cupric oxide is an oxidizing agent—a reactive chemical that removes electrons from other compounds—it may pose a risk. Oxidation caused by metal oxides has been shown to induce DNA damage in certain organisms. What Nelson and his colleagues wanted to learn was whether nanosizing cupric oxide made the generation and accumulation of DNA lesions more or less likely in plants. If the former, the researchers also wanted to find out if nanosizing had any substantial effects on plant growth and health.

To obtain the answers, the NIST/UMass researchers first exposed radishes and the two ryegrasses to both cupric oxide nanoparticles and larger sized cupric oxide particles (bigger than 100 nanometers) as well as to simple copper ions. They then used a pair of highly sensitive spectrographic techniques to evaluate the formation and accumulation of DNA base lesions and to determine if and how much copper was taken up by the plants.

For the radishes, twice as many lesions were induced in plants exposed to nanoparticles as were in those exposed to the larger particles. Additionally, the cellular uptake of copper from the nanoparticles was significantly greater than the uptake of copper from the larger particles.

The DNA damage profiles for the ryegrasses differed from the radish profiles, indicating that nanoparticle-induced DNA damage is dependent on the plant species and on the nanoparticle concentration.

Finally, the researchers showed that cupric oxide nanoparticles had a significant effect on growth, stunting the development of both roots and shoots in all three plant species tested. The nanoparticle concentrations used in this study were higher than those likely to be encountered by plants under a typical soil exposure scenario.

"To our knowledge, this is first evidence that there could be a 'nano-based effect' for cupric oxide in the environment where size plays a role in the increased generation and accumulation of numerous mutagenic DNA lesions in plants," Nelson says.

Next up for Nelson and his colleagues is a similar study looking at the impact of titanium dioxide nanoparticles—such as those used in many sunscreens—on rice plants.

More information: D.H. Atha, et al. Copper oxide nanoparticle mediated DNA damage in terrestrial plant models. *Environmental Science and Technology*, Vol. 46 (3): pages 1819-1827 (2012), DOI: 10.1021/es202660k

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