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Science for Environment Policy

Overview of nanomaterials for cleaning up the environment

Researchers have presented an extensive analysis of the role of nanomaterials in environmental remediation and monitoring. Nanomaterials can be used to clean up toxins and bacteria from natural waters, wastewaters and the air.

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Contact:
nniansn@nus.edu.sg
seeram@nus.edu.sg

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Nanomaterials' unique properties allow them to remove pollutants from the environment. The extremely small size of nanomaterial particles, typically in the range between 1 and 100 nanometres (billionth of a metre), creates a large surface area in relation to their volume, which makes them highly reactive, compared to non-nano forms of the same materials.

Silver, iron, gold, titanium oxides and iron oxides are some of the commonly used nanoscale metals and metal oxides cited by the researchers that can be used in environmental remediation. Silver nanoparticles, for example, have proved to be effective antimicrobial agents and can treat wastewater containing bacteria, viruses and fungi. Nanoscale titanium dioxide can also kill bacteria and disinfect water when activated by light.

Gold nanoparticles may potentially be another useful material for removing contaminants, such as toxic chlorinated organic compounds, pesticides and inorganic mercury, from water. They can also be used to remediate air. In combination with titanium dioxide, gold nanoparticles have been shown to convert the toxic air pollutant, sulphur dioxide, to sulphur. Titanium dioxide nanomaterials are commonly used in some processes to disinfect water, in addition to breaking down halogenated compounds, and removing dyes and metal toxins from drinking water and wastewater.

The researchers point to studies that show that carbon nanomaterials are particularly suited to removing a broad range of pollutants. Carbon nanotube clusters, for example, are used to purify water by adsorbing bacteria that contaminate the water. Heavy metals, such as cadmium, as well as organic pollutants including benzene and 1,2-dichlorobenzene can also be removed from water by carbon nanotube materials.

The researchers suggest that nanoparticles can be attached to host polymer materials, such as porous resins, cellulose and silica, to reduce potential harm to human health and the environment derived from the release of nanoparticles into the environment. The nanoparticles fixed to the host material are thus bulkier and can be more easily removed and captured from wastewater. Nanoparticles, such as nanoscale zinc oxide, fixed in this way, are used, for example, to break down organochlorine pesticides, halogenated herbicides and azo dyes.

In addition to remediating pollution, nanoparticles can be used as sensors to monitor toxins, heavy metals and organic contaminants in land, air and water environments and have been found to be more sensitive and selective than conventional sensors. Sensor strips composed of nylon 6 nano-fibre nets are one example. These are used to detect formaldehyde, a toxic air pollutant widely used in the manufacture of household materials and building products. The yellow sensor strips turn red upon exposure to formaldehyde.

The researchers acknowledge that ongoing work is needed to further improve the shape, sizes, structures, functionality and manufacture of nanomaterials that show promise in cleaning up contaminants that enter water, land and air environments from industries, transport and other human activities. A better understanding of the behaviour of nanomaterials and their potential harm to the environment is also required.