'Holey' Nanosheets for Wastewater Dye Removal

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(PhysOrg.com) -- Researchers have discovered that extremely thin sheets of nickel oxide with hexagonally shaped holes can absorb hazardous dyes from wastewater nearly as well as the best traditional methods, but are recyclable. The research was reported recently in the journal *Nanotechnology*.

The group, consisting of scientists from the Colorado School of Mines and South-Central University for Nationalities, in China, compared the performance of their nickel-oxide (NiO) “nanosheets” to the absorption properties of a powdered form of NiO as well as to activated carbon, a material often used for absorption applications because it has a very large overall surface area.

In a similar way, the hexagonal holes in the NiO nanosheets also possess a high surface area. Each sheet has a polar surface, containing distinct regions of positive and negative charge.

According to Colorado School of Mines scientist Ryan Richards, one of the paper's authors, “Metal oxides like NiO have the main advantage that the absorbed material can be burned off and the NiO can be reused. Additionally, the polar surface of the NiO nanosheets may provide some advantages in adsorbing certain substrates. Methods for the recycling of activated carbon are often expensive and in this way and the carbon and the material it has absorbed must be discarded.”

Richards and his colleagues tested the absorption performance of the

nanosheets and the NiO powder using three common synthetic dyes: reactive brilliant red X-3B, congo red, and fuchsin red. These dyes are used for many industrial purposes, including paper and pulp manufacturing, cloth dyeing, leather treatment, and printing.

The textile industry is a heavy user of dyes, consuming 60% of the world's supply, and experts estimate that 10 to 20 percent of water-soluble dyes are lost during the dyeing process and released into wastewater. The dyes pose a threat to environmental health on their own, but as they undergo chemical reactions in the water other toxic and hazardous intermediate compounds are created.

Various remediation methods exist, but physical absorption - using an absorbent material to “catch” and trap the dye - is the most common. Activated carbon is widely used, although many other materials have been investigated, including silica, clay, natural polymers, synthetic polymers, and various types of nanotubes.

The group prepared solution samples containing all three dyes and stirred in either powdered NiO or a small amount of nanosheets. They found that the nickel oxide nanosheets could remove, on average, two to three times as much dye as the powdered NiO. The nanosheets still do not perform as well as activated carbon - for example, the nanosheets absorbed about 71 percent of the congo red dye while the activated carbon took up 98 percent - but they have the advantage that the absorbed material can be readily burned off and the sheets reused. The sheets are also inexpensive to produce and can be created using “green” methods.

“We think that this means NiO nanosheets or similar materials could become the preferred media for dye removal in the future,” said Richards.

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