Microwaves improve green workings of materials used to clean wastewater

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A new method for making the material used for cleaning wastewater makes the production process greener - and 20 times faster. In a study published in *Applied Materials Today*, researchers show how using microwaves can reduce the temperature and pressure needed to make photocatalysts.

Powered with sunlight, materials like titanium dioxide (TiO_2) and bismuth vanadate ($BiVO_4$) are used to clean wastewater, break down dyes and even kill bacteria in transparent bandages. Despite being considered 'green', the processes traditionally used to make these materials are energy intensive.

Now, researchers at Chiang Mai University and the National Nanotechnology Center in Thailand, and the University of Wollongong in Australia, have come up with one-step method using microwaves to make $BiVO_4$ nanoparticles that doesn't require high temperatures and pressures. This, say the researchers, makes the material truly environmentally friendly, and will cut production costs and time.

"These materials have a wide range of applications, but there has been little done to improve the way we make them," said Dr. Jun Chen, one of the authors of the new study from the University of Wollongong, Australia. "People say photocatalysts are green, but sometimes the way we generate these materials is not really energy efficient."

Traditionally, $BiVO_4$ is made using a hydrothermal method that requires

high pressure and high temperature. This is energy intensive, and can take around six hours. The process involves several crystal phases, which determine the structure of the material - the size and shape of the nanoparticles. With the traditional method, these phases can't be controlled, so an additional process has to be added at the end of production to tidy up the particles. This involves high temperatures of around 500 degrees Celsius, costing even more energy.

Microwaves are sometimes used to support the traditional hydrothermal approach, to improve the purity and structure of the final material. The new method uses pure direct microwaves to make $BiVO_4$, so doesn't require high temperature and pressure, or an additional process to improve the material.

The new method is a simplified, one-step process carried out at 60-90 degrees Celsius, making it industrially viable and safer. It is also much quicker - compared to the standard 6 hours, the new method takes just 16 minutes.

What's more, the $BiVO_4$ nanoparticles made using the new process are pure and uniform in shape and size. The team adjusted the pH, temperature and reaction times to control the crystal phase of production. This meant they could control the shape and size of the nanoparticles, without the need for an additional process.

The team tested how well the material can break down a dye called Rhodamine B (RhB). They found their materials to be highly photocatalytic, and works as well as $BiVO_4$ made using traditional methods.

"We were so surprised that not many people are focusing on this area - only a few studies have been done using microwaves," said Dr. Chen. "We hope this work will be of considerable interest to materials

scientists who want to employ green technology to simplify the synthesis process for inorganic crystal materials."

The researchers now hope to extend the method to synthesizing other metal oxides and related composites.

More information: Kanlaya Pingmuang et al. Phase-controlled microwave synthesis of pure monoclinic BiVO4 nanoparticles for photocatalytic dye degradation, *Applied Materials Today* (2015). DOI: 10.1016/j.apmt.2015.09.003

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