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Nanoparticles cooked up in aerosol spray

Semiconductor nanoparticles have many potential uses, but it's neither easy not cheap to make them. A new approach conjures them out of mist.

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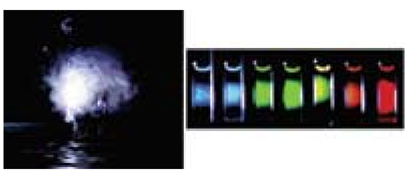

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The success of a new technology often hinges on the most prosaic of considerations: how much it costs. That's why a new way of making nanoparticles developed by researchers at the University of Illinois in Urbana-Champaign could make a big difference to nanotechnology.

Yuri Didenko and Kenneth Suslick have found a way to generate semiconductor nanocrystals of a well-defined mean size and narrow size distribution from a fine spray of a solution of the precursor compounds. When the spray is heated in a furnace, each droplet acts as a microreactor in which many nanoparticles are precipitated[1].

There are already several reliable methods for making nanoscale particles of a specified size and composition. One of the most popular, used for making nanoparticles of crystalline semiconductors such as cadmium selenide (CdSe), involves the injection of an organometallic precursor compound into a hot, high-boiling point organic solvent, resulting in pyrolysis of the precursor[2]. This method has been modified so that less toxic and less expensive non-organometallic precursors can be used instead[3,4].

But these synthesis techniques have drawbacks for large-scale production. For example, obtaining uniform particle sizes requires that the solutions be well mixed and the temperature be uniform throughout, which is not easy to ensure.

That is what stimulated Didenko and Suslick to develop their aerosol-spray synthesis. Aerosol-based methods for making nanoparticles have also been widely explored before — a common technique is called flame spray pyrolysis — but these typically use vapour-phase precursors and generate solid particles dispersed in a gas, which again makes the reactions hard to control. In the technique devised by the Illinois researchers, a solution of the precursors is turned into a fine mist by a commercial sprayer that uses ultrasound to produce very small droplets (less than a micrometre across). The researchers simply took this device from a home humidifier unit, which normally generates fine sprays of water.

Didenko and Suslick use a similar mixture of reagents to those in the earlier pyrolysis method[3,4]. To make CdSe nanocrystals, they mixed inorganic compounds of cadmium, such as CdO or $CdCO_3$, with elemental selenium dissolved in trioctylphosphine (TOP): the TOP coordinates to the selenium atoms. A surfactant such as stearic acid helps to stabilize the surfaces of the nanoparticles, limiting their growth.

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The spray itself consists of droplets of a mixture like this diluted with toluene. When the droplets are carried by a flow of argon gas into a furnace heated to between 180 and 400 °C, the toluene evaporates and the inorganic substances combine within each droplet to produce nanoparticles whose size depends on the reaction temperature. At 340 °C, for example, the CdSe particles have an average width of 3.5 nm.

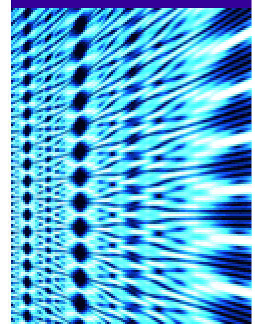
Because the precise size determines the fluorescence wavelength of the nanoparticles, owing to quantum size effects, the two researchers were able to make CdSe nanocrystals of more or less any colour in the visible spectrum just by tweaking the reaction conditions. This ability to tune the emission wavelength of such semiconductor nanoparticles is one of the prime drivers behind their technological interest, suggesting applications ranging from light sources for optoelectronics to fluorescent markers for biological imaging.

Didenko and Suslick have also demonstrated the synthesis of cadmium telluride nanoparticles this way, which are of potential interest for solar-cell technology. They suspect that the method should also be applicable to metals, polymers and other materials.

All the same, TOP is an expensive and toxic solvent. That is why a modification of the original solvent pyrolysis method that dispenses with TOP, reported by Fangqiong Tang of the Technical Institute of Physics and Chemistry in Beijing, China, and co-workers looks appealing[5]. Their technique uses simple long-chain alkanes (C18–C24) as the solvent, which are both cheaper and 'greener' than TOP. If this approach can be combined with Didenko and Suslick's 'chemical aerosol flow synthesis', making nanoparticles should become a much more amenable business.

References

1. Didenko Y. T. & Suslick K. S Chemical aerosol flow synthesis of semiconductor nanoparticles. *J. Am. Chem. Soc.* **127** 12196–12197 (2005)
Article
2. Murray C. B., Norris D. J. & Bawendi M. G. Synthesis and characterization of nearly monodisperse CdE (E = S, Se, Te) semiconductor nanocrystallites. *J. Am. Chem. Soc.* **113** 8706–8715 (1993)
Article
3. Peng Z. A. & Peng X.Formation of high quality CdSe and CdS nanocrystals using CdO as precursor. *J. Am. Chem. Soc.* **123** 183–184 (2001)
Article
4. Qu L., Peng A. & Peng X. Alternative routes towards high quality CdSe nanocrystals. *Nano Lett.* **1** 333–337 (2001)
Article
5. Deng Z., Cao L., Tang F. & Zou B. A new route to zinc-blende CdSe nanocrystals: mechanism and synthesis. *J. Phys. Chem. B* **109** 16671–16675 (2005)
Article



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