(Al-6.3Li-0.069Sc-0.018Yb, at.%) and characterized by dark field transmission electron microscopy and atom probe tomography (APT). The alloy is homogenized at 640°C followed by quenching in iced brine which generates large (1.5 μm) particles at grain boundaries containing Li, Sc, and Yb.

The first aging step, at 325°C, results in precipitation of $Al_3X$ core–shell nanoparticles (where X can be Li, Sc, or Yb). The core is richer in Yb, and Sc is simultaneously enriched in the shell. The alloy is subsequently quenched to 170°C and aged, promoting the formation of a second shell around the particles composed of δ′-$Al_3Li$.

APT studies also revealed two populations of nanoparticles. The first is an abundant population of core–single-shell nanoparticles, with an average diameter of 2.2 nm ± 0.8 nm. The second particles are core–multishell nanoparticles with an average diameter of 12.2 nm ± 0.3 nm.

A representative particle has a core region of about 3.3 nm, a 1.8-nm thick (on average) first shell, and a 10-nm thick (on average) second shell. As an interesting case, one of these particles was actually a multicore–multishell particle containing two cores with single-shell encapsulated together in a δ′-$Al_3Li$ second shell.

According to the researchers, this is a demonstration of the limitation of control over nanoscale features with this technique, but also an unexpected new architecture possible with this solid-state synthesis technique representing a minor but measureable subpopulation. Vickers microhardness tests show an increase in microhardness from 725 ± 10 MPa after the first aging step, when the core–single-shell nanoparticles are present, to 960 ± 20 MPa after the second aging, when core–multishell nanoparticles are also present providing evidence that the more complex multishell architecture has an advantage over core–single-shell particles.

The researchers said that this solid-state synthesis technique should be generally applicable to a range of alloys. Key considerations are (1) choice of alloying elements, relative diffusivities, and solubilities, and (2) choice of aging temperatures, which significantly affects the ability to segregate the elements and form multiple shells.

Continued tuning and understanding of the effects of complex multishell (and multicore) nanoparticles within solid matrices will allow even greater flexibility in tailoring alloy mechanical properties.

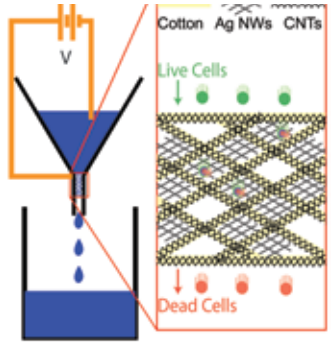
**Alia P. Schoen**

## Nano Focus

### Electrified nanostructures enable low-cost water sterilization

Waterborne bacterial diseases represent a major global problem killing over two million people worldwide annually, mostly children in developing countries. Conventional filters used to prevent such diseases are made from membranes but clogging of such devices is a common problem. A new strategy for deactivating bacteria by incorporating antibacterial silver nanowires (Ag NWs) in a carbon nanotube (CNT)-coated cotton fiber matrix has now been demonstrated. The material is mechanically robust, electrically conductive, and uses a very small amount of current to inactivate bacteria, while the open structure allows for high volume water filtration. The work led by Y. Cui and S. Heilshorn at Stanford University was published in the September 8th issue of *Nano Letters* (DOI: 10.1021/nl101944e; p. 3628).

Three components with different functionalities spanning three length scales formed the filter: (1) inexpensive cotton cloth formed the structural backbone, (2) Ag NWs (diameters of 40–100 nm, up to 10 μm long) with antibacterial properties formed a secondary mesh, and (3) carbon nanotubes formed a conductive coating on the cotton fibers. The final material (Ag NW/CNT cotton) was shaped into a cylindrical filter (4 mm diameter, 2.5 mm length) and placed in the stem of a glass funnel. Water was poured through the funnel at a typical flow rate of 1 L/h, with an applied low voltage of up to ±20 V. *Escherichia coli* was used as the representative bacterial species.




Schematic of the filtration device showing the three components used and the testing technique used for evaluation. NWs is nanowires and CNT is carbon nanotube. Reproduced with permission from *Nano Lett*. **10** (9) (2010) DOI: 10.1021/nl101944e; p. 3628. © 2010 American Chemical Society.

When no bias voltage was applied, neither the Ag NW/CNT cotton filter nor CNT-only cotton eliminated bacteria. On the other hand, the Ag NW/CNT cotton inactivated 89% of bacteria at −20 V and 77% at +20 V applied voltage, much higher than the CNT-only cotton. The Ag NW/CNT cotton device consumed 60 mW power, compared to 250 mW consumed by an equivalent ultrafiltration membrane. The Ag NW/CNT cotton device was effective in deactivating bacteria over a range of bacterial concentrations with modest power consumption. Three stages of this process were used in series to attain inactivation efficiencies of over 98%.

The material developed could form the basis of inexpensive point-of-use water filters for deactivating water-based microorganisms with high volume throughput. Such filters are ideal for use in developing countries due to the low cost of the filter and the modest electricity requirements.

**Gopal R. Rao**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