Bio Focus

Bionic plants point toward leafy sensors and power sources

Plants are hardy organisms, built to withstand the elements. A new field, plant nanobionics, intends to tap into that power to not only create more robust plants, but also form more robust materials. As reported in the April issue of *Nature Materials* (DOI: 10.1038/nmat3890; p. 400), a research team from the Massachusetts Institute of Technology (MIT) has shown how the fusion of plants, carbon nanotubes, and ceria nanoparticles improves plant function, especially in the power-generating chloroplasts.

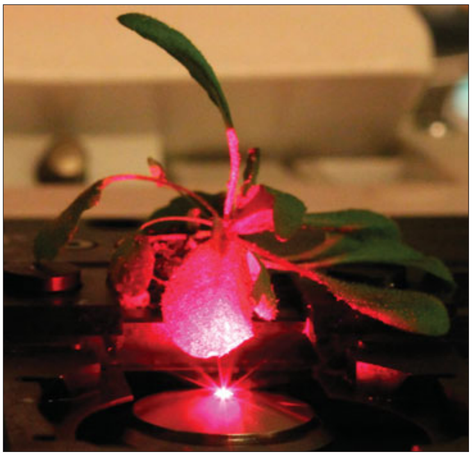
"Plants can do so much," said Michael Strano, a chemical engineer at MIT. "And humans [and other animals] have nothing that compares to the [tissue] repair cascade that plants can do. So we flipped our thinking. Why not see plants as technology?"

Together with plant biologist Juan Pablo Giraldo, Strano and his research team chose nanoparticles and solutions that had proven nontoxic in previous experiments with mice. Due to their special optical and electronic properties, single-walled carbon nanotubes (SWNTs) can enhance photosynthesis processes. The team was also particularly interested in ceria nanoparticles (nanoceria), which have been shown to boost healing properties in bioimplants by absorbing free radicals that can cause tissue damage.

But getting the nanoparticles into the plant was another matter. Going up the roots seemed the logical pathway, but plants have evolved safeguards to prevent foreign objects from entering that way, said Strano. Giraldo identified another possible pathway: through the leaves.

On the underside of leaves, pores allow carbon dioxide in and oxygen out. When a solution containing the nanoparticles was applied, a backflow effect occurred, with the carbon nanotubes getting absorbed into the leaf. Because the nanotubes were wrapped with polymers or materials that had an affinity for lipids in the chloroplast, they were drawn there, attaching and creating nano-enhanced plants.

Strano and Giraldo ran three experiments, testing the capabilities of the new bionic plants. First, the carbon nanotubes were tuned to respond as a sensor, dropping their near-infrared light emission in the presence of toxins such as pollutants. Second, since the nanotubes could be used to absorb light at wavelengths outside the normal photosynthesis range, extracted chloroplasts with the nanoparticles showed a 49% boost in light energy capture outside plants and 30% inside leaves of living plants. And third, with the help of the nanoceria combined with nanotubes, the chloroplasts were even more robust outside of the plant, rendering them capable of capturing light energy for several hours more than nontreated chloroplasts.



The *Arabidopsis* plant, with carbon nanotubes absorbed inside its leaves, has augmented light energy capture and may act as a photonic biochemical detector. Image credit: Juan Pablo Giraldo.

"This is unlike anything we've seen before," said Giraldo. "But we need to do more work to understand how the carbon nanotubes" aid in boosting the plants' abilities.

While these are proof-of-concept ideas right now, Strano foresees many possible applications, not the least of which is materials that have a self-healing property. Imagine, his team said, a cell-phone case that fixes itself after a drop. In addition, there is also the hope of a plant-powered solar cell that could have a negative carbon footprint; it would actually use carbon dioxide to produce clean, environmentally friendly energy.

Meg Marquardt

Nano Focus

Stable bimetallic interfaces achieved in extreme plastic deformation

Generating uniformly ordered interfaces in bulk nanostructured metals is a challenge in designing materials that are stable under extreme environment conditions, such as next-generation, highly energy-efficient systems. Irene J. Beyerlein, Amit Misra, and their colleagues at Los Alamos National Laboratory have shown that by imposing an extreme amount of plastic strain in a Cu–Nb nanolayered crystal system, low-energy, well-ordered bimetal interfaces evolve.

According to Beyerlein, the project lead in this work, the research team has been studying interfaces in bimetallic nanocomposites in order to understand this phenomenon at the microscopic and atomic-scale level. She said that under extreme conditions defects, voids, or damage in a material is expected. However in this case, "what was surprising is that the interface that emerged was ordered, similar to the interfaces found in epitaxially grown films," she said. Most remarkably, experimental evidence showed that this preferred interface occurs ubiquitously throughout the volume (>cm^3) of the nanocomposite. This interface was also stable with respect to further straining, high-temperature exposure, and irradiation, giving the nanomaterial extraordinary tolerances in other extreme environments.

As reported in the March 25 issue of *PNAS* (DOI: 10.1073/pnas.

https://doi.org/10.1557/mrs.2014.109 Published online by Cambridge University Press