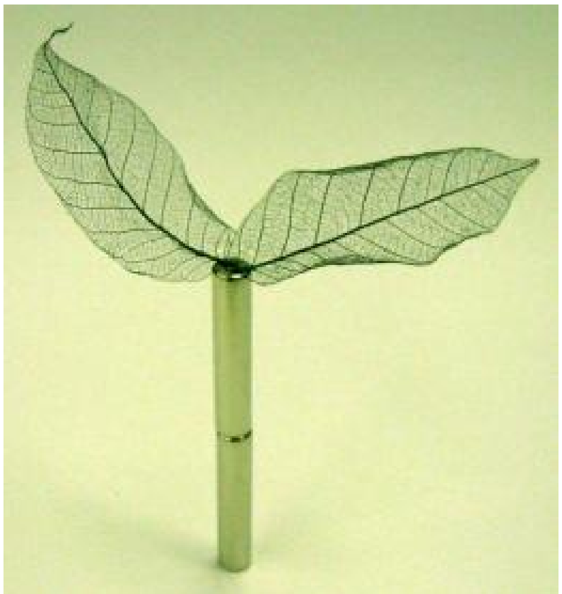
Turning over a new leaf

September 20 2010



A magnetic leaf: Using a simple chemical process, researchers from the Max Planck Institute of Colloids and Interfaces converted a leaf skeleton into iron carbide, which is magnetic and conducts electricity. Wide-ranging biological forms can be used as templates for filigree metal carbide structures using this method. Image: Max Planck Institute of Colloids and Interfaces

(PhysOrg.com) -- German researchers have transformed the skeleton of a leaf into iron carbide. The new technique enables the conversion of metal carbides into intricate microstructures in just one step.

As recently confirmed by a group of chemists from the Max Planck Institute of Colloids and Interfaces, nature can provide very useful templates for technical applications. The scientists have devised a new process involving the almost complete conversion of a leaf skeleton into magnetic iron carbide. To do this, they treated the leaf with iron acetate, nitrogen and heat. This technique can be used to recreate all natural carbonaceous structures with metal carbides. The result is not just beautiful, but also very useful. Biology's intricate forms provide a wide range of templates for a variety of applications. (*Angewandte Chemie, International Edition*)

Nature's fine structures are also suitable for technical applications - they exist in a myriad variety of forms, they usually display high mechanical stability and, due to their large surfaces, provide suitable templates for catalysts and electrodes. Researchers from the Max Planck Institute of Colloids and Interfaces in Potsdam have now succeeded in converting the filigree skeleton of a leaf into iron carbide using a very simple method. Materials scientists are interested in metal carbides because they are magnetic, conduct electricity and can withstand both high temperatures and mechanical stress. However, due to the stability of the material, it has proven almost impossible thus far to convert it into a specific form.

The Potsdam-based chemists have now succeeded in doing this in a very simple way. They started by dipping the leaf skeleton of leaves from a rubber tree into an iron acetate solution. They then air-dried the soaked skeleton at 40 degrees Celsius before treating it with nitrogen gas and heating it to 700 degrees Celsius. "The structure was conserved down to the last detail," says Zoe Schnepp, who carried out the experiment.

When heated, the iron acetate in the leaf skeleton is converted into iron oxide, which is then reduced by the carbon in the leaf skeleton to iron carbide. "The skeleton provides both the basis for the form and the carbon for the reaction," says Zoe Schnepp. "As a result, we can convert the organic substance in just one step. This is what distinguishes our method from other techniques which also use biological forms as templates for inorganic structures." Researchers have been producing metal oxides on the basis of natural materials like leaves for some time now. "One team has already succeeded in generating silicon carbide from pre-treated natural materials," says Zoe Schnepp. "We've now developed this process even further."

To test whether the leaf was fully converted into iron carbide, the researchers hung it in an electrolytic cell as an anode. Oxygen from the cell bubbled at the leaf and hydrogen bubbles rose at the cathode. "The experiment confirms that most of the leaf was converted into iron carbide. Apart from that, it only contains a bit of carbon," says Zoe Schnepp. The researchers also used a permanent magnet to demonstrate that the leaf had acquired the magnetic characteristics of the iron carbide.

The new method should function with all natural carbonaceous materials. "We would now like to test it on other materials," says Schnepp. "What is important about this study is that it shows how we can exploit nature's formal variety to produce wafer-thin metal carbide structures in one simple step."

More information: Zoe Schnepp, Wen Yang, Markus Antonietti, Cristina Giordano, Biotemplating of Metal Carbide Microstructures: The Magnetic Leaf
Angewandte Chemie, International Edition, August 16, 201, DOI: 10.1002/anie.201001626

Provided by Max-Planck-Gesellschaft