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# Innovations
from Savannah River National Laboratory

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## Mission

- Nanostructuring is an extremely important factor in its catalytic activity. Higher surface area and more "active" sites on the surface makes them attractive to use compared to bulk catalytic materials.
- A smaller amount of reactants and catalysts is needed for chemical reactions.
- Can be prepared in large quantities
- Does not require expensive instrumentation
- Can be prepared in several hours
- Stable for years

## Contact Information

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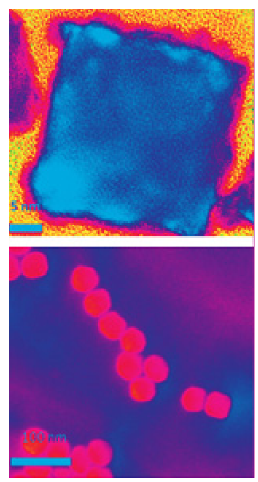
# Shape-selective nanocatalysts for direct methanol fuel cell applications

### Direct Methanol Fuel Cells: The Ideal System

Fuel cells have been studied and developed extensively throughout the world as one of the most feasible next-generation clean energy devices. Fuel cells are electrochemical devices that convert a fuel such as hydrogen, methanol or natural gas directly to electricity through an electro-catalytic process. The Direct Methanol Fuel Cell (DMFC) is considered an ideal system because it produces electric power by the direct conversion of the methanol fuel at the anode.

### Out-of-the-Box Thinking – Science at Work



Researchers at the Savannah River National Laboratory have taken process, chemical, and materials discoveries and translated them for technological solution and deployment. The group has developed state-of-the art shape-selective gold-platinum nanostructures with outstanding catalytic capabilities that address many of the DMFC's current shortcomings. The newly developed nanostructures not only greatly exceed the performance of the platinum catalyst, but also reduce the material cost and overall weight of the fuel cell. The presence of a shell metal on the core lattice affects the original crystal structure, resulting in changes to the electronic and optical properties of the material.

Gold-platinum nanocatalysts can also effectively suppress carbon monoxide. Carbon monoxide is an intermediate product created during DMFC operation, which forms due to the slow kinetics of the oxidation reaction at the anode. Many times, carbon monoxide poisons the platinum nanocatalysts, significantly reducing efficiency by slowing down the methanol oxidation reaction at the cathode. A gold core significantly reduces this problem, but also stabilizes and supports a platinum nanolayer during the electrochemical processes, which is a problem in fuel cells for vehicle applications.

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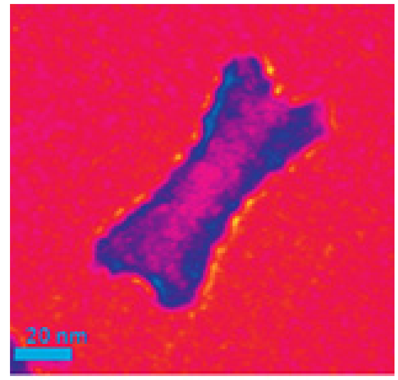
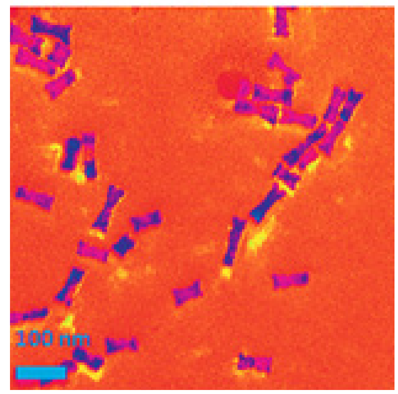
## Out-of-the-Box Thinking: Science at Work *(continued)*

The new classes of shape-selective gold-platinum nanomaterials have high catalytic activity and stability and are easy to prepare in large quantities, or scale up. The nanomaterials are prepared using solution chemistry in a seed-mediated approach. Gold seeds are made and used as templates to grow nanolayers of platinum. Shape selection is vital in that depending on the geometry of the nanocatalyst (hexagons, dog bones, cubes, etc.) and the platinum to gold ratio, platinum-based catalysts reduced, and in some cases eliminated, the detrimental effects of methanol crossing over to the cathode.

The catalytic activity of a catalyst depends highly on the size, shape, morphology and composition of the nanoparticles. Self-assembling allowed researchers to not only uniformly distribute the nanocatalysts, but to also expose the maximum number of active catalyst sites to the reaction. This allows an efficient use and response of platinum catalysts.




## Innovation from Science to Successful Deployment

There are a number of applications where the DMFCs can provide real benefit based on its high energy density and instantaneous refueling time with the simply exchange of the fuel cartridge. The next generation of high bandwidth mobile devices and battery chargers are examples of niche markets for DMFCs. These applications often require higher power densities than existing batteries. Military and security applications for this technology are also being explored.

The US Department of Energy estimates that platinum-based catalysts will use roughly four times less platinum than is used in current proton exchange membrane fuel cell designs in order to represent a realistic alternative to internal combustion engines. Internal combustion engines are most commonly used for mobile propulsion in vehicles and portable machinery. For portable electronic devices, the DMFCs have the potential to offer ten times the power density of current lithium-ion rechargeable batteries. By using nanomaterials, every single atom on the surface is active and an effectively be used in the catalytic reaction.

The ability to deliberately manipulate matter at atomic levels and create novel nanostructures with unique properties and functions may become the leading manufacturing approach for the next generation of materials. These cutting-edge nanomaterials hold promise for designing alternative, sustainable and innovative solutions to the current global energy crisis.

**Innovation: Getting more for less**

*Considering the current challenges in shape-controlled synthesis of nanocatalysts, we at SRNL have a unique skill to prepare shape selective nanocatalysts. Research using sphere-shaped nanoparticles can be found in many laboratories. Shape selective catalysts can also be found, but in small quantities and only by using expensive instrumentation – sometimes taking two or three days to prepare a small silicon wafer with nanomaterials.*

*At SRNL, we can prepare these uniquely shaped nanomaterials in large quantities, for less money and in less time.*





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