**Docket #:** S11-094

# Spinel Nanocrystals on Graphene

Researchers in Prof. Hongjie Dai's laboratory have developed nanocarbon/inorganic nanoparticle hybrid materials for various electrocatalytic and electrochemical applications, such as batteries and fuel cells. Three types of hybrid materials have been created:

1) Nanocrystals on Graphene Nanoplates or Nanorods:

- Designed for use as electrodes in energy storage and conversion devices.
- Demonstrated high specific capacitance in pseudocapacitor materials, such as Ni(OH)2 nanocrystals grown on graphene sheets.
- Showed excellent cycling ability and performance at different charge and discharge current densities.

2) Nanocrystals on Reduced Graphene Oxide:

- Created high-performance, bi-functional catalysts for oxygen reduction reaction (ORR) and oxygen evolution reaction (OER).
- Examples include Mn3O4 on reduced graphene oxide for high-capacity anodes in lithium-ion batteries.
- Co3O4/N-doped graphene exhibited catalytic activity similar to platinum but with superior stability in alkaline solutions.

3) Carbon Nanotube-Graphene Complexes:

- Used for ORR catalysts with high activity and stability.
- Demonstrated high ORR activity in both acidic and alkaline solutions, approaching the performance of platinum.

For more information, please see related docket S09-371.

Stage of Development:
The technology has been applied in various devices with promising results

## Applications

- **Batteries**
- Fuel Cells
- Supercapacitors

## Advantages

- **High performance** - high energy densities, high power densities, ultrafast charge/discharge rates, high catalytic activity
- **Low cost** - materials made from graphene, nanotubes and common metals are much less expensive than precious metals (such as platinum and iridium)
- **Scalable**
- **Environmentally friendly** materials that can be used with safe electrolytes (such as water and potassium hydroxide for the nickel-iron battery)
- **Durable catalysts** in both acidic and alkaline electrolytes

## Publications


- Yongye Liang,Yanguang Li, Hailiang Wang, Jigang Zhou, Jian Wang, Tom Regier & Hongjie Dai, Co3O4 nanocrystals on graphene as a synergistic catalyst for oxygen reduction reaction, Nature Materials 10, 780–786 (2011), published online 07 August 2011, doi:10.1038/nmat3087


## Patents

- Published Application: 20130189580
- Published Application: 20140333264
- Issued: 9,237,658 (USA)

## Innovators

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