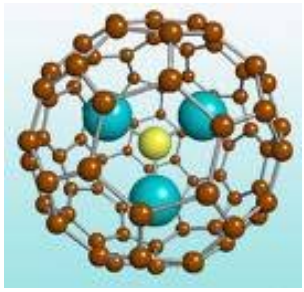
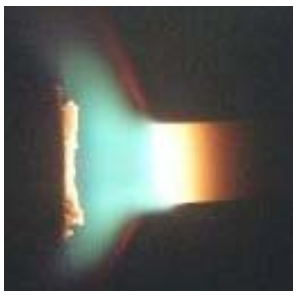
Real-Time Characterization of Nanomaterials Manufacturing

The capability for real-time, in-process monitoring of nanoscale materials in gas-phase synthesis processes, and for monitoring of emissions from nanoparticles production processes, is essential for successful manufacture of nanomaterials and for accelerating the commercialization of nanotechnologies.

Through funding from the Industrial Technologies Program, a multidisciplinary team from Oak Ridge National Laboratory worked with Luna nanoWorks, a division of Luna Innovations, and Materials Technology Institute to develop and demonstrate the capability of a differential mobility analyzer for real-time characterization of nanoparticles in industrial manufacturing environments. The approach was demonstrated on a process at the Luna nanoWorks facility in Danville, Virginia for commercial production of Trimetaspheres™. Trimetaspheres™, which are carbon nanoparticles consisting of fullerene spheres enclosing three metal atoms in a nitride molecule, have unique properties that are being explored for energy, medical, and security applications.

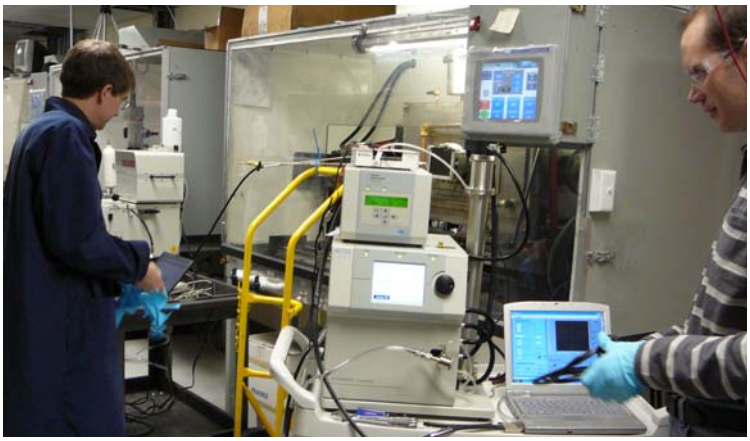




Images of Trimetasphere structure (left) and a plasma arc (right) from www.lunananoworks.com

An innovative approach was developed to provide, for the first time, sampling and analysis of these materials during production. ORNL staff modified commercial instrumentation and software to address challenges posed by subambient pressures and high particle concentrations. This approach also reduced scan times from minutes to seconds, enabling high-resolution monitoring.

Measurements were taken from multiple sources along the production path, including the arc-plasma reactor, in the safety hood, operation room, and the process stream from the separation unit. Both the size distribution (in the range of 3 to 600 nanometers) and number concentration were measured on-line continuously in particle streams.



Staff of Luna nanoWorks and ORNL conduct real-time characterization tests during a production run

The analytical tool proved successful in providing in-process monitoring of the variations in nanoparticle size distribution and concentration. This type of data can provide a better understanding of the root causes of product variation, and can lead to improved process control and improved product yield. These results indicated that real-time characterization may be useful for process development and process monitoring and control.

Use of the tool for in-process monitoring in the workplace also demonstrated the value of monitoring for system development and design to mitigate environmental release of nanoparticles.

Success in these efforts indicates value in continued industry/ national lab collaboration on research and development into advanced, responsible nanomanufacturing. This demonstration illustrates that real-time characterization can be applied to basic manufacturing processes for nanomaterials.

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