Nano Application Chart
The chart below is a guide for selecting an instrument that best fits your measurement needs.

<table>
<thead>
<tr>
<th>Model</th>
<th>Research and Development</th>
<th>Manufacturing and Process Monitoring</th>
<th>Health Effects/Toxicology</th>
<th>Nanoparticle Exposure and Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanoparticle Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrospray Nanoparticle Generator</td>
<td>3490</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrostatic Particle Classifier</td>
<td>32906</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online Concentration Measurement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nanoparticle Condensation Particle Counter</td>
<td>3776</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-line Size Characterization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scanning Mobility Particle Size™ Spectrometer</td>
<td>1893</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Mobility Particle Size™</td>
<td>2081</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nanoparticle Exposure and Risk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nanoparticle Surface Area Monitor*</td>
<td>3550</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axio™ 9900 Nanoparticle Aerosol Monitor**</td>
<td>6600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-held Condensation Particle Counter</td>
<td>3007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-Tox™ Ultrafine Particle Counter</td>
<td>6620</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PicoCure™ Plus Respirator Fit Tester</td>
<td>6239</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axio™ Portable Particle Counter</td>
<td>3110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nano Aerosol Sampler</td>
<td>3469</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* U.S. Patents 6,544,484 and 7,812,306

TSI Service, Service Agreements and Extended Warranties

**Protect Your Investment…Protect your Data Accuracy**

TSI’s Particle Instruments are the most reliable and accurate measurement instruments in the industry. Ensure your instruments are properly calibrated and at peak performance with routine annual service or a TSI QualityGuard™ Service Agreement.

**Value**

TSI has a vested interest in having an installed base of well serviced and calibrated instrumentation. We’ve priced our service agreements to provide an incentive for routine maintenance and calibration.

**Upfront Fixed Costs**

Budgeting made simple. No need to procure additional money for annual calibration or repairs. A QualityGuard™ service agreement guarantees your costs are fixed no matter what happens to parts or labor prices in the future.

**Quality**

TSI strives to meet or exceed our customers’ needs and expectations through continual improvement of our processes, products and services. Our Quality System is registered to ISO 9001:2000 and TSI uses NIST traceable analytical tools and NIST traceable standard reference materials to check out and calibrate instruments.

**Technical Expertise**

No one knows more about a product than the manufacturer. TSI has invested in sophisticated instrumentation to allow our experienced repair technicians to checkout, test, calibrate and repair our instruments with unparalleled precision.

TSI Incorporated serves a global market by investigating, identifying and solving measurement problems. As an industry leader in the design and production of precision instruments, TSI partners with research institutions and customers around the world to set the standard for measurements relating to aerosol science, air flow, health and safety, indoor air quality, fluid dynamics and biohazard detection. With headquarters based in the U.S. and field offices throughout Europe and Asia, TSI has established a worldwide presence in the markets we serve. Every day, our dedicated employees turn research into reality.
### Portable Particle Counter

**Optical Particle Sizer Model 3330**

A 16-channel, adjustable binned Optical Particle Counter to measure airborne particles from 0.3 to 10 microns. Optical particle counters (OPCs) are frequently used to measure worker air quality. Comparisons of outdoor versus indoor particle concentration levels can provide an excellent baseline assessment. The Optical Particle Sizer Model 3330 is a cut above the field of standard OPCs providing a higher quality measurement paired with a state-of-the-art user interface.

- Size range: 0.3 to 10 microns
- 16 size channels with user adjustable size binning
- Built-in data logging capability for up to 30,000 samples
- Portable, battery powered
- Modern GUI with intuitive user interface
- Filter-based sample collection for later gravimetric or chemical analysis

#### Application Focus: Emission Assessment

For nanoparticle emission assessment, the National Institute for Occupational Safety and Health (NIOSH) uses the Nanotechnology Emission Assessment Technique (NEAT). Outlined below, the approach is to measure the environment using both a CPC and an OPC, like the OPS Model 3330, to determine the concentration of airborne particles which are less than 100 nm.

\[
\text{Np(<300 nm) = CPC - OPC(0.3-1 \mu m)}
\]

<table>
<thead>
<tr>
<th>Nanoparticles (nm)</th>
<th>CPC</th>
<th>OPC (0.3-1 μm)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>3007</td>
<td>500</td>
<td>3007 - 500 = 2500</td>
</tr>
</tbody>
</table>

Nanoparticles <300 nm

#### Respirator Fit Tester

**PORTACOUNT® PRO and PRO+ Respirator Fit Testers Model 8038**

Protect your workers. Test their Personal Protective Equipment (PPE).

- OSHA compliant for all respirators, including N95, P1 and P2
- Automated fit testing with FitPro™ Fit Test Software
- Objective measurements
- Fit test record database
- Stand-alone operation
- Fast fit times
- Simple and easy to use

### Nanoparticle Processing and Respirator Use

1. Respirators are recommended for nanoparticle manufacturing to safeguard against potentially harmful substances.
2. Although there is still limited information on the health effects of engineered nanomaterials, the US Environmental Protection Agency recently outlined a new research strategy to better understand how manufactured nanomaterials may harm human health and the environment.

Meets Nanotechnology

What Is a Nanoparticle?
A nanoparticle is typically defined as a particle which has at least one dimension less than 100 nanometers (nm) in size.

Why Nano?
The answer is simple: better material properties. Nanomaterials have novel electrical, catalytic, magnetic, mechanical, thermal, and optical properties which are primarily attributed to the unusually large portion of surface molecules in a nanoparticle. Take a four nm CdS nanoparticle, a third of the 1500 atoms are on its surface! Surface molecules also have different bonding and quantum states than bulk materials, resulting in unique material properties. For instance, a 50 nm copper nanoparticle is extremely hard; and both zinc oxide and titanium oxide nanoparticles are clear rather than white.

Real-time Nanoparticle Measurements
Real-time aerosol measurements are a powerful tool in nanotechnology for many professionals, including researchers, process engineers, and industrial hygienists. Immediate feedback can detect exposure and process problems sooner, protecting workers and saving product. An added bonus: on-line measurements are often more cost-effective than expensive off-line surface imaging techniques.

Types of Nanoparticles
Nanoparticles are made from a wide variety of materials and are routinely used in medicine, consumer products, electronics, fuels, power systems, and as catalysts. Below are a few examples of nanoparticle types and applied uses:

- **Carbon-based:**
  - Buckeyballs (targeted antibiotics)
  - Nanotubes (stronger tennis rackets)

- **Metal Oxides:**
  - TiO2 (transparent sunscreens)
  - ZnO (hydrogen sensors)

- **Metals:**
  - Ag (plastic containers to keep food fresh longer)
  - Au (breast cancer detection)
  - Al (fast burning rocket fuels)

- **Metal Alloys:**
  - Pd-Au (groundwater pollutant removal)
  - Au-Pt (enhanced fuel cells)

- **Semiconductors:**
  - CdS (nanowires - smaller computer chips)
  - GaAs (quantum dots - security inks)
  - CdTe (efficient solar cells)

- **Polymers:**
  - Nanofibers (stain resistant materials)
  - Nanopolymers (cancer cell targeting)

Nanoparticles: The Scale of Things

- **Single-walled carbon nanotube:**
  - 1 nanometer in diameter

- **A strand of human hair:**
  - (with a nanowire curled into a loop)

- **House:**
  - 10 meters wide

(Top) A strand of human hair with a nanowire curled into a loop. Image credit: Limin Tung, Harvard University. Above image concept: National Nanotechnology Institute.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.

Hand-Held Nanoparticle Counter

Condensation Particle Counter Model 3007

Portable hand-held CPC is ideal for quantitative nanoparticle emission surveys and work area assessments. Track down point sources of nanoparticles with this battery powered CPC that can detect and count nanoparticles down to 10 nm. The Model 3007 is one of our smallest Condensation Particle Counters. At only 3.8 pounds, it provides versatility not common with larger particle counters. Active volumetric flow control increases data accuracy and provides a more quantitative measurement.

- Battery powered operation
- Particle size range of 10 nm to 1,000 nm
- Built-in LED display
- Small and light weight; ergonomic design
- +/- 10% particle concentration accuracy

TSI also offers the P-Trak® Ultrafine Particle Counter Model 8525 (pictured at left). This base model can provide qualitative measurements and comes with a convenient telescoping sample probe. The Model 8525 is routinely used by industrial hygienists to qualitatively assess the workplace, check HVAC system filter efficiency, evaluate effectiveness of engineering controls, and track down point sources of ultrafine and nanoparticle generation.
Nanoparticle Workplace Exposure Measurement

**AEROTRAK™ 9000 Nanoparticle Aerosol Monitor**

Nanoparticle exposure measurements for industrial hygiene applications.

This portable, battery-operated instrument uses the same technology as the NSAM but is aimed at more industrial applications and features TRAKPRO™ Industrial Hygiene Software. The AEROTRAK 9000 monitor provides a simple and fast solution for indicating the surface area equivalent dose of particles in the size range of 10 to 1,000 nanometers.

- **Field portable**
- **Touch screen with real-time display**
- **Custom sampling protocols**
- **Test statistics of real-time data or 8-hour time weighted averages (TWA)**
- **Alarm setpoint for use in workplace exposure monitoring**
- **Battery powered operation**
- **Rugged, durable stainless steel case**

**Application Focus: Particle Deposition in the Lungs**

It is important to understand how and where airborne particles will deposit in the lung because inhalation is the most common route of exposure for aerosols. Comprehensive lung deposition models are well developed for reference workers and model results show that deposition rates differ as a function of particle size and specific lung area (e.g., tracheobronchial or alveolar).

**Surface Area Measurement Facts**

1. Surface area relates well to particle induced adverse health effects.
2. Surface area plays an important role in toxicity of nanoparticles.
3. In chronic rat inhalation studies:
   - Lung tumor response was found to be highly correlated with particle surface area.
   - Inflammatory response was found to be best correlated with surface area.

**Nanoparticle Generator**

**Electrospray Aerosol Generator Model 3480**

High number concentrations of uniform nanoparticles in minutes.

The Electrospray Aerosol Generator Model 3480 outputs monodisperse particles as small as two nanometers. It can be used to generate catalytic and precursors or to aerosolize nanoparticle product from wet synthesis processes. Easy to set up and run, the Model 3480 eliminates the need for complex reactors or difficult-to-control furnaces.

- **2 nm to 100 nm**
- **Variety of particle types**
- **Single-sized nanoparticles**
- **Variety of particle sizes**
- **Uniform size and shape**

**Images:** This Page (Left): Single-walled carbon nanotubes generated by electrospray of aqueous suspensions. Provided by Dr. Bon-Ki Ku from CDC-NIOSH (Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health). Provision of the image does not constitute or imply an endorsement by NIOSH or the federal government of the contents of this brochure. Middle of Page, Right: 30 nm gold nanoparticle generated from electrospraying a gold colloid solution which is then sized using the SMPS™ spectrometer. Image provided by Professor Knut Deppert, Head of the Nanocrystals and Epitaxy group at Lund University. Next Page (Top Right): Electrically assisted flame synthesis of titania nanoparticles. Image provided by Professor Sotiris Pratsinis, Director of the Particle Technology Laboratory at ETH Zürich (Swiss Federal Institute of Technology).
Nanoparticle Size Selector

Electrostatic Classifier Model 3080

Selects only the nanoparticle size of interest.

The Model 3080 is effectively a band pass filter for particle size – a wide distribution of aerosol goes in and only one particle size comes out resulting in more uniform nanoparticles as a final product or as a process precursor. Used by product researchers, inhalation toxicologists, and process engineers, the Model 3080 narrows the incoming size distribution to create a more controlled nanoparticle.

- Narrow size distributions: \( \sigma_g < 1.05 \)
- Electronically select particle size
- Size classify particles from 2 nm to 1,000 nm
- Fully automated instrument controls

State-of-the-Art Flow Control
- Precise flow measurement
- Electronically adjustable flow rates
- Recirculating flow scheme
- Automatic Pressure and Temperature Correction

Application Focus: Product Research and Development

Nanometer Particle Sampler

Nanometer Aerosol Sampler (NAS) Model 3089

Collect nanoparticle samples for surface analysis techniques.

This electrostatic precipitator was designed to couple directly downstream of our 3080 Electrostatic Classifier to capture samples of 2 nm to 100 nm particles onto TEM grids, AFM substrates, or glass slides. The nanometer aerosol sampler allows easy and convenient nanoparticle collection for chemical analysis or off-line imaging.

- Uniform deposition on substrate
- High collection efficiency
- Adjustable flow and voltage
- Built-in pump and flowmeter
- Ability to use wide variety of substrates
- Simple to operate

Nanoparticle Surface Area

Nanoparticle Surface Area Monitor (NSAM) Model 3550

Measure the dose of inhaled nanoparticles in the lung quickly and easily.

The Model 3550 provides a more direct way to measure worker exposure. Many nanoparticle toxicology experts believe that the health effects of nanoparticles are better correlated to the surface area of the particles. The NSAM is a unique tool that quantifies the surface area of nanoparticle aerosols that deposit in the lung, corresponding to the International Commission on Radiological Protection (ICRP) lung deposition curves for the tracheobronchial (TB) and alveolar (A) regions of the human respiratory tract.

- Measure lung deposited surface area of inhaled particles
- Tracheobronchial or alveolar lung deposition
- Easy to use—turn on and go
- Built-in LCD display
- Comprehensive data collection software
- Excellent sensitivity
- Wide dynamic range
- High time resolution
- Custom calibration option for more flexible research options

Application Focus: Product Research and Development

Nanoparticle Surface Area Monitor (NSAM) Model 3550

Precursor Gases

Nanoparticle Reactor

Polydisperse Nanoparticles

Neutralizer

Size Classifier

Monodisperse Nanoparticles

Images: This Page (Left): Flame-made SnO2 column. Image provided by Professor Pratim Biswas, Chairman of the Department of Energy, Environmental and Chemical Engineering at Washington University.

Next Page (Upper Right): Cu-TiO2-SiO2 composite nanoparticle. Image provided by Professor Pratim Biswas, Chairman of the Department of Energy, Environmental and Chemical Engineering at Washington University.
Application Focus: Manufacturing Process Control

In nanoparticle manufacturing, as in semiconductor manufacturing, "time is quite literally money" due to the extreme value of the finished product and the potentially hazardous precursors and products that must be carefully controlled during processing. As such, Statistical Process Control (SPC) is frequently applied to detect and quickly correct variations.

On-line measurements of particle concentration or count median diameter can be a powerful metric that immediately alerts process engineers when the nanoparticle synthesis process is out of control and is producing an inferior product. In fact, even small changes in concentration or particle size can be early warning signs that nanoparticle product quality is a concern, thus saving time and money.

Application Focus: Inhalation Toxicology

Inhalation toxicology of engineered nanoparticles is a growing area of research. Government agencies across the world are calling for more information on the toxicity of these new materials.

Below is a typical experimental set up for an inhalation “in-vivo” study. A condensation particle counter (CPC) sampling just upstream of the exposure chamber can improve the accuracy of the measured dose. An Electrostatic Classifier downstream of the challenge aerosol can tighten up the aerosol size distribution and lead to more firm conclusions about the effect of nanoparticle size on health.

On-Line Nanoparticle Size Characterization

Nanoparticle Counter

Ultrafine Condensation Particle Counter (CPC) Model 3776

On-line single particle counting of nanoparticle concentrations down to 2.5 nm.
The Model 3776 provides accurate, real-time nanoparticle number concentration measurements in as little as 1/10th of a second online. Nanoparticles do not scatter enough light to be detected by conventional optical particle counters. In order to achieve real-time single particle counting, a condensation technique must be used; in this case, a working fluid is deposited on the nanoparticles in order to grow them to an optically detectable size. The particles are then passed through a laser and detector where every single particle in the sample stream is counted.

- Fast response to rapid changes in concentration
- Single particle counting to 3 x 10^6 particles/cm^3
- High accuracy
- Built-in data logging with removable memory card
- Easy to use and maintain
- Rugged enough for industrial use

Images: This Page (Left): Porous zinc sulfide particles made by spray pyrolysis. Image provided by Professor Mark T. Swihart, Director of Integrated Nanostructured Systems, University at Buffalo (SUNY).

Next Page (Top Right): Gold nanoparticles created by NIST and National Cancer Institute’s Nanotechnology Characterization Laboratory for use as reference standards in biomedical research laboratories. Image credit: Andras Vladar, NIST.

SMPS™ Spectrometer Nanoparticle Applications

Research and Development
Faster, more reliable size measurement for immediate feedback. Significantly reduces research timeline.

Process Control
Expedite quality control processes and save money.

Health Effects – Inhalation Toxicology
Size the challenge aerosol just prior to subject introduction and quantify inhalation dose.

Nanoparticle Emission Control
Characterize fugitive nanoparticles and track sources.

Nanoparticle Size Resolution
TSI’s SMPS™ spectrometer has superior nanoparticle resolution. The example data depicted below is the size distribution from a sample of mixed molecular weight proteins that were aerosolized using the Electrospray Aerosol Generator Model 3480. Since proteins have a fixed molecular weight (i.e., particle size) when they are aerosolized, they can be used as a type of size standard.


Powerful System Software

All TSI SMPS™ spectrometers come equipped with Aerosol Instrument Manager® software, a program designed for use with Windows® operating systems to control instrument operation, collect high-resolution data, and provide impressive file-management capabilities. Data can be weighted by any moment of number concentration, including diameter, surface area, volume, and mass while comprehensive statistical analysis is computed automatically for the entire distribution or specific size ranges defined. An export function allows easy transport of files to spreadsheets or other applications for customized data handling. Additional software capabilities include multiple-scan averaging, a buffer for comparing data sets, programmable start/stop times, and automatic file storage and printout options.

- Automated data inversion
- Advanced post-processing options
- Comprehensive statistical analysis
- Real-time data display
- Play-back feature
- Easy data export

Images (Right): (a) Immunoaffinity. (b) Thromboglobulin. (c) alpha-fetoprotein. (d) Bovine albumin.
Nanoparticle Sizing

Application Focus: Nanoparticle Emissions from Laser Printers

1. Recent research has focused on nanoparticle emissions from certain types of laser printers. In 2007, a group from Australia found that nearly 30% of printers tested emitted high concentrations of nanoparticles; however, a full 60% of the printers did not emit any particles.

2. The size of particles released from printers is typically 30 nm to 100 nm.

3. Recent scientific publications reveal particle number emission rates from $10^8$ to $10^{13}$ particles/hour.

4. NIOSH is currently investigating exposures from printer emissions.

5. International ecolabel “Blue Angel” requires laser printer particle emission testing.

Application Focus: Fast Changing Aerosols

Morphology changes from sintering of silver nanoparticles generated by evaporation/condensation. (Below): Image provided by Dr. Bon Ki Ku of Centers for Disease Control, The National Institute for Occupational Safety and Health (CDC-NIOSH).

One Second Nanoparticle Sizing

Fast Nanoparticle Sizer

Fast Mobility Particle Sizer™ (FMPS™)

Spectrometer Model 3091

Capture nanoparticle nucleation events, characterize nanoparticle formation, and catch nanoparticle emission bursts with this ultra-fast, on-line sizer. The FMPS™ spectrometer is routinely used for research and development, manufacturing control, point source exposure research, and other applications where particle events occur too quickly to characterize with other analytical methods.

- Complete size distributions in 1 second
- Front panel display to visualize events
- Easy to use and maintain
- 5.6 nm – 560 nm
- High sample flow rate
- No radioactive neutralizer or working fluids

One Second Nanoparticle Sizing

Fast Mobility Particle Sizer™ (FMPS™)

Spectrometer Model 3091

One Second Nanoparticle Sizing

Fast Mobility Particle Sizer™ (FMPS™)

Spectrometer Model 3091

Close relation to the SMPS™ spectrometer with one second time resolution.

Capture nanoparticle nucleation events, characterize nanoparticle formation, and catch nanoparticle emission bursts with this ultra-fast, on-line sizer. The FMPS™ spectrometer is routinely used for research and development, manufacturing control, point source exposure research, and other applications where particle events occur too quickly to characterize with other analytical methods.

- Complete size distributions in 1 second
- Front panel display to visualize events
- Easy to use and maintain
- 5.6 nm – 560 nm
- High sample flow rate
- No radioactive neutralizer or working fluids

Images: This Page (Left): Nanostars of vanadium(IV) oxide. Next Page (Top Right): Silver nanoparticle aggregates generated by evaporation/condensation. Image provided by Dr. Seong Chan Kim and Professor David Pui, Distinguished McKnight University Professor at the University of Minnesota.