Comprehensive Handbook of Advanced Materials

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Introduction

This comprehensive handbook covers a wide range of advanced nanomaterials available from ACS Material and similar suppliers. For each material, we provide detailed information on technical properties, applications, and available variations. This resource is designed for researchers, engineers, and industry professionals working with these cutting-edge materials.

Graphene and Graphene-Based Materials

Single Layer Graphene

Technical Properties:

- Structure: Single atomic layer of sp^2-bonded carbon atoms arranged in a hexagonal lattice
- Thickness: 0.345 nm (one atom thick)
- Electrical conductivity: ~10^6 S/cm
- Thermal conductivity: ~5000 W/mK
- Optical transparency: ~97.7% for single layer
- Tensile strength: ~130 GPa (strongest material known)
- Young's modulus: ~1 TPa
- Surface area: 2630 m^2/g (theoretical)

Applications:

- Transparent conductive electrodes for touch screens and displays
- High-frequency electronic devices and transistors
- Composite materials for mechanical reinforcement
- Energy storage devices (supercapacitors, batteries)
- Sensors (chemical, biological, pressure, strain)
- Heat dissipation materials for thermal management
- Protective and functional coatings
- Biomedical devices and drug delivery systems

Available Variations:

- Single Layer Graphene - 500 mg powder
- Monolayer Graphene Factory Powder
- Monolayer Graphene Factory Powder - 5 g

Graphene Oxide

Technical Properties:

- Structure: Single-layer carbon sheets with oxygen-containing functional groups
- C/O ratio: Typically 2.1-2.9
- Thickness: 0.7-1.2 nm (thicker than graphene due to functional groups)
- Lateral size: 0.5-5 μm (dependent on preparation method)
- Conductivity: Significantly lower than pristine graphene (semi-insulating)
- Hydrophilicity: Highly hydrophilic due to oxygen functional groups
- Dispersibility: Forms stable colloidal suspensions in water and polar solvents

Applications:

- Precursor for reduced graphene oxide and other graphene derivatives
- Water purification and filtration membranes
- Biomedical applications (drug delivery, tissue engineering)
- Biosensors and chemical sensors
- Energy storage materials (supercapacitors, batteries)
- Paper-like materials with tunable properties

- Composite materials reinforcement
- Transparent conductive films (after reduction)
- Support material for TEM imaging

Available Variations:

- Single Layer Graphene Oxide Flake (H Method) - 1 g
- Single Layer Graphene Oxide Flake (H Method) - 500 mg
- Single Layer Graphene Oxide Powder (H Method) - 1 g
- Single Layer Graphene Oxide Powder (H Method) - 500 mg
- Graphene Oxide (S Method) - 10 gm
- Graphene Oxide (S Method) - 100 gm
- High Surface Area Graphene Oxide - Type A, 500 mg
- High Surface Area Graphene Oxide - Type B, 500 mg
- Single Layer Graphene Oxide Dispersion (various formulations)
- Graphene Oxide (GO) TEM Support Films
- Graphene Oxide Film-Super Paper - 1 pc

Reduced Graphene Oxide

Technical Properties:

- Structure: Partially restored graphene lattice with residual oxygen groups
- C/O ratio: 5-15 (higher than GO, depends on reduction method)
- Conductivity: 100-1000 S/cm (intermediate between GO and pristine graphene)
- Surface area: 400-1500 m^2/g
- Thickness: ~1 nm (slightly thicker than pristine graphene)
- Thermal stability: Higher than GO but lower than pristine graphene
- Dispersibility: Less hydrophilic than GO, better dispersion in organic solvents

Applications:

- Conductive inks and coatings
- Electrodes in energy storage devices (supercapacitors, batteries)
- Conductive fillers in polymer composites
- Flexible electronics and sensors
- Electromagnetic interference (EMI) shielding
- Thermal management materials
- Catalyst supports
- Water treatment and purification

Available Variations:

- Reduced Graphene Oxide (rGO) - 1 g
- Highly Conductive Reduced Graphene Oxide (rGO) - 500 mg

Graphene Dispersions

Technical Properties:

- Concentration: Typically 0.1-4 g/L
- Solvent types: NMP (N-Methyl-2-pyrrolidone), water, ethanol
- Particle size: 1-3 μm lateral dimensions
- Stability: Long-term stable without precipitation
- Viscosity: Depends on concentration and solvent
- Oxygen content: Varies (standard vs. oxygen-reduced versions)

Applications:

- Conductive inks and coatings
- Thin film fabrication

- Polymer composite additives
- Solution-processable electronics
- Energy storage device fabrication
- Spray coating applications
- Research and development of graphene-based materials

Available Variations:

- Graphene Dispersion in NMP (Dia:1-3μm) - various quantities
- Graphene Dispersion in NMP - 1g/L, 1 L
- Graphene Dispersion in NMP - 1g/L, 5L/10L
- Graphene Dispersion in NMP - 4g/L, various quantities
- Graphene Dispersion in NMP (Oxygen Reduced) - various concentrations and volumes
- Graphene Dispersion in Water (Dia:1-3μm) - 1 Kg

Graphene Nanoplatelets

Technical Properties:

- Structure: Stacked graphene sheets (few to multi-layer)
- Thickness: Ranges from 1-2 nm to 2-10 nm (depending on type)
- Lateral dimensions: 1-5 μm (varies by product)
- Specific surface area: 300-750 m^2/g
- Electrical conductivity: 10^7 S/m (in-plane)
- Thermal conductivity: 3000-5000 W/mK (in-plane)
- Density: ~2.2 g/cm^3

Applications:

- Polymer composites for mechanical reinforcement
- Thermally conductive materials and thermal interface materials
- Electrically conductive additives for polymers and coatings
- Energy storage devices (supercapacitors, battery electrodes)
- EMI shielding materials
- Sensors and electrochemical devices
- Barrier materials for gas and moisture resistance
- Lubricant additives for friction reduction

Available Variations:

- Graphene Nanoplatelets (1-2nm) - 500 mg
- Graphene Nanoplatelets (1-5nm) - 1 g, 5 g, 10 gm
- Graphene Nanoplatelets (2-10nm) - 50 gm, 500 gm, 1 Kg

Functionalized Graphene

Technical Properties:

- Base material: Usually graphene, rGO, or graphene nanoplatelets
- Functional groups: Amino, carboxyl, hydroxyl, fluorine, or polymer chains
- Dispersibility: Enhanced in specific solvents depending on functionalization
- Surface reactivity: Tailored for specific chemical interactions
- Electrical properties: Usually lower conductivity than pristine graphene
- Thickness: Slightly increased due to functional groups

Applications:

- Biomedical applications (drug delivery, biosensing)
- Polymer nanocomposites with enhanced interfacial bonding

- Selective chemical and biological sensors
- Catalysis and photocatalysis
- Specialized coatings with targeted properties
- Energy storage devices with improved electrolyte interactions
- Water purification and environmental remediation
- Smart materials with stimulus-responsive behavior

Available Variations:

- Aminated Graphene Amino-PEG covalently linked - 500 mg
- Aminated Graphene Octadecylamine covalently linked - 500 mg
- Aminated Graphene Piperazine covalently linked - 500 mg
- Carboxyl Graphene - 500 mg
- Carboxyl Graphene Water Dispersion - 100 mL
- Fluorinated Graphene - A-200 mg, B-1 g
- Industrial Fluorinated Graphene - 50 gm
- Nitrogen-doped Graphene Powder - 1 g
- Hydroxyl Functionalized Graphene - 1 g, 500 mg

CVD Graphene

Technical Properties:

- Growth method: Chemical Vapor Deposition
- Crystallinity: High, with few defects
- Layer control: Precise (single to few layers available)
- Transparency: >97% for single layer
- Sheet resistance: 200-500 Ω/sq for single layer
- Substrate compatibility: Copper, SiO_2, Si, quartz, PET, etc.
- Transfer options: PMMA-assisted or Trivial Transfer® process
- Size: Available in various dimensions up to 12" x 8"

Applications:

- High-performance electronics and transistors
- Transparent conductive electrodes for displays and touch screens
- Photonic and optoelectronic devices
- Flexible electronics
- Barrier films and coatings
- Sensor platforms
- TEM sample supports
- Fundamental research on graphene properties
- Prototype development for graphene-based technologies

Available Variations:

- CVD Graphene on Copper Foil - various sizes and layer numbers
- CVD Graphene on SiO_2 Substrate - various sizes and layer numbers
- CVD Graphene on Silicon Substrate - various sizes and layer numbers
- CVD Graphene on Si/SiO_2 (Graphene Factory) - various diameters
- CVD Graphene on PET Substrate - various sizes and layer numbers
- CVD Graphene on Plastic Substrate
- CVD Graphene on Quartz Substrate - various sizes and layer numbers
- CVD Graphene on Copper-PMMA Coated - various sizes and layer numbers
- Trivial Transfer Graphene™ - various layer numbers and sizes
- Graphene on various TEM grids (Lacey Carbon, Ultra-fine, Silicon Nitride)

- Graphene on Ultra-flat Thermal SiO2 Substrate

Graphene Aerogels and Foams
Technical Properties:
- Density: Extremely low (1-10 mg/cm³)
- Porosity: >99%
- Surface area: 400-1200 m²/g
- Compressibility: Highly elastic, can recover after >90% compression
- Thermal conductivity: Low (0.01-0.02 W/mK) due to porosity
- Electrical conductivity: 1-100 S/m (depends on density)
- Oil absorption capacity: 60-150 times its own weight

Applications:
- Ultralight structural materials
- Energy storage (supercapacitor electrodes, battery components)
- Thermal insulation
- Oil and organic solvent absorption for environmental cleanup
- Catalyst supports with high surface area
- Pressure and strain sensors
- Electromagnetic interference (EMI) shielding
- Biomedical scaffolds
- Acoustic damping materials

Available Variations:
- Graphene Aerogel - Type A and Type B
- Nitrogen-Doped Graphene Aerogel - Type A, B, and C
- Graphene Film-Super Paper - 1 pc
- 3D Freestanding Graphene Foam - various sizes
- 3D Graphene on Nickel/Copper Foam - various substrates and sizes

Graphite Materials
Graphite Oxide
Technical Properties:
- C/O ratio: Typically 2-3
- Interlayer spacing: 6-12 Å (expanded compared to graphite)
- Particle size: Varies based on precursor graphite
- Thermal stability: Decomposes above ~200°C
- Hydrophilicity: Highly hydrophilic due to oxygen groups
- Electrical conductivity: Very low (insulating)
- Exfoliation potential: Easily exfoliates to form graphene oxide in water

Applications:
- Precursor for graphene oxide production
- Flame-retardant additives
- Barrier materials for gas impermeability
- Polymer composites
- Catalysis support materials
- Energy storage materials
- Precursors for graphene-based materials

Available Variations:
- Graphite Oxide - 1 g, 5 gm, 500 mg
- Large-Size Graphite Oxide

- Industrial-Grade Graphite Oxide - 10 gm, 50 gm, 0.2-10 μm
- Low-Defect Graphite Oxide - 5 gm, 10 gm

Graphite Flakes

Technical Properties:

- Structure: Stacked graphene layers with AB stacking
- Particle size: Varies with mesh size (50-3500 mesh)
- Purity: >99% carbon
- Density: ~2.2 g/cm^3
- Thermal conductivity: ~100-400 W/mK (depends on quality)
- Electrical conductivity: ~10^4 S/m (in-plane)
- Layer spacing: 3.35 Å
- Chemical stability: High resistance to acids and bases

Applications:

- Lubricants and lubricant additives
- Refractory materials and crucibles
- Conductive fillers in polymers and coatings
- Battery electrodes (especially lithium-ion)
- Graphene production precursor
- Pencil leads and writing materials
- Heating elements
- EMI shielding materials
- Gaskets and seals for high-temperature applications

Available Variations:

- Graphite Flake - 100 gm, Mesh 50/80/100/200/300/500/1000/3500
- Graphite Flake - 500 gm, Mesh 50/80/100/200/300/500/1000/3500

Highly Oriented Pyrolytic Graphite (HOPG)

Technical Properties:

- Structure: Highly aligned graphene layers
- Mosaic spread: 0.4° (Grade A), 0.8° (Grade B), >0.8° (Grade C)
- Surface smoothness: Atomically flat after cleaving
- Density: 2.26 g/cm^3
- Electrical resistivity: ~4×10^{-5} Ω·cm (in-plane)
- Thermal conductivity: ~1800 W/mK (in-plane), ~8 W/mK (c-axis)
- Dimensions: Available in various sizes (5×5 mm to 30×30 mm)
- Thickness: 1 mm to 2 mm

Applications:

- Calibration standard for scanning probe microscopy (AFM, STM)
- Monochromators for X-ray and neutron optics
- Substrate for molecular self-assembly studies
- Reference material for Raman spectroscopy
- Source material for mechanical exfoliation of graphene
- UV/X-ray photoemission spectroscopy
- Electrodes for electrochemical studies
- Fundamental research on graphitic materials

Available Variations:

- Highly Oriented Pyrolytic Graphite (HOPG-Grade A)
- Highly Oriented Pyrolytic Graphite (HOPG-Grade B) - various sizes

- Highly Oriented Pyrolytic Graphite (HOPG-Grade C) - various sizes

Transition Metal Dichalcogenides
Molybdenum Disulfide (MoS_2)
Technical Properties:

- Structure: Layered 2D material with S-Mo-S sandwich structure
- Layer thickness: ~0.65 nm per layer
- Bandgap: 1.2 eV (bulk) to 1.9 eV (monolayer)
- Electrical properties: Semiconductor with tunable bandgap
- Mechanical properties: Young’s modulus ~270 GPa, breaking strength ~16-30 GPa
- Thermal conductivity: 34.5 W/mK (in-plane)
- Lubrication properties: Very low friction coefficient (0.003-0.05)
- Stability: Chemically stable in air and moisture

Applications:

- Solid lubricants for extreme conditions
- Field-effect transistors and electronic devices
- Photovoltaics and photodetectors
- Hydrogen evolution reaction (HER) catalysts
- Energy storage devices (lithium-ion batteries, supercapacitors)
- Biosensors and chemical sensors
- Optoelectronic devices
- Memory devices
- Reinforcement in polymer composites

Available Variations:

- Nano Size Monolayer Molybdenum Disulfide (MoS_2) - 200 mg, 500 mg
- Monolayer Molybdenum Disulfide (MoS_2) - 200 mg, 500 mg
- Molybdenum Disulfide (MoS_2) Powder - 1.5 μm, 15 μm, 1 Kg
- Mechanically Exfoliated Monolayer MoS_2 on Substrates (SiO_2, Al_2O_3, Sapphire)
- CVD Method Monolayer MoS_2 Film - Sapphire Substrate
- Monolayer Molybdenum Disulfide (MoS_2) Quantum Dots - various forms
- Bio MoS_2 - 100 mL, HB/SA

Tungsten Disulfide (WS_2)
Technical Properties:

- Structure: Layered 2D material similar to MoS_2
- Layer thickness: ~0.7 nm per layer
- Bandgap: 1.4 eV (bulk) to 2.1 eV (monolayer)
- Electrical properties: Semiconductor with layer-dependent bandgap
- Thermal stability: Up to 1200°C in inert atmosphere
- Lubrication properties: Excellent dry lubricant (coefficient of friction: 0.03)
- Hardness: 5-7 Mohs scale
- Chemical resistance: Excellent against acids and oxidation

Applications:

- High-temperature lubricants
- Aerospace and military applications
- Optoelectronic devices (photodetectors, LEDs)
- Field-effect transistors

- Catalysts for hydrogen evolution
- Energy storage (lithium-ion batteries, supercapacitors)
- Reinforcement in composites
- Sensors and biosensors
- Protective coatings

Available Variations:

- Tungsten Disulfide (WS_2) - various particle sizes, 1 Kg
- Nano Size Monolayer Tungsten Disulfide (WS_2) - 200 mg, 500 mg
- Monolayer Tungsten Disulfide (WS_2) - 200 mg, 500 mg
- Mechanically Exfoliated Monolayer WS_2 on Substrates (SiO_2, Al_2O_3, Sapphire)
- CVD Method Monolayer WS_2 - various substrates
- Monolayer Tungsten Disulfide (WS_2) Quantum Dots - various forms

Exfoliated TMDs

Technical Properties:

- Thickness: Few atomic layers (typically 1-5 layers)
- Lateral dimensions: 0.5-5 μm
- Crystal quality: High, with minimal defects
- Surface cleanliness: Superior to liquid-exfoliated materials
- Substrate adhesion: Strong van der Waals bonding
- Optical properties: Strong photoluminescence (for monolayers)
- Electronic properties: High mobility and well-defined bandgap

Applications:

- Fundamental research on 2D materials
- Prototype optoelectronic devices
- High-performance transistors and sensors
- Quantum electronic devices
- Heterostructure fabrication with other 2D materials
- Photodetectors with tailored spectral response
- Valleytronics research
- Strain-engineered devices

Available Variations:

- Mechanically Exfoliated Monolayer MoS_2 on Substrates
- Mechanically Exfoliated Monolayer $MoSe_2$ on Substrates
- Mechanically Exfoliated Monolayer WS_2 on Substrates
- CVD Method Monolayer TMDs on various substrates

TMD Quantum Dots

Technical Properties:

- Size: 2-10 nm
- Optical properties: Strong photoluminescence with size-dependent emission
- Bandgap: Tunable based on size and composition
- Quantum yield: 10-45% (material dependent)
- Dispersibility: Excellent in water and polar solvents
- Surface chemistry: Tunable with functional groups
- Stability: Higher chemical stability than conventional quantum dots
- Biocompatibility: Generally better than heavy metal-based QDs

Applications:

- Bioimaging and cellular labeling
- Photocatalysis
- Light-emitting devices
- Sensors for heavy metals and biomolecules
- Photodynamic therapy
- Security inks and anti-counterfeiting
- Solar cells and photovoltaics
- Memory devices

Available Variations:

- Monolayer Molybdenum Disulfide (MoS_2) Quantum Dots - water dispersions and powders
- Monolayer Tungsten Disulfide (WS_2) Quantum Dots - water dispersions and powders

Hexagonal Boron Nitride Materials

h-BN Powders

Technical Properties:

- Structure: Layered hexagonal crystal similar to graphite
- Chemical composition: Equal ratio of boron and nitrogen atoms
- Bandgap: ~5.9 eV (wide bandgap insulator)
- Thermal conductivity: 300-400 W/mK (in-plane)
- Thermal stability: Up to 1000°C in air, 2800°C in inert atmosphere
- Dielectric constant: 3-4
- Dielectric strength: 7.5 MV/cm
- Lubricity: Excellent solid lubricant properties
- Chemical resistance: Inert to most chemicals and metals

Applications:

- High-temperature lubricants
- Thermal interface materials
- Electrically insulating substrates
- Cosmetic products (due to optical properties)
- Neutron shielding (due to boron content)
- Composite reinforcement
- Dielectric layers in electronic devices
- Crucibles for metal casting
- Protective coatings for harsh environments

Available Variations:

- Hexagonal Boron Nitride (h-BN) Powder - Type A, B, C, 50 gm

CVD h-BN

Technical Properties:

- Thickness: Controllable from monolayer to few layers
- Crystallinity: High, with large single-crystal domains
- Surface roughness: Atomically smooth
- Dielectric properties: Breakdown field >10 MV/cm
- Optical bandgap: ~6 eV
- Thermal conductivity: ~400 W/mK (in-plane)
- Substrate compatibility: Copper, silicon, silicon dioxide
- Transfer capability: Can be transferred to arbitrary substrates

Applications:

- Dielectric substrate for graphene and other 2D materials
- Gate insulators in high-performance electronics
- Atomically thin barriers in van der Waals heterostructures
- Tunnel barriers in quantum devices
- Protective encapsulation of air-sensitive 2D materials
- Deep ultraviolet light emitters
- Ultraflat substrates for molecular electronics
- Research on 2D materials and devices

Available Variations:

- Hexagonal Boron Nitride (h-BN) on Copper Foil - various sizes
- Hexagonal Boron Nitride (h-BN) on Si/SiO_2 - various diameters

Trivial Transfer h-BN

Technical Properties:

- Transfer method: Proprietary process without chemical etching
- Layer control: Precise single to few layers
- Substrate compatibility: Can be transferred to various substrates
- Contamination level: Minimal compared to conventional transfer methods
- Interface quality: Clean interfaces for heterostructure formation
- Size: Available in cm-scale dimensions
- Uniformity: Highly uniform coverage

Applications:

- Research on 2D material heterostructures
- Prototype development for 2D material devices
- Quantum electronic devices
- Tunneling devices and barriers
- Encapsulation of air-sensitive 2D materials
- Dielectric layers in field-effect transistors
- Optical devices in the deep UV range
- Atomic-scale engineering of electronic properties

Available Variations:

- Trivial Transfer Hexagonal Boron Nitride (TTh-BN) - 1 Layer, various sizes

Carbon Nanotubes

Single-Walled Carbon Nanotubes

Technical Properties:

- Structure: Single graphene sheet rolled into a cylinder
- Diameter: 0.7-2 nm
- Length: From 1-3 μm to 5-30 μm (varies by product)
- Specific surface area: 400-1000 m^2/g
- Electrical conductivity: 10^6-10^7 S/m (for metallic SWCNTs)
- Thermal conductivity: 3000-3500 W/mK
- Tensile strength: 50-500 GPa
- Young’s modulus: ~1 TPa
- Aspect ratio: 100-10,000

Applications:

- Transparent conductive films

- Field-effect transistors
- Sensors (chemical, biological, strain)
- Conductive composites
- Energy storage (supercapacitor electrodes, battery additives)
- Thermal interface materials
- Field emission devices
- Biomedical applications (drug delivery, imaging)
- High-strength composite reinforcement

Available Variations:

- Highly Purified Single-Walled Carbon Nanotubes - various lengths
- Purified Single-Walled Carbon Nanotubes - various lengths
- Functionalized SWCNTs (carboxylic, hydroxylate, amino)
- Industrial Single-Walled Carbon Nanotubes
- Single-Walled Carbon Nanotube Paper

Multi-Walled Carbon Nanotubes

Technical Properties:

- Structure: Multiple concentric graphene cylinders
- Diameter: From <8 nm to >50 nm (various categories available)
- Length: 0.5-2 μm to >50 μm (varies by product)
- Wall count: 3-30 walls (depends on diameter)
- Specific surface area: 50-400 m^2/g
- Electrical conductivity: 10^3-10^5 S/m
- Thermal conductivity: 2000-3000 W/mK
- Tensile strength: 10-100 GPa
- Young's modulus: 0.8-0.9 TPa
- Thermal stability: Up to 600°C in air, >2800°C in vacuum

Applications:

- Polymer composite reinforcement
- Electrically conductive additives
- EMI shielding materials
- Thermal interface materials
- Energy storage devices
- Catalyst supports
- Field emission devices
- Filtration membranes
- Sensors and actuators
- Sporting goods and structural materials

Available Variations:

- Purified Multi-Walled Carbon Nanotubes - various diameters and lengths
- Functionalized MWCNTs (carboxylic, hydroxylate, amino)
- Graphitized Multi-Walled Carbon Nanotubes
- Ni-Coated Multi-Walled Carbon Nanotubes
- Double-Walled Carbon Nanotubes
- Carbon Nanotube Sponges - various sizes

Functionalized Carbon Nanotubes

Technical Properties:

- Functional groups: Carboxyl (-COOH), hydroxyl (-OH), amino ($-NH_2$)
- Functionalization degree: 2-8 wt% (varies by type)

- Dispersibility: Enhanced in water or organic solvents (depends on functional group)
- Surface chemistry: Tailored reactivity based on functional groups
- Purity: >95% (after purification during functionalization)
- Thermal stability: Reduced compared to pristine CNTs
- Electrical conductivity: Lower than pristine CNTs due to sp^3 defects

Applications:

- Polymer nanocomposites with improved interfacial bonding
- Biomedical applications (drug delivery, imaging)
- Chemical and biological sensors
- Catalyst supports with anchoring sites
- Water purification and contaminant removal
- Electrochemical electrodes with enhanced activity
- Dispersible conductive additives
- Self-healing materials
- Printed electronics

Available Variations:

- Purified Carboxylic Single/Multi-Walled Carbon Nanotubes
- Purified Hydroxylate Single/Multi-Walled Carbon Nanotubes
- Purified Amino Single/Multi-Walled Carbon Nanotubes
- Fluorinated Carbon Nanotubes
- Carbon Nanotubes, Multi-walled, Nitrogen-doped (MWCNTs)

Quantum Dots and Upconverting Nanoparticles

Carbon Quantum Dots

Technical Properties:

- Size: 2-10 nm
- Composition: Carbon with various surface functional groups
- Photoluminescence: Excitation-dependent emission
- Quantum yield: 10-80% (depends on synthesis and functionalization)
- Excitation/emission wavelengths: UV to visible range
- Solubility: Excellent in water and polar solvents
- Biocompatibility: Generally high
- Chemical stability: Good resistance to photobleaching

Applications:

- Bioimaging and cellular labeling
- Chemical sensing and biosensing
- Photocatalysis
- Light-emitting devices
- Anti-counterfeiting
- Solar cells and photovoltaics
- Drug delivery and theranostics
- Metal ion detection
- Optoelectronic devices

Available Variations:

- Carbon Quantum Dots - various formulations
- Carbon Quantum Dots Powder
- Aminated Carbon Quantum Dots - water and methanol dispersions

Graphene Quantum Dots

Technical Properties:

- Size: 2-20 nm
- Structure: Disc-shaped graphene fragments
- Photoluminescence: Tunable emission based on size and functional groups
- Quantum yield: 10-60%
- Excitation/emission wavelengths: UV to NIR
- Edge structure: Zigzag or armchair (affects properties)
- Surface functionality: Various groups available (carboxyl, amino, etc.)
- Biocompatibility: Excellent compared to heavy metal QDs

Applications:

- Bioimaging with low toxicity
- Photodynamic therapy
- Biosensors and chemical sensors
- LED and display technologies
- Photocatalysis and solar cells
- Anti-counterfeiting
- Drug delivery systems
- Energy storage device additives
- Photodetectors

Available Variations:

- Aminated Graphene Quantum Dots - water dispersions and powders
- Carboxylated Graphene Quantum Dots - water dispersions and powders
- Blue Luminescent Graphene Quantum Dots - various solvents
- Green Graphene Quantum Dots
- Hydroxylated Graphene Quantum Dots
- Chlorine Functionalized Graphene Quantum Dots
- Imidazole-modified Graphene Quantum Dots

Upconverting Nanoparticles

Technical Properties:

- Composition: Rare-earth doped materials (typically Y, Gd, Yb, Er, Tm)
- Size: 10-100 nm
- Optical properties: Convert lower-energy photons to higher-energy photons
- Excitation wavelengths: Typically NIR (980 nm, 808 nm)
- Emission wavelengths: UV, visible, or NIR (365-804 nm)
- Surface modifications: Various functionalities available
- Quantum yield: 0.1-10% (depends on composition)
- Photostability: Excellent resistance to photobleaching

Applications:

- Deep-tissue bioimaging
- Photodynamic therapy
- Drug delivery with NIR triggering
- Anti-counterfeiting and security printing
- Solar energy harvesting (improving photovoltaic efficiency)
- Temperature sensing (thermometry)
- Optogenetics
- Displays and volumetric 3D displays
- NIR-activated catalysis
- Point-of-care diagnostics

Available Variations:

- Upconverting Nanoparticles - various emission waveleng

Quantum Dots and Upconverting Nanoparticles (continued)
Upconverting Nanoparticles (continued)
Applications (continued):

- Deep-tissue bioimaging
- Photodynamic therapy
- Drug delivery with NIR triggering
- Anti-counterfeiting and security printing
- Solar energy harvesting (improving photovoltaic efficiency)
- Temperature sensing (thermometry)
- Optogenetics
- Displays and volumetric 3D displays
- NIR-activated catalysis
- Point-of-care diagnostics

Available Variations:

- Upconverting Nanoparticles - various emission wavelengths
- PEG-Modified Upconverting Nanoparticles
- Silica-Coated Upconverting Nanoparticles
- Oil Dispersible Upconverting Nanoparticles
- Mesoporous SiO2 coated Upconverting Nanoparticles
- PEG-NH2 Modified Upconverting Nanoparticles
- '-COOH Modified Upconverting Nanoparticles
- PEG-COOH Modified Upconverting Nanoparticles
- '-NH2 Modified Upconverting Nanoparticles

Nanowires
Silver Nanowires
Technical Properties:

- Diameter: 40-120 nm (varies by product)
- Length: 10-60 μm
- Aspect ratio: 100-1000
- Electrical conductivity: ~6.3 × 10^7 S/m (near bulk silver)
- Thermal conductivity: ~429 W/mK
- Mechanical flexibility: Excellent bendability
- Optical properties: Surface plasmon resonance
- Dispersibility: Available in water, ethanol, and IPA dispersions

Applications:

- Transparent conductive films for touch screens and displays
- Flexible and stretchable electronics
- EMI shielding materials
- Wearable electronics
- Heating elements (transparent heaters)
- OLED and solar cell electrodes
- Surface-enhanced Raman spectroscopy (SERS)
- Sensors (strain, pressure, temperature)
- Printed electronics

Available Variations:

- Silver Nanowire (500mg) - various diameters (Agnw-40, 60, 90, 120)
- Silver Nanowire (500mg) - various lengths (Agnw-L30, L50, L70, L100)
- Silver Nanowire (500mg) - available in Ethanol, IPA, or Water

Copper Nanowires

Technical Properties:

- Diameter: 50-200 nm
- Length: 10-50 μm
- Aspect ratio: 100-500
- Electrical conductivity: ~5.8×10^7 S/m (close to bulk copper)
- Thermal conductivity: ~400 W/mK
- Oxidation resistance: Lower than silver (requires protection)
- Cost advantage: Significantly lower than silver
- Mechanical flexibility: Good flexibility for electronics

Applications:

- Low-cost transparent conductive films
- Flexible electronics
- Thermal interface materials
- Conductive inks and pastes
- EMI shielding
- Heating elements
- Catalysis
- Antibacterial applications
- Electrochemical sensors

Available Variations:

- Copper Nanowire in Water (1g)
- Copper Nanowire (50-200nm), 1g - Ethanol or Water dispersion

Metal Oxide Nanowires

Technical Properties:

- Composition: SiC, ZnO, TiO_2
- Diameter: 50-200 nm (varies by material)
- Length: 1-100 μm
- Crystal structure: Material-dependent (wurtzite for ZnO, anatase/rutile for TiO_2)
- Bandgap: 3.3 eV (ZnO), 3.0-3.2 eV (TiO_2), 2.3-3.3 eV (SiC)
- Thermal stability: Excellent at high temperatures
- Chemical stability: Excellent resistance to oxidation and corrosion
- Surface area: High specific surface area

Applications:

- Photocatalysis and environmental remediation
- Gas sensors and chemical sensors
- Piezoelectric devices and nanogenerators
- UV photodetectors
- Field emission displays
- Solar cells (especially dye-sensitized)
- Battery and supercapacitor electrodes
- Antibacterial surfaces
- High-temperature electronic devices (SiC)

Available Variations:

- SiC Nanowire - various product codes
- Zinc Oxide Nanowire - Dia:50-120 nm, 500 mg and 1 g
- TiO_2 Nanowire - TiO_2-NW-A and TiO_2 NW-B, 1 g

Molecular Sieves and Porous Materials
Zeolites
Technical Properties:
- Structure: Crystalline aluminosilicates with uniform pores
- Pore size: 0.3-1.5 nm (precisely controlled)
- Surface area: 300-800 m^2/g
- Thermal stability: Up to 1000°C for some types
- Acidity: Tunable Brønsted and Lewis acid sites
- Ion exchange capacity: High for many formulations
- Hydrophilicity/hydrophobicity: Tunable based on Si/Al ratio
- Framework types: Over 40 different structures available (MFI, FAU, BEA, etc.)

Applications:
- Catalysts for petrochemical industry (cracking, isomerization)
- Ion-exchange for water softening
- Molecular sieving and gas separation
- Desiccants and moisture control
- Odor control and gas adsorption
- Detergent builders
- Environmental remediation
- Slow-release fertilizers and drug delivery
- Heat storage materials

Available Variations:
- ZSM-5 Series Zeolite (MFI) Powder - various formulations
- ZSM-5 Adsorbent Series
- ZSM-5 Catalyst
- ZSM-11, ZSM-22, ZSM-23, ZSM-35
- SAPO-11
- SSZ-13 Zeolite
- Beta Zeolite - various codes
- Y-type Series Zeolites - various modifications
- Mordenite Zeolite - synthetic and natural
- Ultrastable Y Zeolite

Metal-Organic Frameworks
Technical Properties:
- Structure: Coordination networks of metal nodes and organic linkers
- Surface area: Extremely high (1000-7000 m^2/g)
- Pore size: Tunable from micropores to mesopores
- Pore volume: 0.5-4.0 cm^3/g
- Thermal stability: 250-500°C (framework dependent)
- Chemical stability: Varies widely (some water/acid stable, others sensitive)
- Functionality: Highly tailorable through linker and metal selection
- Crystallinity: Highly crystalline materials

Applications:
- Gas storage (H_2, CH_4, CO_2)

- Gas separation and purification
- Catalysis (heterogeneous, photocatalysis)
- Drug delivery and controlled release
- Sensing of chemicals, gases, and biomolecules
- Proton conductivity for fuel cells
- Water harvesting from air
- Heat transformation applications
- Heavy metal removal from water

Available Variations:

- Zeolitic Imidazolate Framework-8 (ZIF-8) - various types
- Zeolitic Imidazolate Framework-67 (ZIF-67) - Type A and B
- Metal-Organic Framework Cu-BTC (HKUST-1)
- CPT Method Zeolitic Imidazolate Framework-8 (ZIF-8)

Covalent Organic Frameworks

Technical Properties:

- Structure: Crystalline polymers with ordered porous structure
- Composition: Entirely organic (C, H, N, O, B)
- Linkage types: Boroxine, imine, hydrazone, triazine, etc.
- Surface area: 1000-4000 m^2/g
- Pore size: Precisely controllable (0.8-5 nm)
- Thermal stability: 300-500°C
- Chemical stability: Generally excellent in various solvents
- Density: Extremely low (0.15-0.5 g/cm^3)

Applications:

- Gas storage and separation
- Heterogeneous catalysis
- Energy storage (batteries, supercapacitors)
- Photocatalysis and solar energy conversion
- Chemical sensing
- Environmental remediation
- Drug delivery and controlled release
- Optoelectronic devices
- Membranes for molecular separation

Available Variations:

- Covalent Organic Framework-LZU1 (COF-LZU1) - Type A and B
- Covalent Organic Framework-TpPa-1 (COF-TpPa-1)
- Covalent Organic Framework-DAAQ-TFP (DAAQ-TFP-COF)

Ordered Mesoporous Materials

Technical Properties:

- Structure: Ordered arrangement of uniform mesopores
- Pore size: 2-50 nm (tunable)
- Surface area: 500-1500 m^2/g
- Pore volume: 0.5-2.0 cm^3/g
- Wall composition: Silica, carbon, metal oxides
- Pore geometry: Hexagonal, cubic, or lamellar arrangements
- Thermal stability: Up to 800°C for silica-based materials
- Chemical stability: Excellent for silica, variable for others

Applications:

- Catalysis and catalyst supports
- Drug delivery systems
- Adsorption and separation
- Enzyme immobilization
- Controlled release
- Energy storage (battery/supercapacitor electrodes)
- Sensors and biosensors
- Low-k dielectric materials
- Template for nanostructure synthesis

Available Variations:

- MCM-41, MCM-48, Al-MCM-41
- SBA-15, SBA-16
- KIT-5, KIT-6
- FDU-12
- High Surface Area SBA-15
- Monodisperse Mesoporous Silica Nanosphere Stellate MSN
- Ordered mesoporous carbon cmk-3, cmk-8
- Disordered Mesoporous Carbon

MXene Materials

Technical Properties:

- Composition: Transition metal carbides/nitrides (Ti_3C_2Tx, Ti_2CTx, etc.)
- Structure: 2D layered materials with surface terminations
- Surface terminations (Tx): -OH, -O, -F functional groups
- Electrical conductivity: Up to 10^5 S/m
- Mechanical properties: Young's modulus ~330 GPa
- Hydrophilicity: Generally hydrophilic due to surface groups
- Dispersibility: Forms stable colloidal solutions in water
- Aspect ratio: Very high (lateral size/thickness > 1000)

Applications:

- Energy storage (supercapacitors, batteries)
- Electromagnetic interference (EMI) shielding
- Water purification and desalination
- Gas separation membranes
- Photothermal therapy
- Biosensors and chemical sensors
- Catalysis (HER, ORR, etc.)
- Conductive additives for composites
- Transparent conductive films

Available Variations:

- Ti_3C_2Tx MXene (multilayer nanoflakes) - 1 g, 5 g
- Ti_3C_2Tx MXene (few-layer nanoflakes) - 500 mg

Other Nanoparticles and Materials

Porous Silicon

Technical Properties:

- Structure: Nanocrystalline silicon with interconnected pores
- Pore size: 2-50 nm (tunable)

- Porosity: 30-95%
- Surface area: 200-800 m²/g
- Photoluminescence: Tunable from visible to near-IR
- Biodegradability: Degrades to silicic acid in aqueous environments
- Biocompatibility: Generally biocompatible and non-toxic
- Surface chemistry: Easily modified with various functional groups

Applications:

- Drug delivery and controlled release
- Bioimaging (photoluminescence, MRI)
- Biosensors and chemical sensors
- Photocatalysis
- Energy storage (battery anodes)
- Thermal insulators
- Optical filters and Bragg reflectors
- Microelectronics and optoelectronics
- Tissue engineering scaffolds

Available Variations:

- Porous Silicon - 50 gm

Silicon Nanoparticles

Technical Properties:

- Size: 20-100 nm
- Crystallinity: Crystalline or amorphous
- Surface chemistry: Various functionalizations available
- Optical properties: Size-dependent photoluminescence
- Electrical properties: Semiconductor with tunable bandgap
- Specific capacity: Up to 4200 mAh/g (theoretical)
- Surface area: 30-150 m²/g
- Thermal conductivity: Lower than bulk silicon

Applications:

- Lithium-ion battery anodes
- Printed electronics
- Solar cells and photovoltaics
- Thermoelectric materials
- Bioimaging agents
- Drug delivery systems
- Photodynamic therapy
- Chemical and biological sensors
- Quantum dots for optoelectronics

Available Variations:

- Silicon nanoparticles - 1 g, 5 g, Type B and C

Anodic Aluminum Oxide (AAO) Templates
Technical Properties:
- Structure: Highly ordered hexagonal array of cylindrical pores
- Pore diameter: 10-400 nm (controllable)
- Pore density: 10^8-10^{10} pores/cm^2
- Thickness: 10-200 μm
- Aspect ratio: Up to 1000
- Thermal stability: Up to 800°C
- Chemical stability: Good in neutral and moderately acidic/basic conditions
- Optical properties: Transparent to translucent depending on pore size

Applications:
- Template for nanowire/nanotube growth
- Filtration and separation membranes
- Controlled drug release
- Biosensors and chemical sensors
- Photonic crystals
- Energy storage device electrodes
- Catalysis support
- Electronic and optoelectronic devices
- Fundamental research on nanomaterials

Available Variations:
- Single-Pass AAO (5p/Pack) - various specifications
- Double-Pass AAO (5p/Pack) - various specifications
- V-Shape AAO (5P/Pack) - various specifications

Black Phosphorus
Technical Properties:
- Structure: Layered material with puckered honeycomb structure
- Bandgap: 0.3 eV (bulk) to 2.0 eV (monolayer)
- Electrical properties: p-type semiconductor with high carrier mobility
- Anisotropic properties: Highly directional physical properties
- Stability: Reactive with oxygen and water (requires protection)
- Thermal conductivity: Anisotropic (12-30 W/mK, direction-dependent)
- Optical properties: Direct bandgap with strong absorption from visible to IR
- Mechanical properties: Flexible with Young's modulus ~27-166 GPa

Applications:
- Field-effect transistors
- Photodetectors (visible to IR range)
- Gas sensors
- Battery and supercapacitor electrodes
- Photocatalysis
- Biomedical applications (photodynamic therapy, drug delivery)
- Thermal management materials
- Optoelectronic devices
- Thermoelectric materials

Available Variations:
- Black Phosphorus Powder - 200 mg, 500 mg
- Black Phosphorus Crystal - 500 mg

Metal and Metal Oxide Nanoparticles

Technical Properties:

- Size: 5-150 nm (varies by product)
- Composition: Silver, copper, nickel, titanium dioxide, aluminum oxide, etc.
- Shape: Mostly spherical with some variations
- Surface area: 10-200 m^2/g
- Surface chemistry: Can be bare or functionalized
- Optical properties: Some show surface plasmon resonance (Ag, Cu)
- Catalytic activity: Size-dependent enhanced catalytic properties
- Stability: Varies (silver more stable than copper)
- Antimicrobial properties: Especially for silver and copper

Applications:

- Antimicrobial agents and disinfectants
- Catalysis
- Conductive inks and pastes
- Sintering additives
- Medical devices and wound dressings
- Water treatment
- Sensors and biosensors
- Photocatalysis (TiO_2)
- Polymer additives for enhanced properties
- Energy storage materials

Available Variations:

- Silver Nanoparticles - 50 gm
- Copper Nanoparticles (100nm) - 25 g
- Nickel Nanoparticles - 25 g
- Titanium Dioxide (TiO_2) P25 - 500 mg, 10-40 μm
- Black Titanium Dioxide (TiO_2-x) - 500 mg, 10-40 nm
- Gamma-Aluminum Oxide Powder - various quantities
- Cerium Oxide (CeO_2) - various sizes
- Lanthanum Oxide (La_2O_3) - various sizes
- Yttrium Oxide (Y_2O_3) - various sizes

Applications Guide

Electronics and Optoelectronics

- **Transparent Conductive Films**: Silver nanowires, CVD graphene, graphene/silver nanowire composites
- **Transistors**: CVD graphene, MoS_2, WS_2, mechanically exfoliated 2D materials
- **Semiconductor Devices**: Silicon nanoparticles, black phosphorus, TMDs
- **Photovoltaics**: Graphene, upconverting nanoparticles, quantum dots, TMDs
- **Photodetectors**: Black phosphorus, MoS_2, graphene, quantum dots
- **Thermal Management**: Graphene, BN, graphite, carbon nanotubes
- **EMI Shielding**: MXenes, carbon nanotubes, graphene, silver nanowires

Energy Storage and Conversion

- **Lithium-ion Batteries**: Graphene, silicon nanoparticles, Si/C composites, MXenes
- **Supercapacitors**: Graphene, activated carbon, MXenes, metal oxides
- **Fuel Cells**: Platinum nanoparticles, graphene, nitrogen-doped carbon
- **Hydrogen Storage**: MOFs, COFs, graphene, carbon nanotubes
- **Catalysts**: Metal nanoparticles, 2D materials, MOFs, zeolites

Biomedical Applications

- **Drug Delivery**: Mesoporous silica, porous silicon, graphene oxide, carbon dots
- **Bioimaging**: Quantum dots, upconverting nanoparticles, carbon dots
- **Biosensors**: Graphene, carbon nanotubes, quantum dots, metal nanoparticles
- **Antibacterial Materials**: Silver nanoparticles, copper nanoparticles, graphene oxide
- **Tissue Engineering**: Graphene, carbon nanotubes, hydroxyapatite

Environmental Applications

- **Water Purification**: Graphene oxide, carbon nanotubes, MOFs, zeolites
- **Air Filtration**: Carbon nanotubes, graphene, MOFs
- **Environmental Remediation**: Metal nanoparticles, graphene oxide
- **CO_2 Capture**: MOFs, COFs, zeolites, carbon materials
- **Photocatalysis**: TiO_2, ZnO, graphitic carbon nitride, black phosphorus

Advanced Materials

- **Composite Reinforcement**: Carbon nanotubes, graphene, boron nitride
- **Coatings**: Graphene, silver nanowires, metal nanoparticles
- **Lubricants**: Graphite, MoS_2, WS_2, h-BN
- **Inks and Printing**: Silver nanowires, graphene, carbon nanotubes
- **3D Printing Additives**: Carbon nanotubes, graphene, metal nanoparticles

Safety and Handling

General Safety Guidelines

- Always wear appropriate personal protective equipment (PPE) including gloves, lab coat, and eye protection
- Work in well-ventilated areas, preferably with local exhaust ventilation
- Avoid generating and breathing dust or aerosols
- Prevent skin and eye contact with nanomaterials
- Wash hands thoroughly after handling any nanomaterials
- Clean work surfaces using wet methods or HEPA vacuum cleaners

Material-Specific Precautions

- **Metal Nanoparticles**: May be reactive; keep away from oxidizers and acids
- **Carbon Nanotubes**: Potential respiratory hazard; avoid inhalation
- **Graphene Materials**: Handle powders carefully to avoid inhalation
- **Quantum Dots**: May contain heavy metals; avoid ingestion and skin contact
- **2D Materials**: Some (like black phosphorus) are reactive with air/moisture

Storage Recommendations

- Store in tightly closed containers in cool, dry places
- Keep away from incompatible materials
- Follow specific storage instructions for light-sensitive materials
- Store reactive materials (black phosphorus, some metal nanoparticles) under inert atmosphere
- Label all containers clearly with contents and hazard information

Waste Disposal

- Follow local regulations for nanomaterial waste disposal
- Do not dispose of nanomaterials in regular trash or down drains
- Collect waste in proper containers labeled for hazardous waste
- Consult your institution’s environmental health and safety office for guidance

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