Date of Issue:
05 April 2017

SAFETY DATA SHEET

1. SUBSTANCE AND SOURCE IDENTIFICATION

Product Identifier

SRM Number: 2484
SRM Name: Multiwall Carbon Nanotubes (Raw Soot)
Other Means of Identification: Not applicable.

Recommended Use of This Material and Restrictions of Use

This Standard Reference Material (SRM) is intended primarily for use in evaluating chemical and instrumental methods of analysis of carbon nanotubes. A unit of SRM 2484 consists of a bottle containing approximately 6 g of nanotube soot.

Company Information

National Institute of Standards and Technology
Standard Reference Materials Program
100 Bureau Drive, Stop 2300
Gaithersburg, Maryland 20899-2300

Telephone: 301-975-2200
FAX: 301-948-3730
E-mail: SRMMSDS@nist.gov
Website: http://www.nist.gov/srm

Emergency Telephone ChemTrec:
1-800-424-9300 (North America)
+1-703-527-3887 (International)

2. HAZARDS IDENTIFICATION

Classification

Physical Hazard: Not classified.
Health Hazard: Respiratory Sensitization – Category 1
Skin Sensitization – Category 1
Carcinogen – Category 2
STOT, Repeated Exposure – Category 1, Respiratory System
OSHA Defined Hazard: Combustible Dust

Label Elements

Symbol:

Signal Word: DANGER

Hazard Statement(s):

H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled.
H317	May cause an allergic skin reaction.
H351	Suspected of causing cancer.
H373	Causes damage to lungs through prolonged or repeated exposure.
------	May form combustible dust concentrations in air.

Precautionary Statement(s):

P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P260	Do not breathe dust.
P264	Wash hands thoroughly after handling.
P270 + P271	Do not eat, drink or smoke when using this product.
P272	Contaminated work clothing must not be allowed out of the workplace.
P280	Wear protective gloves, protective clothing, and eye protection.
P284	Wear respiratory protection.

P304 + P340 If inhaled: If breathing is difficult, remove person to fresh air and keep comfortable for breathing.
P342 + P311 If experiencing respiratory symptoms: Call a doctor.

P302 + P352 If on skin: Wash with plenty of water.
P333 + P313 If skin irritation or rash occurs: Get medical attention.
P363 Wash contaminated clothing before reuse.

P308 + P313 If exposed or concerned: Get medical attention.
P405 Store locked up.
P501 Dispose of contents and container according to local regulations.

Hazards Not Otherwise Classified: Not applicable.

Ingredients(s) with Unknown Acute Toxicity: 10 % of this material is proprietary with unknown acute toxicity.

3. COMPOSITION AND INFORMATION ON HAZARDOUS INGREDIENTS

Substance: Multiwall Carbon Nanotubes

Other Designations: Nanotubes, carbon nanotubes (CNT); tubular fullerenes; short tangled multiwalled nanotubes.

Components are listed in compliance with OSHA's 29 CFR 1910.1200; for the actual values see the NIST Certificate of Analysis.

Hazardous Component(s)	CAS Number	EC Number (EINECS)	Nominal Mass Concentration (%)
Multiwall Carbon Nanotubes[(a)]	308068-56-6	not available	90
Material undisclosed	n/a	n/a	10

[(a)] CAS number assigned to carbon nanotubes, tubular fullerenes, tubulenes, and single-walled nanotubes.

4. FIRST AID MEASURES

Description of First Aid Measures:

Inhalation: If adverse effects occur, remove to uncontaminated area. If not breathing, give artificial respiration or oxygen by qualified personnel. Seek immediate medical attention.

Skin Contact: Wash skin with soap and water for at least 15 minutes. If necessary, seek medical attention.

Eye Contact: Flush eyes with water for at least 15 minutes. If necessary, seek medical attention.

Ingestion: Do not induce vomiting; if vomiting occurs spontaneously, keep head below hips to prevent aspiration. Obtain medical attention.

Most Important Symptoms/Effects, Acute and Delayed: Coughing, respiratory effects (pulmonary inflammation).

Indication of any immediate medical attention and special treatment needed, if necessary: If any of the above symptoms are present or suspected, seek medical attention if needed.

5. FIRE FIGHTING MEASURES

Fire and Explosion Hazards: Slight fire hazard. Dust may form explosive mixtures with air. See Section 9, "Physical and Chemical Properties" for flammability properties.

Extinguishing Media:
Suitable: Use extinguishing media appropriate for the surrounding area.
Unsuitable: High volume water jet.

Specific Hazards Arising from the Chemical: None listed.

Special Protective Equipment and Precautions for Fire-Fighters: Avoid inhalation of material or combustion byproducts. Wear full protective clothing and NIOSH approved self-contained breathing apparatus (SCBA).

NFPA Ratings (0 = Minimal; 1 = Slight; 2 = Moderate; 3 = Serious; 4 = Severe)

Health = 2 Fire = 1 Reactivity = 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions, Protective Equipment and Emergency Procedures: Any accumulated material on surfaces should be removed and properly disposed of. Keep unnecessary personnel away. Use suitable protective equipment; see Section 8, "Exposure Controls and Personal Protection".

Methods and Materials for Containment and Clean up: Notify safety personnel of spills. Dry sweeping or air hoses should not be used to clean work areas. Use of HEPA-filtered vacuum cleaners is recommended. Collect spilled material in appropriate container for disposal. Isolate hazard area and deny entry. Prevent discharge to natural waters, sewers and biological waste water treatment plants.

7. HANDLING AND STORAGE

Safe Handling Precautions: Minimize dust generation and accumulation on surfaces. Routine housekeeping should be instituted to ensure that dusts do not accumulate on surfaces. Avoid generating dust. See Section 8, "Exposure Controls and Personal Protection".

Storage: Store and handling in accordance with all current regulations and standards.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

Exposure Limits:

NIOSH (TWA): 1 $\mu g/m^3$ (respirable nanotubes-elemental carbon)
OSHA (PEL): No occupational limits established for carbon nanotubes.

Engineering Controls: Provide local exhaust or process enclosure ventilation system. Ensure compliance with applicable exposure limits.

Personal Protection: In accordance with OSHA 29 CFR 1910.132, subpart I, wear appropriate Personal Protective Equipment (PPE) to minimize exposure to this material.

Respiratory Protection: At a minimum wear a National Institute for Occupational Safety and Health NIOSH certified air-purifying tight-fitting full-face respirator with N-100, P-100 or R-100 cartridge or equivalent in accordance with respiratory protection requirements specified in OSHA 29 CFR 1910.134 and NIOSH 42 CFR 84 whenever exposure to the product by inhalation is possible.

Eye/Face Protection: Wear chemical goggles or safety glasses at all times unless the NIOSH fullface respirator discussed immediately above is being worn. The respirator's mask provides appropriate eye. An eyewash station should be readily available near areas of use.

Skin and Body Protection: Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Protecting gloves:

Suitable materials for safety gloves/ EN 374-3: Nitrile rubber (NBR; > 0.35 mm).

Unsuitable material: Do not wear neoprene gloves, as neoprene absorbs nanoparticles. Each such item of personal protective equipment must be selected and used in accordance with OSHA dermal protection requirements at 29 CFR 1910.132, 1910.133 and 1910.138.

9. PHYSICAL AND CHEMICAL PROPERTIES

Descriptive Properties:	**Nanotubes**
Appearance (physical state, color, etc.):	black powder
Molecular Formula:	not applicable
Molar Mass (g/mol):	not applicable
Odor:	odorless
Odor threshold:	not available
pH:	not available
Evaporation rate:	not available
Melting point/freezing point (ºC):	not available
Bulk Density (g/L):	60 g/L
Vapor Pressure (mmHg):	not available

Descriptive Properties:	**Nanotubes**
Vapor Density (air = 1):	not available
Viscosity (cP):	not available
Solubility(ies):	insoluble in water
Partition coefficient (n-octanol/water):	not available
Particle Size:	< 1.5 µm

Thermal Stability Properties:	**Nanotubes**
Autoignition Temperature (°C):	not applicable
Thermal Decomposition (°C):	not applicable
Initial boiling point and boiling range (°C):	not applicable
Explosive Limits, LEL (g/m^3):	180
Explosive Limits, UEL (Volume %):	not applicable
Explosive class:	ST1 (VD 22263)
Explosive properties:	Kst = 42 bar·m·s^{-1}
Flash Point (°C):	not applicable
Smouldering Temperature (°C):	>400 (>752 °F)
Flammability (solid, gas):	Not available
Minimum Ignition Energy (J):	>10

10. STABILITY AND REACTIVITY

Reactivity: Stable at normal temperatures and pressure.

Stability: X Stable _____ Unstable

Possible Hazardous Reactions: No data available.

Conditions to Avoid: Avoid generating dust. Keep out of water supplies and sewers.

Incompatible Materials: Strong oxidizing and reducing agents.

Fire/Explosion Information: See Section 5, "Fire Fighting Measures".

Hazardous Decomposition: Oxides of carbon, metal oxides.

Hazardous Polymerization: _____ Will Occur X Will Not Occur

11. TOXICOLOGICAL INFORMATION

Route of Exposure: X Inhalation X Skin _____ Ingestion

Symptoms Related to the Physical, Chemical and Toxicological Characteristics: Coughing, respiratory effects (pulmonary inflammation).

Potential Health Effects (Acute, Chronic and Delayed):

Inhalation: The National Institute for Occupational Safety and Health (NIOSH) systematically reviewed 54 laboratory animal studies, many of which indicated that carbon nanotubes (CNTs) and carbon nanofibers could cause adverse pulmonary effects including inflammation, granulomas, and pulmonary fibrosis. There are well established correlations between results of animal studies and adverse effects in workers exposed to particulates and other air contaminants. In addition, NIOSH considers these animal study findings to be relevant to human health risks because similar lung effects have been observed in workers exposed to respirable particulates of other materials in dusty jobs. Moreover, in animal studies where CNTs were compared with other known fibrogenic materials (e.g., silica, asbestos, ultrafine carbon black), the CNTs were of similar or greater potency, and the effects, including fibrosis, developed soon after exposure and persisted. This SRM contains >0.1 % of a substance classified as Category 1 for respiratory sensitization.

Skin Contact: This SRM contains >0.1 % of a substance classified as Category 1 for skin sensitization.

Eye Contact: No toxicity data available; dust may cause mechanical irritation.

Ingestion: No information available.

Numerical Measures of Toxicity:

Acute Toxicity: Not classified.
Rat Oral LD50: >5000 mg/kg
Rat Dermal LD50: >2000 mg/kg

Skin Corrosion/Irritation: Not classified; no data available.

Serious Eye damage/ Eye irritation: Not classified; no data available.

Respiratory Sensitization: Category 1.
This SRM contains >0.1 % of a substance classified as Category 1.

Skin Sensitization: Category 1.
This SRM contains >0.1 % of a substance classified as Category 1.

Germ Cell Mutagenicity: Not classified.
Not mutagenic (Ames test).

Carcinogenicity: Category 2

Listed as a Carcinogen/Potential Carcinogen _____ Yes __X__ No

CNTs are not listed by NTP, IARC or OSHA as carcinogen/potential carcinogen. This material is classified as Category 2 suspected of being carcinogenic based on animal studies, see potential health effects for inhalation.

Reproductive Toxicity: Not classified; no data available.

Specific Target Organ Toxicity, Single Exposure: Not classified; no data available.

Specific Target Organ Toxicity, Repeated Exposure: Category 1, Respiratory System.
Target organ: Lung (pulmonary inflammation)
Rat Inhalation, repeated dose, 90 days, LOAEC: 0.0001 mg/L

Aspiration Hazard: Not applicable.

12. ECOLOGICAL INFORMATION

Ecotoxicity Data:

Fish Toxicity:
Zebrafish (*Danio rerio*) EC50: > 100 mg/L (14 d)
Zebrafish (*Danio rerio*), EC10 (semi-static): 100 mg/L

Invertebrate:
Water flea (*Daphnia magna*) EC50: > 100 mg/L (48 h, freshwater)
Water flea (*Daphnia magna*) NOEC (semi-static): > 25 mg/L

Algae:
Green weed (*Desmodesmus subspicatus*) EC50: 134 mg/L (72 h, freshwater)

Persistence and Degradability: No biodegradation expected.

Bioaccumulative Potential: No data available.

Mobility in Soil: No data available.

Other Adverse effects: No data available.

13. DISPOSAL CONSIDERATIONS

Waste Disposal: Dispose of waste in accordance with all applicable federal, state, and local regulations. Prevent discharge to natural waters, sewers and biological waste water treatment plants.

14. TRANSPORTATION INFORMATION

U.S. DOT and IATA: Not regulated by DOT or IATA.

15. REGULATORY INFORMATION

U.S. Regulations:

CERCLA Sections 102a/103 (40 CFR 302.4): This SRM is not regulated.

SARA Title III Section 302 (40 CFR 355.30): This SRM is not regulated.

SARA Title III Section 304 (40 CFR 355.40): This SRM is not regulated.

SARA Title III Section 313 (40 CFR 372.65): This SRM is not regulated.

OSHA Process Safety (29 CFR 1910.119): This SRM is not regulated.

SARA Title III Sections 311/312 Hazardous Categories (40 CFR 370.21):

ACUTE HEALTH:	No.
CHRONIC HEALTH:	Yes.
FIRE:	No.
REACTIVE:	No.
PRESSURE:	No.

State Regulations:

California Proposition 65: Not listed

U.S. TSCA Inventory: Synthetic graphite is listed.

TSCA 12(b), Export Notification: Not listed.

Canadian Regulations:

WHMIS Information: Not provided for this material.

16. OTHER INFORMATION

Issue Date: 05 April 2017

Sources: Vendor Nanocyl, MSDS *NC7000*, 28 January 2014.

CDC; NIOSH; Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC), National Institute for Safety a*nd Nanofibers*; NIOSH 161-A; available at http://www.cdc.gov/niosh/docs/2013-145/ (accessed Apr 2017).

CDC; NIOSH; Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC), National Institute for Safety and Health; *Approaches to Safe Nanotechnology: Managing the Health and Safety Concerns Associated with Engineered Nanomaterials*; NIOSH Publication 2009-128; available at http://www.cdc.gov/niosh/docs/2009-125/ (accessed Apr 2017);

ChemADVISOR, Inc., SDS *Graphite, Synthetic* 21 March 2014.

Key of Acronyms:

ACGIH	American Conference of Governmental Industrial Hygienists	NOEC	No Observed Effect Concentration
ALI	Annual Limit on Intake	NRC	Nuclear Regulatory Commission
CAS	Chemical Abstracts Service	NTP	National Toxicology Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	OSHA	Occupational Safety and Health Administration
CFR	Code of Federal Regulations	PEL	Permissible Exposure Limit
DOT	Department of Transportation	PNOR	Particulates Not Otherwise Regulated
EC50	Effective Concentration, 50 %	RCRA	Resource Conservation and Recovery Act
EC10	Effective Concentration, 10 %	REL	Recommended Exposure Limit
EINECS	European Inventory of Existing Commercial Chemical Substances	RM	Reference Material
EPCRA	Emergency Planning and Community Right-to-Know Act	RQ	Reportable Quantity
IARC	International Agency for Research on Cancer	RTECS	Registry of Toxic Effects of Chemical Substances
IATA	International Air Transport Association	SARA	Superfund Amendments and Reauthorization Act
IDLH	Immediately Dangerous to Life and Health	SCBA	Self-Contained Breathing Apparatus
LC50	Lethal Concentration, 50 %	SRM	Standard Reference Material
LD50	Lethal Dose, 50 %	STEL	Short Term Exposure Limit
LEL	Lower Explosive Limit	TLV	Threshold Limit Value
MSDS	Material Safety Data Sheet	TPQ	Threshold Planning Quantity
LOAEC	Lowest Observable Adverse Effect Concentration	TSCA	Toxic Substances Control Act
NFPA	National Fire Protection Association	TWA	Time Weighted Average
NIOSH	National Institute for Occupational Safety and Health	UEL	Upper Explosive Limit
NIST	National Institute of Standards and Technology	WHMIS	Workplace Hazardous Materials Information System

Disclaimer: Physical and chemical data contained in this SDS are provided only for use in assessing the hazardous nature of the material. The SDS was prepared carefully, using current references; however, NIST does not certify the data in the SDS. The certified values for this material are given in the NIST Certificate of Analysis.

Users of this SRM should ensure that the SDS in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 948-3730; e-mail srmmsds@nist.gov; or via the Internet at http://www.nist.gov/srm.