
Introduction to Materials Science

Student Guide

IS3470

INTRODUCTION

Materials are an integral part of our everyday lives. We use them for shelter, transportation, communication, clothing, energy, and more; nearly every part of our modern lives is influenced by materials and materials science. The development and utilization of materials is vital to human history and survival, so much so that early civilizations are often referred to by the main material used, for example, the Bronze Age, Stone Age, and Iron Age. Incredible advancements in technology have been made due to the discovery and development of new materials, allowing us to travel long distances in cars and planes, talk to friends and family over the phone or video chat, treat and cure illnesses that were previously untreatable, and much more.

What is Materials Science?

Materials science is the study of the relationship between a material's structure and its properties. It is an interdisciplinary subject that combines other scientific fields such as chemistry, physics, and engineering. In addition to structure, the way a material is processed also affects its properties and the way it performs in certain applications. These aspects of materials science are all related, as the method of processing affects the structure of a material. This in turn determines its properties, which influence its performance.

When studying materials science, it is important to understand what is meant by structure and property. **Structure** refers to the arrangement of a material's internal components, and is important on many different levels from the subatomic to the macroscopic. The subatomic structure deals with electrons within atoms and their interactions with their nuclei, while the atomic structure refers to the organization of atoms or molecules within a material relative to one another. On the microscopic level, structure deals with groups of atoms that are clustered together, and can be seen using some type of microscope. Finally, the macrostructure refers to the collections of microfeatures that show distinct characteristics and can be observed with the naked eye. A **property** is the way in which a material responds to an imposed stimulus, including the magnitude of that response. As mentioned previously, the properties of a material are determined by its chemical composition and structure, and can also be altered by the method of processing.

The field of materials science is incredibly important, as it has applications in the design, development, and manufacture of real products that can often make our lives easier or more comfortable. The job of a materials scientist is to explore the relationships between the structure and properties of different materials, and use these relationships to design new materials that have the specific set of properties required for particular applications.

Types of Materials

There are four main types of materials: metals, polymers, ceramics, and composites. Each of these material classes will be discussed in more detail below.

Metals

Metals are characterized by the type of chemical bonds that exist between their atoms, known as metallic bonds, in which free valence electrons are shared among the positively charged ions in the lattice. The atoms within a metal are typically close together and arranged in an orderly fashion, which allows the electrons to move between different atoms rather than orbit one particular atom, forming what is sometimes referred to as a “sea of electrons.” This metallic bonding is the source of many properties of metals, such as their excellent electrical and thermal conductivity. In addition to being good conductors, metals typically have a lustrous, or shiny, appearance, and are durable and malleable. Other properties, such as strength and hardness, vary and are dependent on the type of metal being used. These properties make metals suitable for many applications, such as electronics and wiring, machinery, automobiles, and structural building materials. However, metals are also susceptible to corrosion, which can cause them to rust and eventually break down in certain environments.

Polymers

Polymers have a long, chain-like structure that is made up of repeating units called monomers. These monomers are generally organic molecules containing carbon, hydrogen, and other nonmetallic atoms, and are linked together via covalent bonds to form a polymer chain. The chemical composition of a polymer, as well as the way it is processed, can greatly change its structure and, therefore, its properties. Different polymers have a wide variety of properties, ranging from flexible and ductile to hard and brittle. For example, plastic bags and shampoo bottles are both made from polymers, but they have very different properties. Some polymers are strong, durable, and resistant to corrosion, so they can be useful in environments where a metal might eventually break down. However, the durability of polymer materials is also one of the disadvantages of using them—they can take thousands of years to break down and proper recycling is difficult, leading to increased pollution. Additionally, many polymers will soften or degrade at higher temperatures, so they cannot be used for certain applications that require the product to withstand a lot of heat.

Ceramics

Ceramics are non-metallic, inorganic solids and typically contain covalent bonds between atoms. Many ceramic materials are made of metal oxides, in which a metal is bound to oxygen, or other nonmetallic elements such as carbon, nitrogen, and silicon. Most ceramics are insulators, meaning they do not conduct heat or electricity, however, there are some ceramic materials that are thermal or electrical conductors. These conductive ceramics can be used in a variety of applications, such as solar panels, liquid crystal displays, batteries, and more. Ceramics are typically hard, brittle, and stiff, and resistant to high temperatures and corrosion. These properties make ceramics extremely useful for products used in high temperature or corrosive environments, where a metal or polymer may degrade.

Composites

Composites are materials that contain a mixture of two or more metals, polymers, and/or ceramics. They display a wide variety of properties depending on their component materials, and are typically designed to take the best properties of each component and create a combination of properties not possible with only one material. An example of a commonly used composite material is fiberglass. Fiberglass is polymer material that is reinforced with glass fibers (a ceramic material) that can be flattened into a sheet or woven into a fabric. It is lightweight and has the strength and corrosion resistance of a ceramic combined with the toughness and durability of a polymer, making it ideal for applications where other materials may be too heavy, brittle, or prone to degradation. Fiberglass is used in the automotive industry to make car bodies and paneling, in the marine industry for boat hulls, the electronic industry for circuit boards, and in so many others applications. Other examples of composite materials include concrete, wood, brick, shell, bone, and plywood.

Properties of Materials

As mentioned previously, a property is the way in which a material responds to an imposed stimulus. There are two main categories of properties: physical and chemical. **Physical properties** are ones that can be measured and observed without changing the chemical composition of a material. **Chemical properties**, on the other hand, can only be observed by changing a substance's chemical composition, which is done by involving it in a chemical reaction. In this activity, we will focus on physical properties. Examples of physical properties include density, melting and boiling point, conductivity, luster, and color, among others. Some physical properties belong to a subcategory known as **mechanical properties**, which describe how a material performs when a force is applied to it. Examples of mechanical properties include strength, hardness, ductility, malleability, toughness, and more.

In this activity, you will measure the physical and mechanical properties of eight different material samples. Based on your results, you will then categorize each material sample and determine whether it is a metal, polymer, ceramic, or composite. In addition to

observation of the appearance of each sample, four properties will be tested. More detail on each of these properties is given below.

Electrical conductance - How easily electricity flows through a material. Conductance is the inverse of resistance, and can be determined by first measuring the resistance of a material using a voltmeter. A material that conducts electricity is called a conductor, and will have a very low resistance. If a material has a high resistance, it is not conductive and is called an insulator.

Hardness - The ability of a material to resist localized deformation or indentation. In other words, hardness is a measure of how easy it is to scratch a material. Simple hardness tests can be performed by testing how much force is required to scratch a material with a given object (such as a nail or piece of harder material).

Toughness - The ability of a material to absorb impact. If a material can absorb the energy from an impact without breaking, it has a higher toughness. On the other hand, if a material fractures easily under the force of an impact, it is considered brittle.

Stiffness - The ability of a material to resist bending. Stiffness can be qualitatively determined by attempting to bend a sample of a material. If the material bends easily, it is considered more flexible. If it does not bend easily, it is considered stiff.

Procedure

Materials Needed per Group

- 2 Aluminum strips
- 2 Copper strips
- 2 Tongue depressors
- Playing cards
- 2 Tile pieces
- 2 Glass slides
- 2 Plastic chips
- 2 Balloons
- Steel nail
- Zipper bag

Shared Materials

Voltmeters
Hammers

1. Obtain two of each of the following material samples: aluminum strip, copper strip, plastic chip, balloon, tile, microscope slide, tongue depressor, playing card. Record your observations of each material in Data Table 1 in the Data Analysis section.
 2. Perform a conductance test:
 - a. Obtain a voltmeter, and set it to measure resistance (turn the dial to the 200 Ω setting).
 - b. Place the tip of each probe on the aluminum strip, being careful that the probes do not contact each other.
 - c. Read the resistance measurement and determine whether the material is conductive or insulating. Record your result in Data Table 2 in the Data Analysis section.
- Note to Students:** *When reading the voltmeter, if the display changes after placing the probes on the material and shows a small number, the material has a low resistance. If the display does not change, the material has a very high resistance that cannot be read by the meter.*
- d. Repeat for each of the remaining material samples.

3. Perform a hardness test:

- a. Using a steel nail, attempt to scratch the aluminum strip.
- b. Rate how difficult it was to scratch the material on a scale of 1-5 (1 being very easy to scratch, 5 being hard to scratch). Record your results in Data Table 2 in the Data Analysis section.
- c. Repeat the test for each of the remaining material samples.

4. Perform a stiffness test:

- a. Attempt to bend the aluminum strip. Rate the stiffness of the material on a scale of 1-5 (1 being very flexible, 5 being very stiff).
- b. Record your results in Data Table 2 in the Data Analysis section.
- c. Repeat for each of the remaining material samples.

Note to Students: *The stiffness test for the microscope slide should be carefully performed over a paper towel on the bench top. If the slide breaks, ask your instructor for assistance in cleaning up and disposing of the broken pieces.*

5. Perform a toughness test:

- a. Place the aluminum strip in a zipper bag and put it on the bench top. Using a hammer, gently hit the material.
- b. Carefully observe the material in the bag. Determine if the material is tough or brittle, and record your results in Data Table 2 in the Data Analysis section.
- c. If the material did not break, carefully remove it from the bag. If it did break, ask your instructor for assistance in cleaning up the broken pieces and obtain a new bag if needed.
- d. Repeat for each of the remaining material samples.

6. Based on your results, determine the material class (metal, polymer, ceramic, or composite) of each sample. Record your classification in Data Table 3 in the Data Analysis section.

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Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

Data Table 1: Initial Observations

Material	Observations
Aluminum	
Copper	
Tongue Depressor	
Playing Card	
Tile	
Microscope Slide	
Plastic chip	
Balloon	

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Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

Data Table 2: Physical Properties

Material	Conductance	Hardness	Stiffness	Toughness
Aluminum				
Copper				
Tongue Depressor				
Playing Card				
Tile				
Microscope Slide				
Plastic Chip				
Balloon				

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Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

Data Table 3: Classification of Material Samples

Material	Classification
Aluminum	
Copper	
Tongue Depressor	
Playing Card	
Tile	
Microscope Slide	
Plastic Chip	
Balloon	

Section 1 Identification

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**CHEMTREC 24 Hour Emergency
 Phone Number (800) 424-9300**
 For laboratory and industrial use only.
 Not for drug, food or household use.

Product	ALUMINUM METAL
Synonyms	Aluminum ; Aluminum Metal Strips

Section 2 Hazards identification

This substance or mixture has not been classified as hazardous according to the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals.

Signal word: Not classified
Pictograms: Not classified
Target organs: None known.

GHS Classification: Not classified
GHS Label information: Hazard statement(s): Not classified
Precautionary statement(s): Not classified

Supplementary information:

SHARP EDGES! USE CARE WHEN HANDLING.
 Do not inhale dust or fumes. Do not get in eyes, on skin, or on clothing. Wear protective gloves/protective clothing/eye protection/face protection. Wash hands thoroughly after handling. Get medical attention if you feel unwell.

Hazards not otherwise classified:

Health hazards not otherwise classified (HHNOC) - Combustible dust
 Physical hazards not otherwise classified (PHNOC) - Not Known

Section 3 Composition / information on ingredients

Chemical Name	CAS #	%	EINECS
Aluminum strips	7429-90-5	>99.5%	231-072-3

Section 4 First aid measures

INGESTION: Call physician or Poison Control Center immediately. Induce vomiting only if advised by appropriate medical personnel. Never give anything by mouth to an unconscious person.

INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

EYE CONTACT: Check for and remove contact lenses. Flush thoroughly with water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get immediate medical attention.

SKIN ABSORPTION: Remove contaminated clothing. Flush thoroughly with mild soap and water. If irritation occurs, get medical attention.

Section 5 Fire fighting measures

Suitable Extinguishing Media: Sand, dry chemical, or CO2 should be used on surrounding fire. Do NOT use water on fire where molten metal is present.

Protective Actions for Fire-fighters: In fire conditions, wear a NIOSH/MSHA-approved self-contained breathing apparatus and full protective gear.

Specific Hazards: During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Molten metals produce fume, vapor and/or dust that may be toxic and/or a respiratory irritant. Metal reacts with oxidizing agents. Reacts with some acids and caustic solutions to produce hydrogen. Molten aluminum may explode on contact with water. It may also react violently with rust, certain metal oxides (e.g. oxides of copper, iron and lead) and nitrates (e.g. ammonium nitrate and fertilizers containing ammonium nitrate).

Section 6 Accidental release measures

Personal Precautions: Evacuate personnel to safe area. Use proper personal protective equipment as indicated in Section 8. Provide adequate ventilation.

Environmental Precautions: Avoid runoff into storm sewers and ditches which lead to waterways.

Containment and Cleanup: Sweep or vacuum up and place in a suitable container for proper disposal. Wash spill area with soap and water.

Read label on container before using. Do not wear contact lenses when working with chemicals. Keep container tightly closed. Keep out of reach of children. Use with adequate ventilation. Wash thoroughly after handling.

Handling: Use with adequate ventilation. Avoid contact with eyes, skin and clothing. Avoid ingestion. Do not inhale fumes. Wash thoroughly after handling. Remove and wash clothing before reuse.

Storage: Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 Exposure controls / personal protection

Exposure Limits:	Chemical Name	ACGIH (TLV)	OSHA (PEL)	NIOSH (REL)
	Aluminum, metal and insoluble compounds	TWA: 1 mg/m ³ (A4) Respirable fraction	TWA: 5 mg/m ³ Respirable fraction	TWA: 5 mg/m ³ Respirable fraction

Engineering controls: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower and fire extinguishing material. Personnel should wear safety glasses, goggles, or faceshield, lab coat or apron, appropriate protective gloves. Use adequate ventilation to keep airborne concentrations low.

Respiratory protection: None should be needed in normal laboratory handling at room temperatures. If dusty conditions prevail, work in fume hood or wear a NIOSH/MSHA-approved respirator.

Section 9 Physical and chemical properties

Appearance: Solid. Silver-grey metallic strips. Odor: No odor. Odor threshold: Data not available. pH: Data not available. Melting / Freezing point: 660°C (1220°F) Boiling point: Data not available Flash point: Not applicable	Evaporation rate (= 1): Not applicable Flammability (solid/gas): Not applicable Explosion limits: Lower / Upper: Not applicable Vapor pressure (mm Hg): Data not available Vapor density (Air = 1): 0.95 - 0.113 lb/in ³ Relative density (Specific gravity): Data not available Solubility(ies): Insoluble	Partition coefficient: Data not available Auto-ignition temperature: Not applicable Decomposition temperature: Data not available. Viscosity: Data not available. Molecular formula: Al Molecular weight: 26.98
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Section 10 Stability and reactivity

Chemical stability: Stable **Hazardous polymerization:** Will not occur.

Conditions to avoid: Excessive temperatures and heat.

Incompatibilities with other materials: Strong oxidizers, mineral acids, strong alkalis, halogenated hydrocarbons, and water.

Hazardous decomposition products: Reacts with water (in molten form), acids or alkalis to generate hydrogen gas.

Section 11 Toxicological information

Acute toxicity: Data not available

Skin corrosion/irritation: Data not available

Serious eye damage/irritation: Data not available

Respiratory or skin sensitization: Data not available

Germ cell mutagenicity: Data not available

Carcinogenicity: Data not available

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Ca Prop 65: This product does not contain any chemicals known to the State of California to cause cancer or reproductive toxicity.

Reproductive toxicity: Data not available

STOT-single exposure: Data not available

STOT-repeated exposure: Data not available

Aspiration hazard: Data not available

Potential health effects:

Inhalation: Inhalation of dust or fumes may irritate respiratory system.

Ingestion: May be harmful if swallowed.

Skin: Sheets have sharp edges and may cause cuts or scratches. May cause irritation.

Eyes: Contact with eyes may cause irritation.

Signs and symptoms of exposure: It has been reported that chronic exposure has been suspected of causing lung injury. To the best of our knowledge, the chemical, physical and toxicological properties have not been thoroughly investigated. Specific data is not available. Exercise appropriate procedures to minimize potential hazards.

Additional information: RTECS #: BD0330000

Section 12 Ecological information

Toxicity to fish: Salmo trutta (Fish, Fresh water, marine) NOEC: >100 mg/l/96 hours

Toxicity to daphnia and other aquatic invertebrates: Daphnia magna (Crustacea) NOEC: >100 mg/l/48 hours

Toxicity to algae: Selenastrum capricornutum (Algae) NOEC: >100 mg/l/72 hours

Persistence and degradability: No data available

Bioaccumulative potential: No data available

Mobility in soil: No data available

PBT and vPvB assessment: No data available

Other adverse effects: An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Section 13 Disposal considerations

These disposal guidelines are intended for the disposal of catalog-size quantities only. Federal regulations may apply to empty container. State and/or local regulations may be different. Dispose of in accordance with all local, state and federal regulations or contract with a licensed chemical disposal agency.

Section 14 Transport information

UN/NA number: Not applicable

Shipping name: Not Regulated

Hazard class: Not applicable

Packing group: Not applicable

Reportable Quantity: No

Marine pollutant: No

Exceptions: Not applicable

2024 ERG Guide # Not applicable

Section 15 Regulatory information

A chemical is considered to be listed if the CAS number for the anhydrous form is on the Inventory list.

Component	TSCA	CERLCA (RQ)	RCRA code	DSL	NDSL	CA Prop 65
Aluminum	Listed	Not listed	Not listed	Listed	Not listed	This product does not contain any chemicals known to the State of California to cause cancer or reproductive toxicity.

Section 16 Other information

The information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use of these materials and the safety and health of employees. NTP: National Toxicology Program, IARC: International Agency for Research on Cancer, OSHA: Occupational Safety and Health Administration, STOT: Specific Target Organ Toxicity, SE: Single Exposure, RE: Repeated Exposure, ERG: Emergency Response Guidebook.

Section 1 Identification

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**CHEMTREC 24 Hour Emergency
Phone Number (800) 424-9300**
For laboratory and industrial use only.
Not for drug, food or household use.

Product	COPPER METAL
Synonyms	Copper Metal Strips / Copper Strip

Section 2 Hazards identification

This substance or mixture has not been classified as hazardous according to the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals.

Signal word: Not classified
Pictograms: Not classified
Target organs: Liver, Kidneys

GHS Classification: Not classified
GHS Label information: Hazard statement(s): Not classified
Precautionary statement(s): Not classified

Supplemental information:

SHARP EDGES! ABRASIVE TO SKIN. USE CARE WHEN HANDLING.
Do not breathe dust or fume. Do not get in eyes, on skin, or on clothing. Wear protective gloves/protective clothing/eye protection/face protection. Wash hands thoroughly after handling. Get medical attention if you feel unwell.

Hazards not otherwise classified:

Health hazards not otherwise classified (HHNOC) - Not Known
Physical hazards not otherwise classified (PHNOC) - Not Known

Section 3 Composition / information on ingredients

Chemical Name	CAS #	%	EINECS
Copper metal	7440-50-8	100%	231-159-6

Section 4 First aid measures

INGESTION: MAY BE HARMFUL IF SWALLOWED. Call physician or Poison Control Center immediately. Induce vomiting only if advised by appropriate medical personnel. Never give anything by mouth to an unconscious person.

INHALATION: HARMFUL IF INHALED AS FUME. Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

EYE CONTACT: MAY CAUSE IRRITATION. Check for and remove contact lenses. Flush thoroughly with water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get immediate medical attention.

SKIN ABSORPTION: MAY CAUSE IRRITATION. Remove contaminated clothing. Flush thoroughly with mild soap and water. If irritation occurs, get medical attention.

Section 5 Fire fighting measures

Suitable Extinguishing Media: Use triclass, dry chemical fire extinguisher. Do NOT use water on fire where molten metal is present.

Protective Actions for Fire-fighters: In fire conditions, wear a NIOSH/MSHA-approved self-contained breathing apparatus and full protective gear. Use water spray to keep fire-exposed containers cool.

Specific Hazards: During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Molten metals produce fume, vapor and/or dust that may be toxic and/or a respiratory irritant. Metal reacts with oxidizing agents.

Section 6 Accidental release measures

Personal Precautions: Evacuate personnel to safe area. Use proper personal protective equipment as indicated in Section 8. Provide adequate ventilation.

Environmental Precautions: Avoid runoff into storm sewers and ditches which lead to waterways.

Containment and Cleanup: Recover for reuse if not contaminated. Remove all sources of ignition. Sweep or vacuum up and place in a suitable container for proper disposal. Wash spill area with soap and water.

Read label on container before using. Do not wear contact lenses when working with chemicals. Keep container tightly closed. Keep out of reach of children. Use with adequate ventilation. Wash thoroughly after handling.

Handling: Use with adequate ventilation. Avoid contact with eyes, skin and clothing. Avoid ingestion. Do not inhale fumes from molten metals. Wash thoroughly after handling. Remove and wash clothing before reuse.

Storage: Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 Exposure controls / personal protection

Exposure Limits:	Chemical Name	ACGIH (TLV)	OSHA (PEL)	NIOSH (REL)
	Copper, dusts and mists, as Cu	TWA: 1 mg/m ³	TWA: 1 mg/m ³	TWA: 1 mg/m ³

Engineering controls: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower and fire extinguishing material. Personnel should wear safety glasses, goggles, or faceshield, lab coat or apron, appropriate protective gloves. Use adequate ventilation to keep airborne concentrations low.

Respiratory protection: None should be needed in normal laboratory handling at room temperatures. If dusty conditions prevail, work in fume hood or wear a NIOSH/MSHA-approved respirator.

Section 9 Physical and chemical properties

Appearance: Solid. Red-brown, lustrous metal. Turns green on exposure to moist air.

Odor: No odor.

Odor threshold: Data not available.

pH: Data not available.

Melting / Freezing point: 1083°C (1981°F)

Boiling point: 2595°C (4703°F)

Flash point: Not applicable

Evaporation rate (= 1): Not applicable

Flammability (solid/gas): Not applicable

Explosion limits: Lower / Upper: Not applicable

Vapor pressure (mm Hg): 1 mm @ 1628°C

Vapor density (Air = 1): Data not available

Relative density (Specific gravity): 8.92 @ 20°C

Solubility(ies): Insoluble

Partition coefficient: Data not available

Auto-ignition temperature: Not applicable

Decomposition temperature: Data not available.

Viscosity: Data not available.

Molecular formula: Cu

Molecular weight: 63.55

Section 10 Stability and reactivity

Chemical stability: Stable

Hazardous polymerization: Will not occur.

Conditions to avoid: Excessive temperatures and heat.

Incompatibilities with other materials: Strong oxidizers may cause a violent reaction.

Hazardous decomposition products: At temperatures above melting point, toxic fumes or vapors may be emitted.

Section 11 Toxicological information

Acute toxicity: Data not available

Skin corrosion/irritation: Data not available

Serious eye damage/irritation: Data not available

Respiratory or skin sensitization: Data not available

Germ cell mutagenicity: Data not available

Carcinogenicity: Data not available

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Ca Prop 65: This product does not contain any chemicals known to the State of California to cause cancer or reproductive toxicity.

Reproductive toxicity: Data not available

STOT-single exposure: Data not available

STOT-repeated exposure: Data not available

Aspiration hazard: Data not available

Potential health effects:

Inhalation: Inhalation of dust or fumes may irritate respiratory system. Symptoms include cough, headache, sore throat, shortness of breath.

Ingestion: May be harmful if swallowed. Symptoms include abdominal pain, nausea, vomiting.

Skin: May cause irritation and redness.

Eyes: Contact with eyes may cause redness and pain.

Signs and symptoms of exposure: Over-heating of alloy can produce metal fumes and oxides. Fumes of copper may cause metal fume fever with flu-like symptoms and skin and hair discolorization. Copper dust and fume cause irritation of the upper respiratory tract, metallic taste in the mouth, and nausea. Chronic poisoning results in Wilson's disease characterized by a hepatic cirrhosis, brain damage, demyelination, renal disease and copper deposition in the cornea.

Additional information: RTECS #: GL5325000

Section 12 Ecological information

Toxicity to fish: No data available

Toxicity to daphnia and other aquatic invertebrates: No data available

Toxicity to algae: No data available

Persistence and degradability: No data available

Bioaccumulative potential: No data available

Mobility in soil: No data available

PBT and vPvB assessment: No data available

Other adverse effects: An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Section 13 Disposal considerations

These disposal guidelines are intended for the disposal of catalog-size quantities only. Federal regulations may apply to empty container. State and/or local regulations may be different. Dispose of in accordance with all local, state and federal regulations or contract with a licensed chemical disposal agency.

Section 14 Transport information

UN/NA number: Not applicable

Shipping name: Not Regulated

Hazard class: Not applicable

Packing group: Not applicable

Reportable Quantity: No

Marine pollutant: No

Exceptions: Not applicable

2024 ERG Guide # Not applicable

Section 15 Regulatory information

A chemical is considered to be listed if the CAS number for the anhydrous form is on the Inventory list.

Component	TSCA	CERLCA (RQ)	RCRA code	DSL	NDSL	CA Prop 65
Copper	Listed	Not listed	Not listed	Listed	Not listed	This product does not contain any chemicals known to the State of California to cause cancer or reproductive toxicity.

Section 16 Other information

The information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use of these materials and the safety and health of employees. NTP: National Toxicology Program, IARC: International Agency for Research on Cancer, OSHA: Occupational Safety and Health Administration, STOT: Specific Target Organ Toxicity, SE: Single Exposure, RE: Repeated Exposure, ERG: Emergency Response Guidebook.