THE MARTIAN GARDEN

MMS-2 MARS REGOLITH SIMULANT
SAFETY DATA SHEET (SDS)
REVISED MARCH 2021

SECTION 1. IDENTIFICATION

1.1 Trade Name:	MMS-2 Enhanced Mars Regolith Simulant
1.2 Common Names:	Mars Regolith Simulant, Mars Simulant, Mojave Mars Simulant, Mars Dirt, Mars Soil, Enhanced Mars Simulant, Enhanced Mars Regolith Simulant
1.3 Reccomended Use:	Simulation of the physical, chemical, and aesthetic qualities of Mars regolith in educational and research settings
1.4 Manufacturer's Name:	The Martian Garden
1.5 Manufacturer's Contact Information:	The Martian Garden PO BOX 92528 AUSTIN, TX 78749 Website URL: https://www.themartiangarden.com Email Address: info@themartiangarden.com
1.6 Emergency Contact Information:	Not applicable

SECTION 2. HAZARD(S) IDENTIFICATION

2.1 Classification Overview:

MMS-2 Enhanced Mars Regolith Simulant is a reddish-brown, fine-grained powder based on Mojave Mars Simulant (Saddleback Basalt). Superfine MMS is mixed with Iron III Oxide (Fe_2O_3), Gypsum ($CaSO_4$ * 2 H_2O), Silica Sand (SiO_2), and Magnesium Oxide (MgO).

2.2 Signal Words(s):

Danger

2.3 Hazard Statement(s):

May cause respiratory irritation
May cause cancer (inhalation)
Causes damage to organs (lungs/respiratory system) through prolonged or repeated exposure (inhalation)

2.4 Symbol(s):

2.5 Precautionary Statements:

- If Inhaled: Remove person to fresh air and keep comfortable for breathing
- Call a POISON CENTER/doctor if you feel unwell
- If exposed or concerned: Get medical advice/attention
- Get medical advice and attention if you feel unwell
- Wash hands and forearms thoroughly after handling

- Do not eat, drink or smoke when using this product
- Obtain special instructions before use
- Do not handle until all safety precautions have been read and understood
- Wear eye protection, protective clothing, protective gloves
- Do not breathe dust
- Use only outdoors or in a well-ventilated area
- Store in a well-ventilated place. Keep container tightly closed
- Store locked up
- Dispose of contents/container according to local, regional, national, and international regulations

2.6 Other Hazards: No additional information

2.7 Mixture: Not applicable

2.8 Other Non-GHS Classifications:

SECTION 3. COMPOSITION / INFORMATION ON INGREDIENTS

Table 3.1 Compositional Information

Material	Weight %	GHS-US Hazard Classification
Basalt Powder	77.00%	CAS Number 12765-06-9 H350 H335 H372 P501
Iron III Oxide (Fe_2O_3)	10.00%	CAS Number 1309-37-1 P262 P280 P305 P351 P338 P501
Silica Sand (SiO_2)	8.00%	CAS Number 14808-60-7 H372 P260 P285 P501
Gypsum ($CaSO_4$ x 2 H_2O)	4.00%	CAS Number 13397-24-5 H373 H332 H312
Magnesium Oxide (MgO)	1.00%	CAS Number 1309-42-8 Not a hazardous substance/ HNOC/Not covered by GHS

SECTION 4. FIRST AID MEASURES

4.1 Necessary Measures:

4.1.1 Inhaled:	Shortness of breath, coughing, reduced pulmonary function. Prolonged inhalation of respirable silica may result in permanent lung damage, silicosis. No specific first aid is necessary since the adverse health effects associated with exposure to crystalline silica result from chronic exposures. If there is a gross inhalation of crystalline silica, remove the person immediately to fresh air, give artificial respiration as needed, seek medical attention as needed.
4.1.2 Swallowed:	May cause gastrointestinal discomfort. Give one or two glasses of water. Do not induce vomiting. If discomfort persists, see a physician.
4.1.3 Eye Contact:	Wash with water for at least fifteen (15) minutes. If irritation or redness persists see a physician
4.1.4 Skin Contact:	Skin Contact – Wash with soap and water. If irritation persists see a physician.
4.1.5 Ingestion:	No detrimental effects are expected if small amounts are ingested. Obtain medical attention if gastric discomfort occurs.

4.2 Symptoms / Effects:

4.2.1 Inhalation:

4.2.1.1 Silicosis: Respirable crystalline silica can cause chronic silicosis, a fibrosis (scarring) of the lungs. Silicosis may be progressive; it may lead to disability and death. Acute Silicosis can occur with exposures to very high concentrations of

respirable crystalline silica over a very short time period, sometimes as short as a few months. The symptoms of acute silicosis include progressive shortness of breath, fever, cough and weight loss. Acute silicosis is fatal.

4.2.1.2 Cancer: Crystalline silica inhaled from occupational sources in sufficient concentrations is classified as carcinogenic to humans. In its Ninth Annual Report on Carcinogens, the National Toxicology Program (NTP) listed crystalline silica as a known human carcinogen, based on sufficient evidence of carcinogenicity from studies in humans indicating a casual relationship between exposure to respirable crystalline silica and increased lung cancer rates in workers exposed to crystalline silica and determined that "crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1)."

4.2.1.3 Autoimmune diseases: There is evidence that exposure to respirable crystalline silica (without silicosis) or that the disease silicosis may be associated with the increased incidence of several autoimmune disorders, -- scleroderma, systematic lupus erythematosus, rheumatoid arthritis and diseases affecting the kidneys

4.2.1.4 Tuberculosis: Silicosis increases the risk of tuberculosis

4.2.1.5 Nephrotoxicity: There is evidence that exposure to respirable crystalline silica (without silicosis) or that the disease silicosis is associated with the increased incidence of kidney diseases, including end stage renal disease.

4.2.2 Eye Contact: Crystalline silica may cause abrasion of the cornea.

4.2.3 Skin Contact: May cause abrasion to skin.

4.2.4 Ingestion: No known health effect.

4.3 Acute Effects: One form of silicosis, Acute Silicosis, can occur with exposures to very high concentrations of respirable crystalline silica over a very short time period, sometimes as short as a few months. The symptoms of acute siliccosis include progressive shortness of breath, fever, cough and weight loss. Acute silicosis is fatal.

4.4 Chronic Effects: The adverse health effects -– lung disease, silicosis, cancer, autoimmune disease, tuberculosis, and nephrotoxicity -- are chronic effects.

4.5 Signs and Symptoms of Exposure: There are generally no signs or symptoms of exposure to crystalline silica . Often, chronic silicosis has no symptoms. The

symptoms of chronic silicosis, if present, are shortness of breath, wheezing, cough and sputum production. The symptoms of acute silicosis are the same as those associated with chronic silicosis; additionally, weight loss and fever may also occur. The symptoms of scleroderma include thickening and stiffness of the skin, particularly in the fingers, shortness of breath, difficulty swallowing and joint problems.

4.6 Medical Conditions Generally Aggravated by Exposure: The condition of individuals with lung disease (e.g., bronchitis, emphysema, chronic obstructive pulmonary disease) can be aggravated by exposure.

4.7 Seek immediate medical attention if symptoms persist

SECTION 5. FIRE FIGHTING MEASURES

5.1 Extinguishing Media:	Compatible with all media; use the medium appropriate to the surrounding fire.
5.2 Specific Hazards:	None.
5.3 Hazardous Combustion Products:	Carbon oxides or other toxic vapors. Thermal decomposition may release irritating gases and vapors.
5.4 Special Fire Fighting Procedures:	Wear self-contained breathing apparatus for firefighting if necessary.
5.5 NFPA Hazard Class:	Health: 1 Flammability: 0 Instability: 0

SECTION 6. ACCIDENTAL RELEASE MEASURES

6.1 Wear appropriate personal protective equipment as described in Section 8 of this document.

6.2 If uncontaminated, collect the material using a method which does not produce dust [High-Efficiency Particulate Air (HEPA) vacuum or thoroughly wetting down the material]. Place the silica in a covered container appropriate for disposal. If contaminated: a) use appropriate method for the nature of the contamination, b) consider possible toxic or fire hazards associated with the

contaminating substances. Dispose of the silica according to federal, state, and local regulations.

SECTION 7. HANDLING AND STORAGE

7.1 This product is not to be used for abrasive blasting. Do not breathe dust which may be created during the handling of this product. Do not rely on vision to determine whether respirable silica is present in the air, as it may be present without a visible cloud. Use good housekeeping procedures to prevent the accumulation of silica dust in the workplace. Avoid the creation of respirable dust.

7.2 Use adequate ventilation and dust collection equipment. Ensure that the dust collection system is adequate to reduce dust levels to below the appropriate occupational health limit. Maintain and use proper, clean respiratory equipment in accordance with the provisions of this Safety Data Sheet.

7.3 Store product in a cool, dry and ventilated area away from sources of heat. Safeguard from weather and prevent exposure to sustained moisture.

7.4 Do not eat, drink, smoke, or use personal products when handling product.

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Table 8.1 Exposure Limits (respirable fraction) in Air:

8.1.1 OSHA & MSHA – PEL:	5 mg/m^3	(8-Hour TWA)
8.1.2 ACGIH – TLV	0.05 mg/m^3	(8-Hour TWA)
8.1.3 NIOSH	0.05 mg/m^3	(10-Hour TWA)

8.1.4 Definitions:
Exposure Limits refer to the respirable fraction.
PEL means OSHA Permissible Exposure Limit.
TLV means American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value.
MSHA means Mine Safety and Health Administration Exposure Limit.
TWA means 8 hour Time Weighted Average.

8.2 **CAUTION:**
Silica is classified as hazardous under Occupational Safety and Health Administration (OSHA) regulations (29 CFR 1910.1200). The Permissible Exposure Limits (PEL) reported above are the pre-1989 limits that were reinstated by OSHA June 30, 1993 following a decision by the 11th Circuit Court of Appeals. There PELs are now being enforced by the Federal OSHA. Be aware that more restrictive exposure limits may be enforced by some states, agencies, or other authorities. Crystalline silica exists in several forms, the most common of which is quartz. If crystalline silica is heated to more than 870 C it can change to a form of crystalline silica known as trydimite, and if crystalline silica is heated to more than 1470 C, it can change to a form of crystalline silica known as cristobalite. Crystalline silica as trydimite and cristobalite are more fibrogenic than crystalline silica as quartz. The OSHA PEL for crystalline silica as trydimite and cristobalite is one-half the PEL for crystalline silica; the ACGIH TLV for crystalline silica as trydimite and cristobalite is one-half the TLV for crystalline silica as quartz.

8.3 Engineering Controls:

8.3.1 Ventilation: Use sufficient local exhaust to reduce the level of respirable crystalline silica to below the PEL. See ACGIH “Industrial Ventilation, A Manual of Recommended Practice” (latest edition).

8.4 Individual Protection Measures:

8.4.1 Gloves: Recommended in situations where abrasion from sand may occur.

8.4.2 Eye: Use safety glasses and protection as appropriate for the task at hand.

8.4.3 Other: Use protective clothing as appropriate for the work environment. Dusty clothing should be laundered before reuse. Make sure to always wash hands after handling the material.

8.4.4 Respiratory Protection: This product is not to be used for abrasive blasting. Consult with OSHA regulations and NIOSH recommendations to determine the appropriate respiratory protection during use of this product. Use only NIOSH-approved or MSHA-approved respiratory protection equipment. Avoid breathing dust produced during the use and handling of this product. If the workplace airborne crystalline silica concentration is unknown for a given task, conduct air monitoring to determine the appropriate level of respiratory protection. Consult with a certified industrial hygienist, your insurance risk manager, or the OSHA Consultative Services group for detailed information. Ensure appropriate respirators are worn during and following the task, including clean-up or whenever airborne dust is present, to insure ambient dust levels are below occupational health limits. Provisions should be made for a respiratory protection training program (see 29 CFR 1910.134 – Respiratory Protection for minimum program requirements).

Table 8.5 Respiratory Protection at Specified Concentration

Particulate Concentration	Minimum Respiratory Protection
10 X PEL or Less	Any particular respirator, except single-use or quarter-mask respirator. Any fume respirator or high efficiency particulate filter respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
50 X PEL or Less	A high efficiency particulate filter respirator with a full-face piece. Any supplied-air respirator with a full-face piece, helmet, or hood. Any self-contained breathing apparatus with a full-face piece.
500 X PEL or Less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode
Greater than 500 X PEL or Unknown Conditions	Self-contained breathing apparatus with a full-face piece operated in pressuredemand mode. A combination respirator which includes a Type C supplied-air respirator with a full-face piece operated in pressure- demand or other positive pressure continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Appearance:	Red/tan/pink granular solid
9.2 Odor:	None
9.3 Odor Threshold:	Not applicable
9.4 PH:	Not applicable
9.5 Melting Point:	5166 F
9.6 Freezing Point:	Not Applicable
9.7 Boiling Point:	6512 F
9.8 Flash Point:	None
9.9 Evaporation Rate:	None
9.10 Flammability:	None
9.11 Upper/Lower Explosive Limit:	Not Combustible
9.12 Vapor Pressure:	Not Applicable
9.13 Vapor Density:	10mm @ 3146 F
9.14 Relative Density:	2.12 g / cm^3
9.15 Solubility in Water:	Insoluble
9.16 Partition Coefficient:	Not Applicable
9.17 Auto-ignition Temperature:	None
9.18 Decomposition Temperature:	Not Applicable
9.19 Viscosity:	Not Applicable

SECTION 10. STABILITY AND REACTIVITY

10.1 Reactivity:	Not Applicable
10.2 Chemical Stability:	Stable
10.3 Hazardous Reaction:	Will Not Occur
10.4 Conditions to Avoid:	Incompatible Materials
10.5 Incompatible materials:	Strong oxidizing agents, strong acids, strong bases. Chloroformates, Peroxides.
10.6 Hazardous Decomposition Products:	Dissolves in Hydrofluoric acid producing a corrosive gas, silicon tetrafluoride.

SECTION 11. TOXICOLOGICAL INFORMATION

11.1 Routes of exposure: Inhalation, eye contact, skin contact

11.2 Inhalation:

11.2.1 Silicosis:
Respirable crystalline silica can cause chronic silicosis, a fibrosis (scarring) of the lungs. Silicosis may be progressive; it may lead to disability and death. Acute Silicosis can occur with exposures to very high concentrations of respirable crystalline silica over a very short time period, sometimes as short as a few months. The symptoms of acute silicosis include progressive shortness of breath, fever, cough and weight loss. Acute silicosis is fatal.

11.2.2 Cancer:
Crystalline silica inhaled from occupational sources in sufficient concentrations is classified as carcinogenic to humans. In its Ninth Annual Report on Carcinogens, the National Toxicology Program (NTP) listed crystalline silica as a known human carcinogen, based on sufficient evidence of carcinogenicity from studies in humans indicating a casual relationship between exposure to respirable crystalline silica and increased lung cancer rates in workers exposed to crystalline silica and determined that “crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1).”

11.2.3 Autoimmune Diseases:
There is evidence that exposure to respirable crystalline silica (without silicosis) or that the disease silicosis may be associated with the increased incidence of several autoimmune disorders, -- scleroderma, systematic lupus erythematosus, rheumatoid arthritis and diseases affecting the kidneys.

11.2.4 Tuberculosis:
Silicosis increases the risk of tuberculosis.

11.2.5 Nephrotoxicity:
There is evidence that exposure to respirable crystalline silica (without silicosis) or that the disease silicosis is associated with the increased incidence of kidney diseases, including end stage renal disease.

11.3 Eye Contact:
Material may cause abrasion of the cornea.

11.4 Skin Contact:
May cause abrasion to skin.

11.5 Ingestion:
No known health effect.

11.6 Effects:

11.6.1 Acute: One form of silicosis, Acute Silicosis, can occur with exposures to very high concentrations of respirable crystalline silica over a very short time period, sometimes as short as a few months. The symptoms of acute silicosis include progressive shortness of breath, fever, cough and weight loss. Acute silicosis is fatal

11.6.2 Chronic: The adverse health effects -– lung disease, silicosis, cancer, autoimmune disease, tuberculosis, and nephrotoxicity -- are chronic effects.

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particularly in the fingers, shortness of breath, difficulty swallowing and joint problems.
Numerical Measures of Toxicity:
Not applicable

11.7 NTP/IARC/OSHA:
11.7.1 Suspected Cancer Agent: Yes
11.7.2 Federal OSHA: No
11.7.3 NTP: Yes
11.7.4 IARC: Yes

11.7.5 NTP: Respirable crystalline silica has been listed in the Sixth Annual Report on Carcinogens

11.7.6 IARC: Monographs on the Evaluation of the Carcinogenic Risk of Chemical to Humans (vol. 68, 1997) concludes that there is sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the forms of quartz and cristobalite (Group 1) in certain industrial circumstances, but that carcinogenicity may be dependent on inherent characteristics of the crystalline silica or on external factors affecting is biological activity or distribution of its polymorphs.

11.8 Additional Information:

11.8.1 Long term inhalation exposure to iron (oxide fume or dust) can cause spider pneumoconiosis and does not normally cause significant physiologic impair having a mottled appearance. To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

SECTION 12. ECOLOGICAL INFORMATION

12.1 No components of MMS-2 are known to have adverse effects on ecology.

SECTION 13. DISPOSAL CONSIDERATIONS

13.1 Contact a licensed waste disposal service to dispose of this material. Always dispose of material in compliance with local, state, and federal regulations.

SECTION 14. TRANSPORT INFORMATION

14.1 MMS-2 (and its components) is not a hazardous material for purposes of transportation under the U. S. Department of Transportation Table of Hazardous Materials, 49 CFR §172.101.

SECTION 15. REGULATORY INFORMATION

15.1 Massachusetts Right To Know Components: Iron III Oxide, Crystalline Silica

15.2 Pennsylvania Right To Know Components: Iron III Oxide, Crystalline Silica

15.3 New Jersey Right To Know Components: Iron III Oxide, Crystalline Silica

15.4 California Prop 65 Components: Crystalline Silica

SECTION 16. ADDITIONAL INFORMATION

 The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. The Martian Garden shall not be held liable for any damage resulting from handling or contact with the above product.