

Team 19  
Reinforced Ceramic – Polymer 3D Printer  
**Operations Manual**



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## 1. Introduction

Team 19 has retrofitted a TAZ 4 3D printer to make it capable of both extruding and curing a ceramic-polymer composite reinforced with carbon nanotubes (CNT) or silicon carbide particles. Though much of the printer system remains the same, the customized components and additions require specific procedures for safe operation. Furthermore, significant information concerning the handling, maintenance, and basic information concerning the printer will be included for the best understanding of the system. The goal of this document is to provide the user with information specific to the modifications made to the TAZ 4 device by the team, as well as information pertaining to the safe mixing and use of the extrusion material. Information on printer subsystems may be paraphrased or quoted from manufacturer texts, these are included for the benefit of the reader, and should not be considered to be an exhaustive listing of safety or of technical details. The operator of any prototype devices assumes all risk of bodily injury or harm, and shall hold harmless all members of the project team, both individually and collectively.

## 2. Safety Information

Despite the best efforts of any designer, no equipment can be made entirely safe. Every time an operator uses a piece of equipment there is the chance of a health or safety impacting event. Part of any risk mitigation strategy is to ensure that operators understand the potential risks involved in the operation of a piece of equipment, so that they can protect and educate themselves. The project team has identified some of the risk factors that may be present while operating the device.

### 2.1 3D Printing Hazards

In its default configuration, any 3D printer poses a number of safety hazards to the user. The use of heated, motorized, and electrically active components means that caution should be exercised whenever using, modifying, or repairing the TAZ printer. General safety warnings from the manufacturer of the TAZ 4 printer are reprinted in Appendix A. No modifications performed by the project team should be assumed to reduce or eliminate any of the risks posed by use of the printer.

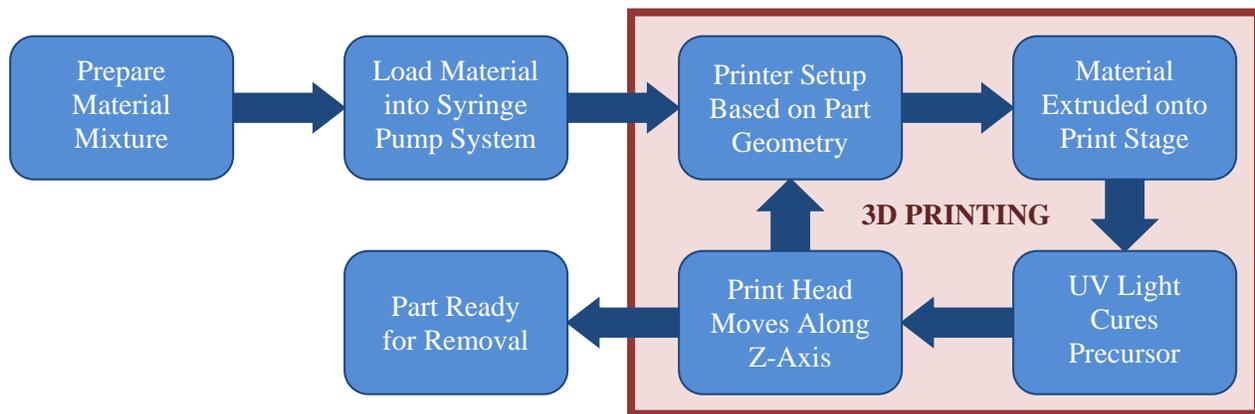
### 2.2 Carbon Nanotube Hazards

Carbon Nanotubes (CNT) are microscopic hollow structures comprised mostly of carbon that exist at the scale of a nanometer, or one billionth of a meter. The exact hazards posed by exposure to CNTs is currently under experimentation, with animal studies indicating "that as a precautionary default: all biopersistent CNTs, or aggregates of CNTs, of pathogenic fibre dimensions could be considered as presenting a potential fibrogenic and mesothelioma hazard unless demonstrated otherwise by appropriate tests..." [1]. Thus the proper handling and use of nanomaterials should be a priority in the operation of the prototype device. As no exact type of CNT is indicated for exclusive use with the printer, users should be

aware of the type of nanomaterial being used with the polymer precursor, as the risks inherent to each type will vary with the characteristics of the material. Points of consideration include: whether the CNT are single or multi-walled, the quantity to be used, the aspect ratio of the CNT, how tightly bound the CNT are to each other, and have they been functionalized or treated with any substance that can affect their health risk [2].

### 2.3 Ultraviolet Radiation Hazards

The printer device uses lamps that emit electromagnetic radiation in the ultraviolet (UV) spectrum. The lamps emissions are tuned to emit primarily light with a wavelength of 365nm. This wavelength is within the UV A band, which is considered to be among the least harmful types of UV radiation. However, precautions should be taken in the presence of any UV radiation source. Long-sleeved clothing should be worn, as well as eye protection in order to minimize exposure. Polycarbonate lenses and face shields will block 99% of UV radiation, and surface treatments and films can increase protection further. The American Conference of Governmental Industrial Hygienists has set Threshold Limit Values (TLV) for tolerable repeated exposure levels to UV radiation. For energy in the UVA band, the TLV is approximately 1000 mJ/cm<sup>2</sup> [3]. The UV lamps installed on the printer dissipate a nominal 36W of power; thus indicating that if one square centimeter of skin is exposed, the TLV could be exceeded in 0.028 seconds. This does not take into consideration the insulating effects of air, which could extend the safe exposure time limit.



### 3. Functional Analysis

Team 19's project scope is motivated by the desire to simplify an already existing subtractive manufacturing process that consumes a large portion of time and wastes large amounts of a costly material. In the functional diagram above one can see that the 3D printing process highlighted from the other steps. This printer's main functions are to extrude and cure a ceramic-polymer composite reinforced with CNTs and SiC powder. The material will be contained in a 60mL syringe, which is the the default size; this can be varied as desired as the pump is designed to mount multiple syringe types. Models to be printed must be

saved as STereoLithography (STL) files and uploaded into the Repetier-Host software to be sliced and translated into G-code. A stepper motor will control the syringe flow rate and extrude layers of the material in the shape of the desired model. Four nine-watt UV bulbs will cure the uppermost layer of material continuously throughout the printing process. Once the print job is complete, the model will be ready for pyrolysis.

## 4. Key Product Components

The printer device that the team has designed is a combination of modified subsystems designed to meet the goals of the sponsor. Because of the use of the novel print material and the challenges inherent in 3D printing, many of these components have either entirely bespoke designs or are repurposed commercially available devices adapted into the printer assembly. Below are detailed descriptions of key printer components.

### 4.1 Syringe Pump

The syringe pump module is illustrated in Figure 5-1. This module consists of a syringe mounted into a plastic housing, with the plunger affixed to a movable slider. By turning a length of threaded rod, the slider can apply pressure to the syringe, depositing the contents onto the print stage. This design incorporates a variable flow rate that is controlled by the speed of the stepper motor. Details on the individual parts of the pump are to follow.

#### 4.1.1 Syringe

Material will be contained in the syringe until it is slowly forced out by the syringe pump. 60 mL is the default syringe volume; however, the bracket was designed to accommodate other sizes as they are desired.

#### 4.1.2 Needle

A one inch, 400 micron needle attaches to the nozzle of the syringe for precision deposition of the material onto the print bed. This was determined to be the optimal gauge needle for this system after numerous tests involving viscosity, flow rate, and line dimensions.

#### 4.1.3 Motor and Gear Set

The gear set consists of a 10 tooth pinon gear attached to the shaft of the stepper motor and a 50 tooth gear attached to the

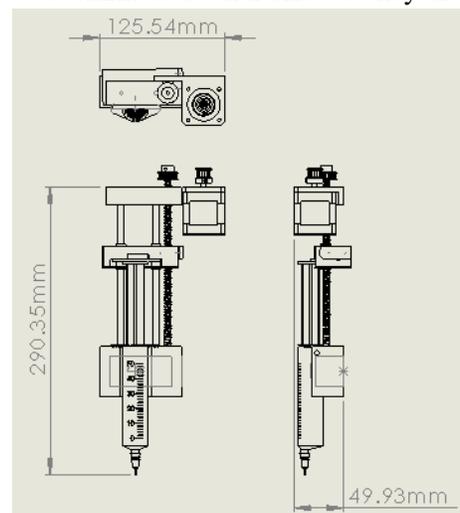


Figure 4-1 The syringe pump assembly with significant dimensions labelled.

threaded rod. This 5:1 gear ratio is used to turn the threaded rod resulting in a translational movement of the syringe's plunger insert. The gears are made from 3D printed ABS polymer, and can be considered self-lubricating.

## 4.2 TAZ 4 3D Printer

The team and the team sponsor decided to purchase a commercially available 3D printer to be retrofitted to fit the objective profile required. The TAZ 4 printer was selected after several rounds of analysis of market offerings. The most important selection criterion for the team was having open source availability for both hardware and software. The TAZ 4 includes a RAMBo (RepRap Arduino-compatible Mother Board) microcontroller to drive the stepper motors. The RAMBo is an open/libre hardware solution that allows the user to modify the firmware using the Arduino development environment. The TAZ is currently running using the Marlin firmware package, updated Q4 2014. Information on the proper use and maintenance of the TAZ printer can be found in the user manual published by Lulzbot [3].

## 4.3 Controller PC

The Taz 4 is able to be operated independently with the installed Smart LCD controller and display module. However, the team has acquired and installed a desktop computer in order to give finer control over the printer and for use in preparing and organizing model files. The PC is a Dell Optiplex 2500 with an Intel Core 2 Duo processor, 2GB of RAM, and 755 GB installed hard disk space. The printer is connected to the printer via a USB 2.0 B-type connector, which is standard for Arduino based printer platforms. The PC has Windows 7 Home Premium installed as the operating system, and a plurality of software required for 3D printing activities are developed for Windows as well as Mac OSX and Linux. Software installed by the team is listed in the table below.

*Table 4-1 Installed Software Used for 3D Printing*

Application	Purpose
Repetier Host	Printer controller. Allows the user to place 3D objects on the print platform, adjust printer settings, and manually control the printer
Slic3r	Slicing program. Converts STL file information to G-Code to dictate printer path and steps.
Amcap	Webcam software that allows for creation of time-lapse videos and remote monitoring.
Netfabb Basic	3D model viewer/editor. Repairs STL file meshes for use with the 3D printer.

## 4.4 UV Lamp Array

The print material as supplied by the manufacturer is a colorless liquid thermosetting polymer precursor. The precursor can be cured to its solid form via ultraviolet radiation in the presence of a suitable reagent called a UV sensitizer. To deliver the UV radiation, the project team has repurposed a commercial

nail dryer commonly used to cure resin based nail polish. The core of the product is four 9W UV fluorescent bulbs and the appropriate starters and electronic control components. The back panel features a main power switch, timer selector switch, and start button. To manually cure, the main power switch should be turned “ON”, the timer switch set to “OFF”, and the start button depressed and released. The timer switch has two other settings, for 120 and 180 seconds of illumination respectively. These settings may be useful for experimental purposes, but are of limited utility in the context of a 3d print job. The bulbs emit UVA radiation centered on a wavelength of 365nm. Additional details of the dryer including manufacturer information can be found in Appendix B, item B2.

#### 4.5 Infrared Thermometer

Sponsor requirements indicated a means to test and verify part temperature during the curing process. This will be achieved by using an infrared thermometer. The Etekcity Lasergrip thermometer allows the user to get temperature readings without the use of a contact probe. To use the Lasergrip, aim the sensor window at the part to be measured, and pull the trigger. A red laser indicator dot will appear to guide the user on what area is being measured. If the indicator dot does not appear, use of the “MODE” button will cycle between usage modes, including turning the built in back light on and off. Additional buttons will change the temperature display, from holding at last value, to constant updates, and the display units from Fahrenheit to Celsius. Additional technical details, such as measurement range and distance to spot ratio, can be found in Appendix B, item B3.

#### 4.6 Webcam

The project team has incorporated a webcam in order to remotely monitor the 3D printing process and to record images or videos for documentary purposes. The webcam is a Logitech C920 HD camera connected to the PC via a USB 2.0 connection. The camera is a plug and play device under Windows 7, and should not require drivers or other setup by the user. The webcam is attached to the lab countertop via a gooseneck camera mount. Using the mount it is possible to position the camera to tightly focus on the object of attention.

### 5. Product Assembly

The printer device will be delivered in an assembled state, and thus should not require further assembly unless changes have been made after project completion. This section will list the procedures, tools, and equipment relevant to different assembly operations.

#### 5.1 TAZ 4 Printer Assembly

The TAZ 4 is shipped as a semi-assembled unit by the manufacturer which the customer puts together 4 sub assemblies together and the 3D printer is ready for a printjob. The construction materials include 8020

Aluminum square rails, printed ABS components, acrylic corner brackets, and sheet steel electronics enclosures. The primary type of fasteners used are socket head cap screws with metric threads and sockets. The TAZ ships with a small tool set that includes an assortment of hex keys that can be used to adjust and take down the machine.

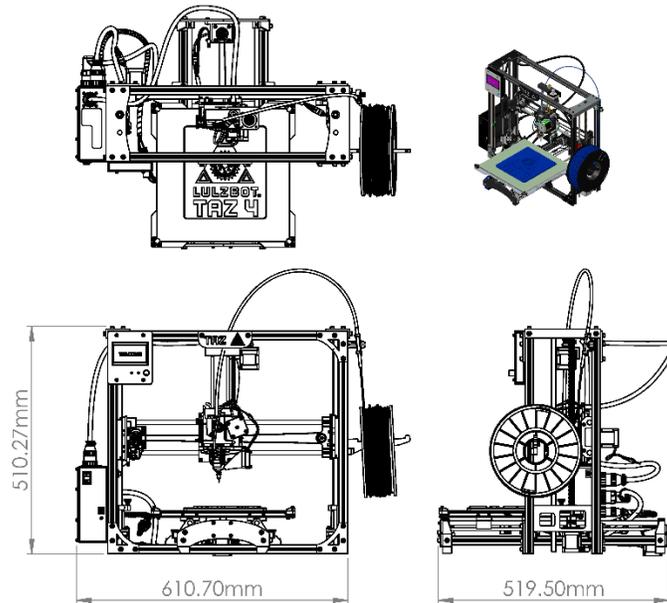


Figure 5-1 A model of the full 3D printer assembly with significant dimensions labeled.

## 5.2 Syringe Pump Assembly

The syringe pump assembly consists of printed ABS parts, stainless sheet steel, injection molded polymer components, and hardened steel smooth and threaded rods. The steel thrust rods are press fit into the receiving holes of the ABS rod guides, and the plastic components are secured to the sheet metal stiffener plate via Phillips drive cap headed self-tapping screws.

## 6. Operation Instructions

In order to print a model using the ceramic-polymer material, follow these instructions.

1. Verify that the syringe is filled with the material and properly fitted into the syringe pump bracket on the 3D printer. The needle should not be touching the printer bed.
2. Turn on the PC and 3D printer (using the switch on the power box) for operation.
3. Open Repetier-Host on the PC desktop and click “Connect” to connect to the printer.
4. Import the model into the program.
  - a. Alter the object placement using “Object Placement” tab as desired. Keep in mind how the object will be printed when doing so.

- b. If not already sliced, slice the model with Slic3r (using “Slic3r” tab).
5. Access “Manual Control” to ascertain all settings are properly set. This includes setting the printer bed temperature to 0° to ensure no heat is introduced to the system. When G-code is ready, send it to the 3D printer by clicking “Send”.
6. When ready to print, turn on the curing system array with the power supply switch. For added safety measures, UV protective goggles are provided and recommended for use. Once the array is on, click “Start Print”. If you will be using the webcam, this would be the time to turn it on. This can be done from the PC desktop.
7. From this point the printer will proceed to extrude and cure a 3D model using the material. If this is a large model, then it is highly recommended that the print process is observed and the user is ready to refill the syringe when it gets low. The print job must be paused by clicking “Pause Print”. If it becomes necessary to stop the print altogether due to a failure of the print job, click “Kill Print”.

In an emergency, cut all power to the printer by unplugging the power strip from the wall. If trying to print using the ABS filament, you must switch the brackets so that the proper extruder is attached. Be sure that the printer is turned off completely, with power unplugged, before doing so to prevent any damage or harm. Instructions for how to use the system with FDM can be found in the manual or online at <https://www.lulzbot.com/>. No notifications will be given when the print job is complete, nor will any notification be given if a print job goes wrong, whether the layers begin collapsing or the syringe runs out of material, the only way the user will be made aware of an issue is if they observe it themselves. A webcam has been set up with the PC for remote observation access to the printer from within the school so that the print job can be monitored.

## **7. Maintenance and Troubleshooting**

Timely maintenance is needed for keeping the modified version of the 3D printer operational and free of problems as much as possible. Section below gives detailed information about what needs to be done for a routine maintenance, replacement information and spare parts the team has for using the printer.

### **7.1 Routine Maintenance**

For optimal operation, it would be best to complete a number of actions with every use of the printer:

- Wipe the printer bed clean with a soft cloth or paper towel and acetone solution before and after each print job.
- Rinse out the syringe and dispose of the remaining solution and the needle properly.
- If using acetone, check the condition of the syringes after each use. Dispose of any syringes that show signs of chemical decomposition.

## 7.2 Key component replacement

Unique to 3D printers is their ability to print out their own components for construction of another printer or replacement of the original printer's parts; any ABS filament parts can be printed out using the original extruder head and the source files located on the Lulzbot website. Other components, such as the servo motors and rods, will need to be purchased.

## 7.3 Spare Parts Inventory

Spare parts list for extended operation and avoid operation interruption

*Table 7-1 Inventory Levels of Consumable Items*

<b>Part</b>	<b>Amount</b>	<b>Supplying Vendor</b>
20ml Syringe	36	Sigma Aldrich
22ga. ½" Length Dispensing Needles	55	CMT Supply
Polycarbonate UV safety glasses	8	Amazon
Luer-Lock Syringe Needles, Assorted Sizes	60	CMT Supply

## 8. Troubleshooting

It is possible that the user will encounter one or more errors while attempting to print ceramic parts. These errors may be related to environmental conditions, mistakes in the configuration and operation of the printer, or problems stemming from the material mixture composition. The table below details some problems users may face during operation, and the recommended course of action to resolve them.

*Table 8-1 Troubleshooting Guide for Potential Print Errors*

<b>Problem</b>	<b>Actions</b>
G-code not importing to printer	<ul style="list-style-type: none"> <li>• Make sure printer is on and available for input.</li> <li>• Check to see if the USB cord is connected from the computer to the printer.</li> <li>• Make sure model was sliced properly in Slic3r - look for any errors or anomalies in the G-code.</li> </ul>
Material is not extruding from syringe	<ul style="list-style-type: none"> <li>• Make sure the syringe is properly fitted within the syringe pump and that the syringe plunger is properly aligned within the syringe plunger insert.</li> <li>• There is potential for the syringe plunger to reach a "dead zone" at the 3mL mark. If material within the syringe is low, refill the syringe to capacity.</li> <li>• Clogs may occur within the needle. Be sure to use a clean syringe with every print job. Rinsing the syringe thoroughly before and after each use is a suggested preventative measure. If clogging does occur, replace the needle. If clogging continues to occur, replace syringe entirely.</li> </ul>
Base layers of model not supportive; melting, falling over, peeling up, etc.	<ul style="list-style-type: none"> <li>• If printing with ceramic-polymer composite, ensure the bed temperature is set to 0°C – heat is not required while printing with this material and may have undesired effects.</li> <li>• Check to see if power is being supplied to all 9W UV bulbs and that all bulbs are functional.</li> <li>• Alter object placement using "Object Placement" tab to place object in best printing position so largest, strongest layers are printed first.</li> <li>• Clean printer bed using an acetone solution to clean up any residue and dust.</li> </ul>

## 9. Digital Support Materials

In order to assist future users who may wish to repair, modify, or improve components of the printer device, the project team is including a disc containing all of the digital files used in the design and fabrication of the printer. The following table lists the subdirectories contained on the disc and a summary of their contents.

Folder Name	Primary File Type	Notes
Experiments	MS Excel Spreadsheets *.xlsx	Experimental results from material and syringe tests
Model	3D Models & GCode *.stl *.gcode	Production parts for the printer, novelties from the AME open house, and calibration test models
MSDS Files	Adobe Documents *.pdf	Safety documents to be on file during printer use
Pictures Videos	Still images and videos *.jpg *.m4v	Documentary video and images for recording project progress and events
POs	Adobe Documents *.pdf	Purchase request/order forms to acquire necessary project materials and components
Research Papers	Adobe Documents *.pdf	Research literature used for concept generation and support

## References

- [1] R. Drew and J. Frangos, "Engineered nanomaterials: a review of the toxicology and health hazards," Toxikos Pty Ltd., Canberra, 2009.
- [2] University of California Irvine, "Ultraviolet Lamp Safety Factsheet," [Online]. Available: <https://www.ehs.uci.edu/programs/radiation/UV%20Lamp%20Safety%20Factsheet.pdf>. [Accessed 29 March 2015].
- [3] Aleph Objects, "TAZ 4 User Manual," 4 April 2014. [Online]. Available: [http://download.lulzbot.com/TAZ/4.0/documentation/2014Q2/manual/TAZ\\_4\\_Manual.pdf](http://download.lulzbot.com/TAZ/4.0/documentation/2014Q2/manual/TAZ_4_Manual.pdf).
- [4] CSIRO, "Safe Handling and Use of Carbon Nanotubes," Safe Work Australia, Canberra.

## Appendix A. TAZ 4 Safety Warnings

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Aleph Objects, Inc. is the creator and copyright holder of the material and the original work can be found at:

[http://download.lulzbot.com/TAZ/4.0/documentation/2014Q2/manual/TAZ\\_4\\_Manual.pdf](http://download.lulzbot.com/TAZ/4.0/documentation/2014Q2/manual/TAZ_4_Manual.pdf)

## WARNING!

### Read Me First!

**READ THIS MANUAL COMPLETELY BEFORE UNPACKING AND POWERING UP YOUR PRINTER.**

## Hazards and Warnings

The TAZ 3D printer has motorized and heated parts. Always be aware of possible hazards when the printer is operational.

### Electric Shock Hazard

Never open the electronics case when the printer is powered on. Before removing the electronics case cover always power down the printer and completely turn off and unplug the power supply. Allow the power supply to discharge for at least one minute.

### Burn Hazard

Never touch the extruder nozzle or heater block without first turning off the hot end and allowing it to completely cool down. The hot end can take up to 20 minutes to completely cool. Never touch recently extruded plastic. The plastic can stick to your skin and cause burns. The heated bed can reach high temperatures that are capable of causing burns.

### Fire Hazard

Never place flammable materials or liquids on or near the printer when it is powered on or operational. Liquid acetone and vapors are extremely flammable.

### Pinch Hazard

When the printer is operational take care to never put your fingers in any moving parts including belts, pulleys, or gears. Tie back long hair or clothing that can get caught in the moving parts of the printer.

## HAZARDS AND WARNINGS

### Static Charge

Make sure to ground yourself before touching the printer, especially its electronics. Electrostatic discharge can damage electronic components. Ground yourself by touching a grounded source like the metal power supply housing or your computer case.

### Age Warning

For users under the age of 18, adult supervision is recommended. Beware of choking hazards around small children.

Appendix B. Subcomponent Specifications Sheets

B1 Logitech C920 HD Webcam

<b>General Product Information</b>	<a href="#">[Compliance Certification (CE) Link]</a>	
<b>Warranty / Self Help</b>	Please see product support page for warranty duration and frequently asked questions.	
<b>Category</b>	Webcam	
<b>Software Support (at release)</b>	Logitech Webcam Software Version: 2.4 NOTE: If software is available, check website for latest software release.	
<b>OS Support (at release)</b>	Windows XP x32 / x64, Windows Vista x32 / x64, Windows 7 x32 / x64	
	<b>Basic Requirement</b>	<b>HD Requirement</b>
<b>System Requirements</b>	CPU Minimum = 1.0 Ghz CPU Recommended = Core 2 Duo 2.4Ghz or better RAM Minimum = 256 RAM Recommended = 2GB	CPU Minimum = Core 2 Duo 2.4Ghz or better CPU Recommended = i7 Quad Core 2.6Ghz or better RAM Minimum = 2GB RAM Recommended =4GB
<b>General Product Information</b>	<a href="#">[Compliance Certification (CE) Link]</a>	
<b>Warranty / Self Help</b>	Please see product support page for warranty duration and frequently asked questions.	
<b>Category</b>	Webcam	
<b>Software Support (at release)</b>	Logitech Webcam Software Version: 2.4 NOTE: If software is available, check website for latest software release.	
<b>OS Support (at release)</b>	Windows XP x32 / x64, Windows Vista x32 / x64, Windows 7 x32 / x64	
	<b>Basic Requirement</b>	<b>HD Requirement</b>
<b>System Requirements</b>	CPU Minimum = 1.0 Ghz CPU Recommended = Core 2 Duo 2.4Ghz or better RAM Minimum = 256 RAM Recommended = 2GB	CPU Minimum = Core 2 Duo 2.4Ghz or better CPU Recommended = i7 Quad Core 2.6Ghz or better RAM Minimum = 2GB RAM Recommended =4GB

## Webcam Specifications

<b>Connection Type</b>	USB
<b>USB Protocol</b>	USB 2.0
<b>USB VID_PID</b>	082D
<b>UVC Support</b>	Yes
<b>Microphone</b>	Yes
<b>Microphone Type</b>	Stereo
<b>Lens and Sensor Type</b>	Glass
<b>Focus Type</b>	Auto
<b>Optical Resolution</b>	True:3MP Software Enhanced:15MP
<b>Diagonal Field of View (FOV)</b>	78°
<b>Focal Length</b>	3.67 mm
<b>Image Capture (16:9 W)</b>	2.0 MP, 3 MP*, 6 MP*, 15 MP*
<b>Video Capture (16:9 W)</b>	360p, 480p, 720p, 1080p
<b>Frame Rate (max)</b>	1080p@30fps
<b>Right Light</b>	RightLight 2
<b>Video Effects (VFX)</b>	N/A
<b>Buttons</b>	N/A
<b>Indicator Lights (LED)</b>	Yes
<b>Privacy Shade</b>	No
<b>Tripod Mounting Option</b>	Yes
<b>Cable Length</b>	6 feet

## Product Dimensions

Product component	Width	Depth/Length	Height	Weight
Webcam	94 mm	24 mm	29 mm	162g

B2 Melody Susie UV Nail Dryer

[http://www.melodysusie.com/products/product\\_detail/195](http://www.melodysusie.com/products/product_detail/195)

Melody Susie - Violeteer UV Nail Dryer –

Product Details: Color: black

- Auto timer control: 120s, 180s, up to infinite

- Material: Molded ABS

- 5\*9W 365nm UV Bulb

Package Includes:

- 1\* Melody Susie UV Nail Dryer (Black, 36W)

- 5\* 9W 365nm UV Bulb

- 1 \* Manual

Product Details

Product Dimensions: 9.4 x 8.3 x 3.9 inches; 2.2 pounds

Shipping Weight: 2.7 pounds (View shipping rates and policies)

### B3 Infrared Thermometer Specifications

Etekciti Lasergrip 774 (ETC 8380) Temperature Gun Non-contact Digital Laser Infrared IR Thermometer, 2-Year Warranty, -58~+716°F, 12:1 D:S, Instant-read, FDA/FCC/CE/ROHS Approved

Temperature Range: -50°C~380°C (-58°F~716°F)

Accuracy:  $\pm 2\%$  or 2°C

Distance Spot Ratio: 12:1

Emissivity Adjustable: 0.95(fixed)

Response Time and Wavelength: 500ms and (8-14) $\mu\text{m}$

Repeatability:  $\pm 1\%$  or  $\pm 1^\circ\text{C}$

Resolution: 0.1°C or 0.1°F

Storage Temperature: -20-50°C (-4-122°F)

Operating Temperature: 0-50°C (50-122°F)

NOTE: The measuring surface is about 2cm below the infrared aiming point. When the temperature is beyond measuring range, the LCD will display "HI" and "LO".

Package Included: 1 x Etekciti Non-Contact Infrared Thermometer 1 x 9-Volt Battery 1 x User's Manual



## Appendix C. Material Safety Data Sheets

## C1 Polymer Precursor



Revision Date: February 2, 2005

**KiON<sup>®</sup> Corporation**

1957-A Pioneer Road, Huntingdon Valley, Pennsylvania 19006

Phone: 1-215-957-6100

Fax: 1-215-957-6324

24-Hour Emergency Phone:

CHEMTREC (USA) 1-800-424-9300, (International) 1-703-527-3887

**MATERIAL SAFETY DATA SHEET****SECTION 1 Chemical Product Identification**NAME: **KiON<sup>®</sup> Ceraset<sup>®</sup> Polysilazane 20**

PRODUCT CODE: C-2001

**SECTION 2 Composition/Information on Ingredients**

## COMPOSITION:

CAS No:	503590-70-3
Chemical Name:	"Cyclosilazanes, methyl hydrogen, methyl vinyl"
Chemical Identity:	Polysilazane
Percent:	>99 %

**SECTION 3 Hazards Identification**

## HMIS RATINGS

Health hazard	3	Serious
Flammability hazard	3	Serious
Reactivity hazard	1	Slight

## POTENTIAL HEALTH EFFECTS:

Signs and Symptoms of Overexposure in the Workplace:

WARNING: Corrosive, Flammable liquid  
 May cause severe eye irritation or eye burns.  
 Causes skin burns with redness, pain and swelling.  
 May cause irritation of mucous membranes if vapor or mist is inhaled.

Medical Conditions Aggravated by Exposure: None known

Primary Routes of Exposure/Entry:

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Product Code: C-2001

Eye or skin contact; inhalation of dust. Ingestion unlikely.

Note: Contact of this product with moisture can produce ammonia, which can cause irritation of the eyes, skin, nose, throat, lungs, etc.

#### **SECTION 4 First-Aid Measures**

##### **EYE EXPOSURE:**

In case of contact with eyes immediately flush with copious amounts of water for at least 15 minutes. If irritation or redness persists seek medical treatment.

##### **DERMAL EXPOSURE:**

In case of contact with skin or clothing; remove contaminated clothing and wash skin thoroughly with soap and water. If irritation or redness persists seek medical treatment.

##### **INHALATION EXPOSURE:**

If inhaled, remove to fresh air. If breathing is difficult, give oxygen and seek immediate medical assistance. If not breathing give artificial respiration and seek immediate medical assistance.

##### **ORAL EXPOSURE:**

If swallowed do not induce vomiting. Seek immediate medical treatment.

#### **SECTION 5 Fire Fighting Measures**

##### **EXTINGUISHING MEDIA:**

Carbon dioxide, dry chemical powder or appropriate foam.

##### **SPECIAL FIREFIGHTING PROCEDURES:**

Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.  
Use water spray to cool fire-exposed containers.

##### **UNUSUAL FIRE AND EXPLOSIONS HAZARDS:**

Container explosion may occur under fire conditions.  
May emit toxic fumes under fire conditions.

#### **SECTION 6 Accidental Release Measures**

For small spills: Cover with an inorganic absorbent, like vermiculite, perlite, ground clay, or sand, sweep up, and dispose appropriately.

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Product Code: C-2001

For large spills: Dike to contain and pump into drums for use or disposal. If any material remains add inorganic absorbent (as above), sweep up, and dispose appropriately. Clean contaminated area with soap and water. In case of accidental spill or release, refer to Section 8, Personal Protective Equipment and General Hygiene Practices.

## **SECTION 7 Handling and Storage**

Flammable. Store in areas designated for flammable liquid storage (see NFPA requirements). Keep away from heat, sparks, and open flame. Keep tightly closed. Vent periodically to release head pressure.

## **SECTION 8 Exposure Controls/Personal Protection**

### **APPROPRIATE HYGIENIC PRACTICES:**

Avoid contact with eyes, skin, and clothing. Avoid breathing vapors, fumes and mists. Avoid prolonged or repeated exposure. Wash thoroughly after handling, and before eating, drinking, or smoking.

### **ENGINEERING CONTROLS:**

Engineering controls should always be used when available as a first choice over personal protective equipment. Provide adequate ventilation. Use of fume hoods or closed booths recommended when product is used in a manner that may generate mist or aerosol.

### **PERSONAL PROTECTIVE EQUIPMENT:**

Normal laboratory protective clothing recommended, i.e. lab coat and/or apron, impervious gloves and safety glasses. If mists or aerosols are generated during handling, and engineering controls are not present to prevent exposure, wear chemical safety goggles and a respirator equipped with an organic vapor cartridge.

### **WORK PRACTICES:**

Easily accessible eyewash fountains and safety showers recommended.

### **PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE:**

Completely isolate and thoroughly clean all equipment, piping or vessels with high flash non-polar solvents before beginning maintenance or repairs.

## **SECTION 9 Physical and Chemical Properties**

**APPEARANCE AND ODOR:** Liquid, clear to pale yellow. May detect slight odor of ammonia immediately after opening container.

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Product Code: C-2001

**PHYSICAL PROPERTIES:**

Boiling Point: Not applicable, material slowly cross-links to a solid upon heating.  
Flash Point: Not Determined (note: a similar material had a flash point of 29°C (84°F) closed cup)  
Specific Gravity: 1.0  
Viscosity: 184 cps at 19°C (67°F) nominal  
Refractive Index: Not Determined

**SECTION 10 Stability and Reactivity**

STABILITY: Stable

**INCOMPATIBILITIES:**

Reacts vigorously and exothermically with isocyanates. Material will react slowly with water and other protic solvents. This product may react with mineral acids, alkalies, and oxidizing agents. Caution should be taken when mixing this product with any of these materials.

**HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS:**

Carbon monoxide, Carbon dioxide, Silicon dioxide

HAZARDOUS POLYMERIZATION: Will not occur.

**SECTION 11 Toxicological Information****CARCINOGENICITY INFORMATION:**

Not listed as a carcinogen by NTP (National Toxicology Program]; not regulated as a carcinogen by OSHA (Occupational Safety and Health Administration); not evaluated by IARC (International Agency for Research on Cancer).

**REPORTED HUMAN EFFECTS:**

No human studies have been conducted with this material. The use of recommended protective equipment should prevent any adverse effects. The KION Corporation has not received any reports of adverse effects from workers handling this material.

**REPORTED ANIMAL EFFECTS:**

Oral LD50, rat: > 2,000 mg/kg.  
Skin irritation, rabbit: severe erythema with signs of necrosis after 1-hour exposure.

**SECTION 12 Ecological Information**

This material may be hazardous to aquatic organisms. Avoid release to surface waters and waste treatment systems.

KION CORPORATION  
Product Code: C-2001

MATERIAL SAFETY DATA SHEET - KION® Ceraset® Polysilazane 20

### SECTION 13 Disposal Considerations

Do not mix this product with aqueous or other protic wastes streams. Incineration of combustible waste material in a permitted facility in accordance with the local, state, and federal regulations is the recommended disposal method.

### SECTION 14 Transportation Information

US DOT: Corrosive liquid, flammable  
IATA: Corrosive liquid, flammable, n.o.s., (polysilazane), 8.3, UN2920, II

### SECTION 15 Regulatory Information

SARA 313: This product does not contain any chemicals subject to reporting under Section 313 of Title III of the Superfund Amendments and Reauthorization Act and 40CFR372.

CERCLA: This product does not contain any chemicals subject to reporting as a CERCLA Hazardous Substance under 40CFR302.4.

TSCA: This product is TSCA listed and Compliant under EPA Accession# P88-1778.

#### EU Labeling

C: Corrosive  
F: Flammable

#### EU Risk and Safety Phrases:

R10: Flammable  
R35: Causes severe skin burns.  
S16: Keep away from sources of ignition. No smoking.  
S23: Do not breathe gas/fumes/vapor/spray.  
S24/25/26: Avoid contact with skin and eyes. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.  
S28: After contact with skin, wash immediately with plenty of water.  
S37/39: Wear suitable gloves and eye/face protection.

### SECTION 16 Other 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. KION Corporation shall not be held liable for any damage resulting from handling or from contact with the above product.

C2 Acetone



Health	2
Fire	3
Reactivity	0
Personal Protection	H

## Material Safety Data Sheet Acetone MSDS

### Section 1: Chemical Product and Company Identification

<b>Product Name:</b> Acetone <b>Catalog Codes:</b> SLA3502, SLA1645, SLA3151, SLA3808 <b>CAS#:</b> 67-64-1 <b>RTECS:</b> AL3150000 <b>TSCA:</b> TSCA 8(b) inventory: Acetone <b>CI#:</b> Not applicable. <b>Synonym:</b> 2-propanone; Dimethyl Ketone; Dimethylformaldehyde; Pyroacetic Acid <b>Chemical Name:</b> Acetone <b>Chemical Formula:</b> C <sub>3</sub> H <sub>6</sub> O	<b>Contact Information:</b> <b>Sciencelab.com, Inc.</b> 14025 Smith Rd. Houston, Texas 77396 US Sales: <b>1-800-901-7247</b> International Sales: <b>1-281-441-4400</b> Order Online: <a href="http://ScienceLab.com">ScienceLab.com</a> <b>CHEMTREC (24HR Emergency Telephone), call:</b> 1-800-424-9300 <b>International CHEMTREC, call:</b> 1-703-527-3887 <b>For non-emergency assistance, call:</b> 1-281-441-4400
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### Section 2: Composition and Information on Ingredients

#### Composition:

Name	CAS #	% by Weight
Acetone	67-64-1	100

**Toxicological Data on Ingredients:** Acetone: ORAL (LD50): Acute: 5800 mg/kg [Rat]. 3000 mg/kg [Mouse]. 5340 mg/kg [Rabbit]. VAPOR (LC50): Acute: 50100 mg/m 8 hours [Rat]. 44000 mg/m 4 hours [Mouse].

### Section 3: Hazards Identification

#### Potential Acute Health Effects:

Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

#### Potential Chronic Health Effects:

CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Classified Reproductive system/toxin/female, Reproductive system/toxin/male [SUSPECTED]. The substance is toxic to central nervous system (CNS). The substance may be toxic to kidneys, the reproductive system, liver, skin. Repeated or prolonged exposure to the substance can produce target organs damage.

### Section 4: First Aid Measures

**Eye Contact:**

Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention.

**Skin Contact:**

In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

**Serious Skin Contact:**

Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

**Inhalation:**

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.

**Serious Inhalation:**

Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

**Ingestion:**

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

**Serious Ingestion:** Not available.

### Section 5: Fire and Explosion Data

**Flammability of the Product:** Flammable.

**Auto-Ignition Temperature:** 465°C (869°F)

**Flash Points:** CLOSED CUP: -20°C (-4°F). OPEN CUP: -9°C (15.8°F) (Cleveland).

**Flammable Limits:** LOWER: 2.6% UPPER: 12.8%

**Products of Combustion:** These products are carbon oxides (CO, CO<sub>2</sub>).

**Fire Hazards in Presence of Various Substances:** Highly flammable in presence of open flames and sparks, of heat.

**Explosion Hazards in Presence of Various Substances:**

Risks of explosion of the product in presence of mechanical impact: Not available. Slightly explosive in presence of open flames and sparks, of oxidizing materials, of acids.

**Fire Fighting Media and Instructions:**

Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog.

**Special Remarks on Fire Hazards:** Vapor may travel considerable distance to source of ignition and flash back.

**Special Remarks on Explosion Hazards:**

Forms explosive mixtures with hydrogen peroxide, acetic acid, nitric acid, nitric acid + sulfuric acid, chromic anhydride, chromyl chloride, nitrosyl chloride, hexachloromelamine, nitrosyl perchlorate, nitryl perchlorate, permonosulfuric acid, thiodiglycol + hydrogen peroxide, potassium ter-butoxide, sulfur dichloride, 1-methyl-1,3-butadiene, bromoform, carbon, air, chloroform, thitriazylperchlorate.

### Section 6: Accidental Release Measures

**Small Spill:**

Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

**Large Spill:**

Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

### Section 7: Handling and Storage

**Precautions:**

Keep locked up. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, reducing agents, acids, alkalis.

**Storage:**

Store in a segregated and approved area (flammables area). Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Keep away from direct sunlight and heat and avoid all possible sources of ignition (spark or flame).

### Section 8: Exposure Controls/Personal Protection

**Engineering Controls:**

Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

**Personal Protection:**

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

**Personal Protection in Case of a Large Spill:**

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

**Exposure Limits:**

TWA: 500 STEL: 750 (ppm) from ACGIH (TLV) [United States] TWA: 750 STEL: 1000 (ppm) from OSHA (PEL) [United States] TWA: 500 STEL: 1000 [Australia] TWA: 1185 STEL: 2375 (mg/m3) [Australia] TWA: 750 STEL: 1500 (ppm) [United Kingdom (UK)] TWA: 1810 STEL: 3620 (mg/m3) [United Kingdom (UK)] TWA: 1800 STEL: 2400 from OSHA (PEL) [United States] Consult local authorities for acceptable exposure limits.

### Section 9: Physical and Chemical Properties

**Physical state and appearance:** Liquid.

**Odor:** Fruity. Mint-like. Fragrant. Ethereal

**Taste:** Pungent, Sweetish

**Molecular Weight:** 58.08 g/mole

**Color:** Colorless. Clear

**pH (1% soln/water):** Not available.

**Boiling Point:** 56.2°C (133.2°F)

**Melting Point:** -95.35 (-139.6°F)

**Critical Temperature:** 235°C (455°F)

**Specific Gravity:** 0.79 (Water = 1)

**Vapor Pressure:** 24 kPa (@ 20°C)

**Vapor Density:** 2 (Air = 1)

**Volatility:** Not available.

**Odor Threshold:** 62 ppm

**Water/Oil Dist. Coeff.:** The product is more soluble in water;  $\log(\text{oil/water}) = -0.2$

**Ionicity (in Water):** Not available.

**Dispersion Properties:** See solubility in water.

**Solubility:** Easily soluble in cold water, hot water.

### Section 10: Stability and Reactivity Data

**Stability:** The product is stable.

**Instability Temperature:** Not available.

**Conditions of Instability:** Excess heat, ignition sources, exposure to moisture, air, or water, incompatible materials.

**Incompatibility with various substances:** Reactive with oxidizing agents, reducing agents, acids, alkalis.

**Corrosivity:** Non-corrosive in presence of glass.

**Special Remarks on Reactivity:** Not available.

**Special Remarks on Corrosivity:** Not available.

**Polymerization:** Will not occur.

### Section 11: Toxicological Information

**Routes of Entry:** Absorbed through skin. Dermal contact. Eye contact. Inhalation.

**Toxicity to Animals:**

WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE. Acute oral toxicity (LD50): 3000 mg/kg [Mouse]. Acute toxicity of the vapor (LC50): 44000 mg/m<sup>3</sup> 4 hours [Mouse].

**Chronic Effects on Humans:**

CARCINOGENIC EFFECTS: A4 (Not classifiable for human or animal.) by ACGIH. DEVELOPMENTAL TOXICITY: Classified Reproductive system/toxin/female, Reproductive system/toxin/male [SUSPECTED]. Causes damage to the following organs: central nervous system (CNS). May cause damage to the following organs: kidneys, the reproductive system, liver, skin.

**Other Toxic Effects on Humans:**

Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

**Special Remarks on Toxicity to Animals:** Not available.

**Special Remarks on Chronic Effects on Humans:**

May affect genetic material (mutagenicity) based on studies with yeast (*S. cerevisiae*), bacteria, and hamster fibroblast cells. May cause reproductive effects (fertility) based upon animal studies. May contain trace amounts of benzene and formaldehyde which may cause cancer and birth defects. Human: passes the placental barrier.

**Special Remarks on other Toxic Effects on Humans:**

Acute Potential Health Effects: Skin: May cause skin irritation. May be harmful if absorbed through the skin. Eyes: Causes eye irritation, characterized by a burning sensation, redness, tearing, inflammation, and possible corneal injury. Inhalation: Inhalation at high concentrations affects the sense organs, brain and causes respiratory tract irritation. It also may affect the Central Nervous System (behavior) characterized by dizziness, drowsiness, confusion, headache, muscle weakness, and possibly motor incoordination, speech abnormalities, narcotic effects and coma. Inhalation may also affect the gastrointestinal tract (nausea, vomiting). Ingestion: May cause irritation of the digestive (gastrointestinal) tract (nausea, vomiting). It may also

affect the Central Nervous System (behavior), characterized by depression, fatigue, excitement, stupor, coma, headache, altered sleep time, ataxia, tremors as well as the blood, liver, and urinary system (kidney, bladder, ureter) and endocrine system. May also have musculoskeletal effects. Chronic Potential Health Effects: Skin: May cause dermatitis. Eyes: Eye irritation.

### Section 12: Ecological Information

**Ecotoxicity:**

Ecotoxicity in water (LC50): 5540 mg/l 96 hours [Trout]. 8300 mg/l 96 hours [Bluegill]. 7500 mg/l 96 hours [Fathead Minnow]. 0.1 ppm any hours [Water flea].

**BOD5 and COD:** Not available.

**Products of Biodegradation:**

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

**Toxicity of the Products of Biodegradation:** The product itself and its products of degradation are not toxic.

**Special Remarks on the Products of Biodegradation:** Not available.

### Section 13: Disposal Considerations

**Waste Disposal:**

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

### Section 14: Transport Information

**DOT Classification:** CLASS 3: Flammable liquid.

**Identification:** : Acetone UNNA: 1090 PG: II

**Special Provisions for Transport:** Not available.

### Section 15: Other Regulatory Information

**Federal and State Regulations:**

California prop. 65: This product contains the following ingredients for which the State of California has found to cause reproductive harm (male) which would require a warning under the statute: Benzene California prop. 65: This product contains the following ingredients for which the State of California has found to cause birth defects which would require a warning under the statute: Benzene California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer which would require a warning under the statute: Benzene, Formaldehyde Connecticut hazardous material survey.: Acetone Illinois toxic substances disclosure to employee act: Acetone Illinois chemical safety act: Acetone New York release reporting list: Acetone Rhode Island RTK hazardous substances: Acetone Pennsylvania RTK: Acetone Florida: Acetone Minnesota: Acetone Massachusetts RTK: Acetone Massachusetts spill list: Acetone New Jersey: Acetone New Jersey spill list: Acetone Louisiana spill reporting: Acetone California List of Hazardous Substances (8 CCR 339): Acetone TSCA 8(b) inventory: Acetone TSCA 4(a) final test rules: Acetone TSCA 8(a) IUR: Acetone

**Other Regulations:**

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

**Other Classifications:**

**WHMIS (Canada):**

CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F). CLASS D-2B: Material causing other toxic effects (TOXIC).

**DSCL (EEC):**

R11- Highly flammable. R36- Irritating to eyes. S9- Keep container in a well-ventilated place. S16- Keep away from sources of ignition - No smoking. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

**HMIS (U.S.A.):**

**Health Hazard:** 2

**Fire Hazard:** 3

**Reactivity:** 0

**Personal Protection:** h

**National Fire Protection Association (U.S.A.):**

**Health:** 1

**Flammability:** 3

**Reactivity:** 0

**Specific hazard:**

**Protective Equipment:**

Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

### Section 16: Other Information

**References:**

-Material safety data sheet issued by: la Commission de la Santé et de la Sécurité du Travail du Québec. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. LOLI, RTECS, HSDB databases. Other MSDSs

**Other Special Considerations:** Not available.

**Created:** 10/10/2005 08:13 PM

**Last Updated:** 05/21/2013 12:00 PM

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## C3 Single Walled Carbon Nanotubes

**SIGMA-ALDRICH**[sigma-aldrich.com](http://sigma-aldrich.com)**SAFETY DATA SHEET**Version 5.4  
Revision Date 07/01/2014  
Print Date 03/29/2015**1. PRODUCT AND COMPANY IDENTIFICATION****1.1 Product identifiers**

Product name : Carbon nanotube, single-walled

Product Number : 704113  
Brand : Aldrich

CAS-No. : 308068-56-6

**1.2 Relevant identified uses of the substance or mixture and uses advised against**

Identified uses : Laboratory chemicals, Manufacture of substances

**1.3 Details of the supplier of the safety data sheet**

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832  
Fax : +1 800-325-5052

**1.4 Emergency telephone number**

Emergency Phone # : (314) 776-6555

**2. HAZARDS IDENTIFICATION****2.1 Classification of the substance or mixture**

**GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)**  
Eye irritation (Category 2A), H319  
Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335  
For the full text of the H-Statements mentioned in this Section, see Section 16.

**2.2 GHS Label elements, including precautionary statements**

Pictogram



Signal word

Warning

Hazard statement(s)

H319

Causes serious eye irritation.

H335

May cause respiratory irritation.

Precautionary statement(s)

P261

Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.

P264

Wash skin thoroughly after handling.

P271

Use only outdoors or in a well-ventilated area.

P280

Wear protective gloves/ eye protection/ face protection.

P304 + P340

IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.

P305 + P351 + P338

IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P312

Call a POISON CENTER or doctor/ physician if you feel unwell.

P337 + P313

If eye irritation persists: Get medical advice/ attention.

P403 + P233 Store in a well-ventilated place. Keep container tightly closed.  
 P405 Store locked up.  
 P501 Dispose of contents/ container to an approved waste disposal plant.

### 2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

## 3. COMPOSITION/INFORMATION ON INGREDIENTS

### 3.1 Substances

Synonyms : Carbon Nanotubes

CAS-No. : 308068-56-6

#### Hazardous components

Component	Classification	Concentration
<b>Carbon Nanotubes</b>		
	Eye Irrit. 2A; STOT SE 3; H319, H335	-

For the full text of the H-Statements mentioned in this Section, see Section 16.

## 4. FIRST AID MEASURES

### 4.1 Description of first aid measures

#### General advice

Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

#### If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

#### In case of skin contact

Wash off with soap and plenty of water. Consult a physician.

#### In case of eye contact

Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

#### If swallowed

Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

### 4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

### 4.3 Indication of any immediate medical attention and special treatment needed

no data available

## 5. FIREFIGHTING MEASURES

### 5.1 Extinguishing media

#### Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

### 5.2 Special hazards arising from the substance or mixture

Carbon oxides

### 5.3 Advice for firefighters

Wear self contained breathing apparatus for fire fighting if necessary.

### 5.4 Further information

no data available

## 6. ACCIDENTAL RELEASE MEASURES

### 6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

For personal protection see section 8.

**6.2 Environmental precautions**

Do not let product enter drains.

**6.3 Methods and materials for containment and cleaning up**

Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

**6.4 Reference to other sections**

For disposal see section 13.

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**7. HANDLING AND STORAGE**
**7.1 Precautions for safe handling**

Avoid contact with skin and eyes. Avoid formation of dust and aerosols. Provide appropriate exhaust ventilation at places where dust is formed. Normal measures for preventive fire protection. For precautions see section 2.2.

**7.2 Conditions for safe storage, including any incompatibilities**

Keep container tightly closed in a dry and well-ventilated place.

**7.3 Specific end use(s)**

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

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**8. EXPOSURE CONTROLS/PERSONAL PROTECTION**
**8.1 Control parameters****Components with workplace control parameters**

Contains no substances with occupational exposure limit values.

**8.2 Exposure controls****Appropriate engineering controls**

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

**Personal protective equipment****Eye/face protection**

Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

**Skin protection**

For any handling steps where the substance is in particulate form or in a suspension with pure water where the substance is not solubilized, the gloves must be comprised of material that successfully passes ASTM F-1671. For any handling steps where the substance is part of a carrier liquid, other than the aqueous suspension noted in the previous paragraph, gloves must be comprised of material that successfully passes ASTM F-739 (continuous liquid contact method). Gloves must be changed before they show degradation and before the designated breakthrough time for the carrier liquid (as determined by the ASTM F-739 testing or by the manufacturer).

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

**Body Protection**

Impervious clothing. The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

**Respiratory protection**

The EPA mandates the use of full face respirators with minimum N100 grade cartridges if there is any risk of exposure to carbon nanotube dust.

For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator. For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

**Control of environmental exposure**

Do not let product enter drains.

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**9. PHYSICAL AND CHEMICAL PROPERTIES**
**9.1 Information on basic physical and chemical properties**

a) Appearance	Form: solid
b) Odour	no data available
c) Odour Threshold	no data available
d) pH	no data available
e) Melting point/freezing point	3,652 - 3,697 °C (6,606 - 6,687 °F)
f) Initial boiling point and boiling range	no data available
g) Flash point	no data available
h) Evaporation rate	no data available
i) Flammability (solid, gas)	no data available
j) Upper/lower flammability or explosive limits	no data available
k) Vapour pressure	no data available
l) Vapour density	no data available
m) Relative density	no data available
n) Water solubility	insoluble
o) Partition coefficient: n-octanol/water	no data available
p) Auto-ignition temperature	no data available
q) Decomposition temperature	no data available
r) Viscosity	no data available
s) Explosive properties	no data available
t) Oxidizing properties	no data available

**9.2 Other safety information**

no data available

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**10. STABILITY AND REACTIVITY**
**10.1 Reactivity**

no data available

**10.2 Chemical stability**

Stable under recommended storage conditions.

**10.3 Possibility of hazardous reactions**

no data available

**10.4 Conditions to avoid**

no data available

**10.5 Incompatible materials**

Strong oxidizing agents

**10.6 Hazardous decomposition products**Other decomposition products - no data available  
In the event of fire: see section 5

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**11. TOXICOLOGICAL INFORMATION****11.1 Information on toxicological effects****Acute toxicity**

no data available

Inhalation: no data available

Dermal: no data available

no data available

**Skin corrosion/irritation**

no data available

**Serious eye damage/eye irritation**

no data available

**Respiratory or skin sensitisation**

no data available

**Germ cell mutagenicity**

no data available

**Carcinogenicity**

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.

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

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.

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.

**Reproductive toxicity**

no data available

no data available

**Specific target organ toxicity - single exposure**

Inhalation - May cause respiratory irritation.

**Specific target organ toxicity - repeated exposure**

no data available

**Aspiration hazard**

no data available

**Additional Information**

RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

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**12. ECOLOGICAL INFORMATION****12.1 Toxicity**

no data available

**12.2 Persistence and degradability**

no data available

**12.3 Bioaccumulative potential**

no data available

**12.4 Mobility in soil**  
no data available

**12.5 Results of PBT and vPvB assessment**  
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**  
no data available

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### 13. DISPOSAL CONSIDERATIONS

#### 13.1 Waste treatment methods

**Product**

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

**Contaminated packaging**

Dispose of as unused product.

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### 14. TRANSPORT INFORMATION

**DOT (US)**

Not dangerous goods

**IMDG**

Not dangerous goods

**IATA**

Not dangerous goods

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### 15. REGULATORY INFORMATION

**SARA 302 Components**

SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**SARA 311/312 Hazards**

Acute Health Hazard

**Massachusetts Right To Know Components**

No components are subject to the Massachusetts Right to Know Act.

**Pennsylvania Right To Know Components**

	CAS-No.	Revision Date
Carbon Nanotubes	308068-56-6	

**New Jersey Right To Know Components**

	CAS-No.	Revision Date
Carbon Nanotubes	308068-56-6	

**California Prop. 65 Components**

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

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### 16. OTHER INFORMATION

**Full text of H-Statements referred to under sections 2 and 3.**

Eye Irrit.	Eye irritation
H319	Causes serious eye irritation.
H335	May cause respiratory irritation.

STOT SE                    Specific target organ toxicity - single exposure

**HMS Rating**

Health hazard:                    2

Chronic Health Hazard:                    0

Flammability:                    0

Physical Hazard                    0

**NFPA Rating**

Health hazard:                    2

Fire Hazard:                    0

Reactivity Hazard:                    0

**Further information**

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**Preparation Information**

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