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LASER-CUTTING-SAFETY 3D PRINTING

Health and Safety in Metal Jewelry: Overview

gold plated jewelry | Spanish emerald and gold pendant (V+A) (Wikipedia)

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This article will discuss the health and safety hazards involved in metal jewelry, including silver soldering, soft soldering, lost wax casting, electroforming, electroplating, anodizing, surface design, and finishing.

These jewelry processes should not be done by children under the age of 12 years, and the children should not be in the area while jewelry is being made. Pregnant women should be aware of potential hazards to the fetus from many of the chemicals used in jewelry processes, and should avoid exposure to metal fumes and dusts in particular.

Soldering

Soldering utilizes hot molten metals to join metal parts. The metals are coated with a flux to prevent the buildup of metal oxides on the surface.
Soldering can be divided into hard soldering (silver or gold soldering) or brazing with a filler metal having a melting point in the range of 600°F to 1400°F, (316°C to 760°C); and soft soldering with a filler metal having a melting point below 600°F (316°C). The solder can be made of various combinations of metals creating filler materials with different melting points.

Silver Soldering

Silver solders are commonly used with gold and silver. The lowest melting silver or brazing solders typically contain the metal cadmium to lower the melting point of the solder, in addition to silver. Many manufacturers now produce low-melting silver solders that do not contain cadmium, and higher-melting silver solders (hard, medium, easy) do not contain cadmium. Fluxes used with silver soldering often contain fluorides (e.g. potassium bifluoride or fluoroborate). A torch is typically used with silver soldering.
Pickling is the process of removing flux and oxide from the surface of the gold or silver. The pickling solution is either a solution of sulfuric acid, or nitric acid in water or the commercially prepared Sparex (sodium bisulfate).

Hazards

1. High, airborne concentrations of metal fumes, including cadmium, can be expected with silver soldering. Cadmium-containing fumes are extremely toxic, and acute overexposure can cause chemical pneumonia and be fatal. Chronic exposure can cause lung tissue damage, kidney damage, lung cancer, and prostate cancer. Cadmium fume has poor warning properties and excessive exposure will occur before symptoms are noted.
2. The fumes of other metals found in silver solders, including antimony (a cadmium replacement) are also toxic.
3. Fluxes used in silver soldering can also create toxic fumes, especially fluoride-containing fluxes. Possible decomposition products are hydrogen fluoride gas and fluoride fumes. These materials are very toxic and highly irritating to the skin, eyes, and respiratory tract.

4. Pickling baths are corrosive because they are acidic. Concentrated acid solutions can cause severe burns to the skin or eyes. Gold or silver that has just been heated during the soldering process may cause splashes when put directly into a pickling bath. These acids can react violently with alkaline or basic compounds. Sparex is less hazardous since you are not working with concentrated acids, but the pickling bath is still acidic and can cause skin burns, especially when hot.
5. The sulfur oxide gases that can result from heating the pickling bath are respiratory irritants. Asthmatics may particularly be at risk.
6. Propane tanks, or other sources of liquefied gases for torches, are highly flammable and explosive.

Precautions

1. Eliminate the use of cadmium-based solders. Use higher melting silver solders, or the new lower melting cadmium-free silver solders.
2. Do not use fluoride-based fluxes. Use borax fluxes instead.
3. All soldering should be done with local exhaust ventilation (e.g. slot hood or window exhaust fan at work level 1-2 feet away).
4. If adequate local exhaust ventilation is not available, wear a respirator with a dusts, mists, and fumes filter that is approved by the National Institute for Occupational Safety and Health (NIOSH). Consult with your physician prior to wearing a respirator if you have heart or lung problems, including asthma.

5. When soldering, wear protective goggles with a shade number of at least 4 to protect against infrared radiation. They should be approved by the American National Standards Institute (ANSI). Full-face shields are also available to protect the face. Use leather protective gloves to handle hot metals.
6. Do not purchase concentrated pickling solutions which must then be diluted with water. To avoid concentrated acids, purchase pickling solutions in dilute form, or use Sparex. The pickling bath should also be vented to the outside. Keep the bath covered.
7. Wear gloves, ANSI-approved chemical splash goggles, and protective apron when using pickling baths.
8. If acid is splashed on skin, rinse with water; in case of contact with the eyes, rinse for 15 minutes. An eyewash fountain connected to the plumbing should be available.

9. If concentrated acids are used, always add the acid to the water when mixing, never the reverse. An emergency shower should be readily accessible in case of splashes of concentrated acid on the body.
10. Wet mop all work surfaces and floor to remove toxic dusts.
11. Keep a supply of sodium bicarbonate (baking soda) near the acid storage area in case of a spill or leak. Dilute acids can be safely neutralized with sodium bicarbonate. Once the bubbling stops, the acid has been neutralized. This should be done before pouring the waste pickling bath down the drain.

12. Take precautions against fire and explosion when handling liquefied gas cylinders. Chain them securely, away from other flammable materials and away from sources of ignition. Do not use near flammable materials. Follow the manufacturer's instructions.

Soft Soldering

Soft solders are sometimes used when making jewelry out of non-precious metals. Soft solder is commonly a mixture of 50/50 or 60/40 lead and tin, and is usually used with an electric soldering iron. Low-lead and leadless soft solders are now available. Some of these substitutes contain antimony. Soft solder fluxes typically consist of an acid type, zinc chloride, an alcohol rosin type, or an organic non-rosin base.

Hazards

1. Because of the low melting temperatures of soft solders and the low temperature of the soldering iron, soft soldering does not usually result in significant airborne concentrations of metal fumes unless a person is directly

breathing in the soldering plume that is created. However, lead dust collecting on work surfaces from settled soldering fumes can be a hazard due to the high toxicity of lead. Ingestion or inhalation of lead fumes and dust can cause neurological problems, anemia, kidney damage, reproductive system damage, miscarriages, and birth defects. Antimony is also highly toxic, but is considered less of a hazard than lead.

2. When fluxes are heated during the soldering operation, fumes and mist can be generated. Zinc chloride fumes have acidic properties and may cause chronic bronchitis. Zinc oxide fumes are also generated, and may cause metal fume fever if there is sufficient exposure.

3. The alcohol rosin type flux is flammable, and should not be stored near open flames. The fumes from the rosin and non-rosin based fluxes can also be irritating to the lungs and prolonged exposure may cause respiratory damage. Rosin fumes may also cause asthma.

Precautions

1. Use lead-free and antimony-free soft solders, and non-acid fluxes whenever possible.
2. Flammable alcohol or solvent-based fluxes should be stored away from heat or open flames.
3. All soldering should be done with local exhaust ventilation (e.g. slot hood or window exhaust fan at work level 1-2 feet away). If adequate local exhaust ventilation is not available, wear a NIOSH-approved respirator with a dusts, mists, and fumes filter.
4. Wear protective gloves, a protective apron, and chemical splash eye goggles when handling fluxes.
5. Wet mop work surfaces and floor to remove toxic dusts.
6. Do not eat, drink, or smoke in the studio. Wash hands carefully after work.

Lost Wax Casting

Lost wax casting is a process by which a model is made from wax and a mold is cast around it. A mold is typically a casting plaster that contains cristobalite and other additives. The casting process involves heating the mold in a container in an oven. After the mold has set, the wax model is heated and burned off, leaving only the cast. The metal is melted with a torch. Usually, centrifugal casters are used to pour the molten metal into the mold, rather than gravity pouring. Vacuum casting systems are also used. After the metal has cooled, the mold is removed from the jewelry.

Hazards

1. The materials used to make the plaster molds often contain cristobalite, a highly toxic form of free crystalline silica. Inhalation of crystalline silica can cause silicosis, a serious lung disease that results in scarring of lung tissue. Silicosis usually takes ten to twenty years of exposure to develop.
2. Burning wax can cause burns or a fire, and produces fumes from incomplete combustion. Some of these fumes are highly irritating to the respiratory tract.
3. Fumes of gold or silver are not known to be toxic, although silver fumes may cause a skin and internal organ discoloration called argyria. However, other metals alloyed with gold or silver may be toxic. Such metals include zinc, copper, nickel, or lead. Exposure to zinc fumes may cause metal fume fever. All airborne nickel compounds are regarded as carcinogenic by inhalation. Lead fumes are also highly toxic.

4. The containers used to heat molds may be insulated with asbestos. Heat-resistant gloves used for handling hot objects were also usually made out of asbestos. Some soldering and pounding boards have previously been formed out of asbestos-containing materials. In the last ten years, the use of asbestos in these materials has been discontinued. Asbestos can cause lung cancer, mesothelioma (cancer of the lining of the chest cavity), and asbestosis which results in scarring of the lung tissue. Cases of mesothelioma have been found in jewelers.

Precautions

1. Use metal alloys that do not contain lead or nickel.
2. Replace equipment that is insulated with asbestos, especially when the insulation is exposed or damaged. Damaged or exposed insulation and other products may release airborne asbestos fibers which can then be inhaled. Removal of asbestos should be done by a licensed asbestos contractor.

3. Use a nonsilica investment plaster when possible. If a silica-type material is used, mix the investment in a glove box. A glove box can be made by sealing the inside of a cardboard box with shellac, attaching a plexiglas, glass, or plastic film top, and cutting two holes in the sides for your arms. The powder is mixed into a paste or concentrated solution inside the glove box. Otherwise, wear a NIOSH-approved toxic dust respirator.

4. Clean up all debris immediately. Use wet cleaning methods to control any dusts, or use a vacuum cleaner with a

high efficiency (HEPA) filter. Do not sweep, since that can stir up dust.

5. When melting metals, especially if zinc is contained in the alloy, use a slot hood or window exhaust fan at work level 1-2 feet away.
6. Paraffin wax readily burns. Always store paraffin wax in a cool place away from all ignition sources.

7. Wear clothing and gloves that will protect against burns when handling molten metals. Protective goggles (shade number of at least 4) should protect against impact and infrared radiation, and should be ANSI-approved.
8. Wear a NIOSH-approved toxic dust respirator when removing the mold, or work inside a glove box.

Electroplating and Electroforming

Electroplating is a process whereby a light buildup of pure metal from an anode occurs on the surface of a metal object to be plated at the cathode. These two electrodes are powered by a low-voltage power supply. Electroforming is the same process but involves a heavy buildup of the metal and much higher voltages. Both these processes take place in a plating solution.

The plating solution contains an electrolyte consisting of a metal salt of the metal to be applied dissolved in water. The plating solution may also contain other salts, additives, and buffers. The common plating metals include copper, gold, nickel, silver, and their alloys. Copper plating can be done with copper sulfate and sulfuric acid as the electrolyte; many other plating metals, especially gold and silver, use cyanide salts as the electrolyte.

There are non-cyanide silver succinimide and gold sulfite electroplating solutions, but at present they have not been used much by artists. Prior to electroplating, the surface of the metal must be cleaned, often with caustic soda.

Hazards

1. Gold and silver cyanide solutions are extremely toxic by ingestion. If metal cyanide solutions come in contact with an acid, an extremely toxic and poisonous gas, hydrogen cyanide, is released. This also applies to many of the so-called "cyanide-free" substitutes which often contain cyanide complexes that also react with acid to release hydrogen cyanide gas.
2. The electroplating process can produce a mist which contains cyanide salts.
3. Gold salts used in electroplating can occasionally cause skin sensitization and result in allergic reactions.
4. The electrolyte usually used in copper plating is copper sulfate in sulfuric acid. Concentrated sulfuric acid is a corrosive material and can cause burns or irritation to the eyes, skin, or respiratory tract.
5. Electroplating and electroforming processes often use high electrical currents, and have the potential to cause electrical shocks when the electrodes are handled with one hand.

Precautions

1. Avoid cyanide electroplating or electroforming if at all possible by sending the piece out to be electroplated commercially. Only do plating with cyanide solutions if you are willing to take extreme precautions.
2. Electroplating and electroforming with cyanide plating solutions should only be done in a tested laboratory hood. Other types of electroplating also need local exhaust ventilation (e.g. slot hood, laboratory hood).

3. Electroplating involves the use of incompatible and reactive materials. Cyanide solutions are incompatible with acids. Cyanide solutions and acids must never be stored near each other. Find out what materials used in the shop are acids and separate these from the cyanide baths. Under no circumstances should the copper plating bath come in contact with the silver or gold baths.
4. Store acids in a separate cabinet of non-metal construction away from all other chemicals.
5. Wear protective gloves, goggles, and an apron when handling electroplating solutions and concentrated acids.
6. If an acid should come into contact with a cyanide bath, immediately evacuate the area and seek medical attention. Keep a cyanide antidote kit on site and take it to the hospital during an emergency.

7. For small concentrations of acid gases (but not hydrogen cyanide), a NIOSH-approved air-purifying respirator with the yellow acid gas cartridges can be worn.
8. The workspace should have an emergency eyewash and an available source of copious, clean tap water to wash chemicals from the skin. A shower is recommended.
9. Install a ground fault circuit interrupter. Make sure all electrical wiring is in good condition, and that all special equipment (rectifiers, masking tape for resists, etc.) is approved for the voltages and currents used.

10. Install your electroplating unit on a wooden or nonconducting surface, not on metal. Place a heavy rubber mat on the floor where you would stand. Do not use a metal chair. Wear rubber-soled shoes and insulating rubber gloves.
11. To avoid shock, do not touch electroplating bath, wires, or electrodes with bare hands while the current is on. Unplug the power supply before making or undoing connections, or making adjustments to the bath.
12. Spent cyanide solutions must not be poured down the sink. They should be stored in a plastic container until they are disposed of by a licensed hazardous waste company.

Anodizing

Anodizing involves the oxidation of metals such as titanium at the anode of an electrolytic bath, usually using trisodium phosphate as an electrolyte. Water is dissociated, producing hydrogen at the cathode and oxygen at the anode. The oxygen causes a controlled surface oxidation of the anode. Anodizing can be done in an anodic bath, or with anodic painting, where you paint on the anode metal using a paintbrush soldered to the cathode lead. The titanium must be cleaned before anodizing, often with hydrofluoric acid.

Hazards

1. Titanium is a combustible metal like magnesium. Titanium filings and dust will burn.
2. Trisodium phosphate is alkaline, and can cause skin, eye, and respiratory irritation.
3. Hydrofluoric acid is highly corrosive to the skin, eyes, and lungs. Serious deep burns can occur without pain warning several hours after exposure. The vapors may cause severe lung irritation, including chemical pneumonia. Ingestion can be fatal. Hydrofluoric acid can also cause chronic bone and tooth damage (osteofluorosis), and possibly kidney damage. Handling concentrated hydrofluoric acid is very dangerous due to the risk of splashes.
4. Anodizing, like electroplating, can involve large electrical currents which create the hazard of electrical shock.

Precautions

1. Wear insulating rubber gloves, goggles, and a protective apron.
2. Avoid hydrofluoric acid if possible. Instead, wet sand with a very fine grade of emery paper.
3. If you use hydrofluoric acid, do so only in a laboratory hood, or use an acid gas respirator with a full facepiece to protect both lungs and eyes. Wear natural or neoprene rubber gloves, a protective apron, face shield, and chemical splash goggles when handling concentrated hydrofluoric acid. In case of contact, flush exposed skin and eyes with water for at least 15 minutes. Immerse affected area in 0.13% iced solution of Zephiran chloride for 30-60 minutes. Call a physician immediately.
4. Leftover hydrofluoric acid should be handled as hazardous waste.
5. Keep a Class D fire extinguisher for potential titanium fires.
6. See the Electroplating section above for electrical precautions.

Surface Working, Polishing and Finishing

Metals are usually annealed by heating before hammering or chasing.
Finishing operations can include sandblasting, polishing, grinding, and application of patinas.
Hazards

1. Most metals are annealed before hammering or shaping using repoussé. This involves heating the metals to red hot temperatures, creating infrared radiation. Infrared radiation can damage the eyes. Burns are another potential safety hazard.
2. In repoussé or chasing, the metal is usually placed into a bowl of pitch before hammering or shaping. The pitch is then burned off using a torch. Pitch is a recognized skin carcinogen and contains hydrocarbons which are a fire hazard when heated with a torch.
3. The potential for pieces of metal becoming projectiles should be considered when cutting, hammering, or engraving.

4. Metal surfaces are cleaned by sandblasting or abrasive blasting. This involves using compressed air to project particles of sand or other materials at the metal and abrading the surface. Sand contains free crystalline silica and its use in sand blasting can cause silicosis within a few years of exposure.
5. When using a grinding wheel, there is always the potential for pieces of the metal or the wheel to be projected at the worker. Always maintain the guards on a grinding wheel.
6. Many polishing compounds contain free silica as a main ingredient or as a contaminant. Examples are tripoli

and, sometimes, rouge.

7. A variety of toxic chemicals can be used as patinas to color the metal. These can be applied hot or cold. In particular, applying patina chemicals to hot metals can result in the release of hazardous decomposition products (e.g. hydrogen cyanide from decomposition of potassium ferricyanide).

Precautions

1. Do not use sand for abrasive blasting. Instead, use glass beads, crushed walnut shells, alumina, or silicon carbide.
2. Abrasive blasting booths should be properly ventilated.
3. Grinding wheels should have eyeshields. For occasional grinding, wear a NIOSH-approved toxic dust respirator; for frequent grinding, equip the grinder with a dust collection system.

4. Use ANSI-approved safety goggles, or face shields plus safety goggles when grinding or working metal surfaces.
5. Do not wear ties, loose long sleeves, necklaces or other dangling jewelry, or anything which could get caught in the grinders or buffers. Keep long hair tied back or wear a hair net.
6. Use wet techniques whenever possible to minimize dust levels.

7. Wear gloves and goggles when preparing and using patinas. Highly toxic powders should be mixed in a glove box, with local exhaust ventilation, or while wearing a NIOSH-approved toxic dust respirator. Dip or brush on patinas rather than spraying them. Spraying should only be done in a spray booth.
8. Use local exhaust ventilation for applying patinas, especially hot, or when burning off pitch (e.g. slot hood or window exhaust fan at work level 1-2 feet away.)

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