Piranha solutions are strong oxidizers used to remove organic residues from substrates such as wafers in clean rooms. They are extremely corrosive, reactive, and can be explosive. At MIT, there have been several instances of bottles without vented caps containing piranha etch shattering due to a buildup of pressure from gasses generated during the reaction or from mixing with incompatible materials. The most commonly used solution at MIT is typically a 3:1 mixture of sulfuric acid and hydrogen peroxide. A second type of piranha etch is the base piranha: a 3:1 mixture of ammonium hydroxide with hydrogen peroxide. This mixture is not self-starting and must be heated to 60°C before the reaction begins.

Acid piranha is a self-starting reaction and is extremely exothermic. The solution becomes hot when the peroxide is added to the sulfuric acid. Skin or eye exposure to piranha can cause severe burns. The vapor is highly corrosive and can be destructive to mucosal membranes and lungs.

There are many things which can cause the reaction to accelerate out of control. “Out of control” can range from piranha foaming out of the beaker to an explosion with a shock wave and glass shard.

**Exposure Controls:**

**Engineering Controls:** All work involving piranha solutions must be done inside a fume hood or exhausted wet bench to prevent inhalation exposure. During use of piranha solutions, label the fume hood with a sign such as “Extremely Hazardous. Piranha solution in fume hood, highly corrosive and reactive.” Keep the fume hood sash between you and the solution. Do not store bottles containing organic materials (such as wash bottle with IPA) in the fume hood when working with Piranha.

**Personal Protective Equipment:** Wear proper laboratory gear for work with acids, including lab coat, pants, and closed-toe shoes. Use heavy duty neoprene gloves, neoprene apron, safety goggles, and a face shield. Do not use standard nitrile laboratory gloves: concentrated sulfuric acid can penetrate some types in 5 minutes.

**Handling Procedures:**

- Consult with your PI, laboratory supervisor and/or EHS Coordinator prior to initial use to discuss special hazards and precautions.
- Do not work with piranha solutions alone. Work within sight or hearing of at least one other person familiar with the hazards and procedures.
- Develop a written Standard Operating Procedure (SOP) for your procedure that includes safety precautions for each step of your lab activities. Work must be done in a designated area. For development of an SOP, refer to the template on the MIT EHS web site at: [https://ehs.mit.edu/site/chemical-safety/chemical-hygiene-program/plan-template](https://ehs.mit.edu/site/chemical-safety/chemical-hygiene-program/plan-template)
- Only use glass, Pyrex, or Teflon containers; piranha solutions are not compatible with plastics. Only use vented caps when spent solutions are first sealed.
- Mix/prepare small batches of fresh solutions for each application. Do not store solutions for reuse.
- When preparing acid piranha solution, always slowly add the peroxide to the acid.
- Add the peroxide immediately before etching, because it produces an immediate exothermic reaction with gas release.
- Handle glassware with extreme care as solutions may reach up to 50 - 100 °C.
After use, allow the solution to cool down in an open container inside the labeled fume hood for several hours or overnight. As a safety precaution, add roughly 3g of ferric chloride to every 2.4L of byproduct solution to neutralize the peroxides.

**To Prevent Potential Explosions:**

*Piranha solutions are very energetic and reactive:*

- Ensure that hydrogen peroxide concentration is always less than 50% (v/v) during any part of the process. H2O2 concentrations greater than 50% are potentially explosive.
- Never mix with incompatible materials such as other acids, gases, and organic materials such as acetone, isopropyl alcohol, photoresist, nylon, etc. during cleaning and during disposal.
- Ensure all substrates are cleaned and dried before placing them in piranha solution.
- Never use airtight containers.

**Waste Storage and Disposal:**

1. Transfer the spent solution to a compatible waste collection container (glass or Teflon bottle) with a vent cap provided by MIT EHS. Do not store waste solutions in an airtight container because explosions can occur from the buildup of gasses. Only use thoroughly cleaned glass or Teflon bottles to collect waste solutions to prevent mixing with incompatible chemicals.
2. Place this container in the lab's Satellite Accumulation Area (SAA) with a properly labeled red tag. Indicate “Piranha Solution” and spell out, in English, all chemical constituents within the bottle, including the ferric chloride if you choose to neutralize the peroxides prior to collection.
3. Leave the waste container with the vent cap in the SAA until the reaction has come to full completion, this may take several days.
4. Prior to requesting a waste pickup or bringing the waste container to the lab’s Main Accumulation Area (MAA), the lab may replace the vent cap with the original bottle cap or they may leave the vent cap on the bottle as an added safety precaution.

**Emergency Procedures:**

- Ensure that detailed emergency procedures are included in your SOP. Always keep acid neutralization materials at all locations where piranha is made or used.
- Eye/Skin Contact. Flush contamination from eyes/skin using the nearest emergency eyewash shower for a minimum of 15 minutes. Remove any contaminated clothing.
- If medical attention is required, call 100 from a campus phone or 617-253-1212 from a cell phone.
- When seeking medical attention, bring along a copy of this fact sheet and your SOP.
- Spills. Notify personnel in the area and your supervisor. Restrict access and eliminate all sources of ignition if safe to do so
  - Spills (<50 ml) may be absorbed with wet paper towels. Keep towels wet and collect for disposal.
  - Large spills: Immediately call to report a piranha solution spill that is health threatening. Evacuate laboratory and standby to provide information to emergency responders.

For questions or additional information, contact the MIT EHS Office at 617-452-3477 or environment@mit.edu.