

Aqua Regia SOP

Summary

- Aqua regia is commonly used to remove minor organic contaminants or metals.
- Solutions of aqua regia are very hazardous as they are extremely corrosive and oxidizing and may result in explosions or skin burns if not handled properly.
- Proper disposal must be used for solutions after use.

What is Aqua Regia?

Aqua regia is a solution that is traditionally comprised of a 3:1 mixture by volume of hydrochloric acid and nitric acid. It is commonly used to dissolve metals (including the noble metals gold and platinum) for analysis or to remove trace contamination. The solution is also used to wash glassware to remove trace organic compounds. When mixed, the acids react to form nitrosyl chloride and chlorine, resulting in a yellow, volatile solution. Any work with this chemical should follow proper guidelines as laid out in this SOP including proper hazard mitigation procedures.



What are the Hazards?

GHS classifies aqua regia as corrosive and oxidizing with target organ effects, and as harmful by ingestion. Aqua regia is extremely corrosive and may result in explosions or skin burns if not properly handled.



This solution can burn eye tissue or skin if exposed, destroy the mucous membrane and upper respiratory tract tissue if inhaled, and burn organs if ingested. In addition to health hazards, aqua regia can pose explosive risks when contacting organics, as it is a strong oxidizer. Dissolving of metals in this solution can also release toxic or flammable gases. Precautions should be taken when handling this chemical to avoid adverse health effects.

Occupational Exposure Limits and Symptoms of Exposure

The permissible exposure limit (PEL) to nitric acid as set by OSHA is 2 ppm or 5 mg/m³. The PEL for hydrochloric acid is 5 ppm or 7mg/m³. If exposed to these chemicals through the eyes there will be an intense burning and eye watering with rapid tissue destruction. Exposure through inhalation can cause burning, choking, coughing, wheezing, laryngitis, shortness of breath, headache, or nausea. Skin exposure can cause burning, itching, redness, inflammation, or swelling of the exposed area. The nitric acid in aqua regia typically causes characteristic yellowing of skin for mild contact exposures. Ingestion can cause severe and rapid burns of the mouth, gullet and gastrointestinal tract as well as choking, nausea, vomiting and severe pain.

What Activities Could Pose a Risk?

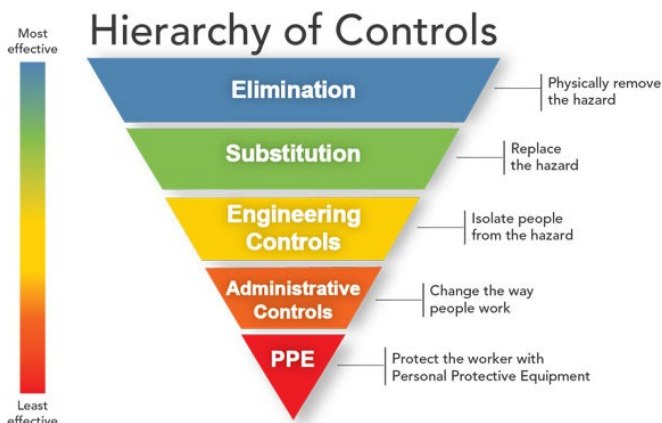
Aqua regia presents both health and physical hazards. The health effects explained above can occur through inhalation, dermal exposure, and ingestion. If not using proper engineering controls, inhalation is a likely route of exposure due to the fumes given off. When handling the acids it is important to adhere to the following procedures:

- Always use glass containers as plastics may melt and most metals will corrode/dissolve.
- Never prepare or manipulate while alone.
- If something needs to soak overnight, clearly label “Aqua Regia, Extremely Corrosive and Oxidizing!”
- **Always** add the nitric acid to hydrochloric acid **SLOWLY**.
- Work in an uncluttered hood with the sash between you and the solution.
- Do not add other acids or bases to aqua regia or spray with water.
- Leave hot aqua regia in an open container in the hood until it is cool
- Never store in a closed container without a venting cap.
- Do not store aqua regia as it quickly loses its effectiveness. Mix a fresh solution of the exact quantity you need every time.
- Aqua regia becomes hot when mixing. Avoid handling containers of freshly prepared reagent when possible. Use tongs or hot mits to handle containers when necessary.
- Always wear appropriate PPE when handling and preparing aqua regia. Eye protection, gloves and a lab coat are necessary.

How Can Exposures be Minimized?

As with any other hazardous material, always conduct a thorough risk assessment and employ the hierarchy of controls to minimize risk when working with aqua regia. Some specific applications of the hierarchy of controls to these hazards are listed below.

Always apply the controls in the order of most effective to least effective (see graphic), and apply as many controls as possible to reduce the risk to the lowest achievable level.



Elimination/Substitution

- Only use aqua regia when completely necessary. Simple cleaning with lab grade detergent and high purity water can often suffice for producing glassware clean enough for many applications.
- Use and produce only the smallest amount necessary for the experiment being conducted. Aqua regia must be prepared fresh for every use, so only the minimum amount should be made each time.

Engineering Controls

- ALWAYS work in a chemical fume hood when making, working with, and disposing of aqua regia.
- Proper sash height must be used to provide splash protection and proper ventilation throughout the experiment.
- Check that chemical fume hoods are operating at the proper face velocity before each use. Report any issues with fume hoods to the Solutions Center: <https://www.umass.edu/af-forms/physicalplant/service-request>.

Administrative Controls

- Before use:
 - Consult the manufacturer's Safety Data Sheet and additional chemical information at <https://cems.unh.edu/umass/CEMS/SearchSDS>
 - Locate nearest eyewash and shower and confirm that they are accessible and within 50 ft. of the work area.
 - Ensure all glassware is in good working order, do not use any cracked, chipped, or otherwise damaged equipment.

- Let aqua regia cool in the hood in an open container after use before disposal. Cool aqua regia will not be bubbling.
- Use pressure venting caps for waste containers. These can be requested through CEMS on the lab supplies form.

Personal Protective Equipment

- Always wear appropriate PPE when handling aqua regia solutions including:
 - Appropriate eye protection consisting of at least safety glasses. Chemical splash goggles and face shields should be used for quantities in excess of 100 mL.
 - Lab coat, long pants, closed toe shoes
 - Neoprene gloves worn over exam-style nitrile gloves

Waste Handling

Used aqua regia should be treated as hazardous and disposed of properly. Solutions should be allowed to cool and degas fully before disposal of waste. Waste should be stored until pickup in a glass bottle, appropriately labeled, with a pressure venting cap. Aqua regia should be disposed of alone with its own dedicated container; never put solution into a waste container with other materials, as a violent reaction could occur. The spent solution should still be considered an oxidizer, and therefore the waste should not be stored in the same secondary container as incompatible (e.g. organics, bases) waste. To have the waste picked up by EH&S staff, complete a Hazardous Materials Pickup Request form in CEMS.

Exposure and Spill Procedure

In the event of a spill involving aqua regia contained in a hood, it should be safe for lab personnel to clean up following the general procedure for small spills detailed in the University's Chemical Hygiene Plan. People nearby should be alerted to the spill. PPE should be worn while cleaning the spill. Use acid spill neutralizer such as sodium bicarbonate, collect residue using absorbent material, and label and dispose of as hazardous waste. For larger spills or spills outside the fume hood, the area should be evacuated (with the emergency exhaust/purge pushed if safe and present) and EH&S should be immediately called (413-545-2682). If you ever feel unsafe cleaning up a small spill, feel free to contact EH&S.

Exposures to hazardous materials should follow the general procedures for exposures outlined in the University's Chemical Hygiene Plan.

For a major exposure requiring the use of a drench shower or eye wash:

- Have someone call 911 (report the building name, room number, and street address) or 413- 545-3111 (or simply 5-3111 from a campus line) to report the incident and request medical help. If possible, communicate to the first responders the nature of the exposure.
- Help the affected individual to position their head over the eyewash and

activate it, or position them under the drench shower and activate it as appropriate.

- Always ensure your own safety before helping others. Only help if it is safe for you to do so.
- Wear gloves, safety glasses, and a lab coat.
- If using an eyewash: Instruct the affected individual to open their eyes and roll them around while the water is flowing. Help them to hold their eyes open if necessary and safe to do so.
- If using a drench shower: Remove all clothing from the affected area while under the shower.
- Flush the affected area for 15 minutes with water.

For minor exposures such as a spill to readily accessible extremities (e.g. hand)

- Flush the affected area in a sink equipped with potable water for at least 15 minutes.
- Go to University Health Services (UHS) for medical evaluation, and tell them you have had a lab exposure.
- Notify EH&S (413-545-2682) as soon as possible and complete the lab incident form (<https://ehs.umass.edu/lab-incidents-and-lab-incident-report-form>).

References and Additional Resources

1. Safety Data Sheet for Aqua regia from Purdue (<https://www.physics.purdue.edu/primelab/safety/MSDS/SDS/Aqua%20Regia.pdf>)
2. EH&S website from Princeton (<https://ehs.princeton.edu/laboratory-research/chemical-safety/chemical-specific-protocols/aqua-regia>)
3. Safety Data Sheets for hydrochloric acid and nitric acid available through CEMS (<https://cems.unh.edu/umass/CEMS/SearchSDS#searchform>)