Aqua Regia

Standard Operating Procedure

Revision Date: 05/11/2022

Laboratory Director (LD) Approval is Required Prior to Performing this Procedure

This standard operating procedure (SOP) outlines the handling and use of aqua regia. Review this document and supply the information required in order to make it specific to your laboratory. In accordance with this document, laboratories should use appropriate controls, personal protective equipment, and disposal techniques when handling aqua regia.

# Description [Provide additional information as it pertains to your research protocol]

Aqua regia is a highly corrosive mixture of hydrochloric and nitric acids. It can be used to clean glassware since it dissolves any metal and trace organic compounds. Aqua regia is also used to remove noble metals such as gold, platinum and palladium from substrates.

Aqua regia must be prepared and used in a fume hood. To prepare, combine three (3) parts of hydrochloric acid to one (1) part nitric acid in a glass container. The hydrochloric acid must be measured into the glassware first, and then the nitric acid is slowly added.

* Never exceed 38% nitric acid.
* Never use plastic or metal containers to prepare or use aqua regia.

## Process [Write the steps for using the chemical in your research protocol]

# Potential Hazards [Provide additional information as it pertains to your research protocol]

* **Inhalation of vapors or aerosols (mists, fumes) may cause lung edema; symptoms may be delayed up to 24 hours**
* Aqua regia has many potential physical and health hazards. A less hazardous solution/process should be used if possible.
* Aqua regia is an oxidizer. Oxidizers are agents that initiate or promote combustion in other materials, generally through the release of oxygen.
* Aqua regia will oxidize over time to form toxic gases (nitrosyl chloride, nitrogen dioxide, and chlorine).
* Aqua regia solution is very energetic, very likely to become hot (> 100C) and potentially explosive.
* Aqua regia solutions are extremely corrosive. Corrosive materials can cause destruction of living tissue by chemical action at the site of contact and can be solids, liquids, or gases. Corrosive effects can occur not only on the skin and eyes, but also in the respiratory tract and, in the case of ingestion, in the gastrointestinal tract as well.
* If aqua regia is not handled properly, an explosion, skin burns, or eye/respiratory tract irritation may result.

Concentrated nitric acid is considered to be a Particularly Hazardous Substance (PHS) due to its acute toxicity and reactivity. The MIOSHA 8-hour Permissible Exposure Limit (PEL-TWA) for nitric acid is 2 ppm and 4 ppm for a 15-minute short-term exposure limit (STEL).

The toxic gases formed as aqua regia oxidizes – nitrosyl chloride, nitrogen dioxide, and chlorine – are also PHSs. Nitrosyl Chloride does not have a PEL. Nitrogen dioxide has a STEL of 1 ppm. Chlorine gas has a PEL of 0.5 ppm and a STEL of 1.0 ppm.

Contact EHS for assistance in performing an exposure assessment.

# Engineering Controls [Provide additional information as it pertains to your research protocol]

An eyewash and safety shower must be available in the immediate work area for any work with aqua regia.

When working with aqua regia, always work in a clean fume hood that contains NO organic material and keep the sash down while reactions are in progress.

# Work Practice Controls [Provide additional information as it pertains to your research protocol]

* Do not use aqua regia while working alone.
* Set up a designated area for storage and work with aqua regia.
* Only prepare the amount you need for immediate use and follow the instructions for dilution and neutralization of unused solution.
* Work with the smallest practicable amount of aqua regia needed to perform your task.
* Never put aqua regia in a closed vessel; evolved gases will cause a pressure build-up and possible explosion.
* Never take aqua regia out of the fume hood.
* Once work with aqua regia is complete, wipe down the area with a soap and water solution.

When working with aqua regia you must have specific HazMat absorbent pads or pillows that can be used on nitric acid, and these must be available in the immediate work area. These absorbent pads will be needed for clean-up in case of a small spill inside of the fume hood.

# Personal Protective Equipment [Provide additional information as it pertains to your research protocol]

Goggles, lab coat, disposable nitrile gloves underneath chemical-resistant gloves (18 mil neoprene, Silver Shield, or any other glove rated to protect against hydrochloric AND nitric acid).

Face shield and acid-resistant apron are recommended if working with a larger volume (>200ml).

# Transportation and Storage [Provide additional information as it pertains to your research protocol]

* Never store aqua regia for later use; only make enough for immediate use.
* Never put aqua regia in an organic solvent cabinet; it is a strong oxidizer and incompatible with organic chemicals/solvents and any reducing agents.
* Never put a container of aqua regia near flammables or combustibles.
* Ensure primary and secondary containment is free from organic chemicals/solvents.

# Waste Disposal [Provide additional information as it pertains to your research protocol]

Disposal: Obtain piranha waste bottles and piranha venting caps from Environment, Health & Safety (EHS) Hazardous Materials Management (HMM) at 763-4568. Be sure the waste bottles and caps are present in the lab before you prepare any aqua regia. Prior to adding any waste to the bottle, place a completed hazardous waste label on it. Be sure to put the accumulation start date on the label when you begin adding waste.

Because most spent, unused, and expired chemicals/materials are considered hazardous wastes, they must be properly disposed of. **Do not dispose of chemical wastes by dumping them down a sink, flushing in a toilet or discarding in regular trash containers, unless authorized by EHS Hazardous Materials Management (HMM)**. Contact EHS-HMM at (734) 763-4568 for waste containers, labels, manifests, waste collection and for any questions regarding proper waste disposal. Also, refer to the EHS [Hazardous Waste](http://ehs.umich.edu/haz-waste/) Web page for more information.

# Spill Procedure [Provide additional information as it pertains to your research protocol]

If less than 200 ml of spent solution (no longer evolving gases) is spilled in the fume hood, lab personnel can soak up spill with absorbent/neutralizer for acid spills. Wipe contaminated area again with soap and water solution. Dispose of absorbent material in properly labeled container as solid hazardous waste.

**If reactive solution (still evolving gases) is spilled in the fume hood, close the sash, leave the lab and call the University of Michigan Division of Public Safety and Security (DPSS) at 911 to request assistance from EHS**. Do not take any action to cover the spill. Post a warning on the lab and do not allow others to enter. Have a person available that has knowledge of the incident and laboratory to assist emergency personnel.

**If any aqua regia solution is spilled OUTSIDE of the fume hood:**

* **Do not take any action to cover the spill**
* **Open the hood sash fully**
* **Attend to injured or contaminated persons and remove them from exposure**
* **Leave the lab, alerting others in the lab to evacuate**
* **Call University of Michigan Division of Public Safety and Security at 911 to request assistance from EHS**.
* **Post a warning on the lab and do not allow others to enter**
* **Have a person available that has knowledge of the incident and laboratory to assist emergency personnel**

For additional information regarding spill response procedures, refer to the EHS [Hazardous Waste Spill Response](http://ehs.umich.edu/hazardous-waste/spill-response/) Web page.

# Training of Personnel

All personnel shall read and fully adhere to this SOP when handling aqua regia.

# Certification

I have read and understand the above SOP. I have received approval from my Lab Director to perform this procedure. I agree to contact my Lab Director if I plan to modify this procedure.

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### Major Revisions (Tracking purposes only -- Do not print as part of SOP)

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| Date | Revision |
| 09-13-18 | EHS name and logo were added, updated the formatting, and revised the content under Exposure/Unintended Content (AKJ). |
| 03-04-19 | Updated web links |
| 05-15-20 | Updated editing rights to headings (RSH) |
| 03-21-22 | Reviewed and updated links (LGS) |
| 05-11-22 | Removed section on Exposures/Unintended Contact (LGS) |

**References**

National Center for Biotechnology Information (2022). PubChem Compound Summary for CID 90477010, Nitrohydrochloric acid. Retrieved April 12, 2022 from <https://pubchem.ncbi.nlm.nih.gov/compound/Nitrohydrochloric-acid>.