**University of Arizona**

***Aqua regia* Standard Operating Procedure**

*[This is a template. Fill in all necessary blanks and delete all highlighted areas when complete. Add any sections necessary for your laboratory. This will be appended to your Laboratory Chemical Hygiene Plan.]*

**Title:**  **Click here to enter the title of your SOP.**

**Approval Holder (AH):** Click here to enter text **Approval #:** Click here to enter text

**Approval Holder Phone Number(s):** Click here to enter text

**Approval Safety Coordinator (ASC):** Click here to enter text

**Approval Safety Coordinator Phone Number(s):** Click here to enter text

**Department:** Click here to enter text

1. **Purpose**

This standard operating procedure (SOP) is intended to provide guidance on how to safely store, use, and dispose of aqua regia in Enter AH’s name’s laboratory. Laboratory personnel should review this SOP, as well as the appropriate Safety Data Sheet(s) (SDSs), before Describe the procedure or process this SOP will address. If you have questions concerning the requirements within this SOP, contact your Approval Holder (AH) or Approval Safety Coordinator (ASC).

1. **Scope**

*[Describe when this SOP applies and to whom this SOP applies.]*

1. **Hazard Description**

*[Describe the hazards presented by the procedure or process this SOP addresses. What makes it hazardous? Provide an example, if applicable.]*



*Aqua Regia* (Latin for “royal water”) is an acidic, corrosive, and oxidative solution created from three parts hydrochloric acid (HCl) and one-part nitric acid (HNO3). It can dissolve many stubborn metals and is commonly used by for cleaning metal-contaminated items; it is particularly effective for gold (Au), platinum (Pt), and palladium (Pd). The creation of aqua regia can release toxic vapors and gases, namely chlorine and nitric oxide as per the reaction below:

HNO3 (aq) + 3HCl (aq) → NOCl (g) + 2H2O (l) + Cl2 (g)

Nitrosyl chloride (NOCl) decomposes over time, producing chlorine gas and nitric oxide (NO) that auto-oxidizes to nitrogen dioxide (NO2), a poisonous reddish-brown gas.

2NOCl (g) → 2NO (g) + Cl2 (g)

2NO (g) + O2 (g) → 2NO2(g)

These products of the reaction, chlorine (Cl2), nitric oxide (NO), and nitrogen dioxide (NO2), are extremely hazardous. The gas evolution will lead to pressure build-up and container rupture if the container is closed.

1. **Process & Hazard Controls**

*[Describe the steps needed to set up and complete the procedure or process in safe manner following the* [*hierarchy of controls*](https://www.cdc.gov/niosh/topics/hierarchy/default.html)*. Use as much detail as is necessary to ensure all laboratory workers can complete the procedure or experiment safely.]*

* 1. **Elimination/Substitution**

*[Describe any eliminations of hazardous chemicals or processes; alternatively, any substitutions with less hazardous alternatives that could be used to accomplish the task. Delete this section if you are unable to eliminate or substitute.]*

* 1. **Engineering Controls**

*[Describe any engineering controls (e.g. fume hoods, gas cabinets, local exhausts, blast shields, etc.) that are used to safely accomplish the task.]*

* Aqua regia must be made and used within a fume hood or with a local exhaust ventilation, such as a snorkel.
* Contact RLSS if processes require use outside of a fume hood.
  1. **Work Practices**

*[Describe any work practices (e.g. staggering schedules, additional cleaning measures for particulates, etc.) that are used to safely accomplish the task.]*

* Perform all work in a secondary container that is clean and free of organic matter.
  + NEVER add any organics to aqua regia solution, it could cause an explosion. Any chemical containing a C-H bond, e.g., acetone, isopropanol, ethanol, photoresist, detergents, is organic. Even small amounts of organics could make the aqua regia solution unstable.
* Make only small, fresh batches of aqua regia for each use.
* When preparing aqua regia, always add nitric acid to hydrochloric acid, never vice versa.
  1. **Personal Protective Equipment**

*[Describe the personal protective equipment needed to adequately protect laboratory workers when performing the process or procedure addressed by this SOP. Ensure to specify any personal protective equipment beyond the minimum (i.e. safety glasses, lab coat, gloves, long pants and closed-toed shoes).]*

* **Hand and Arm Protection**: Elbow-length, acid resistant gloves should always be used when creating, working with, or cleaning up aqua regia solutions.
* **Face and Eye Protection**: Safety goggles are a minimum protection; the use of a face shield with eye protection is strongly recommended to protect both the eyes and face from splashes.
* **Body Protection**: A 100% cotton lab coat should be used and can be combined with an acid resistant apron to prevent exposure to the body.
* **Respiratory Protection**: Respirators may be required if exposures are not able to be adequately controlled by the use of engineering controls or other means. All uses of respiratory protection require RLSS assessment and consultation (for assessment of work, selection of respirator and filtration, and OSHA-mandated medical clearance and fit testing). Contact [rlss-ppe@arizona.edu](mailto:rlss-ppe@arizona.edu) with any questions or concerns.
  1. **Transportation and Storage**

*[Describe how to safely transport and/or store (e.g. ventilated cabinet, flammable cabinet, under inert blanket, etc.) the hazardous chemical(s) or processes.]*

* **Storage:** 
  + Never store a stoppered bottle of aqua regia as the pressure build may cause an explosion.
  + Aqua regia should be made fresh before every use and excess amounts neutralized and/or disposed of shortly after use.
* **Disposal**:
  + If approved by Risk Management Services Hazardous Waste ([hazmat@arizona.edu](mailto:hazmat@arizona.edu)), you may pour excess and waste aqua regia into a large quantity of ice (500 grams of ice per 100 mL of aqua regia). Neutralize the mixture with an aqueous basic solution, such as 1M or 10% sodium hydroxide (NaOH) or saturated sodium bicarbonate (NaHCO3) in water until pH is neutral. The neutralized solution may then be collected in a waste bucket.
  + For all other solutions, collect in a 3.5-gal waste bucket and have picked up for disposal promptly. Do not tightly close the cap as pressure build up may cause an explosion.

1. **Spills, Cleanup & Disposal**

*[Describe how to safely end the procedure or process, clean up the process or spills, and/or dispose of any waste generated.]*

Spill response should always follow the [University Chemical Hygiene Plan](https://rgw.arizona.edu/sites/default/files/cs-univeristy_chemical_hygiene_plan.pdf) Section 8.2. Please find general guidance below:

* Minor spills in well-ventilated should be neutralized immediately with sodium bicarbonate or other acid neutralizer.
* Major spills or spills in poorly ventilated areas require evacuation of the laboratory; evacuate and call 911.

**Exposure Response**

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| --- | --- | --- | --- |
| **Inhalation** | **Ingestion** | **Skin Contact** | **Eye Contact** |
| May irritate the respiratory tract.  Conscious persons should be assisted to an area with fresh, uncontaminated air.  Seek medical attention in the event of respiratory irritation, cough, or tightness in the chest.  Symptoms may be delayed. | Rinse mouth. Do not induce vomiting. Seek medical attention immediately. | May cause skin burns.  Flush the skin with copious amounts of water for at least 15 minutes.  Seek medical attention immediately. | Aqua Regia is corrosive and irritating to the eyes.  Flush contaminated eye(s) immediately with copious quantities of water for at least 15 minutes.  Seek medical attention immediately. |

1. **Enter Additional Section Title**

*[Add as many sections as necessary to adequately describe how to safely perform the procedure or process addressed by this SOP.]*

1. **References**

* Periodic Videos: Aqua Regia Dissolves Gold. <http://www.periodicvideos.com/videos/mv_aqua_regia.htm> (accessed Oct 2019).
* Pitt, M. J. In Bretherick’s Handbook of Reactive Chemical Hazards 6th ed.; Urben, P. G. Ed.; Butterworth-Heinemann Ltd: Oxford, 1999; Vol. 2, pp 307-312.
* Princeton EHS: <https://ehs.princeton.edu/laboratory-research/chemical-safety/chemical-specific-protocols/aqua-regia>
* University of Illinois Aqua regia SOP: <https://drs.illinois.edu/Page/SafetyLibrary/AquaRegia>