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| **Lab-Specific Standard Operating Procedure (LSOP)- Aqua Regia Solution** | | | | | | | | | |
| Principal Investigator (PI)/Lab Manager: | | | | | | | | | |
| Building: | | | | | | Lab(s) Covered by LSOP: | | | |
| Department: | | | | | | Lab Phone Number(s): | | | |
| **Chemical** | | | **GHS Pictograms** | | **Definitions** | | | | |
| **Aqua Regia Solution** | | | A picture containing text, sign, clipart  Description automatically generated  *A picture containing text, clipart, sign  Description automatically generated* | | **Oxidizing liquid** means a liquid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.  **Serious eye damage** is the production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the anterior surface of the eye, which is not fully reversible within 21 days of application.  **Skin corrosion** is the production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis, following the application of a test substance for up to 4 hours. | | | | |
| **Hazard Awareness** | | | | | | | | | |
| Aqua regia solutions are primarily used to remove noble metals such as gold, platinum, and palladium from substrates, particularly in microfabrication and microelectronics labs. In some cases, it may be used to remove trace amounts of organic compounds from glassware. The traditional solution is composed of a 3:1 mixture of hydrochloric acid and nitric acid.  The reaction of hydrochloric acid and nitric acid leads to the formation of toxic nitrosyl chloride (NOCl) and chlorine gas (Cl2), resulting in a yellow, volatile solution. The nitrosyl chloride will continue to decompose over time to release additional chlorine gas and nitric oxide (NO). The NO will continue to react with oxygen to form nitrogen dioxide (NO2). The reaction is exothermic and the resulting heat can bring the solution to temperatures up to 100oC (212oF).  Aqua regia solutions are corrosive and may result in skin burns, serious eye damage, irritation or burns to the respiratory tract, or an explosion if not handled properly. The reaction products (i.e., nitrosyl chloride, chlorine gas, nitrogen oxide, and nitrogen dioxide) are toxic. Aqua regia solutions **must never be stored in sealed containers** as the pressure build-up could lead to explosions. | | | | | | | | | |
| **SECTION 1. ADMINISTRATIVE CONTROLS** | | | | | | | | | |
| 1.1 | Lab-specific safety training must be provided by the principal investigator (PI) or other qualified personnel to all researchers working with aqua regia solution. Documentation of training is required. | | | | | | | | |
| 1.2 | Read the **safety data sheet (SDS)** for each component of aqua regia solution prior to use. | | | | | | | | |
| 1.3 | Whenever possible, find safer substitutes or reduce the quantity of aqua regia solution being used. | | | | | | | | |
| 1.4 | Researchers must not work alone with aqua regia solution. | | | | | | | | |
| 1.5 | Lab personnel must not leave aqua regia solution unattended when hot. | | | | | | | | |
| 1.6 | Experiments should be performed during normal business hours (i.e., 8:00 am-5:00 pm Mon-Fri) if possible. | | | | | | | | |
| 1.7 | An eyewash and safety shower must be in the immediate work area where aqua regia solution is used. | | | | | | | | |
| 1.8 | **Add additional administrative controls specific to the laboratory.** | | | | | | | | |
| **SECTION 2. ENGINEERING CONTROLS** | | | | | | | | | |
| 2.1 | Perform all operations with aqua regia solution in a properly functioning chemical fume hood. | | | | | | | | |
| 2.2 | Chemical fume hoods must be running between 80-120 linear feet/minute and tested by EHS within the last year. If the hood is not working properly, contact Facilities (486-3113) to repair the hood or EHS to retest (486-3613). | | | | | | | | |
| 2.3 | **Add additional engineering controls specific to the laboratory.** | | | | | | | | |
| **SECTION 3. WORK PRACTICES** | | | | | | | | | |
| 3.1 | ALWAYS add the nitric acid to the hydrochloric acid slowly, never vice versa. | | | | | | | | |
| 3.2 | Always use glass containers (preferably Pyrex). Aqua regia solutions can melt plastic and corrode metal. | | | | | | | | |
| 3.3 | Never seal containers of aqua regia solutions. Use a vented cap. Airtight containers can build-up pressure, leading to container ruptures or explosions. | | | | | | | | |
| 3.4 | Prepare small amounts immediately prior to use. Do not maintain a stock supply. Aqua regia solution will quickly lose its effectiveness due to the oxidation of its reactive components. | | | | | | | | |
| 3.5 | Never use aqua regia solution for routine cleaning. | | | | | | | | |
| 3.6 | Label glass containers with the words “Aqua Regia Solution,” the chemical names, and the appropriate hazard classes. | | | | | | | | |
| 3.7 | Post a warning sign on or near the fume hood that states “Aqua Regia Solution- Corrosive, Oxidizer” to communicate the hazards to others working in the lab. The sign must also indicate the contact information of the person responsible for the aqua regia solution. | | | | | | | | |
| 3.8 | Do not store wash bottles containing organic compounds on the same work surface as the aqua regia solution. | | | | | | | | |
| 3.9 | Work with the fume hood sash lowered as much as possible. | | | | | | | | |
| 3.10 | Never remove hot aqua regia solution from the fume hood. | | | | | | | | |
| 3.11 | Do not add acids, bases, organic compounds (e.g., acetone, methanol, isopropanol) or other incompatible substances to prepared aqua regia solutions. Do not spray aqua regia solutions with water. | | | | | | | | |
| 3.12 | Never transport aqua regia solutions in beakers. | | | | | | | | |
| 3.13 | **Add additional work practices specific to the laboratory.** | | | | | | | | |
| **SECTION 4. PERSONAL PROTECTIVE EQUIPMENT** | | | | | | | | | |
| 4.1 | At a minimum, chemical splash goggles or safety glasses that meet *American National Standards Institute* (ANSI) standard Z-87.1 must be worn when handling aqua regia solution. | | | | | | | | |
| 4.2 | Gloves indicated in the safety data sheet (SDS) for the specific concentrations of nitric acid and hydrochloric acid must be worn while handling aqua regia solution. | | | | | | | | |
| 4.3 | A lab coat must be worn when working with aqua regia solution. Lab coats must be buttoned and fit properly to cover as much skin as possible. | | | | | | | | |
| 4.4 | Long pants or attire that cover the entire leg must be worn while using aqua regia solution. Shorts, skirts, or other clothing that expose the skin of the legs is not allowed. | | | | | | | | |
| 4.5 | Closed-toed footwear, which covers the entire foot, must be worn when working with aqua regia solution. | | | | | | | | |
| 4.6 | An acid-resistant apron, gloves with extended cuffs, and/or face shields are required when splashing is more likely or when required by the PI/Lab Manager. | | | | | | | | |
| 4.7 | **Add additional personal protective equipment requirements specific to the laboratory.** | | | | | | | | |
| **SECTION 5. STORAGE** | | | | | | | | | |
| 5.1 | **DO NOT STORE AQUA REGIA SOLUTIONS IN CLOSED CONTAINERS!** Nitrosyl chloride, nitrogen oxides, and chlorine gases released from self-decomposition can cause the container to over-pressurize and explode. | | | | | | | | |
| 5.2 | Once cooled, store aqua regia solution in a glass container with a vented cap provided by EHS in a chemical fume hood. | | | | | | | | |
| 5.3 | **Add additional lines for storage requirements specific to the laboratory.** | | | | | | | | |
| **SECTION 6. SPILLS AND ACCIDENTS PROCEDURES** | | | | | | | | | |
| 6.1 | Evacuate the laboratory. | | | | | | | | |
| 6.2 | Close door(s) to lab and post a “**NO ENTRY**” sign(s) or other warning information on the door. | | | | | | | | |
| 6.3 | Call **911**. | | | | | | | | |
| 6.4 | Do not re-enter area until instructed to do so by UCFD or other emergency personnel. | | | | | | | | |
| 6.5 | Report accident to PI/Supervisor and EHS. | | | | | | | | |
| **SECTION 7. FIRST AID PROCEDURES** | | | | | | | | | |
| First Aid- Eyes | | | 1. Immediately move to the eyewash station, hold eyelids open and flush with water. Remove contact lenses while flushing (if applicable). 2. Have another person from the lab dial **911**. 3. Continue flushing the eyes until emergency personnel arrives. 4. Report the incident to the PI/Supervisor and EHS. | | | | | | |
| First Aid- Skin | | | 1. Immediately move to safety shower or other water source and begin rinsing affected area(s). 2. Remove contaminated clothing (if applicable) while flushing. Do not pull contaminated clothing over the head. 3. Have another person from the lab dial **911**. 4. Keep rinsing the affected area until emergency personnel arrive. 5. Report the incident to the PI/Supervisor and EHS. | | | | | | |
| First Aid- Inhalation | | | 1. Move to fresh air. 2. Dial **911.** 3. Report the incident to the PI/Supervisor and EHS. | | | | | | |
| First Aid- Other | | | **Describe additional first aid procedures based on hazards.** | | | | | | |
| **SECTION 8. AQUA REGIA SOLUTION WASTE MANAGEMENT** | | | | | | | | | |
| 8.1 | Prior to placing aqua regia solution in a waste container, allow the solution to completely react and cool down in a labeled, open-top glass container inside a fume hood for at least 24 hours. | | | | | | | | |
| 8.2 | Aqua regia wastes must be diluted and stored alone in a one-liter container with a vented cap provided by [**EHS**](mailto:ehs@uconn.edu). **NO OTHER CHEMICALS OR WASTES MAY BE ADDED TO AQUA REGIA SOLUTION WASTE.** | | | | | | | | |
| 8.3 | Aqua regia containers must be labeled with a hazardous waste label, full chemical names (**include any metals on the label if applicable**), estimated percentages of each chemical constituent, the applicable hazard classes, and the contact and building information. | | | | | | | | |
| 8.4 | Aqua regia wastes must be at least 50% water by volume and never exceed one liter. Wear the personal protective equipment indicated in the safety data sheets (e.g., splash goggles, chemical resistant gloves, etc.), work in a fume hood, and slowly add aqua regia waste to water. **NEVER ADD WATER TO AQUA REGIA SOLUTION**. | | | | | | | | |
| 8.5 | Aqua regia solution waste must be stored alone in a chemical fume hood at or near a green “Satellite Accumulation Area” sign. Secondary containment is recommended during storage. | | | | | | | | |
| 8.6 | Lab personnel must submit a [**chemical waste pickup request**](https://ehs.uconn.edu/regulated-waste-management/) through the EHS website to have the waste removed. | | | | | | | | |
| 8.7 | **Describe additional waste management procedures for aqua regia solution specific to the laboratory.** | | | | | | | | |
| **SECTION 9. DECONTAMINATION PROCEDURES (*Attach or insert steps. Add more lines as necessary).*** | | | | | | | | | |
| Equipment | | **Describe how equipment will be decontaminated after use (e.g., use manufacturer instructions, specifications, etc.).** | | | | | | | |
| Glassware | | **Describe how glassware contaminated with aqua regia solution will be decontaminated after use.** | | | | | | | |
| Work Area | | **Describe how the work area (e.g., fume hoods, trays, etc.) will be decontaminated after use.** | | | | | | | |
| Personal Hygiene | | **Describe how the researchers will decontaminate after procedure.** | | | | | | | |
| **SECTION 10. SPECIFIC PROCEDURE** | | | | | | | | | |
| **List or attach a copy of the steps and appropriate safety controls for procedures using aqua regia solution.** | | | | | | | | | |
| **SECTION 11A. LAB PERSONNEL APPROVAL** | | | | | | | | | |
| I have reviewed, understand, and agree to follow this lab-specific standard operating procedure (LSOP) regarding aqua regia solution. Failure to follow the LSOP and lab-specific training guidelines for research with aqua regia solution is a violation of the [**University Health and Safety Policy**](http://policy.uconn.edu/2011/05/19/health-and-safety-policy/) and [**University Code of Conduct**](http://policy.uconn.edu/2011/05/17/employee-code-of-conduct/). Further approval from the PI is required if any of the following events occur:   * A change in amount (**Add volume**) or substitution of the chemicals in the procedure is planned * A change in the agreed-upon experimental set-up is planned * Signs of a failure in safety design or equipment are observed * Signs or symptoms of a chemical exposure to any personnel are observed * Unexpected and/or potentially dangerous experimental results occur (e.g., fire, uncontrolled buildup of heat and/or pressure, etc.) | | | | | | | | | |
| **Lab Personnel Name** | | | | **Lab Personnel Signature** | | | **Trainer Signature** | | **Training Date** |
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| **SECTION 11B. PRINCIPAL INVESTIGATOR/LAB MANAGER APPROVAL** | | | | | | | | | |
| *I approve the contents of the lab-specific standard operating procedure listed above regarding the use of aqua regia solutions.* | | | | | | | | | |
| **Principal Investigator/Lab Manager Signature:** | | | | | | | | **Date:** | |
| **A HARD OR ELECTRONIC COPY OF THE LSOP MUST BE READILY AVAILBALE IN THE LAB.** | | | | | | | | | |