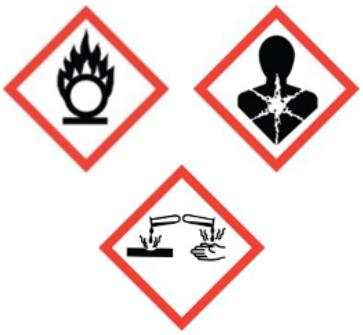
Principal Investigator: _____ ***Date Approved:*** _____

Aqua Regia



Aqua regia (Latin for "royal water") is an acidic, corrosive, and oxidative mixture of three parts concentrated hydrochloric acid (HCl) and one part concentrated nitric acid (HNO_3). It is called aqua regia because it is one of the few acid mixtures that can dissolve the "noble" metals: gold (Au), platinum (Pt), and palladium (Pd).

HNO_3 (aq) + 3HCl (aq) → NOCl (g) + $2H_2O$ (l) + Cl_2 (g)

Nitrosyl chloride (NOCl) decomposes over time, producing chlorine gas and nitric oxide (NO) that auto-oxidizes to nitrogen dioxide (NO_2), a poisonous reddish-brown gas.

2NOCl (g) → 2NO (g) + Cl_2 (g) 2NO (g) + O_2 (g) → $2NO_2$(g)

WARNING: Chlorine (Cl_2), nitric oxide (NO), nitrosyl chloride (NOCl), and nitrogen dioxide (NO_2) are poisonous!

Never place aqua regia in a closed container. The gas evolution will lead to pressure build-up and container rupture or explosion.

NEVER add any organics to an aqua regia solution; it could cause an explosion. Any chemical containing a C-H bond (e.g., acetone, isopropanol, ethanol, detergents) is organic. Even small amounts of organics could make the aqua regia solution unstable.

Personal Protective Equipment & Personnel Monitoring			
 **Lab Coat**	 **Gloves**	 **Eye Protection**	 **Face Shield**
Traditional lab coat.	Heavy-duty (≥10 mm) chemically resistant gloves, such as butyl rubber, Viton, or equivalent, is recommended when handling significant volumes of aqua regia and its components.	ANSI Z87.1-compliant splash goggles. Wear a face shield if a splash hazard is present.	

Engineering Controls, Equipment, & Materials

Fume Hood

All handling of aqua regia MUST be done with compatible glassware inside a fume hood. ***Never remove a container with aqua regia from the fume hood until completely neutralized.*** Keep the fume hood sash as low as possible to capture the toxic fumes. Never raise the sash above the maximum height (generally 18 inches).

Never bring any organic chemicals into the hood while using aqua regia. Do not bring any metal stopcock holders, spatulas, etc. to the fume hood while using aqua regia.

Preparation

Perform all work with aqua regia in the fume hood; glassware should be cleaned to remove residual organics prior to cleaning with aqua regia.

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.

Slowly add 1 part HNO_3 to 3 parts HCl inside of the fume hood. The appearance of an orange/red solution color and gas bubbles is an indication that the reaction is progressing. When working with aqua regia in the hood, the extent of reaction can be observed visually by the production of gas, which can be liberated by gently tapping on the side of the container.

Handling

Only prepare the amount of aqua regia necessary to clean the glassware of interest, as the reaction proceeds upon mixing and extra aqua regia both increases the safety concern and the amount of wasted reagents.

Under no circumstances should aqua regia be placed in a closed container. The gases generated will build up pressure, which will create a hazardous situation. When you are not actively using aqua regia, always ensure that the fume hood sash remains down and closed.

Neutralization in the Hood

Although the aqua regia remaining after cleaning glassware may not be spent, ***it must be neutralized immediately after use*** as part of the process. This is not a neutralization of waste, but an important safety step to minimize the risks associated with storing aqua regia.

Working inside the fume hood, pour the aqua regia ***very slowly and carefully*** into a large quantity of ice (500 grams of ice per 100 mL of aqua regia), remembering to add acid to water. Neutralize the mixture ***very gradually and slowly*** (to avoid heating) in a wide mouth open container with an aqueous basic solution, such as saturated sodium bicarbonate ($NaHCO_3$) in water, until pH is neutral. **ALWAYS** use a pH test strip to confirm the solution is neutral.

Storage

WARNING: Never store a stoppered/closed bottle of aqua regia—it may explode!

Aqua regia should be made fresh before every use and excess amounts neutralized in a timely manner after use.

Housekeeping

Waste

If the solution does NOT contain heavy metals, the neutralized solution may then be poured down the drain.

If the neutralized mixture DOES contain heavy metals (e.g., gold, platinum, lead, chromium), the solution should be labeled with the TWU hazardous waste label and subsequently disposed of through EH&S. You can submit an online waste pickup request or contact EH&S (940-898-4001 ext. 3; risk@twu.edu) to arrange for a waste pickup.

Spills

The level of response for a spill depends on the amount of spill, completion of the reaction and the location of the spill. If you do NOT have the training or materials to clean a small spill OR the spill occurs outside of the fume hood, do not clean the spill and follow the large spills procedure.

> ***Small Spills (spills less than 1 liter)***
> Spills should be neutralized immediately with sodium bicarbonate or other acid neutralizer. Do NOT use organic or combustible materials to clean un-neutralized aqua regia.
>
> ***Large Spills (spills over 1 liter) OR spills outside of the fume hood***
> Notify others in the area of the spill, including your supervisor. Evacuate the location where the spill occurred and place a "Do Not Enter- Corrosive Spill" sign on the door. Call TWU DPS (940-898-2911 in Denton; 214-689-6666 in Dallas; 832-870-6128 in Houston). Report any exposure to EH&S at 940-898-4001. Remain on-site (at a safe distance) to provide detailed information to first responders.

First Aid & Emergencies

Skin Contact

Rinse the affected skin immediately with copious amounts of water for about 15 minutes; if necessary, use the safety shower. Remove contaminated clothing. Seek medical attention as necessary.

Eye Contact

Use the eye wash to rinse the eye thoroughly for at least 15 minutes, occasionally lifting the upper and lower eyelids and rolling the eyeballs. **Always seek medical attention after eye contact with corrosives.**

Inhalation
Move affected individual(s) into fresh air. Seek medical attention.

Ingestion
Do not induce vomiting. Rinse mouth with water. Seek medical attention. Provide the medical team with the Safety Data Sheets (SDS) for hydrochloric acid and nitric acid.

By signing and dating the log below, individuals are certifying that they have been informed and understand this Standard Operating Procedure and agree to abide by its contents.

Name	Signature	Date