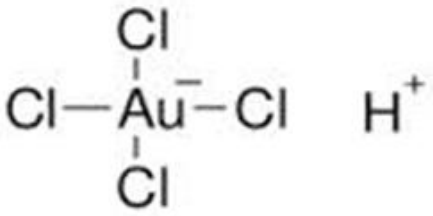
Chloroauric Acid



QH, Niloy Kumar Das

Shahjalal Science & Technology University, Bangladesh

"I decided to dissolve it."

- Georgy de Hevesy

When Germany invaded Denmark in World War II, Hungarian chemist George de Hevesy dissolved the gold Nobel Prizes of German physicists Max von Laue (1914) and James Franck (1925) in aqua regia to prevent the German soldiers from confiscating them. Later the medals were reconstructed from disolved chloroauric acid and handed over to its rightful owners after the war.

Pic. György de Hevesy

Chloroauric acid is an inorganic acid that is widely used in gold refining processes. Gold is one of the least reactive metals but gold reacts with *aqua regia* to yield chloroauric acid.

$$Au + HNO_3 + 4\ HCl \rightarrow HAuCl_4 + NO + 2\ H_2O$$

Chloroauric acid shows acidic behavior by releasing proton in solution. It is a strong monoprotic conjugate acid. Even if chloroauric acid forms in aqueous solution, such solution are unstable due to hydrolysis of tetrachloriodoaurate ion.

$$H_3O^+ \rightarrow H_2O + H^+$$

$$H_3OAuCl_4 + 2\ H_2O \rightleftharpoons Au(OH)_3 + 4\ HCl$$

Gold is oxidized by halogens; so a solution of $HAuCl_4$ can be obtained by the action of chlorine or chlorine water on metallic gold in hydrochloric acid. Oxidation of gold by chlorine is used to recover gold from anode muds.

$$2Au + 3Cl_2 \rightarrow 2\ AuCl_3$$

$$2\ Au + 3\ Cl_2 + 2\ HCl \rightarrow 2\ HAuCl_4$$

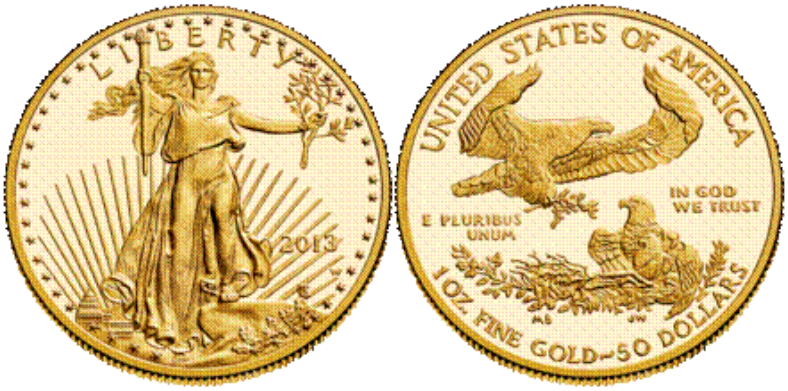
There are many reducing agents that reduce ionic gold into the metal, such as: SMB (sodium metabisulfite), copperas (Iron II Sulfate), Sulfur dioxide gas (SO_2), hydroquinone, formaldehyde, hydrazine sulfate and many more.

Major Applications

- **Gold refining:**

  Traditionally chloroauric acid has been used to refine gold. Gold became the basis of money in many ancient civilizations, and even today most countries maintain large reserves of gold for financial credibility.

Front and back of a coin from King Croesus's mint – one of the first coins minted in human history, over 2500 years ago.



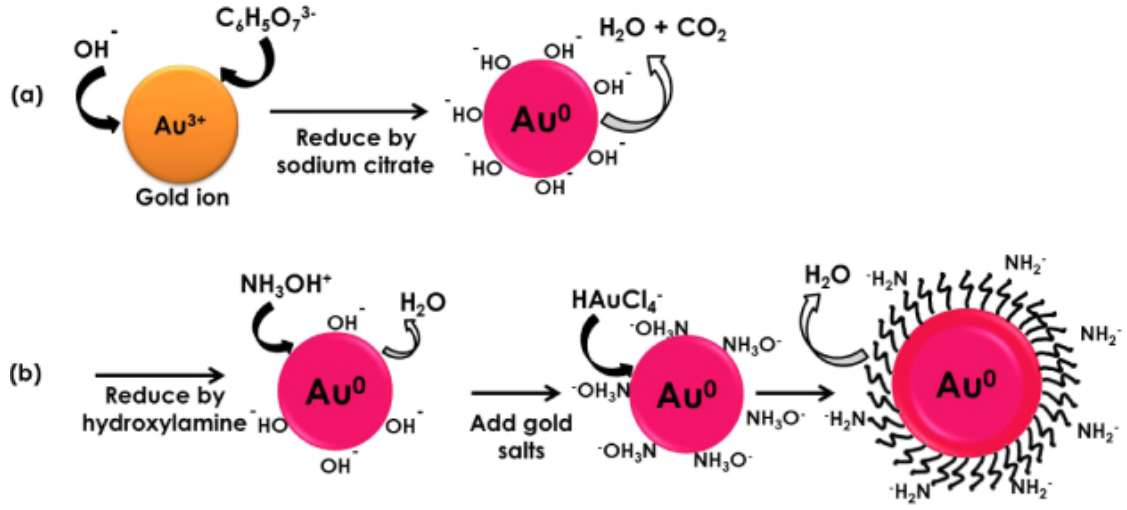
American Gold Eagle; an official gold bullion coin of the United States

- **Gold nanoparticles:**

  Today with the development of nanotechnology; gold nanoparticles of 5 nm to 400 nm in diameter have been produced from chloroauric acid. An interesting fact is that the process requires traditional reducing agents in one or another form. Some practical applications of gold nanoparticles are listed below.

1. Gold nanoparticles are designed for use as conductors from printable inks to electronic chips.
2. Near-IR absorbing gold nanoparticles (including gold nanoshells and nanorods) produce heat when excited by light at wavelengths from 700 to 800 nm. This enables these nanoparticles to eradicate targeted tumors.
3. The large surface area-to-volume ratio of gold nanoparticles enables their surface to be coated with hundreds of molecules (including therapeutics, targeting agents, and anti-fouling polymers).

4. Gold nanoparticles are used in a variety of sensors. For example, a colorimetric sensor based on gold nanoparticles can identify if foods are suitable for consumption.
5. Gold nanoparticles also scatter light and can produce an array of interesting colors under dark-field microscopy. The scattered colours of gold nanoparticles are currently used for biological imaging applications.
6. Gold nanoparticles are also used to detect biomarkers in the diagnosis of heart diseases, cancers, and infectious agents.
7. Gold nanoparticles are used as catalysts in a number of chemical reactions. The surface of a gold nanoparticle can be used for selective oxidation or in certain cases the surface can reduce a reaction (nitrogen oxides). Gold nanoparticles are being developed for fuel cell applications.



(a) Gold salts are reduced by simple fatty acids to colloidal gold; (b) Additional functional groups are attached to the gold nanoparticle by chemical treatment

- **Gold toner**

One of the most popular uses for chloroauric acid is in photography as a gold toner. Toning is a chemical process which changes the colour of a photograph. It has a further benefit in that a toned image is far more permanent. In 1840 Frenchman Hippolyte Fizeau created a gold chloride toning bath to increase the stability of Daguerreo-type images. A black and white print toner that is commonly used in photography is actually created from real metallic gold. This process sees gold metal deposited onto the silver image. There are many different reasons for this. The main reason is that silver will eventually tarnish, however gold will not. As a result gold toning has proven to be one of the most effective processes for images, especially if printed on a well-washed archival fibe paper.

$$KAuCl_4 + Ag \rightarrow Au + AgCl + KCl$$

Gold toned photo; courtesy Andrew Sanderson

- **Glass coloring agent**

  Cranberry glass or 'Gold Ruby' glass is a red glass made by adding chloroaurates or colloidal gold to molten glass.

Vintage cranberry glass bowl, scent bottles

References

1. Feather, A; KC Sole; Lj Bryson (July 1997). "Gold refining by solvent extraction—the minataur™ process" (PDF). *Journal of the Southern African Institute of Mining and Metallurgy*: 169–173. Retrieved 2013-03-17.
2. Morris D. F. C., Khan M. A. "Application of solvent extraction to the refining of precious metals, Part 3: purification of gold" *Talanta*, 1968. **15**, 1301—1305.
3. Birgitta Lemmel (2006). "The Nobel Prize Medals and the Medal for the Prize in Economics". The Nobel Foundation.
4. T.G.H. James, The British Museum, Gold Technology in Ancient Egypt: Mastery of Metal Working Methods., 1972, Gold Bulletin V, p42.
5. Encyclopædia Britannica 1911, *Alchemy*
6. Chloroauric acid; ChemSpider

Back to Molecule of the Month page. [DOI:10.6084/m9.figshare.15097203]