Don't Mix Ammonia and Bleach!

"Household ammonia" is a water solution that usually contains 2.5% ammonia (NH_3). "Household bleach is an other water solution which usually contains about 6% sodium hypochlorite (NaOCl). These are sold as dilute solutions because concentrated ammonia and concentrated sodium hypochlorite are quite dangerous to handle.

Both of these "household" liquids are used for cleaning, and there is a temptation to do even "better" cleaning by using both. This should never be done. Even as dilute solutions, these should never be mixed since they produce even more dangerous chemicals when they react. Here are some of the reactions that can happen.

The sodium hypochlorite partially reacts with the water to produce sodium hydroxide (NaOH) and hypochlorous acid (HClO). A subsequent reaction with ammonia produces chloramine (NH_2Cl):

$$\mathrm{NaOCl} + \mathrm{H_2O} \Leftrightarrow \mathrm{NaOH} + \mathbf{HClO} \quad \text{followed by} \quad \mathbf{HClO} + \mathrm{NH_3} \Leftrightarrow \mathbf{NH_2Cl} + \mathrm{H_2O}$$

The chloramine can react with the ammonia and sodium hydroxide to produce hydrazine (N_2H_4):

$$\mathbf{NH_2Cl} + \mathrm{NH_3} + \mathrm{NaOH} \Leftrightarrow \mathbf{N_2H_4} + \mathrm{NaCl} + \mathrm{H_2O}$$

Hydrazine is a highly toxic and unstable (e.g. explosive) compound. It is used as a rocket fuel.

$$\mathbf{N_2H_4}(\mathrm{l}) + \mathrm{O_2}(\mathrm{g}) \Rightarrow \mathrm{N_2}(\mathrm{g}) + 2\,\mathrm{H_2O}(\mathrm{g}) + 1242\,\mathrm{kJ}$$

The net result of these equations is

$$\mathrm{NaOCl}(\mathrm{aq}) + 2\,\mathrm{NH_3}(\mathrm{aq}) \Rightarrow \mathbf{N_2H_2}(\mathrm{aq}) + 2\,\mathrm{H_2O}(\mathrm{l}) + \mathrm{energy}$$

It, however, can simply explode without any oxygen:

$$\mathbf{N_2H_4}(\mathrm{l}) \Rightarrow \mathrm{N_2}(\mathrm{g}) + 2\,\mathrm{H_2}(\mathrm{g}) + 53\,\mathrm{kJ}$$

When the ratio of bleach to ammonia is large, the following reaction can occur with nitrogen trichloride NCl_3 being produced:

$$3\,\mathbf{NaClO} + \mathrm{NH_3} \Leftrightarrow 3\,\mathrm{NaOH} + \mathbf{NCl_3}$$

Nitrogen trichloride is a very toxic and unstable chemical. The Wikipedia entry on NCl_3 has the following interesting paragraph:

> The pure substance (rarely encountered) is a dangerous explosive, being sensitive to light, heat, even moderate shock, and organic compounds. Pierre Louis Dulong first prepared it in 1812, and lost two fingers and an eye in two explosions. In 1813, an NCl_3 explosion blinded Sir Humphry Davy temporarily, inducing him to hire Michael Faraday as a co-worker. They were both injured in another NCl_3 explosion shortly thereafter.

A hydrazine explosion in Henderson, Nevada, that destroyed a chemical plant is on YouTube entitled "Destroyed in Seconds- Chemical Plant Explosion" (*https://www.youtube.com/watch?v=_KuGizBjDXo*).

So don't mix bleach and ammonia because they produce lots of dangerous chemicals.