Physicochemical Resistance of Engineering Materials in Ammonia and its Derivatives

Alec Groysman

The Israeli Society of Chemical Engineers & Chemists, Tel Aviv, Israel
Technion (The Israel Institute of Technology), Haifa, Israel
E-mail: alecgroysman@gmail.com

The aim of this work is to describe and analyze physicochemical resistance of engineering materials in ammonia and its derivatives, corrosion mechanism, mitigation, preventive measures, and monitoring methods.

Ammonia is one of the most interesting and important substances in chemical industry and in life, probably after water. Ammonia is used in liquid, gaseous, and soluble in water and aqueous solutions. Ammonia is the source of producing of hundreds of materials, for good and bad: fertilizers and explosives, to name a few. Ammonia is one of paradoxical chemical compounds, which is used for people life and death.

Many of physicochemical processes in chemical industry are realized with participation of ammonia and its derivatives under harsh conditions. It is important to know the behavior of materials under different wide conditions because implementation of these technologies is associated with processes safety.

Ammonia has many-faced corrosive properties. It is a corrosion inhibitor of carbon steel in aqueous solutions, but it is highly corrosive towards copper, nickel, zinc and their alloys. Anhydrous liquid ammonia can cause stress corrosion cracking (SCC) of storage vessels and tanks made of carbon steel. This is one of the reasons of stopping of exploitation of carbon steel storage tank in Haifa, Israel in 2017.

Copper alloys also are susceptible to SCC in aqueous ammonia solutions. “Season cracking” was one of the first failures observable on brass cartridge cases of bullets which occurred because of ammonia appearance as a result of decomposition of organic material in Indian forests.

Ammonia is a commonly used nitriding gas for case hardening of steel at 500-590^{o}C. Furnace equipment subjected to these service conditions suffer brittle failures because of nitridation attack.

General corrosion of copper, zinc and nickel occurs in ammonium solutions with the formation of complex compounds. Under deposit, pitting corrosion occurs on carbon steel surface in oil refinery equipment when ammonia is injected for corrosion control and undesirable ammonium chloride deposits are formed. Can we control these corrosion phenomena?

People who just begin to deal with selection of materials in contact with ammonia and its derivatives, can be confusing. In some MSDS of ammonia one can read that “*ammonia has alkaline properties and is corrosive*”. However, it is not indicated to which materials. In some text books it is written that “*ammonia and ammoniacal solutions generally do not present difficult corrosion problems*”. It is necessary to indicate specific materials which are influenced and not influenced by ammonia and under which conditions.

In this work, we summarize the experience of physicochemical resistance of varied materials (mostly metals and alloys) in contact with ammonia and its aqueous solutions under wide conditions, remedies against corrosion, and corrosion monitoring methods. This knowledge is essential for design, maintenance, and process safety in ammonia chemical industry.

Keywords: *ammonia, corrosion, engineering materials, mitigation, monitoring*.