

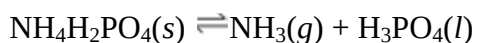
Lecture 22

Ammonium Phosphates

There are two major types of ammonium phosphates, namely: mono-ammonium phosphate and di-ammonium phosphate. Mono-ammonium phosphate is made by reacting ammonia with phosphoric acid, centrifuging and drying in a rotary dryer. Di-ammonium phosphate requires a two-stage reactor system in order to prevent loss of ammonia. A granulation process follows with completion of the reaction in a rotary dryer which is heated by a furnace using fuel.

Ammonium dihydrogen phosphate (ADP), or monoammonium phosphate, $\text{NH}_4\text{H}_2\text{PO}_4$, is formed when a solution of phosphoric acid is added to ammonia until the solution is distinctly acidic. It crystallizes in tetragonal prisms. Monoammonium phosphate is often used in the blending of dry agricultural fertilizers. It supplies soil with the elements nitrogen and phosphorus in a form which is usable by plants. The compound is also a component of the ABC powder in some dry chemical fire extinguishers. This substance is also supplied in an emerald green or aquamarine crystal growing box kit for children.

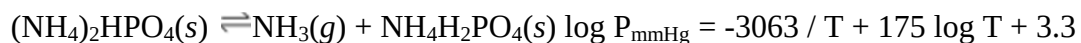
Solid mono ammonium phosphate show a dissociation pressure of ammonia of 0.05 mmHg at 125°C based on the decomposition reaction as follows:



ADP is a widely used crystal in the field of optics due to its birefringence properties. As a result of its tetragonal crystal structure, this material has negative uniaxial optical symmetry with typical refractive indices $n_o=1.522$ and $n_e=1.478$ at optical wavelengths.

ADP crystals are piezoelectric which is a property required in some active sonar transducers (the alternative being transducers that use magnetostriction).

Diammonium phosphate (DAP) (chemical formula $(\text{NH}_4)_2\text{HPO}_4$, IUPAC name diammonium hydrogen phosphate) is one of a series of water-soluble ammonium phosphate salts which can be produced when ammonia reacts with phosphoric acid. Solid diammonium phosphate shows a dissociation pressure of ammonia as given by the following expression and equation:



where:

P = the resultant dissociation pressure of ammonia

T = absolute temperature (K)

At 100°C, the dissociation pressure of diammonium phosphate is approximately 5 mmHg

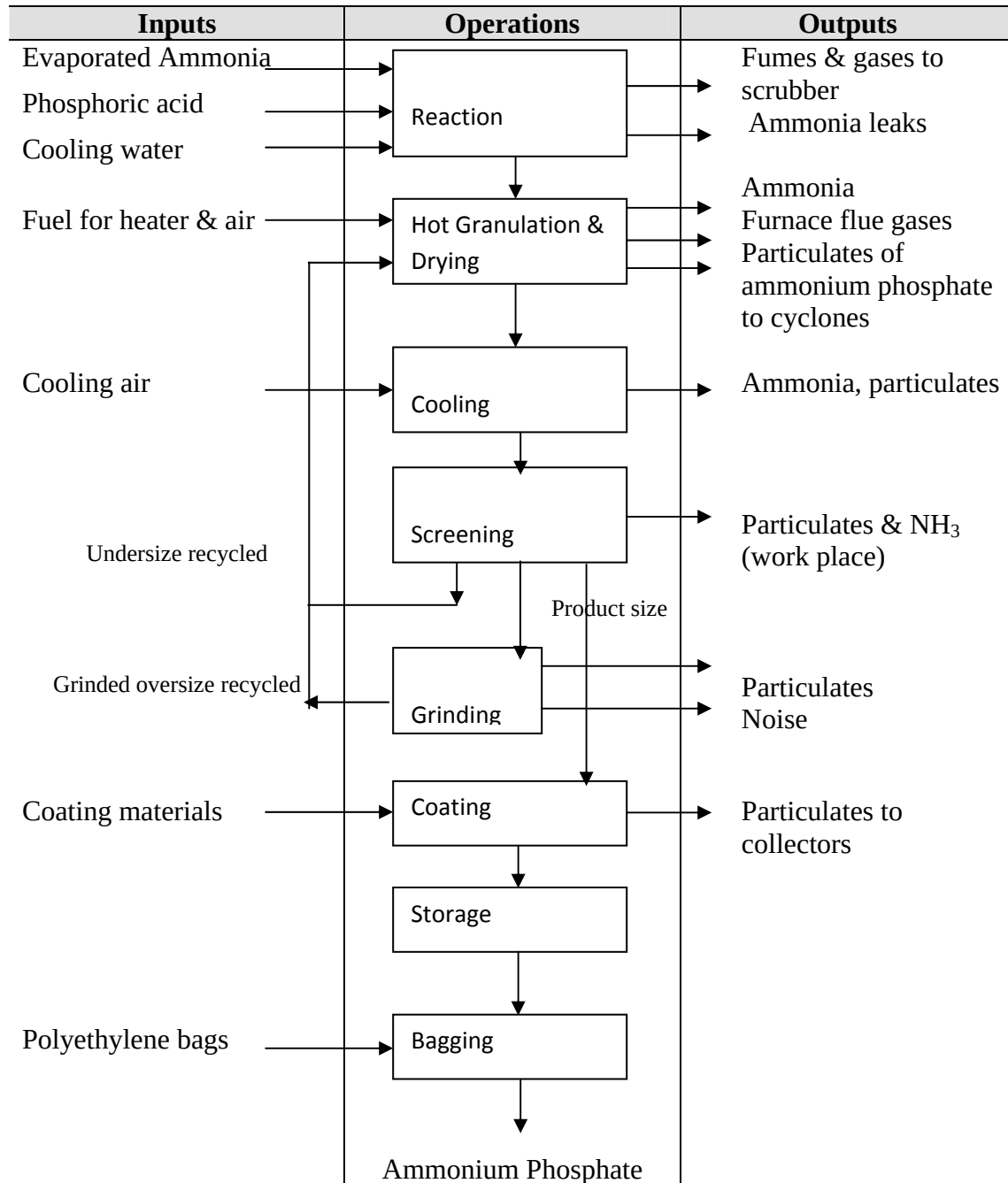
DAP is widely used as a fertilizer. When applied as plant food, it temporarily increases the soil pH, but over a long term the treated ground becomes more acidic than before upon nitrification of the ammonium. It is incompatible with alkaline chemicals because its ammonium ion is more likely to convert to ammonia in a high-pH environment.

To produce mono-ammonium phosphate, ammonia to phosphoric acid ratio is 0.6 in the pre-neutralizer and then 1.0 in the granulator. For production of di-ammonium phosphate, the ratios are 1.4 and 1.0 in the pre-neutralizer and granulator respectively.

The resulting ammonium phosphate is then screened. The undersize particles are recycled back to the granulation operation, while the oversized particles are grinded first before recycling to the granulator. After screening the fertilizer granules are coated with specific material in order to regulate its dissolving process in the soil when used.

The figure below illustrates the process block diagram for the manufacturing of ammonium phosphate fertilizer.

Fig (13) : Process Flow Diagram for Ammonium Phosphate Manufacturing



Ammonium polyphosphate is an inorganic salt of polyphosphoric acid and ammonia containing both chains and possibly branching. Its chemical formula is $[\text{NH}_4 \text{ PO}_3]_n$ showing that each monomer consists of an orthophosphate radical of a phosphorus atom with three oxygens and one negative charge neutralized by an ammonium cation leaving two bonds free to polymerize. In the branched cases some monomers are missing the ammonium anion and instead link to three other monomers.

The properties of ammonium polyphosphate depend on the number of monomers in each molecule and to a degree on how often it branches. Shorter chains ($n < 100$) are more water sensitive and less thermally stable than longer chains ($n > 1000$), but short polymer chains (*e.g.* pyro-, tripoly-, and tetrapoly-) are more soluble and show increasing solubility with increasing chain length.

Ammonium polyphosphate can be prepared by reacting concentrated phosphoric acid with ammonia. However, iron and aluminum impurities, soluble in concentrated phosphoric acid, form gelatinous precipitates or "sludges" in ammonium polyphosphate at pH between 5 and 7. Other metal impurities such as copper, chromium, magnesium, and zinc form granular precipitates. However, depending on the degree of polymerization, ammonium polyphosphate can act as a chelating agent to keep certain metal ions dissolved in solution.

Ammonium polyphosphate is used as a food additive and emulsifier, (E number: E545). It is also used as a flame retardant for polyolefins and polyurethanes and as a fertilizer.

As a fire retardant, ammonium polyphosphates decompose to form ammonia and phosphoric acid. The phosphoric acid acts as an acid catalyst in the dehydration of carbon-based polyalcohols, such as cellulose in wood. The phosphoric acid reacts with alcohol groups to form heat-unstable phosphate esters. The esters decompose to release carbon dioxide and regenerate the phosphoric acid catalyst. The release of non-flammable carbon dioxide helps to dilute the air of oxygen and flammable decomposition products of the material that is burning. The resultant carbonaceous char is less-flammable than before. Use as an intumescent is achieved when combined with starch-based materials