INTRODUCTION

Ammonium phosphate (\((\text{NH}_4)_3\text{PO}_4\)) also known as ammonium orthophosphate is the salt of ammonia and phosphoric acid. It consists of ammonium cations and phosphate anion. It is water soluble and the aqueous solution on boiling losses ammonia.

Ammonium orthophosphates are applied to soil either directly, or as a solution, or in a suspension form, depending on the proportion of insoluble phosphates present in the soil. Ammonium phosphates refer to a generic class of phosphorus fertilizers and are manufactured by reacting anhydrous ammonia with orthophosphoric acid or super phosphoric acid. These are either in solid or liquid form.

There are two major types of ammonium phosphate which are monoammonium phosphate (MAP, \(\text{NH}_4\text{H}_2\text{PO}_4\)) and diammonium phosphate (DAP, \((\text{NH}_4)_2\text{HPO}_4\)) and these can be inter-converted by changing ammonia or phosphoric acid as needed. Mono-ammonium phosphate is manufacture by reacting ammonia with phosphoric acid, centrifuging and drying in a rotary dryer. While diammonium phosphate requires two-stage reactor system in order to prevent loss of ammonia. The granulation process followed by neutralization is completed in rotary dryer, which is heated by a furnace using fuel.

Two grades of ammonium phosphate are available

1. **Monoammonium phosphate (MAP)**

   Anhydrous ammonia added to liquid phosphoric acid gives monoammonium phosphate (MAP). It is a fertilizer or fertilizer intermediate with high \(\text{P}_2\text{O}_5\) content of about 55% and nitrogen content 11-12%.

2. **Diammonium phosphate (DAP)**

   With more ammonia, technical grade diammonium phosphate (DAP) containing 16 to 18% nitrogen and 20 to 21 % phosphorus (46% \(\text{P}_2\text{O}_5\)) is formed.
MANUFACTURE

Raw Materials

Basis: 1000kg of Diammonium phosphate
- Ammonia = 200kg
- Phosphoric acid = 465kg
- Electricity = 200MJe
- Fuel = 525MJ
- Direct labour = 0.5 work-hr

Reactions

\[
\begin{align*}
\text{NH}_3 + \text{H}_3\text{PO}_4 & \rightarrow \text{NH}_4\text{H}_2\text{PO}_4 \\
\text{NH}_3 + \text{NH}_4\text{H}_2\text{PO}_4 & \rightarrow (\text{NH}_4)_2\text{HPO}_4
\end{align*}
\]

Sources of raw material

Ammonia can be synthesized by Haber – Bosch or Modern process as described in Module: 2, Lecture: 6.

Phosphoric can be manufacture by electric arc furnace, blast furnace or wet process as described in Module: 4, Lecture: 21.

Manufacture
Block diagram of manufacturing process

Diagram with process equipment

Animation

The two principal steps are

a) Neutralization
b) Granulation

a) Neutralization

Quantities of phosphoric acid and ammonia in the neutralization step are different from mono ammonium phosphate (MAP) and diammonium phosphate (DAP). To manufacture mono ammonium phosphate, ammonia to phosphoric acid ratio is 0.6 in the neutralizer and then 1.0 in the granulator. While for diammonium phosphate, the ratios are 1.4 and 1.0 in the neutralizer and granulator respectively.

Phosphoric and ammonia are added to the first of three continuous mixed reactors, anhydrous ammonia is added beneath the slurry level in the first neutralizer in an amount equivalent to 80% neutralization. Further ammonia is added in the 2nd and 3rd tanks to obtain conversion to the diammonium salt if a higher nitrogen containing fertilizer is needed.

The exothermic reaction heats the slurry nearly to the boiling point (130°C). Unreacted and excess NH₃ vapor is collected from the top of each tank and recharged below the liquid level for reducing NH₃ losses (less than 3%). The hot slurry containing about 16 to 20% water is pumped into the granulator, where more ammonia is added to increase the molar ratio to approximately 2.0.

b) Granulation

Slurry from the third neutralized is mixed with KCl and absorbed in a bed of dry recycle fertilizer moving through a rotating drum granulator. This provides a tumbling action to coal recycle material with a slurry film.

A rotary adiabatic drier reduces the moisture to less than 1%, with 10 minute contact time with air initially at 150°C. Dried product is separated into three fractions on a double deck screen. A portion of the product from the deck of the lower screen is sent to bagging operations. The balance, together with pulverized oversize and fines, is returned to the granulator. The weight ratio of recycle to product is 6: 1-15: 1 depending on the grade produced.
Powder ammonium phosphate

Powdered ammonium phosphate is still in use because of its high phosphorus content (as P₂O₅).

In addition, a group of fertilizers, such as ammonium phosphate-sulfates, ammonium phosphate-chloride and ammonium phosphate-nitrate are produced by a number of processes involving the neutralization of ammonia with a mixture of phosphoric acid and plant waste acids like sulfuric acid, nitric acid or hydrochloric acid. These fertilizers are free flowing and non-hygroscopic (or less hygroscopic) compared to the individual components, and have been successfully used in many types of soils.

Major engineering problem

Ammonia losses

Ammonia loss should be kept below 3%. It can be achieved by using multistage reactors along with efficient recycling mechanism of collecting the vapour of ammonia from top of the neutralization tower and recycle back to the process.

Corrosion

Use of corrosion resistance material like SS316 for hot acid and fumes ducts, carbon steel for granulation, drying and screening

PROPERTIES

- Molecular formula : NH₄H₂PO₄
- Molecular weight : 115.03gm/mole
- Appearance : White crystal
- Odour : Odourless
- Melting point : 190°C
- Density : 1.803gm/mL
- Solubility : Moderately soluble in water
- pH : 4-4.5
- Ammonium phosphate fertilizers are highly soluble in water and fast acting in soil to give nitrogen and phosphorus in a chemical combination.
- Storage properties and the ease of granulation depend on the amount of impurities, which form a gel like structure (mainly aluminum and iron phosphates). This gel promotes granulation and serves as a conditioner to prevent caking even at moderately high moisture levels. A small proportion of phosphate rock added to phosphoric acid before ammoniation improves the granulation.
- The standard commodity grade of diammonium phosphate is 18-46-0.
Pure and completely soluble ammonium phosphates are used mainly as liquid fertilizers.

DAP is unstable at temperatures above 150°C while monoammonium phosphate remains stable even at much higher temperatures.

These two fertilizers usually form a part of concentrated compound fertilizers and are rarely used individually in their pure states.

**USES**

- Used as a high effective non-chloride N, P compound fertilizer in agriculture. It contains totally 73% fertilizer elements \((N+P_2O_5)\), and may be used as a basic raw material for N, P and K compound fertilizer
- In flame-proofing, plant nutrient solutions
- Used in manufacturing of yeast, vinegar, yeast foods, and bread improvers
- Used in buffer solutions and in analytical chemistry
- Used as a fire prevention agent for fabric, timber and paper, as well as a fire prevention coating, and dry powder for fire extinguisher.
- For food grade, it is mainly used as a fermentation agent, nourishment agent.