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Phosphoric Acid

PERP 08/09S2

Report Abstract
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INTRODUCTION

Phosphoric acids may be considered as derivatives of phosphorus pentoxide and defined by the empirical phosphorus pentoxide-water system. *ortho*-Phosphoric acid is the simplest form of these acids and may be formed from phosphorus pentoxide as follows:

$$P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$$

phosphorus pentoxide — *ortho*-phosphoric acid

When the term phosphoric acid is used on its own, it is usually referring to *ortho*-phosphoric acid which is the simplest form of the acid. When two or more molecules of *ortho*-phosphoric acid combine together by elimination of water molecules they form larger molecules; these larger molecules may be referred to as condensed phosphates or more commonly polyphosphoric acids (e.g., tetrapolyphosphoric acid). Another common term used in relation to phosphoric acid is superphosphoric acid (SPA): This term is often used to refer to preparations of the acid having phosphorus pentoxide concentrations above ~68 percent (it is to be noted that at such high concentrations the acid is increasingly a mixture of poly- and *ortho*-phosphoric acids).

PRODUCTION TECHNOLOGY

Phosphoric acid can be produced using technologies that are referred to as the wet process and the furnace (or thermal) process. In the wet process, phosphate rock is digested by a strong acid. The phosphoric acid is then filtered and concentrated. However, before phosphate rock can be used in this process, it has to be mined, beneficiated (whereby impurities are removed), calcined (or dried) and sometimes ground (the so called hemihydrate wet process requires grinded phosphate rock). The main producers of phosphate rock are the United States, China, and Morocco.

With respect to the wet process, sulfuric acid is the most widely used acid; however hydrochloric acid and potentially nitric acid may also be used. A process using hydrochloric acid has been licensed. The corrosion issues associated with this process, which requires the use of equipment made of special materials of construction, makes this process feasible only in areas where there is low cost hydrochloric acid. There is currently no commercial production of phosphoric acid employing nitric acid. However, nitric acid is used to make nitrophosphate fertilizers.

There are many impurities (such as dirt, silica, and various metals) in phosphate rock that can affect the phosphoric acid process. Sometimes impurities are removed prior to the start of the process or they are removed during the filtration step.

There are two important byproducts of the wet process: “gypsum” (hydrated calcium sulphate) and fluoride. Depending on the reaction conditions, there are two types of crystalline forms of hydrated calcium sulfate formed in commercial processes. At low temperatures dihydrate

crystals of calcium sulphate are formed. While at high temperatures hemihydrate crystals of calcium sulphate are produced. There is no commercial process to produce anhydrite crystals (i.e., anhydrous or nearly anhydrous calcium sulphate) because of the severe reaction conditions required for its formation.

In the thermal process, phosphoric acid is produced by burning elemental phosphorus in air and then reacting with water. This process, which produces phosphorus furnace slag as a byproduct, yields a phosphoric acid of high purity suitable for industrial applications. Less than five percent of the world's phosphoric acid is produced via the thermal process.

There are 3 major licensors of phosphoric acid: Technip, Prayon, and Jacobs Engineering. Technip offers the Single Tank (or Reactor) process in addition to the newly developed DIPLO process, a variation of the Single Tank process, in which the reaction takes place in two tanks in series. Prayon offers different processes dependent on the costs of phosphate rock, energy and the ability to dispose of the "gypsum" byproduct. Jacobs offers the D-II dihydrate process for the production of phosphoric acid.

There have been a number of companies with recent patent publications on phosphoric acid technology. One of the recent major process technology developments has been the introduction of a dry process for the production of phosphoric acid.

- A detailed discussion of the processes offered by the three largest phosphoric acid production licensors is given in the report

ECONOMICS

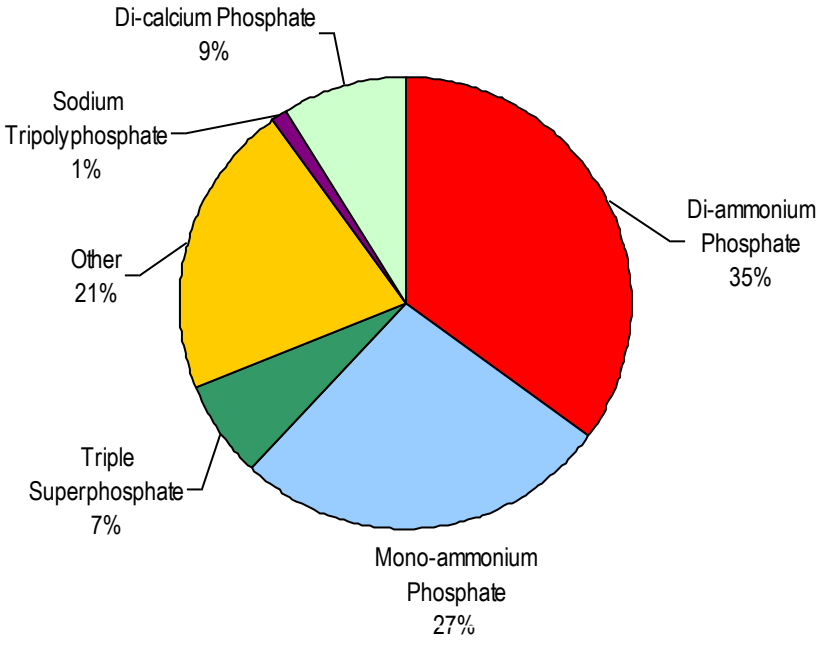
Cost estimates for the production of 54 percent phosphoric acid have been developed. The selected cases are:

- Dihydrate Process to produce Phosphoric Acid
- Hemihydrate Process to produce Phosphoric Acid

COMMERCIAL APPLICATIONS

Phosphate fertilizers are the major end-use of phosphoric acid accounting for more than 80 percent of phosphoric demand (see Figure below) and it is estimated they will continue to be the major factor influencing future phosphoric acid consumption. Triple superphosphate (TSP) is the major uncompounded phosphate used as fertilizer followed by single superphosphate (SSP). A high proportion of total phosphate is being produced in the form of compounds such as ammonium phosphates. The most important phosphate fertilizer in international trade is diammonium phosphate (DAP), followed by triple superphosphate.

Global Phosphoric Acid Demand by End-Use



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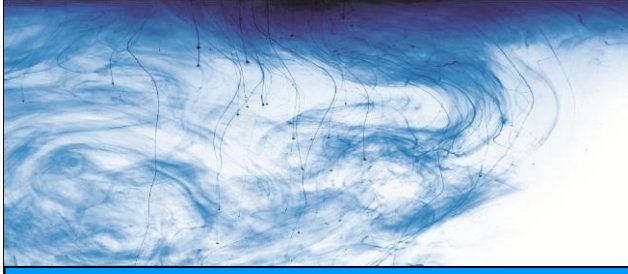
In addition to the fertilizers sector, phosphoric acid is used in the production of industrial phosphates. Industrial phosphate applications include use in soaps and detergents, metal surface treatment, animal feeds, pharmaceuticals, water treatment, catalysts, fermentation, and the food industry.

World consumption of phosphoric acid is estimated to increase in the next few years. This is attributed to the continued trend toward higher analysis fertilizers. Industrial and other non-fertilizer uses of phosphoric acid are also forecasted to grow.

- Phosphoric acid supply, demand and trade data for the United States, Western Europe, and Asia Pacific regions are given and discussed in the report.



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