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Non hygroscopic superphosphate fertilizer from apatite and hydrochloric acid

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Abstract. A method is described for the production of a nonhygroscopic fertilizer from apatite by treatment with hydrochloric acid .

Apatite is acidulated with HCl to the stoichiometric level needed for generating dicalcium phosphate. The reaction product when mixed with ammonium sulphate sufficient to double-decompose calcium chloride and dicalcium phosphate yields a nonhygroscopic product containing almost all phosphorus in the water-soluble form. Results of laboratory experiments conducted to determine the optimum conditions for the process, chemical properties of the material and its agronomic effectiveness are described. The studies were carried out with the intention of utilizing the reserve of apatite at Eppawala in Sri Lanka using indegenous raw materials.

Introduction

The beneficiation of rock phosphate is heavily dependent upon the use of sulphuric acid [1–4). In fact the largest consumer of this acid is the phosphate fertilizer industry. Sulphur is becoming an expensive commodity in the world market. Sulphur and sulphide ores that could be used for the manufacture of sulphuric acid are not as widely distributed as the rock phosphate. Unless alternative routes are devised for the beneficiation of apatite, the superphosphate industry would be limited by the shortage of sulphur. Several countries possessing reserves of rock phosphate are finding it difficult to develop superphosphate industries mainly because of the cost of sulphur. The established alternative methods for the production of superphosphates are the furnace process for direct conversion of apatite into phosphoric acid and the nitric-phosphate process. The furnace process is capital-intensive and not sufficiently developed to supersede the wet process based on sulphuric acid. The chief factor that restricts the production of nitric-phosphates is the cost of nitric acid. Almost all commercial nitric acid is made by the oxidation of ammonia. Ammonia synthesis is energy expensive and depends on fossel fuels for the hydrogen requirements. It is unlikely that any developing nation not having an established ammonia industry could economically utilize the phosphate reserve for manufacturing nitric-phosphates. The other avenue available for solublization of apatitite is the use of hydrochloric acid. Hydrogen chloride as an alternative to sulphuric or nitric acids has attractive features. This acid is an under-utilized by-product of the sodium hydroxide industry. Provided the energy requirements are met, the raw material (NaCl) needed for its production is inexhaustible. In the conventional method for production of HCl, hydrogen and chlorine generated in the electrolysis of brine are burnt together. The possibility remains that hydrogen is saved for ammonia manufacture and that chlorine is photochemically reacted with water to obtain HCl and oxygen. From laboratory experiments it is known that this reaction can be carried out using sunlight and a semiconductor photocatalyst [5].

Unfortunately, calcium chloride resulting from °°acidulation apatite°° with HCl makes the fertilizer hygroscopic and unsuitable for storage and handling in the field. Although methods have been devised for the removal of phosphoric acid from calcium chloride, the complicated separation technique becomes the cost-determining factor. In a method developed by the Israel Mining Industries, H_3PO_4 is separated from $CaCl_2$ by solvent extraction with butyl or isoamyl alcohol which is recycled [6].

We have studied a simpler method where the calcium chloride is rendered insoluble by double decomposition with ammonium sulpate. The method has the following advantages. (1) Phosphate fertilizers are generally used in conjunction with nitrogeneous sources. Although ammonium nitrate and urea are becoming more popular nitrogeneous fertilizers, substantial quantities of ammonium sulphate are still used. Several industries yield this salt as a by-product. (2) Ammonium sulphate can be manufactured independently of sulphuric acid using gypsum. The world reserve of gypsum is far in excess of sulphur or sulphide ores available for the manufacture of sulphuric acid. (3) Most high analysis nitrogen and/or phosphate fertilizers do not contain sulphur which is an essential plant nutrient [7–8]. Fertilizer made by this method contains sulphur in addition to phosphorus and nitrogen.

This study was motivated by the necessity of finding a method for beneficiation of apatite mined at Eppawala in Sri Lanka, using local raw materials [9–12]. At present the only mineral acid that is manufactured in Sri Lanka is HCl. The apatite reserve at Eppawala in Sri Lanka is estimated to be 25,000,000 tonnes and at the present demand rate in Sri Lanka, the deposit