MONOMAGNESIUM PHOSPHATE
TRISODIUM DIPHOSPHATE

Chemical and Technical Assessment (CTA)

First draft prepared by M. Rao

1 Summary

Phosphates are used as stabilizers, leavening agents, emulsifiers and nutrient in several processed foods. Phosphates, diphosphates and polyphosphates are evaluated by JECFA at its sixth, seventh, eighth, ninth, thirteenth, fourteenth, seventeenth, twenty sixth and fifty seventh meetings. At the 57th meeting of JECFA, the phosphates listed in Table-1 were evaluated, specifications were prepared and published in FNP 52 Add 9 (2001). Monomagnesium phosphate and Trisodium diphosphates exist in anhydrous form as well as hydrates. Information on the loss on drying, loss on ignition, test method for loss on ignition and assay method for the hydrates forms of the two phosphates was not available and they were placed in the agenda for the 61st JECFA for the revision of specifications.

Information on loss ignition for trisodium diphosphate (anhydrous and monohydrate) and loss on drying on anhydrous material were received and specifications were revised for this compound. The tentative status of the specifications was maintained pending the data on loss on drying for monohydrate.

No information was received on monomagnesium phosphate and the tentative specifications prepared at the 57th JECFA were maintained for this compound.

2 Description

The description of the phosphates is given in Table-1.

Table-1: Description of phosphates

INS	Name	C.A.S.	Chemical formula	Formula wt.
343(i)	Monomagnesium phosphate	13092-66-5	$Mg(H_2PO_4)_2.xH_2O$ (x = 0 to 4)	218.3 (anhydrous) (dihydrate)
452(vi)	Dimagnesium diphosphate	-	$Mg_2P_2O_7$	222.57
450(iv)	Dipotassium diphosphate	14691-84-0	$K_2H_2P_2O_7$. xH_20 (x = 0 or 1)	254.16 (anhydrous)
450(ii)	Trisodium diphosphate	14691-80-6	Na_3 HP_2O_7. xH_20 (x = 0 or 1)	243.93 (anhydrous) (monohydrate)
450(vii)	Calcium dihydrogen diphosphate	14866-19-4	$CaH_2P_2O_7$	215.97
452(iii)	Sodium calcium polyphophate	-	$(NaPO_3)n$ .CaO (typically n = 5)	-

3 Manufacturing

3.1 Raw materials

Phosphoric acid is the principle raw material used in the manufacture of various phophates. Bases such as sodium carbonate, sodium hydroxide, calcium oxide, calcium hydroxide, calcium carbonate, potassium hydroxide, aluminium hydroxide and ammonia are used to get phosphate of interest. The general procedure for the manufacture of phosphoric acid and phosphates are given below:

3.2 Method of manufacture

Phosphoric acid is produced commercially by two methods:: (a) Electro thermal Process. (b) Wet process

Electro Thermal process

In electro thermal process phosphoric acid is manufactured from elemental 'P' (obtained from ores). A carbon source such as coke, is added to the ore (eg. Flourapatile) at temperatures above 1100oC (ideal 1400-1600 °C) to get 'P' from the ore. The 'P' thus obtained is burned in excess of air and the resulting phosphorus pentoxide is hydrated, heats of combustion and hydration are removed and the phosphoric acid mist is collected. Within the limits, the concentration of product acid is controlled by the quantity of water added and the cooling capabilities.

The main impurity is about 20-100 ppm of Arsenic, present in the phosphorus acid. The phosphoric acid, destined for food, pharmaceutical and some industrial grade applications, is treated with excess H2S, filtered and blown with air to strip off excess H_2S. This treatment generally reduces the 'As' content of 'PA' to less than 0.5 ppm.

The phosphoric acid obtained by this process is considerably to be higher purity than than the one from the wet process.

Wet process

In this process the PA is produced in two steps.

Step1: The phosphate rock is digested with sulfuric acid (rarely - HCl also may be used)

Step2: 'PA' generated is separated from resultant $CaSO_4$ slurry by filtration.

To generate filterable slurry and to enhance the P_2O_5 content, much of the acid filtrate is recycled to the reactor.

The two filtration processes are as follows:

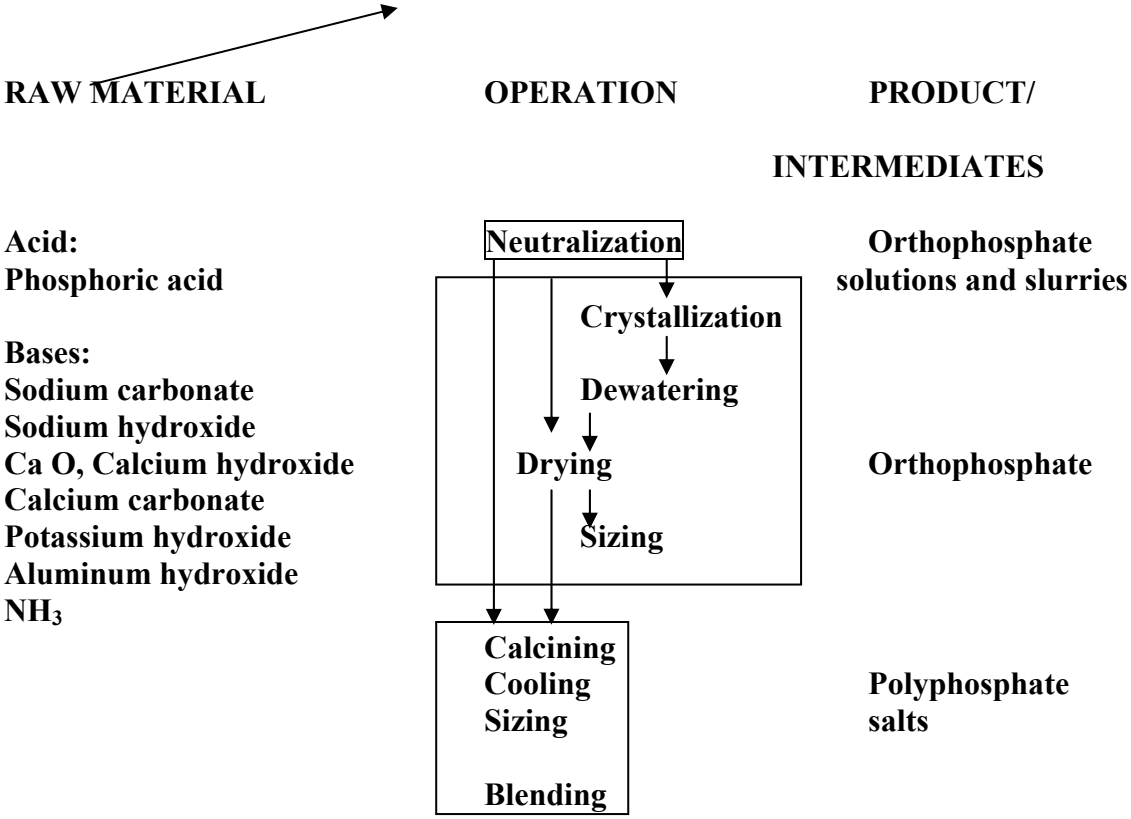
1. Operation at 70-80^oC and about 30% P_2O_5 in the liquid phase resulting in precipitation of filterable $CaSO_4$ 2 H_2O
2. Operation at 80-90^oC and about 40% P_2O_5 providing a filterable $CaSO_4$ 0.5 H_2O

Operations beyond these conditions generally result in poor filtration rates.

'PA' produced by wet-process is being used primarily in the production of fertilizers and animal feed supplements. However, for the manufacture of technical grade and food grade applications, it is purified by following either - the (a). double neutralization process or (b) the solvent extraction purification process, where by the impurities such as Fe, Al, Ca, Mg, sulfate, fluoride etc.,

The solvent extraction purification process is being carried out using C_4 - C_8 alcohols, ethers, ketenes.

3.3 General procedure for the manufacture of phosphates (from phosphoric acid)



Phosphoric acid (PA) is neutralized to form a solution or slurry with a carefully adjusted acid/base ratio according to the desired orthophosphate product.

The orthophosphate can be recovered from the solution, or the entire solution/slurry is evaporated to dryness. The dewatering method is determined by the solubility properties of the product and its desired physical properties such as crystal size/shape, bulk density and surface area. Acid orthophosphate salts may be converted to condensed phosphates by thermal dehydration (calcination)

Preparation of alkali metal phosphates

These compounds generally exhibit congruent solubilities and are therefore usually manufactured by crystallization from solution or by drying of the entire mass.

NaH_2PO_4	Crystallization / evaporation on steam heated drum-dryers
NaH_2PO_4	Crystallization at 40 - 95^oC, centrifugation and drying.

Potassium phosphates are analogues to the sodium salts and share many of the functional properties.

The higher cost of KOH has restricted those salts to applications where high solubilities or nutrient value is important.

Many of the phosphates are more deliquescent than their sodium analogues and may require special storage and moisture proof conditions/ containers.

Preparation of alkaline - earth and other phosphate salts of polyvalent cations

These phosphates typically exhibit incongruent solubility and are prepared either by precipitation from solutions having metal oxide / P_2O_5 ratio considerably lower than that of the products, or by drying a solution or slurry with proper metal oxide / P_2O_5 ratio.

3.4 Method of manufacture

Monomagnesium phosphate

Manufactured by partial neutralization of phosphoric acid with magnesium oxide and drying the resultant product.

Trisodium diphosphate

Manufactured by calcining sodium orthophosphate of appropriate Na_2O : P_2O_5 ratio.

4 Chemical characterization

4.1 Composition

The composition of phosphates is described in the Table-1. Monomagnesium phosphate and Trisodium diphosphates exist in anhydrous form as well as hydrates. Information on loss ignition for trisodium diphosphate (anhydrous and monohydrate) and loss on drying on anhydrous material were received and specifications were revised for this compound. The tentative status of the specifications was maintained pending the data on loss on drying for monohydrate.

No information was received on monomagnesium phosphate and the tentative specifications prepared at the 57th JECFA were maintained for this compound.

4.2 Possible impurities

The possible impurities in phosphates arise from the impurities in the phosphorous. The phosphorous produced from ores by thermal process may contain up to 30-250 ppm of arsenic and other trace metal and these are kept at levels appropriate to the needs of customers by further purification processes.

Levels of impurities such as sulfate, fluoride, arsenic etc., are kept at very low levels (eg., fluoride at less than or equal to 10 ppm, As around 0.5 ppm, in the chemicals of 'PA' or phosphates meant for food / pharmacy applications.

4.3 Analytical methods

Analytical method for the phosphates are documented in the Guide to Specifications, Food and Nutrition Paper 5 (FNP 5) and Compendium of Food Additives Specifications, Food and Nutrition Paper 52 (FNP 52), Addendum 9 and 11.

5 Functional uses

5.1 Technological function

Magnesium phosphates are used as acidulants in raising agents in dough. The magnesium phosphates react slowly and are used to stabilize doughs that will be held for some time before baking

Diphosphates are used as leavening agents in baking industry. The diphosphates function as stabilizers in meat products where they work synergistically with salt, interacting with the meat fibers and causing the fibers to expand and retain water within them. They also work with salt to extract meat proteins, allowing the formation of a meat protein exudates, which will bind meat pieces together in a comminuted or reformed product. In processed cheese, cheese preparations and cheese-based sauces, the phosphates act as emulsifying salts. In this application, they break the calcium bridges between the cheese protein molecules by means of the ion exchange, converting the insoluble cheese protein complexes into individual soluble protein molecules. The protein molecules are then able to emulsify the fat associated with the cheese, in a manner similar to that of sodium caseinate. As this interaction relies on the exchange of sodium or potassium for

the calcium associated with the cheese proteins, the calcium phosphates cannot function in this way. The diphosphates can aid gel formation in products such as instant whips.

The polyphosphates function as stabilizers in foods like diphosphates. In fish and seafood processing, the polyphosphates substantially reduce the drip loss on storage, maintaining the succulence of the products and avoiding the dry and fibrous texture otherwise encountered. In contrast to their functionality in meat products, in this application, the phosphates work both with and without salt. In cheeses, polyphosphates work as emulsifying agents like the diphosphates. The calcium polyphosphate can be used for calcium fortification but their poorer solubility may restrict this function in many food types.

5.2 Food categories and use levels

Monomagnesium phosphate and calcium dihydrogen diphosphate is used in fine bakery wares at levels of 20g/Kg expressed as P_2O_5. Trisodium diphosphate is used in meat products at level of 5g/Kg expressed as P_2O_5 . Sodium calcium polyphosphate is used in processed cheese and processed cheese analogues at level of 5g/Kg expressed as P_2O_5 .

6 Reactions and Fate in Food

Data not available.

7 References

Essential guide to food additives, Mike Saltmarsh (ed.), Leatherhead Publishing, 2000.

Encyclopedia of Food and Colour additives, George A. Burdock, Vol. II, CRC Press.

EC Directives 98/72/EC, 96/85/EC and 2000/63/EC.

Food Chemicals Codex, IIIrd Edn., 1981, National Academy Press, Washington DC