AgriSystems International™
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December 10, 2001

Mr. Robert Pooler
National Organic Program
Agricultural Marketing Service
USDA/AMS/TM/NOP
Room 4008 – So., Ag. Stop 0268
1400 Independence Avenue
Washington, D.C. 20090-6456

Dear Mr. Pooler:

It was good to talk with you last Friday, December 7, 2001 regarding the disposition of our Material Petition submitted to the **NOSB/NOP** for our client, **Kansas City Ingredient Technologies** of Kansas City, Kansas.

As I understand the situation, due to the slow movement of the mail caused by the anthrax problem you have not yet received our formal petition sent by Priority Mail.

Please find herewith *two (2) additional copies* of the Petition we submitted to you for our client **Kansas City Ingredient Technologies, Petition for Evaluation of Substance (Tetrasodium Pyrophosphate) for Inclusion On the National List of Substance Allowed in Organic Handling**.

Also included is a copy of our original letter sent to you with our petition. It is our hope that *Federal Express* gets these materials in your hands prior to December 14, 2001. Please call collect 610 863-6700 to confirm receipt.

If you have any questions and/or if I can be of assistance in any way, please contact me.

Thank you.

Very truly yours,

AGRISYSTEMS INTERNATIONAL

Thomas B. Harding, Jr.
President

cc: KCIT
Midwest Grain Products

UNITED STATES DEPARTMENT OF AGRICULTURE

NATIONAL ORGANIC STANDARDS BOARD

Materials Petition
For Inclusion On The National List

Material
Tetrasodium Pyrophosphate
CAS #7722-88-5

Petitioner

Kansas City Ingredients Technologies

Date Submitted
November 2, 2002

Petition Prepared By

AgriSystems International
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Wind Gap, Pennsylvania 18091
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COPY

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November 2, 2001

National Organic Standards Board
c/o Mr. Robert Pooler
Agricultural Marketing Specialist
USDA/ams/TM/NOP
Room 2510 – So., Ag Stop 0268
P.O. Box 96456
Washington, D.C. 20090-6456

Dear Mr. Pooler:

We are pleased to submit to you for our client **Kansas City Ingredient Technologies,** two (2) copies of our **Petition for Evaluation of Substance (Tetrasodium Pyrophosphate) for Inclusion On the National List of Substance Allowed in Organic Handling.**

To the best of our knowledge, our petition is complete and meets the requirements for petitions as laid out in the OFPA and published in the Federal Register (7 CFR Part 205) (TM-00-04), RIN 0581-AA40.

If you have any questions relative to this Petition please do not hesitate to contact us.

Thank you.

Very truly yours,

AGRISYSTEMS INTERNATIONAL

Thomas B. Harding, Jr.
President

cc: Kansas City Ingredient Technologies

MATERIALS PETITION

TO: **National Organic Standards Board**
c/o Mr. Robert Pooler
Agricultural Marketing Specialist
USDA/AMS/TM/NOP
Room 2510 – So., Ag Stop 0268
P.O. Box 96456
Washington, D.C. 20090-6456

PETITIONER: **Kansas City Ingredient Technologies**
Roger J. Schmidt, President
16 Kansas Avenue
Kansas City, Kansas 66105 U.S.A.
Phone: 913 627-1234
Fax: 913 627-1288
Email: rogers@kcitinc.com

SUBMITTED FOR THE PETITIONERS BY:

AgriSystems International
Organic Program Consultants
Thomas B. Harding, Jr., President
125 West Seventh Street
Wind Gap, Pa. 18091 USA
Phone: 610 863-6700
Fax: 610 863-4622
Email: agrisys1@aol.com

Tetrasodium Pyrophosphate

Processing

Identification

Chemical Name: tetrasodium pyrophosphate

CAS Number: 7722-88-5

Other Names: tetrasodium salt, Phosphotex, TSPP, **sodium phosphate** ($Na_4P_2O_7$), sodium diphosphate ($Na_4P_2O_7$), Victor TSSP, **sodium pyrophosphate**

Other Codes:
ACX # X10000138-0
RTECS UX7350000

Proposed Category

Synthetic / Non-Synthetic:	Allowed or Prohibited:	Suggested Annotation:
Synthetic	*Allowed (processing only)*	*For use with milled or processed grain products*

Product Manufacturer:

Haifa Chemical LTD.
P.O. Box 10809
Haifa Bay, 26120
Israel

HCL Technical
Resource Center
St. Louis, Mo.
Tele: 314 353-6500

Characterization

Composition: $Na_4O_7P_2$

Properties: A condensed orthophosphate, it is a colorless, transparent crystal (decahydrate form) or granular white powder

The Food Chemicals Codex (1996) specifications for $Na_4O_7P_2$ are as follows;
Identification A 1 in 20 solution gives positive tests for sodium.
Assay Not less than 95% of $Na_4O_7P_2$ calculated on the ignited basis.
Arsenic (as As) Not more than 3 ppm.
Fluoride Not more than 0.005%
Heavy Metals (as Pb) Not more than 10 ppm.
Insoluble Substances Not more than 0.2%.
Loss on Ignition $Na_4O_7P_2$ (anhydrous): not more than 0.5%;

How Made:
Food grade tetrasodium pyrophosphate is obtained commercially from the reaction of furnace grade phosphoric acid with sodium carbonate to form disodium phosphate which is in turn heated to 450 degrees Centigrade. (SRI) It can also be produced by molecular dehydration of dibasic sodium phosphate at 500 degrees Centigrade. (The Merck Index, 1989)

Specific Uses:
Its main uses in food processing are as an emulsifier, buffer, nutrient, sequestrant, and dietary supplement (Food Chemicals Codex, 1981). It is used in dairy products, baked goods, cocoa, fruits, vegetables, soft drinks, and meat, poultry and shellfish. Among the main foods that use TSPP are: dairy substitutes, meat and poultry, cheeses, breads and cereals (R H Elliger, 1972). The petitioned use is as a buffer (pH agent) and dough conditioner for milled and processed grain products. An extra benefit is the nutrient value of the phosphorus absorbed as free phosphates when used as a food additive. No limits are placed on food use other than current good manufacturing practices, and the ingredient must meet the specifications of the Food Chemicals Codex.

Other allowed food contact uses include; as an optional ingredient in acrylate ester copolymer food coatings (21CFR175.210), an emulsifying agent in pasteurized process cheese (21CFR133.169), an ingredient for washing/peeling beets at levels not to exceed 0.3ppm (21CFR173.315). It can also be used as a scalding agent for hog and poultry processing (9CFR424.21), water conditioning (levels in steam cannot exceed 15 ppm) (21CFR173.310).

Non-food uses include: an anti-calculus agent for toothpaste; a de-flocculant for well drilling, as a dispersant such as to remove rust stains, as an ingredient in one-fluid ink eradicators, in electrodeposition of metals, as a builder for detergents. Kirk-Othmer (6:419, 7:1001, 8:302, 15:668, 18:679-690), (Merck Index, Eleventh ed.)

Mode of Action: Tetrasodium pyrophosphate (TSPP) in a solution of 1:100 has a pH of 10. It is considered a "neutral" sodium salt of pyrophosphoric acid containing sodium atoms in place of all of the hydrogens. It is useful because of its alkalinity and ability to complex or precipitate alkaline earth and heavy metal ions. It has been shown to inhibit oxidative rancidity in cereal products (Muhler, US Patent 3,467,529) and undesirable enzyme activity (Takabayashi, Y, Nippon Shokuhin Kogyo Gakkaishi, 1965).

TSPP is a well-known protein-solubilizing agent which provides a clean and functional production process. Proteins included in this category are *wheat gluten*, *soy proteins* and *milk proteins* to name a few. Increased solubility of proteins greatly increases the qualitative values, functionality and uses in food systems (ASTARIS LCC Bulletin). **Included in petition.**

Status

OFPA, NOP Final Rule
This product is not currently listed as an approved material on the National List. The previous TAP review of an analog of this product, sodium phosphate, was approved for use in dairy foods only, processing category (NOSB 1995). *Tetrasodium phosphate*, being a condensed orthophosphate, is somewhat chemically analogous to sodium phosphate but with different properties for food use.

However, it is our professional opinion since **Sodium phosphate**, the parent material is approved and on the **National List**, therefore its' direct analogue, **Tetrasodium pyrophosphate** should qualify for inclusion on the National List for use with *"milled and processed grain products"*. Further we see no problem in broadening the category annotation to include other qualified foods.

Regulatory
FDA lists tetrasodium pyrophosphate as GRAS for humans (21 CFR 182.6789). In Canada it is listed as allowed for non-standardized foods with the only annotation being used in accordance with Good Manufacturing Practices (GMP's).

EPA/NIEHS/IRCH/NIOSH

EPA – does not recognize tetrasodium pyrophosphate as a hazardous substance. Manufacturers are exempt from reporting requirements for release or emissions of TSPP (40CFR372.30, 40CFR355.40).

The Indiana Clean Manufacturing Technology and Safe Materials Institute at Purdue University has developed the IRCH hazard evaluation systems for chemicals that establishes separate rankings for ecological effects and occupational health hazards and a combined score for both. Using this system, they have given TSPP an Environmental Hazard Value Score (IRCH) of 1 (1= least hazardous, 100=most hazardous). The Total Hazard Value Score (IRCH) of 6 ranks tetrasodium pyrophosphate at the very bottom of chemicals with any hazard ranking. (IRCH: Indiana Pollution Prevention and Safe Materials Insitute. *The Development of Pollution Prevention Progress Measurement Methods.* Project NP996, EPA Region V. 1996)

NIEHS – No data available

OSHA – Does not regulate tetrasodium pyrophosphate

NIOSH (National Institute for Occupational Safety and Health) – Has established a recommended exposure limit (REL) for TSPP of 5 mg per cubic meter of air for up to a 10 hour work day and 40 hour work week (NIOSH 1992). Rationale for limit is based on the risk of eye and respiratory irritation.

Status Among U.S. Certifiers

Tetrasodium pyrophosphate is not currently approved by any U.S Certifiers. However, Sodium phosphate is included on the **National List** and also the **Organic Materials Review Institute (OMRI) List**, for *dairy use only* and these lists are currently used by most U.S. Certifiers as their organic materials guide!

International

CODEX – Does not appear in Annex 2, 1999)
EU 2092/91 – Does not appear in Annex VI.
IFOAM – Does not appear in Appendix 4 (IFOAM, 2000).
Canada – Does not appear in Appendix C, Permitted Substances List for Processing.
Japan – Does not appear on Processing List.

Special Note: At this present time few processing materials appear on the above reference organizations list, partly due to the incompleteness of several of these regulatory guidelines, annexes and/or standards.

Further in several cases there is no formal materials petition process in place. Also the "prepared foods" category, technology and/or markets are not yet advanced or fully developed. Certainly planned bi-lateral harmonization negotiations will speed along this critical area of the organic foods industry and the regulatory instruments.

Summary of Toxicology

1. **Effects on animals.** tetrasodium pyrophosphate is primarily an irritant when experimental animals were exposed to significant exposure. It caused severe irritation and corneal injury in the eye of rabbits when directly applied. It is also probably a skin irritant because of its alkaline nature (ACGIH 1991; NLM 1992). The oral LD 50 in rats is 4,000mg/kg (NIOSH 1991). A 1 year study in rats indicated no adverse effect level fed a diet of containing 0.1% tetrasodium pyrophosphate (approximately 50mg/kg day) for one year (ACGIH 1991). Toxicology studies have reported that tetrasodium pyrophosphate may inhibit the deposition of calcium salts and the formation of a calcifiable matrix in the aorta of rats treated with large doses of Vitamin D (ACGIH 1991). Teratogenic effects have been shown to result in animals after injection of tetrasodium pyrophosphate. Teratogenic potency was greater at 96-hours that at 0-hour incubation time (ACGIH 1991). However, rat kidneys are capable of concentrating salts to a greater

degree than the kidney of other species. Therefore, it is questionable whether the information obtained from animals and then calculating the effects on humans is valid (Datta, P.K, et.al., J. Sci. Food Agric.1962)

2. **Effects on humans**. Direct exposure to tetrasodium pyrophosphate causes irritation in humans. Acute exposures have resulted in moderate irritation of the eyes, skin, nose, throat and respiratory passages (ACGIH 1991). Pyrophosphate is hydrolyzed to the orthophosphate in the gut (ACGIH 1991). There is actually very little data on the human health effects of the use of phosphates in food processing. Due to long years of experience with no incidence of toxicity or related health effects, there has been apparently very little demand for research into short or long term effects of such use.

   Phosphorus compounds play an important role in the functioning of the body. It is believed that phosphorus is absorbed from the gastrointestinal tract as free phosphate, the various inorganic esters being hydrolyzed by various phosphatase enzymes prior to absorption. Although absorption of inorganic phosphorus is closely associated with the amount of calcium in the diet, it is also influenced by the presence of other elements, e.g. iron, strontium, aluminum, etc. In adults under normal conditions, approximately 2/3 of the ingested phosphates are absorbed (Chapman & Pugsley, 1970. Symposium: Phosphates in Food Processing).

Petition Justification

The use of tetrasodium pyrophosphate as a food additive at allowed levels poses no threat to human health and can actually provide necessary phosphorus in the form of free phosphates. There is virtually no environmental impact from its manufacture, use and disposal. Its intended use as stated in the proposed annotation and specific uses in this petition are primarily not as a preservative, or to recreate flavor, color or texture. Its use as a dough conditioner and pH agent is indispensable because it greatly improves protein process flow. Further with pH adjustments, the protein solubility increases significantly which increases Nitrogen solubility indexes, which is most important for the texturization of the proteins which is also critical to the quality characteristics of the end-use products. Buffering of the protein at 7 to 8 pH appears to be optimal for good textured wheat gluten proteins **(Internal Communications MWGP).**

TSPP also has a sequestrate functionality which naturally inhibits or delays rancidity of the textured products. This helps to maintain its wholesomeness and improves the product shelf-life naturally.

The type of milled and processed products that are produced as a result of this product allow for a much greater extension of use for organic grains that supports and grows the production of organic farm products.

Further it allows innovative organic food processes to enter into a rapidly growing food category and to fully utilize these unique high quality and functional organic protein ingredients to make healthy foods, i.e. meat alternatives and vegetarian prepared foods.

Currently no alternatives exist for the functional properties displayed by tetrasodium pyrophosphate when used according to the proposed annotation.

As a result of our internal proprietary research and process development, we have yet to find a material(s) equal to **TSPP** in overall functionality and process flow, at such minor processing amounts and therefore is essential to our proprietary process and the final qualitative values of the final product for the end user.

Further, commonly used and accepted alternative materials, i.e. *sodium hydroxide, sulfur compounds*, or *tetrapotassium phosphate* offers us no serious processing advantage and none are currently approved for organic processing. Equally important these materials greatly reduce our product quality, functionality and

affordability – and cause unwanted product discoloration and undesirable odor and foul taste to these unique products.

References

American Conference of Governmental Industrial Hygienists, Inc. 1991. *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 6th ed. VOL I,II, III. Cincinnati, OH: ACGIH.

Budavari, S. (ed.) 1989. *The Merck Index.* Whitehouse Station, NJ: Merck and Co.

Curlin, L.C., T.V. Bommarju, and C.B. Hansson. 1991. Phosphates, *Kirk-Othmer Encyclopedia of Chemical Technology* 18: 679-690.

Deman & Melnychyn, (eds.) 1970. *Symposium: Phosphates in Food Processing, University of Guelph.* The Avi Publishing Co. Westport CN.

Elliger, R.H. 1972 *Phosphates as Food Additives.* CRC Press, Cleveland OH.

FAO/WHO Joint Standards Programme. 1999. *Codex Alimentarius Guidelines for the Production, Processing, Labelling and Marketing of Organic Processed Foods.*CAC/GL 32-1999. Rome, Italy: FAO/WHO.

Food Phosphates By ASTARIS – Astaris LLC, St. Louis, Missouri

Furia, T.E. 1980. *Handbook of Food Additives, 2nd Ed.* CRC Press, Cleveland, OH.

Food and Nutrition Board, National Academy of Sciences. 1996. *Food Chemicals Codex* 4th Ed. Washington, DC: National Academy Press.

International Federation of Organic Agriculture Movements. 2000. *Basic Standards.* Tholey-Theley, Germany: IFOAM.

IRCH: Indiana Pollution Prevention and Safe Materials Institute. The Development of Pollution Prevention Progress Measurement Methods Project. Project No. NP996. EPA Region V. 1996

National Organic Standards Board (NOSB). 1995. Organic Good Manufacturing Practices (Final Recommendation Addendum 7). Orlando, FL: April 25.

Occupational Safety and Health Guideline for Tetrasodium Pyrophosphate. http://www.osha-soc.gov/SLIC/healthguidelines/tetrasodiumpyrophosphate/html. September 1, 2001.

Taylor, R.J. 1980. *Food Additives.* John Wiley & Sons.NY.

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: Tetrasodium pyrophosphate pwd FCC
DOCUMENT IDENTIFIER: 03133
APPLICABLE CODES: 03133; 10000193
SYNONYMS: TSPP; Tetrasodium pyrophosphate
CHEMICAL FAMILY NAME: Inorganic, salt
NFPA HAZARD RATINGS(H-F-R): 1-0-0
HMIS HAZARD RATINGS(H-F-R): 1-0-0
DISTRIBUTOR: HCI USA Distribution Companies
IN CASE OF EMERGENCY CALL: 1-800-424-9300

MSDS PREPARED BY: HCI Technical Resource Center
St. Louis, MO 63111
(314) 353-6500

2. COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENTS	CAS NUMBERS	Percent
Tetrasodium pyrophosphate	007722-88-5	100

Trace impurities and additional material names not listed above may also appear in the Regulatory Information Section (Section 15) towards the end of the MSDS. These materials may be listed for local "Right to Know" compliance and for other reasons.

3. HAZARDOUS IDENTIFICATION

EMERGENCY OVERVIEW: CAUTION! May cause irritation to skin, eyes, respiratory tract, and gastrointestinal tract.

POTENTIAL HEALTH EFFECTS:

SKIN CONTACT: Contact with the skin may cause irritation.
SKIN ABSORPTION: No data available
EYES: Contact with the eyes may cause irritation.
INGESTION: Ingestion may cause gastrointestinal irritation, nausea, vomiting, and diarrhea.
INHALATION: Inhalation may be irritating to respiratory tract.

MEDICAL CONDITIONS AGGRAVATED:
No data available

This product does not contain any chemicals reportable under California Proposition 65.
Components found on one of the OSHA designated carcinogen lists are listed below.

INGREDIENT	NTP	IARC	OSHA
Tetrasodium pyrophosphate	N	N	N

4. FIRST AID MEASURES

SKIN CONTACT: Remove contaminated clothing and shoes.
Wash exposed areas with soap and water.
Call a physician if irritation persists.

EYE CONTACT: Flush eyes with water for at least 15 minutes.
Call a physician if irritation persists.

INGESTION: Call a physician immediately!
Rinse mouth with water.
Do not give anything by mouth to an unconscious person.

INHALATION: Remove to fresh air.
If breathing has stopped, give artificial respiration.
Get medical attention.

NOTES TO PHYSICIAN: No data available

5. FIRE FIGHTING MEASURES

FIRE AND EXPLOSIVE PROPERTIES

FLASH POINT: Not applicable °F

FLASH POINT: Not applicable °C

FLASH POINT METHOD: Not applicable

LOWER FLAMMABILITY LIMIT: Not applicable

UPPER FLAMMABILITY LIMIT: Not applicable

AUTOIGNITION TEMPERATURE: Not applicable °F, Not applicable °C

FLAMMABILITY CLASSIFICATION: Not applicable

EXTING. MEDIA: This product is not flammable. Use extinguishing media for surrounding fire.

FIRE FIGHTING : Cool fire-exposed containers with water spray.

PROTECTIVE EQUIPMENT: Use NIOSH-approved self-contained breathing apparatus and complete protective clothing when fighting chemical fires.

FIRE HAZARDS: During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion.

6. ACCIDENTAL RELEASE MEASURES

SMALL SPILLS: Contain spill and ventilate area. Sweep up and containerize for disposal.

LARGE SPILLS: Contain spill and ventilate area. Permit only trained personnel wearing full protective equipment to enter the spill area. Collect the spill in a waste container or remove with a vacuum truck. Prevent spill from entering natural watercourses.

PROTECTIVE EQUIPMENT\ SPILL-RELEASE INSTRUCTIONS:
Wear complete protective clothing when cleaning up chemical spills. Spills and releases may have to be reported to federal and/or local authorities. See the Regulatory Information section (section 14) regarding reporting requirements.

7. HANDLING AND STORAGE

HANDLING: Avoid contact with skin, eyes, and clothing.
Avoid breathing product dust.
Do not take internally.
Wash thoroughly after handling this material.
Use this material only with adequate ventilation.

STORAGE : Keep container closed when not in use.
This material should be stored in a dry, cool place. Store in well ventilated areas and at moderate temperatures.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS:
Special ventilation is not required under normal use. Use local exhaust ventilation where dust, mist, or spray may be generated.

PERSONAL PROTECTIVE EQUIPMENT

SKIN: Wear protective gloves made of neoprene or rubber.

EYE : Wear chemical safety goggles.

RESPIRATORY: Use a NIOSH-approved respirator for dusts/mists when necessary.
Emergency showers, eye-wash stations, and fire blankets should be accessible.

OTHER: Wear protective clothing.

EXPOSURE GUIDELINES :

INGREDIENT	ACGIH TLV	ACGIH STEL	OSHA PEL	OSHA STEL
Tetrasodium pyrophosphate	5 mg/m3	N/EST	N/EST	N/EST

N/EST = Not established

See 29 CFR 1910.1000 (D) (2) and ACGIH "Threshold Limit Values for Chemical Substances and Physical Agents Biological Exposure Indices" booklet (Appendix C) for the determination of exposure limits for mixtures. Consult an industrial hygenist or similar professional to confrim that the calculated exposure limits are approriate.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE:	Solid
APPEARANCE	White powder or granules
ODOR:	Odorless
SPECIFIC GRAVITY:	2.534
SOLUBILTY (IN WATER):	7% @ 25C
BOILING POINT (°F):	Not applicable
BOILING POINT (°C):	Not applicable
FREEZING POINT (°F):	1810.4
FREEZING POINT (°C):	988
MELTING POINT (°F):	1810.4
MELTING POINT (°C):	988
PRODUCT pH :	10 (1% soln)
VAPOR PRESSURE:	Not applicable
VAPOR DENSITY:	Not applicable
EVAPORATION RATE:	Not applicable
% VOLATILES:	Not applicable

10. STABILITY AND REACTIVITY

STABILITY:	Stable
CONDITIONS TO AVOID:	Exposure to high temperatures should be minimized. Avoid generating dust.

DECOMPOSITION:	Oxides of sodium Oxides of phosphorus
POLYMERIZATION WILL OCCUR:	no

11. TOXICOLOGICAL INFORMATION

IMMEDIATE EFFECTS:	May cause irritaiton to skin, eyes, respiratory tract, and gastrointestinal tract. TOXICITY DATA: LD50: 4 gm/kg oral-rat; LD50: 59 mg/kg intraperitoneal-rat; LD50: 100 mg/kg intravenous-rat; LD50: 2980 mg/kg oral-mouse; LD50: 400 mg/kg subcutaneous-mouse; LD50: 69 mg/kg intravenous-mouse; LD: >300 mg/kg skin-rabbit
CARCINOGENICITY:	No data available
MUTAGENICITY:	No data available
EPIDEMIOLOGY:	No data available
TERATOGENICITY:	No data available
REPRODUCTIVITY:	No data available
NEUROTOXICITY:	No data available

12. ECOLOGICAL INFORMATION

ECOTOXICITY DATA: FISH TOXICITY: LC50: 700000 ug/L 48 hours (Mortality) Medaka, high-eyes (Oryzias latipes); INVERTEBRATE TOXICITY: LC50: 391000 ug/L 48 weeks (Mortality) Water flea (Daphnia magna)

13. DISPOSAL CONSIDERATIONS

RCRA WASTE:	No
RCRA ID NUMBER:	Not applicable
VOC CONTENT (lbs/gal):	Not available
Waste Disposal Procedure:	Discharge, treatment, or disposal may be subject to Federal, State, or Local laws. State and Local regulations and restrictions are complex and may differ from Federal disposal regulation. The information offered here is for the product as shipped. Use and/or alterations to the product such as mixing with other materials may significantly change the characteristics of the material and alter the RCRA Classification and the proper disposal method.

14. TRANSPORTATION INFORMATION

D.O.T. SHIPPING NAME: Not D.O.T. regulated
D.O.T. HAZARD CLASS: None
DOT ID NUMBER: UN N/AP
DOT PACKING GROUP: None
DOT RQ (lbs): N/AP
OTHER: None
IMDG HAZARD CLASS: None
ICAO HAZARD CLASS: None

15. REGULATORY INFORMATION

FEDERAL REGULATIONS

TSCA (Toxic Substance Control Act): yes
SECTION 311/312 HAZARD CLASS: Immediate (acute) health hazard

SARA TITLE III (Superfund Amendments and Reauthorization Act):

INGREDIENTS	CAS NUMBERS	Section 313	Section 302
Tetrasodium pyrophosphate	007722-88-5	N	N

FOREIGN REGULATIONS

WHMIS CLASSIFICATION (CANADA): Not restricted
FOREIGN INVENTORY: EINECS (European Inventory of Existing Commercial Chemical Substances)
Canadian DSL (Domestic Substances List)

STATE RIGHT TO KNOW

CALIFORNIA PROP 65

This product does not contain any chemicals reportable under California Proposition 65.

MASSACHUSETTS SUBSTANCE LIST:	Tetrasodium pyrophosphate
NEW JERSEY SUBSTANCE LIST:	Tetrasodium pyrophosphate
PENNSYLVANIA HAZARDOUS SUBSTANCE LIST:	Tetrasodium pyrophosphate

16. OTHER INFORMATION

CREATION DATE: 03/31/1997
REVISION DATE: 05/01/2000

DISCLAIMER:
The information herein is presented in good faith and is believed to be correct as of the date hereof. However, HCI makes no representation as to the completeness and accuracy thereof. Users must make their own determination as to the suitability of the product for their purposes prior to use. No representations or warranties, either expressed or implied, of merchantability, fitness for a particular purpose, or of any other nature with respect to the product or to the information herein is made hereunder. HCI shall in no event be responsible for any damages of whatsoever nature directly or indirectly resulting from the publication, or use of, or reliance upon the information contained herein.

Subpart F—Dietary Supplements [Reserved]

Subpart G—Sequestrants [1]

§ 182.6085 Sodium acid phosphate.

(a) *Product.* Sodium acid phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6197 Calcium diacetate.

(a) *Product.* Calcium diacetate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6203 Calcium hexametaphosphate.

(a) *Product.* Calcium hexametaphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6215 Monobasic calcium phosphate.

(a) *Product.* Monobasic calcium phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6285 Dipotassium phosphate.

(a) *Product.* Dipotassium phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6290 Disodium phosphate.

(a) *Product.* Disodium phosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6757 Sodium gluconate.

(a) *Product.* Sodium gluconate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6760 Sodium hexametaphosphate.

(a) *Product.* Sodium hexametaphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6769 Sodium metaphosphate.

(a) *Product.* Sodium metaphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6778 Sodium phosphate.

(a) *Product.* Sodium phosphate (mono-, di-, and tribasic).

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6787 Sodium pyrophosphate.

(a) *Product.* Sodium pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6789 Tetra sodium pyrophosphate.

(a) *Product.* Tetra sodium pyrophosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

§ 182.6810 Sodium tripolyphosphate.

(a) *Product.* Sodium tripolyphosphate.

(b) *Conditions of use.* This substance is generally recognized as safe when used in accordance with good manufacturing practice.

Subpart H—Stabilizers

§ 182.7255 Chondrus extract.

(a) *Product.* Chondrus extract (carrageenin).

[1] For the purpose of this subpart, no attempt has been made to designate those sequestrants that may also function as chemical preservatives.

Heavy Metals A solution of 2 g in 25 ml of water meets the requirements of the *Heavy Metals Test*, page 512, using 20 µg of lead ion (Pb) in the control (*Solution A*).

Iron Dissolve 300 mg in 40 ml of water, and add 2 ml of hydrochloric acid, about 40 mg of ammonium persulfate, and 10 ml of ammonium thiocyanate TS. Any red or pink color does not exceed that produced by 0.9 ml of *Iron Standard Solution* (9 µg Fe) in an equal volume of solution containing the quantities of reagents used in the test.

Water Determine by the *Karl Fischer Titrimetric Method*, page 552.

Packaging and Storage Store in tight containers.

Functional Use in Foods Preservative; mold and rope inhibitor.

Sodium Pyrophosphate

Tetrasodium Diphosphate; Tetrasodium Pyrophosphate

$Na_4P_2O_7$ Mol wt 265.90

DESCRIPTION

Sodium pyrophosphate is anhydrous or contains 10 molecules of hydration. It occurs as a white, crystalline or powder. The decahydrate effloresces slightly in dry air. It is soluble in water, but is insoluble in alcohol. The pH of a 1 in 100 solution is about 10.

REQUIREMENTS

Identification

A. A 1 in 20 solution gives positive tests for *Sodium*, page 517.

B. Dissolve 100 mg of the sample in 100 ml of diluted nitric acid TS. Add 0.5 ml of this solution to 30 ml of quimociac TS. A yellow precipitate does not form. Heat the remaining portion of the sample solution for 10 min at 95°, and then add 0.5 ml of the solution to 30 ml of quimociac TS. A yellow precipitate forms immediately.

Assay Not less than 95.0% of $Na_4P_2O_7$, calculated on the ignited basis.

Arsenic (as As) Not more than 3 ppm.

Fluoride Not more than 0.005%.

Heavy Metals (as Pb) Not more than 10 ppm.

Insoluble Substances Not more than 0.2%.

Loss on Ignition $Na_4P_2O_7$ (anhydrous): not more than 0.5%; $Na_4P_2O_7 \cdot 10H_2O$ (decahydrate): between 38% and 42%.

TESTS

Assay Dissolve an accurately weighed quantity of the sample, equivalent to 500 mg of anhydrous $Na_4P_2O_7$, in 100 ml of water in a 400-ml beaker. Adjust the pH of the solution to 3.8 with hydrochloric acid, using a pH meter, then add 50 ml of a 1 in 8 solution of zinc sulfate (125 g of $ZnSO_4 7H_2O$ dissolved in water, diluted to 1000 ml, filtered, and adjusted to pH 3.8), and allow to stand for 2 min. Titrate the liberated acid with 0.1 *N* sodium hydroxide until a pH of 3.8 is again reached. After each addition of sodium hydroxide near the endpoint, time should be allowed for any precipitated zinc hydroxide to redissolve. Each ml of 0.1 *N* sodium hydroxide is equivalent to 13.30 mg of $Na_4P_2O_7$.

Arsenic A solution of 1 g in 35 ml of water meets the requirements of the *Arsenic Test*, page 464.

Fluoride Determine on a 2-g sample as directed in *Method IV* under the *Fluoride Limit Test*, page 512, using *Buffer Solution A* and 0.1 ml of *Fluoride Standard Solution*.

Heavy Metals A solution of 2 g in 25 ml of water meets the requirements of the *Heavy Metals Test*, page 512, using 20 µg of lead ion (Pb) in the control (*Solution A*).

Insoluble Substances Dissolve 10 g in 100 ml of hot water, and filter through a tared filtering crucible. Wash the insoluble residue with hot water, dry at 105° for 2 h, cool, and weigh.

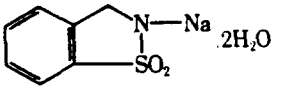
Loss on Ignition Dry at 110° for 4 h, and then ignite at about 800° for 30 min.

Packaging and Storage Store in tight containers.

Functional Use in Foods Emulsifier; buffer; nutrient; dietary supplement.

Sodium Saccharin

1,2-Benzisothiazolin-3-one 1,1-Dioxide Sodium Salt; Sodium *o*-Benzosulfimide; Soluble Saccharin



$C_7H_4NNaO_3S.2H_2O$ Mol wt 241.19

DESCRIPTION

White crystals or a white, crystalline powder. It is odorless or has a faint, aromatic odor. It has an intensely sweet taste, even in dilute solutions. In powdered form, it effloresces to the extent that it usually contains only about one third the amount of water indicated in its molecular formula. One g is soluble in 1.5 ml of water and in about 50 ml of alcohol.

REQUIREMENTS

Identification

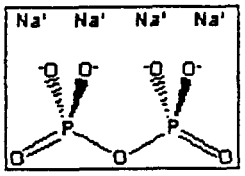
A. Dissolve about 100 mg in 5 ml of sodium hydroxide solution (1 in 20), evaporate to dryness, and gently fuse the residue over a small flame until it no longer evolves ammonia. After the residue has cooled, dissolve it in 20 ml of water, neutralize the solution with diluted hydrochloric

Sodium Pyrophosphate [7722-88-5]

Synonyms: Pyrophosphoric acid, tetrasodium salt; Tetrasodium Pyrophosphate; Phosphotex; TSPP; Sodium Diphosphate; Diphosphoric acid, tetrasodium salt; Sodium diphosphate (Na4P2O7); Sodium phosphate (Na4P2O7); Sodium pyrophosphate (4:1); Sodium pyrophosphate (Na4P2O7); Tetrasodium diphosphate; Victor TSPP;

$Na_4O_7P_2$

265.9024



View with ChemDraw Plugin
Save in CDX format

Add Compound Add or Change Property Add Link Feedback

ACX Number	X1000138-0	CAS RN	7722-88-5
Melting Point (°C)		Density	
Boiling Point (°C)		Vapor Density	
Refractive Index		Vapor Pressure	
Evaporation Rate		Water Solubility	
Flash Point (°C)		EPA Code	
DOT Number		RTECS	UX7350000

Comments: Colorless, transparent crystals or white powder

More information about the chemical is available in these categories:

Chemical Online Order Health Pesticides/Herbicides Physical Properties Regulations

TETRASODIUM PYROPHOSPHATE

CASRN: 7722-88-5

For other data, click on the Table of Contents

FDA Requirements:

Tetrasodium pyrophosphate used as a sequestrant in food for human consumption is generally recognized as safe when used in accordance with good manufacturing practice.
[21 CFR 182.6789 (4/1/93)]**PEER REVIEWED**

Tetrasodium pyrophosphate used as a sequestrant in animal drugs, feeds, and related products is generally recognized as safe when used in accordance with good manufacturing or feeding practice.
[21 CFR 582.6789 (4/1/93)]**PEER REVIEWED**

TETRASODIUM PYROPHOSPHATE

CASRN: 7722-88-5

For other data, click on the Table of Contents

Methods of Manufacturing:

REACTION OF FURNACE-GRADE PHOSPHORIC ACID WITH SODIUM CARBONATE TO FORM DISODIUM PHOSPHATE WHICH IS IN TURN HEATED TO 450 DEGREES CENTIGRADE, FORMING TETRASODIUM PYROPHOSPHATE
[SRI]**PEER REVIEWED**

PRODUCED BY MOLECULAR DEHYDRATION OF DIBASIC SODIUM PHOSPHATE @ 500 DEG C: BELL, INORG SYN 3, 98 (1950).
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1455]**PEER REVIEWED**

By fusing sodium phosphate, dibasic
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 1067]**PEER REVIEWED**

TETRASODIUM PYROPHOSPHATE

CASRN: 7722-88-5

For other data, click on the Table of Contents

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

WHEN TSPP WAS ADDED TO THE DIET OF RATS FOR A PERIOD OF 6 MONTHS, MAXIMUM LEVEL TOLERATED EXCEEDED 1.8%, BUT WAS LESS THAN 3.0%. EXCESS PHOSPHATE CAUSED KIDNEY DAMAGE. /FROM TABLE/

[Furia, T.E. (ed.). CRC Handbook of Food Additives. 2nd ed. Cleveland: The Chemical Rubber Co., 1972. 638]**PEER REVIEWED**

WHEN TSPP WAS ADDED TO THE DIET OF RATS FOR A PERIOD OF 16 WK, MAXIMUM LEVEL TOLERATED WAS LESS THAN 1%. EXCESS PHOSPHATE CAUSED KIDNEY DAMAGE. /FROM TABLE/

[Furia, T.E. (ed.). CRC Handbook of Food Additives. 2nd ed. Cleveland: The Chemical Rubber Co., 1972. 638]**PEER REVIEWED**

SIGNIFICANT TOXICITY WAS PRODUCED IN DEVELOPING CHICKEN EMBRYOS UNDER ALL TEST CONDITIONS; YOLK TREATMENT (0.125-5 MG/EGG) @ 0 HR RESULTED IN ONLY 1 BIRD WITH SERIOUS ANOMALY (ECTOPIA CARDIS). TREATMENTS RESULTED IN MANY BIRDS WITH SEVERE & USUALLY MULTIPLE TERATA.

[VERRETT M ET AL; TOXICOL APPL PHARMACOL 56, 265 (1980)]**PEER REVIEWED**

Acute studies show that direct contact causes severe irritation and corneal injury in the rabbit eye and that it may be irritating to skin.

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I,II, III. Cincinnati, OH: ACGIH, 1991. 1529]**PEER REVIEWED**

A 1 yr diet study in rats indicated a no adverse effect level ... of 0.1% (approximately 50 mg/kg/day) for TSPP.

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I,II, III. Cincinnati, OH: ACGIH, 1991. 1259]**PEER REVIEWED**

... Can be considered moderately toxic on ingestion, inducing metabolic acidosis and hypocalcemia.

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I,II, III. Cincinnati, OH: ACGIH, 1991. 1529]**PEER REVIEWED**

TETRASODIUM PYROPHOSPHATE

CASRN: 7722-88-5

For other data, click on the Table of Contents

Pharmacology:

Interactions:

... Sodium pyrophosphate inhibits both the deposition of calcium salts and the formation of a calcifiable matrix in the aorta of rats treated with large doses of vitamin D.

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I,II, III. Cincinnati, OH: ACGIH, 1991. 1529]**PEER REVIEWED**

Minimum Fatal Dose Level:

3(?). 3= MODERATELY TOXIC: PROBABLE ORAL LETHAL DOSE (HUMAN) 0.5-5 G/KG, BETWEEN 1 OZ AND 1 PINT (OR 1 LB) FOR 70 KG PERSON (150 LB). ... SOME ANIMAL DATA SUGGEST THAT PYROPHOSPHATE IS CONSIDERABLY (AND UNACCOUNTABLY) MORE TOXIC THAN IMPLIED BY TOXICITY RATING OF 3.

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-121]**PEER REVIEWED**

TETRASODIUM PYROPHOSPHATE

CASRN: 7722-88-5

For other data, click on the Table of Contents

Metabolism/Metabolites:

Pyrophosphate is hydrolyzed to the orthophosphate in the gut.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I,II, III. Cincinnati, OH: ACGIH, 1991. 1529]**PEER REVIEWED**

ABOUT THE CHEMICALS | Human Health Hazards

Chemical: TETRASODIUM PYROPHOSPHATE
CAS Number: 7722-88-5

The Indiana Clean Manufacturing Technology and Safe Materials Institute at P University has developed a hazard evaluation system for chemicals that prod separate rankings for ecological effects and occupational health effects, as we hazard score that integrates both types of hazards. This system, the Indiana I Chemical Hazard Ranking System (formerly known as 3P2M), combines inforn about a chemical's toxicity to humans and ecosystems with information about characteristics that influence the likelihood of exposure to a substance.

WHAT DO THE SCORES MEAN?

IRCH environmental hazard value scores indicate how a chemical compares w in terms of its capacity to impact human health, ecosystems, or environmenta generally. The scores combine the UTN total hazard value scores with air, lan global hazard values that are based on the presence of a chemical on several and target lists. The graphic shows where a compound's hazard score falls rel chemicals that have been ranked using this system, indicating whether it is n hazardous than most chemicals. Chemicals that score at the far right end of t are significantly more hazardous (in the worst 10% of all chemicals according scoring system).

All chemicals scored by a system have been placed in "bins" defined by perce a chemical's score is in the least toxic 25% of chemicals scored by a system). graphic illustrates which bin a chemical falls in according to each scoring syst Scorecard. Looking across these different systems, it is possible to identify ch that consistently score as high or low hazards, as well as chemicals that score some measures (such as human health hazards) but low on others (such as e hazards).

STRENGTHS AND WEAKNESSES OF THIS TYPE OF SCORING SYSTEM?

The IRCH environmental hazard scores are based on toxicity and persistence considerations. Since persistence can be a useful surrogate for exposure pote scores provide an improved indicator of the potential environmental health im environmental releases. Moreover, Because the IRCH environmental scores in UTN total hazard value scores, not the UTN (aquatic) ecological efects scores, include measures of human health impacts. This makes them more like gener environmental health indicators than purely ecological indicators.

ENVIRONMENTAL HAZARD VALUE SCORE (IRCH) FOR TETRASODIUM PYROPHOSPHATE

Environmental Hazard Value Score (IRCH) = 1

TECHNICAL DETAILS ON HOW SCORES ARE DERIVED

The IRCH system assigns hazard scores between 0 and 100 based on the follc algorithm:

Environmental Hazard = HVwater+ HVair + HVland + HVglobal

EDF was unable to extend the IRCH system to additional chemicals because t
Scorecard lacks some of data elements that are required by this system.

REFERENCE

IRCH: Indiana Pollution Prevention and Safe Materials Institute. *The Developr
Pollution Prevention Progress Measurement Methods Project*. Project No. NP9
EPA Region V. 1996.
http://www.ecn.purdue.edu/CMTI/Pollution_Prevention_Progress_Measureme

ENVIRONMENTAL DEFENSE

Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

PollutionWatch Canada

ABOUT THE CHEMICALS | Human Health Hazards

Chemical: TETRASODIUM PYROPHOSPHATE

CAS Number: 7722-88-5

The Indiana Clean Manufacturing Technology and Safe Materials Institute (CM Purdue University has developed a hazard evaluation system for chemicals th produces separate rankings for ecological effects and occupational health effe as a total hazard score that integrates both types of hazards. This system, the Relative Chemical Hazard Ranking System (formerly known as 3P2M), combin information about a chemical's toxicity to humans and ecosystems with inforr about chemical characteristics that influence the likelihood of exposure to a si

WHAT DO THE SCORES MEAN?

IRCH environmental hazard value scores indicate how a chemical compares w in terms of its capacity to impact human health, ecosystems, or environmenta generally. The graphic shows where a compound's hazard score falls relative t chemicals that have been ranked using this system, indicating whether it is m hazardous than most chemicals. Chemicals that score at the far right end of t are significantly more hazardous (in the worst 10% of all chemicals according scoring system).

All chemicals scored by a system have been placed in "bins" defined by perce a chemical's score is in the least toxic 25% of chemicals scored by a system). graphic illustrates which bin a chemical falls in according to each scoring syst Scorecard. Looking across these different systems, it is possible to identify ch that consistently score as high or low hazards, as well as chemicals that score some measures (such as human health hazards) but low on others (such as e hazards).

STRENGTHS AND WEAKNESSES OF THIS TYPE OF SCORING SYSTEM?

IRCH total hazard value scores are based on toxicity and exposure considerati Moreover, IRCH total scores are the only scores that integrate concerns about and (occupational) human health impacts into a combined score. This ensures chemicals that pose low human health hazards, for example, remain priorities pose high ecological hazards.

TOTAL HAZARD VALUE SCORE (IRCH) FOR TETRASODIUM PYROPHOSI

Total Hazard Value Score (IRCH) = 6

TECHNICAL DETAILS ON HOW SCORES ARE DERIVED

The IRCH system assigns hazard scores between 0 and 200 based on the follc algorithm:

Total Hazard Value = [(1.15 x Worker Exposure Hazard Value) + (Environmer Value/3.5)]/2

The components of the total hazard value include a wide variety of measures a chemical's toxicity and physical-chemical properties such as vapor pressure to bioaccumulate, corrosivity, and so on.

- HVwater = UTN total hazard value score
- HVair = sum of hazard values assigned if a chemical is a criteria polluta hazardous air pollutant, a high risk pollutant, or an extremely hazardou substance
- HVland= hazard value assigned according to its hazardous waste classif characteristics
- HVglobal = hazard value assigned if a chemical is a Class I or Class II o depleting substance

The IRCH system is an improvement over other ranking systems because it c ecological impacts in water, air, and land. In contrast, the UTN system, for ex only considers aquatic ecosystem effects.

Several policy choices influence the rankings that result from use of this algo First, it is possible to give equal or different weights to hazard values for the endpoints within an effect category (e.g., to give double weight to compounds aquatic life). Second, some method of assigning hazard values to parameters data is required (e.g., to treat the absence of data as indicating the absence or to penalize data gaps). IRCH uses several alternative chemical rankings ba different versions of these policy choices.

EDF was unable to extend the IRCH system to additional chemicals because t Scorecard lacks some of data elements that are required by this system.

REFERENCE

IRCH: Indiana Pollution Prevention and Safe Materials Institute. *The Developr Pollution Prevention Progress Measurement Methods Project.* Project No. NP9 EPA Region V. 1996.
http://www.ecn.purdue.edu/CMTI/Pollution_Prevention_Progress_Measureme

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR TETRASODIUM PYROPHOSPHATE

INTRODUCTION

This guideline summarizes pertinent information about tetrasodium pyrophosphate for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine whether new information is available.

SUBSTANCE IDENTIFICATION

* Formula

Na(4)P(2)O(7)

* Structure

(For Structure, see paper copy)

* Synonyms

Anhydrous tetrasodium pyrophosphate, phosphotex, pyrophosphate, sodium pyrophosphate, TSPP

* Identifiers

1. CAS No.: 7722-88-5

2. RTECS No.: UX7350000

3. Specific DOT number: None

4. Specific DOT label: None

* Appearance and odor

Tetrasodium pyrophosphate is a white anhydrous powder that can also be in the form of a crystalline decahydrate material.

of a crystalline decahydrate material.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 265.90

2. Boiling point: Data not available.

3. Specific gravity: 2.534 (anhydride) at 20 degrees C (68 degrees F)

4. Vapor density: Data not available.

5. Melting point: 880 degrees C (1616 degrees F)

6. Vapor pressure: Data not available.

7. Solubility: Both the anhydride and decahydrate are soluble in water; insoluble in alcohol (decahydrate).

8. Evaporation rate: Data not available.

* Reactivity

1. Conditions contributing to instability: None reported.

2. Incompatibilities: Contact between tetrasodium pyrophosphate and strong oxidizing agents or acids should be avoided.

3. Hazardous decomposition products: Toxic gases such as oxides of phosphorus and sodium may be released in a fire involving tetrasodium pyrophosphate.

4. Special precautions: None reported.

* Flammability

Tetrasodium pyrophosphate is not combustible.

The National Fire Protection Association has not assigned a flammability rating to tetrasodium pyrophosphate.

1. Flash point: Data not available.

2. Autoignition temperature: Data not available.

3. Flammable limits: Data not available.

4. Extinguishant: Use an extinguishant that is suitable for the materials involved in the surrounding fire.

Fires involving tetrasodium pyrophosphate should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary

personnel. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving tetrasodium pyrophosphate.

EXPOSURE LIMITS

* OSHA PEL

The Occupational Safety and Health Administration (OSHA) does not currently regulate tetrasodium pyrophosphate.

* NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for tetrasodium pyrophosphate of 5 milligrams per cubic meter (mg/m(3)) of air as a TWA for up to a 10-hour workday and a 40-hour workweek [NIOSH 1992].

* ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned tetrasodium pyrophosphate a threshold limit value (TLV) of 5 mg/m(3) as a TWA for a normal 8-hour workday and a 40-hour workweek [ACGIH 1994, p. 33].

* Rationale for Limits

The NIOSH limit is based on the risk of eye and respiratory irritation [NIOSH 1992]. The ACGIH limit is based on the risk of irritation [ACGIH 1991, p. 1529].

HEALTH HAZARD INFORMATION

* Routes of Exposure

Exposure to tetrasodium pyrophosphate can occur through inhalation, ingestion, and eye or skin contact.

* Summary of toxicology

1. Effects on Animals: Tetrasodium pyrophosphate is primarily an irritant in experimental animals. It causes severe irritation and corneal injury in the rabbit eye and is probably irritating to the skin because of the alkaline nature of the chemical [ACGIH 1991; NLM 1992]. The oral LD(50) in rats is 4,000 mg/kg [NIOSH 1991]. No adverse effects were observed in rats fed a diet containing 0.1 percent tetrasodium pyrophosphate (approximately 50 mg/kg/day) for one year [ACGIH 1991]. Toxicology studies have reported that tetrasodium pyrophosphate may inhibit calcium deposition and the formation of calcifiable matrix in the aorta of rats following treatment with large doses of vitamin D [ACGIH 1991]. Teratogenic effects have been shown to result in animals after injection of tetrasodium pyrophosphate; teratogenic potency was greater at 96-hours than at 0-hour incubation time [ACGIH 1991].

2. Effects on Humans: Exposure to tetrasodium pyrophosphate causes irritation in humans. It is an alkaline chemical and acute exposures have resulted in mild to moderate irritation of the eyes, skin, nose, throat, and respiratory passages [ACGIH 1991; Sittig 1991].

* Signs and symptoms of exposure

1. Acute exposure: Acute exposure to tetrasodium pyrophosphate may cause mild to moderate irritation of the eyes, skin, nose, throat, and respiratory passages.

2. Chronic exposure: No signs or symptoms of chronic exposure to tetrasodium pyrophosphate have been reported in humans.

EMERGENCY MEDICAL PROCEDURES

* Emergency medical procedures: [NIOSH to supply]

5. Rescue: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures, the location and proper use of emergency equipment, and methods of protecting themselves during rescue operations.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve tetrasodium pyrophosphate and lead to worker exposures to this substance:

The manufacture and transportation of tetrasodium pyrophosphate
* Use as a water softener, dispersing and emulsifying agent, metal cleaner, sequestrant, and a nutritional supplement
* Use in drilling muds, boiler water treatment, soaps and detergents, dyes, and in wool scouring

Methods that are effective in controlling worker exposures to tetrasodium pyrophosphate, depending on the feasibility of implementation, are as follows:

* Process enclosure
* Local exhaust ventilation
* General dilution ventilation
* Personal protective equipment

Workers responding to a release or potential release of a hazardous substance must be protected as required by paragraph (q) of OSHA's Hazardous Waste Operations and Emergency Response Standard [29 CFR 1910.120].

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation--a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation--a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL SURVEILLANCE

OSHA is currently developing requirements for medical surveillance. When these requirements are promulgated, readers should refer to them for additional information and to determine whether employers whose employees are exposed to tetrasodium pyrophosphate are required to implement medical surveillance procedures.

* Medical Screening

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures. To detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

* Preplacement medical evaluation

Before a worker is placed in a job with a potential for exposure to tetrasodium pyrophosphate, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, and respiratory system [NIOSH 1994]. Medical surveillance for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society.

A preplacement medical evaluation is recommended to assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to tetrasodium pyrophosphate at or below the prescribed exposure limit. The health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the eyes, skin, or respiratory system [NIOSH 1994].

* Periodic medical evaluations

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended

by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to tetrasodium pyrophosphate exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of tetrasodium pyrophosphate on the eyes, skin, or respiratory system [NIOSH 1994]. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

* Termination medical evaluations

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

* Biological monitoring

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. No biological monitoring test acceptable for routine use has yet been developed for tetrasodium pyrophosphate.

WORKPLACE MONITORING AND MEASUREMENT

Determination of a worker's exposure to airborne tetrasodium pyrophosphate is made using a low-ash polyvinyl chloride (LAPVC) filter of 5 microns. Samples are collected at a recommended flow rate of 2 liters/minute until a recommended collection volume of 960 liters is reached. Initial screening is conducted by gravimetric methods. This method (OSHA ID-121) is used to measure the amount of sodium in the sample and is described in the OSHA Computerized Information System [OSHA 1994] and is fully validated. A second method (OSHA ID-111) is used to measure the amount of phosphorus in the sample.

PERSONAL HYGIENE PROCEDURES

If tetrasodium pyrophosphate contacts the skin, workers should flush the affected areas immediately with plenty of water, followed by washing with soap and water.

Clothing contaminated with tetrasodium pyrophosphate should be removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the hazardous properties of tetrasodium pyrophosphate.

A worker who handles tetrasodium pyrophosphate should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, applying cosmetics, or taking medication.

Workers should not eat, drink, use tobacco products, apply cosmetics, or take medication in areas where tetrasodium pyrophosphate or a solution containing tetrasodium pyrophosphate is handled, processed, or stored.

STORAGE

Tetrasodium pyrophosphate should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's Hazard Communication Standard [29 CFR 1910.1200]. Containers of tetrasodium pyrophosphate should be protected from physical damage and should be stored separately from strong oxidizing agents or acids.

SPILLS AND LEAKS

In the event of a spill or leak involving tetrasodium pyrophosphate, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been completed. The following steps should be undertaken following a spill or leak:

1. Ventilate the area of the spill or leak.

2. Collect the powdered material in the most convenient and safe manner possible and deposit it into sealed containers.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

* Emergency planning requirements

Tetrasodium pyrophosphate is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) (Title III) in 42 USC 11022.

* Reportable quantity requirements for hazardous releases

A hazardous substance release is defined by EPA as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of contaminated containers) of hazardous substances. In the event of a release that is above the reportable quantity for that chemical, employers are required to notify the proper Federal, State, and local authorities [40 CFR 355.40].

Employers are not required by the emergency release notification provisions in 40 CFR Part 355.40 to notify the National Response Center of an accidental release of tetrasodium pyrophosphate; there is no reportable quantity for this substance.

* Community right-to-know requirements

Employers are not required by EPA in 40 CFR Part 372.30 to submit a Toxic Chemical Release Inventory form (Form R) to EPA reporting the amount of tetrasodium pyrophosphate emitted or released from their facility annually.

* Hazardous waste management requirements

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA has specifically listed many chemical wastes as hazardous. Although tetrasodium pyrophosphate is not specifically listed as a hazardous waste under RCRA, EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (703) 412-9810 (in the Washington, D.C. area) or toll-free at (800) 424-9346 (outside Washington, D.C.). In addition, relevant State and local authorities should be contacted for information on any requirements they may have for the waste removal and disposal of this substance.

RESPIRATORY PROTECTION

* Conditions for respirator use

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of tetrasodium pyrophosphate exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should only use respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

* Respiratory protection program

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's Respiratory Protection Standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the latest edition of the NIOSH Respirator Decision Logic [NIOSH 1987b] and the NIOSH Guide to Industrial Respiratory Protection [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Workers should use appropriate personal protective clothing and equipment that must be carefully selected, used, and maintained to be effective in preventing skin contact with tetrasodium pyrophosphate. The selection of the appropriate personal protective

equipment (PPE) (e.g., gloves, sleeves, encapsulating suits) should be based on the extent of the worker's potential exposure to tetrasodium pyrophosphate. There are no published reports on the resistance of various materials to permeation by tetrasodium pyrophosphate.

To evaluate the use of PPE materials with tetrasodium pyrophosphate, users should consult the best available performance data and manufacturers' recommendations. Significant differences have been demonstrated in the chemical resistance of generically similar PPE materials (e.g., butyl) produced by different manufacturers. In addition, the chemical resistance of a mixture may be significantly different from that of any of its neat components.

Any chemical-resistant clothing that is used should be periodically evaluated to determine its effectiveness in preventing dermal contact. Safety showers and eye wash stations should be located close to operations that involve tetrasodium pyrophosphate.

Splash-proof chemical safety goggles or face shields (20 to 30 cm long, minimum) should be worn during any operation in which a solvent, caustic, or other toxic substance may be splashed into the eyes.

In addition to the possible need for wearing protective outer apparel (e.g., aprons, encapsulating suits), workers should wear work uniforms, coveralls, or similar full-body coverings that are laundered each day. Employers should provide lockers or other closed areas to store work and street clothing separately. Employers should collect work clothing at the end of each work shift and provide for its laundering. Laundry personnel should be informed about the potential hazards of handling contaminated clothing and instructed about measures to minimize their health risk.

Protective clothing should be kept free of oil and grease and should be inspected and maintained regularly to preserve its effectiveness.

Protective clothing may interfere with the body's heat dissipation, especially during hot weather or during work in hot or poorly ventilated work environments.

REFERENCES

ACGIH [1991]. Documentation of the threshold limit values and biological exposure indices. 6th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ACGIH [1994]. 1994-1995 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ATS [1987]. Standardization of spirometry -- 1987 update. American Thoracic Society. Am Rev Respir Dis **136:1285-1296**.

CFR. Code of Federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Genium [1988]. Material safety data sheet No. 242. Schenectady, NY: Genium Publishing Corporation.

Mickelsen RL, Hall RC [1987]. A breakthrough time comparison of nitrile and neoprene glove materials produced by different glove manufacturers. Am Ind Hyg Assoc J **48 (11): 941-947**.

Mickelsen RL, Hall RC, Chern RT, Myers JR [1991]. Evaluation of a simple weight-loss method for determining the permeation of organic liquids through rubber films. Am Ind Hyg Assoc J **52(10): 445-447**.

NIOSH [1987a]. NIOSH guide to industrial respiratory protection. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-116.

NIOSH [1987b]. NIOSH respirator decision logic. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-108.

NIOSH [1991]. Registry of toxic effects of chemical substances: Tetrasodium pyrophosphate. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Standards Development and Technology Transfer, Technical Information Branch.

NIOSH [1992]. Recommendations for occupational safety and health: Compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

NIOSH [1994]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-116.

NJDH [1986]. Hazardous substance fact sheet: Tetrasodium pyrophosphate. Trenton, NJ: New Jersey Department of Health.

NLM [1992]. Hazardous substances data bank: Tetrasodium pyrophosphate. Bethesda, MD: National Library of Medicine.

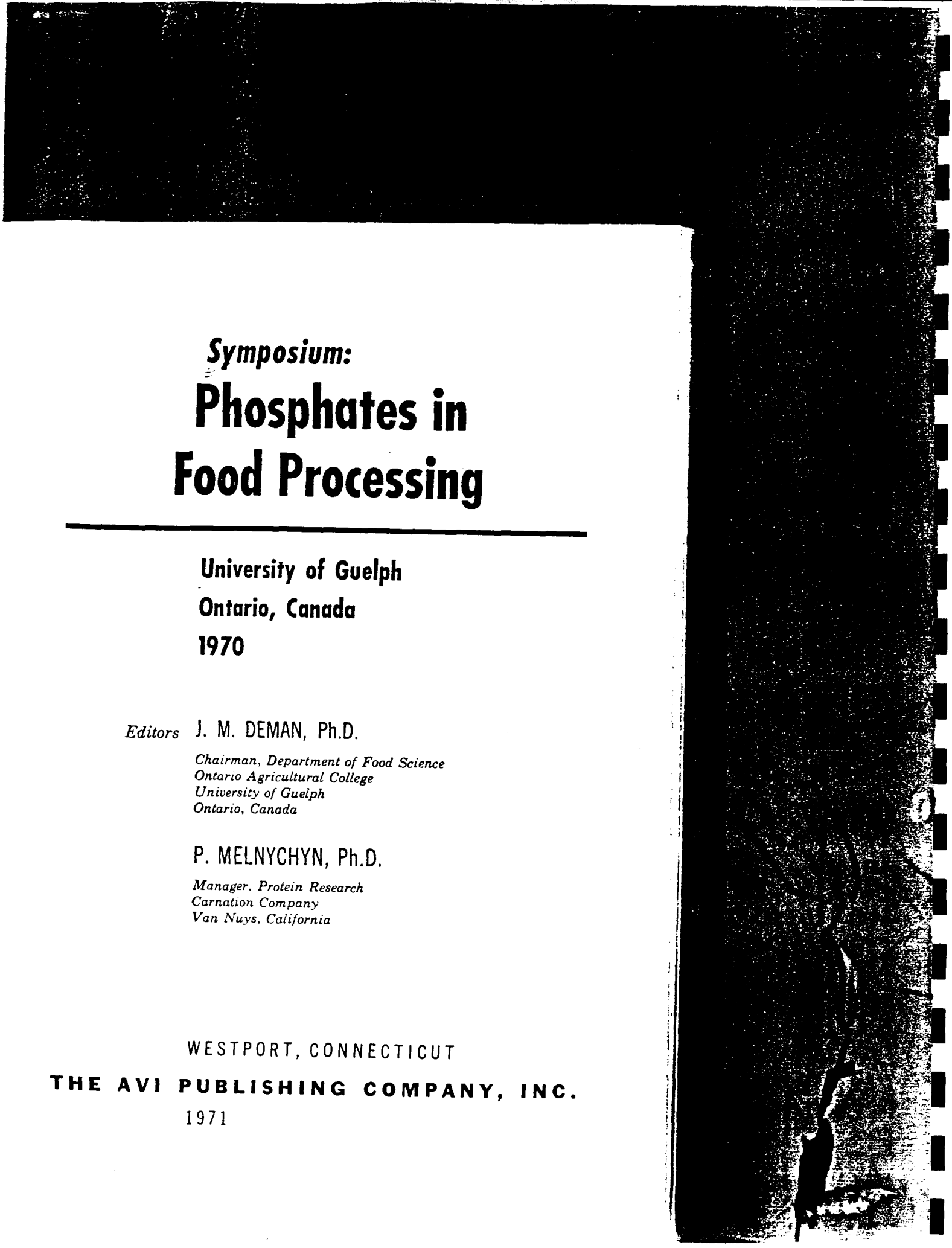
OSHA [1994]. Computerized information system. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration.

Sax NI, Lewis RJ [1989]. Dangerous properties of industrial materials. 7th ed. New York, NY: Van Nostrand Reinhold Company.

Sittig M [1991]. Handbook of toxic and hazardous chemicals. 3rd ed. Park Ridge, NJ: Noyes Publications.

USC. United States code. Washington, DC: U.S. Government Printing Office.

Windholz M, ed. [1983]. Merck Index 10th ed. Rahway, NJ: Merck & Company.



Symposium:

Phosphates in Food Processing

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SIGNIFICANT PROPERTIES OF THE PHOSPHATES[1]

Phosphates and polyphosphates are used extensively in food processing because these substances occur naturally in foodstuffs utilized by man. The ortho-, pyro- and triphosphates occur in all kinds of natural foods, not only as the adenosine and related biological derivatives but also as "inorganic phosphates." The very long-chain polyphosphates are found in such traditional human foodstuffs as fungi and cultures of microorganisms.

Practical Classification of Phosphate Properties

Phosphates and polyphosphates are generally used in food processing because of their effects on the various functional properties of the food products of which they become a part. These effects can be ascribed to the properties of the phosphates themselves—properties categorized below into five classes. Of course a given food application may involve several of these categories which may not be mutually independent. Those categories which should be useful in discussing the pertinent effects of the phosphates are as follows.

(1) Acidic and pH Buffering Properties.—The acid salts of ortho and pyrophosphate are good solid-phase sources of acidity. Of particular importance in this respect are monosodium orthophosphate, NaH_2PO_4 and its mono and dihydrate; monocalcium phosphate, $Ca(H_2PO_4)_2$, and its monohydrate; sodium aluminum phosphate, $NaH_{14}Al_3(PO_4)_8 \cdot 4H_2O$; as well as sodium acid pyrophosphate, $Na_2H_2PO_4$. Acid salts of the longer-chain polyphosphates have not found application as acidifying agents because of their relatively short buffering range in the pH region from 5.5 to 7.5, and because they are somewhat difficult to prepare.

Orthophosphoric acid itself is used as an acidifying agent in various food preparations, such as cola drinks. On a price-performance basis, orthophosphoric acid is about 20 times less expensive to use than are such organic acids as citric, malic, and tartaric.

The ortho- and pyrophosphate anions are good buffering agents for the three pH ranges of 2 to 3, 5.5 to 7.5, and 10 to 12. The polyphosphate anions are not as good buffering agents in the important middle range of 5.5 to 7.5 (as can be seen in Fig. 1.4), and their buffering ability decreases with increasing chain length (Van Wazer and Holst 1950). This diminution in buffering capacity comes about because there is one weak-acid function at either end of a polyphosphate chain so that, for infinitely long chains, the buffering capacity in this pH range is nil.

Acid association constants have been determined for a number of acids of phosphorus as functions of ionic strength (Irani and Callis 1961 and Van Wazer 1958). These constants are of value for precise theoretical work. It should be noted that the phosphate systems are generally so complicated that acid associa-

[1] Van Wazer, 1961.

phosphates must remember that the applicable values of the pertinent physical properties of the phosphate under study are interrelated. The six groups of properties (including nutritional supplementation) given above for the phosphates represent equilibrium situations and could be interrelated on such a basis. However, on some occasions (e.g. dissolution of precipitates) the equilibrium situation may be reached only very slowly. Then, it would also be necessary to consider rate processes in treating practical problems.

SOME FOOD APPLICATIONS

The major applications in foods of the commercial phosphates are listed in Table 1.3 in which the various phosphates added to specific products of the various segments of the food industry are listed, and what appears to be the prime function of the phosphate is given. In the latter case the number in parentheses indicates the particular group of phosphate properties referred to in the preceding section entitled "Practical Classification of Phosphate Properties."

A few important or novel applications of phosphates in foods are discussed briefly below. For a more detailed presentation, the reader is referred to Van Wazer (1961).

Bacteriocidal Action

An interesting property of the polyphosphates is their action in reducing the amount of gram-positive bacteria (and inhibiting certain viruses) in media which otherwise would be good nutrients for these organisms. Ebel *et al.* (1965) have reported the growth-inhibiting action of condensed phosphates on *Staphylococcus aureus* and *Bacillus subtilis* in a broth medium, as well as the preservative action of these phosphates on fish. A vitreous phosphate having an average chain length of 6 was the most effective, followed by a glass having an average chain length of 4, and then by the pyrophosphate. Pyrophosphate has also been used to inactivate the T-even coliphages (Van Vunakis and Herriott 1962), and orthophosphate has been employed in the suppression of proliferation of bacteriophages in a dairy starter (Hargrove *et al.* 1961).

Kichline and Scharpf (1969) have reinvestigated the effects of polyphosphates on *Staphylococcus aureus* and found that vitreous sodium phosphates of the "hexameta" variety cause a continuous reduction of bacteria in the nutrient broth so that, after 10 days, the bacterial count is reduced about a millionfold by addition of a 1 wt-% solution of the polyphosphate. A control in which sodium chloride was added, also at the 1% level, showed essentially no change in the bacterial count. This was also true of an orthophosphate mixture consisting of 60 wt-% disodium phosphate and 40 wt-% monosodium phosphate. A 50/50 mixture of tetrasodium pyrophosphate with sodium acid pyrophosphate gave a small improvement which amounted to tenfold less bacteria in 10 days. Other bacteria which similarly are affected by polyphosphates are *Salmonella typhi-*

SECTION IV

Public Health Consideration of the Use of Phosphates in Food Processing

CHAPTER 13

D. G. Chapman
and L. I. Pugsley

Public Health Aspects of the Use of Phosphates in Foods

The public health aspects of the use of phosphates in foods is a most timely subject and one which has many ramifications. Those aspects of the use of phosphates as food additives from the standpoint of their effect on the health of consumers will be discussed in this chapter, with brief mention of phosphates used in food as mineral nutrients.

It can be truly said that none of the elements essential to the body plays a more important role in life processes than does phosphorus. Compounds of phosphorus serve a most important function in the transformation of energy in the body and one of the recent achievements in biochemistry has been concerned with "high energy phosphate bonds" (Hegsted 1968).

Occurrence, Absorption, Metabolism, and Excretion of Phosphates

In anatomical terms, phosphorus is ubiquitous and is important in a large number of reactions in virtually all organs and tissues. The major proportion of phosphorus in the body is found in the bones where it plays an important role in osteoblastic and osteoclastic reactions. The phosphorus-containing nucleoproteins make up a large proportion of the nuclear material in the cytoplasm of all cells and are key materials in the processes of reproduction, cell division and transmission of hereditary characteristics. Phosphorus is an essential element in the formation and development of teeth, which are so necessary in processing food for the body.

It is believed that phosphorus in food is absorbed from the gastrointestinal tract as free phosphate, the various inorganic esters being hydrolyzed by various phosphatase enzymes prior to absorption. Although absorption of inorganic phosphorus is closely associated with the amount of calcium in the diet, it is also

influenced by the presence of other elements e.g., iron, strontium, alu
beryllium, etc., which form insoluble phosphates and retard the availab
ingested phosphates. In adults under normal conditions approximately
thirds of the ingested phosphates are absorbed.

The metabolism of phosphates is a most involved subject and only som
basic contributions will be indicated in order to provide some understan
the importance of phosphates in metabolism. The discovery by Harden
Young in 1905 that phosphates have an important function in cell-free fe
tion occurring in yeast extracts formed a basis for a number of advance
metabolism of phosphates. Their contribution in establishing the existenc
hexose monophosphate and diphosphate in these extracts stimulated resea
the role of phosphates in human metabolism. Undoubtedly this discov
also implicated in the advantages obtained by addition of ammonium, cal
and potassium phosphates and phosphoric acid to malt liquors and bakery pr
ucts as yeast foods.

Returning to the metabolism of phosphates, Embden in 1915 showed t
same hexose phosphates present in yeast extracts are present in muscle. T
stimulated further research on phosphates in metabolic energy release. B
1926 and 1936 four major conclusions were reached in this connection: (
hexose phosphate is an intermediate substance in a series of step reactions;
that three coenzyme systems containing phosphorus are involved in these re
tions, namely the adenylic acid system (ADP-ATP) concerned with phosph
tion reactions, the pyridine nucleotide system (DNP-TPN) concerned with
tion reduction reactions, and the diphosphothiamine system concerned with
removal of CO_2 from compounds (decarboxylation); (3) that the trans
phosphates between molecules occurs without passing through the ino
phosphate state; (4) that in these phosphorylation reactions, intermediate co
pounds are formed which upon hydrolysis yield large amounts of energy (C
1951).

Energy-rich phosphate bonds are concerned in various metabolic pathw
such as the metabolism of disaccharides and polysaccharides, of hexose, pent
and triose phosphates, and of two-carbon compounds such as acetate. Th
mation of urea and the synthesis of proteins also involve phosphate bond e
Phosphorus is utilized in the production of a variety of phospholipids in
body and plays an important role in basic hemostatic mechanisms of the
the primary function being conservation and transfer of energy.

The phosphorus present in the blood and in cellular and extracellular fluid
generally classified as lipid, ester, and inorganic. In infants, the serum inor
phosphorus is between 5.0 and 6.6 mg per 100 ml and the level in healthy
is 3 to 4 mg. Ordinarily there is a reverse relationship between serum inor
phosphorus and serum calcium.

Under normal conditions, 30% of the phosphorus in the diet is excreted
feces. This is represented both by unabsorbed phosphorus and by that se

to the intestinal tract. It is difficult to distinguish between the two sources, but they are believed to be affected by the same factors. If large amounts of phosphates are ingested, much of it may escape absorption, and a cathartic action results. In fact, phosphate salts have been employed as mild laxatives. The excretion of phosphate in the urine is largely inorganic phosphate, the amount depending primarily upon the quantity absorbed from the gastrointestinal tract. Urinary phosphates are usually higher than fecal phosphates. It is believed that phosphate in plasma is filterable by the kidney tubules. The net tubular reabsorption in healthy individuals ranges from virtually all the phosphate filtered to as low as 80%.

Many factors influence the excretion of phosphate by the kidneys to maintain normal blood level. In this connection the role of the hormones from the parathyroids and the anterior pituitary and possibly vitamin D are of particular interest. There is an interrelation between the rate of excretion of phosphate and the titratable acidity of the urine. The ingestion of large amounts of sodium acid phosphate lowers the pH of urine. Concentration of phosphates in the renal tubules provides an excellent buffering system and assists in the excretion of large amounts of acid without lowering the pH of urine to a degree that would interfere with the transport of other ions.

Phosphates as Food Additives

Since phosphorus compounds play such an important role in the functioning of the body, it is only natural that aspects of their use as food additives be given attention in order that the health and interests of the public receive adequate consideration. Because of the variety of properties exhibited by these compounds they have found wide application by the food industries. Some 9.7 million pounds of phosphates were distributed for use by these industries in 1969 (Cale 1970). Approximately 50% of the amount of phosphates distributed was contributed by sodium, potassium, and ammonium phosphates; 25% by calcium phosphates, and the remainder by phosphoric acid.

The variety of phosphates and other chemicals used as food additives have been described by Chapman and Kertesz (1966). It may appear that many of these uses are more a matter of convenience than necessity. However, with the controls currently exercised under laws governing the use of food additives, mere convenience on the part of the food industry is not sufficient justification to add phosphates or other chemicals to food. The dividing line between what is need and what is convenience is not always easy to determine. The decision as to which applies to an additive often requires familiarity with some obscure details of the mechanisms inherent in the production of food. The purpose or function of food additives contributes to one or more of the characteristics that consumers have often come to expect in their food supply, namely safety, nutritive value, acceptability, stability, convenience, and esthetic value.

Safety is of prime importance in considering the use of chemicals in foods.

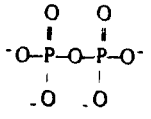
pH dependent, the necessary pH may dictate which orthophosphate salts or mixture must be used.

Double sodium phosphate salts are also known.[30,32] However, the only one of importance in food applications is *hemisodium orthophosphate.* This compound is considered to be the double salt of monosodium phosphate and phosphoric acid.[31,32,35] Brout[39] reports, however, that hemisodium phosphate is actually the double salt of monosodium phosphate and polyphosphoric acid. He has proposed the revised formula $(HPO_3)_n \cdot NaH_2PO_4 \cdot H_2O$, although no other evidence for this formula has been found.

Sodium aluminum phosphates (SALP) have recently been approved for use as food ingredients – as leavening acids and cheese emulsifiers. The two acidic salts commonly used in leavening systems have the formulas $NaH_{14}Al_3(PO_4)_8 \cdot 4H_2O$ and $Na_3H_{15}Al_2(PO_4)_8$. An *alkaline sodium aluminum phosphate* used in cheese processing has the formula $Na_{15}Al_2 \cdot 8(PO_4)_8$. These three salts are only slightly soluble in water at room temperature, but they increase in solubility as the temperature is increased. Therefore, they are used in applications requiring delayed release of acidity or alkalinity.

The Pyrophosphates

The pyrophosphates, also called diphosphates in some of the European literature, are the simplest of the condensed or polymeric phosphates. The pyrophosphate anion contains two phosphorus atoms linked through a shared oxygen atom, as follows:



Pyrophosphoric Acid

Pyrophosphoric acid is the only polymeric phosphoric acid that can be crystallized. It crystallizes in one of two forms from a seeded, concentrated solution of the acid cooled to about 10°C below its melting point. Although these crystalline forms are very pure pyrophosphoric acid, if melted or dissolved in water, the pyrophosphoric acid immediately begins to revert to the equilibrium mixture of ortho- and polymeric phosphoric acids represented by the P_2O_5 content of the solution.[30,32] It is impossible to have a solution of any of the polymeric phosphoric acids that is not a mixture of two or more acids of different chain lengths (see Table 3).

Crystalline pyrophosphoric acid is very difficult to maintain in its pure crystalline state, as it is extremely hygroscopic. Therefore, unless the crystalline compound is well protected, it will rapidly absorb water from the atmosphere and become a solution of the equilibrium distribution of polyphosphoric acids indicated for its P_2O_5 content in Table 3.

Calcium Pyrophosphates

Although *calcium acid pyrophosphate*, $CaH_2P_2O_7$, has been proposed as a leavening acid, few, if any, calcium salts of pyrophosphoric acid are used in foods. The *dibasic calcium pyrophosphate*, $Ca_2P_2O_7$, has no applications in foods.

Potassium Pyrophosphate

Anhydrous *tetrapotassium pyrophosphate* (TKPP) is commercially available and is used to a limited extent in foods. Its applications are similar to the sodium salts, but, as in the orthophosphates, the costliness of the potassium salt limits its use.

Sodium Pyrophosphates

Two crystalline sodium salts of pyrophosphoric acid are used in foods. One is the acidic salt *sodium acid pyrophosphate* (SAPP), $Na_2H_2P_2O_7$, used in numerous acidification applications. It is possible to reduce the rate at which sodium acid pyrophosphate goes into solution by modifying its manufacturing processes and the use of certain additives that form slowly soluble coatings around each crystal. Such compounds have been especially useful as delayed reaction leavening acids.

The second crystalline sodium salt of pyrophosphoric acid is its "neutral" salt containing sodium atoms in place of all of the hydrogens, i.e., *tetrasodium pyrophosphate* (TSPP), $Na_4P_2O_7$. It is useful because of its alkalinity and its ability to complex or precipitate alkaline earth and heavy metal ions.

A complex sodium salt of pyrophosphoric acid also used in foods is the iron enrichment compound, *sodium iron (or ferric) pyrophosphate* (SIP), $Na_8Fe_4(P_2O_7)_5 \cdot xH_2O$ (formula derived

potassium with the same levels of calcium and phosphorus.

These latter two papers probably explain the wide variations in the levels of phosphate reported to cause adverse physiological or biological effects. Optimum ratios of calcium to phosphorus, or of magnesium and potassium to phosphorus most likely explain why the diets of some studies required higher levels of phosphates in order to demonstrate adverse physiological effects. It is impossible to determine these ratios from the data given in most of the papers reviewed for this chapter.

Pyrophosphates

Hahn and Seifen[68] and Hahn[69] reported the results of six-month studies on rats fed 1.8%, 3%, and 5% "tetrasodium diphosphate" ($Na_4P_2O_7$). As with the DSP diets, 1.8% of the TSPP produced a slight increase in weight of the kidneys and renal calcification in some, but not all, of the rats to which it was fed. Later, a diet containing 1.1% of added TSPP was compared with a similar level of DSP. The growth again was slightly retarded, but it required 39 weeks on the diet in order to produce a slight degree of calcification in the tissues.

Datta and co-workers[59] studied the effects of 1%, 2.5%, and 5% levels of TSPP in the diets of rats for 16 weeks. Even the lowest level, 1%, of the TSPP caused a reduction in kidney function and an increase in its weight. They reported that the rat kidney is capable of concentrating salts to a greater degree than the kidney of other species. Therefore, they questioned the validity of using the information obtained from animals and calculating the effects on humans.

Van Esch and co-workers[58] reported the results of feeding studies with rats through three generations. Levels of 0.5%, 1%, 2.5%,and 5% TSPP were added to their diets. Kidney damage was observed at all levels of phosphate from 1% and above, and a significant reduction in growth, fertility, and life span was found at the 5% level.

Polyphosphates

Hodge[70] compared diets of rats containing 0.2%, 2%, and 10% STP with diets containing 10% sodium chloride or 5% disodium phosphate. Diets with 10% sodium chloride and 10% polyphosphate decreased the growth, increased the kidney weights, and damaged the kidneys, although no rats died. The rats fed the 2% polyphosphate diet had normal outward appearances, but their kidneys were found to be damaged upon histological examination. The 0.2% polyphosphate diet caused no changes at all.

Hahn and co-workers[64,68,69] reported that rats fed 1.8% STP or SHMP showed no evidence of physiological change; however, 3% and 5% of either phosphate caused severe kidney damage. The 5% phosphate diet also caused a reduction in growth. The amount of kidney damage in the animals was practically identical to that of animals fed similar levels of DSP, which indicated to the authors that the polyphosphates must be hydrolyzed to orthophosphate before they can be absorbed through the intestinal walls.

Hodge[70] fed diets that contained 0.1 g/kg/day of STP and SHMP to four dogs. Another group of four dogs was given the same phosphates in increasing dosages, beginning at 1.0 g/kg/day and increasing to 4.0 g/kg/day for the last month of the five-month feeding period. The dog given 0.1 g/kg/day showed no adverse effects. The dog given increasing dosages of SHMP began to lose weight when the daily dose reached 2.5 g/kg/day or more, while the dog fed STP did not begin to lose weight until his diet reached 4.0 g/kg/day.

Gassner and co-workers[74] fed 750 mg of potassium Kurrol's salt to rats for six days. Urine was collected for 10 days and analyzed by paper chromatography for evidence for the various types of phosphates. The results indicated that approximately 25% of the daily intake of the potassium metaphosphate was found in the urine as orthophosphate. After the first two days, when no condensed phosphate was found in the urine, an average of about 4% of the daily dose was found in the form of condensed phosphates. Approximately 80% had an average chain length of 4 to 5, and the balance was tripolyphosphate or pyrophosphate. A few samples contained trimetaphosphate in quantities below 0.2%.

Cyclic Polyphosphates

Hodge[70,73] studied the toxicity of the cyclic polyphosphates. Rats fed 0.2%, 2%, and 10% sodium trimetaphosphate and others fed similar quantities of sodium tetrametaphosphate showed fewer physiological effects than with any of the other phosphates in the study.[70] The 10% tetrametaphosphate caused slight increases in kidney weights and less evidence of kidney injury than with the straight-chain polyphosphates. Only

transient kidney injury resulted from the 10% trimetaphosphate. No adverse effects were found in diets containing lower levels of these two phosphates. Dogs were also fed the cyclic phosphates; no adverse effects were noticed until the level of the phosphates had reached 4 g/kg/day.

Hodge[73] reported the results of a two-year study in which 100 rats were fed 0.1%, 1.0%, and 10% sodium trimetaphosphate in their diets. Male rats failed to grow as rapidly on 1% trimetaphosphate diets, although female rats grew normally. At 10% trimetaphosphate growth of all rats was retarded, although excessive mortalities were not observed. Histological studies and studies of reproduction through two generations showed no further abnormalities.

Biochemical Aspects of Phosphate Toxicity

As stated in the introduction to this chapter, the phosphate anion is essential to the metabolism of all living organisms. However, since no living organism is known to synthesize the phosphate anion, it must be supplied in the diet.[1,75] Special mechanisms for maintaining the required level of phosphate in the blood serum of higher organisms are therefore required; these stabilize the level of inorganic phosphate in the blood through mechanisms controlled by the parathyroid gland. Hormones from this gland, regulated by the blood calcium level, are able to trigger the release or deposition of phosphate from and into the skeleton. It should not be necessary to point out that phosphate is essential in the metabolic processes; this has been demonstrated many times by the various schemes showing the metabolism of protein, fat, and carbohydrate. All living tissue must contain a certain level of phosphate, which is regulated by mechanisms that either prevent absorption or cause elimination of excess phosphate.[37,75] A further regulatory mechanism in the metabolism of phosphates is that of the phosphatase enzymes. Divalent cations, such as magnesium and calcium, are required for activation of these enzymes.

It has been estimated that adult humans require a minimun of 0.88 g of phosphorus in their daily diets. The blood serum of human adults normally carries approximately 2.5 to 4.5 mg phosphorus per 100 ml, while that of children carries a higher level.[75]

Phosphates, and particularly polyphosphates, are known to precipitate or sequester calcium, iron, magnesium, copper, and similar ions essential to human metabolism. However, numerous studies have demonstrated that absorption and metabolism of these ions are not inhibited in any way, even by excessive levels of the various phosphates in the diet.[37,62,64,65,76] Several investigators have shown that the addition of polyphosphates to the diet increases retention of essential mineral ions.[37,65,77], Borenstein and Schwartz[77] found that the addition of 7% STP or SHMP to the diets actually increased the absorption and retention of calcium in the bodies of rats, and SHMP caused higher calcium retention than STP. They also reported evidence indicating that SHMP complexed with calcium was absorbed intact through the intestinal walls. After absorption, SHMP was hydrolyzed to orthophosphate. In contrast, STP and calcium are absorbed independently, and the STP is then hydrolyzed to orthophosphate after absorption.

Orthophosphates are readily absorbed through the intestinal wall. However, the chain length of the condensed phosphates determines the amount that will be absorbed. The pyrophosphates are readily absorbed intact but then are completely hydrolyzed to orthophosphate.[78] Mitchell[79] demonstrated that synthetic digestive fluids were capable of hydrolyzing polyphosphates to orthophosphate in a step-wise fashion. Several investigators have shown that feeding condensed phosphates to animals resulted in absorption of only the short-chain polyphosphates or the orthophosphates resulting from their hydrolysis.[21,75,79-84] Furthermore, only 10 to 40% of hexametaphosphate and the longer-chain, Graham's, Tammann's, and Kurrol's salts are absorbed from the digestive tract.[61,76,80-82] Studies in which radioactive polyphosphates, from tripolyphosphate through Kurrol's salts, were fed to animals showed that these compounds are absorbed only after hydrolysis to ortho- or pyrophosphate in the gut and that only radioactive orthophosphates could be recovered from the urine. Approximately half of the administered radioactivity was found to be absorbed; the other half was recovered in the feces as polyphosphate.[78]

Acceptable Daily Intakes for Humans

The FAO/WHO Expert Committee on Food Additives has evaluated much of the experimental data on the toxicity of phosphates and has issued

mates of acceptable levels in human diets.[37] The fact that levels of calcium and other minerals in the diet affect the levels that will produce the earliest signs of adverse effects was also considered. The experimental data indicated that the total amount of phosphorous in the diet, other than only that added as a food ingredient, must be considered. Furthermore, the toxic effects of the condensed phosphates are directly proportional to the extent of their hydrolysis to ortho- or pyrophosphate. The extent of hydrolysis in the intestine depends on many unpredictable variables. Therefore, for the purpose of setting acceptable dietary limits, the Committee assumed that all of the condensed phosphate would hydrolyze to orthophosphate.[37]

With these considerations in mind, the Committee recommended an unconditional acceptance level for total daily dietary phosphorus as well as a conditional acceptance level. The *unconditional acceptance level* is the level considered safe under all conditions of diet. The *conditional acceptance level* is acceptable only when the dietary calcium level is high. These levels are as follows[37]

	mg/kg body wt
Acceptable levels for all diets	<30
Acceptable levels for high calcium diets	30 to 70

Summary

The results of animal feeding studies reported in the scientific literature indicate that levels of 0.5% of the phosphates could be tolerated in the diet without adverse physiological effects. Higher levels could possibly be tolerated if a proper dietary balance of other ions, particularly calcium, magnesium, and potassium, is maintained. Few, if any, applications for the phosphates require over 0.5% to obtain the desired effect, and higher levels often produce adverse physical and chemical effects and off-flavors. In addition, the phosphates produce adverse effects in numerous food systems so that it is not possible that they would be added to all foods. As a result, the level of phosphates likely to be found in the diet, even though they are fully utilized in all their potential applications, is self-limiting. It is highly unlikely that a level of 0.5% phosphate could ever appear in the total human diet.

products, against microbiological growth was reported by Kohl and Ellinger.[102,103] The most effective polyphosphates were found to be those having an average length of 18 to 34 phosphate units. The shorter-chain and longer-chain polyphosphates were also found to inhibit the growth of yeasts and molds.

Mineral Enrichment

Although the inorganic salts, commonly called minerals, make up a small percentage of total body weights, they are as important to the well-being as the proteins, carbohydrates, and fats that provide energy. In fact, it is impossible to obtain energy from these foodstuffs without the mineral elements. The elements calcium and iron are two of the minerals required for the total well-being of all organisms. Calcium and iron salts and often their phosphates are commonly added to foodstuffs in order to provide these essential mineral elements. Since phosphorus, as the phosphate anion, is also an essential mineral, the phosphate salts of these mineral elements are doubly useful.

Calcium and phosphorus – Calcium and phosphorus are present in living organisms in the largest quantities of all the minerals. Children require calcium and phosphorus for normal growth. Most of the calcium and phosphorus is incorporated in the formation of the skeleton. A newborn child contains approximately 24 g of calcium and 14 g of phosphorus. Adults require calcium and phosphorus for maintenance and replacement. A normal adult contains approximately 1,150 g of calcium and 650 g of phosphorus, which, based upon total ash, represents 39% calcium and 22% phosphorus. Pregnant and lactating women require larger quantities of calcium and phosphorus than other adults, because a portion of their intake is utilized by the growing fetus or child.[165,166]

In addition to being a necessity for formation and maintenance of skeletal tissue, calcium and phosphorus are both needed for growth and replacement of blood and soft tissues. Most of the calcium in blood and tissues is associated with protein. Most of the phosphorus is incorporated in the phosphate anion, which functions as a portion of the overall buffering system in the body as well as in the mechanism of energy transfer during metabolism of foodstuffs.[166]

Present knowledge indicates that the optimum ratio of calcium to phosphorus for children is between 1:1 and 2:1; that for adults is slightly less than 1:1. Calcium deficiency in children results in stunting of growth, bone malformation, and poor quality bones and teeth. When the human diet lacks sufficient calcium and phosphorus, or has improper ratios of calcium to phosphorus, these elements are removed from the skeletal tissue as required.[166]

Since most modern methods of food processing tend to remove portions of the calcium in the food before processing, it is common practice to supplement the food product with this element through the addition of calcium phosphates. However, foodstuffs such as meat, fruits, and vegetables are difficult to supplement with calcium, since the calcium ion often introduces undesirable physical characteristics to the processed foods. As an example, calcium toughens the skins of fruits and vegetables and precipitates pectins.

Cereals, however, are easily fortified with calcium phosphates, since they are seldom adversely affected by them. In fact, it is often possible to improve some of the physical characteristics of doughs and batters by the addition of these compounds. As a result, federal definitions for flour and many baked products allow the optional addition of certain minimum levels of calcium compounds, including the phosphates. These levels are therefore provided by the addition of calcium phosphates to provide the minimum levels of these elements required in the definitions. The type of calcium phosphate and the quantity required to provide the minimum level depend on the type of cereal product, the amount of naturally occurring calcium, and the amount of the element contributed by the selected compound. Table 14 shows the levels of calcium and phosphorus in each of the three calcium

TABLE 14

Levels and Ratios of Calcium and Phosphorus in Commercial Calcium Phosphates

Compound	% Ca	% P	Ca/P ratio
Monocalcium phosphate	16.4	24.2	0.68/1.0
Dicalcium phosphate	23.6	18.0	1.31/1.0
Tricalcium phosphate	36.7	17.3	2.12/1.0

Source: *The Importance of Calcium and Phosphorus Supplements in Foods*, Technical Service Bulletin, Stauffer Chemical Co., New York, with permission.

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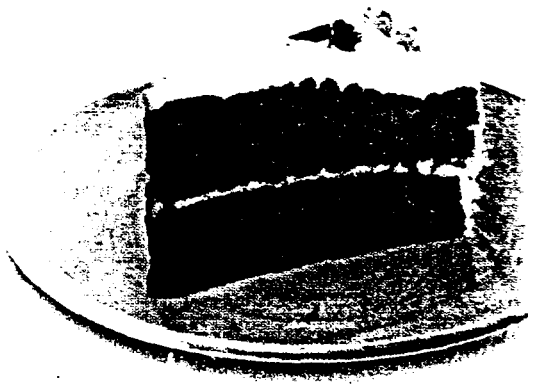


food phosphates

Our commitment to you.

Solutia has been providing the food industry with food phosphates for over 60 years. At Solutia, our goal is to help you obtain the most efficient utilization of phosphate ingredients – by providing you with high-quality phosphates for your specific applications. Our commitment to supply our customers with quality ingredients, service and assistance is ensured by using statistically proven Total Quality Methods and manufacturing resource planning (MRP II) for manufacturing, customer service, research and delivery.

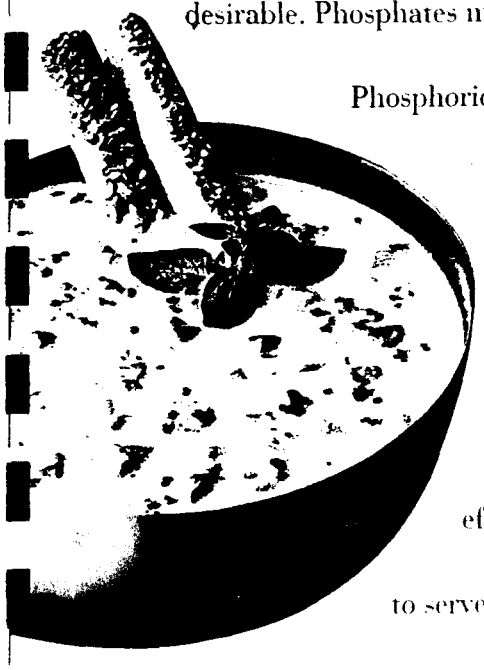
When developing and manufacturing food products, it's important to use only the most consistent and effective ingredients. Ingredients coupled with dependable technical assistance make Solutia a leader in the food phosphate industry. Our team of experienced technologists wants to work with you in support of your product development and in support of the use of our ingredients. Solutia is your partner in product development and delivery.

That's our promise to you.

Table of Contents

Phosphates are well-established ingredients for many food products. Their strength and versatility are founded on their multifunctional and diverse properties. Individual phosphates also are capable of providing more than one functionality. The phosphates furnish a means to control many texture, appearance and flavor problems. Baked products leavened with phosphates exhibit excellent texture, color, volume and lightness. In process cheese products, phosphates provide the meltability and smooth mouthfeel that is so desirable. Phosphates make processed meat more juicy and tender.

Phosphoric acid enhances the clean, sparkling flavor of beverages.



Solutia food phosphates meet or exceed the standards established in the Food Chemicals Codex. In addition, specific products meet U.S. Pharmacopeia and/or National Formulary standards for pharmaceutical use. Solutia provides phosphates which are consistent and effective. With these phosphorus-based ingredients comes our commitment to serve your information needs on the functions of phosphates in food. At Solutia, you have direct access to a team of technologists. With Solutia phosphates and know-how, you can achieve even greater quality and profitability for your food products.

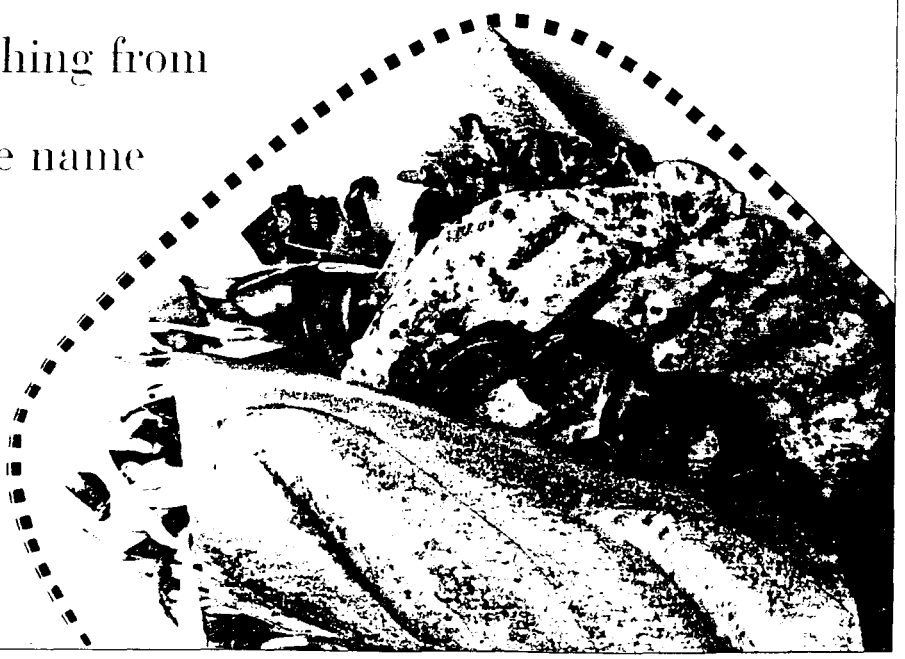
Phosphates for Every Application

We're Solutia, formerly the chemical businesses of Monsanto Company. For more than 60 years, we've been producing food phosphates that apply to your applications.

Your formulas.

And your manufacturing processes.

We begin by tailoring innovative solutions that fit the specific needs of our customers. Then we design dynamic new products. So whether you use food phosphates in anything from cakes to hams, we're the name to remember for new creative solutions.



SOLUTIA

Table A – Functions of Solutia Food Phosphates

Function	Phosphate Ingredients	
Acidulant	■ Adipic Acid	■ Pan-O-Lite®
	■ H.T.® Monocalcium Phosphate Monohydrate	■ Phosphoric Acid
	■ Levn-Lite® Sodium Aluminum Phosphate	■ Py-Ran® Anhydrous Monocalcium Phosphate
	■ Monoammonium Phosphate	■ Sodium Acid Pyrophosphate
	■ Monopotassium Phosphate	■ Stabil-9®
	■ Monosodium Phosphate	■ Leverage® Heat Activated Leavener
Absorbent	■ Disodium Phosphate	■ Tricalcium Phosphate
Alkalinity	■ Diammonium Phosphate	■ Nutrifos L-50
	■ Disodium Phosphate	■ Nutrifos SK
	■ Emulsi-Phos® 440, 660 and 990	■ Nutrifos STP Powder
	■ Katch® Fish Phosphate	■ Sodium Potassium Tripolyphosphate
	■ Nutrifos® 088	■ Sodium Tripolyphosphate
	■ Nutrifos BC	■ Tetrapotassium Pyrophosphate
	■ Nutrifos B-75	■ Tetrasodium Pyrophosphate
	■ Nutrifos B-90	■ Trisodium Phosphate
	■ Nutrifos H30	
Buffering Agent	■ Adipic Acid	■ Sodium Acid Pyrophosphate
	■ Diammonium Phosphate	■ Sodium Hexametaphosphate
	■ Disodium Phosphate	■ Sodium Potassium Tripolyphosphate
	■ H.T. Monocalcium Phosphate	■ Sodium Tripolyphosphate
	■ Monoammonium Phosphate	■ Tetrapotassium Pyrophosphate
	■ Monopotassium Phosphate	■ Tetrasodium Pyrophosphate
	■ Monosodium Phosphate	■ Trisodium Phosphate
	■ Phosphoric Acid	
Coagulant	■ Adipic Acid	■ Sodium Potassium Tripolyphosphate
	■ Phosphoric Acid	■ Sodium Tripolyphosphate
	■ Sodium Acid Pyrophosphate	■ Tetrapotassium Pyrophosphate
	■ Sodium Hexametaphosphate	■ Tetrasodium Pyrophosphate
Dispersing Agent	■ Sodium Acid Pyrophosphate	■ Sodium Tripolyphosphate
	■ Sodium Hexametaphosphate	■ Tetrapotassium Pyrophosphate
	■ Sodium Potassium Tripolyphosphate	■ Tetrasodium Pyrophosphate
Emulsifying Agent	■ Disodium Phosphate	■ Sodium Hexametaphosphate
	■ Emulsi-Phos 440, 660 and 990	■ Sodium Potassium Tripolyphosphate
	■ Monopotassium Phosphate	■ Sodium Tripolyphosphate
	■ Monosodium Phosphate	■ Tetrapotassium Pyrophosphate
	■ Sodium Hexametaphosphate	■ Tetrasodium Pyrophosphate
	■ Sodium Acid Pyrophosphate	■ Tetrasodium Phosphate

Table A – Functions of Solutia Food Phosphates

Function	Phosphate Ingredients	
Esterification	■ Sodium Trimetaphosphate	
Flow Conditioner	■ Tricalcium Phosphate	
Leavening Agent	■ Leverage®	■ Stabil-9
	■ Diammonium Phosphate	■ Monoammonium Phosphate
	■ Dicalcium Phosphate Dihydrate	■ Monopotassium Phosphate
	■ H.T. Monocalcium Phosphate Monohydrate	■ Monosodium Phosphate
	■ Levn-Lite Sodium Aluminum Phosphate	■ Py-Ran Anhydrous Monocalcium Phosphate
	■ Pan-O-Lite	■ Sodium Acid Pyrophosphate
Mineral Supplement	■ Dicalcium Phosphate	■ Calcium Pyrophosphate
	■ H.T. Monocalcium Phosphate Monohydrate	■ Tricalcium Phosphate
	■ Mag-nificent® Source of Magnesium	
Nutrient	■ Diammonium Phosphate	■ Phosphoric Acid
	■ Monoammonium Phosphate	■ Mag-nificent
	■ Monopotassium Phosphate	
Protein Modifier	■ Dicalcium Phosphate	■ Nutrifos SK
	■ Disodium Phosphate	■ Nutrifos STP Powder
	■ Emulsi-Phos 440, 660 and 990	■ Py-Ran Anhydrous Monocalcium Phosphate
	■ H.T. Monocalcium Phosphate Monohydrate	■ Sodium Acid Pyrophosphate
	■ Katch Fish Phosphate	■ Sodium Hexametaphosphate
	■ Monosodium Phosphate	■ Sodium Potassium Tripolyphosphate
	■ Nutrifos 088	■ Sodium Tripolyphosphate
	■ Nutrifos B-75	■ Tetrapotassium Pyrophosphate
	■ Nutrifos B-90	■ Tetrasodium Pyrophosphate
	■ Nutrifos H-30	■ Trisodium Phosphate
	■ Nutrifos L-50	
Sequestrant	■ Sodium Acid Pyrophosphate	■ Sodium Tripolyphosphate
	■ Sodium Hexametaphosphate	■ Tetrapotassium Pyrophosphate
	■ Sodium Potassium Tripolyphosphate	■ Tetrasodium Pyrophosphate
Stabilizer	■ Disodium Phosphate	■ Tetrapotassium Pyrophosphate
	■ Sodium Hexametaphosphate	■ Tetrasodium Pyrophosphate
	■ Sodium Potassium Tripolyphosphate	■ Trisodium Phosphate
	■ Sodium Tripolyphosphate	

Bakery Applications of Solutia Phosphates

Solutia food phosphates find many uses in baking:

- Leavening acidulants
- Mineral supplementation
- Dough conditioners
- pH and buffering

The phosphates used include ingredients tailored to meet the home and commercial baker's specific leavening acid requirements. In addition to their role as the most commonly used acidulants for chemical leavening formulas, the phosphates also play an important part in bread and roll production. Food phosphates contribute to bread production directly in dough improvers and yeast foods, as well as indirectly as acidifiers in the production of yeast.

In every baking application, you will find Solutia phosphate ingredients uniformly high in quality and reliable in their functionality. You can depend on Solutia to supply expert advice when you encounter a challenge in formulating or processing.

Leavening

In baking, the phosphates function as leavening acids, which react with sodium bicarbonate, baking soda, to release carbon dioxide gas. The amount of gas and the rate of gas production determine the main effects of leavening. Table B below shows leavening uses of Solutia phosphates.

Exact levels of the phosphates needed to obtain a balanced leavening system can be calculated by use of the Neutralizing Value (NV), defined as the parts of baking soda neutralized by 100 parts of the leavening acid. See "Properties for Solutia Food Phosphates" in Table G on pages 30-31 for the NV of specific phosphates.

Table B – Leavening Applications of Solutia Phosphates

Product	Sodium Bicarbonate (%)	Leavening Acids (To Neutralize)
Baking Powders	30 - 40	H.T. MCP, Py-Ran, SAPP 28, Levn-Lite, Adipic Acid, Leverage
Biscuit Mixes	1.5 - 2.0	Stabil-9, Levn-Lite, SAPP 28
Breading Batter Mixes	0.0 - 2.0	SAPP 40, Levn-Lite, Pan-O-Lite, SAPP 28
Cake Doughnut Mixes	0.5 - 1.0	SAPP 40, SAPP 28, Levn-Lite, Py-Ran, SAPP 26, SAPP 37, SAPP 43, Leverage
Cake Mixes-Angel	1.5 - 2.0	H.T. MCP, Py-Ran, SAPP 40, Levn-Lite
Cake Mixes-Layer	0.6 - 1.0	Levn-Lite, Pan-O-Lite, SAPP, DCPD, Py-Ran, Leverage
Cookie Mixes	0.0 - 0.7	Stabil-9, SAPP RD-1, Levn-Lite
Crackers	0.5 - 1.8	H.T. MCP, Py-Ran, SAPP 28
Frozen Biscuit Doughs	1.5 - 2.0*	Levn-Lite, SAPP 28, SAPP 26, Leverage
Frozen Cake Batter	0.6 - 1.25	Levn-Lite, Pan-O-Lite, SAPP 28, H.T. MCP, DCPD, Leverage
Frozen Pancake Batter	1.7 - 2.2*	Pan-O-Lite, Levn-Lite, DCPD, Leverage
Hush Puppy Mixes	1.5 - 2.0	SAPP 28, SAPP 40, Py-Ran, Stabil-9
Muffins	1.5 - 2.0	Stabil-9, Pan-O-Lite, SAPP 28, DCPD, Leverage
Pancake Mixes	1.5 - 2.0	Pan-O-Lite, Levn-Lite, H.T. MCP, Py-Ran, SAPP 40, SAPP 28
Pizza Mixes	0.3 - 1.2	Pan-O-Lite, Levn-Lite, SAPP 28, DCPD, Leverage
Refrigerated Dough	2.0 - 2.5*	SAPP RD-1, SAPP 26, Levn-Lite, Leverage
Self-Rising Corn Meal	1.5 - 2.0	Py-Ran, Stabil-9, Levn-Lite, H.T. MCP
Self-Rising Flour	1.2 - 1.5	Stabil-9, Py-Ran, SAPP 28
Waffle Mixes	1.5 - 2.0	Pan-O-Lite, Levn-Lite, H.T. MCP, Py-Ran, SAPP 40, SAPP 28, Leverage

* % of solids

Phosphates for the Bakery Industry

SAPP (sodium acid pyrophosphate) leavening acids are supplied in several grades which have different rates of reaction with baking soda. In general, the grades of Solutia SAPP ingredients are designated by a number related to the Dough Rate of Reaction (DRR), which is expressed as the percentage of available carbon dioxide released in 8 minutes under standardized test conditions.

SAPP RD-1 and SAPP 26 are the slowest reacting SAPPs. Their primary use is in products that require a long production cycle, long bench tolerance or long storage life. For refrigerated doughs, the low rates of carbon dioxide gas production provide tolerance to process variation, yet the carbon dioxide is released at the right time to ensure that proper pressure is produced in the container.

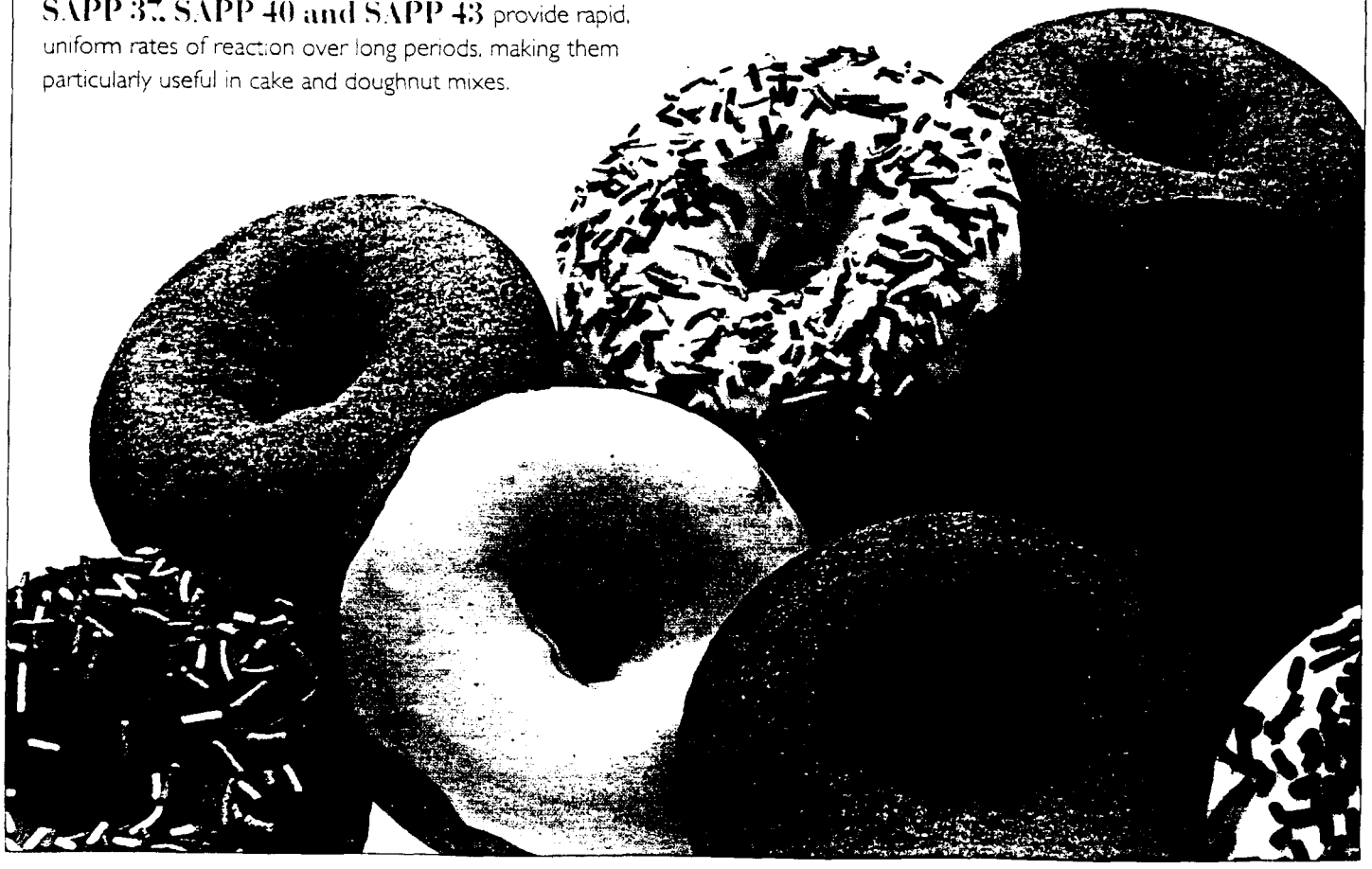
SAPP 28 is an all-purpose leavening phosphate. Its delayed gas release is especially suited to institutional and commercial baking of large batches, where extended mixing and forming times are necessary. The low reaction rate is stabilized by a special Solutia process. Doughnut applications employ SAPP 28 in combination with faster reacting SAPPs. SAPP 28 is also used in the manufacture of baking powders, either alone or in combination with MCP.

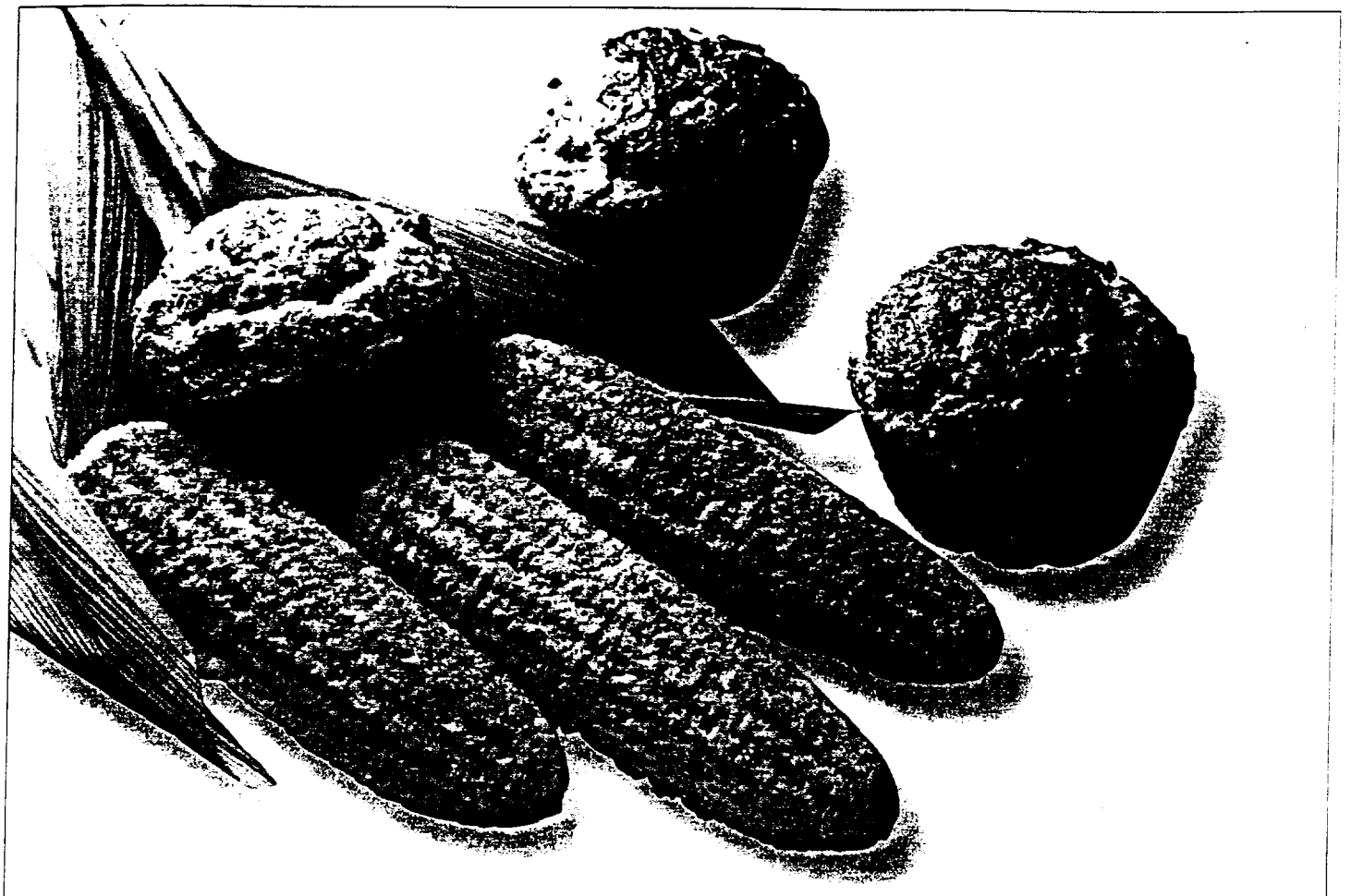
SAPP 37, SAPP 40 and SAPP 43 provide rapid, uniform rates of reaction over long periods, making them particularly useful in cake and doughnut mixes. These agents combine well with slower leavening acids to accommodate variation in other ingredients. In a balanced leavening system using any grade of SAPP, the final pH is typically 7.2 to 7.6.

SALP (sodium aluminum phosphate and blends) offers consistency in leavening rate throughout dough or batter storage and use. It also provides desired batter thickness, baking tolerance, and increased crumb whiteness and resiliency. SALP is an ideal leavening agent for prepared mixes.

Solutia's three SALP products are Levn-Lite, Stabil-9 and Pan-O-Lite leavening agents.

Levn-Lite® is SALP. Its major leavening action takes place only when the product is heated. Levn-Lite is used in cake, pancake and waffle mixes, where it helps ensure good volume. In cake formulations, it is employed with high-aerating emulsifiers. Levn-Lite has application in frozen and refrigerated products and in some commercial baking powders.





Stabil-9® combines SALP with anhydrous monocalcium phosphate for "double action": the early release of carbon dioxide by anhydrous monocalcium phosphate and the heat-triggered release by SALP in the oven. Available in regular and high calcium grades, Stabil-9 is used primarily in self-rising flours and biscuit mixes, where its properties permit long storage life of the dry mix. Furthermore, batters and doughs containing Stabil-9 retain satisfactory leavening action even when held for hours or days in the refrigerator. Stabil-9 gives finer grain to cakes. Other uses include self-rising corn meal and muffin mixes.

Pan-O-Lite®, a blend of SALP and monocalcium phosphate monohydrate, works well in pancake, waffle and cake mixes. It is used in cakes that do not contain high-aerating emulsifiers. Batter made with Pan-O-Lite resists thickening and loss of leavening power during storage under refrigerated or room temperature conditions, so this leavening agent is particularly appropriate for refrigerated pancake batters.

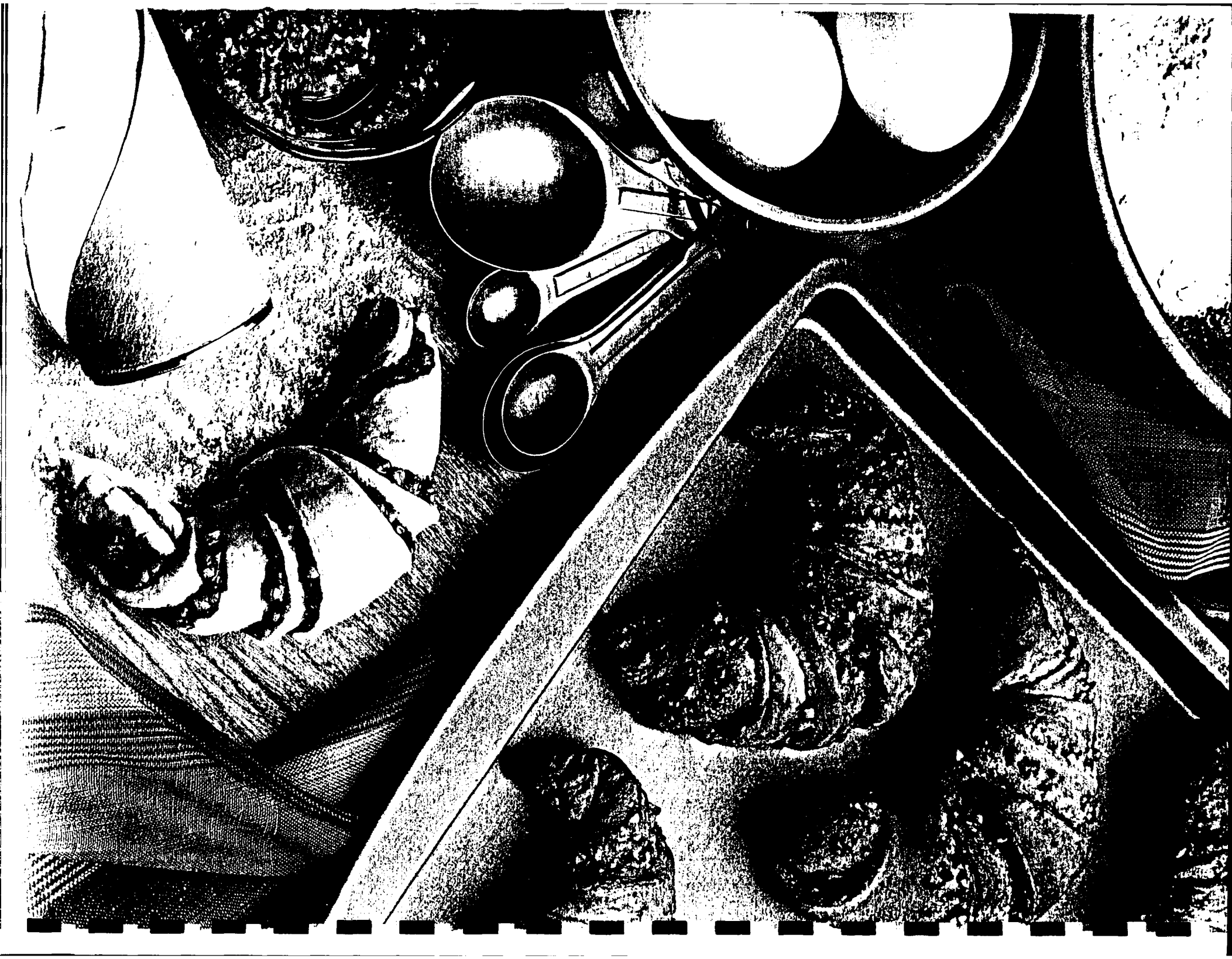
H.T.® MCP (monocalcium phosphate monohydrate) reacts rapidly with baking soda, so it is well suited for use in double-acting baking powders and in products that require double action, such as cake and pancake mixes. MCP's spherical particles make it a free-flowing compound that lends itself to use in phosphated flours.

Py-Ran® (anhydrous monocalcium phosphate) is stabilized by a coating that protects against premature leavening action by slowing dissolution and the subsequent reaction with baking soda. Consequently, Py-Ran has excellent leavening characteristics in self-rising and phosphated flours, self-rising corn meal, cake and pancake mixes, and household baking powder.

DCPD (dicalcium phosphate dihydrate or duohydrate) is useful in bakery products with a high set temperature, such as high sugar cakes. It begins to react with baking soda when the batter or dough temperature rises to about 135°F-140°F.

Adipic Acid is a white crystalline powder that's ideal for multiple food applications. In many food applications, adipic acid is preferred because of its non-hygroscopisity, which means dry products containing adipic acid have a longer storage life under humid conditions.

Leverage (dimagnesium phosphate) is a heat-activated leavening agent that provides no leavening action before baking. It provides a consistent leavening rate for greater control in batters and dough. Leverage produces finished products which are moist and tender.



Other Bakery Applications

Frosting and icing rely upon phosphates for pH adjustment and stabilization. Calcium phosphates are also used in gum-based systems to give proper gelling and thickening.

Dough conditioners, also known as dough improvers or yeast foods, often include MCP to optimize dough pH and to provide calcium in yeast-raised products. One dough conditioner employs a high level of dicalcium phosphate anhydrous. Monoammonium phosphate in a dough conditioner can buffer the pH and provide nitrogen.

Yeast production sometimes utilizes phosphoric acid to adjust the pH of growth media. Diammonium phosphate, monoammonium phosphate, monopotassium phosphate and dipotassium phosphate are sometimes used to provide nourishment to the yeast.

Breakfast cereals and pasta have shorter cooking times and richer, creamier color with the addition of DSP. Use of DSP also decreases processing time for ready-to-eat cereals. The use of DSP is permitted by the FDA Standards of Identities found in the CFR Title 21.

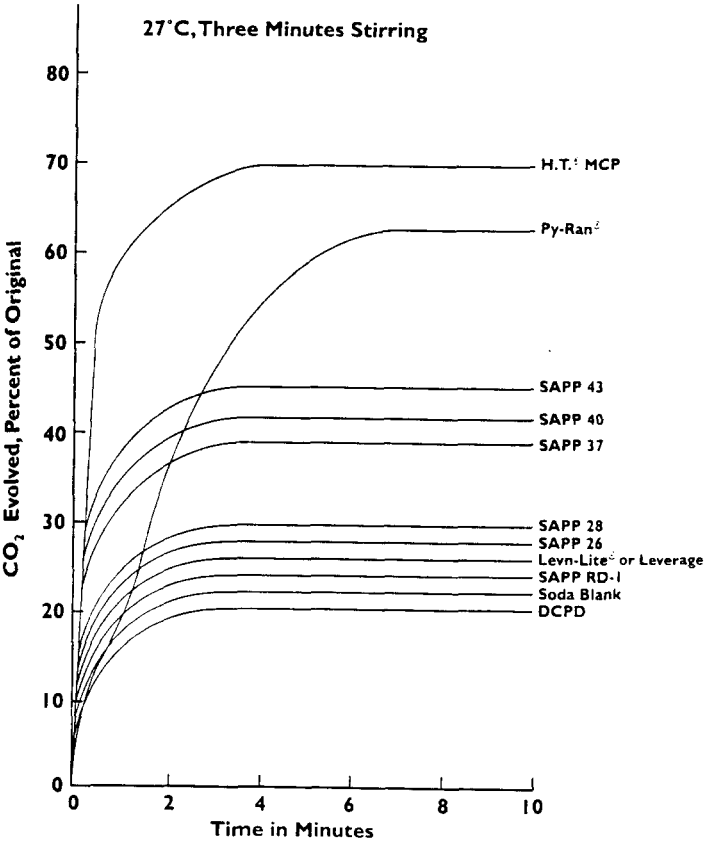
Starches, modified by addition of phosphate groups, exhibit several desirable properties, which include resistance to freeze-thaw breakdown, greater clarity, higher water-binding capacity, and high viscosity without gel formation.

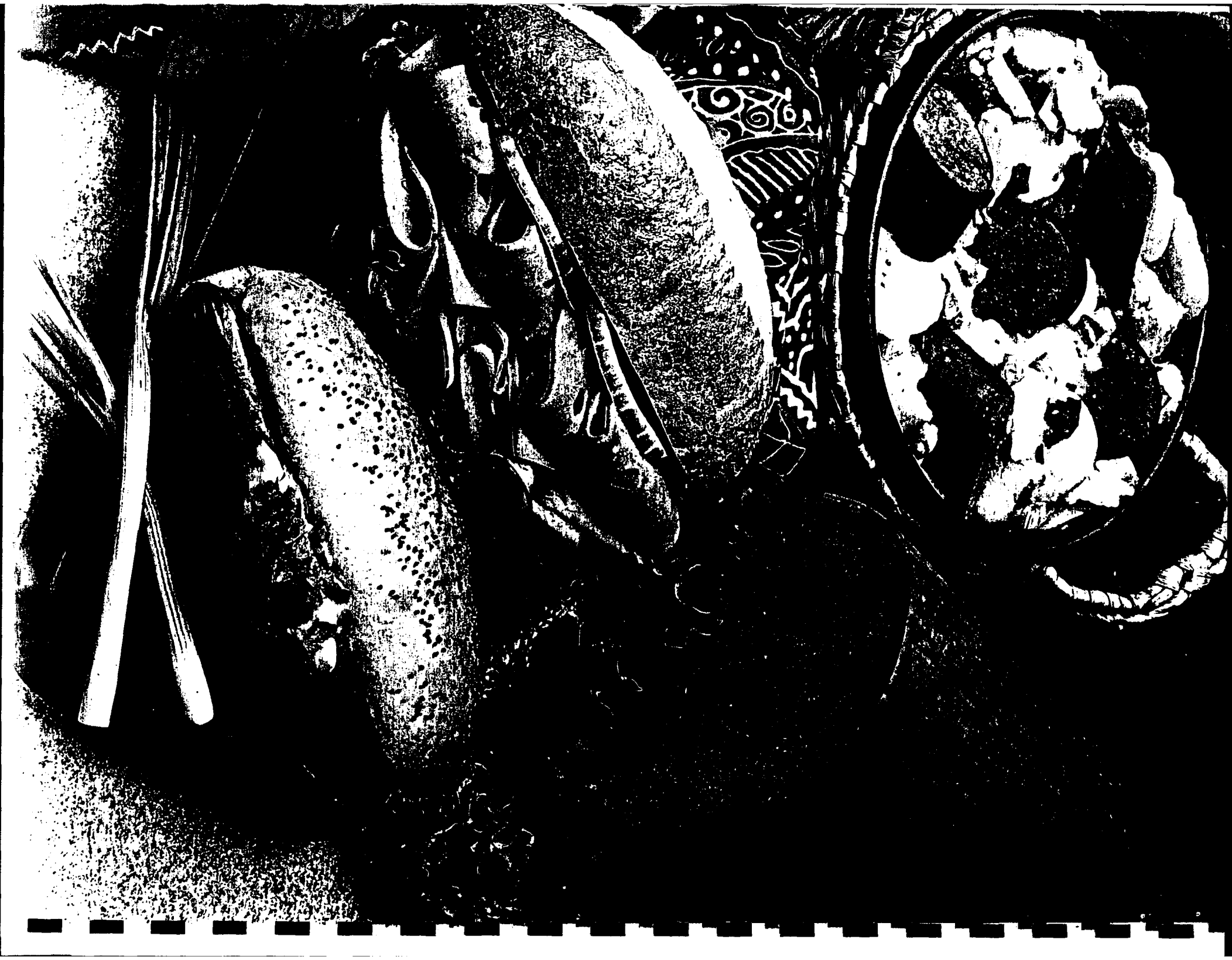
Dough Rate of Reaction

The selection of the leavening acid is based upon the rate of release of carbon dioxide in your dough or batter mixture. The rate of leavening action is the key to a successful application. Solutia manufactures and markets a diverse line of leavening acids with varying reaction rates. The baker or formulator can select the right product for their particular "critical zone"... the point in the preparation process where it is desired to have the necessary gas released. The Dough Rate of Reaction test is used as a guide because it shows typical reaction curves for leavening acids.

Figure 1 demonstrates the leavening rates of various leaveners as characterized by the DRR test. The soda blank curve includes all the ingredients minus the leavening acid. These tests were conducted at 27°C with three minutes of stirring. Note that increase in temperature, stir time and other ingredients will impact the final rate of reaction. In general, higher temperatures accelerate the rate of reaction.

Figure 1 – Typical Dough Rates of Reaction





Meat, Poultry and Seafood Applications of Solutia Phosphates

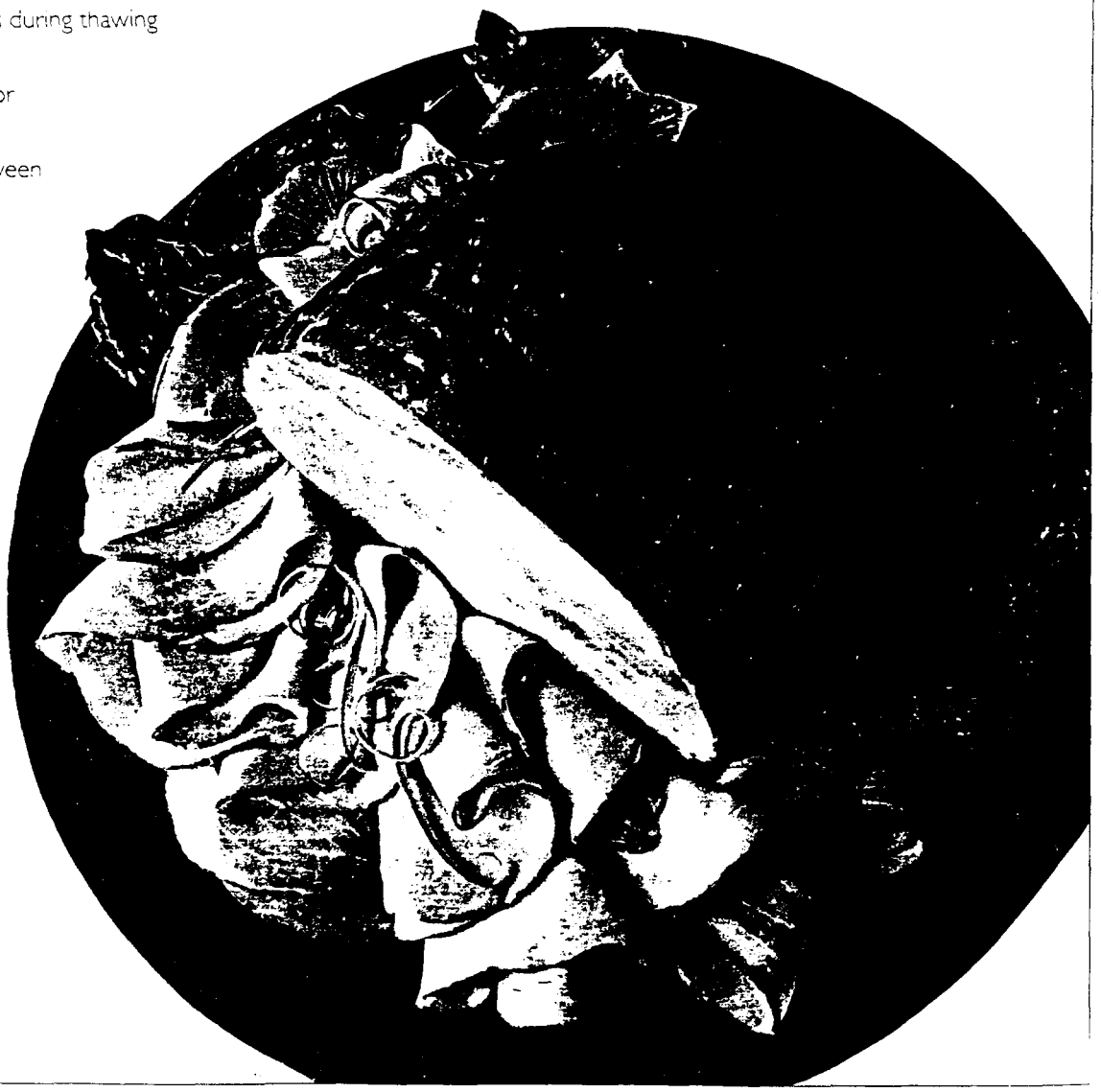
Polyphosphates are primarily used in meat, poultry and seafood products to provide protection from moisture loss during processing. In general, processors utilize sodium tripolyphosphate (STP), which can be used alone or in blends with sodium hexametaphosphate (SHMP). Alkaline polyphosphates, like STP, are believed to increase the local pH and ionic strength surrounding the protein. These changes allow the protein to uncoil exposing sites, which increases the protein's capacity to bind water. During cooking or thawing, the protein will release significantly lower quantities of moisture, therefore increasing total product yield. The increase in water-binding capacity results in:

- Reduced moisture loss during cooking
- Improved yield following cooking
- Reduced moisture loss during thawing
- Increased tenderness
- Improved cooked flavor
- Reduced freezer burn
- Increased binding between muscle pieces

Other functions of polyphosphates include:

- pH adjustment and buffering
- Sequestration of multivalent cations to inhibit oxidative rancidity
- Stabilization of the color of cured products
- Emulsion stabilization and/or viscosity reduction
- Emulsification of fat and protein

United States Department of Agriculture (USDA) regulations generally allow addition of phosphate ingredients up to 0.5% by weight of the finished product. In the following sections, specific phosphates are recommended for particular applications.



Cured Meat and Poultry

Incorporation of phosphates confers several benefits on bacon, ham, corned beef and cured poultry products. By decreasing moisture loss during processing, phosphates increase yields and give products that are more moist to eat. Keeping the moisture level up and partially dissolving fibrous protein make the products more tender. By sequestering metal ions, especially iron, phosphates inhibit development of rancidity during storage. Phosphates also extend shelf life by stabilizing the red color of cured meat and poultry.

Processed Meat and Poultry

Blending Nutrifos H30 or SAPP (sodium acid pyrophosphate) into the meat during the chopping operation will accelerate development of red color in wieners, bologna and similar emulsion products. These ingredients offer the potential of increased production in a plant that is operating at smokehouse capacity and is able to increase smokehouse temperature. Including phosphates also makes the emulsion more resistant to a drop in pH.

Adding sodium tripolyphosphate, sodium hexametaphosphate or tetrasodium pyrophosphate, either singly or in any combination, increases emulsion stability and reduces fat cook-out when the product is prepared for consumption.

Frozen Products

Meats, poultry, fish and other seafoods all benefit from treatment with phosphate solutions before they are frozen.

Addition of phosphate:

- Inhibits development of rancidity during storage
- Decreases loss of protein-containing juices at thawing
- Reduces shrinkage when the product is cooked

The result is a cooked product that is juicier, more tender and better flavored.

Shrimp

Phosphates can help the seafood processor by making the shells of shrimp easier to remove, thereby increasing the meat yield of the deshelling operation. STP or a blend of STP and SHMP is added to the boiling water, and the shells are removed with high-pressure water jets.

Canned Seafood

Addition of SAPP to albacore tuna during canning decreases or prevents formation of troublesome struvite crystals. Phosphates will also inhibit white protein curd formation in canned salmon.

Reformed and Restructured Products

In production of frozen products, such as restructured steaks, shrimp shapes, formed poultry parts, meat loaves, sectioned and formed roasts, turkey and chicken rolls, and fish blocks, phosphate solubilizes the protein that binds the pieces together and aids in moisture retention.

For surimi production and seafood analog manufacturing, Nutrifos polyphosphates have been found especially useful as cryoprotectants and binding aids.

Phosphates for the Meat, Poultry and Seafood Industries

Nutrifos® 088 sodium tripolyphosphate (STP) is an extremely fast-dissolving, multi-purpose phosphate for all meat, poultry and seafood applications. It is economical to use and provides most all the functions of more expensive phosphate blends. Nutrifos 088 is versatile. It is well-suited for injection use (hams, poultry and fish fillets), in solution (marinades, fish and shellfish), for dry addition (sausage, meat toppings), and for tumbling.

Nutrifos BC combines the high performance of STP with the ability to dissolve concurrently with salt. Usual STP procedure requires phosphate dissolution before the addition of sodium chloride. With Nutrifos BC this requirement is no longer necessary. Nutrifos BC dissolves rapidly and completely in combination with salt, potentially shortening preparation time. Nutrifos BC is ideal for prepackaged marinades and blends containing spices, salt and other ingredients.

Nutrifos B-90 is a blend of STP and the more soluble sodium hexametaphosphate (SHMP). Nutrifos B-90 is ideal when increased solubility or water softening are desired. It has a marked advantage in highly concentrated pickles, like those for hams where the high solubility of SHMP allows a processor to keep more phosphate in solution. Due to its sequestration, Nutrifos B-90 will delay oxidative rancidity in processed meat, poultry and seafood. Nutrifos B-90 substantially reduces the risk of clogged needles.

Nutrifos B-75 is a blend of STP and SHMP developed for applications requiring extremely high solubility. It is formulated to dissolve in hard water and has tremendous compatibility with high solid brines, such as those used for preparing canned hams. It is ideal for products requiring a slow cure. Nutrifos B-75 will also improve overall sliceability in bacon and ham.

Nutrifos H-30 is a blend of polyphosphates specially formulated for emulsion meat and poultry products, such as hot dogs and bologna. It has a near neutral pH which favors rapid cured color development. This allows for faster processing with the potential for increased production. Nutrifos H-30 improves emulsion stability and helps control viscosity, which is important when pumping emulsions. It also ensures the characteristic bite associated with emulsion products. With Nutrifos H-30, the processor does not have to sacrifice yield in order to have maximal bind.

Nutrifos SK sodium potassium tripolyphosphate (SKTP) is a reduced sodium polyphosphate combining the benefits of phosphate functionality with high solubility and handling ease. Use of Nutrifos SK does not result in off flavors usually associated with potassium. Nutrifos SK is a cost-effective alternative for achieving reduced sodium in meat, poultry and seafood products while retaining the benefits of polyphosphate functionality.

Nutrifos L-50 is a powder blend of STP and tetrasodium pyrophosphate (TSPP) developed for the seafood analog industry. Through its unique ability to solubilize and extract protein, Nutrifos L-50 results in surimi with optimal gel strength. Nutrifos L-50 is added dry to the minced fish, which avoids additional moisture incorporation.

Katch® fish phosphate is a blend of sodium polyphosphates created for the fish and seafood industries. Katch maintains moisture levels by minimizing cook and thaw loss. It also works as a cryoprotectant to help extend shelf life in frozen products and delays the onset of oxidative rancidity in even the fattiest of fish species. This versatile blend can be used as a dip (fillets, shrimp, scallops), for injection applications, and in tumbling.

Sodium acid pyrophosphate (SAPP NL) is an acid phosphate frequently used as a dry ingredient to stabilize emulsions. SAPP NL favors color development and improves flavor and texture in hot dogs and luncheon meats.

Tetrasodium pyrophosphate (TSPP), a highly alkaline phosphate, is used when maximal protein solubilization is desired. However, TSPP use is limited by its low solubility, and it is primarily utilized in combination with other more soluble phosphates or in specialty applications.

Tetrapotassium pyrophosphate (TKPP). like TSPP, is a very alkaline phosphate. TKPP is suitable for applications requiring extremely high solubility (60%) and/or reduced sodium. TKPP is an excellent choices for specialized applications and pet foods.

Table C - Phosphate Usage in Meat, Poultry and Seafood Products

Application Summary	Phosphates	Method
Meat		
Ham, Bacon, Corned Beef, Roast Beef, Pastrami	Nutrifos 088, BC, B-90 or B-75	injection, vacuum tumbling 0.4-0.5% by weight
Frozen Hamburger Patties and Ground Beef Patties (Cooked or Frozen)	Nutrifos 088 or STP Powder	dry addition 0.2-0.4% by weight
Cooked Sausage	Nutrifos 088, BC, SK STP Powder or B-90	dry addition 0.15-0.35% by weight
Frankfurters, Bologna, Luncheon Meats	Nutrifos H-30, BC, SK, SAPP NL, Nutrifos 088	dry addition 0.15-0.35% by weight
Reduced Sodium Products	Nutrifos SK, TKPP	injection, tumbling, dry addition 0.15-0.5% by weight
Poultry		
Whole Turkeys 0.5% by weight	Nutrifos 088 or B-90	injection, tumbling
Turkey Hams, Pastrami, Corned Beef	Nutrifos 088, B-90, B-75, or BC	injection, tumbling 0.5% by weight
Restructured Poultry, Patties, Rolls, Nuggets, Cooked Sausage	Nutrifos 088, B-90 or STP Powder	dry addition 0.15-0.35% by weight
Ground Chicken or Turkey	Nutrifos 088 or B-90	dry addition 0.15-0.35% by weight
Frankfurters, Bologna, Luncheon Meats	Nutrifos H-30, SAPP NL, Nutrifos 088, BC, SK	dry addition 0.2-0.3% by weight
Reduced Sodium Products	Nutrifos SK, TKPP	injection, tumbling, marinades, dry addition 0.15-0.5% by weight
Seafood		
Fish Fillets	Katch, Nutrifos 088 or B-90	injection, dipping or tumbling to achieve 0.4-0.5% by weight
Shrimp Deshelling	Nutrifos 088, BC or B-90	dipping fresh shrimp in a 5-7% solution
Shrimp for Freezing or Cooking	Nutrifos 088, BC or B-90	dipping fresh shrimp in a 5-7% solution
Scallops	Nutrifos 088 or B-90	dipping fresh scallops in a 5-7% solution
Surimi	Nutrifos L-50, TSPP or TKPP	dry addition 0.1-0.5% by weight
Canned Tuna or Crab	SAPP NL	dry addition 0.3-0.5% by weight
Salmon for Canning	Nutrifos 088	dipping fillets in 3-5% solution
Reduced Sodium Products	Nutrifos SK, TKPP	injection, tumbling, marinades dry addition 0.15-0.5% by weight or dipping in 5-7% solution

Dairy Applications of Solutia Phosphates

There is a great variety of phosphate applications in the dairy industry. Phosphate functionality in dairy products involves interactions between phosphates and milk proteins and between phosphates and calcium. Solutia phosphates perform the following functions in dairy products:

- Buffer products within the desired pH range
- Stabilize casein proteins in milk against heat coagulation
- Disperse flavors and proteins in reconstituted milk powders
- Coagulate proteins to enhance gelation
- Acidify products
- Interact with proteins to promote emulsification

Solutia has the appropriate phosphate for virtually any dairy application. We will work with you and supply any technical support you may need.

Process Cheese Products

Phosphates are used in process cheese products primarily to help maintain the emulsion of butterfat in its protein-water matrix. Consequently, the product is uniform in flavor, and fat does not separate from the cheese when melted. In addition to stabilizing the protein-water-fat emulsion, phosphates also buffer the product at an optimum pH and give the product appropriate firmness and melting characteristics.

Phosphates are used for the same functionality in "filled cheese" products, imitation cheese products, and pasteurized cream cheese products.

Federal regulations govern the use of emulsifying agents in the manufacture of pasteurized process cheese (CFR 133.169), cheese food (CFR 133.173), and cheese spread (CFR 133.179). Under these regulations, emulsifying agents may not exceed 3% of the weight of the finished product.

The most economical level of use for the cheese processor is the maximum limit of 3%. Few phosphates can be used at this maximum level without compromising the quality of the finished product. Solutia has developed three blends that can be used at the maximum 3% level: Emulsi-Phos® 440, Emulsi-Phos 660 and Emulsi-Phos 990. These specially developed phosphate blends permit the optimum combination of desirable processing and end-product properties, such as viscosity, melt spread, body and hardness. Table D on the next page describes the phosphates for process cheese manufacturing.

Table D – Solutia Phosphates for Process Cheese Manufacture

Emulsifying Agent	Properties	Recommended Usage Level
Emulsi-Phos 440	A blend of DSPA and IMP. Produces soft, easily melted product. Gives greater flexibility than using either DSP or TSP.	3% Can be used singly or in combination
Emulsi-Phos 660	A blend of TSPA and IMP. Used exclusively when high processing fluidity and softer, more meltable cheese is desired. Gives greater flexibility than using either DSP or TSP.	3% Can be used singly or in combination
Emulsi-Phos 990	A blend of TSPA and IMP. Normally used in combination with another phosphate for process cheese production to maximize desired texture and melt characteristics. Gives greater flexibility than using either DSP or TSP.	3% Can be used singly or in combination
MSP	Used to decrease the pH and melt spread and to firm the cheese. Added late in mixing. Produces acidic cheese if used alone.	Very low Used in combination with DSP, TSP or TSPP
DSPA	Produces cheese that is soft and meltable. Sufficiently prevents oil-off during melting. Allows for optimum pH control.	1.8% in process cheese; higher in cheese foods and spreads
DSPD	Hydrated species of DSP. Same properties as DSPA.	2.3% in process cheese; higher in cheese foods and spreads
TSPA	An alkaline orthophosphate which, like DSPD, produces soft, easy-melting products. Recommended where maximum melt strength is desired.	1.2%
TSPC	Hydrated species of TSP. Same properties as TSPA.	2.8%
MKP	Low-sodium alternative to MSP. Used to decrease pH and melt spread and to firm the cheese.	Very low Used in combination with other emulsifying agents
SAPP	Produces hard, non-melting cheese for use in specialty products. Melts only at higher temperatures. Produces acidic cheese if used alone.	Very low Used in combination with TSPP, DSP and/or TSP
TSPP	Produces hard cheese, which will melt only at higher temperatures.	2% Used in combination with MSP, DSP and/or TSP
TKPP	Alkaline, sodium-free pyrophosphate with excellent solubility to produce hard cheese with sharp flavor.	2%
SHMP	Contributes texture to process cheese. Normally used in conjunction with other emulsifying agents to increase firmness of product. Produces brittle cheese if used alone.	0.5-1.5%

Natural Cheese

Phosphates can be used during the production of natural cheese. Bacteriophages typically require free calcium to multiply in starter cultures. Through precipitation of calcium by DSP, these cultures can be protected from phages. Ammonium and potassium phosphates are used to supply valuable nutrients to the starter culture media.

During cheese manufacture, milk can be directly acidified by MCP or phosphoric acid to decrease processing time, increase yield, and increase calcium levels in cheese, especially cottage cheese. The use of TSPP will also shorten processing time. It is added with the culture, rennet and phosphoric acid to produce a curd that can be molded and allowed to start the aging process immediately.

Dried Milk Products

Incorporating DSP into skim milk before drying yields a nonfat dry milk that will dissolve more smoothly in water. The phosphate keeps milk proteins dispersed by protecting them from heat coagulation during spray drying.

Powdered TSPP helps disperse and suspend cocoa and malted milk powder in milk, thus minimizing sediment. In addition, incorporating TSPP at the appropriate level promotes formation of a thin gel layer around the milk proteins. The gel enriches both the flavor and the color and contributes to the smooth mouthfeel of the final beverage.

The use of instant pudding and "no-bake" cheesecake mixes depends on the reaction between TSPP and calcium in the milk protein, which induces gelation. The addition of DSPA will accelerate setting of the pudding but may not be necessary, depending on the calcium content of the milk protein. In some cases, calcium is added to the pudding system in the form of MCP to strengthen the gel.

DSP and SHMP are commonly used during the production of spray-dried cheese. These phosphates protect milk proteins from heat denaturation. In addition, they act to disperse milk proteins upon spray drying to assist in solubility of cheese powder upon reconstitution with water. They also stabilize the protein-water-fat emulsion to enhance flavor, body and appearance of the reconstituted product.

Fluid Milk Products

To prevent heat coagulation in condensed and evaporated milk or cream, DSP is used to stabilize casein in the milk.

Sterilized milk, cream and half-and-half products, including UHT concentrated products, gain added storage life when stabilized with DSP or SHMP to prevent age gelation during storage. Buttermilk produced by direct acidification via the addition of phosphoric acid has a reduced processing time and a longer refrigerated shelf life than cultured buttermilk. Addition of TSPP prior to acidification acts as a dispersing agent for the curd that would normally be formed in the acidic medium. Thus, TSPP enhances: flavor, viscosity, body, stability to whey-off, and appearance of buttermilk.

Cream Products

To maintain fat dispersion in ice cream mix, DSP, TSPP or SHMP may be added so "churning" will not form lumps of butter during the freezing operation. In chocolate ice cream, DSP, TSPP and SHMP also function to maintain a stable chocolate suspension. These phosphate ingredients can also serve the same purpose in other frozen desserts.

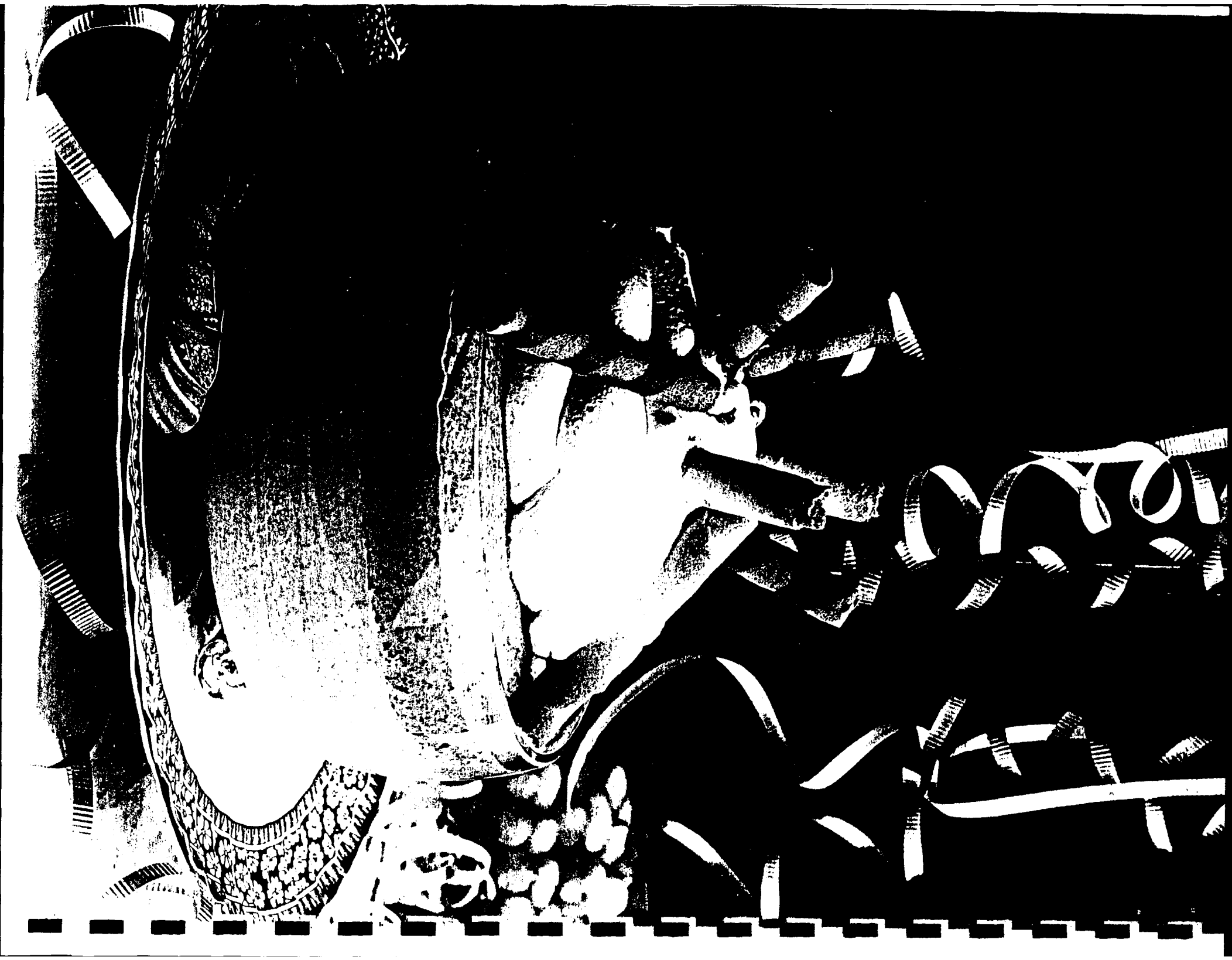
DSP is used in canned cream and cheese soups which are subjected to high sterilization temperatures. The DSP functions as a stabilizer to prevent proteins from flocculation and to maintain a smooth appearance and taste.

The addition of STP in imitation sour cream and chip dips controls syneresis. STP interacts with proteins to promote swelling of the molecules.

Whipped Toppings and Non-Dairy Coffee Whiteners

Whipped toppings of various composition obtain increased whipping efficiency and foam stability from addition of TSPP. By stabilizing the protein films, SHMP inhibits weeping in milk-based toppings, while DSP functions similarly in products based on other protein sources such as soybean.

In non-dairy coffee whiteners, a phosphate buffering system consisting of DSP, SAPP and/or STP contributes to stability of the protein layer around the fat droplets, thus preventing syneresis. This buffer system also prevents feathering and fat separation when the coffee whitener is added to the hot acidic coffee medium. TSPP has also been used as a stabilizing agent to help disperse soy proteins.



Some of the major applications for phosphates in the dairy industry are described in Table E, along with recommended usage levels for each particular application.

Table E – Dairy Applications of Solutia Phosphates

Application	Phosphates	Usage Level
Evaporated, Condensed Milk, Cream	DSP	0.02-0.10% of final product
Flavored Milk Powders	TSPP, TKPP	0.1-0.3%
Non-Dairy Coffee Creamers	DSP	1.0-2.0% of dry product 0.1-1.0% of liquid product
Buttermilk	TSPP, TKPP, Phosphoric Acid	0.01-1.0%
UHT Concentrated Milk	SHMP	0.1-1.0%
Dried Milk-Drink Products	DSP	2.0% milk solids' weight
Sterile Concentrated Milk, Cream	SHMP	0.1-1.0%
Instant Pudding, No-Bake Cheesecake	TSPP, DSP, MCP, SAPP, STP, TKPP	2-7% total phosphate
Milk Foams	TSPP, TKPP, SHMP	1.5-2.0% milk solids' weight
Imitation Sour Cream, Chip Dips	STP	0.05-0.20% oil basis
Spray-Dried Cheese	DSP, SHMP	1-3%
Canned Cream and Cheese Soups	DSP	0.2%
Whipped Toppings	TSPP, TKPP, DSP	0.025-1.0% of complete liquid base
Process Cheese	Emulsi-Phos 440, 660, 990, MSP, DSP, TSP, MKP, SAPP, TSPP, SHMP, TKPP	0.5-3.0%
Cheese Sauce	DSP, TSP, SHMP	0.5-3.0%
Starter Cultures	DSP, MAP, DAP, MKP	2-3%
Frozen Desserts, Ice Cream	DSP, TSPP, SHMP, TKPP	0.1-0.2% of final product
Direct-Set Cottage Cheese	MCP, Phosphoric Acid	0.03%

Other Applications of Solutia Phosphates

Pharmaceutical and Nutritional Products

The calcium phosphates are broadly utilized in nutritional supplementation and fortification, since they are a quality source of both calcium and phosphorus. For infant foods and formulas, the calcium phosphates provide both calcium and phosphorus, essential nutrients for proper growth and bone development. The fine particle size of both DCP and TCP make them particularly useful in infant formulas. Both DCP and TCP can be used as excipients for tableting applications in vitamins and drugs.

Mag-nificent is an ideal source of magnesium and phosphorus for a number of products, such as infant formula, geriatric beverages, nutritional supplements, vitamins and ready-to-eat cereals. It is compatible for use with calcium phosphates, so that all the essential minerals can be balanced.

Beverages

Phosphoric acid is used as an acidulant for cola and root beverages. The usual cola contains about 0.05% phosphoric acid and has a pH of about 2.3. Root beer has a higher pH of about 5.0 and contains 0.01% phosphoric acid. On a price performance basis, phosphoric acid is less expensive than organic acid alternatives. It provides many advantages in the formulating of these products:

- Sparkling bite and astringency counteract the heaviness of root and cola flavors
- Low pH improves flavor and storage stability
- Chelation of troublesome metal ions helps establish a stable carbonation

Monocalcium phosphate monohydrate (MCP) can be used in the formulation of beverage powders. MCP has many benefits:

- Economical pH buffer to control tartness
- Nonhygroscopic acidulant replaces up to 50% of citric acid
- Calcium and phosphorus are contributed to the products' nutrient profile.

Tricalcium phosphate (TCP) is also commonly used for dry powder formulations where it contributes several useful properties:

- Flow conditioner for dry base products
- Clouding agent in reconstituted beverages
- Calcium and phosphorus are contributed to the products' nutrient profile

Monosodium phosphate (MSP) and **Monopotassium phosphate** (MKP) are used in isotonic formulations. They are added to the formulation to replace sodium and/or potassium that are lost as a result of athletic or physical activity.

In nutritionally fortified beverages, the metal complexing properties of polyphosphates afford protection for Vitamin C, which is readily oxidized in the presence of some metal ions.

Monoammonium and Diammonium phosphates are used in the wine industry in production of sparkling wines.

Produce

Potatoes

Sodium acid pyrophosphate non-leavening (SAPP NL) and **Tetrasodium pyrophosphate** (TSPP) are used for several processed potato applications:

- Protection from after-cooking darkening in french fries and frozen potatoes. This iron-induced phenomenon is eliminated by the metal-complexing ability of SAPP NL and TSPP.
- Production of dehydrated mashed potatoes where SAPP NL or TSPP are added during mixing, just before drying
- Protection of color in sweet potatoes by SAPP NL, TSPP, or SAPP NL plus Nutrifos 088

Fruits

Calcium phosphates, such as MCP, are used to increase the firmness in canned fruit by increasing the calcium pectinate content. Other fruit applications include:

- Phosphoric acid to furnish acidity and optimal gel strength in jellies or bakery filling
- Polyphosphates to delay color changes in preserves made from red berries
- Sodium hexametaphosphate (SHMP) to extend shelf life of apple cider and other juices

Vegetables

Nutrifos 088, Sodium hexametaphosphate (SHMP) or **Tetrasodium pyrophosphate** (TSPP) are used in the canning or freezing of fresh peas or beans to improve tenderness. These phosphates, included in the wash or blanch water, can prevent toughening of skins due to absorption of calcium and magnesium from the water.

Egg Products

Phosphates serve a multitude of functions in processed eggs:

- Nutrifos 088 and SHMP inhibit development of rancidity in yolk lipids
- MSP and MKP preserve the color of egg yolk during refrigerated or frozen storage
- Nutrifos 088, Nutrifos B-90 or SHMP can prevent the coagulation of dried eggs during the heat-intensive drying period
- SHMP or Nutrifos 088 improve whipping efficiency and foam stability in dried-egg products. This improves functionality of the dried egg in cakes and meringues.

Fats and Oils

- Phosphoric acid acts synergistically with other additives to prevent oxidative rancidity in vegetable shortening
- TCP added to lard and then filtered out removes color and absorbs iron, which promotes rancidity
- Phosphoric acid can be used in the degumming processes for the purification of soy and other vegetable oils. It also provides pH control and ties up small amounts of transition metal ions, such as iron, nickel and copper, which catalyze the development of rancidity.

Miscellaneous Food Applications

Flow Conditioning

TCP is generally applicable as a flow conditioner for powdered and fine granular products due to its small particle size and inertness.

Gelatin Desserts

MSP and disodium phosphate (DSP) serve as buffers in gelatin desserts. They control the water-binding capacity, which is dependent on pH.

Peanuts

SHMP and Nutrifos 088 are used to economically salt peanuts in the shell by making it possible for brine to quickly penetrate into the shells.

Gels and Gums

Gel strength of alginate, agar, carrageenan and other gums is modified by the presence of phosphates, such as TSPP, TKPP, DSP, DCP, SHMP and Nutrifos 088. Polyphosphates also can retard syneresis in these gels.

Microbiological Operations

Phosphoric acid and phosphate salts are used as nutrients and buffering agents in microbiological operations, such as yeast and antibiotic production.

Sugar Processing

Phosphoric acid aids in the clarification step in sugar processing. Impurities are removed by treating heated sugar liquid with phosphoric acid and lime in a long, shallow tank in the presence of air introduced from the bottom of the tank. The precipate of calcium phosphate, together with occluded insolubles and non-sugars precipitated from the liquid, is carried to the top to form a scum, which is separated mechanically. The scum is filtered to recover contained sugar, but the liquor itself is not filtered. The process is superior to the older procedure (of only liming the liquid) with respect to removal of colored and other soluble impurities.

Salad Dressing

Phosphoric acid is employed in small amounts to impart an acidic flavor to salad dressings. It is also used to increase the biological activity of preservatives in the dressings.

Jams and Jellies

Phosphoric acid is used in the jam and jelly industry, especially for preparing firm, nonsoaking jellies, such as those used in doughnuts, jelly rolls and cake fillings. The acid is added during the final stages of cooking to minimize hydrolysis of the pectin. Phosphoric, together with citric and tartaric acid, is used as a buffering agent to control the acidity so as to give the firmest pectin gel and, at the same time, to complex heavy metal cations, such as iron, which give a dull color to the jelly.

Dental Applications of Solutia Phosphates

Phosphates are used in a variety of dental applications. More effective dentifrices have been developed over the last two decades, combining therapeutic (anticaries), cosmetic (whitening, tarter control), and cleaning benefits. Solutia produces a complete line of calcium phosphate products which span a wide range of abrasive levels for use as polishing agents, including dicalcium phosphate dihydrate, dicalcium phosphate anhydrous, calcium pyrophosphate and Lustre-Phos®. Other phosphates, including sodium and potassium pyrophosphates, sodium tripolyphosphate and tricalcium phosphate, are currently being used in dentifrices and mouthrinses for functions such as anti-calculus activity and sensitive teeth protection.

Pet Food Applications of Solutia Phosphates

Phosphates and phosphoric acid are used in pet foods for the same functionalities they exhibit in human food. For cats, it is important to provide the correct pH in order to meet the cat's palate requirements. Phosphoric acid is used to adjust the pH of both dry and moist food products. The polyphosphates (STP, SKTP, TKPP, TSPP, SHMP) can be used to solubilize protein in the production of canned pet food for both canines and felines. The solubilized protein provides binding and moisture retention, which aid in product release from the can.

The orthophosphates (MSP, DSP, TSP and MKP) are incorporated for pH and buffering. The calcium phosphates are used to provide nutrient supplementation in both pet food and animal feed. The potassium salts can be used to increase potassium levels in food for cats. This aids in the prevention of urinary tract disease. In animal feeds, phosphoric acid is used to adjust the pH for palatability for many different animals. Sodium and potassium phosphates can be used in salt blocks. Phosphates (STP and SAPP) are also Generally Recognized As Safe (GRAS) as general-purpose additives in Animal Feed and Pet Foods and are listed in Title 21 CFR 582. The use of phosphates in animal feed products is regulated by Association of American Feed Control Officials, Incorporated (AFCO).

Technology, New Applications and Formulations

Whether it's new technology for your company or for the industry, Solutia has a staff of technical specialists prepared to assist you in designing a product that meets your specifications. Solutia researchers are continually exploring new trends and are available to assist in optimization of products.

For most applications, a recommendation is available on which phosphate to use and what level to use it. For many applications, starting formulations can be provided.

Solutia stands ready as your partner to create the best food products possible!

Table F – Applications by Product

Solutia Product	Applications		
Acids			
Phosphonic Acid	Beef Jerky Beer Cola Beverages	Cottage Cheese Fats & Oils Fillings	Jams & Jellies Pet Food Sugar
Adipic Acid	Bakery Mixes Candy	Desserts Gelatin	Jams & Jellies Pudding
Orthophosphates			
Monoammonium Phosphate	Breads & Doughs	Cheese Starter Cultures	Yeast
Diammonium Phosphate	Breads & Doughs Cheese Starter Cultures	Cookies Crackers	Yeast
Monosodium Phosphate	Cola Beverages Dry Powder Beverages Egg Yolks	Gelatin Instant Cheesecake	Instant Pudding Isotonic Beverages
Disodium Phosphate	Breakfast Cereal Cheese Concensed Milk Cream Evaporated Milk Flavored Milk Powders Gelatin	Half & Half Ice Cream Imitation Cheese Infant Food Instant Cheesecake Instant Pudding Isotonic Drinks	Nonfat Dry Milk Pasta Pet Food Processed Cheese Starch Vitamin Capsules Whipped Topping
Trisodium Phosphate	Cereals Cheese	Imitation Cheese Isotonic Beverages	Processed Cheese
Monopotassium Phosphate	Breads & Doughs Dry Powder Beverages Eggs	Isotonic Beverages Mineral Supplement	Starter Cultures Yeast
Monocalcium Phosphate	Bakery Mixes Baking Powder Dough Conditioner Dry Powder Beverages	Flour Fruits Infant Food Milk-Based Beverages	Multivitamin Capsules Pet Food Pudding Yogurt
Dicalcium Phosphate	Bakery Mixes Cereals Dry Powder Beverages Flour	Food Bars Infant Food Milk-Based Beverages Mineral Supplementation	Multivitamin Tablets Pet Food Yogurt
Tricalcium Phosphate	Cereal Dry Powders Grated & Powdered Cheese Infant Food Lard	Milk-Based Beverage Mineral Supplementation Multivitamins Pet Food Polymers	Salt Spice Blends Sugar Yogurt
Sodium Aluminum Phosphate	Bakery Mixes	Baking Powder	
Dimagnesium Phosphate	Bakery Mixes Beverages	Cereals Infant Formula	

Table F – Applications by Product

Solutia Product	Applications		
Pyrophosphates			
Sodium Acid Pyrophosphate	Bakery Mixes Baking Powder Canned Seafood Cured Meats	Icing & Frostings Imitation Cheese Potatoes Poultry	Processed Cheese Processed Meat Seafood Vegetables
Tetrasodium Pyrophosphate	Cured Meat Flavored Milk Powders Instant Cheesecake Instant Pudding	Pet Food Poultry Processed Meat Seafood	Starch Vegetables Whipped Topping
Tetrapotassium Pyrophosphate	Cured Meat Flavored Milk Powders Instant Cheesecake Instant Pudding	Pet Food Poultry Processed Meat Seafood	Starch Vegetables Whipped Topping
Polyphosphates			
Sodium Tripolyphosphate	Dips Eggs Meat Pet Food Poultry	Processed Cheese Seafood Sour Cream Table Syrup Vegetable Protein	Vegetables Whey Whipped Toppings Yogurt
Sodium Trimetaphosphate	Starch	Vitamins	
Sodium Hexametaphosphate	Cream Eggs Half & Half Ice Cream	Meat Poultry Processed Cheese Seafood	Table Syrup Vegetables Whey Whipped Toppings
Sodium Potassium Tripolyphosphate	Dips Eggs Meat Pet Food Poultry	Processed Cheese Seafood Sour Cream Table Syrup Vegetable Protein	Vegetables Whey Whipped Toppings Yogurt

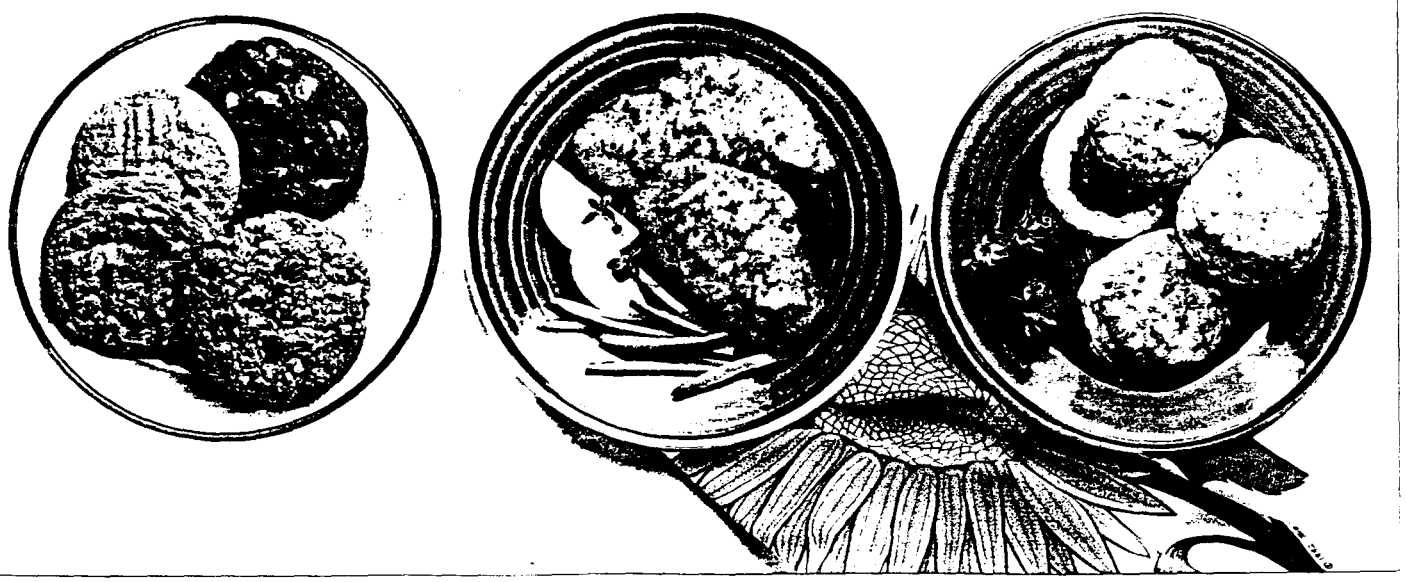


Table G – Typical Properties for Solutia Food Phosphates

Product Name	Abbreviation	Synonyms	Formula
Monosodium Phosphate, Anhydrous	MSP	Monosodium dihydrogen phosphate Sodium phosphate, monobasic Sodium biphosphate Acid sodium phosphate Sodium phosphate, primary	NaH_2PO_4
Disodium Phosphate, Anhydrous	DSPA	Disodium monohydrogen phosphate Sodium phosphate, dibasic Neutral sodium phosphate	Na_2HPO_4
Disodium Phosphate, Dihydrate	DSPD	Disodium phosphate duohydrate	$Na_2HPO_4 \cdot 2\ H_2O$
Trisodium Phosphate, Anhydrous	TSPA	Trisodium orthophosphate Sodium phosphate, tribasic Basic sodium phosphate Sodium phosphate, tertiary	Na_3PO_4
Trisodium Phosphate, Crystalline Decahydrate	TSPC	Trisodium phosphate decahydrate	$Na_3PO_4 \cdot 10\ H_2O$ • $NaOH$
Emulsi-Phos® Phosphate Blends Emulsi-Phos 440 (Blend of DSPA & IMP) Emulsi-Phos 660 (Blend of TSPA & IMP) Emulsi-Phos 990 (Blend of TSPA & IMP)			
Sodium Acid Pyrophosphates Leavening Grades SAPP RD-1 SAPP 26 SAPP 28 SAPP 37 SAPP 40 SAPP 43 Nonleavening SAPP NL	SAPP	Acid sodium pyrophosphate Disodium dihydrogen diphosphate Dibasic sodium pyrophosphate Disodium pyrophosphate	$Na_2H_2P_2O_7$
Tetrasodium Pyrophosphate	TSPP	Sodium pyrophosphate tetrabasic Tetrasodium diphosphate Sodium diphosphate	$Na_4P_2O_7$
Nutrifos® Polyphosphates Nutrifos 088 Sodium Tripolyphosphate	STP	Pentasodium triphosphate Sodium triphosphate Triphosphonic acid, pentasodium salt	$Na_5P_3O_{10}$
Nutrifos B-90 (Blend of STP & SHMP) Nutrifos B-75 (Blend of STP & SHMP) Nutrifos H-30 (Blend of STP, SHMP & SAPP) Nutrifos L-50 (Blend of STP & TSPP)			
Nutrifos SK Sodium Potassium Tripolyphosphate	SKTP	Trisodium dipotassium triphosphate	$Na_3K_2P_3O_{10}$
Katch® Fish Phosphate (Polyphosphate Blend)			
Sodium Hexametaphosphate	SHMP	Graham's salt Sodium phosphate glass	$Na_{n+2}P_nO_{3n+1}$ n=13 - 18
Sodium Trimetaphosphate	STMP	Trisodium metaphosphate	$(NaPO_3)_3$
Sodium Aluminum Phosphates Levn-Lite® SALP Stabil-9® (Blend of SALP & AMCP) Pan-O-Lite® (Blend of SALP & MCP)	SALP		$Na_3Al_2H_{15}(PO_4)_8$
H.T.® Monocalcium Phosphate Monohydrate	MCP	Calcium phosphate, monobasic Calcium phosphate, primary Calcium acid phosphate Calcium biphosphate	$Ca(H_2PO_4)_2 \cdot H_2O$
Py-Ran® Anhydrous Monocalcium Phosphate	AMCP		$Ca(H_2PO_4)_2$
Dicalcium Phosphate, Anhydrous	DCPA	Calcium phosphate, dibasic Calcium phosphate, secondary	$CaHPO_4$
Dicalcium Phosphate, Dihydrate	DCPD		$CaHPO_4 \cdot 2\ H_2O$
Tricalcium Phosphate	TCP	Calcium phosphate, tribasic Calcium hydroxyapatite	$Ca_{10}(OH)_2(PO_4)_6$
Calcium Pyrophosphate	CPP	Cal pyro Tetracalcium pyrophosphate (soft calcium pyrophosphate)	$Ca_2P_2O_7$
Monopotassium Phosphate	MKP	Acid potassium phosphate Potassium phosphate, monobasic	KH_2PO_4
Tetrapotassium Pyrophosphate	TKPP	Potassium pyrophosphate, tetrabasic Tetrapotassium diphosphate Potassium diphosphate	$K_4P_2O_7$
Monoammonium Phosphate	MAP	Ammonium biphosphate Ammonium phosphate, monobasic	$NH_4H_2PO_4$
Diammonium Phosphate	DAP	Ammonium phosphate, dibasic	$(NH_4)_2HPO_4$
Phosphoric Acid — 75%, 80%, or 85%		Acid orthophosphoric Acid monophosphoric	H_3PO_4

[illegible]

[redacted][1]	Solubility[2]	NV[3]	DRR[4]	MW[5]	Grade[6]
4.6	48	70		120.0	G, P
[redacted]					
9.0	11			142.0	G, P
[redacted]					
9.0	13			178.0	G
[redacted]	13			164.0	G
[redacted]					
[redacted]	18			354.2	G, P
[redacted]					P
					P
					P
4.2	13	72		221.9	
[redacted]			21 - 25		P
			22 - 26		P
			24 - 30		P
			34 - 38		P
			37 - 41		P
			41 - 45		P
					P
[redacted]	6			265.9	G, P
[redacted]					
[redacted]	13			369.9	G, P
[redacted]	15				G
[redacted]	>15				G
7.1 - 7.3	13				P
[redacted]	> 6				P
[redacted]	37			400.1	G, P
9.6	15				G
[redacted]	> 60				P, Plate, Crush
6.4	23			305.9	P
3.4	(Slight)			897.8	
[redacted]		100	24		P
		92			P-Reg, P-HiCal
		100			P
4.6	(Slight)	80	70	252.1	Fine Medium Coarse
[redacted]					
4.6	(Slight)	80	62	234.1	FG
[redacted]	(Insoluble)			136.1	P-FCC, P-USP
7.5	(Insoluble)	33	18	172.1	P-FCC, P-USP
[redacted]	(Insoluble)			1004.7	Conditioner, NF, Polymer
6.0	(Insoluble)			254.1	P
[redacted]	21	65		136.1	G
3.5	> 60			330.3	60% Solution
[redacted]	28	62		115.0	G, P
[redacted]	41			132.1	G, P
[redacted]		172		98.0	Liquid
[redacted]					

Typical Nutrient Data for Solutia Food Phosphates

Calories/Gram	Fat (g)	Sodium (%)	Carbohydrates (g)	Protein (g)	Calcium (%)	Iron (ppm)	Phosphorus (%)	Potassium (%)
0	0	19.1	0	0	–	–	25.8	0.2
0	0	32.3	0	0	–	5	21.8	–
0	0	25.8	0	0	–	< 5	17.3	–
0	0	42	0	0	–	3	18.8	–
0	0	19	0	0	–	1.4	7.9	–
0	0	29.4	0	0	–	–	24.2	–
0	0	30.4	0	0	–	–	25.6	–
0	0	23.4	0	0	–	10	29.6	0.01
0	0	20.7	0	0	–	12	27.9	0.1
0	0	34.5	0	0	–	10	23.2	–
0	0	31.1	0	0	–	15	25.3	–
0	0	31	0	0	–	16	25.7	–
0	0	30	0	0	–	16	26.2	–
0	0	27.1	0	0	–	14	26.3	0.04
0	0	32.8	0	0	–	12	24.3	–
0	0	17.2	0	0	–	5	23.2	19.5
0	0	31	0	0	–	16	25.7	–
0	0	23.4	0	0	–	21	29.4	–
0	0	22.5	0	0	–	50	30.4	–
0	0	7.4	0	0	1.3	50	26.9	0.01
0	0	4.6	0	0	reg. 9.8/hical >10.8	200	reg. 24.5/hical 26.1	–
0	0	5.9	0	0	4.3	100	26.4	–
0	0	0.05	0	0	17.6	400	24.4	–
0	0	0.05	0	0	17.5	400	25.8	–
0	0	0.04	0	0	28.7	350	22.3	–
0	0	0.11	0	0	23.2	300	18.1	–
0	0	0.03	0	0	37.9	400	17.6	–
0	0	0.2	0	0	31	260	24.4	–
0	0	–	0	0	–	20	22.7	28.7
0	0	0.04	0	0	–	–	17.8	44.8
0	0	–	0	0	–	–	18.8	47.3
0	0	–	0	0	–	4	26.9	–
0	0	–	0	0	–	< 5	23.4	–
0	0	–	0	0	–	< 5	23.7 (75%), 25.4 (80%), 27.0 (85%)	–

Table H • Phosphoric Acid Typical Analysis and Physical Properties

Characteristics	75%	80%	85%
Appearance	a clear colorless liquid	a clear colorless liquid	a clear colorless liquid
Odor	no foreign odor	no foreign odor	no foreign odor
Specific Gravity @ 25°C	1.575	1.633	1.692
P_2O_5, %	54.39	58.20	61.92
% Equivalent H_3PO_4	75.1	80.35	85.5
Lbs/gallon	13.17	13.66	14.15
Lbs P_2O_5/gallon	7.16	7.95	8.76
Melting Point, °C	-17.5	+4.6	+21.1

Additional Typical Properties and Nutritional Data for Solutia Food Grade Phosphoric Acid:

Color, APHA	10	10	20
Turbidity, APHA	1	1	1
Arsenic as As, ppm	<3	<3	<3
Fluoride as Fl, ppm	<10	<10	<10
Heavy Metal as Pb, ppm	<10	<10	<10
Calories per Gram	0	0	0
Fat (g)	0	0	0
Carbohydrates (g)	0	0	0
Protein (g)	0	0	0
Iron, ppm	<5	<5	<5
Phosphorus, %	23.7	25.4	27.0

Table I • Relative Sourness of Phosphoric Acid and Other Food Acids

Acid Used	R	P	pK
Tartaric acid crystals (99.5%)	100	0.722	3.02
Citric acid crystals (91%)	100	0.773	3.06
Citric acid solution (50%)	100	0.425	3.06
Acetic acid (56%)	70	0.356	4.76
Lactic acid (44%)	100	0.266	3.86
Phosphoric acid (75%)	100	1.000	2.12

R = relative sourness of 0.01 Normal solution of the acid.
P = pounds of 75% phosphoric acid required to give same sourness as one pound of acid used.

Regulatory Information

Solutia food phosphates and phosphoric acid, including the components of blends, meet the specifications of the Food Chemicals Codex (FCC), as well as other codex compendia used by other countries. Solutia food phosphates and phosphoric acid are approved as Kosher (U), and confirmatory letters are available upon request. Many of the phosphates and some grades of phosphoric acid also meet specifications defined by the U.S. Pharmacopeia and the National Formulary.

Solutia food grade phosphates and phosphoric acid are approved for use by the Food and Drug Administration (FDA) in Title 21 in the Code of Federal Regulations (CFR). In Parts 182 and 184, they are identified as substances Generally Recognized As Safe (GRAS). Under Part 182, they are listed with functional groupings as follows:

- Subpart B: Multiple Purpose GRAS Food Substances
- Subpart F: Dietary Supplements
- Subpart G: Sequestrants

  Subpart I: Nutrients

(Note – Not all phosphates are identified under every classification.)

Applications in the Meat and Poultry industry are regulated by the U.S. Department of Agriculture (USDA) and are listed in Title 9 of the CFR. Specific approvals are as follows:

- Part 318.7: Use in Meat Products
- Part 381.147: Use in Poultry Products

The USDA limits the use of phosphates in these products to 0.5% by weight of the final product. The USDA specifically prohibits the use of phosphates in fresh meat and poultry products. Meat and poultry products processed with phosphates should be labeled appropriately, and the label must be approved by the USDA. Only clear solutions may be injected into meat and poultry. Letters issued by the Proprietary Mix Committee of the USDA regarding the use of Solutia food phosphates and blends are available upon request. These provide information on use and proper labeling.

Current regulations by the FDA in the U.S. limit the level of phosphates in seafoods to Good Manufacturing Practice (GMP) and must be labeled accordingly. Solutia recommends phosphate levels should not exceed 0.5% by weight of the final product. Lower levels, however, are generally sufficient for functionality. Current Compliance Guides issued by the FDA limit the amount of water that can be added to seafood products.

Non-food uses of various phosphates in USDA-inspected plants are listed in Miscellaneous Publication Number 1419, "List of Proprietary Substances and Nonfood Compounds." These include such applications as cleaners and egg washing.

Many food phosphates are also approved for use as indirect ingredients and other applications. Specific references follow:

- 21 CFR 172.892: Use of various phosphates in preparation of modified food starches
- 21 CFR 173.310: Use of phosphates and polyphosphates in boiler water
- 21 CFR 173.315: Use of phosphates in washing or to assist in lye peeling of fruits and vegetables
- 21 CFR 175: Subpart B – Substances for use only as components of adhesives; Subpart C – Substances for use as components of coatings
- 21 CFR 176: Indirect Food Additives – Paper and Paperboard Components.

Since regulation of alcoholic beverages is the responsibility of the Bureau of Alcohol, Tobacco and Firearms, the approval of ammonium phosphates for treatment of wine and alcoholic juices is listed in 27 CFR 24.246

Many phosphates are included in the Standards of Identity of many standardized foods, including processed cheese, processed cheese food, processed cheese spread, evaporated milk, baking powder, phosphated flour, self-rising flour, enriched self-rising flour, self-rising white corn meal, self-rising yellow corn meal, and bread, rolls and buns. Certain seafood products are described by a Standard of Identity as well. Limitations are set for some products. Details are listed in 21 CFR Parts 130-169.

In addition, approvals for use in pet foods and animal feeds are listed in 21 CFR Part 582.

Food products containing food phosphates must be appropriately labeled, and attention is directed to Nutrition Labeling and Education Act (NLEA) of 1990. To assist with nutritional labeling requirements, "Nutrient Data" is listed in Table G on page 32.

Packaging Guide

Table J – Food Phosphates

Chemical Description	Solutia Product	Solutia Package Size*
1. Calcium Phosphates		
Anhydrous Monocalcium Phosphate	Py-Ran	50 Lb. Bag
Dicalcium Phosphate Anhydrous	DCPA	50 Lb. Bag/350 Lb. Drum
Dicalcium Phosphate Dihydrate	DCPD	50 Lb. Bag/225 Lb. Drum
Monocalcium Phosphate Monohydrate	H.T. MCP	50 Lb. Bag
Spray-Dried Grade 200	MCP Fines	50 Lb. Bag
Spray Dried Grade 110	MCP Regular	50 Lb. Bag
Spray-Dried Grade 130	MCP Granular	50 Lb. Bag
Tricalcium Phosphate	TCP	50 Lb. Bag
Tetracalcium Pyrophosphate Normal	TCPP	50 Lb. Bag
2. Sodium Phosphates		
Disodium Phosphate Anhydrous	DSPA	50 Lb. Bag
Disodium Phosphate Dihydrate	DSPD	50 Lb. Bag
Monosodium Phosphate Anhydrous	MSP	50 Lb. Bag
Sodium Acid Pyrophosphates		
Slowest Reacting Grade	SAPP RD-1	50 Lb. Bag
Second Slowest Grade	SAPP 26	50 Lb. Bag
Baking Powder Grade	SAPP 28	50 Lb. Bag
Fast Reacting Grade	SAPP 37	50 Lb. Bag
Doughnut Grade	SAPP 40	50 Lb. Bag
Fastest Reacting Grade	SAPP 43	50 Lb. Bag
Food Grade (Non-Leavening)	SAPP NL	50 Lb. Bag
Sodium Hexametaphosphate	SHMP	50 Lb. Bag
Sodium Tripolyphosphate	Nutrifos 088, Nutrifos BC	50 Lb. Bag
Sodium Tripolyphosphate Powder	Nutrifos STP Powder	50 Lb. Bag
STP/SHMP Blend	Nutrifos B-90	50 Lb. Bag
STP/SHMP Blend	Nutrifos B-75	50 Lb. Bag
Polyphosphate Blend	Nutrifos H-30	50 Lb. Bag
Sodium Potassium Tripolyphosphate	Nutrifos SK	50 Lb. Bag
STP/TSPP Blend	Nutrifos L-50	50 Lb. Bag
Sodium Polyphosphate Blend	Katch Fish Phosphate	50 Lb. Bag
Tetrasodium Pyrophosphate	TSPP	50 Lb. Bag
Trisodium Phosphate Anhydrous	TSPA	50 Lb. Bag
Trisodium Phosphate Decahydrate	TSP Crystalline	50 Lb. Bag
DSPA/IMP Blend	Emulsi-Phos 440	50 Lb. Bag
TSPA/IMP Blend	Emulsi-Phos 660	50 Lb. Bag
TSPA/IMP Blend	Emulsi-Phos 990	50 Lb. Bag
3. Sodium Aluminum Phosphates		
Sodium Aluminum Phosphate (SALP)	Levn-Lite	50 Lb. Bag
SALP + MCP Blend	Pan-O-Lite	50 Lb. Bag
SALP + AMCP Blend	Stabil-9	50 Lb. Bag
4. Ammonium Phosphates		
Monoammonium Phosphate	MAP Granular	50 Lb. Bag
	MAP Powder	50 Lb. Bag
Diammonium Phosphate	DAP Regular	50 Lb. Bag
	DAP Powder 2% TCP	50 Lb. Bag
5. Potassium Phosphates		
Monopotassium Phosphate	MKP	50 Lb. Bag
Tetrapotassium Pyrophosphate	TKPP (60% solution)	Bulk T.T.
6. Acidulants		
Phosphoric Acid	75%, 80%, 85%	Bulk
Adipic Acid	Adipic Acid	50 Lb. Bag

Glossary of Abbreviations

AMCP	Monocalcium Phosphate Anhydrous
DAP	Diammonium Phosphate
DCPA	Dicalcium Phosphate Anhydrous
DCPD	Dicalcium Phosphate Dihydrate
DMP	Leverage
DMPT	Mag-nificent
DSPA	Disodium Phosphate Anhydrous
DSPD	Disodium Phosphate Dihydrate
Emulsi-Phos 440	DSP & IMP
Emulsi-Phos 660	TSP & IMP
Emulsi-Phos 990	TSP & IMP
H.T. MCP	Monocalcium Phosphate Monohydrate
IMP	Insoluble Metaphosphate
Katch Fish Phosphate	Polyphosphate Blend
Leverage	DMP
Levn-Lite	SALP
Mag-nificent	DMPT
MAP	Monoammonium Phosphate
MCP	Monocalcium Phosphate
MKP	Monopotassium Phosphate
MSP	Monosodium Phosphate
Nutrifos STP Powder	STP
Nutrifos 088	STP
Nutrifos BC	STP
Nutrifos STP Powder	STP
Nutrifos B-90	STP & SHMP
Nutrifos B-75	STP & SHMP
Nutrifos H-30	Polyphosphate Blend
Nutrifos L-50	STP & TSPP
Nutrifos SK	SKTP
Pan-O-Lite	SALP & MCP
Py-Ran	AMCP
SALP	Sodium Aluminum Phosphate
SAPP	Sodium Acid Pyrophosphate
SHMP	Sodium Hexametaphosphate
SKTP	Sodium Potassium Tripolyphosphate
Stabil-9	SALP & AMCP
STP	Sodium Tripolyphosphate
STMP	Sodium Trimetaphosphate
TCP	Tricalcium Phosphate
TCPP	Tetracalcium Pyrophosphate
TKPP	Tetrapotassium Pyrophosphate
TSPA	Trisodium Phosphate Anhydrous
TSPC	Trisodium Phosphate Crystalline (Decahydrate)
TSPP	Tetrasodium Pyrophosphate

Glossary of Terms

Absorbant
A material which physically removes soluble or dispersed substances (e.g., colors, ions) from a solution or dispersion, and holds them at its surface.

Acid
A chemical substance (e.g., phosphoric acid) whose properties include the ability to react with bases or alkalis in water solutions to form salts.

Aerating
Supply of air or gas to bakery products; high-aerating emulsifiers increase the amount of trapped air and create a lighter baked product.

Bacteriophage
A virus capable of replicating in a bacterial cell; can destroy bacterial cultures during cheese fermentation.

Brine
A concentrated solution of sodium chloride with other ingredients used for treating meat or poultry. Polyphosphates are an important component.

Buffer
A substance that stabilizes pH; used in foods and pharmaceuticals.

CFR
The Code of Federal Regulation which lists regulations published by Federal regulatory agencies; FDA is listed in Title 21 and USDA in Title 9.

Carbon Dioxide
The gas produced by the action of acid with baking soda; also by yeast during the fermentation of carbohydrates.

Casein
The major protein present in milk (about 80%).

Chelating Agent
A special type of sequestering agent that reacts with metallic ions in water and with other substances. Many are organic compounds, but polyphosphates and other materials are also very effective. (See Sequestering Agent.)

Chelation
Holding or trapping a metal ion between two atoms of a single molecule; often used as a synonym for sequester.

Clarification
A process for clearing a turbid solution by removing dispersed insoluble particles or color bodies.

Coagulant
A material which has the ability to cause small particles in a dispersion to agglomerate, which can then be removed.

Color Development
(Red meat color) Forms from the reaction of nitrite with myoglobin, an iron-containing protein. Processing conditions often do not allow sufficient time for full color to develop. The addition of pyrophosphate lowers the pH and thus accelerates the color development while maintaining suitable emulsion conditions in such products as frankfurters, sausages, etc.

Comminuted
Material which has been chopped or ground to small particle sizes (e.g., hamburger, sausages).

Cryoprotection
Protecting various properties during freezing (e.g., meat texture, water retention).

Cure
Imparting a unique flavor and/or color to a food, especially as applied to meats, and which generally also results in increased shelf life.

Denaturation
A process in which a protein structure is changed by treatment with a chemical, heat, radiation, shear, etc.

Dispersing Agent
A material that increases the stability of particles in a liquid (e.g., minimizes settling or agglomeration).

Double Acting
A leavening system that provides leavening action during mixing, is dormant during bench holding, and is reactivated and generates carbon dioxide during baking.

Dough Rate of Reaction (DRR)
The rate of carbon dioxide released during mixing and in the holding period of the bakery product. The rate number is the percentage of CO_2 released at a given time compared with the total available CO_2 from the bicarbonate.

Emulsification
The process of dispersing one liquid into another liquid with which it is immiscible or insoluble. In process cheese and meats, phosphates will cause solubilization of proteins which then form a coating around fat particles, making the modified fats disperse or become miscible with the water.

Glossary of Terms

Emulsifier
Substances which modify the surface tension of components in a dispersion and enable the formation of a uniform single phase dispersion or emulsion.

Emulsion
A homogeneous, uniform system formed by initially incompatible liquid phases (e.g., oil and water, air and batter).

Esterification
The process of forming an ester by the reaction of an acid and an alcohol.

FCC
The Food Chemicals Codex: A publication listing properties and tests for food additives. Although it is published in the U.S., many other countries also use it as a standard.

FDA
The U.S. Food and Drug Administration which is responsible for implementing federal legislation for regulating the food and drug industries in the U.S.

Flow Conditioner
Substances added to finely divided powdered or crystalline products to minimize caking, lumping or agglomeration.

Gelation
The process of converting a liquid to a non-flowing phase. Starches in cereal products absorb water from the batter to undergo gelatinization.

GRAS
The abbreviation used to refer to Generally Recognized As Safe – listing in the CFR of approved food additives. There are two lists – the second listing is identified as Reaffirmed As Generally Recognized As Safe. This refers to materials which have been re-evaluated as safe. These listing are found in Title 21, Parts 182 and 184, respectively.

Hydrophilic
Water-loving. A descriptive term applied to materials which are preferentially wet by water rather than non-aqueous materials.

Hydrophobic
Water-hating. The opposite of hydrophilic and applied to materials which are preferentially wet by non-aqueous materials.

Inorganic
Substances which are generally comprised of elements other than carbon (e.g., salts, minerals).

Isoelectric
A property at which proteins exhibit no electrical charge and will generally precipitate.

Isotonic
Compositions in which the electrolytes are present at the same concentrations as in body fluids.

Leavening
The process of expanding dough or batter by generating a gas (e.g., carbon dioxide by the fermentation of carbohydrate with yeast, or chemically by the neutralization of bicarbonates by acids).

Leavening Acid
A dry powder which provides acid when dissolved or solubilized in water and then reacts with sodium bicarbonate to generate carbon dioxide.

Meat Binding
The process of adhering meat pieces together into a cohesive whole.

Meltability
The melting characteristics of process cheese under various cooking conditions.

Mineral Supplementation
The addition of substances (e.g., calcium phosphates) to foods to increase their nutritional characteristics.

NF
National Formulary, a compendium listing materials approved for use in over-the-counter drugs and which includes required specifications and test methods.

Neutralize
A process in which acidic or alkaline material react. If equal molar quantities are used, the composition will contain no free acid or base and will have a neutral pH of 7.

Neutralizing Value
The parts of soda neutralized by 100 parts of leavening acid.

Nucleation
Formation of many small bubbles in the batter when mixing. The bubbles expand in size during baking producing a fine cell structure.

Nutrient
A substance metabolized by microorganisms as part of their growth cycle.

Glossary of Terms

Organic
A material which is comprised of carbon and hydrogen. The term was orginally used to describe products resulting from animal, including human, and vegetable metabolism.

Oxidation Inhibition
The prevention of color and/or flavor deterioration in meat and fatty products resulting from reaction with air.

pH
A chemical symbol used to express the degree of acidity or alkalinity. It is related to the concentration of hydrogen ions.

Phage
See bacteriophage.

Pickle
A solution of salt, spices, flavoring with or without polyphosphates which are added to processed meats and poultry.

Pickling
The process of adding a pickle, as above. This should not be confused with the pickling used for fermentation of vegetables.

Precipitation
A process in which an insoluble material is formed, generally by the reaction of two soluble components.

Processing Aid
Substances used as manufacturing aids to enhance the appeal or utility of a food or food component (e.g., clarifying agents, clouding agents, catalysts). When processing aids are carried over into a food product at levels at which they are no longer functional, they do not have to be listed on the label.

Protein Modification
The ability of phosphates to change the proteins in meat, poultry, seafood and dairy products so as to improve water retention, texture and stability to other processing conditions.

Rennet
A suspension containing rennin. The rennin enzyme changes curd texture, increases the ability of each curd cube to remain intact, enhances whey expulsion during heating, and permits a cure bed to be cut at a slightly higher pH, thus avoiding a sweeter cheese.

SIC
Standard Industrial Classification.

SID
Standard of Identity – as defined in the CFR Title 21, Part 130-169.

Sequestering agent
Any compound that, in aqueous solution, combines with a metallic ion to form a water-soluble combination in which the ion is substantially inactive.

Stabilizer
In foods, the FDA defines these as substances used to improve consistency or emulsion properties, including suspending and bodying agents.

Syneresis
A property in which liquid is expressed or squeezed from aged gels, generally accompanied by volume shrinkage.

USDA
The U.S. Department of Agriculture, which regulates the meat and poultry industry, as well as some aspects of dairy plants and operations and the grain industry.

USP
The U.S. Pharmacopeia, (currently the 21 ed.), is a listing of ingredients approved for use in prescription pharmaceuticals.

Viscosity
The property of liquids which describes their fluidity. High-viscosity fluids do not flow readily, whereas low-viscosity fluids do flow readily.

Water Binding
The property of foods, especially meats, poultry and seafood, to retain water during processing and cooking. Polyphosphates are especially effective at relatively low levels for increasing water binding.

Water Hardness
Soluble metal salts, (such as calcium and magnesium [and sometimes iron and manganese]) present in water.
In the food industry, hard water will inhibit dissolution of soluble salts (such as phosphates and polyphosphates) and interfere with their functionality.

Yield
The yield in meat, poultry and seafood processing refers to relative weight of processed food obtained following processing. A 100% yield means that the processor obtains 100 lbs. of final product from 100 lbs. of unprocessed food stuff.

Available Literature

Included with all the products from Solutia comes our commitment to serve your information needs. For the products described in this brochure, the following information can be requested:

- Material Safety Data Sheets
- Specification Sheets
- Kosher Certification
- Nutritional Data Sheets

In addition, here's a sampling of the literature you can obtain regarding Solutia Food Phosphates:

- Leavening Phosphates by Solutia
- Leavening Agent Calculator
- Solutia Phosphoric Acid: A Guide to Applications, Handling and Storage
- Katch® Fish Phosphates by Solutia
- Nutrifos® Polyphosphates for Meat, Poultry and Seafood Applications
- Adipic Acid
- Dicalcium Phosphate Dihydrate - Dentifrice Code 260

For copies of available literature, contact your Solutia sales representative or technical specialist. Some literature is also available in other languages. Please refer to the listing of sales offices on the back cover.

Applications Index

Applications are summarized in Table F on pages 28-29.

Product Index

"Functions of Solutia Food Phosphates" are summarized in Table A on pages 4-5.

"Properties of Solutia Food Phosphates" are summarized in Table G on pages 30-31.

ASTARIS
Quality Products. Exceptional Response.

ASTARIS LLC
385 Marshall Avenue
Webster Groves, MO 63119-1897

September 7, 2001

Mr. Tom Harding
Agra Systems International
125 W. 7th Street
Windgap, PA 18091

Dear Mr. Harding:

Mr. Csiemmaswamy of Midwest Grain requested we send you the enclosed copy of the latest Astaris Food Phosphates brochure. Astaris is currently in the process of revising this brochure and we hope to have the new ones available for distribution within six months. Please contact us for a copy of the new brochure at a later date.

Thank you for your interest in Astaris products. If we can be of further assistance, please let us know.

Sincerely,

Debbie Duke/bl

Debbie Duke
Administrative Assistant
Marketing Technical Services

Enclosure