Pacific Standard Specialties, Inc.

SLOW PHOS

SLOWLY SOLUBLE POLYPHOSPHATES

GENERAL DESCRIPTION

SLOW PHOS products are available in small, glassy beads or crystals. As their name implies, slowly soluble polyphosphates dissolve at a controlled concentration to prevent scale formation and corrosion. They offer operator convenience in feeding, only requiring addition of the product at monthly or quarterly intervals; expensive proportioning and feeding equipment is not required. Three SLOW PHOS products are currently available:

SLOW PHOS
Standard SLOW PHOS is manufactured from FDA approved food grade raw materials. The USDA has approved SLOW PHOS as a water conditioner for the treatment of entire potable water systems at concentrations not to exceed 10 ppm calculated as phosphate ion. Dissolution rate: 150 to 180 days.

SLOW PHOS-P
Formulated with manganese to provide enhanced corrosion protection. Ideal product for treatment of fountains, ponds, etc. Dissolution rate: Minimum 2 to 3 days.

SLOW PHOS-Z
Formulated with zinc to provide enhanced corrosion protection. Dissolution rate: 90 to 120 days

All SLOW PHOS dissolution rates can be customized to fit a specific need.

PRINCIPLE BENEFITS

⇒ **Scale Prevention**
Sequesters hardness, inhibiting precipitation and formation of deposits.

⇒ **Corrosion Inhibition**
Forms a protective coating on metal surfaces, providing corrosion protection against acidity, alkalinity, and many other mineral salts which may lead to the "rusting out" of water system pipes and equipment.

⇒ **Iron Control**
Sequesters dissolved iron up to 10 ppm and prevent the iron from precipitating, staining, discoloring, and unflavorful taste.

APPLICATION

SLOW PHOS can be fed at different concentrations in order to fit particular treatment situations or requirements. Normally a concentration of SLOW PHOS at threshold levels of 0.5 to 5.0 ppm polyphosphate will inhibit scale and corrosion.

(Continued)

APPLICATION (Continued)

- Industrial Cooling Towers
- Evaporative Coolers
- Refrigeration Equipment
- Coffee Machines
- Vending Machines
- Food Service Equipment
- Air Conditioning Equipment
- Water Purifying Equipment
- Water Processing Equipment
- Domestic Water Systems
- Prefilter for RO Equipment
- Water Coolers
- Water Wells
- Ice Machines

1. Start with a clean system. Drain and flush the entire system and remove any scale or debris present.

2. Determine the amount and type of SLOW PHOS required:

   For most water, 0.5 to 1.0 pounds per ton of refrigeration is sufficient. Use 5.0 to 10.0 pounds of beads per feeder. The feeder should be placed in an area where there is good water flow.

3. A proper bleed off system is absolutely essential for proper maintenance of concentrating recirculating water systems. This prevents the build up of mineral salts on equipment surfaces.

4. To increase polyphosphate levels and feed rate, use multiple phosphate cartridges or larger feeder.

TOM R. THOMSON, Ph.D.

May 24, 1995

REPORT ON DISSOLVING RATES OF PACIFIC STANDARD SPECIALTIES' SLOW DISSOLVING PHOSPHATES -- PART I.

Introduction

The purpose of this study is to be able to predict the "half-life" of the various slow dissolving phosphates (hereafter referred to as SDP's) without having to run the entire lifetime of the product. Dissolving rates (also hereafter referred to as DR's) were studied on several products under various conditions so that the half-lives could be predicted. More exactly, the length of time for approximately 90% of the product to be dissolved would be useful. Actually, since, as will be shown, the DR is proportional to the amount left, it will be 87.5% gone after three half-lives.

Several factors are involved in the dissolving rate. Among these are the following:

1. Composition of the SDP.
2. Size of the granules (because of changing surface-to-volume ratios).
3. Temperature of the water.
4. The amount of the sample.

Dissolving rates (leach tests) were first run on equal size (10.0g) samples of our product of different composition. Later, tests were run on some of the products at different temperature. Finally, our product was screened to obtain a sample comparable in size to that of a competitor, which is smaller than our regular pellets. Some of the results are given in this report, and the rest will be reported in a subsequent report. For simplicity, graphs are shown instead of numerical data.

The dissolving rates of three different Pacific Standard samples of slow dissolving phosphates were run in a stirred, thermostatically controlled water bath set to 42°C (108°F).

Each sample was selected to include a certain number of large, somewhat identical pellets, and were tied in a nylon net and suspended in the water bath. Samples were removed from time to time, mostly once a day, drained and air-dried with a heated hair blower in a beaker, then weighed and dried repeatedly to constant weight, and then examined under a 40 power stereo microscope, then replaced in the bath again.

Figures 1 and 2 show graphs of the results. Products A and B were similar enough to be placed on the same graph, though shifted because of their similarity. Product C dissolved faster and needed to be placed on a separate graph (Fig. 2) for an appropriate scale.

(See Figs. 1, and 2)

Discussion of the Results

The most obvious difference in the results is the relation between dissolving rate and composition. The samples (A and B) dissolve much slower than sample C, which has a different formula. It is interesting, too, that the DR of A and B are almost the same despite the fact that A contains 3 times as much hardening agent. This would seem to indicate that only a certain amount of hardening agent is needed to impart insolubility, and that more is unnecessary excess. It is believed that the role of the hardening agent, being trivalent as opposed to the divalency of calcium and magnesium, is more effective in cross-linking the polyphosphate chains.

The second noticeable feature of the graphs is that there is a definite curvature, not noticeable at first, indicating a decrease in DR as dissolving proceeds. On consideration, this should have been expected --- the more the sample, the more that will dissolve in a given time, and vice versa.

This rate behavior lends itself to a first order differential equation, similar to that of the decay of radioactive materials. Like the latter, it should also lead to the phenomenon of half-life, based upon mathematical analysis.

The dissolving rate, $DR = dW/dt = -k\ W$

Figure 3 shows a plot of Weight (W) vs time (t) for product C on semi-log paper, hence actually plots log W vs t.

On the basis of the plot in Figure 3, it can be seen that product C has a half-life of about 2.7 days. After two half-lives (a total of 5.4 days) the amount left should be 25%, and after three half-lives it should be 12.5%. Again, from the graph, we get 2.4 g, or 24% after 5.4 days and 1.4, or 14%, after 7.2 days, which is a fairly good indication that the theory is right. A calculation of the amount left after three half-lives, then, is a fair estimate of the useful life of the product.

Figures 4 and 5 are log plots for products A and B. Because of their slower DR's a plot on semi-log paper could not be made. Instead, the actual logs of W were calculated from log tables and values of W, and plotted on a regular linear scale graph paper. It must be realized that the data is only good to two significant figures, so the logs are rounded off to about 120 days +/- about 12 days. The date, at best, then would indicate that both A and B would be about 87.5% gone in 3 half-lives, or 360 days, and we cannot differentiate between the two, with the balance that we are using.

SLOW PHOS

SLOW PHOS is a slowly soluble Food Grade glassy polyphosphate that has been around for many years and is used in thousands of homes and commercial drinking water systems.

It's a well-established fact that the use of polyphosphate will correct "red iron water" problems, inhibit lime scale formation, and control corrosion.

Recent tests conducted by our Research Chemist, Dr. Tom Thomson, have helped us identify characteristics of our proprietary product, SLOW PHOS. The following are laboratory results as reported by Dr. Thomson.

1. Dissolution Rate

Approximately 6 months. The glass will completely dissolve with time; however, a shell may remain for several weeks after the polyphosphate has completely dissolved. (See #2 below, Rate of Release)

2. Rate of Release

0.75 to 2 ppm, depending upon water temperature, volume of flow, and glass size. (See Figure 1)

Temperature

Water temperature should be under 100°F for product longevity.

Glass Size

Generally the smaller the bead, the faster it will dissolve. For releases of 1 ppm or less polyphosphate, select a larger bead size. For greater polyphosphate levels, the smaller, crushed and sized particles should give the desired results.

3. Phosphates

94% of the dissolution is polyphosphate; 6% ortho and other phosphate. The glass does not become gummy or tacky in the cartridge. However, periods of no water flow can cause a temporary elevation of the total phosphates concentration for a short time. (See Figure 2)

Conclusion

The dissolution of polyphosphate glass is well established and the rate, although variable, is fairly predictable. SLOW PHOS does conform to the rigid filter cartridge industry standards.

4. Market Equivalent Comparison

A comparative study was conducted through a joint venture between Pacific Standard Specialties and a prospective client. The results of the study are given below.

No.	Cartridge SLOW PHOS	No.	Cartridge Competitor Product	Volume of Water Run Through Cartridge
#1	0.88 ppm	#7	0.82 ppm	1000 gallons
#2	0.98 ppm	#8	0.44 ppm	2500 gallons
#3	0.72 ppm	#9	0.21 ppm	5000 gallons
#4	0.61 ppm	#10	1.17 ppm	7500 gallons
#5	0.63 ppm	#11	0.24 ppm	10,000 gallons
#6	0.72 ppm	#12	0.98 ppm	1 gallon

The results indicate that SLOW PHOS has a more uniform release than the competitor's product. Also, there is not a preferential dissolving of the ortho phosphate. This indicates a homogeneous product, further proof that SLOW PHOS will give a consistent, uniform release of phosphate.

Test results for total phosphate (conducted after the time/temperature test was completed) corresponded with the weight loss results.

Observations performed with a 40-power stereo microscope showed many structures in the beads. As dissolution occurred, layers would peel off in conchoidal shape with sharp edges, similar to the spallation observed in certain minerals of this type.

USDA Approved
SLOW PHOS has been approved by the United States Department of Agriculture for use in potable water systems.

Availability
Pacific Standard Specialties has committed significant resources to the manufacturing of SLOW PHOS in order to insure a high quality product in sufficient quantities to supply the filter cartridge industry market.

Microscopic Observations on the Leached Products

What is most characteristic of these products is the way in which they seem to dissolve. Pieces of the SLOW PHOS seem to flake off the surface, like layers of an onion. These flakes are thin, curved, similar to what is termed mineralogically as spallation, or conchoidal fracture. In between material, between the bead and these flakes, is what is apparently dissolving.

The remaining surfaces show evidence of stress fracturing, with the formation of ridges and pitting that resembles small craters on the moon. Product C, however, which showed much greater solubility, dissolved with deep crevasses, resulting in an appearance similar to that of a partially melted ice cubes. Product C definitely dissolved differently from A and B.

The results of this report indicate that (1) good prediction of DR can be obtained if the DR is fast enough, as in Product C.