# Effect of Polypyrophosphate on the Spontaneous Precipitation of DCPD

**A.A. Baig*, D.J. White**
**Procter & Gamble Co., Mason, OH, USA**

**1805**

## ABSTRACT

The clinical efficacy of crystal growth inhibitors (CGI), when incorporated into tooth-pastes, towards the prevention and control of dental calculus formation have been well documented. In the present study the effectiveness of polypyrophosphate, a crystal growth inhibitor, was investigated as an anti-calculus agent by monitoring the increase in induction times for the nucleation/spontaneous precipitation of DCPD. A pH-stat system was used to follow the precipitation reaction of DCPD phase from a supersaturated solution maintained at 37°C and pH 5.3. To a 40 ml beaker 12 ml of 0.0334 M $NaH_2PO_4$ solution and 4 ml of deionized water was added and the pH adjusted to 5.3. To this solution, 4 ml of 0.1 M $CaCl_2$ solution was added and the pH-stat system was started. The final concentration of calcium and phosphate in the reaction media was 0.02 M each. For investigation of polypyrophosphate and pyrophosphate effects on DCPD precipitation, the reaction solution also contained varying levels of sodium hexametaphosphate and sodium acid pyrophosphate. The decrease in pH associated with spontaneous precipitation of DCPD was compensated for by the automatic addition of 0.025 M NaOH as titrant to maintain the pH at 5.3. The precipitates were filtered, dried and analyzed by x-ray diffraction for phase identification. For control runs, the spontaneous precipitation of DCPD started reproducibly within a few minutes after the addition of calcium solution. The addition of polypyrophosphate produced significant time delays in the spontaneous precipitation of DCPD. Conclusions: **Polypyrophosphate acts as an effective tartar control agent by controlling the nucleation and crystal growth of DCPD. The results of this study support the observed clinical efficacy of the currently marketed tooth-paste containing sodium hexametaphosphate as the tartar control agent.**

## INTRODUCTION

Dental calculus results from the mineralization of bacterial plaque formed on the surfaces of teeth. Several calcium phosphate phases have been identified in the inorganic matrix of human dental calculus including amorphous calcium phosphate (ACP), dicalcium phosphate dehydrate (DCPD), octacalcium phosphate (OCP), magnesium substituted tricalcium phosphate (whitlockite) and carbonated apatite (CAP). Since saliva is saturated with respect to calcium phosphate phases, the relative abundance of these phases are influenced by fluctuations in pH and composition of saliva. Generally, DCPD has been found to form very early in the mineralization process which then slowly transforms into more stable phases such as OCP and CAP.

Of the various approaches utilized in the control of dental calculus formation, the use of crystal growth inhibitors have been found to be very effective in the prevention of calculus development. Crystal growth inhibitors may act by influencing any or all of the steps involved in the overall mineralization process such as nucleation, crystal growth and phase transformation. Condensed phosphates are a class of crystal growth inhibitors that have been examined in a number of studies for their role in the prevention of calculus development. Although the effects of pyrophosphate and polypyrophosphate (i.e., sodium hexametaphosphate) on the crystal growth and nucleation of HAP is well documented, their role in the nucleation and spontaneous precipitation of DCPD have not been reported. In the present study the influence of pyrophosphate and polypyrophosphate on the spontaneous precipitation of DCPD was investigate.

## PURPOSE

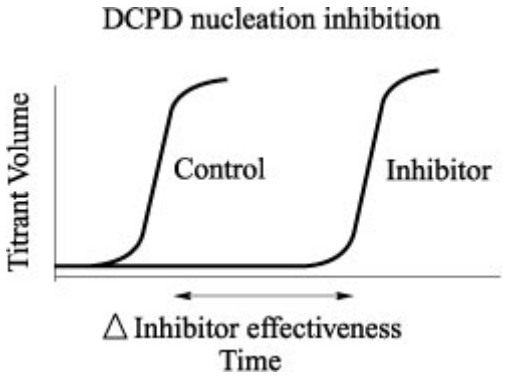
The purpose of the present study was to assess the efficacy of polypyrophosphate as an effective inhibitor of DCPD nucleation and growth.

## MATERIALS AND METHODS

The time dependent spontaneous precipitation of DCPD was followed by use of a pH stat system. The method involved precipitation of DCPD from a saturated calcium phosphate solution maintained at 37°C.

To a 50 ml beaker 12 ml of phosphate solution containing 0.0334 M $NaH_2PO_4$ and 0.0721 M NaCl was added. To this 4 ml of deionized water was added and the pH adjusted to 5.3. To this solution, 4 ml of 0.1 M $CaCl_2$ solution was added and the pH-stat system was started. The final concentration of calcium and phosphate in a 20 ml reaction media was 0.02 M each. To compensate for the decrease in pH with the addition of calcium solution 0.025 M solution of NaOH was added as a titrant to keep the pH at 5.3.

To determine the effects of inhibitors on DCPD precipitation, varying amounts of sodium acid pyrophosphate and sodium hexametaphosphate were added into the reaction media prior to the addition of calcium solution. The inhibitor efficacy was assessed by measuring the increase in induction time for nucleation and spontaneous precipitation of DCPD from saturated calcium phosphate solutions.




*Research presented at the 30th Annual Meeting of the AADR, March 7-10, 2001*

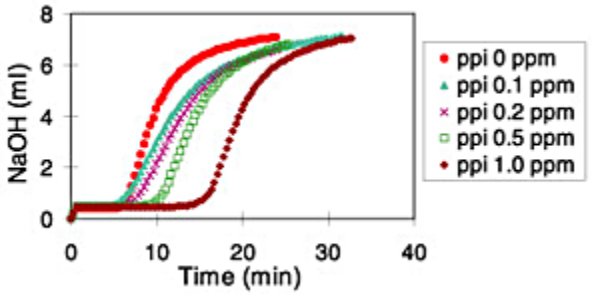
# Effect of Polypyrophosphate on the Spontaneous Precipitation of DCPD

**A.A. Baig*, D.J. White**
**Procter & Gamble Co., Mason, OH, USA**

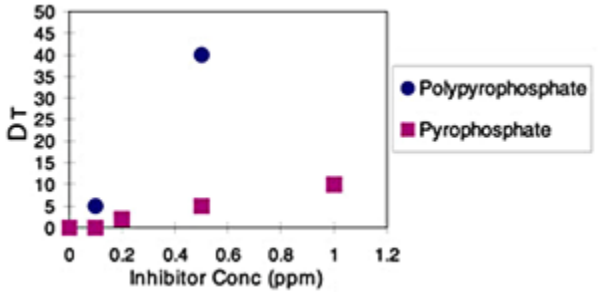


## RESULTS

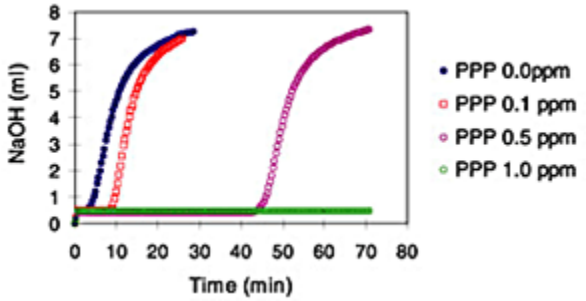
**DCPD precipitation in the presence of pyrophosphate (ppi)**




**Increase in the induction time for DCPD nucleation versus inhibitor concentration**




**DCPD precipitation in the presence of polypyrophosphate (PPP)**




## CONCLUSION

-The addition of pyrophosphate and polypyrophosphate (i.e., sodium hexametaphosphate) produced significant delays in the spontaneous precipitation of DCPD.

-Polypyrophosphate showed superior activity than pyrophosphate.

-The effectiveness of polypyrophosphate as DCPD nucleation inhibitor supports the tartar prevention efficacy of the currently marketed toothpaste containing sodium hexametaphosphate as the tartar control agent.

*Research presented at the 30th Annual Meeting of the AADR, March 7-10, 2001*

P&G