CEEP Centre européen d'Etudes des Polyphosphates

a Sector Group of cefic

CEEP is the West European phosphate industry's joint research association (detergent and industrial phosphate applications) .
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Phosphates in Automatic Dishwasher Detergents

The functions of phosphates in dishwasher detergents

Phosphates ensure several functions in dishwasher detergents, necessary to ensure effective washing of tableware in varying wash conditions (heavily soiled dishes, water hardness …), and so important for hygiene. If phosphates are not used, a number of different chemicals will be necessary to replace them, with possible implications for the aquatic and terrestrial ecosystem, because no other single substance can ensure these different functions:

* render soluble, and maintain in solution, calcium and magnesium ions (sequestrate). This is necessary to ensure good washing efficiency, and good rinsing (avoidance of films and white coatings). This function is necessary because of such ions in tap water in hard water areas, but also in soft water areas (and where water softeners are installed) because of such ions in food wastes on the tableware.
* dispersal of dirt and soil (removal from tableware). Phosphates contribute to this key dishwasher function by the adsorption of the phosphate anion onto the surface of the soil, thus improving solubility in the wash water.
* anti-scaling and clean rinsing. Preventing the formation of scale and films during washing and rinsing of tableware and glassware.
* anti-redeposition, maintaining dirt in suspension in the wash and rinse water, ensuring removal from the machine and limiting cross-contamination (transfer of soils from dirty tableware towards initially cleaner items situated at points of the machine with lower water velocity). Phosphates achieve this as above by the anionic surface effect on dirt particles.
* maintain pH: unused STPP hydrolyses to ortho-phosphate in the wash process, thus ensuring pH buffering necessary for effective operation of surfactants and other wash chemicals, and necessary for sanitisation. A high pH in dishwasher detergents is essential to ensure hygiene (killing and removing microbes) and washing effectiveness, particularly at lower temperatures (< 70°C).

If phosphates are not used in dishwasher detergents, as well as the use of a number of other chemicals, the result is lower wash efficiencies (unsatisfactory wash results over multiple washes), and so increased environmental loading due to larger dosing and re-washes necessary because of performance issues.

Current EU Flower and Nordic Swan Ecolabel criteria allow approximately 45% phosphates (as STPP) in dishwasher detergents and phosphate based domestic dishwashing detergents have been ecolabelled under both schemes.

Which chemicals are used in P-free dishwasher detergents ?

The main "substitute" combinations of chemicals used in P-free laundry detergents cannot be used in dishwasher detergents because they are insoluble, and so would coat tableware and glasses in a dishwasher.

Even in soft water, or dishwashers operating "behind" a water softener, a chelating agent will be necessary in domestic dishwasher detergent because of calcium, magnesium and other ions present in food wastes and soils on tableware. Therefore, strong amino acid derived organic chelating agents (NTA [i], EDTA [ii], MGDA [iii], DTPA [iv], B-ADA [v], IDS [vi] and their salts) are used in P-free domestic dishwashing detergent:

However, these chemicals ONLY act as chelating agents and do not therefore "substitute" phosphates, because phosphates also ensure a number of other essential functions in domestic dishwashing detergents. Therefore P-free domestic dishwashing detergent formulations will also include a number of the following chemicals:

* chelating agents as indicated above
* significantly increased enzyme content
* increased surfactant content
* polycarboxylates (PCA)
* phosphonates
* active chlorine compounds to compensate for poorer soil removal

These substances raise issues of environmental risks, particularly via sewage biosolids, poor biodegradability, increased organic load to sewage works, toxicity.

Dishwasher cleaning performance

Modern dishwashers are moving to lower temperature washes and reduced water consumption, in order to reduce environmental impacts and costs for householders. The good performance of P-based dishwasher detergents is important in this context, avoiding consumer selection of more intensive wash and rinse programmes, and because of questions concerning the links between dishwasher performance and sanitisation (removal of bacteria and micro-organisms).

If tableware is not adequately washed in dishwashers then bacteria and viruses may survive, whereas if soils are completely removed in the wash then sanitisation will be ensured even at reduced temperatures or water consumptions[vii]. The removal of "soil" (that is food wastes, grease, films …) is therefore essential to ensure hygiene.

There are at present only limited choices of P-free dishwasher detergents on the market and, these do not offer adequate wash performance to satisfy consumers in varying conditions (water hardness, soiling of tableware)[viii].

Leading German consumer magazine Stiftung Warentest, after testing P-based and P-free dishwasher detergents[ix], concluded "*Phosphates are much more effective than substitutes such as citrates (lemon juice salt) or polycarboxylates (component made of oil)*".

Resource recycling and life cycle impacts

Lower performance of P-free dishwasher detergents will result in increased energy and water consumption, as consumers switch to more intensive and higher temperature wash cycles to compensate for poor wash performance achieved in some washes with soiled tableware. In some cases, consumers will wash items twice.

The result will be significant environmental negative impacts, because energy and water consumption are the major issues in overall life cycle of dish washing.

Furthermore, phosphates are the only recyclable detergent ingredient. Where sewage nutrient removal is operational (as required in eutrophication sensitive areas by EU legislation), phosphates from detergents can be recovered and recycled, along with phosphates from human and other sources. Sewage phosphates can be recycled either directly to agriculture (through biosolids spreading), or through processes enabling recovery of phosphates as a commercially recyclable product (phosphates recovered from sewage are already being marketed as a “green” ecological fertiliser in the UK, Japan, Canada).

Phosphates therefore offer a better long term environmental solution than P-free detergents because they enable the recycling of resources, reduce energy and water consumption in dish washing, and avoid input of poorly biodegradable chemicals into sewage sludge and the environment.

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i nitrilotriacetic acid, CAS N° 139-13-9

ii ethylenediaminetetraacetic Acid, CAS N° 60-00-4

iii methyl glycine di-acetic acid, CAS n° 29578-05-0,

iv diethylene triamine penta acetic acid, CAS N° 67-43-6

v B-alaninediacetic acid, CAS N° 6245-75-6,

vi Sodium Iminodisuccinate. CAS N° 144538-83-0

vii “Cross-contamination in dishwashers”, Stahl Wernersson, Johansson, Hakanson, J. Hospital Infection 56, pages 312-317, 200. Washes in a dishwasher using a “normal soil” cycle with 64°C wash and 80°C rinse, with a 60% NaOH - 40% NTA detergent, showed that the soil is transferred in the wash from contaminated plates to others, and that when crockery is visually not clean then it also has living micro-organism contamination.

viii For example: Stiftung Warentest Germany dishwasher detergents November 2002, February 2001, January 2000, Que Choisir France dishwasher detergents March 2006, November 2002 and laundry detergents September 1999, Belgium Test Achat laundry detergents March 2000, UK Which laundry detergents March 1999

ix Stiftung Warentest, November 2002, testing 13 dishwasher detergent tablets, in particular supermarket own brands, and August 2005 testing thirteen 3-in-1 and 2-in-1 tablet domestic dishwashing detergents.