Article

DETERGENT RESIDUES

Detergent Residues on Surfaces - Food for Microbes

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CATEGORIES: SCHOOLS, HEALTHCARE, FOOD SERVICE, COMMERCIAL BUILDINGS, CLEANING MEASUREMENT, IEQ MEASUREMENT, HEALTH & HYGIENE, GREEN
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As many authors have previously emphasized, cleaning and sanitization (or disinfection) of surfaces are separate processes that need to be carried out in separate steps. But within the cleaning process there also needs to be a separation between the application of cleaning solutions containing detergents and the removal by rinsing of any detergent residue after the use of the cleaning solutions.

Detergent Chemistry

In Europe, USA, and Japan the use of soaps for cleaning has been largely replaced by synthetic anionic surfactants (detergents) of the class technically called linear alkylbenzene sulfonates (LASs). Linear LASs show very good detergency performance and, as a result of their high solubility, are also frequently used in formulations for liquid detergents. The total world production of LASs now is many millions of tons per year.

The chemical structure of an LAS detergent molecule

The chemical structure of the LAS molecule is in the form of a negative ion. Because of their negative charge, LAS detergents are called anionic detergents. Many commercial cleaner formulations are mixtures of an LAS detergent and a type of detergent molecule that has no ionic charge, i.e., a non-ionic detergent.

Immediately after use in surface cleaning, and independent of whatever method is used to apply them, detergent molecules remain chemically unchanged. However, a small but finite amount of detergent remains on the surface. Detergents are then either rinsed off the surface being cleaned or—in all too many cases—remain as residue on the surface in the absence of good rinsing.

In this article we're interested in the fate of detergent residues left on surfaces after cleaning.

Detergents as Bacterial Nutrients

LAS molecules are composed of atoms of the elements carbon, hydrogen, oxygen, and sulfur. These chemical elements are essential in the nutrients that keep all living organisms alive. During their development over their long history on earth, bacterial species have diversified so that some bacterial species can be found that will use as a food source almost any molecule containing the elements just named.

For example, members of the species Actinomycetes will degrade amyl alcohol, paraffin, and rubber and the species Burholderia cepacia will degrade over 100 different carbon compounds. As a practical example, environmental bacteria can degrade the environmental polluting ethylene/diethylene glycol mixtures used in aircraft de-icing at airports (Revitt, Garelick et al. 2002). Some species of bacteria can even live and propagate using as food the minute amounts of any organic molecules that are found in ordinary distilled or deionized water!

So it is not surprising that some bacterial species can use as food the organic detergent molecules such as LASs in common use for cleaning. Thus, in hyper-clean pharmaceutical cleanroom operations the cleaning solutions that are used are sterilized before use and rinsing after use is strictly observed.

Detergents as Bacterial Food

The detergents used in commercial cleaning solutions used in the US are strongly encouraged by the EPA to be “biodegradable” and in Europe are required by law to be such. While many in the cleaning industry are aware of the advantages of biodegradability for cleaning products, they may not make the connection between biodegradability and its implication: that cleaning products can form food sources for common environmental microbials.

Because of their ubiquitous use in cleaning, their resulting environmental load, and the requirements for

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their biodegradation, the microbiology and biochemistry of detergent degradation have been intensely studied. A recent paper reviews and summarizes some of this work (Ying 2006). In particular, the complete biodegradation of LAS detergents by environmental mixtures of bacterial species has been described (van Ginkel 1996).

The nutritional use by bacteria of organic molecules like detergents that are adsorbed on surfaces has been studied for almost 70 years (Zobell 1943). A major conclusion from this body of work is that, while the exact mechanisms of the biodegradation processes may differ from those in solution, adsorbed detergent and other organic molecules on surfaces can be used for bacterial growth.

Detergents and Sanitizers

As previously noted, a well-executed cleaning and sanitization program consists of two separate steps: cleaning and then application of a sanitizer.

We have just seen that detergent residues left on surfaces can provide nutrients for bacteria also left on the surface. But won't the sanitizers then applied to the surface after cleaning kill the bacteria? The answer is no, and the reason is based on the chemistry of common sanitizer molecules. The structure of a very widely used group of sanitizers, the benzalkonium series of sanitizers (commonly called "Quats") is based on a permanently positively charged (cationic) ion consisting of a nitrogen atom with 4 substituents on it (i.e., making it a quaternary substituted ammonium ion). Quats act as sanitizers by killing bacteria via the action of their positive charges on bacterial membranes.

So the problem is, if a surface is not thoroughly rinsed free of anionic detergent residue prior to the application of a Quat sanitizer, the positively charged Quat becomes electrically neutralized by the negatively charged detergent residue and its anti-microbial action can be totally inactivated. And since the detergent-Quat complex so formed contains even more nutrient molecules than the detergent residue alone, it's an even better growth medium for bacteria.

The conclusion is that removal of detergent residue by thorough rinsing after the cleaning step is an absolute necessity prior to application of a sanitizer.

References

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Dr. Glasel obtained a B.S. in chemistry and physics from Caltech. His Ph.D. from the University of Chicago was in chemical physics for work on chemical reactions on comets. He has served on active duty in the U.S. Air Force as a nuclear research officer.

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