Redefining 'clean'

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Aiming to take "clean" to a whole new level, researchers at the University of California at Berkeley and the University of Maryland at College Park have teamed up to study how low-temperature plasmas can deactivate potentially dangerous biomolecules left behind by conventional sterilization methods. Using low-temperature plasmas is a promising technique for sterilization and deactivation of surgical instruments and medical devices, but the researchers say its effectiveness isn't fully understood yet. The researchers will present their findings at the AVS Symposium, held Oct. 30 – Nov. 4, in Nashville, Tenn.

"Bacteria are known to create virulence factors – biomolecules expressed and secreted by pathogens – even if they have been killed," says David Graves, a professor working on the research at UC Berkeley's Department of Chemical and Biomolecular Engineering. These molecules are not always inactivated by conventional sterilization methods, such as heating surgical equipment in an autoclave, and can cause severe medical problems.

The misfolded proteins called "prions" that are thought to cause mad cow disease are one well-known example of harmful biomolecules, Graves says. "These molecules may not be inactivated by conventional autoclaves or other methods of disinfection or sterilization," he says. "In some cases, expensive endoscopes used in the brain must be discarded after a single use because the only way to reliably decontaminate them would destroy them."

Another harmful biomolecule is called lipopolysaccharide (LPS), which

are found in the membranes of E. coli bacteria. In humans, LPS can initiate an immune response that includes fever, hypotension, and respiratory dysfunction, and may even lead to multiple organ failure and death.

Graves' research team, in conjunction with a group led by Gottlieb Oehrlein at the University of Maryland in College Park has focused their attention on Lipid A, the major immune-stimulating region of LPS. The researchers exposed Lipid A to the effects of low-temperature plasmas using a vacuum-beam system.

"Low-temperature plasma generates vacuum ultraviolet photons, ions/electrons, and radicals that are known to be able to deactivate these molecules even at low temperature," notes Graves. "However, the mechanisms by which they do this [are] poorly understood, so we can't be sure when they work and when they don't. Our measurements and calculations are designed to reveal this information."

One of the biggest challenges, Oehrlein says, was producing samples of lipopolysaccharide and Lipid A that were compatible with the equipment typically used to study plasma-surface interactions. "The collaboration of Professor Joonil Seog, who is an expert on biological assay methodologies and characterization, has been crucial in this respect," Oehrlein notes. The scientists' results suggest that plasma-generated vacuum ultraviolet light can reduce the toxicity of Lipid A. "We have been surprised by the high sensitivity of endotoxins to UV or vacuum UV irradiation," says Oehrlein. The results mean that the ability of plasma to sterilize equipment might strongly depend on what the plasma is made of, since plasma optical emissions vary based on plasma compositions. As a next step, Oehrlein says that his group plans to focus their efforts on understanding the influence of plasma-generated radicals on the deactivation of biomolecules.

Both groups' results are a good indication that "clean" can indeed be redefined.

More information: The AVS 58th International Symposium & Exhibition will be held Oct. 30 – Nov. 4 at the Nashville Convention Center.

Presentation PS+BI-MoA7, "Deactivation of Lipopolysaccharide and Lipid A by Ar/H2 Inductively Coupled Plasma," will be presented by Oehrlein's doctoral student, Elliot Bartis, at 4 p.m. on Monday, Oct. 31.

Presentation PS+BI-MoA-10, "Plasma Deactivation of Pyrogenic Biomolecules: Vacuum Ultraviolet Photon and Radical Beam Effects on Lipid A," will be presented by Graves's doctoral student, Ting-Ling Chung, at 5 p.m. on Monday, Oct. 31.

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