Electroporation System for Sterilizing Water

Amounts of chemicals needed for sterilization are reduced.

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A prototype of an electroporation system for sterilizing wastewater or drinking water has been developed. In electroporation, applied electric fields cause transient and/or permanent changes in the porosities of living cells. Electroporation at lower field strengths can be exploited to increase the efficiency of chemical disinfection (as in chlorination). Electroporation at higher field strengths is capable of inactivating and even killing bacteria and other pathogens, without use of chemicals. Hence, electroporation is at least a partial alternative to chlorination.

The transient changes that occur in microorganisms at lower electric-field strengths include significantly increased uptake of ions and molecules. Such increased uptake makes it possible to achieve disinfection at lower doses of chemicals (e.g., chlorine or ozone) than would otherwise be needed. Lower doses translate to lower costs and reduced concentrations of such carcinogenic byproducts as trichloromethane. Higher electric fields cause cell membranes to lose semipermeability and thereby become unable to function as selective osmotic barriers between the cells and the environment. This loss of function is the cause of the cell death at higher electric-field intensities. Experimental evidence does not indicate cell lysis but, rather, combined leaking of cell proteins out of the cells as well as invasion of foreign chemical compounds into the cells.

The concept of electroporation is not new; it has been applied in molecular biology and genetic engineering for decades. However, the laboratory-scale electroporators used heretofore have been built around small (400-microliter) cuvettes, partly because the smallness facilitates the generation of electric fields of sufficient magnitude to cause electroporation. Moreover, most laboratory-scale electroporators have been designed for testing static water. In contrast, the treatment cell in the present system is much larger and features a flow-through geometry, such that electric fields strong enough to effect 99.9-percent disinfection can be applied to water flowing in a pipe.

The figure schematically depicts one version of the prototype system, wherein high-voltage pulses are applied to a pair of electrodes as water flows between them. Depending on the pulse amplitude, the resulting electric field between the electrodes either makes pathogens in the water more vulnerable to a disinfecting chemical or else inactivates them even in the absence of such a chemical.