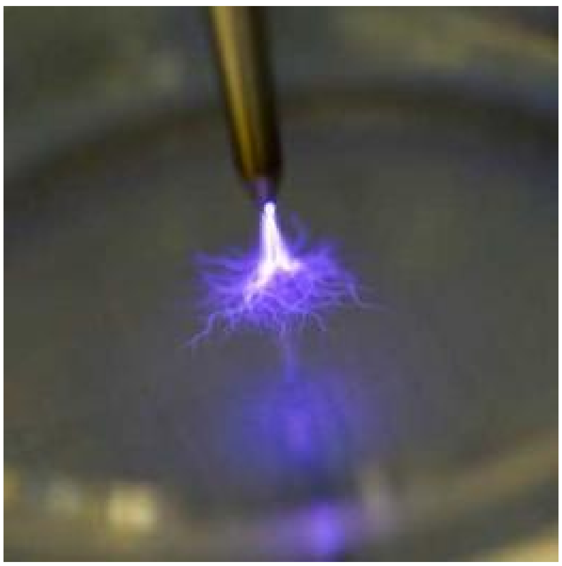
Using ionized plasmas as cheap sterilizers for developing world

November 15 2011, By Robert Sanders



A brief spark in air produces a low-temperature plasma of partially ionized and dissociated oxygen and nitrogen that will diffuse into nearby liquids or skin, where they can kill microbes similar to the way some drugs and immune cells kill microbes by generating similar or identical reactive chemicals. Credit: Steve Graves

(PhysOrg.com) -- University of California, Berkeley, scientists have shown that ionized plasmas like those in neon lights and plasma TVs not only can sterilize water, but make it antimicrobial – able to kill bacteria – for as long as a week after treatment.

Devices able to produce such plasmas are cheap, which means they could be life-savers in developing countries, disaster areas or on the battlefield where sterile water for medical use – whether delivering babies or major surgery – is in short supply and expensive to produce.

“We know plasmas will kill bacteria in water, but there are so many other possible applications, such as sterilizing medical instruments or enhancing wound healing,” said chemical engineer David Graves, the Lam Research Distinguished Professor in Semiconductor Processing at UC Berkeley. “We could come up with a device to use in the home or in remote areas to replace bleach or surgical antibiotics.”

Low-temperature plasmas as disinfectants are “an extraordinary innovation with tremendous potential to improve health treatments in developing and disaster-stricken regions,” said Phillip Denny, chief administrative officer of UC Berkeley’s Blum Center for Developing Economies, which helped fund Graves’ research and has a mission of addressing the needs of the poor worldwide.

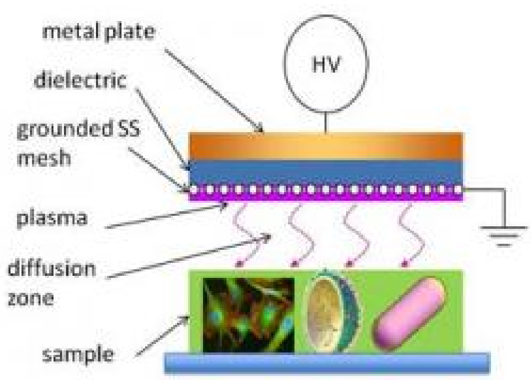


Diagram of dielectric barrier discharge, which generates a plasma (pink) that diffuses into a nearby liquid and kills bacterial contaminants. Credit: Graves lab, UC Berkeley

“One of the most difficult problems associated with medical facilities in low-resource countries is infection control,” added Graves. “It is estimated that infections in these countries are a factor of three-to-five times more widespread than in the developed world.”

Graves and his UC Berkeley colleagues published a paper in the November issue of the *Journal of Physics D: Applied Physics*, reporting that water treated with plasma killed essentially all the E. coli bacteria dumped in within a few hours of treatment and still killed 99.9 percent of bacteria added after it sat for seven days. Mutant strains of E. coli have caused outbreaks of intestinal upset and even death when they have contaminated meat, cheese and vegetables.

Based on other experiments, Graves and colleagues at the University of Maryland in College Park reported Oct. 31 at the annual meeting of the American Vacuum Society that plasma can also “kill” dangerous proteins and lipids – including prions, the infectious agents that cause mad cow disease – that standard sterilization processes leave behind.

In 2009, one of Graves’ collaborators from the Max Planck Institute for Extraterrestrial Physics built a device capable of safely disinfecting human skin within seconds, killing even drug-resistant bacteria.

“The field of low-temperature plasmas is booming, and this is not just hype. It’s real!” Graves said.

In the study published this month, Graves and his UC Berkeley colleagues showed that plasmas generated by brief sparks in air next to a container of water turned the water about as acidic as vinegar and created a cocktail of highly reactive, ionized molecules – molecules that have lost one or more electrons and thus are eager to react with other molecules. They identified the reactive molecules as hydrogen peroxide and various nitrates and nitrites, all well-known antimicrobials. Nitrates and nitrites have been used for millennia to cure meat, for example.

Graves was puzzled to see, however, that the water was still antimicrobial a week later, even though the peroxide and nitrite concentrations had dropped to nil. This indicated that some other reactive chemical – perhaps a nitrate – remained in the water to kill microbes, he said.

Plasma discharges have been used since the late 1800s to generate ozone for water purification, and some hospitals use low-pressure plasmas to generate hydrogen peroxide to decontaminate surgical instruments. Plasma devices also are used as surgical instruments to remove tissue or coagulate blood. Only recently, however, have low-temperature plasmas been used as disinfectants and for direct medical therapy, said Graves, who recently focused on medical applications of plasmas after working for more than 20 years on low-temperature plasmas of the kind used to etch semiconductors.

“I'm a chemical engineer who applies physics and chemistry to understanding plasmas,” Graves said. “It's exciting to now look for ways to apply plasmas in medicine.”

Graves' UC Berkeley coauthors are former post-doctoral fellow Matthew J. Traylor; graduate students Matthew J. Pavlovich and Sharmin Karim; undergraduate Pritha Hait; research associate Yukinori Sakiyama; and chemical engineer Douglas S. Clark, The Warren and Katharine Schlinger Distinguished Professor in Chemical Engineering and the chair of the Department of Chemical and Biomolecular Engineering.

The work on deactivating dangerous and persistent biological molecules was conducted with a group led by Gottlieb Oehrlein, a professor of materials science and engineering at the University of Maryland in College Park.

More information: • Long-term antibacterial efficacy of air plasma-activated water (*J. Phys. D: Appl. Phys.*)
• Redefining 'clean' (Press release from AVS meeting, 10/31/11)

Provided by University of California - Berkeley