Galen Stucky takes the chemistry of "boiling" rocks into new frontiers of first aid.

Scientists sometimes find it hard to explain exactly what impact their research will have in the here and now. Galen Stucky, a professor of chemistry and biochemistry at UC Santa Barbara, has no such difficulty with his work on the technology known commercially as QuikClot®. The focus, about as real-world as it gets, is on stopping bleeding and saving lives, including the lives of U.S. troops in Iraq and Afghanistan.

With faculty positions not only in chemistry and biochemistry but also in biomolecular sciences and materials, Stucky has a wide range of research interests, from biomineralization in marine animals to the production of motor fuel from methane. But he says his work does point to a general theme, which he sums up as ?How to use inorganic materials to control chemical and biological processes.? He has recently been drawing on his knowledge of zeolite chemistry to make better blood-clotting agents.
Zeolites, the term comes from the Greek words for ‘boil’ and ‘stone’, are minerals that occur naturally in volcanic formations and have been synthesized in many forms. Highly porous, the rocks can hold huge amounts of water, which causes zeolite rocks to jump around as the water evaporates under rapid heating—hence the ‘boiling’ label. Zeolites are also energetic when they absorb water, easily heating up to water’s boiling point. They have a structure and chemistry that make them highly useful in water purification, oil refining, and other processes that involve the filtering and separation of liquid or gas compounds. Every gallon of gasoline has been processed through zeolites, Stucky notes, and zeolites are used in laundry detergent to soften the wash water by replacing calcium with sodium.

Zeolites have played a role in military first aid since 2002, when the Navy and Marine Corps adopted QuikClot to staunch battlefield wounds (the Army also uses a different coagulant, called HemCon, made from the chitin molecules in shrimp shells). As Stucky and others tell the story, the idea of a zeolite blood-clotting agent came about by accident when inventor Frank Hursey, who was working with absorptive materials, cut himself shaving and stopped the bleeding with a handy zeolite sample. Hursey went on to develop QuikClot and founded Z-Medica Corp., the Connecticut-based company that markets the product. Today all U.S. military branches carry packets of the granulated material, a synthetic zeolite that can quickly be applied to hemorrhaging wounds to kick-start the clotting process.
Just how many lives have been saved by this one product? It’s impossible to say for sure, given all the factors that determine the survival rate after battlefield injuries. But along with other advances in first aid and trauma care, QuikClot has contributed to an encouraging trend in military medicine. According to a 2006 study co-authored by Col. John Holcomb, a trauma surgeon who heads the Army’s Institute of Surgical Research, the case fatality rate in Afghanistan and Iraq since 2001 was 9.4. In other words, slightly more than nine out of 100 troops injured but not immediately killed in battle die eventually from their wounds or from complications. In the context of military history, that number reflects a remarkable advance. The case fatality rate was 15.8 in the Vietnam War and 19.1 in World War II. Much earlier, in the U.S. Civil War, Stucky says an injured soldier had a 15% to 20% chance of survival. That amounts to a case fatality rate of at least 80.

On the home front, first responders such as police and paramedics also started to use QuikClot when it was adopted for military use. But the product still needed improvement. Early uses in the field turned up a serious side-effect. The QuikClot sand stopped bleeding but also released intense heat that sometimes caused second or third-degree burns. Stucky got an urgent request from the Office of Naval Research (ONR) in mid-2003 to deal with the problem. The ONR gave him a short-term grant to study how to cool the QuikClot without robbing it of its effectiveness. It wanted results ASAP. This was not your typical research grant. A monumental timescale compression of academic research to field application was required. Stucky says and the three-way interfaces involving Z-Medica, the University, and ONR that made the science and the technology transfer for a medical product possible have been fantastic?

Stucky’s side of the project got under way at UCSB in 2004. Although all the UCSB researchers’ funding came from ONR, they worked closely with people at Z-Medica who were also pursuing independent investigations. Stucky and Z-Medica realized that the burns could be prevented by optimizing the water content of the zeolite while keeping QuikClot’s efficacy.

The new QuikClot was first tested in blood samples and on pigs. It worked.

Most of the heat is released in the adsorption of the first small amounts of water, Stucky says, so that QuikClot could be kept much cooler if it were less dehydrated when applied to a wound. Stucky also researched other methods of decreasing the heat. The temperature of adsorption could be controlled by changing the ratios of calcium and sodium; the stronger bonds formed by calcium and water produce more heat than the somewhat weaker sodium bonds. Another method discovered by Stucky’s research group is to add silver ions that can both cool the clotting process and take advantage of silver’s antibiotic property—an important bonus. The new QuikClot was tested in test-tube blood samples and on pigs. It worked, and this year it was released for the first time as an over-the-counter consumer product under the name QuikClot Sport? Silver.
Beyond the improvement of QuikClot, Stucky sees important advances in knowledge from the work that he and Z-Medica have done. "I saw it as an opportunity to get in and understand a biosystem process; and, to create new materials that might provide a helpful interface with living systems," Stucky says. The blood coagulation cascade, as that process is technically called, is not fully understood. But the technology for controlling it is rapidly moving forward. "We can now predictively synthesize inorganic and composite agents that either induce coagulation or prevent coagulation," he says. More sophisticated products also may be on the way, such as toothpaste-like clotting agents from bio-active glass, with uniform pores able to deliver antibiotics or other drugs. In short, the chemistry of boiling stones seems destined to save more lives.
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