Laboratory-developed high explosives mitigate risk of accidental detonation

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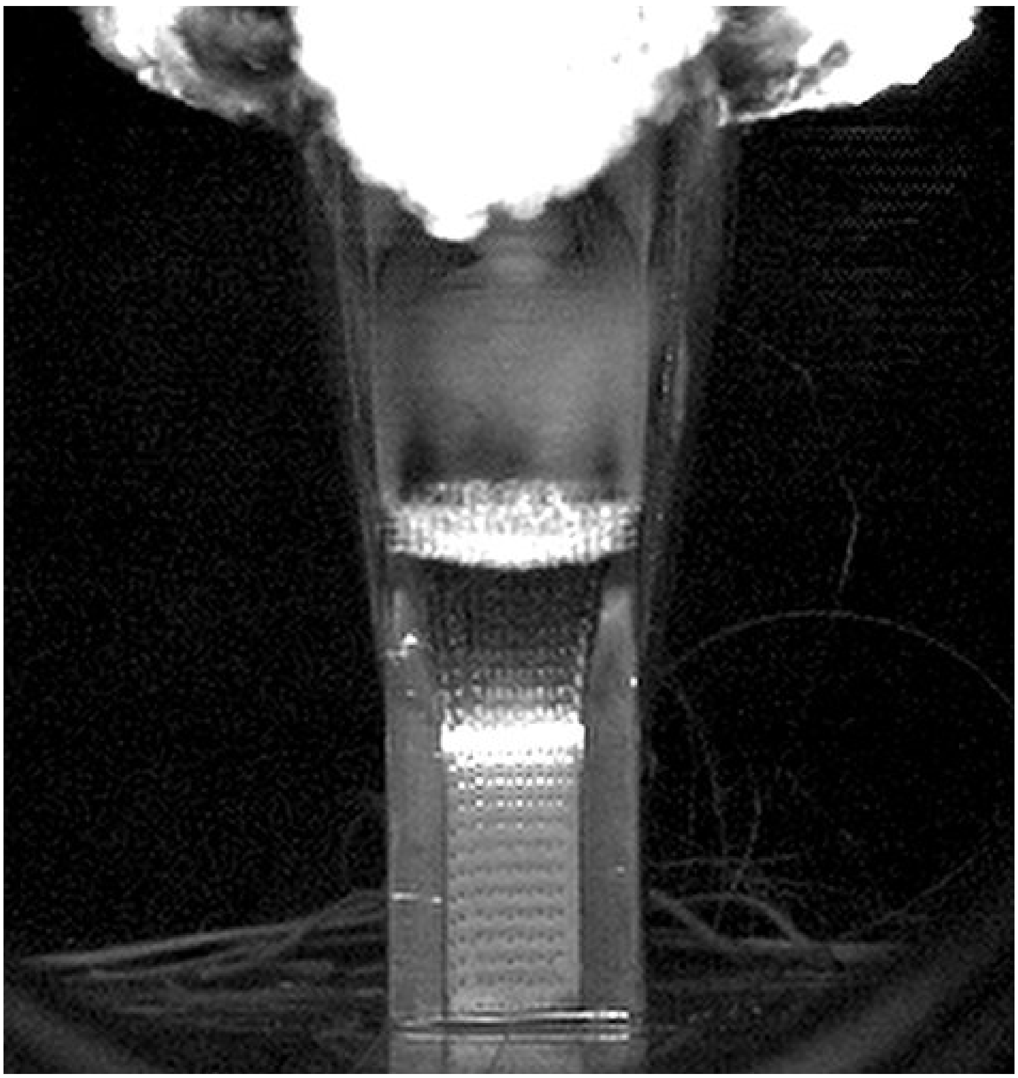

High-speed camera frame of a detonation wave propagating through a liquid-filled, 3D-printed, high-explosive lattice. The lattice was “switched on” when it was filled with water. Credit: Los Alamos National Laboratory

In an effort to mitigate accidental detonations of stored explosives, a multidisciplinary team of Los Alamos National Laboratory scientists developed a way to create "switchable" high explosives that won't detonate unless activated by being filled with an inert fluid, such as water. Their findings were published March 17 in *Physical Review Letters*.

"A system that is completely insensitive to unplanned stimuli but switches to high performance during use is the holy grail of high explosives," said Los Alamos scientist Alexander Mueller, principal investigator for the project. "We've designed a high explosive system that won't work when it's not supposed to, like during transport and storage, but can quickly be made ready when required."

For military planners, personnel who might work with explosives and communities near operations such as mining and munitions, the volatility of certain high explosives presents a potential hazard. Impact, heat and friction are all sensitivities that can produce an unplanned explosion with high explosive materials.

For example, the accidental detonation of stored ammonium nitrate in Beirut, Lebanon, in 2020 killed more than 200 people, including workers and nearby residents. Equivalent to an earthquake, the explosion leveled the port district and was felt across the country and the region. While unusually large, the event was not unprecedented; one estimate showed that 500 unplanned explosions occurred at munitions plants from 1979 to 2013.

The Los Alamos team used additive manufacturing techniques to fabricate high-explosive charges with a lattice structure that by themselves cannot sustain detonation. In experimentation that marked the first time quantifying the effectiveness of the high-explosive charges, the team found that an unfilled charge's Gurney energy—the propulsion resulting from an explosive's gaseous products expanding—was 98% lower than that of an equivalent water-filled charge.

That means that the unfilled high-explosive charges can be safely transported, handled and stored without risk of detonation.

Their experimentation also had the team tuning the detonative performance of the system by changing the mechanical properties of the fluids in fluid-filled charges. The team found that replacing water with higher density fluids increased propulsion by up to 8.5% and decreased detonation velocity by 13.4%. The results point to the technology's possible tenability for a variety of industrial purposes.

"The data suggest a tuneability allowing to optimize the energy delivery for different applications," said Cameron Brown, scientist at Los Alamos and lead author on the paper. "Insight into the Gurney energy and detonation velocity of filled and unfilled charges presents a path forward for quantifying the detonative performance of switchable explosives with different structural parameters, and optimizing them for mining, oil and gas exploration, blasting or military applications."

Further experimentation and data will help evaluate performance with different charge structures and fill fluids. The improved technology, though, offers a path for improving industrial safety and even for making safe things like unexploded ordinance, which in many places can be a hazard for civilians during or after conflicts. The development of switchable high explosives technology, it is hoped, may make disasters and accidents a thing of the past.

More information: Cameron B. Brown et al, Switchable Explosives: Performance Tuning of Fluid-Activated High Explosive Architectures, *Physical Review Letters* (2023). DOI: 10.1103/PhysRevLett.130.116105

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