News Feature

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Green explosives: Collateral damage

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1. Jim Giles is a reporter for *Nature*, based in London.

Abstract

Even munitions that are never used in anger can have a long-term impact on the environment, a
minimize the risks. Jim Giles talks to the chemists who are developing 'green' explosives.

"I know ... some people think it is an oxymoron." Ron Jones sounds weary. He has had to deal w
questioning before. "But we really do need green explosives."

Bombing and shelling can't be good for any ecosystem. But away from the heat of battle, militar
research funds into developing less-toxic explosives that should be better both for the personne
the environment.

Jones and his colleagues at the US Naval Air Warfare Center in China Lake, California, for insta
based compounds used to fire guns. Other groups want to phase out explosives whose residues r
when detonated, but also cause problems when unused ordnance is disposed of. "The environm
beyond what you see in combat," says Jones.

Pollution is a particularly pressing issue at the firing ranges where soldiers and law-enforcemen

When you pull the trigger of a firearm, two small explosions follow. First a hammer or an electri
amount of 'primer' explosive. This ignites a larger amount of explosive, which forces the bullet d

The problem is that the most widely used primers contain lead. Two of the current favourites —
responsible for the dangerously high levels of lead found at some firing ranges. A 1991 survey, fo
who had just cleaned a range run by the FBI in Quantico, Virginia, had levels of lead in their blo
government health limits[1].

Target practice

Jones and his colleagues hope to replace lead compounds with nanoparticles of aluminium, whi
mix particles averaging 50 nanometres across with acetylene black, a form of carbon, and molyb
the mixture electrically conductive, allowing it to be ignited by passing a current through it. The

The researchers are now running tests to assess 'action times' — the gap between the ignition cu
leaving the muzzle of the gun, which for military purposes needs to be less than 4 milliseconds.
and other assessments, they could be in use sometime in the next decade.

At Ludwig-Maximilians University in Munich, Germany, chemists led by Thomas Klapötke have that could make safer primers, funded largely by the German military. A primer must detonate r can fire quickly, so the researchers first measure how much energy it takes to detonate them. Th between sandpaper, dropping weights on them and spraying them with sparks.

Next up are tests that measure destructive power. About 10 grams of the test substance is placed ignited. Each container has a hole of a particular size in the lid. The smaller the hole, the more li explosion will be unable to escape quickly enough, blowing the container apart. The ideal prime enough to ignite the secondary explosive — will destroy a 35-millilitre container with a hole in th

In five years of testing only five compounds, all of them rich in nitrogen, have made it through t as TNTA, consists of a series of N_3 and NO_2 groups attached to a ring of carbon atoms[2]. Like otl of its energy release comes from single or double bonds between nitrogen atoms that break apar bonds. When mixed with an oxygen-rich material such as ammonium nitrate, TNTA explodes to nitrogen and carbon dioxide. The compound is undergoing commercial tests, and Klapötke hop two to five years.

Bomb disposal squad

In addition to certain types of primer, chemists would like to see other explosives phased out. So military testing ranges across the United States are contaminated with unreacted TNT, which th Agency classifies as a possible human carcinogen. TNT is now only rarely used by the US militar mining, raising fears that it could pollute underground water sources.

Replacements for TNT have been in use since the Second World War, but these were chosen ma powerful. James Short, a staff specialist for defence laboratories in the US Department of Defen millions of kilograms of explosives that have reached the end of their shelf-life of about 20–50 y dispose of because of environmental concerns.

> Developing new explosives can be dangerous. Three years ago, a researcher lost the top halves he's still working in the field.

The explosives involved — nitrogen and oxygen-containing substances called HMX and RDX — they can easily be moulded into various shapes for different applications. The polymer–explosiv burning, which does not necessarily raise it to a temperature at which it would explode.

Short argues that the environmental risks are not large. But communities living close to military fearing that burning the polymers could release pollutants such as carbon monoxide. Military of replace HMX and RDX: they want explosives that are cheap and powerful, yet detonate less read

In the 1990s, Short was part of a team at the Office of Naval Research in Arlington, Virginia, tha conventional explosive–polymer mixes. The group found that HMX and RDX could be mixed w allowing the explosives to be removed and stored for future use. Short's team also studied a new compound called TNAZ, which can itself be melted and moulded[3].

But money was an issue. It costs just a few tens of dollars to produce a kilogram of HMX or RDX amount of TNAZ. The new polymers, meanwhile, are extremely viscous when melted, requiring equipment to mix in the explosives during production.

Short still believes that both options are economically viable when you consider the costs of disp
hard to convince the officials responsible for acquiring weapons," he says. "They'd rather pay les

Work on green explosives continues at other US military facilities, such as the Army Research L
Officials are reluctant to discuss these studies for security reasons. But hints about the type of co
come from a closely related effort: the search for greener alternatives to the propellants used to
vehicles.

During the first two minutes of a space shuttle launch, for instance, when the need for thrust is g
burning aluminium in two solid-fuel boosters. The aluminium is supplied with oxygen using a c
perchlorate, but environmentalists note that this means the exhaust plume contains chlorine ion
destroying reactions and acid rain.

Space agencies are continually searching for more efficient propellants and, although they belie
the chlorine ions is minimal, they take such considerations into account. Three main candidates
— are in the frame to replace ammonium perchlorate as an oxidizer. All are chlorine-free, consis

Blast off!

Results from tests in military and civilian labs in Europe and the United States suggest that they
solid-fuel boosters. But introducing a new propellant is a complex business, says Octavia Frota,
ESTEC, the European Space Agency's research and technology-development centre in Noordwij
right combination of fuel and oxidizer, and a compound to bind them together, are subject to str
may have to be redesigned once the right combination is found, she adds.

It could take another decade for any of the three candidate oxidizers to find regular space applic
of nitrogen in these compounds, they can act as explosives as well as oxidizers. And at least one
as an explosive by military researchers in France, Germany and Britain, says Klapötke.

Working to develop new explosives can be dangerous. "If you make one mistake it can be your la
one researcher in his lab lost the top halves of two fingers in an explosion. "But he is still workin

Labs such as his can ill afford to lose staff, due to problems with recruitment. Klapötke admits t
many students. And the pool of recruits is narrowed still further by his decision only to accept st
security reasons. Klapötke understands why some young chemists shy away from military resea
necessary. "We need defence, so we have to train people," he says. "But we don't want to kill the

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