Harnessing the energy of fireworks for fuel

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The world relies heavily on gasoline and other hydrocarbons to power its cars and trucks. In search of an alternative fuel type, some researchers are turning to the stuff of fireworks and explosives: metal powders. And now one team is reporting a method to produce a metal nanopowder fuel with high energy content that is stable in air and doesn't go boom until ignited. Their study appears in the ACS journal *Energy & Fuels*.

Hydrocarbon fuels are liquid at room temperature, are simple to store, and their energy can be used easily in cars and trucks. Metal powders, which can contain large amounts of energy, have long been used as a fuel in explosives, propellants and pyrotechnics. It might seem counterintuitive to develop them as a fuel for vehicles, but some researchers have proposed to do just that. A major challenge is that high-energy metal nanopowder fuels tend to be unstable and ignite on contact with air. Albert Epshteyn and colleagues wanted to find a way to harness and control them, producing a fuel with both high energy content and good air stability.

The researchers developed a method using an ultrasound-mediated chemical process to combine the metals titanium, aluminum and boron with a sprinkle of hydrogen in a mixed-metal nanopowder fuel. The resulting material was both more stable and had a higher energy content than the standard nano-aluminum fuels. With an energy density of at least 89 kilojoules/milliliter, which is significantly superior to hydrocarbons' 33 kilojoules/milliliter, this new titanium-aluminum-boron nanopowder packs a big punch in a small package.

More information: Albert Epshteyn et al. Optimization of a High Energy Ti-Al-B Nanopowder Fuel, *Energy & Fuels* (2016). DOI: 10.1021/acs.energyfuels.6b02321

Abstract
Sonochemically-generated reactive metal nanopowders containing Ti, Al, and B represent a new class of high-energy-density nanopowder fuels with superior energy content and air stability as compared to nano-Al. In this work, we optimize the energy density of a Ti-Al-B reactive metal nanopowder fuel by varying the Ti:Al:B ratios using a sonochemically-mediated complex metal-hydride decomposition. After heating the recovered solids under vacuum to temperatures in the range between 150 °C and 300 °C, the powder's air stability is significantly improved so that it can be handled in air. Variable temperature vacuum heat treatment was used to produce fuels tuned to be stable with a gravimetric energy density exceeding that of pure bulk Al (> 31 kJ/g). The density of the powder was found to be 2.62 g/cc by helium pycnometery, which translates to an impressive volumetric energy content of 89 kJ/cm3. In PMMA protected bomb calorimetry tests commercial nano-Al (SkySpring Nanomaterials, 20% oxide) produced only 25 kJ/g, whereas the sonochemically generated Ti-Al-B nanopowders released 24% more energy per unit mass and 19% more energy per unit volume in identical experiments.

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