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Researchers discover cool-burning flames in space that could lead to better engines here on earth

A team of international researchers has discovered a new type of cool burning flames that could lead to cleaner, more efficient engines for cars. The discovery was made during a series of experiments on the International Space Station by a team led by Forman Williams, a professor of mechanical and aerospace engineering at the University of California, San Diego. Researchers detailed their findings last month in the journal *Microgravity Science and Technology*.

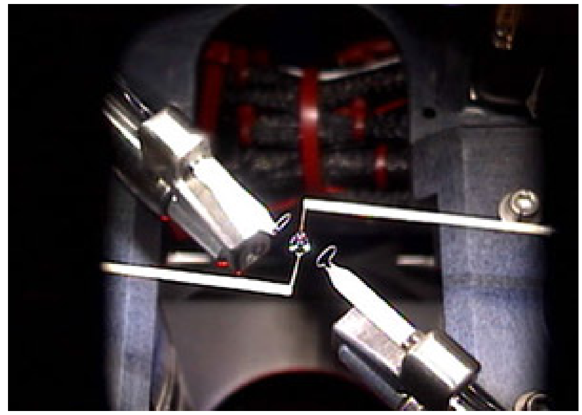
Astronaut Mike Fincke pictured to the left of the Combustion Integrated Rack facility installed in the Destiny module of the ISS shortly after installation. Photo: NASA

“We observed something that we didn’t think could exist,” Williams said.

A better understanding of the cool flames’ chemistry could help improve internal combustion engines in cars, for example by developing homogenous-charge compression ignition. This technology is not currently available in cars. But it could potentially lead to engines that burn fuel at cooler temperatures, emitting fewer pollutants such as soot and nitric oxide and nitrogen dioxide, also known as NOx, while still being efficient.

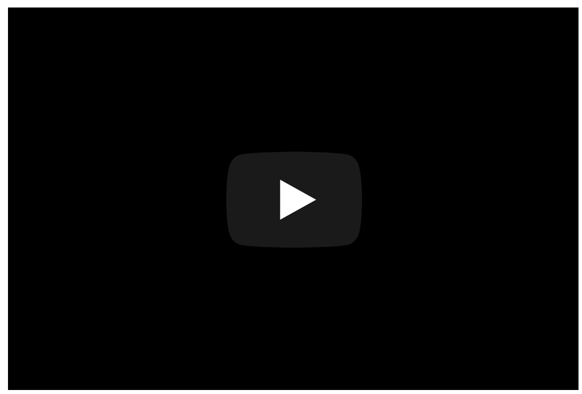
During the experiments, researchers ignited large droplets of heptane fuel. At first, it looked like the flames had extinguished themselves, just as they would have on earth. But sensors showed that the heptane was still burning, although the resulting cool flames were invisible to the naked eye.

The cool flames occurred in a wide range of environments, including air similar to the earth's atmosphere and atmospheres diluted with nitrogen, carbon dioxide and helium. The resulting combustion reaction creates toxic products, such as carbon monoxide and formaldehyde, which in turn burn off.



Researchers believe that the cool flames are the result of elementary chemical reactions that do not have the time to develop around burning fuel droplets on earth, where they can only exist for a very short period of time.

The difference between earth and the space station is buoyancy. When droplets of fuel burn on earth, buoyancy limits the amount of time gases can hang around in the high temperature zone around the droplets. So there isn't enough time for the droplets' chemistry to support the cool flames. But in micro-gravity, there is no buoyancy, so there is enough time for the gases to stay around the droplets and for that chemistry to develop.



The challenge for future applications is to get the right mix of fuels to generate this cool flame combustion here on earth. To investigate this question, NASA is planning a new series of experiments tentatively called COOL FLAME INVESTIGATION, starting next winter and continuing for about a year.

Researchers emphasized that the research is only possible on the ISS, where scientists have access to a microgravity environment that provides a sufficient amount of test time for cool flames to occur. All the experiments take place in the Multiuser Droplet Combustion Apparatus that can generate and ignite droplets from different fuels in different atmospheric conditions. The chamber is crammed with sensors and equipped with video cameras that record experiments. The chamber is inside an experimental facility called the Combustion Integrated Rack, which is roughly the size of a 5.5-foot bookcase and weighs close to 560 lbs and which records the data and transmits it to ground. The Combustion Integrated Rack is located in the Destiny module of the ISS.

"Things can happen out there that can't happen here," Williams said.

Williams has been working on fire research and fire safety with NASA since the 1970s. You will not, however, find him on the space station. The experiments are run by remote control from NASA's John Glenn Research Center in Cleveland. Results were analyzed by a team of scientists from UC San Diego, the University of Connecticut, NASA, Princeton, the University of South Carolina, UC Davis, and Cornell.

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