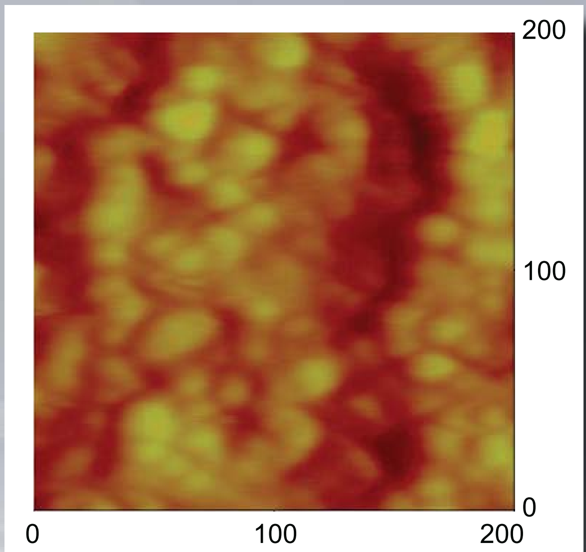
Nano-Additive Demonstrates Potential for JP-900 Fuel

Accomplishment: A new fuel additive based on reactive metal nanoparticles has demonstrated the ability to deoxygenate kerosene-based fuels at controlled temperatures.



Impact: Development of a kerosene-based aviation fuel that can be heated to 900 degrees Fahrenheit (JP-900) is an enabling technology for Mach 4 flight and directly supports the Long Range Strike fighter program, the Versatile, Affordable Advanced Turbine Engine (VAATE) program and the National Aerospace Initiative. This accomplishment validates a new approach with the potential to achieve this requirement.

Motivation and Approach: Onboard aviation fuels are a primary heat sink used to cool engine components, avionics and electronics, munitions bays, and structural parts subjected to aerodynamic heating during supersonic flight. Standard fuels begin to degrade above 325 degrees Fahrenheit by interaction with small amounts of oxygen dissolved in the fuel. Current additives increase the maximum fuel temperature to 425 degrees Fahrenheit, above which the additives lose effectiveness or begin to break down. Many aircraft, including the F-22 and B-2, have significant thermal deficits that limit operational capability by heating the fuel above these temperatures. Summertime thermal aborts are common during pre-flight systems checks at ground idle, and the duration of supersonic flight is restricted. The maximum temperature capability of de-oxygenated kerosene-based fuels is 900 degrees Fahrenheit. This JP-900 class fuel provides a solution to these thermal deficit issues and is an enabling requirement for flight at Mach 4 and above. There are currently no approaches that give this capability.

Reactive metal nanoparticles less than 100 nanometers in diameter were developed in this work as fuel additives. The metal nanoparticles react with dissolved oxygen to remove it from the fuel. The small size ensures that the particles can be suspended easily for compatibility with fuel system pumps and filters, and the very high surface area of the nanoparticles enhances chemical reactivity. A molecular shell less than a few nanometers thick is deposited on the metal nanoparticle to control the temperature at which deoxygenation occurs, preventing early or unwanted reaction, and giving maximum effectiveness. This coating can also be tailored to improve the dispersion of the core-shell nanoparticles in the fuel. Core-shell nanoparticles have been designed and produced, and their ability to deoxygenate fuel at a controlled temperature has been established. These nanoparticle additives have demonstrated thermal stability equal to the current state of the art, with the goal of continued development being to achieve fuel heat sink temperatures up to 900 degrees Fahrenheit.

Team: This research is being conducted at the Propulsion Directorate by Dr. Christopher Bunker and Dr. Elena Guliants (University of Dayton Research Institute). Funding was provided by the Air Force Office of Scientific Research (Dr. Julian Tishkoff, Program Manager) and the Propulsion Directorate.