Kelsa M. Benensky, Carly J. Romnes, Michael Eades, Paolo F. Venneri, Kurt A. Terrani, Steven J. Zinkle

University of Tennessee at Knoxville, University of New Mexico, Oak Ridge National Laboratory

2018 Nuclear and Emerging Technologies for Space

Advanced Fuel Forms for Nuclear Thermal Propulsion Applications

Originally developed to enable very high burnups and enhanced accident tolerant fuels for terrestrial power reactors, fully ceramic microencapsulated (FCM™) fuels offer a modern alternative fuel system design for nuclear space applications. Composed of a structural refractory carbide (RC) matrix (SiC, TiC, ZrC, etc.) impregnated with coated uranium compound particles (UO_2, UN, etc.), RCFCM is a derivative of the original NERVA/Rover loaded graphite matrix fuels. Most refractory carbides are compatible with the hydrogen propellant and are some of the highest known melting temperature compounds, which may enable enhanced tolerance to desirable nuclear thermal propulsion (NTP) operating conditions. This paper summarizes the combined experimental and modelling efforts recently undertaken to survey FCM fuel for NTP applications. Sensitivity of fuel system design to fuel volume loading (UO_2 and UN, low enriched uranium <20 at% U-235) on fuel reactivity was surveyed through infinite lattice calculations using monte carlo n-particle (MCNP) reactor physics code. Matrix coupons of SiC, TiC, and ZrC were thermal cycled using the compact fuel element environmental test (CFEET) at NASA Marshall Space Flight Center at temperatures between 1727–2227 °C (2000–2500 K) to confirm their stability in hot hydrogen and identify potential degradation mechanisms.