Novel Fuel Desulfurization Systems for Fuel Cell Powered APUs

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Abstract

The major drawback to the use of fuel cells as electric generators and auxiliary power units (APUs) by deployed forces is their inability to directly use battlefield fuels. Solid Oxide Fuel Cells (SOFCs) require a clean, essentially sulfur-free feed stream to prevent poisoning of the anode catalyst. Adsorptive removal of refractory sulfur species is highly attractive due to its simple operation and ease of integration with the balance of plant. A successful sorbent must exhibit very high selectivity to sulfur compounds in the presence of a large excess of aromatic and poly-aromatic species. The aromatics have a structure very similar to those of the organic sulfur compounds, making it difficult to develop an effective adsorbent with high selectivity.

One way to improve the selectivity is to operate at a higher temperature at which the adsorption of the aromatics is not strong enough to compete for adsorption sites with the organosulfur compounds. We followed this approach and developed a high temperature fuel desulfurization system for jet fuel to power fuel cell APUs. Another way to improve sorbent selectivity is to oxidize the thiophenic sulfur compounds using molecular oxygen present in ambient air to carryout electrophilic addition of oxygen atoms and convert them into their respective sulfoxides (1-oxides) and sulfones (1,1-dioxides). The chemical and physical properties of sulfoxides and sulfones are significantly different from those of the hydrocarbons in the fuel, and they are much easier to remove by selective adsorption.

Following this second approach TDA is developing a prototype of the oxidative fuel desulfurization system, a key component of a compact fuel processor, to produce a sulfur-free feed for fuel cell power generators that run on high sulfur JP-8 fuel. TDA's desulfurization system uses a catalyst to first oxidize the thiophenic sulfur species in the fuel to their respective sulfones using molecular oxygen in air and then to remove the oxidized sulfur compounds with a novel regenerable, mesoporous sorbent to deliver essentially sulfur-free fuel to the fuel processor. The results from our prototype development efforts will be presented in the meeting.