July 2015 Highlights

ORNL Fuels, Engines, and Emissions Research Center

TECHNICAL HIGHLIGHTS

The Oak Ridge National Laboratory (ORNL)-Shell Cooperative Research and Development Agreement (CRADA)-Discovery of Unique Synergism between Ionic Liquids (ILs) and Zinc Dialkyldithiophosphate (ZDDP) is published in the Prestigious Journal: *Advanced Materials* and highlighted on *MaterialsView*

This study discovered unique synergistic effects between a group of phosphonium-alkylphosphate ILs and conventional ZDDPs when used together as lubricant additives resulting in significant friction and wear reductions. The IL+ZDDP tribifolm distinguishes itself from the IL or ZDDP tribofilm in both chemical composition with more zinc and iron phosphates but less metal oxides and sulfur compounds, and mechanical properties with higher modulus and lower ratio of hardness to stiffness squared. Chemical analysis indicated remarkably 30–70x higher concentrations of the IL and ZDDP active elements than the nominal values on the fluid surface and hypothetical anion-exchange produced new compounds, which may explain the superior tribological performance and distinct tribofilm composition. No such synergy with ZDDP, however, was observed for phosphonium-organophosphinate or ammonium-organophosphate ILs, suggesting that the IL+ZDDP synergism is unique for phosphonium-organophosphate ILs and both the cation and anion play critical roles.

Reference: J. Qu, W. C. Barnhill, H. Luo, H. M. Meyer, D. N. Leonard, A. K. Landauer, B. Kheireddin, H. Gao, B. L. Papke, and S. Dai, "Synergistic Effects between Phosphonium-Alkylphosphate Ionic Liquids and ZDDP as Lubricant Additives," *Advanced Materials*, 2015, DOI: 10.1002/adma.201502037 and *MaterialsView* at http://www.materialsviews.com/reduce-wear-synergistic-lubricant-pair/.

July *Transportation Facts of the Week* based on efforts by Fuels, Engines, and Emissions Research Center (FEERC) Researcher

The four weekly *DOE EERE Transportation Facts of the Week* for July (#880–883) were largely based on results of a recent paper on examining light-duty vehicle energy use by John Thomas (with additional analysis). Stacy Davis of ORNL creates these facts which can be found at http://energy.gov/eere/vehicles/transportation-fact-week The reference paper is John Thomas, "Drive Cycle Powertrain Efficiencies and Trends Derived from EPA Vehicle Dynamometer Results," pp. 1374–1384 in *SAE International Journal of Passenger Cars – Mechanical Systems*, **7**(4), 2014, doi:10.4271/2014-01-2562.

ORNL and Coordinating Research Council (CRC) enter into a CRADA

ORNL and CRC have established a CRADA to support research awarded under a Department of Energy (DOE) Funding Opportunity Announcement (FOA). Additionally, a non-disclosure agreement with General Motors (GM), a CRC member company, was also completed to allow GM to support the project. Completion of these agreements clears the way for the technical work on the Gasoline Engine and Fuels Offering Reduced fuel Consumption and Emissions (GEFORCE) Project to move forward. The GEFORCE project will investigate interactions between expected future engine technologies and potential future fuel formulations on light-duty vehicle fuel efficiency and emissions.

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ORNL Team Completes Third Round of Neutron Imaging of Fuel Injection Dynamics
Eric Nafziger, Derek Splitter, Alex Pawlowski, Charles Finney, Rebecca Neuenschwander, and Todd Toops conducted an intensive effort to capture dynamic fuel injection in the CG1-D neutron imaging beamline at ORNL's High Flux Isotope Reactor (HFIR). The effort is focused on the intra-nozzle fluid dynamics that occur in gasoline direct injection systems, with a specific focus on comparing fuel injection under flash-evaporation conditions to non-flash conditions. The sophisticated system is designed to operate with commercial and prototype injectors and deliver fuel to the injectors at rail pressures up to 150 bar. The spray chamber can be operated at absolute pressures as low as 0.2 bar, i.e. sub-ambient, and the system currently has a maximum pressure of approximately 4 bar. The system can be heated to over 100°C even while flowing 14 L/min sweep gas. In collaboration with GM, ORNL was provided a single-hole injector with the same internal dimensions of a six-hole injector commercial-intent stepped-valve covered orifice (VCO). With the help of neutron scientists Hassina Bilheux and Louis Santodonato, this system was operated continuously for 140 hours at HFIR. At an injection rate of 10 Hz, approximately 1 million injection events are compiled to capture a 10 millisecond (ms) composite injection sequence (2 ms before injection, 1.2 ms injection, 6.8 ms after injection). In the analysis of the neutron images, it is possible to see both internal injector motion and fluid movement within the injector. It is possible to see the fluid fill the sac rapidly and upon closing of the injector pintle, the fluid can be seen leaving the sac at a slower rate. This phenomenon is commonly referred to as "dribble" and is responsible for several non-ideal combustion behaviors that impact efficiency, hydrocarbon emissions, and engine knock.

High-Level or Noteworthy Visits

Vehicle Technologies Office Visits the National Transportation Research Center (NTRC) for Fuel Economy Program Review
Dennis Smith and Shannon Shea of the DOE Vehicle Technologies Office visited ORNL in July for an annual review of the Fuel Economy Information Project. Dennis is the National Clean Cities Director and Vehicle Technologies Deployment Manager. This program supports ORNL's efforts in maintenance of the fueleconomy.gov website, which is managed by the Center for Transportation Analysis. FEERC supports this program by developing and validating driving tips. John Thomas, Shean Huff, and Brian West presented recent results and 2016 plans and took the team on a facilities tour including FEERC, the Power Electronics and Electric Machinery Research Center (PEEMRC), and the Manufacturing Demonstration Facility (MDF).

Invited Talks and Presentations

FEERC Staff Present Results at the United States Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability (USDRIVE) Advanced Combustion and Emissions Control (ACEC) and DOE Crosscut Team Meetings in July
FEERC staffers provided four technical presentations during July's USDRIVE ACEC Tech team meeting and the DOE Crosscut team meetings in July. These two synergistic meetings are held six times a year at the USCAR offices in the Detroit area. Jim Szybist presented "In-Cylinder Fuel Reforming to Support High EGR Dilution" that included results from his recent work investigating fuel reformation in a unique multi-cylinder engine equipped with hydraulic valve actuation for one of its four cylinders. Scott Sluder presented "Preliminary Heat-of-Vaporization Effects in High-Octane Fuel Experiments" that discussed results from work within FEERC that support the notion that fuel heat-of-vaporization effects are largely captured within the standard ASTM octane tests. Scott Curran's presentation "Future Common CI Engine Platform – Discussion" focused on initiating a process to select a replacement for the venerable GM diesel engine that is used by multiple organizations involved in advanced combustion research. Dean Edwards presented recent results from advanced combustion studies supporting the Daimler SuperTruck Team that used a Detroit Diesel DD15 engine in "Exploring the Potential Benefits of Dual-Fuel Low-Temperature Combustion for Heavy-Duty Engine Applications." All four presentations were well-received by DOE and industry participants in the meetings and demonstrate ORNL's leadership and contributions in these areas of research and development (R&D).

Awards

Outreach