

**IASH 2026, the 19TH INTERNATIONAL CONFERENCE ON
STABILITY, HANDLING AND USE OF LIQUID FUELS
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Abstract Summaries

SESSION 1.1: FUEL PRODUCTION - SYNTHETIC FUELS

A PRODUCER-ORIENTED REVIEW OF SAF PATHWAYS: PROCESSES AND FUEL PROPERTIES

Ole Frej Alkilde
Topsoe A/S

Synthetic aviation fuel (SAF) is expected to play a major role in reducing greenhouse-gas emissions from aviation, and multiple production routes are commercially available or progressing from demonstration to industrial scale. This presentation provides a production-oriented overview of selected SAF pathways, with emphasis on how process choice translates into fuel properties. A central focus is hydroprocessed esters and fatty acids (HEFA), currently the dominant SAF route. First-generation HEFA plants typically produce fuels with distillation characteristics close to conventional jet fuel. Second-generation HEFA concepts apply more selective isomerization to improve selectivity, but can also shift product quality toward heavier distillation behavior and higher viscosity. These parameters may affect blending limits, cold-flow margins, and fuel handling. A third category covers refinery-based approaches, including repurposed assets used for co-processing or for dedicated production of synthetic blending components (SBC). Here, resulting fuel properties depend strongly on the refinery unit configuration and operating strategy. The presentation then addresses e-fuel pathways based on Fischer–Tropsch (FT) synthesis, which combine established technology elements to produce synthetic hydrocarbons. FT-based e-fuels are discussed in terms of key property differences versus typical HEFA products. Finally, biomass-based SAF routes are reviewed. While upgrading of biomass-derived intermediates can be challenging, potential feedstock availability is high. Selected examples illustrate how feedstock type (e.g., wood, plastics, sludge) and conversion technology (e.g., pyrolysis, hydrothermal liquefaction) drive variation in product properties and upgrading requirements.

**INVESTIGATING THE INFLUENCE OF MATERIAL COMPOSITION ON
FILAMENTOUS CARBON GROWTH DURING HYDROCARBON THERMAL
CRACKING**

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Formation of carbon deposits on reactor surfaces during the thermal cracking of hydrocarbons in petroleum-derived fuel production results in reduced efficiency and increased downtime, with filamentous deposits in particular resulting in irreversible damage to the metal reactor surface. Filamentous deposits are typically catalyzed by iron or nickel, which interacts with carbon that has absorbed onto and diffused into the surface. Therefore, to further investigate the mechanisms of

filamentous carbon growth as it relates to the catalytic activity of different material compositions, a series of metal alloys and ceramic materials were screened for deposit propensity. Metal alloy powders, of interest for their potential application in additive manufacturing, and ceramic powders, as potential inert coating materials, were evaluated alongside metal alloy coupons. Experiments were conducted in a flowing reactor utilizing an inert quartz tube situated within a heated clamshell furnace. N-octane was used as a representative paraffinic reactant feedstock, with gas-phase pyrolysis taking place at atmospheric pressure to selectively promote filamentous over amorphous morphologies. Post-reaction characterization of the samples was performed visually using scanning electron microscopy (SEM) and quantitatively using carbon burn-off analysis. Additionally, the influence of basic surface pre-treatments, such as annealing and calcination, on the deposition propensity of the materials was also examined and included in the data.

FLEXIFORMING: A COST-EFFECTIVE PATHWAY FOR OIL REFINERS TO ENTER THE SUSTAINABLE AVIATION FUEL MARKET

Denis Pchelintsev, Alexei Beltyukov

Universal Fuel Technologies Inc

Flexiforming® technology offers oil refiners a pragmatic two-step approach to sustainable aviation fuel (SAF) production while generating immediate returns. Unlike conventional SAF pathways requiring substantial greenfield investment, Flexiforming enables repurposing of idle or underutilized naphtha hydrotreaters (NHT) or catalytic reformer units (CRU) through modest piping modifications. In Step 1, refiners upgrade fossil or renewable naphtha, combined with ethanol co-feed, into a high-octane gasoline blendstock (RON 92), achieving conversion margins exceeding \$100/ton. For a 120,000 tpa (3,000 bpd) unit, capital investment into a retrofitting project is \$13.8-14.4M, generating annual EBITDA of \$7-13M, with payback under 20 months and IRR exceeding 35%. The process accounts for less than 6% of product carbon intensity, creating carbon credit opportunities when using renewable feedstocks. Step 2 leverages the same core equipment to produce SAF from fully renewable feeds (HEFA naphtha with alcohol), generating Synthetic Aromatic Kerosene (SAK) that meets aviation fuel specifications. Key reactions include alcohol dehydration, dehydrocyclization, aromatization, and alkylation over proprietary zeolite catalysts. Commercial validation of step 1 includes four operating plants (75-180 bpd capacity) with sub-2-year payback periods and a licensed 480,000 tpa facility. Two additional plants (200 bpd and 3,000 bpd) on the US West Coast reached Final Investment Decision in 2026 with client financing. Flexiforming's flexibility to process diverse feeds (alcohols, ethers, naphthas, LPG, light olefins) positions it as a versatile platform for refiners transitioning to renewable fuels while maintaining profitability throughout the energy transition.

APPLICATION OF ASTM PROCESS CONTROL CRITERIA TO FISCHER-TROPSCH SYNTHETIC AVIATION FUEL (SAF)

Mark Rumizen

AIRCO

Flexibility is built into the conventional aviation turbine fuel specifications to accommodate the inherent variability resulting from the conversion of crude oil to jet fuel. The ASTM specifications do not constrain production methods and allow a range of fuel compositions and properties. In the mid-2000's, the aviation community decided to leverage this existing ASTM approach for

oversight of synthetic jet fuel but with enhanced production process control language. Each of the eight currently issued annexes in ASTM specification D7566 for synthetic jet fuel includes generalized language that describes the permissible production process. Annexes A1 and A4 of ASTM D7566 specify criteria for Fischer-Tropsch (FT) SAF. The criterion for Annex A1 requires that the SAF meet precise fuel property limits and be produced from synthesis gas utilizing the FT process. Annex A4 adds synthesized aromatics from the alkylation of non-petroleum derived light aromatics to the paraffinic FT of Annex A1. Both annexes utilize general terminology to specify only the key elements of the processes, thereby allowing producers the flexibility to design process schemes to best suit their needs, while still complying with the annex. This paper will explore the practical aspects of attempting to control FT synthetic fuel production processes through non-prescriptive specification language. It will highlight the inevitable variability that results from this approach and will discuss the implications for future producers of FT aviation fuels.

POINT OF USE MANUFACTURING OF HIGH-PERFORMANCE FUELS

Oscar N. Ruiz and Mukund Karanjikar

CycloKinetics Inc. 2350 W 1500 S, Salt Lake City, UT 84104.

This presentation describes the development, qualification, demonstration, and performance advantages of CycloKinetics' (formerly CleanJoule) advanced liquid fuels CycloJP, CycloRP, RJ-10, and CycloSAF, across multiple aerospace system applications. CycloKinetics' manufacturing method enables the use of virtually any regional biomass feedstock including corn, sugarcane/beet, agricultural residues, and forestry byproducts, to produce superior fuels at or near the point of consumption. We present several aerospace technology case studies demonstrating how CycloKinetics' fuels deliver clear benefits over conventional petroleum-based fuels in combustion performance. Additionally, our approach enhances supply-chain resiliency through distributed domestic production and the potential for low-intensity, remote "lights-out" manufacturing capabilities.

METHANOL TO JET AND FUTURE SYNTHETIC BLEND COMPONENT PATHWAY CONSIDERATIONS

Dan Kadlecsek, Amanda Graves

ExxonMobil Technology and Engineering

Methanol to jet (MTJ) technology provides access to a wide array of feedstocks for the production of synthetic blend components (SBC) used in the blending of synthetic aviation turbine fuel (SATF). The recently completed ASTM D4054 evaluation of the MTJ pathway highlighted the similarities between synthetic hydrocarbons derived from methanol and those found in conventional jet fuels. However, because MTJ hydrocarbons are predominantly iso-paraffinic in nature, there are some differences in properties relative to conventional fuels that warrant further industry consideration. In particular, some fit for purpose tests included in the ASTM D4054 Standard Practice lack sufficient historical data for conventional fuels and therefore make any direct comparisons to SATFs challenging. One such example is auto-ignition temperature, which relies on a procedure that is influenced by ambient laboratory conditions and therefore generates results with varying levels of precision. This paper will present an overview of the MTJ technology pathway, inclusive of key fit for purpose test results that may warrant further industry development.

SBC AND SATF REQUIREMENTS BEYOND PRODUCT SPECIFICATIONS

Jesse Vilja, Kati Sandberg, Pratik Chandhoke

Neste

The commercialization of Sustainable Aviation Fuel (SAF) must be perceived through the lens of first meeting the standardized product specifications, such as ASTM D7566 for Synthetic Blending Components (SBC) and Synthetic Aviation Turbine Fuel (SATF), and ASTM D1655 / DEF STAN 91-091 for conventional jet fuel. However, for producers and suppliers operating across global supply chains, technical compliance with these specifications at the point of manufacture can be considered as merely a baseline. Additionally, there are many other aspects that need to be considered when entering the market with SAF. Firstly, authorities and regulators have placed additional requirements for the product classification, reporting and documentation depending on the targeted market area. Some examples include those brought by ReFuelEU Aviation and REACH chemical registrations, Californian and other states' LCFS programs, and Proof of Sustainability related aspects (ISCC, RSB). Secondly, there can be additional analytical requirements in the SATF blending process, set by the regulations or agreed with customers case-by-case, in addition to the control checks and recertifications according to EI 1533. Thirdly, more stringent requirements can exist in the downstream supply chain, where e.g. pipeline operators have set such for operational safety, product contamination control and material compatibility reasons. They are important to consider already in the SBC production, and especially in the SATF blending for batches utilizing these supply channels. By analyzing these requirements beyond the standard specifications, this case study highlights the practical realities of global SATF distribution. It demonstrates the various steps and extra resources needed for a successful SAF market entry and for commercial operations start-up. While adding to the total economics of SBC and SATF distribution, the requirements necessitate adherence to robust quality assurance practices which responsible fuel producers and suppliers comply with.

Session 1.2: FUEL PRODUCTION: UL AVIATION GASOLINE

G100UL: THE PATH TO FLEETWIDE UNLEADED AVGAS ADOPTION

Tim Roehl

General Aviation Modifications, Inc. (GAMI)

GAMI's G100UL stands as the only high-octane unleaded aviation gasoline to receive FAA approval for use on every US Type Certificated engine and airplane. Unlike other candidate fuels, G100UL is fully miscible with 100LL and requires no modifications to engine, airframe, or operational procedures, streamlining its adoption across the fleet. GAMI opted not to pursue an ASTM specification approval, instead relying on a rigorous FAA certification process—spanning over 12 years—which ensures the fuel's suitability for real-world operational needs.

A key distinction exists between ASTM specification and FAA certification: the latter emphasizes fit-for-purpose testing and operational approval, whereas ASTM standards may not fully address real-world issues such as non-miscibility or the need for engine modifications that can reduce performance, range and complicated FAA Certification issues. G100UL's deviations from ASTM Table 1 properties are carefully considered to ensure compatibility and fleetwide approval. Given that approximately 70% of avgas is used/purchased by the approximately 30% of aircraft that

require 100 Motor Octane fuel and the limitation that most airports have only one avgas tank, any replacement fuel must serve not only those aircraft that require 100 Motor Octane fuel, but can also serve those aircraft that might be able to use a lower octane fuel in order to be economically feasible. As part of the FAA's Plan for Transition, G100UL's early production and market experience will be monitored, with particular focus on material compatibility. Given the age of the General Aviation fleet, recommendations from Civil Aviation Authorities and OEMs regarding elastomers highlight the importance of addressing material concerns during the shift to unleaded fuel.

GLOBAL TRANSITION TO UNLEADED AVGAS

Chris D'Acosta
Swift Fuels, LLC

Swift Fuels is the global leader in the transition to replace toxic lead in 100LL aviation gasoline (avgas) with a new "unleaded" avgas formulation called 100R. We will discuss the various government requirements for certifying aircraft engines and airframes to use the new fuels and we will discuss the international fuel standards and test methods applied in assuring safe practices along the global fuel supply chain. We will also highlight the global transition plans at airports serving piston aircraft expected over the next 5 years to successfully eliminate the presence on toxic lead emissions in the atmosphere brought by the combustion of 100LL (leaded) aviation fuel.

NEXT GENERATION CFR F4 SUPERCHARGE RATING ENGINE TECHNOLOGY FOR ASTM DG0G

Ricky Archer, Conrad Kader, Kevin Nielson, Robert Lewis
CFR Engines Inc.

The CFR F4 supercharge rating engine is a specialized research engine used to evaluate the knock characteristics and performance of aviation gasoline under supercharged conditions per ASTM test method D909. Developed as part of the Cooperative Fuel Research (CFR) engine series, the F4 configuration incorporates a controlled compressed air supply (that simulates an aircraft engine supercharger) to increase the pressure and density of the intake air supplied to the combustion chamber. This setup allows the engine to replicate the high-pressure operating environments experienced in supercharged aircraft engines. By controlling variables such as boost pressure, intake temperature, and fuel-air mixture, the CFR F4 engine provides a consistent and repeatable platform for studying fuel behaviour during high-load combustion conditions. New F4 systems were out of production for many years, but the system returned to production for 2025 with modern instrumentation, control systems and functionality. The "supercharged" air supply system now operates under closed loop control using electronic pressure regulation. In the past the operator had to manually plot data, perform a "best fit" curve approximation to evaluate the peak of the curve, and interpolate the data points to determine the Performance Number. The curve fit and interpolation logic are now implemented into the HMI and the calculation of the Performance Number is now automated. The paper will introduce the role and technology of the F4, outline the changes to the latest generation of the F4 rating system for ASTM D909, present experimental results obtained with the new system, and discuss the benefits for aviation gasoline research and quality control.

SESSION 1.3: FUEL PRODUCTION & DISTRIBUTION: QUALITY CONTROL

UNDERSTANDING REAL WORLD CONTAMINATIONS IN AIRCRAFT, SHIPS AND FUEL INSTALLATIONS

David Evans, Nathan Matheson

Defence Science and Technology Group

This presentation examines a spectrum of real world contaminations observed in operational fuel systems, highlighting the chemical and physical mechanisms that drive their formation. It will characterise additive/water interfacial gels, as well as coloured aqueous phases produced when antioxidant derived compounds partition into water layers during handling and transfer operations. Whilst often visually striking, do not necessarily indicate fuel degradation. The presentation will also address infrastructure related contamination behaviours that emerge from interactions between fuels and system materials. This includes the influence of elastomers and plasticised components on water separability performance, the time dependent leaching processes involved, and the implications for commissioning new storage and distribution systems. Through comparative evaluation of multiple water separation test methods, the session will illustrate how material fuel equilibria, additive behaviour, and diagnostic method selection shape contamination assessments. Collectively, the presentation provides a technically grounded overview of diverse contamination modes, demonstrating the complexity of modern fuel systems and the analytical approaches required to ensure accurate, fit for purpose fuel quality assurance

EFFECT OF REFINERY PROCESS ADDITIVE ON JET FUEL THERMAL OXIDATION STABILITY

Enrico Lodrigueza

Phillips 66 Fuels Quality & performance, Bartlesville, OK

Refinery jet fuel production was failing thermal oxidation stability test for 2 months. Preliminary analyses of the rundown tank showed significant levels of metals. During this period clay treaters were being spent requiring change after a couple of months instead of once a year. Through further investigation, it was discovered that shutting down the crude antifoulant additive improved jet fuel stability. Additional start-stop injections of the additive confirmed that it was the cause of the oxidation stability failure. Analyses of the clay filter extracts indicate high levels of organic-soluble metals adversely affected the thermal oxidation stability of the fuel, and that the antifoulant additive acted as a transporter/solubilizer of these metals.

IMPACT OF CONTAMINANTS AND ADDITIVES ON CLAY TREATMENT EFFECTIVENESS AND THERMAL OXIDATIVE DEPOSITION IN AVIATION TURBINE FUELS

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A systematic experimental program was conducted to evaluate the impact of contaminants and additives on clay treatment efficacy and on the deposit-forming tendency of aviation turbine fuels with varying levels of hydroprocessing. Four jet fuels were studied, including one hydrotreated fuel and three non-hydrotreated fuels from distinct sources. Baseline characterization included QCM thermal oxidative deposition (TOD) measurement, ASTM D3241 breakpoint, nitrogen speciation, full ASTM D1655 properties, polars speciation, and advanced molecular analysis using GC×GC and LC/MS. The samples of jet fuel were clay treated using fresh Attapulugus clay to evaluate the effect on their thermal stability. Polar heteroatom-containing molecules, especially nitrogen-containing species, are known to be selectively removed during clay treatment which should improve thermal stability. QCM TOD, polars speciation, LC/MS, and total/basic nitrogen measurements were measured to confirm this effect. Fuels were spiked with 4 ppm metal deactivator additive (MDA) and 100 ppm dodecenylsuccinic acid (DDSA) and QCM TOD was measured prior to clay treatment. Clay breakthrough experiments were performed by running the spiked fuels through the clay used to treat the respective fuel, monitoring the effluent of MDA and DDSA. QCM TOD and ASTM D3241 breakpoint were measured on pre-breakthrough and post-breakthrough samples. These experiments explore the effect of contaminants on clay treatment effectiveness, capacity, and TOD behavior. The combined use of stability testing and molecular-level analysis provides mechanistic insight into clay treater deposit precursor removal and breakthrough and sheds light on factors affecting clay treater performance based on fuel composition.

RESTORING OFF-SPEC DISTILLATE FUELS THROUGH TARGETED ADDITIVE TREATMENTS AND MECHANICAL SEPARATIONS

Sai Reddy Pinappu Sankaran Murugesan

Baker Hughes

Off-spec distillate fuels frequently arise from contamination introduced during processing, storage, transport, or blending operations. Common contributors include suspended particulate matter, corrosion-derived oxides and sulfides, free and emulsified water, sulfur-containing species, trace metals, tank bottom sludge, oxidation by-products, and incompatible blend components. These conditions can lead to filter plugging, specification failure, custody transfer delays, and substantial economic losses due to reprocessing, downgrading, or disposal. This paper presents a structured remediation methodology designed to rapidly restore contaminated distillate streams using chemical treatment, mechanical separation, or an optimized combination of both. The workflow begins with rapid diagnostic characterization to identify contaminant class, and separation behavior. Based on these findings, targeted additive treatment strategies are selected, followed by appropriate mechanical processes such as staged filtration, centrifugation, or polishing separation. The progression from laboratory concept validation to full-scale field execution is described through implementation via Baker Hughes Contaminants Extraction Services. Particular emphasis

is placed on treatment selection, operational deployment speed, and maximizing recovery of specification-grade product while minimizing waste generation. Representative case histories will be presented demonstrating recovery of off-spec distillate inventories, reduction in disposal volumes, and prevention of operational disruptions. The results show that a data-driven, integrated chemical-mechanical approach provides a fast and effective pathway to restore product value and mitigate economic impact.

FROM PARTICLE COUNTING TO CONTAMINATION INTELLIGENCE: INLINE HIGH-RESOLUTION DYNAMIC IMAGING MONITORING OF FUELS

Colin Dalton, Tod Canty,
JM Canty

Effective fuel cleanliness monitoring is essential for protecting modern high-precision equipment and maximizing asset life. Accurate differentiation between solid particulates and dispersed water is critical to understanding contamination sources and mitigating system failure risks. Sub-visible particles (<4 μm), soft organic agglomerates, and micro-dispersed water droplets are now recognized as critical contributors to wear, erosion, injector fouling, and premature component failure. As a result, contamination monitoring must evolve beyond conventional particle counting toward true morphological characterization and continuous inline analysis. Traditional light obscuration and pore blockage techniques provide bulk particle counts but lack the capability to differentiate between hard metallic wear debris, soft organic contaminants, and water droplets. These technologies inherently misclassify bubbles and free water as solid particles and are constrained by detection limits and coincidence errors at higher concentrations. Furthermore, their reliance on offline laboratory sampling limits temporal resolution and prevents rapid process intervention. This paper presents an advanced high-magnification dynamic imaging system engineered for real-time inline deployment. The system combines high-resolution optical microscopy with automated image segmentation and morphological based classification algorithms to deliver true two-dimensional particle size and shape analysis down to 1 μm . The integration of dynamic flow cell design with controlled illumination geometry allows stable inline measurements under continuous flow conditions without compromising image fidelity. Advanced filtering algorithms isolate solids from water droplets in real time, effectively eliminating the misclassification errors inherent in non-visual particle counters. The paper further details optimized sampling architecture, flow control considerations, optical calibration protocols, and data validation strategies necessary to ensure measurement repeatability and reproducibility in both laboratory and permanently installed inline systems. This approach redefines fuel cleanliness monitoring from periodic counting to continuous contamination intelligence.

A STEP TOWARDS REAL TIME CONTINUOUS FUEL QUALITY MONITORING

Alan Fougere, Mathew Fielder¹
D-2 Incorporated
¹Sefisco Aviation

D-2 Incorporated, founded in 2002, has developed a series of innovative technologies to assist fuel quality managers to perform their role more easily and accurately. In-Line Conductivity, Density, Filterability, Particle, and Free Water to mention some. The company has successfully combined

these instruments into the “Petroleum Expedition Analysis Kit”, (PEAK), allowing forward area military operators to rapidly perform fuel quality surveillance in the battlefield. At D-2 we believe the “Future Starts Today” so we continue to explore applications of these improved technologies to working toward an integrated real time fuel quality measurement system. A system that provides real time insight into product flowing in a pipeline to see if meets the requirements of ASTM D1655 or MIL STD 91-091. D-2 started the program by completing a survey of airlines fuel quality managers to determine from their perspective the most significant “fuel quality” parameter/specifications. Next a technical analysis of how to measure these key identified parameters was performed. The final technical integration into the real time analyzer. In this talk we will review the design elements and the status of the Continuous Fuel Quality Monitoring, CFQM, system. This program is supported by both commercial entities and the US DOW.

DEMONSTRATION OF A “SMART SENSOR” FOR ON-LINE AVIATION FUEL MONITORING

Hasan Mashni*, Benedict Enderle, Uwe Bauder, Patrick Le Clercq, Georg Eckel
German Aerospace Center, Stuttgart, BW, Germany

The transition to sustainable aviation fuels would benefit from precise, real-time knowledge of fuel properties to optimize aircraft performance, reduce (non-)CO₂ impacts, and monitor safety margins. This talk presents the results from the aLIGHT measurement campaign, which investigated the feasibility of a hybrid “smart sensor” for aviation fuels that combines inexpensive bulk-property measurements (density, kinematic viscosity) with machine-learning (ML) models for the on-line estimation of complex properties such as the Net Heat of Combustion (NHOC). A modular prototype was engineered to operate safely in ATEX-qualified airport fueling infrastructure, featuring temperature-controlled measurement stages to match temperature standards of certification data. Furthermore, a software stack was developed which uses version-controlled ML models, metadata-rich MQTT communication and a real-time GUI, facilitating traceable, auditable data across the fuel supply chain. The system was deployed at Copenhagen Airport and achieved Technology Readiness Level 6 by validation under operational conditions. It demonstrated robust density and viscosity acquisition, while the ML models estimated NHOC (trained on >15k fuel samples from DLR database with a max error of ± 0.2 MJ/kg). A “smart refueling” use case showed that replacing the conservative ASTM D1655 NHOC assumption (42.8 MJ/kg) with measured values can reduce required fuel uplift by up to 1.5% per flight, translating into cumulative CO₂ savings. Furthermore, an uncertainty propagation scheme was introduced into the workflow to support informed decision making under uncertainty. The presentation will cover hardware challenges, modeling architecture, initial result, and the roadmap to a scalable, data driven approach that improves operations, enhances safety monitoring, and cuts climate impact.

AVIATION FUEL PROBLEMS AND SOLUTIONS - A NEW COMPREHENSIVE RESOURCE FOR THE AVIATION FUEL COMMUNITY

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Aviation fuel properties and characteristics are fundamental to modern aviation's safety, efficiency, and sustainability. With the rapid pace of technological and regulatory change over the past decades, an updated perspective is required that captures the extensive industry knowledge shared through IASH, CRC, ASTM, AFC, EI, JIG, and other forums. The book "Aviation Fuel Problems and Solutions" addresses this need by bringing together the collective knowledge of today's industry experts in an engaging and technically practical format. Through international collaboration, a team of professionals has contributed chapters covering the full "refinery-to-wing" supply chain: fuel specifications, refinery production, sustainable aviation fuels (SAFs), aviation gasoline, fuel additives, non-metallic material compatibility, storage and thermal stability, supply chain risk management, fuel handling equipment, filtration, sample collection, microbiology, corrosivity, laboratory research methods, and fuel system failures contributing to safety incidents. This book is intended to serve as an additional resource, emphasizing contemporary problem-solving, remediation methods, and operational insights. It aims to fill a knowledge gap for those who manage fuel-quality challenges in the field, with the goal of advancing safer, more efficient, and more sustainable aviation practices.

SESSION 1.4: POSTER SESSION

MITIGATION OF MICROBIOLOGICAL GROWTH IN HMS PRINCE OF WALES FUEL SYSTEMS VIA CMIT/MIT BIOCIDES TREATMENT

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The HMS Prince of Wales (PWLS) aircraft carrier faced significant operational challenges due to persistent microbiological growth within its F76 diesel fuel systems, requiring specialised intervention to ensure vessel readiness. To address these issues, Fuelcare facilitated the procurement and application of a high-performance CMIT/MIT fuel biocide, following coordination with BAE Systems and the Royal Navy. The treatment process involved technical

logistics, specialised dedicated dosing adapter ensure the precise and safe administration of the biocide into the fuel infrastructure. This comprehensive approach utilised the rapid-acting efficacy of the CMIT/MIT formulation to neutralize microbial contamination and safeguard the carrier's fuel integrity.

ANALYTICAL CHALLENGES AND OPPORTUNITIES IN THE CHARACTERIZATION OF PYROLYSIS OILS AND OTHER ALTERNATIVE RESOURCES

Max Jennerwein, Anne Rott, Michael Becker
ASG Analytik-Service AG

Pyrolysis oils and their intermediate and final products pose significant challenges for conventional fuel analysis. In addition to physical parameters, chemical composition is decisive, as it determines downstream processing requirements, achievable product yields, and overall economic viability. Depending on the feedstock, even large-volume raw materials may yield only small fractions of usable intermediates or require substantial additional processing costs. Even plastic-based pyrolysis oils, particularly waste plastic feedstocks, result in considerable variability. Comprehensive characterization has traditionally relied on advanced techniques such as comprehensive two-dimensional gas chromatography coupled with mass spectrometry (GCxGC-MS), which require expensive instrumentation and highly trained personnel. The introduction of standardized GC-VUV method ASTM D8519 provides a routine and quantitative approach for WPPo analysis. For common fuels like gasoline or jet fuel, the determination of the purity of chemicals and individual analysis of target components, GC-VUV has become well established in modern fuel laboratories. In the case of intermediate and final products in fuel production it enables rapid determination of hydrocarbon class composition and offers significant practical advantages over GCxGC-MS for targeted applications. However, limitations remain, particularly regarding heteroatom-containing compounds, detailed differentiation of saturated hydrocarbons, restricted substance class resolution, and the lack of flexibility for non-target screening of unknown samples. This study systematically evaluates the applicability and limitations of GC-VUV in comparison to GCxGC-MS for plastic-based pyrolysis oils, other pyrolysis feedstocks, and intermediate products from olefin oligomerization in the methanol-to-jet process within the SAFari research project.

REVOLUTIONIZING FUEL SAMPLING: THE AUTOMATED SAMPLING SYSTEM FOR VESSEL STORAGE AND LARGE UNDERGROUND TANKS

Abdullah G. Aldahlan
Saudi Aramco

The technique presents an innovative automated sampling system designed to enhance efficiency, safety, and accuracy in collecting fuel samples from vessel/ marine storage and large underground tanks. The traditional manual sampling method is labor-intensive, prone to inaccuracies, and poses significant challenges in ensuring representative samples. Our innovative system addresses these limitations by offering a fully automated process that collects samples at multiple tank levels in a single operation. The system features a controlled filling volume canister, multistage diaphragm electrohydraulic level switch, and sampling valve actuators that operate at pre-programmed levels. The automated sampling system significantly reduces time and labor requirements, minimizes human error, and ensures

consistent and accurate sampling. The design incorporates safety measures to prevent electrical ignitions in explosive atmospheres, a critical consideration in fuel storage environments. The system's flexibility allows for customization of sampling levels and sequences, adapting to different tank configurations and requirements. This technology has far-reaching implications for the fuel industry, enabling accurate sampling, efficient operation, and time savings. As the system undergoes further development and testing, its potential applications extend beyond fuel storage to other industries requiring precise liquid sampling. We believe that this innovative solution will become a standard practice in the industry, ensuring the integrity of stored substances and the safety of operations. This technology demonstrates the fuel application capabilities and benefits of the automated sampling system, making it an ideal candidate for the Chevron Research Award of Excellence in Honor of John Bacha.

ANCHORING GCXGC-DERIVED ATOM TYPE DESCRIPTORS WITH INDEPENDENT ELEMENTAL ANALYSIS FOR FUEL QSPR

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Atom-type descriptors used in fuel QSPR are commonly inferred from chromatographic characterisation devices such as GC×GC–FID. While GC×GC provides detailed compositional separation, a substantial fraction of signal often arises from unidentified or poorly resolved peaks, leading to uncertain class assignments and unreliable carbon-to-hydrogen ratios. These limitations reduce the chemical consistency of inferred atom-type descriptors and weaken their suitability as physically meaningful QSPR inputs. Here, we show that integrating GC×GC data with complementary characterisation devices and independent elemental constraints resolves these ambiguities. Independent measurements constrain bulk elemental composition and anchor GC×GC class information to physically consistent carbon balances, reducing uncertainty associated with unidentified peaks and correcting systematic bias in inferred C/H ratios. The resulting atom-type descriptor sets are internally consistent across analytical platforms and chemically defensible. This reconciled descriptor framework provides a more reliable and interpretable basis for subsequent fuel QSPR development than GC×GC inference alone. By addressing known analytical limitations at the descriptor level, the approach establishes a stronger starting point for predictive modelling and supports more defensible screening of candidate sustainable aviation fuels.

EXPERIMENTAL ASSESSMENT OF THERMAL STABILITY AND DEPOSITION SENSITIVITY OF JET A-1 AND SAF BLENDS UNDER VARIABLE JFTOT OPERATING PARAMETERS

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The progressive incorporation of sustainable aviation fuels (SAF) into commercial aviation required a detailed assessment of their thermal stability and coke formation behavior under representative fuel system conditions. This study investigates the cokefaction tendencies of standard Jet A-1, selected SAFs, and their blends using the Jet Fuel Thermal Oxidation Tester (JFTOT). In addition to the standard JFTOT operating conditions (ASTM D3241), a parametric condition matrix was implemented in order to vary fuel temperature, flow rate, pressure. This

approach enables exploration of fuel behavior and operational sensitivities under both nominal and abnormal thermal stress environments. Deposit rating, tube discoloration, and pressure drop evolution were analyzed to compare neat fuels (Jet, SAFs) and blended (various blend ratios) compositions across varying operating regimes. These results provide improved insight into SAF compatibility with current aircraft fuel system thermal constraints and contribute to the ongoing efforts to ensure safe and reliable integration of SAF into commercial aviation.

EXPERIMENTAL ASSESSMENT OF DEPOSIT FORMATION AND THERMAL STABILITY THROUGH OXIDATION PROCESSES USING TWO EXPERIMENTAL DEVICES AIMING TO EMULATE START/STOP CYCLES OF AIRCRAFT ENGINES AND OXIDATION INSIDE A CLOSED-OFF CELL.

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Deposit formation from aviation fuel thermo-oxidation is a complex phenomenon whose importance is further accentuated with the progressive incorporation of sustainable aviation fuels (SAF). Major differences are observed with different chemical compositions, as such there is a need to understand how fuels behave regarding this factor. Two experimental setups are presented. The first one aims to emulate start/stop cycles of an engine where small amounts of fuel remain near the injector and are heated up by thermal conduction through the aircraft. Fuel simply drips on a hot crucible forming deposits, this allows the determination for each fuel of mass of deposit over time. The first results highlighted the importance of aromatics on deposit formation, with an HEFA fuel doped with aromatics forming more coke than a Jet A-1. The second setup is the PetroOxy device from Anton Paar. It aims to assess oxidation stability by exposing the fuel to high quantities of oxygen in a heated, closed-off cell. Once pressure inside the cell drops by a set amount, the test stops: the duration of the test is called the induction period. A large fuel matrix from the DECARBJ French Project was tested which highlighted the differences between Jet A-1, HEFA (with and without aromatics) and their blends. Jet A-1 displays the longest induction period whereas all HEFA fuels are quick to oxidize. Once blended, induction period correlates mostly with aromatic content.

EXPERIMENTAL AND NUMERICAL ASSESSMENT OF SAF COMPOSITION EFFECTS ON SOOT EMISSIONS

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This study presents an experimental and numerical assessment of soot emissions of a diverse set of Sustainable Aviation Fuels (SAFs). The fuel matrix includes HEFA-based formulations with varying aromatic contents, an isobutanol-derived ATJ-SPK fuel, and a semi-synthetic HEFA/Jet A-1 blend, benchmarked against conventional Jet A-1. Soot emissions were quantified in a turboshaft engine using four independent diagnostics—Smoke Number, nvPM mass, nvPM number, and particle size distribution—under steady-state conditions across the full engine operating envelope. All SAFs demonstrated substantial reductions in soot emissions relative to Jet

A-1, with the strongest decreases observed at low power. HEFA produced the lowest soot levels, confirming the strong influence of aromatic content on soot formation; however, the comparable soot levels measured for ATJ-SPK and HEFA containing 8% aromatics show that aromatic content alone does not fully determine soot-formation behavior. To further investigate these effects, a numerical methodology was developed using a functional-group-based framework combined with detailed kinetic mechanisms. Comparisons among paraffins and aromatic species aligned with experimental trends. Some discrepancies across hydrocarbons of the same chemical family but with different chain lengths indicate the need for deeper kinetic mechanisms analysis. The proposed numerical approach provides a promising tool for SAF prescreening, enabling early assessment of molecular-structure-driven effects on soot and pollutant emissions.

ASSESSING LINEARITY AND PRECISION OF HYDROGEN MEASUREMENT IN JET FUELS

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Middle-distillate fuel hydrogen content underpins combustion performance, emissions modelling, and regulatory compliance. We report a comparative validation of a characterisation device for routine mass-percent hydrogen determination in jet-range fuels. The four outcomes measured and evaluated are: calibration linearity across multiple mass points using high-purity hydrocarbon standards; relaxation-dependent bias by mapping longest proton relaxation components and defining a conservative recycle-delay rule; precision via within-run repeatability (six replicates) and a three-day reproducibility design (two operators × two replicates); and a complete uncertainty budget linking observed variance to reporting limits. Each outcome is reported as a clear decision metric: pass/fail for calibration fit quality, a delay rule expressed as a multiplier of the longest relaxation component, repeatability/reproducibility estimates with variance components, and a combined expanded uncertainty for routine reporting. Deliverables are a provisional calibration protocol, quantified precision metrics, and auditable decision rules for accepting or re-running calibrations. By isolating instrument calibration and performance before matrix or orthogonal comparisons, the study will allow routine laboratories to adopt this approach with minimal additional resources. The work will provide reproducible, auditable criteria that reduce method uncertainty and support reliable hydrogen reporting across fuel classes.

FUEL PROBLEMS EXPLAINED WITH HUMOR

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Optimal care and maintenance of aviation fuels and infrastructure are crucial to ensuring passenger, personnel, and environmental safety. To increase awareness among fuel technicians, engineers, and decision-makers about safety issues related to the maintenance and handling of fuel in the field, we have produced numerous informative bulletins that will be presented as one A1 and 32 A3 poster pages at the conference. These are written in plain, simple language, making it easy to convey essential knowledge to the layperson. To make the material engaging and

memorable, the bulletins employ a humorous style supported by visually appealing graphics. Topics covered include "Apple Jelly," microbial contamination, fuel filters, static electricity, aviation fuel additives, laboratory tests, critical fuel properties, fuel contamination, and real fuel-related aircraft safety events — emphasizing how minor human mistakes, temperature fluctuations, equipment malfunctions, and unexpected system changes can have major safety implications. The bulletins have greatly increased our organization's personnel's awareness of their handling of aviation fuel, and therefore, we find it essential to share this knowledge with the global community.

PERFORMANCE AND EMISSIONS TRADE-OFFS IN SPK–SAK BLENDS AS DROP-IN ALTERNATIVES TO JET A FUEL

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The aviation industry's transition to Sustainable Aviation Fuels (SAFs) demands a deeper understanding of how different hydrocarbon classes affect gas turbine combustion behavior, including kinetics, stability, and emissions. A key research gap remains in evaluating the combustion performance of fully synthetic aviation fuels, particularly in the context of moving toward 100% SAF usage. Specifically, limited insight exists into how blends of Synthetic Paraffinic Kerosene (SPK) and Synthetic Aromatic Kerosene (SAK) perform as drop-in replacements for conventional Jet A fuel. This study examines regulated emissions (CO, CO₂, NO_x, and total unburned hydrocarbons), particulate matter (PM) number and mass, and unregulated volatile organic compounds (VOCs) across a range of fuels, including conventional jet fuels (Jet A, JP-8, JP-5), pure synthetic fuels (Alcohol-to-Jet [ATJ], Hydroprocessed Esters and Fatty Acids [HEFA], and SAK), and their blends. The findings show that highly branched isoparaffins, such as pure ATJ, enhance primary zone oxidation efficiency, nearly eliminating intermediate CO, unburned hydrocarbons, and nucleation-mode particulate matter. However, their rapid oxidation rates and high heat of combustion create localized thermal hotspots, leading to increased thermal NO_x formation. In contrast, the addition of aromatics acts as a chemical heat sink, reducing NO_x emissions but significantly increasing CO, unburned hydrocarbons, and PM mass due to the formation of polycyclic aromatic hydrocarbon (PAH) soot precursors. Additionally, pure HEFA and pure SAK fuels exhibit poor combustion stability and are prone to lean blowout at lower heat release rates. Overall, the study finds that mid- to high-level blends of SPK with SAK (8–25%) outperform conventional Jet A in terms of overall emissions. While ultra-low aromatic blends (0–4% SAK) improve carbon oxidation, they fail to meet the minimum density requirements specified by ASTM D1655. Nevertheless, these low-aromatic blends maintain stable combustion and still demonstrate performance advantages over the Jet A baseline.

INFLUENCE OF SYNTHETIC FUEL CHEMISTRY ON ELASTOMER SWELLING BEHAVIOUR IN LEGACY AND NEXT-GENERATION AVIATION SYSTEMS

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Synthetic aviation fuels offer a promising pathway to reduce particulate emissions and lifecycle CO₂ output; however, ensuring compatibility with existing aircraft fuel system materials remains critical. This study examines the swelling behaviour of four O-ring elastomers when exposed to

two types of synthesized paraffinic kerosene (SPK) fuels, each blended with varying concentrations of synthesized aromatic kerosene (SAK). The objective is to assess elastomer response as a function of fuel chemistry and aromatic content. The fuels evaluated include Alcohol-to-Jet (ATJ) and Hydroprocessed Esters and Fatty Acids (HEFA), each blended with SAK at 8%, 17%, and 25% by volume. Given that elastomer response is strongly influenced by polymer composition, the study considers nitrile, fluorosilicone, and two fluoroelastomers representative of materials used in legacy, current, and emerging aerospace fuel systems. Results from a 100-hour exposure period show that increasing aromatic content leads to higher swelling forces in O-rings, with distinct behaviour observed across different fuel–elastomer combinations. In contrast, neat SPK fuels resulted in elastomer shrinkage. Additionally, variations in the chemical composition of SPK fuels produced subtle but measurable differences in swelling behaviour, highlighting the importance of fuel formulation in material compatibility assessments.

BLIND TEST STANDARDISATION OF MOLECULAR COMPOSITION OF SYNTHETIC AVIATION TURBINE FUELS FOR ASTM D4054 PURPOSES

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EU SAF Clearing House

The EU SAF Clearing House aims to lower barriers to Sustainable Aviation Turbine Fuel (SATF) deployment by improving the consistency, availability, and reliability of ASTM D4054 Fit-for-Purpose data. A key focus is the development of standardised blind-test studies to benchmark measurement capabilities across laboratories and ensure OEMs receive reliable data. ASTM D4054 Standard Practice is an evolving, OEM-led guidance document aiming at instructing SATF producers and evaluation stakeholders on the best available practices for evaluating new SATF. In recent years, molecular composition of synthetic blending components and their SATFs has received increased prominence in OEM evaluations, due to the greater molecular diversity of these materials compared to the Jet A/A-1 experience base. This metrology challenge is addressed using multidimensional chromatography with sophisticated detectors, which provide detailed identification and quantification. However, such methods are still transitioning from the “research methods” phase toward formal standardisation through bodies such as ASTM International. This study first reviews global in-field testing capabilities, identifying significant variability within “Aviation Turbine Fuel Molecular Composition by Two-dimensional Gas Chromatography”. Using the test methodologies UDR-TR-2018-41 and FED-STD-791F as initial recommended methods, differences were observed in national standards with custom workflows, column types and dimensions, flow modulation approaches, flow rates, temperature programmes, injection volumes, detector configurations, chromatogram analysis identification templates, and calibration approaches. To assess laboratory performance, results from a Blind Test Campaign involving approximately seven international laboratories are presented. Laboratories analysed up to four blind test fuels to determine molecular composition. Findings from the coaching phase highlight key methodological factors that, if harmonised, can lead to improved consistency in determinations.

ANALYSIS OF FATTY ACID METHYL ESTER (FAME) IN AVIATION FUEL SAMPLES BY GC-MS AND GCXGC

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The standard test method for the determination of fatty acid methyl esters (FAME) in aviation fuel utilizes either a FTIR instrument (ASTM D7797) or a referee GC-MS method with selective ion monitoring (IP-585). However, issues with the FTIR method displaying erroneous results have increased the need for verification of FAME content by the GC-MS method. Currently the GC-MS method only specifies seven fatty acid methyl ester compounds of interest. However, since the methods development, new feedstocks and means of production have been used which could exhibit additional FAME compounds that would not be detected by the current GC-MS method. To address this concern, more FAME standards were added to the calibration curve to broaden the number of detectable and quantifiable FAME species using the same instrumental configuration as IP-585. In some fuels, interferences from the fuel sample matrix are still present. Alternatively, a method was also developed on a two-dimensional gas chromatography (GCxGC) to determine FAME content as an additional method for verification. The additional dimension of separation reduces analyte interferences with the fuel background. The inclusion of another instrument for analysis and additional FAME species to the standard calibration curve for both analytical analysis methods were conducted in an effort to determine whether these additions could aid in better FAME content determinations.

SESSION 2.1: MICROBIAL CONTAMINATION / MONITORING

SAMPLING FOR MICROBIOLOGICAL CONTAMINATION TESTING

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A recent study evaluated the degree of agreement for microbiological test results obtained from fuel and fuel associated water using ASTM standard test methods. I am confident that this program includes a paper discussing the study's results. Regardless of the test method's accuracy and precision, the results can be no more reliable than the sample tested. ASTM Practice D7464 details protocols for collecting and handling samples intended for microbiological testing. Most fuel system sampling focuses on the collection of representative samples. Because microbial contamination is concentrated in discrete niches within fuel systems, samples must be diagnostic rather than representative. This presentation provides insights to diagnostic sample identification, collection, and handling when the objective is to assess biodeterioration risk.

ASSESSMENT OF THE SUSCEPTIBILITY OF SEMI-SYNTHETIC JET FUEL AND SYNTHETIC BLENDING COMPONENTS (SBCS) TO MICROBIAL GROWTH

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Microbial contamination and growth in conventional jet fuels can impact fuel quality and aircraft operations. There is limited information on the potential impacts of more widespread use of semi-synthetic jet fuels on the prevalence of problems caused by microbial growth. Since semi-synthetic jet fuels and conventional jet fuels share similarities in their chemical compositions and properties, it could be assumed that susceptibility to microbial growth would also be similar. However, the proportions of chemical constituents in synthetic blending components (SBCs) are not the same, or as wide-ranging, as those found in conventional fuels. This could impact fuel properties, which in turn could influence susceptibility to microbial growth. This paper reports on an Energy Institute-sponsored literature review that was undertaken to document current knowledge, identify gaps and areas of future research in relation to the susceptibility of SBCs and semi-synthetic jet fuel to microbial growth. Fuel properties that hypothetically affect microbiological susceptibility were considered, namely hydrocarbon composition, water solubility, water separability and trace element (nutrient) composition. The processes for SBC manufacture, distribution, storage, supply and blending of semi-synthetic jet fuel were reviewed to understand how these could influence microbial growth. Existing information on the susceptibility of SBCs and semi-synthetic jet fuel to microbial growth was also assessed by review of microbiological monitoring data and published scientific studies.

MICROBIOLOGY IN BIOFUEL SYSTEMS: MICROBIAL RISK AND MANAGEMENT STRATEGIES IN BIODIESEL BLENDS

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Around the world, biodiesel is steadily replacing conventional petroleum diesel in an effort to reduce emissions and increase the use of renewable fuels. As biodiesel content in diesel fuel increases, fuel composition and storage behavior change, raising questions about the susceptibility of these blends to microbial contamination. Biodiesel is more hygroscopic than petroleum diesel, increasing water retention and creating conditions favorable for microbial growth in storage systems. This can lead to fuel degradation, filter plugging, and corrosion. Despite the widespread adoption of biodiesel blends, there remains limited comparative data on how blend ratio and increased water content influences microbial activity and treatment performance. In this study, biodiesel blends representative of globally mandated ratios were compared to neat petroleum diesel under simulated high-contamination storage conditions using laboratory microcosms. Microbial activity was monitored using adenosine triphosphate, supported by microbial community analysis using 16S rRNA gene sequencing. To evaluate microbial control, a commercial fuel biocide was applied to established mixed microbial cultures across the different blend conditions. Results showed that microbial activity increased with biodiesel content, with higher blends supporting greater microbial growth and more complex communities. Microbial

control became more challenging in highly contaminated, higher biodiesel systems, with biocide treatment performance varying by blend ratio. These observations highlight the importance of proactive biocide application to avoid severe contamination, protect fuel quality, and preserve infrastructure. Overall, the findings demonstrate that biodiesel blend ratio directly influences microbial risk and underscore the need for blend-specific monitoring and management strategies as biodiesel use continues to expand.

A RISK-BASED APPROACH TO DETERMINING MICROBIOLOGICAL TESTING INTERVALS AND APPROPRIATE REMEDIAL ACTIONS FOR AVIATION FUEL TANKS

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Microbiological growth (MBG) can develop in aircraft fuel tanks when free water is present, leading to significant operational and maintenance challenges. Formation of microbial biofilms is associated with filter blockage, malfunction of fuel quantity indication systems, and microbiologically influenced corrosion of tank surfaces. Current guidance from the International Air Transport Association (IATA) emphasises minimising free water accumulation, performing routine microbiological testing and visual inspection to identify early signs of MBG before operational impacts occur. When testing of tank drain point samples indicates MBG exceeds pre-defined IATA contamination limits, remediation is instigated, typically involving biocide treatment, with or without internal tank cleaning. These remedial actions involve considerable aircraft downtime. In practice the risk of MBG occurrence is influenced by a range of operational factors including the frequency, distance and altitude of flights, the regularity and completeness of water sumping, the environment during ground time, and physicochemical conditions within the tank. IATA recommends aircraft operators establish microbiological testing intervals based on a risk assessment of their operations along with requirements set out by airframe original equipment manufacturers. However, no standardised approach to performing MBG risk assessments exists. A risk-based system to evaluate the susceptibility for operationally significant MBG (particularly biofilm formation), based on operational factors and aircraft history could help refine appropriate testing intervals, contamination limits and remedial actions to avoid unnecessary aircraft downtime. This paper aims to review known factors influencing MBG development and assesses potential methodologies for developing a formal risk-based approach for application in aircraft fuel tank maintenance programmes.

A NOVEL RAPID LATERAL FLOW TEST FOR THE QUANTITATIVE DETECTION OF MICROBIAL CONTAMINATION IN LIQUID FUELS

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Conidia Biosciences

There is a critical need for a rapid, easy-to-use, quantitative test for microbial contamination in fuels that can be performed onsite. Traditional culture-based methods require several days to generate results, while molecular techniques demand specialist facilities, skilled personnel, and significant cost. At Conidia Biosciences, we have developed FUELSTAT One, a novel lateral flow test (LFT) that provides quantitative onsite results within 20–30 minutes. Fuelstat One detects microbial polysaccharides—complex carbohydrates produced by bacteria, filamentous fungi and

yeasts. These molecules serve structural and functional roles and are a major component of biofilms, often representing 50–90% of total biofilm mass. Their abundance makes them highly sensitive biomarkers for microbial growth and biofilm formation in fuel systems. Fuelstat One detects a broad spectrum of microorganisms, enabling rapid assessment of fuel quality for both localised testing and trend monitoring without specialist equipment. The test is based on lectins, specifically mannan-binding lectin (MBL), a pattern recognition protein from the innate immune system that binds specific carbohydrate motifs on microbial surfaces. The assay is configured similarly to a sandwich immunoassay. Gold nanoparticles conjugated to MBL bind to polysaccharides in the sample. These complexes migrate along a cellulose strip and are captured by immobilised MBL at the test line, producing a visible signal. A proprietary aqueous buffer efficiently extracts polysaccharides from fuel samples prior to analysis. Results are quantified using either a mobile phone app or a dedicated reader.

SESSION 2.2: ANALYTICAL TECHNIQUE & DEVELOPMENT

REVOLUTIONIZING FUEL SAMPLING: THE AUTOMATED SAMPLING SYSTEM FOR VESSEL STORAGE AND LARGE UNDERGROUND TANKS

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The technique presents an innovative automated sampling system designed to enhance efficiency, safety, and accuracy in collecting fuel samples from vessel/ marine storage and large underground tanks. The traditional manual sampling method is labor-intensive, prone to inaccuracies, and poses significant challenges in ensuring representative samples. Our innovative system addresses these limitations by offering a fully automated process that collects samples at multiple tank levels in a single operation. The system features a controlled filling volume canister, multistage diaphragm electrohydraulic level switch, and sampling valve actuators that operate at pre-programmed levels. The automated sampling system significantly reduces time and labor requirements, minimizes human error, and ensures consistent and accurate sampling. The design incorporates safety measures to prevent electrical ignitions in explosive atmospheres, a critical consideration in fuel storage environments. The system's flexibility allows for customization of sampling levels and sequences, adapting to different tank configurations and requirements. This technology has far-reaching implications for the fuel industry, enabling accurate sampling, efficient operation, and time savings. As the system undergoes further development and testing, its potential applications extend beyond fuel storage to other industries requiring precise liquid sampling. We believe that this innovative solution will become a standard practice in the industry, ensuring the integrity of stored substances and the safety of operations. This technology demonstrates the fuel application capabilities and benefits of the automated sampling system.

FOLLOW UP ON THE IMPACT OF SAMPLING CONTAINER ON FUEL ADDITIVE, TRACE ORGANIC, AND TRACE METALS CONCENTRATIONS DURING SHIPPING AND STORAGE

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University of Dayton Research Institute

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Subsampling and shipping fuel to analytical laboratories is essential for fleet logistics and compositional database development. While epoxy-lined steel cans effectively preserve fuel integrity, they are often impractical for small-volume samples (<100 mL). In contrast, glass and plastic containers can compromise sample quality. AFRL and NAVAIR have observed both the loss of additives and the introduction of unexpected contaminants such as polar, olefinic, or metal species depending on container type and storage conditions. Without a clear understanding of these chemical shifts, agencies cannot ensure that test results accurately represent the original fuel. This uncertainty ultimately delays critical decisions on fuel suitability. This work presents recent test results and recommends specific containers optimized for small-volume shipping and chemical characterization.

THE USE OF GCXGC FOR THE ANALYSIS OF MODERN SYNTHETIC FUELS: APPLICATIONS AND LIMITATIONS

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Since its introduction in the 1980s, the main application of GCxGC has been the analysis of (fossil) liquid energy matrices. Over the years, the technique has also been adopted as an official method, as described, for example, in ASTM 8623 and FED-STD-791D, or in company-specific methods such as UOP 990 and UDR-TR-2018-40. With the transition from liquid (fossil) energy sources to synthetic ones, methodological advances in GCxGC have gained momentum once again. Even though these new liquid synthetic energy matrices are still based on hydrocarbons, the potential implications for their safe use are not sufficiently predictable. Detailed knowledge of the composition is of great value here, if not essential. This is reflected throughout the chain, from initial laboratory testing to approval as ASTM-compliant jet fuel. GCxGC is a crucial tool in this regard. However, conventional methods established for fossil energy matrices are not sufficient for this purpose, or at least must take the new requirements into account. In this presentation, we will outline the current state of the art in terms of instruments and methods used in analytics and show the link to important applications such as prescreening and kinetic modeling. In addition, we will show that simple group separation is no longer sufficient, especially for synthetic energy matrices.

CHARACTERIZING SUSTAINABLE AVIATION FUELS: ANALYTICAL CHALLENGES AND OPPORTUNITIES USING GC×GC VUV

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The rapid diversification of feedstocks and fuels presents significant challenges for analytical techniques and standardization in fuel science and technology. Ensuring compliance with regulatory specifications and customer requirements while remaining within the limits of technically feasible conventional methods represents a critical balancing act. This situation necessitates the development, validation, and standardization of new analytical approaches, including interlaboratory testing to ensure accuracy and reproducibility. Such efforts demand substantial investments in time, personnel, instrumentation, and financial resources from contract laboratories, research institutions, and industry, and require interdisciplinary collaboration among stakeholders with differing priorities. Comprehensive two-dimensional gas chromatography (GC×GC), coupled with detection systems such as MS or FID, has become a well-established and versatile tool for resolving complex analytical questions. More recently, vacuum ultraviolet (VUV) detection has emerged as a promising technique that can be combined with GC×GC. When coupled to conventional one-dimensional GC, VUV detection is already routinely applied in fuel analysis, enabling rapid and accurate determination of parameters such as aromatic content and PIONA composition, as well as detailed characterization of complex matrices including pyrolysis oils. In contrast to mass spectrometric detection, VUV spectroscopy allows differentiation between compound classes that may exhibit similar fragmentation patterns, thereby offering additional structural insight. The growing importance of sustainable aviation fuels (SAF), characterized by highly variable compositions, further underscores the need for advanced analytical methodologies. Systematic evaluation of GC×GC combined with different detection techniques is therefore essential to assess their respective strengths, limitations, and overall analytical value for comprehensive fuel characterization.

DIESEL FUEL COLD FILTER BLOCKING

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In the UK from 2011 there was a notable increase in vehicle breakdowns in cold weather, typically when the ambient temperature dropped below 5 °C. A previous IASH paper in 2017 discussed the issues and introduced a new Energy Institute test method, IP 618 Determination of Cold Filter Blocking Tendency (CFBT) which was a modern development of IP 387 / ASTM D2068 Determination of Filter Blocking Tendency. Since then, more information became available leading to a final report by BSI PTI/2. This new report is referenced in the UK national annex for BS EN 590, the UK road diesel specification. This paper presents the key findings.

UPDATES REGARDING A PORTABLE PROBE-BASED ASTM D8148 SYSTEM FOR RATING FUELS CLEANLINESS, CLARITY, AND HAZINESS

Ranzy Morgan

Choice Analytical, Inc.

Ensuring that the end user receives clean “Clear and Bright” fuel has been a focus for a long time with the global refining, transporters, automakers, and engine manufacturers searching for a way to precisely and analytically, determine a fuels cleanliness and fir for use. With modern high performing engines and more new fuels than ever entering the marketplace, the industry is becoming increasingly concerned about fuel cleanliness and clarity. Over the decades, engine manufacturers, fuel producers and distributors, worked within ASTM to establish guidance for fuel haziness and clarity. Because of the variability and subjectivity found with the current visible methods such as D4176, the industry has been supporting efforts towards a more analytical approach to haze and clarity rating and improving the options available to determine if a given fuel meets the “Clear and Bright” requirements. Addressing this need, the optics based, ASTM D8148 offers a much more precise, objective analytical technique to assist these ratings and determinations. This presentation will introduce the Portable Probe based ASTM D8148 instrument, explaining Haze Clarity index as an instrumental objective technique which eliminates the subjectivity of the visual haze methods and update the group on the latest activities within ASTM.

AROMATICS AND SIMULATED DISTILLATION OF JET FUEL BY THE NEWLY REVISED GCVUV ASTM D8267

Dan Wispinski

VUV Analytics

ASTM D8267 GCVUV has rapidly emerged as a high-precision, multi-functional method for jet fuel aromatics and diaromatics analysis, now approved across major commercial, military, and international specifications. Recent ASTM D02.04 multi-method studies confirmed strong agreement with the referee method ASTM D1319, expanded precision ranges, and validated D8267’s capability for low-level aromatics quantification relevant to ASTM D7566 SAF annex limits. Scope revisions extend diaromatics coverage above 3% V/V and support total aromatics measurement at the 0.5% m/m threshold. Beyond compliance testing, D8267 enables detailed aromatic speciation—including regulated compounds such as cumene—and integrates simulated distillation using VUV retention-index calibration with excellent interlaboratory reproducibility. With fast run time, automated validation, and superior proficiency-testing performance, D8267 provides a unified platform for routine jet fuel certification, SAF process monitoring, and advanced compositional characterization. Its expanding acceptance positions it as a key analytical tool for modern aviation fuel quality assurance.

SELECTIVE EXTRACTION AND GC×GC-TOFMS SPECIATION OF SULFUR-CONTAINING COMPOUNDS IN JET FUEL

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The presence of sulfur-containing compounds (SCC's) present in jet fuel are known to adversely affect thermal stability, yet the roles of specific sulfur species and classes remain insufficiently understood. Improved identification and differentiation of these species, and their role in jet fuel performance, are therefore of significant interest. This work describes a solid phase extraction-based methodology employing silver modified silica to preferentially extract and fractionate SCC's into relevant classes. Isolated SCC's are analyzed via two-dimensional gas chromatography and time-of-flight mass spectrometry (GC×GC-TOFMS) to enhance sulfur speciation within complex fuel matrices. The resulting speciation data are used to investigate relationships between sulfur compound classes and observed thermal stability behavior.

GCXGC RETENTION TIME STUDIES: ADVANCING CHROMATOGRAPHIC INFORMATION CONTENT

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Comprehensive multidimensional gas chromatography (GC×GC) has become the premier tool for characterizing bulk and trace organic species in fuels due to its ability to independently detect thousands of individual species in a mixture. Analytes are separated in time and space by differential migration along two independent GC columns with differing stationary phase selectivity. Two-dimensional retention templates are developed by analyzing standards/fuels with mass spectrometry to map out class and carbon number regions. The elution order and qualitative shape of retention regions is dictated by the absorptive selectivity of the first- and second-dimension stationary phases. Each phase possesses unique non-bonding interaction sites that impart a certain affinity (partition coefficient) for analyte molecules based on their size, shape, and chemical functional groups. Linear solvation energy relationships (LSERs) are the prevailing approach for quantifying contributions of each type of non-bonding interaction to each analyte-stationary phase partition coefficient (e.g. van der Waals forces, polarizability, dipole-dipole, H-bond donation, and H-bond acceptance). The column dimensions, stationary phase thicknesses, carrier gas flow rate(s), and temperature program(s) superimpose scaling factors on the elution pattern to dictate the specific 2D location of each vertex in the retention template. Here we present an on-going effort to use LSERs to quantitatively relate GC×GC retention patterns to analyte molecular structure. A valuable capability enabled by this work will be chemically informed retention alignment algorithms. This relationship should also enable researchers to infer specific molecular information from chromatographic retention patterns (i.e. branching patterns of iso-alkanes).

UNDERSTANDING THE CHEMICAL BEHAVIOR OF FUEL SYSTEM ICING INHIBITOR (FSII) DEGRADATION USING NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY (NMR)

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This presentation will show ongoing efforts focused on understanding recent filter plugging events in which off specification fuel system icing inhibitor (FSII) additive, diethylene glycol monomethyl ether, was indicated as a potential cause. Initially, using multidimension gas chromatography (GCxGC) and high-resolution mass spectrometry (HRMS) we saw evidence of FSII polymerization and water inclusion. To gain more insight into the chemical behavior of FSII, a combination of one-dimensional nuclear magnetic resonance spectroscopy (¹HNMR, ¹³CNMR) and two-dimensional nuclear magnetic resonance spectroscopy (COSY, HSQC and DOSY) techniques were deployed. ¹HNMR spectra were used to initially understand the role water plays in the formation of potential water-FSII clusters while ¹³CNMR was used to monitor any changes to the FSII backbone. COSY and HSQC validated the water peak was not related directly to the formation of a new FSII-like compound while the DOSY experiments demonstrated the water peak having an uncharacteristic FSII like diffusion pattern. The results discussed in this investigation highlights how a range of NMR techniques can be used to explore fuel additive changes and correlate potential failure events back to structural changes.

SESSION 2.3: FUEL PRODUCTION - COPROCESSING

PRETREATMENT OF TYRE PYROLYSIS OIL TO ENHANCE PRODUCTION OF SUSTAINABLE AVIATION FUEL

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Wastefront is developing various methods to pretreat Tyre Pyrolysis Oil (TPO) downstream of the pyrolysis unit to make the material a better feedstock for co-feeding to a refinery, specifically ways to enhance the production of Sustainable Aviation Fuel (SAF). Currently most TPO used within refineries enters the refinery via the Fluid Catalytic Cracking Unit (FCCU) and consequently makes a limited contribution to the SAF pool. The objective of the treatments under development is to optimize the TPO as a component (up to 5%) of a blended feedstock for a Diesel Hydrotreater (DHT) in a complex refinery. This is done by addressing known issues for the DHT such as diolefins, nitrogen compounds and metals, as well as TAN and boiling range. Wastefront's development process includes hydroprocessing blends of the candidate pretreated TPO (using Wastefront proprietary methods), with a surrogate "complex refinery DHT feed". The hydroprocessing test is to demonstrate that the kerosene cut of such hydroprocessed material is within the requirements of ASTM D1655, that the conversion of pretreated TPO to SAF is higher

than the yield without such treatments and that catalysts are not adversely impacted. The results thus far have demonstrated at least two methods to produce a material which has a TAN below 0.5, a nitrogen content below 0.3%, a significant reduction in gum formers (diolefins) and a significant reduction in the common metals.

APPLICATION OF RADIOCARBON TESTING IN BIO-CARBON CONTENT DETERMINATION OF MUNICIPAL SOLID WASTE FUEL: FUTURE POTENTIAL OF WASTE TIRE PYROLYSIS OIL AS SUSTAINABLE AVIATION FUEL (SAF)

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SINOPEC Research Institute of Petroleum Processing

In-depth insight into the distribution and hydrocarbons composition on Bio-carbon content in waste is crucial for effectively converting waste into valuable resources. However, the high-value conversion of municipal solid waste represented by waste tires into sustainable carbon-based liquid aviation fuels has not yet received sufficient analysis research attention. In this study, Industrial-grade waste tire pyrolysis oil (WTPO) in China with a Bio-carbon content of 72% was distilled according to the boiling range. The Bio-carbon content of four fractions of WTPO (Gasoline, kerosene, diesel, heavy oil) were 78%, 80%, 76%, and 62%, respectively. Notably, monocyclic aromatic hydrocarbons accounts for 98 % of the total aromatic hydrocarbons in the WTPO aviation kerosene fraction, while naphthalene constitutes merely 1 %. Owing to its high calorific value and favorable combustion characteristics, WTPO can be employed as an alternative feedstock for sustainable fuels in aircraft engines. Further, combining heteroatom removal and olefin hydrogenation, this fraction presents great potential as a blending component of aromatics and naphthenes for SAF.

THE EVOLVING LANDSCAPE OF CO-PROCESSING IN FUEL PRODUCTION

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ExxonMobil

As the global demand for energy continues to increase along with increased demand for reduction in carbon emissions and increasing circularity of petroleum-based products, producers will innovate to increase flexibility in fuel production. Co-processing alternative feedstocks with petroleum feedstocks in refineries has long been acknowledged as a reliable pathway to introduce bio-based feeds and allow recycling of difficult products. An overview of some potential alternative feedstocks and comparisons to petroleum feedstocks will be covered. Data from refineries and pilot plants co-processing of a variety of feedstocks to produce different fuel products including aviation turbine fuel, gasoline, and diesel is presented. These examples will highlight the newest technological advances in co-processing and cover which pathways are allowed today and which ones are currently being implemented.

SESSION 3.1: ROAD FUELS

FROM DIESEL TO METHANOL: REDEFINING LUBRICITY MEASUREMENT FOR FUTURE MARINE FUELS

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The transition from conventional marine diesel to methanol demands a fundamental rethink of established lubricity assessment protocols. The widely used diesel-based HFRR method is technically unsuited to methanol's unique physical and chemical properties: its high volatility, low viscosity, strong water affinity, and susceptibility to temperature-driven artefacts all cause instability under the standard 60 °C, 2.5 mL test conditions. To address this, an adapted HFRR methodology has been developed, employing a substantially larger test volume (15 mL) and a reduced, isothermal test temperature of 25 °C to suppress evaporative losses and maintain boundary-lubrication relevance. Engineering the test environment required stringent controls to mitigate methanol's flammability and toxicity, including redesigned containment, enhanced ventilation interfaces, and real-time temperature stabilisation. Early ruggedness evaluation has been completed, with an international ILS programme now underway with multiple volunteer laboratories. Experimental studies using the new protocol highlight the principal factors governing methanol lubricity. Methanol purity also emerges as critical, with even small variations in water content significantly altering wear behaviour. However, the wear scar diameter generated by the HFRR—long treated as a meaningful correlator for diesel pump wear—currently lacks proven relevance for methanol-fuelled engine hardware. The diesel correlation originated from Bosch rotary pump studies; an equivalent validation programme is required to translate laboratory wear metrics into real-world component durability predictions. Establishing this correlation will be central to defining fit-for-purpose lubricity specifications for future methanol marine fuels.

THE POTENTIAL OF CONSTANT VOLUME COMBUSTION CHAMBER (CVCC) INSTRUMENTS FOR RATING THE RESEARCH AND MOTOR OCTANE NUMBER OF GASOLINE

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Constant Volume Combustion Chamber (CVCC) instruments are essentially piston-less simulators of diesel engine combustion systems. Fuel is injected into an electrically heated combustion chamber charged with compressed air and ignition delay times are measured. CVCC instrument test methods fall under the jurisdiction of the ASTM Combustion Test Methods subcommittee D02.01 (along with cetane and octane engines) and are referenced test methods in ASTM fuel specifications for rating the cetane number of diesel fuel (ASTM D975) and Synthetic Aviation Turbine Fuels (SATF)(ASTM D4054). This paper examines the potential for CVCC instruments to be adapted to rate the anti-knock performance of gasoline, as is normally quantified by the research and motor octane number ratings. The fundamental links and differences between diesel engine spray autoignition (termed “ignition delay”) and spark ignition engine end gas autoignition (termed “knock”) are discussed. The paper examines differences in the combustion environment of a CVCC instrument combustion chamber and the cylinder of the CFR F1 and F2 octane engines (the apparatus

required for ASTM Research Octane Number (RON, D2699) and Motor Octane Number (MON, D2700) ratings). Existing published research in which the CFR Ignition Quality Tester CVCC instrument (the IQT, ASTM D6890) has been used to predict the octane number of gasoline is discussed, and previously unpublished octane research by CFR Engines using the IQT is presented. The paper summarizes the potential and challenges for CVCC instruments to rate gasoline anti-knock performance correlated to RON conditions, MON conditions and conditions in modern automotive engines.

SYNTHETIC AVIATION TURBINE FUEL – ACCURATE PREDICTION AT LOW (BELOW 35) INDICATED CETANE NUMBERS (ICN) TO AVOID LEAN BLOW OUT (LBO)

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At the 2024 Louisville IASH conference, a comparison was made between combustion characteristics Indicated Cetane Number and Derived Cetane Number (DCN), which showed that low cetane values (below 35) were less well correlated between ICN and DCN¹. ICN and DCN are alternatives to Cetane Number (CN). Later ASTM D4054² included ICN, as a predictor for Lean Blow Out (LBO), from 35 to 60. LBO is an undesirable condition in a gas turbine where the fuel-air ratio reduces to such an extent that the flame extinguishes. Too low cetane number, with a corresponding long ignition delay, due to the fuel, can cause this condition. Whilst this is not a concern for AVTUR made from conventional sources, testing showed that Synthetic Blend Components, manufactured in accordance with ASTM D7566, may have significantly low ICN, which might limit blend percentage below 50%. This paper discusses the available data and the low end calibration of ICN, its relevance and relationship with CN (cetane number) and aims to further explain the correlation between ICN and DCN at low cetane values.

CRC PROJECT CM-137-21: ALTERNATIVE TO TETRAETHYL LEAD FOR RATING OCTANE NUMBERS GREATER THAN 100

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Coordinating Research Council

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One of the primary properties used to characterize spark-ignition fuels is the octane number. The research octane number (RON, ASTM D2699) and the motor octane number (MON, ASTM D2700) are industry accepted methods for determining the octane number of on-road gasoline. MON testing by ASTM D2700 is also used to characterize aviation gasoline. Both ASTM D2699 and D2700 require tetraethyl lead (TEL) blends with isooctane as reference fuels to rate gasolines with octane number greater than 100. Due to restrictions on handling lead, there is interest in developing an alternative to TEL blends for rating gasolines with octane number greater than 100. A joint project has been developed between the Coordinating Research Council (CRC) Performance Committee, CRC Aviation Committee, and ASTM Subcommittee D02.1 Combustion to investigate alternative compounds for high octane reference fuel blends for RON and MON testing. A literature study identified four candidate

compounds: m-toluidine, pseudocumene, mesitylene, and ethyl acetate. Laboratory screening tests for material compatibility, low temperature storage stability, and a single-lab octane study were conducted. Following consultation with the aviation community, t-butyl aniline was added as a fifth candidate. Results from these laboratory screening tests will be discussed. Blends of t-butyl aniline and iso-octane have been selected to undergo a multi-laboratory octane study to confirm blending rates and ratings. A long-term storage stability test is also being conducted.

PERFORMANCE EVALUATION OF ADDITIVATED HVO BLENDS UNDER FIELD-RELEVANT CONDITIONS

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Hydrotreated vegetable oil (HVO) is increasingly considered a drop-in alternative for compression-ignition engines due to its favorable combustion characteristics and potential to significantly reduce lifecycle CO₂ emissions compared with conventional B7 diesel (mineral diesel containing 7 % FAME). Depending on feedstock and production pathway, well-to-wheels CO₂ emissions can be reduced by up to about 90 % relative to fossil diesel [1], supporting its role in transport decarbonization. Despite these advantages, uncertainties remain regarding oxidative and storage stability, deposit formation, material compatibility, and tribological behavior under real-world conditions. In this study, a fully additivated HVO blend was evaluated against a representative B7 diesel under field-relevant conditions. The test program combined oxidation stability testing (ASTM D2272 RPVOT), elastomer exposure trials, and tribological measurements assessing friction and wear under loaded sliding conditions. Deposit formation during oxidation and tribological testing was also analyzed. The HVO blend showed significantly improved oxidation stability, with longer induction times and reduced formation of high-molecular-weight oxidation products compared with B7. Elastomer compatibility tests revealed no adverse material interactions within the examined exposure period. Tribological results indicated friction and wear performance comparable to the conventional fuel. Furthermore, reduced deposit formation was observed on sliding surfaces when using HVO. Overall, the results indicate that properly additivated HVO blends can match or exceed conventional diesel performance in key fuel life-cycle attributes. The study highlights the importance of integrated analytical and application-oriented testing to evaluate alternative fuels under service-relevant conditions.

SESSION 3.2: ADDITIVES

TOWARDS 100% SUSTAINABLE FORMULATIONS: INVESTIGATING THE TECHNICAL VIABILITY OF BIO-BASED ADDITIVES FOR RENEWABLE FUELS

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As the global energy sector pivots toward decarbonization, the development of renewable fuels has reached significant milestones. As fuels increasingly incorporate components

derived from renewable sources, a new challenge emerges: ensuring that all constituents of these formulations, including additives, align with the same sustainability objectives. Antioxidants, detergents, corrosion inhibitors, and other fuel additives are essential to preserving fuel quality, preventing degradation, and safeguarding engine durability throughout storage and use. Despite progress in producing renewable fuels, most commercially available additives remain synthesized from conventional feedstocks. While additives are typically used at very low treat rates, their origin and composition remain relevant when considering the overall consistency of sustainable fuel strategies, motivating the evaluation of renewable-origin alternatives with comparable performance. In this context, the present work conducts a prospective assessment of the landscape of renewable-origin fuel additives, aiming to determine their technological readiness and potential integration into future sustainable formulations. A comprehensive mapping of the state of the art has been performed across major additive families, evaluating their functionality, availability, and practical suitability for incorporation in fuel formulations. Building on this survey, the first validation tests have been conducted on selected sustainable antioxidant candidates, comparing their effectiveness against commercial non-renewable alternatives. These initial results provide insight into the feasibility of incorporating renewable-origin additives into fuel formulations and highlight both opportunities and remaining challenges associated with achieving fully sustainable additive packages.

NON-NITROGEN H₂S SCAVENGER

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Conventional hydrogen sulfide (H₂S) scavengers used in fuel treatment commonly rely on nitrogen-based chemistries, which can increase total nitrogen content and introduce secondary challenges related to deposits, corrosion, odors, and wastewater impact. Triazine-based scavengers, while widely adopted due to their effectiveness and low cost, generate amine byproducts that may negatively affect downstream performance. As a result, there is growing industry interest in alternatives that mitigate H₂S without contributing nitrogen-related instability. This study evaluates the performance of a non-nitrogen H₂S scavenger and its impact on finished fuel quality and handling. Laboratory and field testing demonstrate that the non-nitrogen scavenger effectively neutralizes H₂S through an irreversible reaction mechanism without increasing nitrogen content in the fuel matrix. The non-nitrogen scavenger is non-corrosive, odorless, free of solids formation, and exhibits excellent cold flow properties while achieving comparable or improved dosage efficiency relative to traditional triazine treatments. Overall, the results demonstrate that non-nitrogen scavenger technology provides refiners, blenders, and terminal operators with an effective alternative to conventional nitrogen-based scavengers, enabling improved fuel handling reliability while maintaining specification compliance.

INNOVATIVE COLD FLOW ADDITIVE SOLUTIONS FOR RELIABLE RENEWABLE DIESEL TRANSPORT

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The global transition toward lower carbon energy has accelerated the demand for renewable diesel (RD), a hydrotreating derived, paraffinic drop in replacement for petroleum diesel. RD delivers substantial lifecycle greenhouse gas (GHG) reductions—typically 60–80% depending on feedstock—while meeting ASTM D975 specifications. Although conventional diesel additives can address certain fuel quality attributes, RD presents unique challenges that extend beyond the capabilities of traditional petroleum based additive technologies. Its narrow carbon number distribution and high normal paraffin content led to rapid crystallization at low temperatures, forming large wax structures that restrict flow, clog filters, and hinder winter pipeline transport. Traditional cold flow improvers (CFIs), formulated for fossil diesel wax chemistries, show limited effectiveness in RD due to its distinct molecular composition. This paper outlines a systematic additive development program designed to address these challenges through chemistries tailored specifically for RD. Detailed paraffin profiling across multiple RD sources confirmed a dominant C16–C18 hydrocarbon range, reinforcing the need for specialized wax crystal modification strategies. The resulting effort led to the development and validation of a novel cold flow additive engineered for RD’s unique paraffinic structure. A refinery case study further demonstrated the additive’s commercial impact: during winter operations, the RD producer was unable to achieve the required pipeline pour point of below –15°F, resulting in transport constraints. Full scale implementation of the new chemistry successfully restored winter operability, preventing costly delays and generating several million dollars in value while advancing ESG objectives. Overall, the study confirms that purpose built additive technologies can effectively overcome RD’s intrinsic cold flow limitations and enable reliable integration into existing fuel distribution systems.

SESSION 3.3: ANALYTICAL TECHNIQUE: MATERIALS COMPATIBILITY

MATERIAL COMPATIBILITY EVALUATION: REASSESSING ASTM D4054 TESTS AND REFERENCE FUEL REQUIREMENTS

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Material compatibility investigation is required by ASTM D4054 to evaluate synthetic blending components (SBCs) and have been performed for all eight SBCs production pathways currently listed in ASTM D7566 Annexes. However, data analysis reveals that (1) some SBCs and their blends with conventional jet fuel do not meet the requirements listed in ASTM D4054 evaluation criteria for certain non-metallic materials, even though these production pathways have been approved and listed in D7566; and (2) the current D4054 material compatibility test methods and evaluation criteria were established based on studies conducted in the 1990s using JP-8, a military jet fuel containing 20-25% aromatics, which restricts test performance by non-NATO research institutions and regulatory bodies. Although ASTM D4054 provides an alternative formula to

prepare a surrogate Jet Reference Fuel (JRF), this formula—particularly the specifications for sulfur, mercaptan, and additive content—is based on an outdated version of AMS 2696 and is inconsistent with the current version. Furthermore, experimental validation of the prescribed JRF formulation remains limited in the literature. This study systematically compiled material compatibility data from qualification reports of SBC production pathways listed in ASTM D7566. Eleven non-metallic materials representing multiple categories (adhesives, coatings, gasket O-rings, sealants, and Kapton film) were selected based on documented non-conformance with specific evaluation criteria in previous ASTM research reports. Comparative compatibility testing was performed using JP-8, surrogate fuels formulated according to AMS 2696 and ASTM D4054, RP-3, and HEFA blends. The primary objective is to assess the viability of alternative civil aviation fuels—including RP-3, Jet A, and Jet A-1—as reference fuels for material compatibility evaluation, thereby establishing a more globally accessible and scientifically robust testing framework for sustainable aviation fuel qualification.

MEASUREMENTS AND PREDICTIONS FOR NITRILE RUBBER O-RING COMPATIBILITY WITH JET FUEL HYDROCARBONS

Conor Faulhaber, Kaamel Sidiqi, Randall Boehm, Joshua Heyne
Washington State University

As part of the commercial aviation sector's effort to decarbonize operations by 2050, the industry is leaning heavily on the potential of sustainable aviation fuel (SAF) as a 'drop-in' solution to reduce the greenhouse gas emissions within the current operational fleet. One area of jet fuel specifications that has demonstrated sensitivity to the compositional differences between SAF and conventional fossil-derived jet fuel is material compatibility with nitrile rubber o-rings used in fuel systems. Here, fuel-polymer interactions for nitrile rubber are investigated using optical dilatometry, an established method for measuring the volume swell of o-ring materials in solvent baths. Building on previous research, a volume swell database of over 80 neat jet-range hydrocarbons is compiled and used to assess the effects of molecular weight, structural family, and isomerism on nitrile o-ring compatibility. Simple blends of selected species are also measured to establish a blending rule applicable from 0 – 100% volume fraction for nitrile o-ring swelling, and all results are presented within the context of conventional fuel and SAF volume swell measurements to demonstrate the relative impact on real fuel systems. Additionally, empirical modeling techniques are leveraged with this dataset to evaluate current predictive capabilities alongside past efforts to characterize seal swell, including Hansen Solubility Parameters and Flory-Huggins Equilibrium. The outcomes of this work provides a basis for understanding nitrile rubber compatibility as a potential limiting property for SAF deployment scenarios, particularly as it concerns the role of fuel aromatic content towards sooting impacts.

SESSION 3.4: OPTIMIZATION / MODELING

FUEL DESIGN FOR SUSTAINABLE AVIATION FUELS: CONCEPTS, METHODOLOGIES, AND APPLICATION EXAMPLES

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With the steadily increasing emergence of novel sustainable fuel production pathways and an increasing understanding of composition-property relationships, the term “fuel design” is being used more frequently to describe the targeted modification of the fuel. However, the term fuel design is used in many different connotations and for many different scopes. From systematic development in fuel prescreening, technical fuel assessment and optimization, we derived a structured concept for “fuel design”. First, the level of detail has to be described, i.e. whether the fuel composition is altered via blending, through changes at the level of hydrocarbon-family, carbon number or even isomer level. Second, the composition manipulation can be done purely numerically or using experimental approaches. Both approaches can be done through different levels of detail, ranging from purely academic up to real world experiments. Third, system boundaries for the optimization in the fuel design process are important to be clearly defined. As a final point, but very important from the beginning, the figure of merits, i.e. the targets of the fuel design effort have to be clearly described. The usual FOM are subsets of the SAF tension field of safety, production and environmental impact. This paper aims at systematically defining the term fuel design as the knowledge-based, i.e. model- and experimental assisted process of intentionally altering the composition of aviation fuels to achieve specific performance targets, desired physical and chemical properties, cost efficiency, and reduced climate impacts. The proposed definition of the methodology includes different compositional modification levels, numerical and experimental modification methods, and optimization approaches involving fuel production, combustion systems, emissions, and economic factors. Selected application examples illustrate the relevance and real-world implications of systematic fuel design methodologies.

ANALYSIS OF 100% SYNTHETIC AVIATION TURBINE FUEL COMPOSITIONAL SOLUTION SPACE SENSITIVITY TO PROPOSED PROPERTY CONSTRAINTS

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Washington State University

In 2022 the United States set a goal to have a 65% net reduction of carbon emissions in the aviation sector alongside a goal from 2021 to have 3 billion gallons of domestically produced synthetic aviation turbine fuel (SATF). Current production produces SATF that must be blended, increasing handling complexity and cost, and hindering production and adoption. The next step towards meeting these goals efficiently is the publication of constraints that define 100% SATF. This work leverages a database of over 700 individual hydrocarbons with corresponding properties used in Tier α screening to generate SATF mixtures that meet the proposed 100% SATF constraints. Mixture properties are determined using blending rules published and reviewed in the literature. A multi-variate solver that efficiently solves non-linear and discontinuous problems varies the relative volume percentages of each molecule in the mixture. The solver can optimize mixture properties for a specific purpose, determine which mixtures are feasible, and generate pareto front plots. These plots are used to explore the sensitivity of the 100% SATF solution space to specific proposed constraints. The impact of additional or tightened proposed constraints when compared with the current constraints on SATF and conventional fuel blends defined by D7566 Table 1 is also explored. Ties are then drawn between the proposed constraints and the possible effects on meeting the emissions reduction and SATF production goals. This is further illustrated by comparing the solution spaces generated by down selected databases that are representative of approved

SATF production pathways described in D7566.

WORLD JET FUEL SURVEY MODELING: DEVELOPMENT, USE, AND IMPLICATIONS

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The recently published World Jet Fuel Survey (CRC Report AV-33-22) provides a robust set of technical data of current aviation turbine fuels. The primary objective of this project was to report fit-for-purpose property information of existing jet fuels, with the goal of assisting with the qualification of new synthetic aviation turbine fuels (SATF). A corollary objective that emerged was to demonstrate how compositions impact fuel properties. To that end, composition-to-property (C2P) models were trained for 19 properties. The main composition methods used to train the models were hydrocarbon-type analysis (UDRI FCM-101) and trace polars analysis (UDRI FCM-102). This talk provides deeper insight into the modeling done for the World Jet Fuel Survey. Development and application of the models will be covered in detail, including topics such as data scaling, k-fold cross validation, and partial least squares (PLS) regression. For properties with good model error metrics, model coefficients will be discussed for the insight they provide into fuel chemistry. For property models with poor error metrics, models will be used to guide potential future method development. Additional concepts, such as property-to-property (P2P) models will also be addressed.

CONVENTIONAL AND SYNTHETIC JET FUEL PROPERTIES AT ENGINE RELEVANT CONDITIONS

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To accelerate approval and potentially expand the allowable property range for sustainable aviation fuels, we are using high performance computing simulations to reveal fuel property effects on aviation combustor performance. These simulations are supported by fuel property measurements over temperatures and pressures that the fuel experiences in an aircraft engine and by validated chemical kinetics models for SAF combustion. GCxGC analysis of over 16 conventional fuels and SAF, including density, viscosity, and surface tension results from -30°C to 200°C (-40°C for viscosity) and 1 atm to 70 atm including an assessment of method repeatability. Distillation, ICN, LHV, flashpoint, Cp and other properties are also reported. The utility of a group contribution model for predicting properties from the GCxGC data is described. 250 words max.

SESSION 3.5: OPTIMIZATION / PERFORMANCE

IMPACT OF THE COMPOSITION OF SUSTAINABLE AVIATION FUELS ON COMBUSTION INSTABILITIES

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Recent experiments indicate that the dynamical behavior of a combustion system is sensitive to the fuel composition. One may then wonder whether the integration of SAFs with varying compositions into aeroengine combustors might have an impact on the system operability and influence its combustion dynamics, possibly raising instability issues. To examine these questions, experiments are carried out in a single-sector spray-swirled combustor with four fuels: AtJ and HEFA, representative of mature SAF pathways; CHJ, chemically closer to Jet A-1; and a reference iso-dodecane. These fuels differ in their composition distribution and distillation behavior, yet previous measurements showed similar velocity and droplet size profiles. Flame Describing Function (FDF), linking heat release rate and velocity perturbations, are used to characterize the flame dynamical response over a range of frequencies and amplitudes. FDFs of dodecane and AtJ are nearly identical, whereas those of HEFA and CHJ feature a lower gain and phase slope. Phase-locked OH* imaging confirms this grouping and provides clues on its origin. Dodecane and AtJ exhibit spatially localized heat release at the flame tip, whereas HEFA and CHJ display an axially distributed heat release rate, consistent with their broader distillation curves. The setup is then used to examine self-sustained oscillations and observe variations in instability frequencies and amplitudes. Using a recent framework combining FDFs and dynamical equations, it is found that these characteristics are consistent with flame response measurements and that this model can be used with some confidence to predict instability. This also highlights the importance of considering the impact of the fuel distillation properties on flame stability when integrating SAFs into aeroengine combustors.

EXPERIMENTAL CHARACTERIZATION OF AIRCRAFT PROPULSION PERFORMANCE AND EMISSIONS FOR DIFFERENT BLENDS OF JP-8 AND HEFA-SPK FUELS

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Large-scale decarbonization of the aerospace sector represents a major challenge due to the strict weight and volume constraints inherent to aircraft systems. Sustainable Aviation Fuels (SAF), owing to their high energy density, are currently regarded as a key lever to achieving the net CO₂ emission reduction targets established for aviation. Unlike alternative energy carriers such as hydrogen or battery-based systems, SAF can be used as drop-in replacement for conventional aviation fuels without requiring substantial modifications to aircraft or airport infrastructure. Although HEFA-SPK is a certified drop-in fuel, understanding its blending effects on engine operability and emissions requires dedicated experimental assessment. Accordingly, in this work different blends of JP-8, aviation turbine military fuel, and HEFA-SPK fuels have been experimentally evaluated using an EASA-certified microturbine and an atmospheric combustion chamber. Preliminary results concerning propulsion performance parameters and gaseous and

particulate emissions are presented. The findings contribute to the assessment of SAF blending effects on engine operability and environmental impact.

INFLUENCE OF ADDITIVES AND IMPURITIES ON JET FUEL DIELECTRIC CONSTANT

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Aircraft use onboard capacitance probes to determine fuel quantity during flight. Specifically, dielectric constant is measured and used to calculate fuel weight, making dielectric constant essential for aircraft safety. In recent years, airframe original equipment manufacturers have monitored dielectric constant behavior of candidate synthetic aviation turbine fuels because small changes in this property can result in atypical fuel gauging. Previous efforts characterized bulk hydrocarbon composition effects on dielectric constant (Kosir et al., *Energy & Fuels*, 2024), using the Stanhope-Seta JetDC dielectric constant instrument. Here we present an investigation of the effect of trace polar species on dielectric constant. Trace polar species studied include additives such as fuel system icing inhibitor (FSII), corrosion inhibitor/lubricity improver (CI/LI), static dissipator additive (SDA), and incidental materials such as water. This work comprises three sections: 1) quantifying the effect of trace polar species on dielectric constant and Clausius-Mossotti gauging behavior, 2) validation of dielectric constant blending rules with trace polar species, and 3) development of models to predict dielectric constant of pure substances using linear solvation energy relationships (LSERs). Section 2 provides a practical extension of this work for fuel producers and other interested parties, while section 3 probes deeper into the chemical descriptors governing dielectric constant.

MULTISCALE TEST AND EVALUATION OF ALTERNATIVE ROCKET FUELS

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Ensuring a consistent and reliable supply of rocket-grade hydrocarbon fuels is a critical technological challenge to meet the growing demands of modern space operations. The Test and Evaluation of Alternative Rocket Fuels (TEARF) initiative is a comprehensive research and development activity, sponsored by DLA Energy and performed by AFRL, focused on validating new hydrocarbon fuels for liquid rocket propulsion systems. Whereas specification conformance testing verifies quality and fit-for-use properties of conventional fuels for routine use, more detailed analyses and extended testing are necessary for fuel formulations or engine operating environments sufficiently outside the experience base. Accordingly, TEARF implements multiscale, multidisciplinary analysis and testing to evaluate fuel properties, thermal performance, and engine operability. End-to-end evaluation of candidate fuels in this manner enables synthesis of a rapid yet rigorous evaluation and acceptance protocol. This paper summarizes the effort from start to finish, beginning at the molecular level, where the influence of chemical compositional makeup on properties guides fuel down selection. From there, evaluation of fuel thermal performance in controlled heated tube experiments is presented in terms of pressure drop and carbonaceous deposit formation in regenerative cooling channel environments. Combustion testing in a subscale rocket thrust chamber is then reported, with measured and ideal performance comparisons suggesting potential implications of fuel chemical makeup on complex physicochemical behavior in a pure oxygen environment.

Finally, fuel demonstration testing in a full-scale oxygen-rich staged combustion (ORSC) engine at a number of mixture ratio (MR) values will be presented, with comparisons to baseline kerosene provided.

SESSION 4.1: OPTIMIZATION / MODELING

MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN SUSTAINABLE FUELS

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The application of machine learning (ML) and artificial intelligence (AI) in sustainable fuel research has grown exponentially, yet no comprehensive systematic review has mapped this fragmented landscape. This meta-review applies PRISMA 2020 guidelines to systematically map ML/AI applications throughout the sustainable fuel value chain—spanning feedstock processing, fuel production, combustion, and engine performance. We developed a novel hybrid human-LLM screening pipeline that combines tiered keyword and keyphrase searches across three open-access academic repositories (OpenAlex, Semantic Scholar, and Crossref) with LLM-based classification (GPT 5.2) and manual validation using Cohen's kappa inter-rater reliability. The LLM classifier employs researcher-curated parameters and definitions to categorize articles by: primary research domain (Fuel Production, Fuel Combustion, Both, or Neither), subdomains (Feedstocks, Catalysts, Carbon Footprint, Emissions, Engine Performance, etc.), ML/AI usage status, specific algorithms employed, input/output variables (open-category classification), relevance to research objectives, classification confidence level, justification rationale, and primary research inputs/outputs. Our pipeline identified 138,234 unique DOI entries, of which 29,627 articles contained openly accessible abstracts matching our search criteria. Following LLM classification and validation, only 4.8% (1,422 articles) were deemed relevant—demonstrating actual ML/AI application in sustainable fuel research. These findings provide evidence-based insights into the historical application of AI/ML techniques in sustainable fuel research and identify promising directions for future investigation.

CONSTRUCTION OF MOLECULAR DYNAMICS-BASED DATASETS FOR THERMAL CONDUCTIVITY OF PURE AND MIXED HYDROCARBON SYSTEMS WITHIN THE AVIATION FUEL RANGE

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The thermophysical properties of aviation fuels are fundamental to ensuring aircraft safety, operational reliability, and thermal management performance. Among these properties, thermal conductivity is particularly important as it regulates heat transfer within fuel circuits, and combustion chambers. Reliable thermal conductivity dataset for hydrocarbon species is therefore essential for improving the understanding of chemical structure-property relationships, enabling better equipment design and enhanced performance of advanced energy systems. However, the accuracy of experimental measurements is often limited due to technical complexity and challenging operating conditions. In this work, the thermal conductivity of three hydrocarbon classes within the aviation fuel range namely n-paraffins, isoparaffins, and cycloparaffins and their mixtures were predicted using equilibrium molecular dynamics simulation based on the Green-Kubo formalism. The simulations were carried out using the Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS), where thermal conductivity values were derived from heat flux autocorrelation functions calculated from equilibrated molecular trajectories.

DELVING INTO THE COMPLEXITY OF HVOS AND RENEWABLE DIESELS

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Hydrotreated vegetable oils (HVOs) and renewable diesels are an increasingly important new class of renewable fuels. These are complex materials, which undergo different processes, *e.g.*, hydrotreatment, hydrocracking, hydroisomerisation *etc.* to yield a hydrocarbon mixture with high paraffinic content. To address this complexity, a comprehensive multi-technique analytical workflow¹ was applied to more than 40 HVOs sourced globally. Orthogonal methods, including GC×GC-MS, SFC-FID, SFC-ESI-MS and NMR spectroscopy, enabled detailed profiling of paraffinic hydrocarbons, quantitative bulk composition, and selective detection of residual polar species. The datasets reveal substantial variation in *n*-alkane/*iso*-alkane ratios, *cyclo*-alkanes, carbon number distributions, and the presence of free fatty acids, FAMES, triacylglycerides, steranes and terpanes in certain samples. These compositional differences reflect underlying feedstock and process choices, and have direct implications for fuel performance, storage, and handling. The study establishes a robust analytical framework for characterising next-generation renewable diesels and highlights the need for a multi-technique approach to provide detailed compositional assessment of the different HVOs and renewable diesels.

ISOMERIC EFFECTS BEYOND PRIMARY SPECIFICATIONS

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Isomeric structural differences profoundly influence critical fuel properties and operational performance characteristics of aviation fuels, particularly for sustainable aviation fuels (SAFs) produced by catalytic process technology leading to novel compositions and in specific examples reduced number of components compared to conventional petroleum-derived jet fuels. However,

current analytical methods and property prediction models often struggle to accurately capture isomeric effects within hydrocarbon families, introducing significant uncertainties in fuel assessment, certification, and performance optimization for next-generation aviation fuels. This work systematically investigates the influence of isomeric variations on properties beyond the specification properties (e.g. ASTM D4054 or D7566), employing both measured properties and properties predicted by quantitative structure-property relationship (QSPR) approaches. Isomeric effects are characterized utilizing molecular descriptors, structural metrics and branching characteristics across representative hydrocarbon families. Property ranges and performance impacts within given hydrocarbon classes are quantitatively assessed and compared to conventional carbon number and hydrocarbon family dependencies. The results reveal that isomeric variations significantly influence property ranges within hydrocarbon families, with effects comparable to changes in carbon number or hydrocarbon class. This analysis serves as a foundation for improved property prediction methodologies and enhanced fuel assessment protocols, ultimately facilitating the rational design and systematic optimization of next-generation sustainable aviation fuels with superior operational and environmental performance, but also assists in development of future jet fuel specification.

VLLE MODEL CORRECTION FOR POWER-TO-LIQUID PROCESSES

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Accurate thermodynamic modeling is a key enabler in the design and assessment of emerging Power to Liquid (PtL) pathways for sustainable aviation fuel (SAF). Model-based prediction of vapor-liquid-liquid equilibrium (VLLE) is essential for reliably estimated phase behavior in PtL process schemes, such as CO₂-derived methanol and downstream methanol-to-jet (MtJ). Current simulation tools can not accurately predict VLLE phase splitting in multicomponent CO₂-MeOH-H₂O-oxygenate-hydrocarbon mixtures, which introduces bias in flash and recycle predictions that can influence column sizing, energy integration, and CO₂ utilization metrics. In order to improve the accuracy of quantitative benchmarks that are then used for techno-economic analysis and life cycle assessment performance, improved thermodynamic methods for VLLE are necessary. In this work, we present an evaluation of three widely used thermodynamic frameworks: PSRK, NRTL, and Peng-Robinson. To quantify process impact, we compare evaluate the three flash estimation models across a MtJ process scheme comprising of 1) CO₂ hydrogenation 2) MeOH purification 3) MTO/oligomerization 4) hydroprocessing. Four process-scheme KPIs 1) CO₂ utilization 2) Flash sizing 3) Recycle compressor power, and 4) distillation design, are evaluated. We then discuss corrections to initial flash estimates of the three EoS models. This work highlights the importance of lowering model risk for VLLE sensitive nodes in PtL processes and how VLLE-calibrated schemes can reduce oversizing, improve accuracy of recycle streams, and tighten CO₂ balance closures.

AVIATION FUEL HYDROCARBON DENSITY AND PERMITTIVITY DATASET ACROSS THE AIRCRAFT FLIGHT TEMPERATURE RANGE: MOLECULAR DYNAMICS, EXPERIMENT, AND QSPR CORRELATION

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Aviation fuel physico-chemical properties must meet strict specifications and fit-for-purpose requirements. This ensures safe and reliable aircraft operation in all conditions. Fuel chemical composition varies in the distribution of its hydrocarbon classes. Fuel density and permittivity are of particular importance, as they are used for onboard fuel gauging systems. Their reliability can be affected by the variations in the chemistry of aviation fuels. Building on a previously validated molecular dynamics (MD) framework, at a single reference temperature, this study extends the investigation to a wide aircraft-relevant temperature range from -50 to 60 °C. MD simulations were performed for representative hydrocarbon constituents, including normal paraffins, isoparaffins, cycloparaffins, and selected aromatics, as well as for binary, ternary, and quaternary mixtures of these classes. Temperature-dependent density and permittivity were systematically evaluated and compared against dedicated experimental measurements obtained from Jet DC. Overall, good agreement was observed between simulation and experimental data, demonstrating the robustness of the MD approach for exploring quantitative structure–property relationships (QSPR). This highlights the potential for rapid screening and prediction of fuel properties based on molecular composition. The results deliver a temperature-resolved property database and models to guide fuel design and early-stage evaluation of synthetic and blended aviation fuels.

MODELLING OF FOSSIL AND ALTERNATIVE JET FUEL PROPERTIES

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The diversification of aviation fuels, driven by the rise of sustainable aviation fuels (SAF), requires the development of reliable predictive tools to estimate their key physicochemical properties while reducing lengthy and costly experimental campaigns. This study proposes a pragmatic approach combining multiple linear regression applied to properties derived from certificates of analysis with the use of physically consistent mixing laws in order to predict the behaviour of fossil and alternative fuels as well as their blends. A database comprising 62 fuels (Jet A-1, HEFA and blends) was compiled. Seventeen properties were measured in accordance with ASTM standards, including density, viscosity, net heat of combustion, surface tension, flash point, freezing point, derived cetane number, and distillation temperatures. The regression models show excellent predictive performance and highlight that no single property is sufficient on its own: only combinations of variables can properly capture physicochemical interactions. The analysis of mixing laws reveals near-ideal behaviour for the blends studied. Overall, the results confirm that simple or semi-empirical mixing laws, selected in a manner consistent with the physicochemical nature of each property, enable very high-accuracy prediction of the bulk properties of conventional and alternative fuel blends. Combining these two approaches provides robust and operational tools for the design, evaluation, and optimisation of aviation fuels, thereby accelerating the integration of low-carbon solutions.

SESSION 4.2: STABILITY

A NEW MICROREACTOR-BASED APPROACH TO INVESTIGATE THE FORMATION OF AUTOXIDATIVE DEPOSITS: CASE STUDY FOR CYCLOHEXANE

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The exposure of jet fuels to thermal oxidative stress from storage in the fuel tanks until the engine and to the combustion chamber can lead to its degradation. Fuel degradation via thermal oxidation stress can be characterized by the formation of a series of soluble and insoluble products which can lead to the formation of autoxidative deposits. This study investigates the formation of autoxidation deposits and its precursors for cyclohexane, a model cycloalkane fuel surrogate. Oxidation experiments were conducted in the Autoxidation μ Chip Heated Unit with PEEK connectors (PEEK-ACHU), a silicon/glass microreactor offering precise control of residence time, inert material (to exclude products of catalyzed reaction), temperature, and pressure, enabling well-defined kinetic studies [1]. Experiments were performed at long residence times (15-60 min), at 160°C and 20 bar to examine the different stages of fuel autoxidative deposition. Gas chromatography/mass spectrometry-flame ionization detection (GC/MS-FID), Raman spectroscopy and total acid number (TAN) analysis revealed the structure of the different soluble macromolecular oxidatively reactive species (SMORS) as well as insoluble deposits [2]. The study showed that the alcohols and acids formed play a key role in the formation of the larger deposits (linear and cyclic esters) and highlighting their formation mechanism. The deposits formed in the microreactor were collected using solvent extraction followed by freeze-drying treatment for their recovery, validating the PEEK-ACHU reactor for investigating the formation of fuel autoxidative deposits.

FUEL QUALITY AND OPERATIONAL PERFORMANCE OF RENEWABLE DIESEL–BIODIESEL BLENDS IN HEATING SYSTEMS

Ryan Kerr, Thomas Butcher, Neehad Islam

NORA

The liquid heating market is currently moving towards using more renewable fuels. Currently, the most used commonly fuels are a blend of petroleum No. 2 oil and biodiesel (FAME). There is currently interest in using blends of biodiesel and renewable diesel (HVO) as an alternative. NORA, with a team of industry partners, recently completed a field study involving 133 homes located throughout the heating oil market. This test was performed to measure and observe the condition unique to the liquid heating sector. Selected sites provided diverse appliance types including boilers, water heaters, and warm air furnaces. Tanks were not emptied nor cleaned before the start of deliveries of the test fuels. During the one-year test sampling was done to track biodiesel content, TAN, oxidative reserve, water content, and tank bottom biologic activity. Fuel testing found a drop in fuel quality during summer shutdown, the 5-6 month period over the summer where no fuel is delivered, but this recovered during the winter when new fuel was delivered. Some sites saw very limited issues with existing equipment, but overall, most equipment performed with no issue. These results demonstrate that the liquid heating market has a pathway to decarbonization that can be implemented now with limited changes and similar results to existing fuels.

REFERENCE FLUID FOR VALIDATION OF JET FUEL THERMAL STABILITY (JFTOT) MEASUREMENT.

Indresh Mathur

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Thermal stability measurement is an important check for jet fuel. ASTM D3241 (IP323, ISO6249) is standard test method for thermal oxidation stability of aviation turbine fuels. To improve the uncertainty thermal stability measurement, use of reference fluid as a means of operation validation of the test method is desired. A compositionally defined and reproducible REFERENCE material has been produced. The proposed reference fluid is a pure isoparaffinic solvent that has been spiked with specific S and N containing compounds. This validation fluid has been shown to be stable when stored under nitrogen. A comprehensive ILS was conducted to obtain data and statistics for the users of this test method to establish an acceptable validation criterion for the use of this Validation Fluid in D3241 method. Over 80 labs from across the globe participated in an Inter laboratory Study (ILS) under guidance of ASTM Subcommittee J for aviation fuels. The goal of this ILS was to obtain tolerance limits for a single test result obtained using the validation fluid under realistic conditions, using different JFTOT instruments, different heater tubes and Ellipsometric heater Tube Rater (ETR). The ILS protocol involved testing the single use bottle of this Reference fluid in a specified instrument at 275 degrees C with Alcor and Falex heater tubes and measuring the maximum spot deposit thickness on the heater tube by ETR method. Over 140 test results of testing with JFTOT Mark III, JFTOT Mark IV, and Falex 400 instruments were statistically analyzed and showed that there was no statistically significant difference (95% confidence) between the averages and standard deviations of Alcor and Falex tubes for each system (JFTOT III, JFTOT IV and Falex 400). The Alcor and Falex data were therefore combined for each system. Also, there was no statistically significant difference (95% confidence) between the averages and standard deviations of the 3 systems using the combined Alcor and Falex data. The Accepted Reference Value (ARV) for the max. deposit thickness formation was found to be 25.873 nm with a standard deviation of 7.060 nm. The users of the JFTOT test method, now for the first time, have Reference material that they can use to ascertain that their JFTOT instruments are fit for use and the thermal stability test results are reliable.

SESSION 4.3: STABILITY II

A COMPARATIVE FRAMEWORK FOR HETEROATOMIC SPECIES IN AVIATION FUELS AND THEIR SURFACE DEPOSITION BEHAVIOUR

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Thermal-oxidative degradation of aviation fuels is widely recognised as a primary driver of

surface deposit formation in aero-engine fuel systems, where fuel serves as a heat sink. Although the role of heteroatomic species in liquid-phase thermal autoxidation is relatively well established, the mechanisms governing cumulative deposit formation on heated surfaces remain poorly understood. This gap arises from the complex coupling between fuel chemistry and surface interactions, the disparity in characteristic time scales of these processes, and the lack of a universally accepted representative test methodology. In this study, recently published CRC Aviation Fuel Supplementary Data are used to map heteroatomic species, dissolved metals, and sulfur content in aviation fuel samples against their surface deposition propensity. A comparative framework is developed to quantitatively assess similarities and differences among multiple jet fuel samples with respect to deposit formation behaviour. The results suggest that reliance on single metrics derived from standard JFTOT testing (e.g. breakpoint temperature, filter pressure drop, and ellipsometry) is insufficient to capture the time-dependent nature of deposit growth and may lead to inconsistencies in fuel ranking. In contrast, Quartz Crystal Microbalance (QCM) measurements show improved sensitivity to cumulative deposition behaviour. Building on these findings, the framework is extended through comprehensive chemical characterisation of additional fuel samples, supported by PetroOXY oxidation testing and HiReTS experiments. The expanded dataset provides a more consistent mapping between fuel composition and deposition propensity. A predictive mathematical model is also proposed to describe the growth of insoluble deposit formation.

THE PROPENSITY FOR FUEL FILTER BLOCKING ARISING FROM LONG TERM STORED FUEL USED FOR EMERGENCY BACK UP SYSTEMS

Carl Atkinson

EDF Energy

By design emergency backup systems are expected to provide a guaranteed function in the event of loss on the primary system. For power stations one of these systems is that of electrical supplies. Bulk fuel storage systems are maintained with a permanent minimum fuel inventory such that the equipment it supplies have a guaranteed minimum run time. Under normal operation the equipment supplied is on standby and is routinely surveillance tested. Consequently, the fuel within the bulk tanks has a low turnover and reliance is placed on routine fuel testing against a range of parameters including total contamination and filter blocking tendency. An event during the summer of 2025 resulted in the loss of connection to the national grid system triggering the startup of the emergency electrical systems (Gas Turbines). Their performance is closely monitored and the bulk tank replenished with fresh fuel to maintain supplies of fuel to the turbines. The Gas Turbines performed their duty as expected throughout the period and until external electrical supplies were restored. Even though the bulk fuel was routinely tested during the event the frequency of changing the inline fuel oil filters was much higher than anticipated. This paper reports the findings of the subsequent investigation.

INSIGHTS INTO CHEMICAL COMPOSITION OF TURBOCHARGER DEPOSITS USING ADVANCED SURFACE ANALYSIS

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The buildup of insoluble deposits on key engine parts which result in the wear of components and increased emissions is a growing issue that warrants investigations. Previous work by Edney et al investigated deposits in pre-combustion fuel injectors by Orbi secondary ion mass spectrometry depth (OrbiSIMS) profiling. By then applying chemical filtering through SIMS molecular formula predictor (MFP) key chemistries of the deposits such as inorganic salts and carcinogenic polycyclic aromatic hydrocarbons (PAHs) were discovered and strategies to mitigate the deposits could be devised. This investigation applies similar methods but focuses on deposit build up in turbochargers, which are an increasingly popular technology in modern day exhaust systems which increase combustion efficiencies by taking advantage of the high energy combustion exhaust air. Three samples of small sections cut out of once operational fouled turbochargers were analyzed. OrbiSIMS analysis of the samples revealed calcium salts as key inorganic species likely to originate from lubricating oil additives were of a significance presence all through the depths of the deposit and are key to their formation. As the turbocharger is the first thing that combustion exhaust gas encounters after expulsion from the chamber, analysis of the carbon content of the deposits through OrbiSIMS and Raman Spectroscopy provided a unique insight into the formation of soot and how the structure and ordering of carbon differ from that found in pre-combustion fuel injectors. This topic in particular has had long-continued research especially into the unclear “inception” phase in soot development.

STABILITY OF RADICALS DERIVED FROM OXYGEN-CONTAINING COMPOUNDS DETECTED IN THERMALLY UNSTABLE JET FUELS

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Jet fuel is a complex chemical mixture that is essential for the propulsion and cooling of high-performance aircraft. When heated, certain compounds in jet fuel can chemically react to form insoluble deposits in fuel circulation systems. These deposits can jeopardize aircraft performance and safety by obstructing fuel flow through filters and nozzles resulting in dangerous engine flame out. Recent studies have demonstrated that thermally unstable jet fuels contain oxygen-containing compounds (OCCs). Upon heating, these OCCs can undergo autoxidation and form $-C(=O)-O\bullet$ radicals that react to form adverse deposits in fuel circulation systems. To better understand the thermal instability of jet fuels, we used first-principles modeling to quantify the stability of specific carboxyl radicals, $C_{10}H_{19}O_2\bullet$ and $C_{10}H_{17}O_2\bullet$, derived from OCCs previously found in these fuels. The thermodynamic and kinetic contributions to radical stability were determined by density functional theory (DFT) and buried volume (V_{bur}) calculations, and used to compute radical stability scores (RSSs). Our results predict average RSSs in the range of 35–52, consistent with high chemical reactivity. These findings suggest that OCCs in jet fuels should be targeted for suppression through fuel additives or other mitigation techniques.

ENHANCING FUEL OIL STABILITY MANAGEMENT USING PREDICTIVE COMPATIBILITY MODELING AND ADDITIVES

Sai Reddy Pinappu, Roger Metzler, Marco Respini

Baker Hughes

Fuel oil stability is a critical concern for bunker fuel suppliers and power generation operators, especially as blending pools become more diverse and incorporate streams with varying solvency characteristics. Instability and incompatibility in fuels can lead to issues such as asphaltene precipitation, sludge formation, separator overload, filter plugging, and decreased combustion reliability throughout the supply chain—from refinery production to onboard engine usage. Addressing these issues after fuel delivery can be costly and disrupt operations, emphasizing the need for predictive and preventative strategies. This paper presents an integrated approach that combines fuel oil compatibility modeling with targeted additive treatment to proactively manage stability during blending and logistics. The methodology utilizes compositional indicators and solvency balance parameters to forecast the risk of precipitation before blending occurs. The model's outputs are then used to optimize blend ratios and select stabilizing additives that maintain asphaltene dispersion despite changing operating conditions and aging processes encountered during transport, storage, and onboard handling. Case studies demonstrate how merging predictive modeling with preventative additive programs reduces off-spec incidents, minimizes tank cleaning and separator maintenance, and enhances fuel reliability in both marine and stationary power applications. The results indicate that proactive stability management allows for optimized fuel blending while protecting downstream operations from compatibility-related failures.

THE RELATIONSHIP BETWEEN CHEMICAL COMPOSITION OF VLSFOS AND LONG-TERM STABILITY PROPERTIES OF VLSFOS

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Viswa Group

Since the introduction of Very Low Sulfur Fuel Oil (VLSFO) in 2020, one of the primary challenges faced has been fuel instability. This issue has not been limited to samples with high sediment content but has also been observed in samples with sediment content of less than 0.1% on the first day of testing. Many of these samples have shown instability when stored for periods of 2, 4, or 8 weeks. This paper aims to elucidate the relationship between the chemical composition of VLSFOs, specifically their SARA (Saturate, Aromatic, Resin, and Asphaltene) profile, and their potential instability. To achieve this, a screening algorithm was developed to predict the potential instability of VLSFOs over time. This algorithm was based on the SARA analysis and sediment measurements of 100 different types of VLSFOs, ranging from paraffinic to aromatic fuels. Preliminary results indicate that samples with a higher saturate content compared to aromatic content have a 90% likelihood of becoming unstable over time. Conversely, samples with lower saturate fractions relative to aromatic content were further categorized based on the ratio of asphaltene to resin fractions. Those with a higher asphaltene to resin ratio exhibited a significant potential for instability over time. This study provides a comprehensive analysis of the factors contributing to VLSFO instability and offers a predictive model for assessing the long-term stability of these fuels. Understanding these relationships is crucial for improving the storage and handling of VLSFOs, ensuring their reliability and performance in marine applications.

INVESTIGATION OF DIESEL STORAGE STABILITY FOCUSED ON NITROGEN-CONTAINING COMPOUNDS BY USING MASS SPECTROMETRY

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Diesel fuel is essential globally as it plays critical roles for industry, agriculture, military, and healthcare sectors. Hence, diesel storage stability remains a vital aspect for maintaining daily operations worldwide. As nitrogen-containing compounds (NCCs) are known to facilitate storage stability failure of diesel, their chemical characterization is critical. In this work, (+) electrospray ionization coupled to an orbitrap mass spectrometer was employed to qualitatively characterize ionized NCCs derived from stable and unstable diesels, and from sediment obtained from the unstable diesel. Remarkably, up to forty and sixty-three individual homologue ion series (ions sharing the same general molecular formula, each representative of at least one chemical class (*e.g.*, pyrroles, quinolines) were detected in diesels and sediment, respectively. Hence, this investigation provided more comprehensive qualitative information for diesels and sediment than previously documented. Upon comparison of diesel fuels, important compositional differences were observed, notably greater abundances of NCCs with the general formula of C_xH_yNO and $C_xH_yNO_2$ in the unstable diesel. Upon analysis of sediment, ions of the general formula of C_xH_yN , C_xH_yNO , $C_xH_yNO_2$, $C_xH_yNO_3$, and $C_xH_yN_2O_2$ were detected. Interestingly, NCCs of smaller alkyl carbon number showed a greater propensity to contribute to sediment formation. Additional stress studies using ASTM D5304 were completed on copper doped and non-doped diesel fuels. Upon stressing the non-doped and copper doped stable diesel fuels, oxidized NCCs clearly increased in abundance, especially for the copper doped diesels, demonstrating its significance for accelerating oxidative reactions. Overall, the reported qualitative information showcased the proficiency of the orbitrap at providing vital information for enhancing our current understanding of diesel storage stability.

INVESTIGATION OF A SUDDEN SLUDGE FORMATION IN A PRODUCING WELL AND THE SUCCESSFUL MITIGATION BASED ON THE INVESTIGATION RESULTS

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This paper investigates the phenomenon of sludge formation in a pipeline. Sludge is one of the main challenges that the oil and gas companies in oil fields are facing. One of the sludge problems production engineers in the control room noticed is that the pressure had risen, and the production rate was declining. This phenomenon has caused huge economic losses, besides delays in the production schedule and disturbed the whole production operations. Production rate was approximately 5000 barrels per day, but because of this phenomenon, a huge drop occurred, it decreased to approximately 500 barrels per day. Therefore, two unknown random samples were taken from different locations of the pipeline at the surface equipment of the oil well (W) at the (F) field, and three oil samples were collected as well. The sludge samples (A and B) were fractionated into their main components: total soluble organics (TSO) and inorganic fractions. The extraction results showed a high percentage of organic materials (72.973 and 75.102 w/w%), respectively. The remaining inorganic materials in both samples were also relatively high (19.67 and 21.47 %w/w). The separated inorganic materials were characterised for their composition using the semi-quantitative technique of X-ray Diffraction (XRD).^[3, 4] Moreover, asphaltene was isolated, and its percentage was determined for both samples. Physical properties (density, pour

point, wax, sediment & water content, asphaltene, and salt content) were also carried out on the dead oil samples collected. The obtained results indicated that the inorganic fraction separated from the sludge in sample (B) presented a high amount of Polyethylene and Sellaite, while Quartz and Albite were found in the other sample. It can be concluded that the sludge formation was caused by the presence of polyethylene. Since polyethylene is not expected to be found in a reservoir structure, it must be introduced to the well from an outside source, which could have caused sludge formation, especially at the surface when the temperature and pressure conditions changed. A further investigation was carried out based on the results obtained, and it was found that the polymer was introduced to another well across the border and leaked to the affected well. Once the treatment using the polymer was stopped, the well returned to its normal condition before the sludge formation.

A NEW MICROREACTOR-BASED APPROACH TO TEST FUEL OXIDATIVE STABILITY: CASE STUDY FOR ALKANES

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Liquid hydrocarbon fuels remain essential for transport sectors where electrification is not yet feasible, particularly aviation. Their use is tightly regulated, with oxidation stability being a critical performance criterion, as fuel aging can compromise safety and engine operation. This study investigates the early-stage oxidation of representative linear *n*-alkanes, *n*-heptane, *n*-octane, *n*-decane, *n*-dodecane, *n*-tetradecane, and *n*-hexadecane, used as model compounds for gasoline, jet fuel, and diesel surrogates [1]. Oxidation experiments were conducted in the Autoxidation μ Chip Heated Unit with PEEK connectors (PEEK-ACHU), a microreactor offering precise control of residence time, temperature, and pressure for well-defined kinetic studies [2]. Experiments were performed at short residence times ($t = 2-15$ min, $T = 145^\circ\text{C}$, $P = 20$ bar) to examine the early stages of fuel oxidation, with hydroperoxides being the primary products, consistent with autoxidation mechanisms. HPLC-PcR analysis revealed 2 to 4 dominant hydroperoxide species, consistent with the simplified early-stage kinetic scheme used for rate determination [3]. The time-resolved ROOH profiles enable quantitative comparison of low-temperature oxidation across *n*-alkanes. A carbon chain-length dependence was observed up to *n*-decane, whereas C12-C16 alkanes exhibited nearly overlapping ROOH formation kinetics, indicating that oxidation behavior becomes largely insensitive to further carbon chain-length increase. These results demonstrate that oxidative stability trends are not linear with carbon number. The kinetic coefficients derived from ROOH accumulation correlated with PetroOxy induction times, validating the PEEK-ACHU reactor as a rapid and precise tool (<15% deviation) for ranking oxidative stability. Importantly, the method provides mechanistic insight into early radical-driven oxidation processes beyond simple stability screening.