CHJ SAF Commercialization Update

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Applied Research Associates, Inc.

- Engineering & science company that government and industry have turned to for over 40 years for innovative technologies and solutions.
- Founded in 1979. 1500 staff. 100% employee owned. FY20 sales of ~$375M.
- Developing and deploying *ReadiFuels* renewable fuel technologies since 2006.

What is CHJ?

ASTM D7566 Annex 6 - CHJ

A6.1 Scope

A6.1.1 This annex defines *Catalytic Hydrothermolysis Jet (CHJ) as synthesized kerosene containing aromatic compounds* produced from hydrothermally processed fatty acid esters and fatty acids for use as a synthetic blending component in aviation turbine fuels for use in civil aircraft and engines. The specifications in this annex may be used for contractual exchange of synthetic blending components.

CHJ is a Fully Formulated SAF that Meets Table 1 Requirements of D7566 and D1655 without blending

ASTM D7566 Annex 6 - CHJ

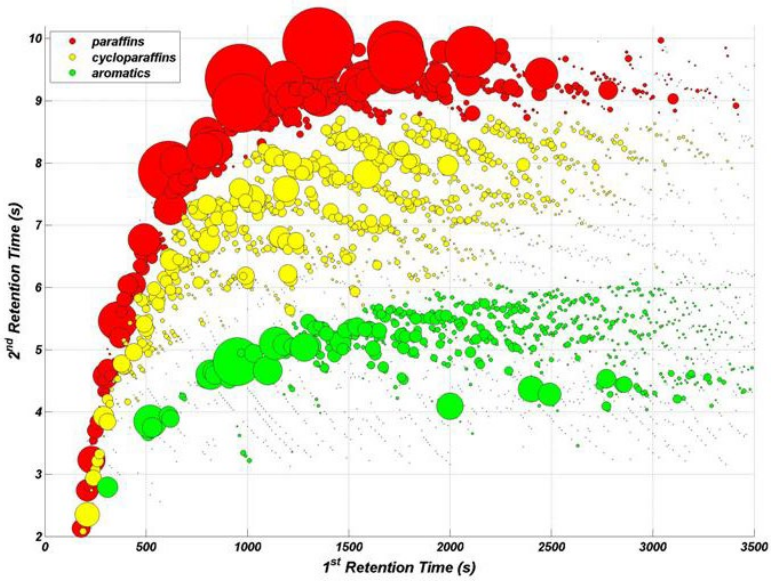
A6.4 Materials and Manufacture

A6.4.1 Synthetic blending component shall be comprised of hydroprocessed synthesized kerosene containing aromatics that is wholly derived from *hydrothermal conversion* of fatty acid esters and free fatty acids. Subsequent processing of the product shall include fractionation and any combination of hydrotreating, hydrocracking, or hydroisomerization, and may include other conventional refinery processes.

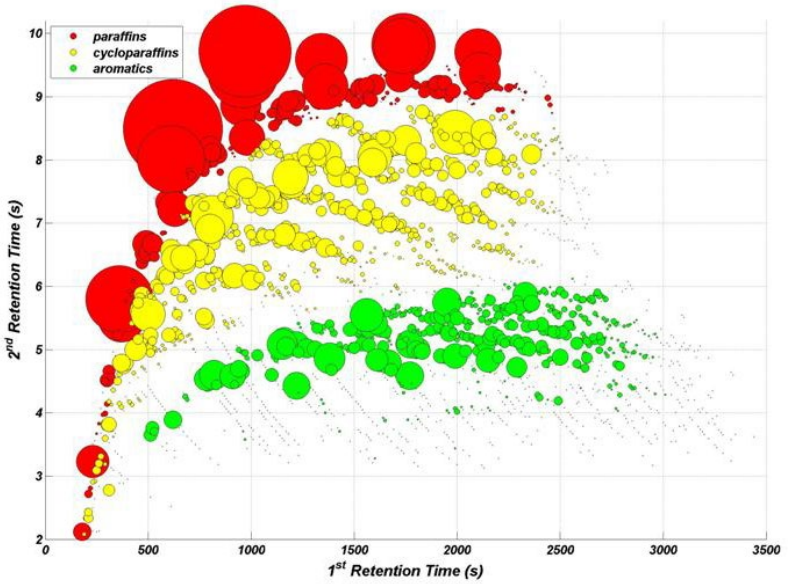
Hydrocarbon Types and Diversity in CHJ is Nearly Identical to Petroleum Jet Fuel

GC x GC Comparison

Petroleum- Derived JP-8



Carinata-Derived JP-8



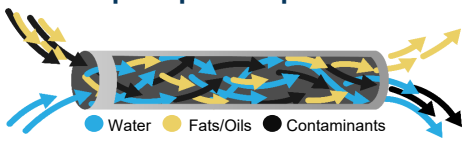
CHJ is produced by the Biofuels ISOCONVERSION (BIC) Process

Converts fats, oils, and greases from plants, animals, or algae into “drop-in” renewable fuels

ARA

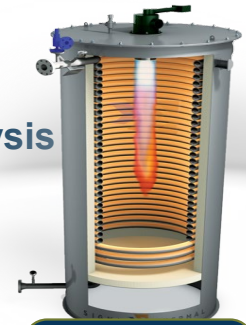
Hydrothermal Cleanup

- Rapid hydrolysis of phospholipids and organic chlorides
- Low metals, phosphorus product



Catalytic Hydrothermolysis

- Supercritical water process
- Produces crude oil that contains the same hydrocarbon types as petroleum crude



2 Minutes
Converts fats oils and greases to crude oil

Hydrotreating

- Saturates olefins
- Removes residual oxygenates

Conventional
Refinery Processes

CLG
Chevron Lummus Global

Fractionation

- Produces finished fuels
- Jet and diesel that meet
- Meets petroleum specs without blending
- Renewable chemicals, and naphtha

CHJ Development Milestones

- World's first 100% CHJ flight Test
  NRC Canada – October 2012

- World's first 100% CHJ Military Jet Flight
  US Navy, F-18 – September 2016

- Secretary of the Navy Ray Maybus Flies on Second 100% CHJ Military Flight – September 2016

- World's First 100% CHJ Single Engine Jet Flight, Saab Gripen, Swedish Defense April 2017
  Over 80,000 gallons of CHJ JP-5 produced

- ASTM Certification of ReadiJet via the CHJ Pathway
  Annex 6 to D7566 approved on 12-15-19

- Navy MILSPEC Certification of CHJ (CHJ-5) - near completion

First 100% drop-in SAF specification

Production of Certification Fuel for DLA-Navy

Fuel production

- Crude oil produced by CH conversion in St Joseph, Missouri, 100 bbl/day pilot
- Finished fuel hydrotreating and distillation – Centauri – Pasadena, TX

	JP-5 (CHCJ-5) 60°C Flash Jet	F-76 (CHCD-76) 60°C Flash Diesel	Gallons Total
U. S. Navy (DLA)	72,000	79,000	151,000
Other*	9,000		9,000
Total	81,000	79,000	160,000

Others performing tests:

- Lufthansa, AFRL, U.S. Army, and Swedish Military

Status of CHJ Certification

- ASTM approved CHJ as Annex 6 to D7566 as a 50% blend component in December 2019
- At the OEM meeting 10 May 2021, ARA was requested to revise the CHJ research report to include 100% CHJ test data and submit it to the ASTM Task Force on 100% drop in SAF
- The U.S. Navy is adopting some of the CHJ Annex 6 requirements to move forward with a specification for 100% CHCJ-5.

Refineries in Engineering/Under construction

Biofuels ISOCONVERSION Refineries

- 2,650 BPD: Engineering Design Package Completed by CLG – IOC 2023
- 3,000 BPD: Engineering Design Package Completed by CLG – IOC 2023
- 5,300 BPD: Engineering Design Package in progress – IOC 2024
- 5 BPD Demonstration Unit (Tokyo) Euglena: Currently in operation
- All units are designed to produce 20 to 30% CHJ

HCU Units for Renewable Diesel & SAF

- Multiple units totaling more than 40,000 BPD are under construction
- Several additional units are in due diligence

Thank You

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