



Haldor Topsoe views on Sustainable Aviation Fuels

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Sustainable Aviation Fuel - Workshop 2018

Copenhagen, November 20 2018

The background is a solid dark blue. On the left side, there is a large, abstract, light blue shape that resembles a stylized 'C' or a thick, curved line. This shape has a smooth, rounded top and a more angular bottom, creating a sense of depth and movement.

Introduction about Haldor Topsoe

Haldor Topsoe

In brief

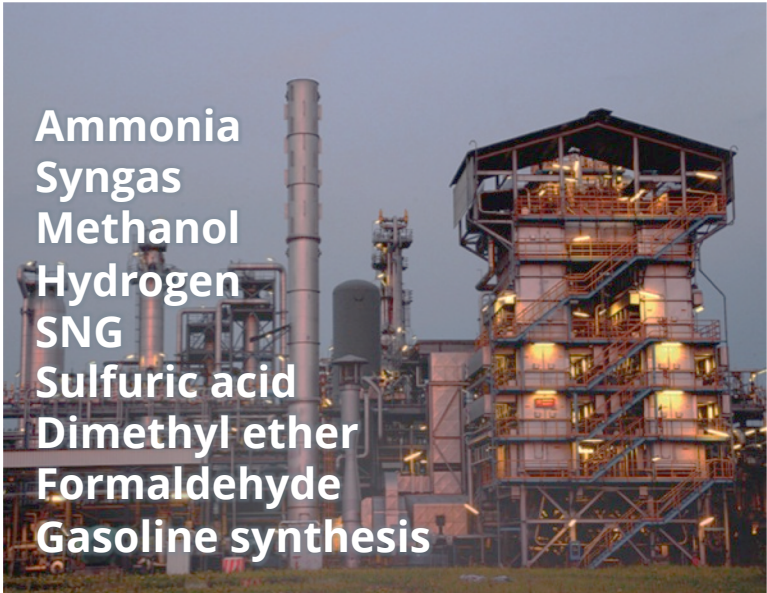
- Established in 1940 by Dr. Haldor Topsøe.
- Private 100% family-owned company.
- Market leader in heterogeneous catalysis and surface science for more than 75 years.
- 2,100 employees in 13 countries.
- Headquarters in Copenhagen, Denmark.
- Production in Frederikssund, Denmark and Houston
- Spends around 10% of revenue on R&D.

2017 revenue
DKK 5,011m
(~USD 760m)

2017 operating
profit DKK 595m
(~USD 90m)

We provide a full range of products and services for a broad range of chemical processing, hydroprocessing, and emissions management processes

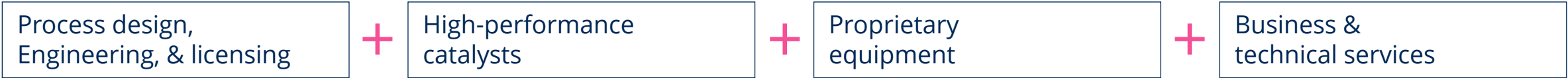
Chemical Processing



Hydroprocessing



Emissions Management





Hydroprocessing of renewable feedstocks

Topsoe's expertise

Market intelligence

Some facts about current units

- About 30 units/refineries processing renewable feedstocks to produce renewable diesel or jet fuel at the moment (mostly in EU and USA)
- Processed feedstocks:
 - 50% of the units are co-processing (2 to 40% renewable feedstock) and 50% are stand-alone units
 - Animal fats/tallow: about 1/3 of units are using animal fat as renewable feedstock (partially or fully)
 - Crude tall oil: 2 units processing pulp mill residue in Northern Europe
 - Used cooking oils used in a handful of units at the moment
 - Vegetable oils used in other refineries (palm oil, soybean oil, rapeseed oil and corn oil mainly)
- The first unit to supply renewable jet fuel on commercial scale is running (AltAir, California)
- More than 50% of the units in the world processing renewable feedstocks are currently using Topsoe catalysts
- Topsoe conducted pilot testing and produced 400 liters of renewable jet fuel from waste fats

Topsoe's experience with renewable feedstocks

<i>Feed</i>	Plant triglyceride	Animal triglyceride	Tall oil	Sulfate turpentine	Hydro-thermal bio crude	Pyrolysis oil	Algae-derived pyrolysis oil
<i>Derived from</i>	Various vegetable oils	Animal fat	Wood	Wood	Biomass or coal	Biomass	Algae
<i>Main product</i>	Diesel and jet	Diesel	Diesel	Gasoline	Jet fuel	Gasoline+ diesel	Gasoline+ diesel
<i>Topsoe's R&D test carried out</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industrial operation (Topsoe's catalyst)</i>	Yes	Yes	Yes	No	No	Yes	No



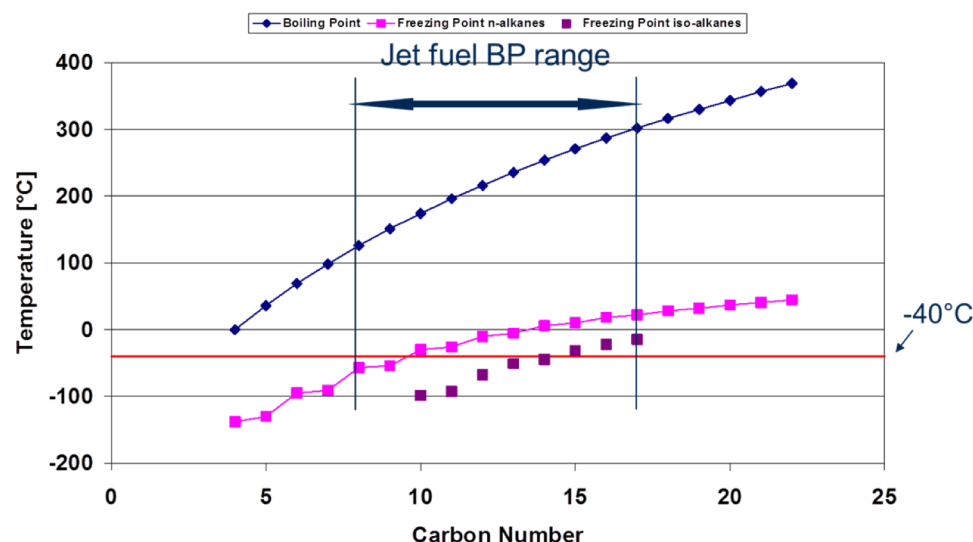
Renewable jet fuels Challenges

Challenges

SPK-HEFA

- Boiling point vs. freezing point of n-paraffins
- Stable supply and quality of feedstocks (incl. pricing, availability, contaminants)
- Specifications for HEFA-SPK, low aromatic content is critical.
 - Max 0.5 wt% (measured with ASTM D2425 and not ASTM D6591)
 - According to D7566, min 8% aromatics in blend so why max 0.5 wt% in renewable part?
 - It can be challenging depending on the nature of the feedstock.

Figure: physical properties of n- and i-paraffins



Challenges

Future feedstocks

- RED II Directive (2021-2030):
 - Specific targets for Annex IX parts A and B feedstocks and cap on food/feed crop-based feedstocks
 - How will these feedstocks be produced and processed?
- Examples of possible technical solutions (not commercial yet):

	Pyrolysis	Hydrothermal liquefaction	Gasification	Hydroprocessing
Algae	*	*	*	* (oil)
Municipal waste	*	*	*	
Agricultural residues (inc. wood)	*	*	*	* (tall oil)
Winter crops				*

Renewable – where to start?

Some of the basic questions

1 - Renewable feed

- How much renewable do you want to process?
- What is the level of contaminants in your feed?
- Do you plan to pre-treat your feedstock?
- Where will you get your feedstock from?
- Which feedstock do you plan to use
- If you consider co-processing, which fossil feed do you plan to use?

2 - Challenges

- What is the TAN number?
- What is the Cl concentration?
- How much H₂ is available?
- If existing unit, do you have dP issue?
- Pressure drop might affect cycle length of your unit. Are you ready for that?

3 - Desired end product

- Which products do you want to obtain?
- What are the specs of these products (incl. cold flow properties, aromatics, etc.)?



Thank you for your attention
Questions?