Advancing Cleaner Aviation Fuels: NH_3-SAF intermediate mixtures

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Abstract

This work investigates ammonia mixtures with key oxygenated intermediates formed during Sustainable Aviation Fuel (SAF) combustion, including acetaldehyde, acetone, and acetic acid. The aim is to improve understanding of their oxidation chemistry, pollutant formation, and potential contribution to low-carbon aviation through dual-fuel combustion strategies.

Introduction and methodology

The growing urgency to address climate change and comply with stringent regulations, such as the European Commission's ReFuelEU Aviation initiative, has placed the aviation sector under increasing pressure to adopt sustainable practices. On the one hand, sustainable Aviation Fuels (SAFs) are widely recognized as a key solution for achieving substantial reductions in greenhouse gas emissions throughout their lifecycle, potentially lowering carbon footprints. However, current SAF adoption faces technical and environmental challenges that demand thorough investigation to ensure their successful integration into the aviation industry. On the other hand, ammonia has emerged as a promising carbon-free fuel, offering a potential solution to this pressing need for sustainable energy sources. Its ability to burn without emitting CO_2 makes it an attractive option for reducing greenhouse gas emissions, especially in sectors like transportation and power generation. However, despite its environmental benefits, the use of ammonia as a fuel presents certain challenges due to its poor combustion characteristics and to the fact that may produce nitrogen oxides during combustion. Among others, these factors imply the necessity of further research and innovation to improve its combustion properties while maintaining its carbon-neutral advantages. To enhance the combustion properties of ammonia, one proposed strategy is to mix it with other more reactive fuels in the so-called “dual fuel approach”. In this context, the conversion of ammonia mixtures with sustainable aviation fuels not only would facilitate ammonia combustion but also presents a promising pathway toward achieving low-carbon aviation systems. Identifying the main intermediates formed during the decomposition of Sustainable Aviation Fuels (SAFs) and how they behave during the combustion process is crucial for understanding the SAF combustion characteristics, pollutant formation, and efficiency in practical applications.

The conversion of SAFs, whether in oxidation or pyrolysis, generates a variety of intermediate species depending on the fuel's chemical composition and operating conditions (temperature, pressure, stoichiometry, etc.) [1]. Among those, key Intermediates from SAFs like terpenes include oxygenated compounds such as aldehydes, ketones and carboxylic acids [2].

In this context, this research investigación includes the experimental and modeling analysis of the conversion regime of SAF-intermediates (i.e. acetaldehyde, acetone and acetic acid) with ammonia under a wide range of operating conditions, including temperature, air excess ratio, SAF-intermediate/ammonia ratio, and pressure. The work will asses the formation of atmospheric pollutants, particularly nitrogen oxides, as well as potential synergies for pollutant emission reduction, and will evaluate the potential use of NH_3/SAF blends as a clean and low-carbon combustion technology to reduce the environmental impact of air transport.

The experimental high-pressure setup (Figure 1), described in previous works [e.g. 3], consists of a quartz tubular flow reactor inside an electrically heated oven that allows to obtain an isothermal reaction zone inside the tube. Experimental results will be simulated and interpreted by using Chemkin-Pro, with a detailed kinetic reaction model, that will be progressively developed, updated and improved according to the experimental results obtained.

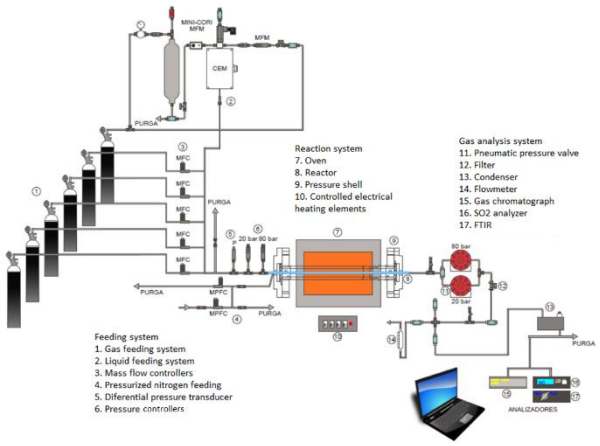

Figure 1. Laboratory-scale high-pressure setup.

This research is carried out within the framework of the project *Towards a Less Polluting Energy System in Aviation: Ammonia Fuel Blends and SAF Combustion Intermediates* (PID2024-155489OB-I00), developed by the Thermochemical Processes Group of the I3A within the research line of Fuel Conversion and Emission Minimization.

Acknowledgments

The authors express their gratitude to grant PID2024-155489OB-I00 and PREP2024-002383 funded by MCIU/AEI/10.13039/501100011033/FEDER/UE, "ERDF A way of making Europe", by the "European Union", and to Aragón Government (Ref. T22_23R).

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