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PROPOSITION DE SUJET DE THESE

Intitulé : Low-carbon hydrogen generation using a micro-structured plasma reactor.

Référence : **PHY-DPHY-2023-13**
(à rappeler dans toute correspondance)

Début de la thèse : octobre 2023	**Date limite de candidature :** 20 juin 2023

Mots clés : Plasma, Hydrogen, Low-carbon, Aviation

Profil et compétences recherchées : Master in Chemical Engineering or Plasma science, Grandes Ecoles. Ability to work in a laboratory (experimental work). Ability to work in an interdisciplinary team.

Présentation du projet doctoral, contexte et objectif

Context : Climate change calls for ambitious goals in terms of carbon emission for the air transportation industry.[1]. Using hydrogen (H_2) as a fuel is one of the different solutions considered, where one key element is the ability to produce low-carbon hydrogen. For this purpose, electrolysis is a proven technology, but other routes are also explored. In particular, the generation of hydrogen from ammonia (NH_3)[1] or methane (CH_4)[2] are interesting because the feedstock storage and transportation is less complex than the one required for H_2, the decomposition energy is lesser than water decomposition, thereby decreasing the energy consumption. For those solutions to be competitive, the process efficiency is paramount. One way to optimize the process is to use plasma-based reactors. Indeed, plasma-based process intensification is a topic which has received a considerable attention in the recent years, for example for the valorization of CO_2 [3]. Plasma-based reactors could prove very useful as compact & efficient on-site hydrogen generators.

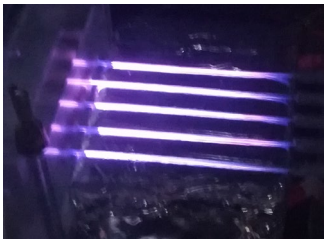

Figure 1 –ONERA-d'Alembert micro-structured plasma reactor

Goals : In this context, ONERA and Institut Jean Le Rond d'Alembert have recently developed a new design of micro-structured plasma reactor (Fig 1) which show promising results for process intensification. The main goal of this doctoral project is assess and optimize the efficiency this reactor for the methane and ammonia decomposition reactions to produce low-carbon hydrogen. For this purpose, it is necessary to find the driving parameters affecting the plasma generation in the reactor and then to understand the reaction kinetic with the plasma. The central question this research seeks to address is *« How efficient is the micro-structured plasma reactor to produce low carbon hydrogen ? »* and as a corollary, « what is its potential to further the use of low-carbon hydrogen ? ».

Method : The project will address both methane and ammonia decomposition. A first part of the project will focus on a detailed characterization of the plasma, using electrical and optical diagnostics, on an existing prototype. In particular, the behavior of the plasma depending on the reactor design parameters (micro-channel size and arrangement, material, pressure) will be investigated. The second part will involve the testing of the plasma system under reactive atmospheres, aiming to seek to find the optimal plasma parameters to achieve the best efficiency in the decomposition of methane and ammonia. For this purpose, and optimized reactor will be designed, building on the findings of the first study. The plasma-based conversion processes will be investigated in a dedicated experimental platform. The products will be analyzed using gas chromatography and other characterization techniques.

Skills : This PhD project is an experimental interdisciplinary work, between plasma science and chemical engineering. The candidate will develop skills in plasma diagnostics, high-voltage systems, chemical engineering, chemical characterization and analysis techniques, data analysis and uncertainty analysis.

Collaborations envisagées

This project is a collaboration between ONERA and Institut Jean Le Rond d'Alembert from Sorbonne University, in the frame of the ANR project MP4Hyp. The candidate will share its time between the two laboratories.

[1] *Resolution A40-18: Consolidated statement of continuing ICAO policies and practices related to environmental protection - Climate change*

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