# FERRET

A FLEXIBLE NATURAL GAS MEMBRANE REFORMER FOR M-CHP APPLICATIONS

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## WP2 – Catalyst development

# D2.3
# Public report on Catalyst development

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| **Dissemination Level** | | |
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*(*) for generating such code please refer to the Quality Management Plan, also to be included in the header of the following pages*

*(**) indicate the acronym of the partner that prepared the document*

## Content

# 1. EXECUTIVE SUMMARY (3 pages max. all points)

## 1.1. Description of the deliverable content and purpose

WP2 is focused on the development of a fluidizable autothermal reforming catalyst that can achieve the necessary activity to allow the FERRET CHP system to produce the target of 5Nm$^3$/h of hydrogen. The catalyst also has to exhibit stability up to a potential of 3000 hours of operation.

The deliverable explains Johnson Matthey's testing process and outlines the supports, dopants and analysis methods used to improve the catalyst up to month 18, which coincides with the end of WP2 and the delivery of catalyst to Hygear.

## 1.2. Brief description of the state of the art and the innovation brought

The FERRET catalyst development activities have resulted in a scalable catalyst that exhibits superior activity and stability in comparison to previous Johnson Matthey materials and can function within a fluidized bed system with minimal degradation.

Previous Johnson Matthey reforming catalysts were not fluidizable.

## 1.3. Deviation from objectives

None

## 2. INTRODUCTION

The aim of the FERRET project is to create a flexible fuel cell CHP system that utilises autothermal reforming (ATR) of natural gas to generate clean hydrogen in a membrane reactor. The system is designed to cope with the variable natural gas compositions from across the EU and produce 5 $Nm^3/h$ of hydrogen.

The partner responsible for producing a catalyst that is active under the required conditions but is also stable to the life time of the system is Johnson Matthey. Testing is supported by Eindhoven University of Technology (TUE).

During the first 6 months of the project, the activities within WP2 focused on platinum group metal (PGM) doped transition metal support materials that were tested in a fixed bed system. The most promising catalyst was supplied to TUE at month 6 for fluidization testing and testing in the presence of the membrane.

Activities during the second half of the first year of the project (months 7-12) were focused on PGM doped metal oxide materials, which exhibited superior conversion to all previously tested materials studied across a range of temperatures. Longer term aging tests have been conducted in order to investigate the stability of the catalyst over 100s of hours and shows stability under space velocities relevant to the project.

Data has been supplied to Hygear on the light-off of the catalyst in order to better assist with the start-up of the FERRET reactor.

The leading catalyst has been tested under differing natural gas compositions from across the EU ranging from high ethane feeds to feeds with higher nitrogen fractions. The catalyst exhibits high activity and stability across all of the feeds tested.

## 3. EXPERIMENTAL TESTING

Transition metal oxide supports were doped with PGM and additional metal oxides to improve the activity and stability of the catalysts. Metal oxide supports were found to be superior in conversion and stability when doped with PGMs to the previously tested transition metal oxides. Additional dopants were added to the supports to improve activity and stability.

Catalysts were tested under autothermal reforming conditions in order to measure the activity of the catalyst over a range of temperatures. The natural gas mixture was varied according to the natural gas composition from across the EU looking at high ethane feed as well as a higher nitrogen feed.

Catalysts were also tested long term to determine the stability of the catalyst to the reaction conditions.

## 4 RESULTS

Transition metal oxide supported catalysts were tested for activity and short term stability in a fixed bed system. The catalysts didn't exhibit suitable activity for the project. When tested under fluidization conditions the catalyst exhibited mechanical stability but was not active enough for the FERRET project. Dopants to the support showed an increase in activity but not enough to meet FERRET targets.

Metal oxide supported catalysts were investigated in the FERRET project and showed enhanced activity and stability compared to previously tested materials. Dopants were added to the catalyst to increase the activity and enhance the long term stability. Many material samples tested were unsuitable for the project due to the lack of mechanical strength under fluidization testing. The chosen catalyst's activity and stability surpasses the targets required for the FERRET project and is stable under fluidization.

Stability tests focused on a program investigating the activity of the catalysts over 200+ hours.

The FERRET catalyst needs to be stable to a variable natural gas composition due to the changing nature of natural gas in the EU. The catalyst has been tested against five different compositions from across the EU and shows stable activity under all of the gas mixtures tested including those with higher ethane fractions and higher nitrogen fractions.

The catalyst received by JM has been tested at TUE under fluidization conditions to evaluate the mechanical stability of the particles under fluidization without reaction. It can be observed that even under high temperature operation in bubbling fluidization regime the particle size distribution of the material does not change. So no agglomeration neither sintering phenomena occur during the fluidization.

The most important result is that the catalyst is stable under fluidization both in terms of structural properties and in terms of activity.

# 5 CONCLUSIONS

Transition metal oxide catalysts were tested when doped with PGMs and showed mechanical stability to the FERRET conditions but exhibited unsuitable activity and stability for the project.

Metal oxide supported catalysts were doped with PGMs and additional metal dopants to produce the FERRET catalysts that was active and stable to the autothermal reforming conditions.

Catalysts have been pushed to perform under more difficult conditions in order to differentiate between the tested materials with the most active being tested at TUE under fluidization conditions. These tests indicate that the catalyst is stable as a fluidizable material under FERRET conditions (i.e. different NG compositions).

# 6 REFERENCES

# 7 ANNEXES