SELECTIVE ELECTROCHEMICAL REDUCTION OF CO_2 TO HIGH VALUE CHEMICALS

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DELIVERABLE REPORT

5.1 – BENCHMARKING GAS DIFFUSION LAYERS DELIVERED TO TUD, DTU, TUB	
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Author (s)	Daniela Galliani
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DISSEMINATION LEVEL		
PU	*Public*	***X***
PP	*Restricted to other programme participants (including the Commission Services)*	
RE	*Restricted to a group specified by the consortium (including the Commission Services)*	
CO	*Confidential, only for members of the consortium (including the Commission Services)*	

NATURE OF THE DELIVERABLE		
R	*Report*	
P	*Prototype*	
D	*Demonstrator*	***X***
O	*Other*	

SUMMARY	
Keywords	*Benchmarking, GDL, GDE, Delivery*
Abstract	*The use of Gas Diffusion Electrodes (GDEs) has been identified as a key tool to obtain an efficient CO2 electrochemical conversion to valuable chemicals. Work Package 5 will focus on obtaining an optimized GDE, which pass through the development of an optimized Gas Diffusion Layer (GDL, i.e. GDE without the catalytic layer) in order to achieve the performance targets.* *Such development phase begins with the evaluation of the currently commercially available GDLs, in order to setting the basis and have a reference benchmark to start from.* *For this reason, commercial DeNora GDL for Fuel Cells (code DN908) was shipped to DTU, TUB, TUD and EPFL. The first three universities will deposit a reactive layer with benchmarking catalysts and test the commercial GDL performances, while EPFL will perform structural studies (3D Tomography) to evaluate the GDL features and support the mass transport model development.*
Public abstract for confidential deliverables	

REVISIONS			
Version	**Date**	**Changed by**	**Comments**

BENCHMARKING GAS DIFFUSION LAYERS DELIVERED TO TUB, DTU, TUD

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1 INTRODUCTION

De Nora Industries is multinational company settled in Italy, with almost a century of experience in electrochemistry. Among its fields of activity, De Nora counts also Gas Diffusion Electrodes (GDEs) and Gas Diffusion Layers (GDLs)[1]. The basic concept of GDE is the possibility to use a gaseous reactant in an electrochemical cell. This leads to the necessity of an electrode with a porous structure that would allow the gas to penetrate it. Since electrolyte solution is needed to let the electrochemical reaction happen, the porous structure of the GDE should allow also the electrolyte solution in, enough to obtain the situation descripted in the simplified Figure 1.1:

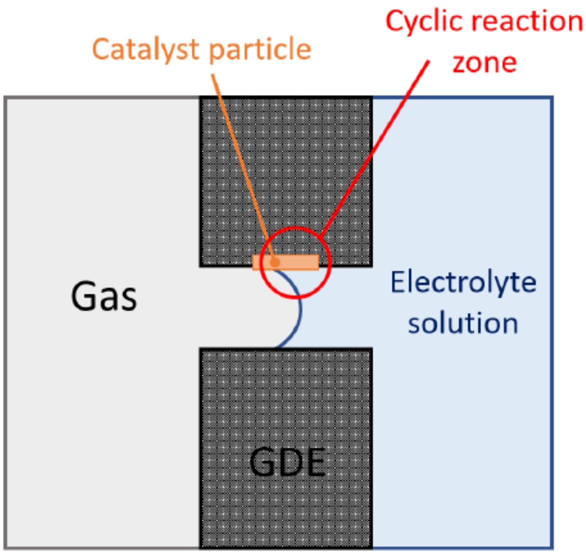

Figure 1.1: Simplified sketch of the cyclic reaction zone into the GDE

The highest efficiency of the GDE is obtained when its structure allows the presence of the depicted cyclic zone reaction, which includes three fundamental elements:

- Gas reactant;
- Electrolyte solution;
- Catalyst particle.

Such peculiar condition is challenging to obtain, because it is determined by a **fine balance between GDE hydrophilicity** (needed to allow wetting by electrolyte solution) and **its hydrophobicity** (needed to avoid the structure flooding by the solution), together with the **good control over porosity structure** (which regulates both gas and electrolyte solution access). Moreover, **the electrical conductivity of the final electrode** is also a key parameter to consider.

Over years, several different strategies were developed in order to obtain these structures[2,3], and nowadays a variety of GDEs and GDLs (which are GDEs without any catalyst) are available on the market for different applications, such as:

- **HCl and NaCl Brine electrolysis**[4]: when the processes involve the use of ODCs (Oxygen Depolarized Cathodes);
- **Fuel Cells**[5]: both as anodes to oxygen production and cathodes for hydrogen evolution.

De Nora has got a facility that produces at a large scale GDLs and GDEs for these applications and developed a strong expertise on their manufacturing.

2 SCOPE

The use of GDE for the direct electrochemical conversion of gaseous CO2 to valuable chemicals has been identified as the right tool in order to achieve the final goal of SelectCO2 project.

The currently available GDEs and GDLs, though, have been optimized for other specific applications. Since there is no already optimized commercial structure for CO2 conversion, it will be developed within the WP5 (Milestone 8). In order to set the starting point of GDE development process, a commercial De Nora GDL was selected as benchmark. This GDL (code name DN908) has been developed for Fuel Cells and it is industrially produced and commercially available. It will be used by Universities in charge of catalyst development (DTU, TUB, TUD) for benchmarking evaluation.

Deliverable 5.1 involves the shipping of this specific GDL to the listed Universities, to allow GDL benchmarking process to begin. Since in the benchmarking phase the reactive layer will be deposited by Universities, for this Deliverable De Nora shipped only GDLs and no completed GDEs to all of them.

3 DISCUSSION

3.1 Production and delivery from DENO

Commercial DeNora GDL for Fuel Cells (DN908) has been shipped to DTU, TUB, TUD and EPFL. The first three universities will deposit a catalyst reactive layer with benchmarking catalysts and test the commercial GDE performances, while EPFL will perform structural studies (3D Tomography) to evaluate the GDL features and support the mass transport model development.

A GDL sample around 25x20 cm was sent to all the Universities, except TUB. Two pieces (both 12,5x20 cm) were sent to TUB, one of them baked, the other one not baked. TUB catalyst was declared to stand up to 900°C, so some trials will be performed with GDE baking after catalyst deposition. The other Universities' catalysts, which cannot stand such high temperature, will be deposited on already baked GDLs. Following, the pictures of packages containing GDL pieces.

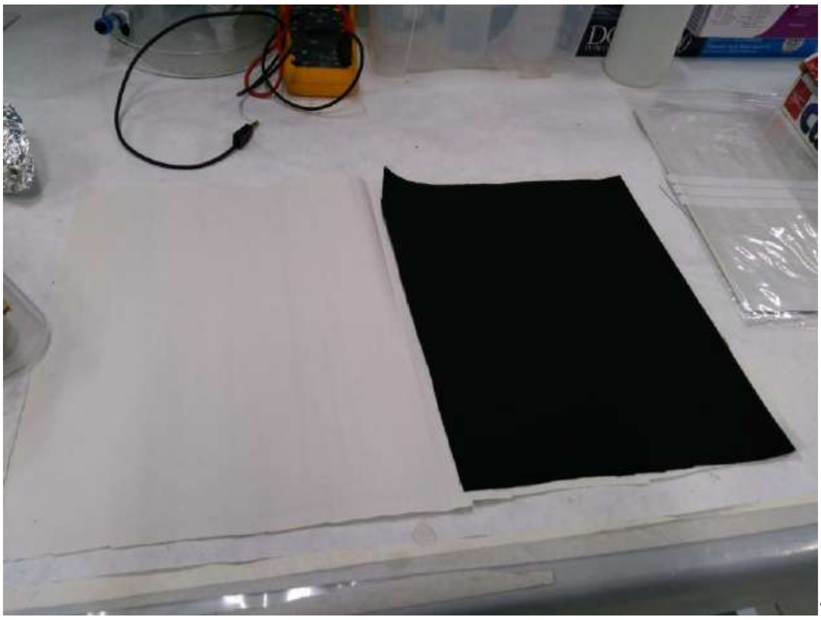
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Figure 3.1: One of GDL pieces in protective paper

Figure 3.2: One of GDL pieces wrapped in protective paper in plastic bag

Figure 3.3: Packages for the Universities

Figure 3.3: DHL Packages for the Universities ready to be shipped

3.2 Products received from partners

TUD received this product on March 17th 2020 from the courier. Due to a Covid-19 virus related shut-down immediately after the package was received, there was insufficient time to inspect the package. TUD has since partially re-opened, and the package has been inspected and it is in good shape for testing.

EPFL received this product on 12.03.20. After a first brief inspection, the GDL seems to be in a good shape and useful to perform tomography scans.

TUB received this product during the week of March 9th. The product was as expected and is available for testing.

DTU has been unable to verify that they have received this material since the entire university was on lock-down from March 12th due to issues related to the Covid-19 virus. De Nora followed the package tracking information, and it was stated to be located at DTU. When DTU partially re-opened, it was discovered to have made it to DTU. On May 14th the GDL's were inspected and determined to be in good shape for testing.

4 Conclusions and future work

The shipment of this commercial GDL is the initial step of GDE benchmarking, which will allow us to understand the features that need to be improved in order to obtain a customised GDL for CO2 electrochemical reduction. The future work will involve the deposition of the catalysts and the evaluation of commercial GDL performances.

5 References

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