Carbon2Chem®

L-III | Scale-Up of a Dielectric Barrier Discharge for Industrial Applications at Elevated Pressure

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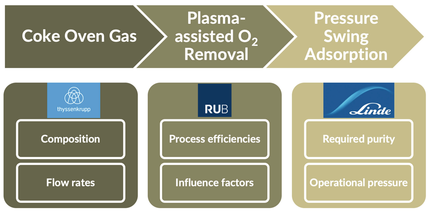
The removal of oxygen traces from coke oven gas is an intermediate step necessary for the gas conditioning in Carbon2Chem® to allow for higher oxygen content in the coke oven gas. A non-thermal plasma was successfully utilized to perform the desired gas conversion in a single electrode lab-scale reactor. The scale-up reactor consists of stacked plane parallel electrodes allowing to operate the process at high volumetric flow rates and elevated pressure while retaining low flow resistance.

INDUSTRY AND ACADEMIA: IMPROVING COMPATIBILITY BETWEEN SUPPLY AND DEMAND

Investigations on the plasma-assisted oxygen trace removal are performed in close contact with partners from industry. Here, thyssenkrupp AG provides necessary information about the composition of the coke oven gas, and other parameters like the flow rate. On a laboratory scale, the complex gas mixture is reproduced and the influence of different parameters is analyzed in detail. Lastly, the requirements of subsequent processing steps, namely the pressure swing adsorption are provided by Linde. Through this mutual exchange of information, the process feasibility can be discussed, and evaluated on the laboratory scale already under near industrial conditions.



The academic investigations are moving another step closer to industrial conditions, by performing measurements in the Carbon2Chem® pilot plant station in Duisburg. It is planned to perform measurements with real coke oven gas at elevated pressures in the near future and prove conclusively the operability under industrial conditions.

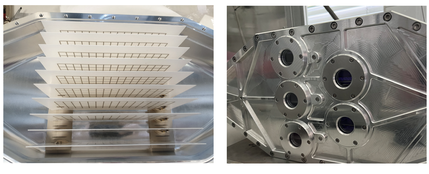


Fig. 1: Top view of the scale-up reactor developed at RUB; assembled in the Carbon2Chem® pilot plant station in Dusiburg. Left: opened, Right: closed.

SCALE-UP CONCEPT: HIGH FLOW RATE AND ELEVATED PRESSURE

The scale-up was realized by a Numbering-Up of the extensively investigated electrode design of the 1st phase (Fig. 1). A prototype reactor for the application in atmospheric pressure was developed to test the electrical circuitry igniting the plasma with high-voltage damped sine waves. To control the system a lab-view programmed interface was built that allows monitoring of discharge parameters and total current power consumption.

Current-voltage characteristics were measured on the high-voltage side and optical emission spectroscopy was applied to determine and compare plasma parameters (e.g. electron density, see Fig. 2).
Furthermore, the reactor was tested with a substitute reaction at varying volumetric flow rates at ambient pressure.

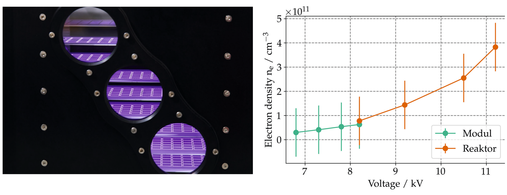


Fig. 2: Left: Ignited plasma in a prototype at atmospheric pressure (side-view). Right: Comparison of electron density of the prototype (green) and single electrode reactor (orange).

Considering the information gained from these experiments a pressure resistant reactor was developed and built. Utilizing this reactor, the oxygen trace removal in synthetic and real coke oven gas will be investigated at elevated pressure and varying flow rates. Results from these measurements such as specific energy input will indicate optimal operating points that are essential for the industrial partners.

A KEY BUILDING BLOCK
FOR THE CLIMATE PROTECTION

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