RHODES2024 19-22 JUNE rhodes2024.uest.gr

11th International Conference on Sustainable Solid Waste Management

Application of a two-stage polymeric membrane system for capturing CO_2 from simulated power plant flue gases

*P. Gkotsis, E. Peleka, A. Chatzis, A. Zouboulis**

Laboratory of Chemical and Environmental Technology, Department of Chemistry, Faculty of Sciences, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece; petgk@chem.auth.gr; peleka@chem.auth.gr; alexandroschatzis01@gmail.com; zoubouli@chem.auth.gr

Abstract

This work is part of a circular economy LIFE project (acronym: CO_2toCH$_4$) which aims to develop and demonstrate an innovative hybrid energy storage unit, based on renewable energy sources (RES) and the Capture, Sequestration and Utilization of carbon dioxide (CCSU) from typical power plant flue/waste gases, burning fossil fuels. This prototype pilot unit will consist of three sub-units: (1) an electrolyser for the production of green hydrogen from water electrolysis, by using preferentially RES, (2) a flue gas purification sub-unit for the effective separation of CO_2 from the flue gases, leading to a CO_2-rich gaseous stream, and (3) an ex-situ bio-methanation unit for the conversion of CO_2 to methane, with the use of appropriate microorganisms and after its reaction with the H_2 obtained from the electrolyser. The present work focuses mainly on the construction, installation and operation of the second integral sub-unit of the aforementioned prototype pilot unit, which aims at the effective capturing of CO_2. This sub-unit will be composed from a two-stage polymeric membrane system and is expected to yield a gas stream with a CO_2 purity of 75-80%.

Pilot-scale process

UBE CO_2 separation polyimide module

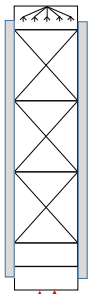
PI: Pressure Indicator
PT: Pressure Transmitter
PR: Pressure Regulator
FI: Flow Indicator
FT: Flow Transmitter
FR: Flow Regulator
SV: Safety Valve
C: Compressor

Electrolyser specifications

Characteristic	Unit
H_2 flow rate	0-2000 mL/min
H_2 purity	> 99.9995 %
Output pressure	0.2 – 4.0 bar
Dew point	-65 °C
Input power	500-1000 Watt
Voltage	AC 220V/110V, 50-60 Hz
Water tank capacity	6.0 L
Operating environment	5-45° C, < 80% υγρασία
Weight	< 30 kg
Water resistivity	> 1 MΩ·cm (< 1 μS/cm)
Dimensions (L x W x H)	505 x 368 x 352 mm
Membrane type	PFSA membrane

Electrolysing unit

Bio-methanation unit
(Trickle Bed Reactor, TBR)



Bio-methane, CH_4

Final product

H_2 CO_2

Anticipated outcome

- The membrane separation unit is expected to effectively separate CO_2 and produce a CO_2-stream that can be subsequently utilized in the bio-methanation unit.
- The flue gas mixture which consists of N_2/CO_2 90/10 mol.% is expected to yield a stream with a purity of 72% CO_2 and a flow rate of 62 L/h.
- The flue gas mixture which consists of N_2/CO_2 85/15 mol.% is expected to yield a stream with a purity of 82% CO_2 and a flow rate of 96 L/h.
- The total conversion efficiency of CO_2 and H_2 to CH_4 is expected to exceed 90%.

Acknowledgements

The "Demonstration of a mobile unit for hybrid energy storage based on CO_2 capture and renewable energy sources (LIFE CO2toCH4)" project has received funding from the LIFE Programme of the European Union.