October 2018

2nd Joint Newsletter of NANOMEMC², GRAMOFON and ROLINCAP EU projects

In the framework of Topic LCE-24-2016 "International Cooperation with South Korea on new generation high-efficiency capture processes", the three European Commission funded projects:

- NanoMEMC² - NanoMaterials Enhanced Membranes for Carbon Capture,
- GRAMOFON - New process for efficient Co_2 capture by innovative adsorbents based on modified graphene aerogels and MOF materials,
- ROLINCAP - Systematic Design and testing of Advanced Rotating Packed Bed Processes and Phase-Change Solvents for Intensified Post-Combustion CO_2 capture.

Organized a second Joint workshop in south Korea with the collaboration of the Korean Council for Reconciliation and Cooperation (KCRC, South Korea). This workshop was held in the Jeju island in conjunction with the "The 8th Korea CCS International Conference" and allowed to have a further overview of the current status and development of the three projects and their collaboration with Korean partners.

This newsletter reports the main results of the joint workshop and also wants to give an overview of the current achievements reached by the different projects that have now completed the first half of their activity. Future conferences organised or attended by partners will also be reported where you can meet partners and know more about their project.

2nd KOREA - EU Joint Workshop on CCS Jeju 24/01/2018

The second EU-South Korea joint workshop on "New generation high-efficiency capture processes" took place in Jeju Island (South Korea) on the 24th of January 2018 within the 8th Korea CCUS International Conference (24-26 January 2018, Jeju, KR). The workshop involved European and South Korean partners from NanoMEMC², GRAMOFON and ROLINCAP projects. The close session among different project partners had 40 participants and the 3 projects shared their experience in the twinning activities. In the open session, the 3 projects presented their first year results to an audience of around 80 people.

The public session of the workshop involved a presentation by Ms Hyejin Lee, of the Korean Carbon Capture and Sequestration R&D Center, outlining the main directions of research in the area of Carbon Capture. A brief overview of the active projects and the prospects for future calls was also presented. In particular the interaction with European projects was stressed and the commitment of KCRC on these activities was confirmed.

KCRC representative outlines Korean priorities in carbon capture research

EU representative explains the European approach in carbon capture research

The status of research in the European Union was presented by Mr. Johan Vandromme (First Counsellor, Trade and Economy Section, EU Embassy). The main research instruments and the key strategic decisions in building a solid plan for the investigation of the main societal challenges in European Union were presented.

Prof. P. Seferlis (ROLINCAP/CERTH) the ROLINCAP project coordinator, gave a presentation on the current status of the twinning activities with Korea within the framework of ROLINCAP. There are two Korean partners in ROLINCAP and both have endorsed the grant agreement. Partner GIST (Gwangju Institute of Science and Technology) is mainly involved in tasks that aim at developing new and highly performing solvents. Within this framework, GIST has developed solvents that exhibit high CO_2 absorption at low temperatures but CO_2 is released due to destabilization effects of the solvents in the mixture at higher temperatures. In this way, the overall thermal duty can be potentially reduced significantly. During the ROLINCAP meeting in Daejeon, the consortium has decided to further extend this idea by using phase change solvents. It is then expected to investigate whether the two phenomena (carbamate destabilization and phase splitting) can show any synergies.

Partner KAIST (Korea Advanced Institute of Science and Technology) is mainly involved in the dynamic modeling of solvent based CO_2 capture processes and the optimization of the dynamic behavior during transient operating points. KAIST participates in WP3 and interacts with other partners involved in modeling and operability tasks.

KAIST presents ROLINCAP research activities

Dr M.C. Ferrari, lead person for the twinning activities of project NANOMEMC^2, gave an overview of the twinning activities with Hanyang University (Professor Ho Bum Park, Energy Engineering), South Korean partner of NANOMEMC^2 project. The twinning activities in NANOMEMC^2 already performed have 4 main streams:

- Exchange of information: organization of meetings, workshops and webinars to exchange information and input on current status of their researches;
- Exchange of materials: Materials (different type of nanofillers) and membranes to be exchanged by the different partners of the two projects;
- Exchange of data: Common database of the project outcomes to exchange experimental results concerning membrane properties and performance;
- Exchange of researchers: Short term missions (STMS) to perform specific activities in the twin project facilities, to work on the exchanged materials characterisation and modelling as well as on different topics agreed between the partners.

Dr. A. Benedito, GRAMOFON project coordinator, gave an overview of the twinning activities for GRAMOFON. He outlined the objectives of the twinning activities and presented a SWOT analysis to define the relation between EU and Korean scientific institutions in CO_2 capture. The main instruments of the twinning activities in the GRAMOFON projects are collaborative workshops, small stays of scientific staff among institutions and joint scientific work to complete the planned tasks. Apart from the 2 joint workshops in Trondheim and Jeju island, a technical meeting on advanced porous materials with Korean institutions KRIST, Korea University, and Chonnam National University took place on January 22nd 2018. The technical collaboration on GO (Graphene oxide) materials between partner CNRS and Korea University resulted in several experimental campaigns and molecular dynamic simulations. The technical collaboration with KRICT aims at the shaping of the MOFs.

Brief description of the NANOMEMC² project

Within the current environmental concerns about global warming, Carbon Capture and Storage (CCS) is seen as a necessary medium term technology to reduce greenhouse gas emissions into the atmosphere while waiting for a complete transition towards a more sustainable energy system.

Currently, the main limit to the application of CCS technologies is its high cost of implementation; therefore, strong research efforts are needed to optimize current capture processes and make CCS an economically viable solution for the decarbonisation of the industrial sector.

The NANOMEMC² project aims at solving such limitations through the development of innovative materials, membranes and processes for CO_2 capture, able to achieve a substantial reduction in the energy penalty related to the decrease of CO_2 emissions. In particular project's objectives are (Fig.1):

- Development of new CO_2 selective membranes with high flux and selectivity

- Development of new H_2 selective membranes with high flux and selectivity

- Development of highly integrated Capture solutions based on innovative process schemes and newly developed membrane technologies

NANOMEMC² applies new membranes to both Pre- and Post-combustion capture schemes in order to increase the flexibility of proposed solutions thus maximizing the chance of success of the resulting technologies.

NANOMEMC² also addresses the development of new, high efficiency capture processes; selected through techno-economic and environmental analysis of possible process schemes tailored for a competitive implementation of membrane based capture steps in the industrial plants of interest.

NANOMEMC² intends to validate the above targets in relevant industrial environments to build a solid business case for future developments towards industrial deployment of membrane based carbon capture solutions.

Finally, NANOMEMC² seeks strong collaboration with the Republic of Korea in the field of CCS to exploit complementary expertise and synergies in the development of new capture solutions.

Fig.1 – NANOMEMC² project's objectives

NANOMEMC²: What has been achieved so far

NANOMEMC² is structured in 3 phases related to Material Development, Process Integration and Technology Validation (Fig.2).

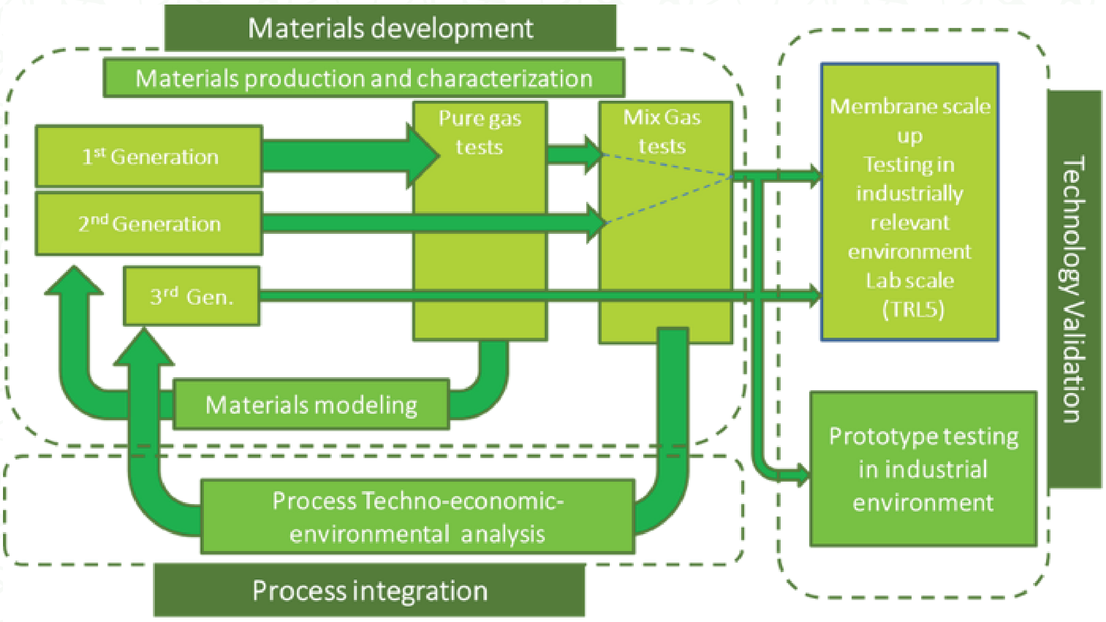


Fig. 2 - NANOMEMC² project workflow

Materials Development focuses on the production of graphene or nanocellulose based hybrid membranes to attain the first two scientific objectives of the project. It moves through the production of three different generations of materials with increased separation efficiency and permeance.

To this purpose, the NANOMEMC² Consortium developed more than fifty 1st generation materials by coupling state of the art nanofillers and commercial or pseudo commercial polymers, to identify and select the best candidates for subsequent activities. All samples were subjected to a basic structural characterization and to pure and mixed gas permeation tests to determine their potential capture performances.

2nd generation materials were also produced starting from the modification of Graphene/Graphene oxide and Nanocellulose to be used as nanofillers in the most promising polymers considered for first generation samples. Currently, these materials are being used for the production of innovative CO_2 and H_2 selective membranes, which will be tested in the subsequent phases of project.

In addition, novel modelling approaches were developed within the project able to guide the material design by focusing on the development of micro- and macro-scopic modelling tools for the description of facilitated transport membranes (Fig.3).

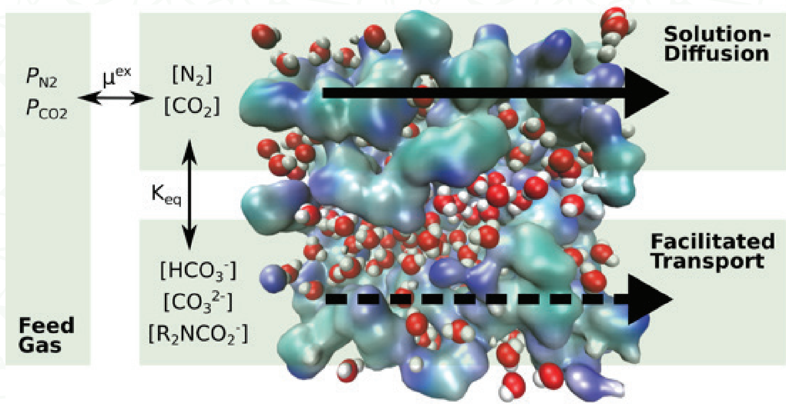


Fig. 3 - NANOMEMC² novel modelling approaches

The Process Integration phase aims at reaching the 3rd scientific objective of NANOMEMC² which is the competitive integration of membranes into different industrial processes. To that aim, existing industrial processes, known for contributing to climate change, were investigated and analysed to become a meaningful benchmark for the quantification the novel NANOMEMC² processes benefits. Four of such Industrial Production Scenarios were selected and analysed considering both pre and post combustion solutions:

Power generation from natural gas

- Power generation by coal gasification
- Clinker production (Cement)
- Hydrogen production via steam methane reforming

During the first half of the project, in particular both "Business As Usual" case, without any carbon capture, and "Base Case" applying state-of-the-art CCS technologies were evaluated for benchmarking purposes.

The Technology Validation phase includes all the activities needed to bring the NANOMEMC^2 membrane technology to TRL 5 and to the validation in an industrially relevant environment. So far, activities of this phase have focused on the development of membrane modules and on the set up of industrial, pilot or pre-pilot scale test rig for the final testing of NANOMEMC^2 membranes.

Module development focused mainly on the scale up of the membrane production process by optimizing the procedures to obtain a continuous, thin, selective layer on top of the considered porous supports (Fig.4).

The main characteristics of the industrial testing rig were also determined to allow the construction of the various systems at the partner's premises, a process that is now close to completion.

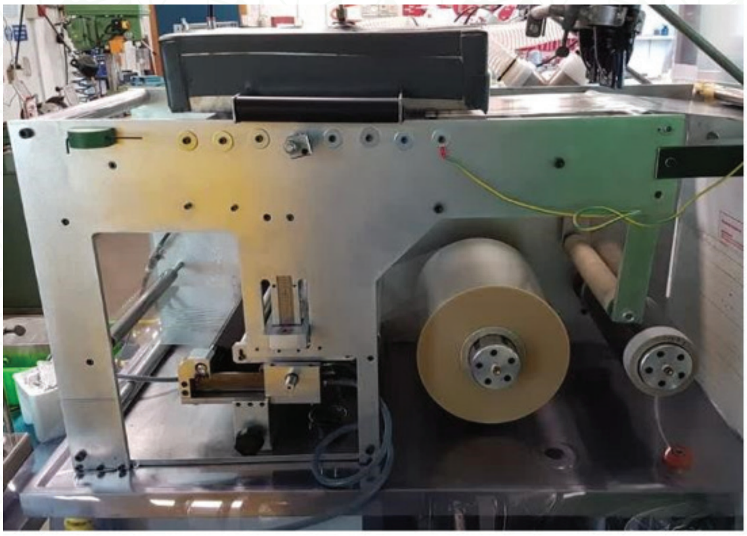


Fig. 4 - NANOMEMC^2 membrane production process

Based on these preliminary results the NANOMEMC^2 Consortium decided to start the production of the first membrane module by considering a 1st generation materials produced by NTNU. This activity will facilitate the execution of the first industrial tests to be performed before months 30, in line with the initial project plan.

Following the successful technical development, several exploitation and dissemination activities were also performed: two exploitation workshops were organized and a stakeholder analysis was carried out as a basis for the project's exploitation strategy. Other dissemination activities included the production of several communication and dissemination materials, the organization of a dissemination workshop, the project presentation at international conferences and events, and the development of the project website.

NANOMEMC^2: Progress beyond the state of the art, next steps and potential impacts

NANOMEMC^2 aims at a substantial decrease of the costs associated to carbon capture, by developing innovative membranes materials with high flux and selectivity and innovative processes able to maximize the membrane impact on the capture performance in industrial applications.

Naturally, a quantification of the impact of NANOMEMC^2 results on CCS costs and on its deployment in the industrial and energy sectors is challenging today considering that the project is still in progress, however during its first 18 months, NANOMEMC^2 obtained a broad range of promising results.

Most of the materials investigated in this period, indeed showed properties in line or above the current permeability/selectivity trade off limit for CO_2 separation membranes, and new modelling tools were applied for the first time to the problem of facilitated transport membranes.

These initial results align well with the planned project outcomes related to the development of:

- New functionalized nanofillers
- Innovative high performance CO_2 or H_2 selective Hybrid Membranes
- New modelling tools for the description of gas transport facilitated transport membranes.
- Innovative membrane based capture processes
- Optimized integration schemes for membrane based capture implementation in different industrial processes.

Interested in knowing more? Download NANOMEMC² open access publications

- Dai, Z.; Aboukeila, H; Ansaloni, L; Deng, J; Giacinti Baschetti, M; Deng, L. Nafion/PEG hybrid membrane for CO_2 separation: Effect of PEG on membrane micro-structure and performance, *Separation and Purification Technology* **2018**
- Janakiram, S.; Ahmadi, M.; Dai, Z.; Ansaloni, L.; Deng, L. Performance of Nanocomposite Membranes Containing 0D to 2D Nanofillers for CO_2 Separation: A Review. *Membranes* **2018**, 8, 24.
- Rea, R.; Ligi, S.; Christian, M.; Morandi, V.; Giacinti Baschetti, M.; De Angelis, M.G. Permeability and Selectivity of PPO/Graphene Composites as Mixed Matrix Membranes for CO_2 Capture and Gas Separation. *Polymers* **2018**, 10, 129

Brief description of the GRAMOFON project

Key EC roadmaps towards 2030 and 2050 have identified Carbon Capture and Storage (CCS) as a central low-carbon technology to achieve the EU's 2050 Greenhouse Gas (GHG) emission reduction objectives, although there still remains a great deal to be done in terms of embedding CCS in future policy frameworks. The selective capture and storage of CO_2 at low cost in an energy-efficient is a world-wide challenge. One of the most promising technologies for CO_2 capture is adsorption using solid sorbents, with the most important advantage being the energy penalty reduction during capture and regeneration of the material compared to liquid absorption. The key objectives of GRAMOFON projects are:

(i) to develop and prototype a new energy and cost-competitive dry separation process for post-combustion CO_2 capture based on innovative hybrid porous solids Metal Organic Frameworks (MOFs) and Graphene Oxide (GO) nanostructures.

(ii) to optimize the CO_2 desorption process by means of Microwave Swing Desorption (MSD) and Joule effect, that will surpass the efficiency of the conventional heating procedures. This innovative concept will be set up by world key players expert in synthesis, adsorption, characterization and modelling, as well as process design and economic projections.

GRAMOFON aims to design new and innovative nanostructured materials for effective post-combustion CO_2 adsorption/desorption processes. In this way, the selection of materials corresponds to the necessity to maximize CO_2 capture effectiveness and reduce cost/time/energy on desorption and regeneration processes. Innovative, selective and modified nanostructured surfaces with high affinity for CO_2 have been selected:

- Metal Organic Frameworks (MOFs);
- MOF/GO composites;
- Mesoporous structures based on GO aerogels.

Microwave Swing Desorption (MSD), is an effective technology for the desorption of captured CO_2. An important issue of this project will be the development of a new prototype of microwave antenna system to optimize MSD process with the innovative nanomaterials, and further characterization of the capture systems in terms of desorption behaviour. In the same way, Joule effect is also responsive to conductive carbonaceous nanomaterials. A prototype at laboratory scale will be developed with the objective to estimate the heating effectiveness in terms of CO_2 desorption.

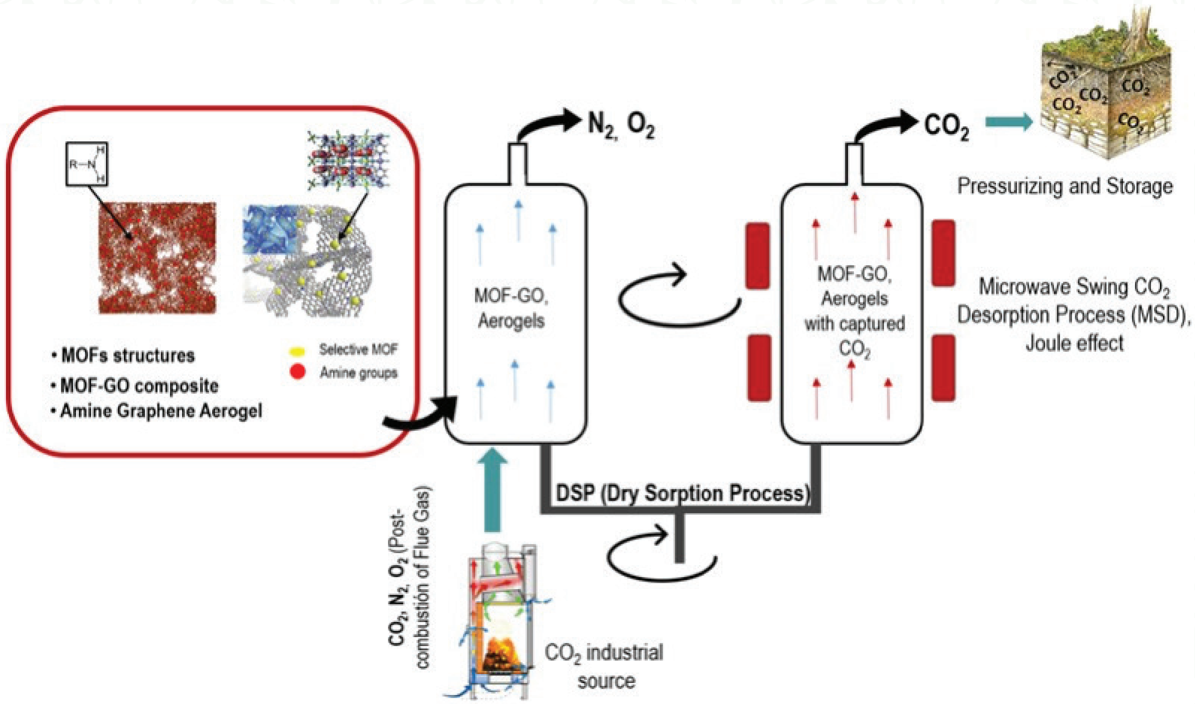


Fig.5 - GRAMOFON working flow.

GRAMOFON will first design a series of advanced nanomaterials, i.e. functionalized GO, MOFs and their composites specifically targeted for CO_2 post-combustion capture. GRAMOFON will further develop CO_2 desorption processes by means of MSD and Joule effect, increasing several times faster than conventional heating procedures. The project has a strong innovation component combining state-of-the-art knowledge and technologies from partners to create a competitive EU manufacturing sector by implementation of innovative materials and technologies for CO_2 capture and desorption, allowing fast, efficient and cost effective CCS technologies. Work plan and project structure include a well-equilibrated consortium balanced between R&D, applicant partners, Korean partner collaboration and twining actions.

The project is currently developing a complete functional prototype at laboratory scale. Post-combustion CO2 emission of flue gas will be simulated in order to develop the innovative CO_2 capture systems based on highly porous surface structures. To create this unique product, the following innovations are being implemented in GRAMOFON:

- Development (shaping and scale-up) of water stable MOF with high CO_2/N_2 selectivity.
- Functionalization of GO sheets with amine groups for an enhancement of the affinity for CO_2.
- Optimization of mesoporous morphology of the GO aerogel structure controlling processing route: supercritical

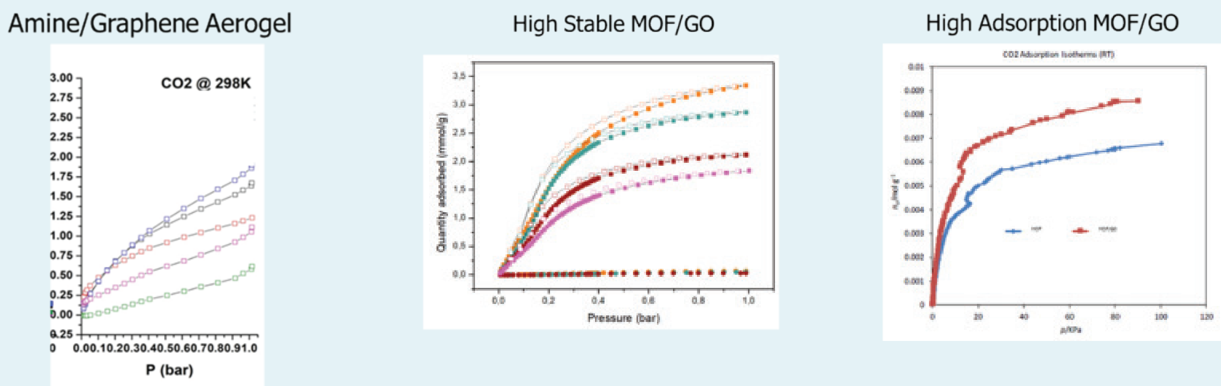
drying, freeze drying; as well as the own graphene morphology (XY ratio, one layer).

- Design of MOFs/functionalized GO composites specifically targeted for the targeted process.
- Economic and ecological assessment of these innovative adsorbents for an optimal cost/benefit ratio.
- Improvement of the long-term cycle life of these novel adsorbents.
- Development of an Effective desorption process based on improved microwave heating technology.
- Exploration of alternative heating routes based on Joule Effect.

Activities developed will be implemented from TRL 2-3 to 4-5, since a technology concept formulated and based on experimental proof of concept validated along the project at laboratory and relevant environme

GRAMOFON: What has been achieved so far

At this moment GRAMOFON is optimizing the new composite materials in terms to maximize adsorption capacities. In detail, GRAMOFON is working on combinations of MOF/GO and GO/amine modified materials with high CO_2 adsorption capabilities and interesting physical properties. Selected materials are currently being shaped to increase mechanical resistance and to reduce potential pressure drop in the future column prototype. This shaping process transforms the materials from powder to pellets -cilindric, cubic- shape. We can divide the materials developed in three different levels: GO/amine with moderate CO_2 adsorption but great stability and microwave adsorption; high MOF/GO CO_2 adsorption capacities with good stability and microwave adsorption; and MOF/GO with very high CO_2 and microwave adsorption but very limited stability. This is summarized in Figure 6.



Moderate CO_2 Adsorption (2 mmol/g); high thermal and chemical stability; no water Adsorption; very high MW susceptor behaviour.

High CO_2 Adsorption (3.2 mmol/g); good thermal and chemical stability; limited sensibility to water; good MW susceptor behaviour; easy production.

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Fig.6 - CO_2 isotherms for developed materials

In another hand, GRAMOFON project continues working on the desorption process with the objective to reduce energy requirements using microwave radiation. Once characterized composite material from dielectric point of view, the work has been focused on the design and requirements of a microwave desorption prototype unit considering the commented microwave absorption behaviour of the studied materials. The 3D design is the following:

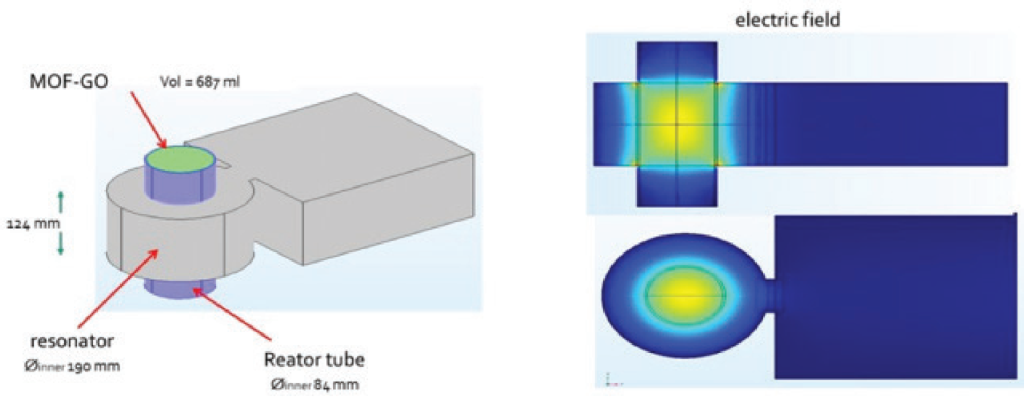


Fig.7 - Prototype design for MSD (Microwave Swing Desorption).

Advancing in the initial objectives of GRAMOFON project, requirements and simulation for CO_2 capture from the main industries that emit CO_2 (steel, cement, and refineries) have been collected, as well as, the initial data for life cycle analysis (LCA).

GRAMOFON: Progress beyond the state of the art, next steps and potential impacts

GRAMOFON project aims to achieve quantitative improvements in Carbon Capture (CCS) technologies, by combining innovative materials and desorption technologies, to ensure the implementation in most of the relevant industrial sectors in Europe, thus guaranteeing the European goals concerning CO_2 emissions and climate change, and promoting the use of industrial feedstock from renewable source with a positive CO_2 balance as a more sustainable approach, reducing the environmental impact and combating the climate change, fully in line with the WFD and reducing the VOC emissions, thus increasing awareness and environmental compatibility as a result of the European VOC Directive. In this way, the new composite materials are showing an important improvement as CO_2 adsorbent. Probably, they are not the highest adsorbent materials developed until today, but yes, they are the most balanced ones from stability, adsorption, and energy saving properties.

Moreover, the participation of Korean partners, to develop project tasks and twinning activities, will ensure a high impact of the project results, the technological transference outside the EU borders, and the alignment with the global environmental policies. Climate change will only be successfully tackled if addressed globally. Leading action by the EU can drive the necessary international cooperation, but there is additionally a clear policy rationale for promoting the use of mitigation technologies in countries that will need them to reorient their expanding economies to a low carbon pathway. This undoubtedly includes CCS, for which the non-EU market is likely to be much bigger than the internal market.

Interested in knowing more? Download GRAMOFON open access publications

Open access publications concerning GRAMOFON project are planned for the last year of the project, this means, during 2019-2020. From dissemination point of view, GRAMOFON project has participated in several events and workshops, leaving apart Korean collaborations. For example, we would like to underline events like PLASTICSAREFUTURE 2018, GRAPHIN 2018, POLYMAT SPOTLIGHT 2018, or GRAPHENE WEEK 2018 under the umbrella of GRAPHENE FLAGSHIP.

Brief description of the ROLINCAP project

ROLINCAP is focusing on two new types of solvents and separation process technologies for CO_2 capture, namely phase-change solvents and rotating packed-bed (RPB) columns.

• Phase-change solvents are able to significantly reduce the energetic requirements of solvent regeneration by more than 50% compared with the conventional monoethanolamine (MEA) solvent used widely in CO_2 capture. This is because their reaction with CO_2, followed sometimes by an increase in temperature, results in spontaneous separation of large amounts of water and solvent (liquid-liquid phase-split, Figure 8), leaving the CO_2 captured in a CO_2-rich, liquid stream with much less water and amine (Figure 9). These two liquid phases can be separated mechanically due to difference in density with practically very little energy. Furthermore, the CO_2-rich stream that enters the thermal separation stage is significantly reduced, hence the large regeneration energy requirements can also be reduced.

Figure 8 - Phase-split in CO_2-amine-H_2O

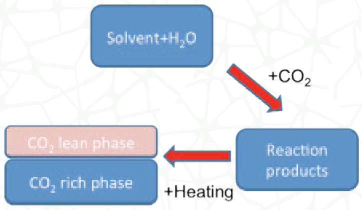


Figure 9 - Phase change concept in carbon capture.

• RPB columns enable a significant enhancement of the mass−transfer rate between the gas and liquid phases because they are contacted in the presence of a high centrifugal field (Figure 10). Numerous advantages of RPB include considerable reduction of the equipment size, very short residence times hence very limited corrosion and use of viscous solvents, which may not be suitable for conventional process systems.

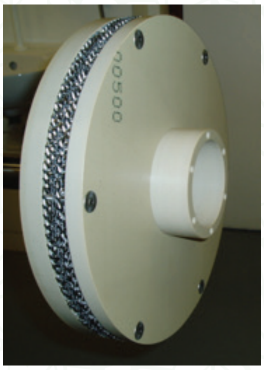


Figure 10 - Rotating packed bed unit.

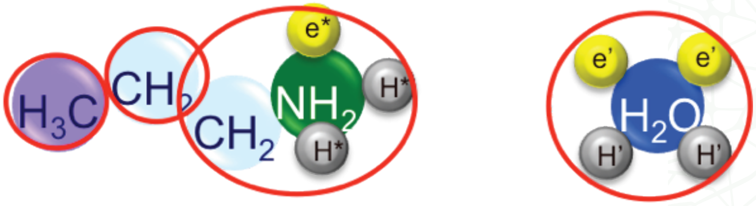


Figure 11 - Group contribution concept in thermodynamic modeling.

ROLINCAP: What has been achieved so far

Thermodynamic model development

ROLINCAP employs the statistical associating fluid theory (SAFT) equation of state to predict important thermodynamic properties relevant to the phase-behaviour of CO_2 and mixed solvents exhibiting liquid-liquid phase-split. The development of SAFT-based models takes a group contribution approach in ROLINCAP (Figure 11). The employed EoS implicitly accounts for the phase and chemical equilibrium characteristics of solvent-water-CO_2 mixtures hence it predicts the mixture behaviour without the need to postulate reactions or reaction products.

• A model able to predict the lower critical solution temperature (LCST) in solvents that appear as a very suitable option for ROLINCAP investigations.

• New ad hoc groups for cyclohexyl substituted amines, which makes the extension of the developed model to all type of amines that currently are being studied in the context of CO_2 capture possible.

Computer-Aided Molecular Design (CAMD) for solvent selection

ROLINCAP approaches for the first time the design of phase-change solvents through optimization-based Computer-Aided Molecular Design (CAMD) (Figure 12). The proposed approach involves a screening stage where molecular structures are generated and evaluated during CAMD based on criteria and constraints such as CO_2 and water solubility in solvent, solvent vapour pressure, heat capacity, viscosity and basicity, to name but a few. Such properties capture the solvent effects on the process thermodynamic and reactivity performance, guiding CAMD toward useful options with the potential to exhibit liquid-liquid phase separation. In addition, we consider during CAMD numerous solvent properties associated with cradle-to-gate life-cycle assessment and safety, health and environmental hazard assessment.

• We find novel solvents, including cyclic and acyclic amines, for use as components in efficient phase-change mixtures. Known phase-change solvents such as N-Methylcyclo hexylamine (MCA) and N,N-Dimethyl cyclohexylamine (DMCA) are also designed during CAMD, hence verifying the validity of our approach.

• A shortlist of few candidates in generated using a systematic analysis method, which are then evaluated using SAFT and lab VLLE experiments.

• The use of the framework in the CAMD approach indicates that there are phase-change solvents which exhibit favorable performance in several sustainability categories, compared with previously identified phase-change solvents in published literature.

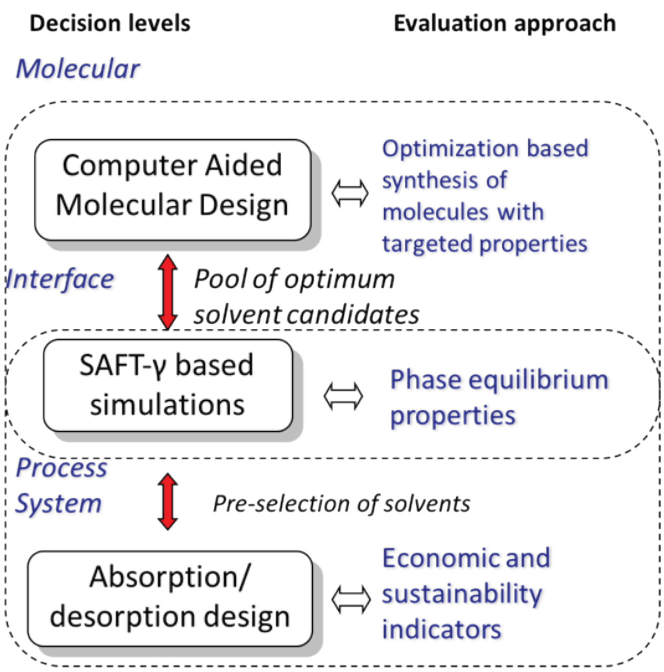


Figure 12 - Computer aided molecular design method

Modelling and design of packed-bed absorption/desorption systems

Two types of models for the design of packed-bed absorption/desorption systems using phase-change solvents have been developed; a non-linear shortcut model and a rigorous column model.

• Very good match of both models with experimental data was shown in key performance indicators including reboiler duty, net efficiency energy penalty points, cyclic capacity, solvent mass flowrate, solvent purchase cost and lost revenue from parasitic electricity upon integration with power plants.

- The process performance of selected phase-change solvents was compared with conventional solvents from literature, indicating a superior performance.

Modelling and design of RPB systems

A reference dynamic process model for carbon capture with phase change solvents using PRB for the absorber and the stripper was developed in gPROMS® GC-SAFT-γ-Mie EoS. Because there is no available process model for RPBs yet, this work has been done in three stages, including (1) selecting appropriate methods for modelling work of RPB, (2) developing a dynamic process model for RPB carbon capture process with MEA solvent, and then (3) developing a dynamic process model RPB carbon capture process with selected phase change solvents.

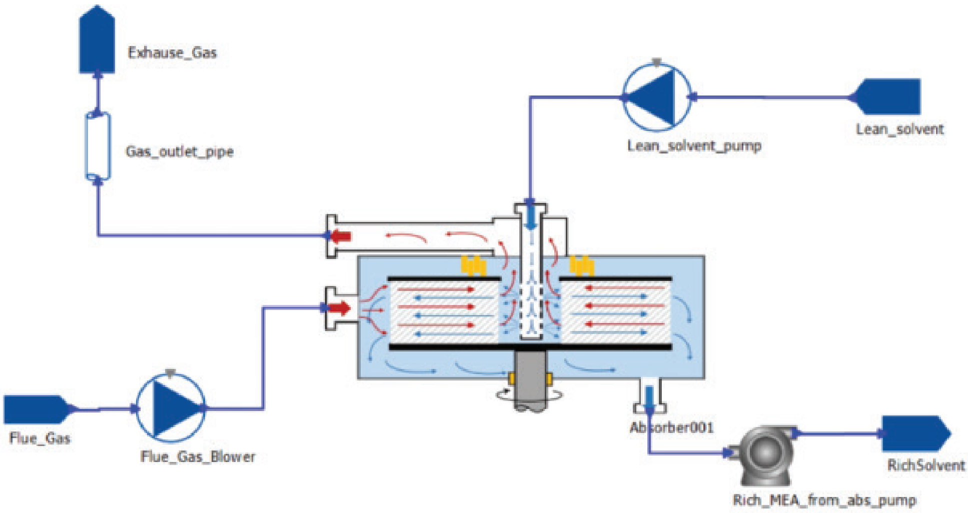


Figure 13 - RPB modeling realization

Pilot plant construction and testing

Absorption/desorption with conventional columns and rotating packed bed pilot plants were constructed and tested (Figure 14). The plants include numerous instruments and measuring devices, together with custom sensors and automatic loops for the control of stream flows, levels, temperatures and pressures. A set of experiments has been performed aiming to determine the range of liquid and gas stream flowrates circulating in the plant.

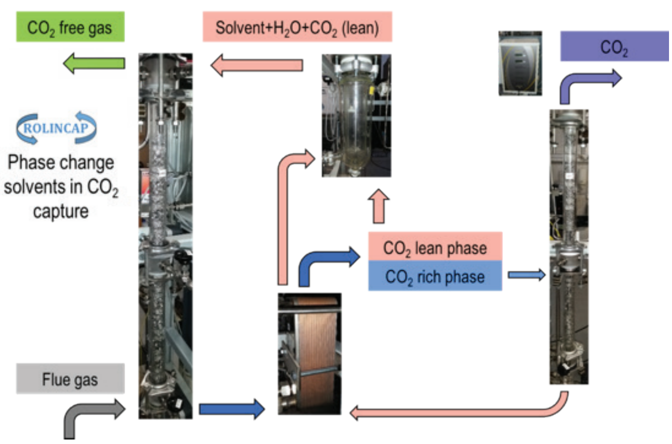


Figure 14 - Absorption column carbon capture pilot plant.

Figure 15. RPB pilot plant

ROLINCAP: Progress beyond the state of the art, next steps and potential impacts

The progress beyond the state of the art expected is summarized as follows:

- A computer-aided approach is developed and used throughout ROLINCAP to support the identification of new phase-change solvents, the rigorous characterization of phase-change behavior, and their process performance in both packed- and rotating packed-bed processes.
- New group-group interaction parameters are developed for structures widely observed in phase-change solvents.
- They are used in the GC SAFT-γ-Mie EoS to rigorously predict the vapour-liquid-liquid equilibrium performance of selected phase-change solvents.
- These solvents are selected using a CAMD approach which considers multiple criteria pertaining to thermodynamics, reactivity and sustainability.
- The sustainability assessment is performed during CAMD through a holistic framework which addresses and eliminates data gaps in conventional models using data mining and similarity assessment techniques.
- Numerous sustainability indicators pertaining to Life Cycle Assessment and Safety, Environmental and Hazard assessment are predicted for all molecules generated in CAMD.
- Solvents are further evaluated through numerous process performance criteria relevant to the capture process as well as down- and up-stream processes.
- Process flowsheets are designed using optimization techniques to determine the optimum operating conditions for the selected solvents.
- RPB process models are developed and their operating conditions are determined using optimization approaches for selected phase-change solvents
- Gate-to-gate holistic sustainability assessment is performed at the process level to determine the expected impacts as well as to identify operating regimes that may reduce them.
- The proposed solvents and processes are introduced into power and lime production plants to identify integration options which will enable further reduction of parasitic losses.

Interested in knowing more? Download ROLINCAP open access publications

Presentation in the Trondheim CCS Conference

- Systematic selection of mixtures as post-combustion CO_2 capture solvent candidates

  T. Zarogiannis, A. I. Papadopoulos, P. Seferlis

- Computer-Aided Molecular Design of CO_2 capture Solvents considering Thermodynamics, Reactivity and Sustainability

  A. I. Papadopoulos, S. Badr, A. Chremos, E. Forte, T. Zarogiannis, P. Seferlis, S. Papadokonstantakis, C. S. Adjiman, A. Galindo, G. Jackson

- Performance assessment of solvent-based CO_2 capture processes: Design of complex flowsheets with different solvents

  Th. Damartzis, A. I. Papadopoulos, P. Seferlis

- Overview of Intensified Solvent-based Carbon Capture Research at the University of Sheffield

  Meihong Wang

Where can you meet NANOMEMC² project partners?

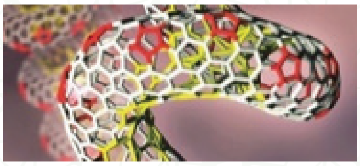
NANOMEMC2 partners will organise an International Industrial Workshop on CCS in Brussels on the 11th of April 2019. Industrial and scientific experts will be invited to share their view on CCS. Register on NANOMEMC2 website to get updates on the event and its final agenda.

Where can you meet GRAMOFON project partners?

The current plans include the participation the next year into the TCCS-10 The **10th Trondheim Conference on CO_2 Capture, Transport and Storage** on June 17-19. Researcher partners such as CNRS-Paris, CNRS-Montpellier, or UMONS University.

Where can you meet ROLINCAP project partners?

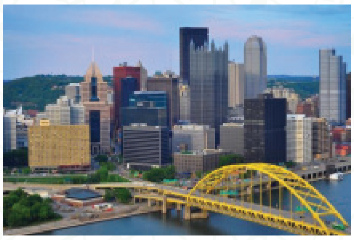
ROLINCAP partners will attend the following events:



• "Frontiers of Molecular Engineering", September 27 - September 28, 2018, Institute of Molecular Engineering (IME), University of Chicago, Chicago, U.S.A.

ROLINCAP conference presentations:

"Design of Phase-Change Solvents for Post-Combustion CO_2 Capture based on Molecular Thermodynamics", Felipe A. Perdomo, Athanasios I. Papadopoulos, Amparo Galindo , Claire S. Adjiman, George Jackson , Panos Seferlis



• "2018 AIChE Annual Meeting", David L. Lawrence Convention Center Pittsburgh, PA, October 28 - November 2, 2018.

ROLINCAP conference presentations:

- "Systematic Design of Phase-Change Solvents for Post-Combustion CO_2 Capture Based on Advanced Thermodynamics and Holistic Sustainability Assessment", Athanasios I. Papadopoulos, Gulnara Shavalieva, Felipe Perdomo-Hurtado, Panos Seferlis, Stavros Papadokonstantakis, Claire S. Adjiman, Amparo Galindo, George Jackson

- "Efficient Selection of Conventional and Phase-Change CO_2 Capture Solvents Based on Nominal and Off-Design Process Operation", Theodoros Zarogiannis, Athanasios I. Papadopoulos, Ioannis Tsivintzelis, Panos Seferlis

Future Joint events

Following the success of the second EU-South Korea joint workshop, NanoMEMC2, GRAMOFON and ROLINCAP partners plan to organise a third joint workshop in the summer of 2019. Details are still being finalised but register your interest with one of project partners above to receive detailed information as soon as it is available or follow us on the websites or socials to know more.

How can you engage with the NANOMEMC², GRAMOFON and ROLINCAP project?

If you want to learn more about the NANOMEMC² project, visit the website at www.nanomemc2.eu and subscribe to the newsletter, or Follow the project on the social.

Follow our @NanoMEMC² tweets on Innovation Place and CiaoTech

Follow our @NanoMEMC² news on Innovation Place

Follow us on Facebook

Follow us on Research Gate

To get in touch with one of the NANOMEMC² partners, please e-mail the Co-ordinator Marco Giacinti Baschetti at Marco.Giacinti@unibo.it or the contact person for *Dissemination and exploitation activities* Ada Della Pia at A.Dellapia@ciaotech.com or visit the website contact page.

If you want to learn more about the GRAMOFON project, visit the website at www.gramofonproject.eu and subscribe to the newsletter, or Follow the project on the social.

Follow our GRAMOFON tweets on @Gramofon_CCS

To get in touch with one of the Gramofon partners, please e-mail the Co-ordinator Adolfo Benedito at abenedito@aimplas.es or the contact person for Dissemination Mark T Smith at Mark.T.Smith@teledyne-e2v.com or visit the website contact page.

If you want to learn more about the ROLINCAP project, visit the website at rolincap-project.eu and subscribe to the newsletter, or Follow the project on the social.

Follow our ROLINCAP tweets on @rolincap

To get in touch with one of the Rolincap partners, please e-mail the Co-ordinator Panos Seferlis at seferlis@cperi.certh.gr or visit the website contact page.

NANOMEMC² Consortium

GRAMOFON Consortium

ROLINCAP Consortium

About Horizon 2020

All three projects have received funding from the European Union's Horizon 2020 research and innovation programme. The H2020 LCE-24-2016 project supports the development of high potential novel technologies or processes for post and/or pre-combustion CO_2 capture. Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020). It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the laboratory to the market. Coupling research and innovation, Horizon 2020 has its emphasis on excellent.

For more information:

https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020