

EPAN EK 2014-2020

OPERATIONAL PROGRAM:

“Competitiveness – Entrepreneurship-Innovation”

The company **CAO HELLAS THESSALIKI ASVESTOPOIIA ABEE**, is participating in the operational program “Competitiveness – Entrepreneurship-Innovation”, in collaboration with the **CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS**, and the **ARISTOTLE UNIVERSITY OF THESSALONIKI**, in the project REALCAP Τ2ΕΔΚ-01911. The project is realized in the periphery of Central Macedonia.

The total budget of the project is: 662.481,92€, from which 594.654,42 € is publicly funded.

The total budget for **CAO HELLAS THESSALIKI ASVESTOPOIIA ABEE** is 271.310,00 €, from which 203.482,50 € is publicly funded.

The total budget for the **CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS** is 291.957,92 €, from which 291.957,92 € s publicly funded.

The total budget for the **ARISTOTLE UNIVERSITY OF THESSALONIKI** is 99.214,00 €, from which 99.214,00 € s publicly funded.

The business plan that has been approved for funding and is realized, includes investments in the following categories:

- ✓ Personnel expenses
- ✓ Instruments and equipment expenses
- ✓ Indirect operational expenses
- ✓ Additional general expenses and other operational expenses

Through its participation, CAO HELLAS THESSALIKI ASVESTOPOIIA ABEE has achieved the following:

- ✓ improvement of its competitiveness
- ✓ enhancement of outreach activities
- ✓ enhancement of entrepreneurship
- ✓ generation and maintenance of quality job positions



The project achievements include the following:

#### EXPERIMENTAL STUDIES- PHASE EQUILIBRIA

Experimental results have been presented for aqueous solutions of MEA and S<sub>1</sub>N/DMCA with and without pollutants  $SO_4^{-2}$ , and  $NO_3^-$ . The concentration of the pollutants was of 1.9 wt. % and 1.2 wt%, respectively. These relatively large concentrations simulate the accumulation of these ions in the solvent in cases of long operation of the unit.

The attained data cover a wide range of pressures. Results were attained and compared with previous literature studies, but also with predictions from a developed model. For the first time a systematic model was presented for the prediction of the phase performance of the above solvents. A modified Ken-Eisenberg model was used in this study to correlate the experimental data. The latter are in agreement with the model predictions. It was proven that the concentration of the free amine is becoming very low and close to zero at partial CO<sub>2</sub> pressures less than 100 kPa. At even higher partial pressure, the CO<sub>2</sub> solubility increases due to molar dissolution and due to significant hydrolysis of the carbamates in the S<sub>1</sub>N case. The results in the presence of contaminants for both systems showed a degradation of the solvent systems in the presence of the studied ions. Also, the presence of H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub> in the DMCA/S<sub>1</sub>N aqueous solution did not affect the separation conditions into two liquid phases in most cases

#### EXPERIMENTAL STUDIES- CORROSION

A study was made to evaluate the corrosion behavior of SS 304L stainless steel and SS 316L stainless steel in two different amine solutions. The first solution concerns the loaded and unloaded biphasic amine DMCA/S<sub>1</sub>N with a ratio of 3:1, content of 46.31 % wt., which additionally contains  $SO_4^{-2}$ , and  $NO_3^-$  (0.06 mol/mol amine). The second solution is CO<sub>2</sub>-loaded and unloaded monoethanolamine (MEA) at ~25% content, to which we added amounts of  $SO_4^{-2}$ , and  $NO_3^-$  (0.06 mol/mol amine).

- 1) SS 316L exhibits better corrosion behavior in loaded amine solution than SS 304L.
- 2) Regarding biphasic amine, in the case of SS 316L, for both amine solutions, increasing the temperature from 25°C to 40°C, causes a decrease in current and corrosion rate.
- 3) Microstructure characterization revealed corrosion product deposits in both SS alloys when using MEA loaded solution
- 4) The biphasic amine DMCA/S<sub>1</sub>N appears more corrosive than MEA.
- 5) The results from the impedance plots (Nyquist and Bode) confirm that the amine loading causes a decrease in the resistance of the material and makes it more susceptible to corrosion.

#### EXPERIMENTAL STUDIES- PILOT UNIT

Experiments took place in a pilot plant with an advanced phase-change solvents under the influence of  $SO_4^{-2}$ , and  $NO_3^-$  ions:



- The low energy requirements of S<sub>1</sub>N/DMCA over MEA stand out, as they remain below 3 GJ/t CO<sub>2</sub> in the entire range of liquid-to-gas ratios examined.
- For MEA, the energy consumption goes to unacceptably high values at high liquid-to-gas ratios
- MEA is better in terms of kinetics.
- Solvent S<sub>1</sub>N/DMCA has up to 49 % increased cyclic capacity and requires 60 – 70 % less regeneration energy.

#### SYSTEM MODELING and DESIGN

A control system was developed for the CO<sub>2</sub> capture process with phase-change solvents, that enables the economic evaluation under realistic operating conditions. The control of the entire CO<sub>2</sub> capture ratio and of the recycle stream loading is attained through the use of two PI controllers that control the thermal duty of the reboiler and the solvent make-up stream.

- Both MEA and S<sub>1</sub>N/DMCA attain the desired 90% CO<sub>2</sub> capture ratio.
- After the end of the disturbances the steam cost exhibited 12.2% change for S<sub>1</sub>N/DMCA and 15.3% change for MEA.

A techno-economic study was also done for the reference solvent and for the phase change solvent with and without pollutants. The presence of pollutants in large concentrations raises the cost by about 25%. However, the phase change solvent remains the most advantageous choice.

In addition, the costs of their ship-based transport chain for geological storage of CO<sub>2</sub>, the CCUS system, were estimated. The transport chain consists of the liquefaction system, intermediate storage stations before and after transport, the cargo ship and the CO<sub>2</sub> preparation facility for injection. Of the individual elements of the transport chain, the cost of liquefaction is the one with the largest contribution, with a rate equal to 60%. This is followed by the cost of the cargo ship with a rate of 25%. Finally, the total specific cost of transporting 1 MtCO<sub>2</sub>/year at a distance of 1000 km was calculated equal to 30.3 €/tCO<sub>2</sub>.

