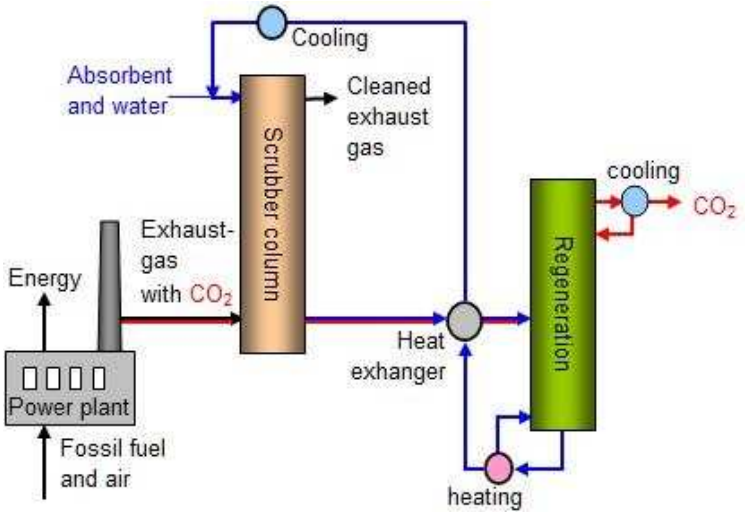
Differential Reaction Calorimetry (DRC) for CO_2 capture in amine solutions

Introduction:

This paper explains how such the Differential Reaction calorimeter (DRC) is used to asses the performance of liquid amine solutions as a gas-liquid absorption medium for CO2 capture.

Most of CCS technologies are based upon gas-solid or gas-liquid adsorption or absorption systems and during such a process, heat is exchanged by the system. By measuring this heat the corresponding thermal data can provide critical information on the amount of adsorbed (absorbed) CO2 at a given temperature and gas pressure and also on the kinetics of the reaction. Such a measurement is ideally performed using the calorimetric technique.

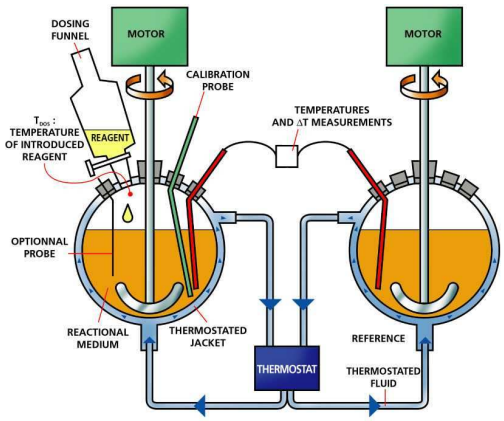


CO_2 is removed by a chemical absorption process involving the interaction of a flue gas stream with an aqueous amine solution. CO_2 reacts with the amines to form a soluble carbonate salt. This reaction is reversible and the CO_2 can be released by heating the solution with the carbonate salt in a separate stripping column (Figure 1). In such an industrial process, the amine solution is introduced at the top of an absorption tower while the exhausted fume containing carbon dioxide is introduced at the bottom. As an intimate contact is reached in the absorption tower, the amine solution chemically absorbs the carbon dioxide from the gaseous stream

Figure 1: Post combustion process ((from Bellona CCS website)

Experimental

A same amount of amine solution (150 ml) is introduced in both reactors.
The temperature of the thermostat is fixed at 40℃.
A 100%CO_2 gas stream is injected in the “measure” vessel.
The stirring is maintained during the whole test.
The ΔT is measured between the sample reactor and the reference reactor.



Differential Reaction Calorimeter

DRC Evolution

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Results and discussion

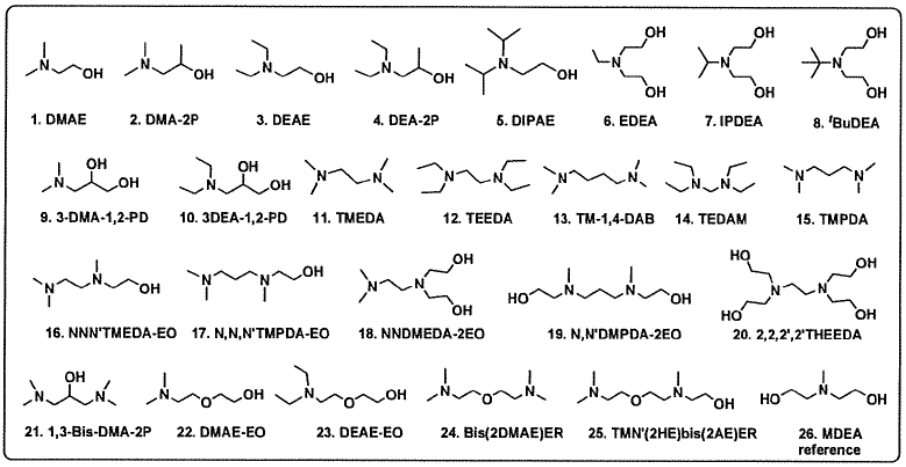

Figure 2: tertiary amine based absorbents and their chemical structures

The CO_2 absorption is measured on various tertiary amine based absorbents by measuring the produced increase of temperature (exothermic reaction) in the sample reactor. After calibration, the corresponding heat of reaction is obtained.

The amount of absorbed CO_2 is obtained using a Total Organic Carbon Analyzer.

To calculate the heat of reaction, the total generated heat is divided by the increase of CO_2 in the solvent during CO_2 injection. The Figure 3 presents the heat values obtained with the different tertiary amines.

The conventional N-methyldiethanolamine (MDEA) has the higher heat of reaction (except one amine). However most of the tertiary amines show superior absorption rates compared with MDEA (Figure 4)

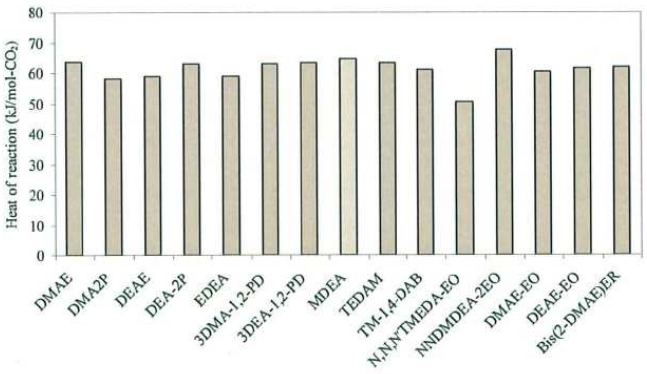

Figure 3: Heats of absorption for the tertiary amines

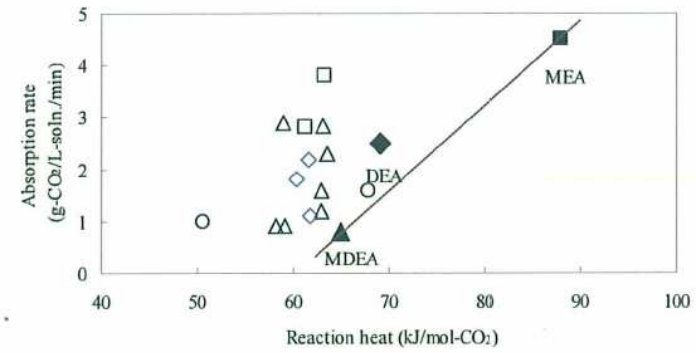

Figure 4: Relationship between heats of reaction and absorption rate

Differential Reaction Calorimeter

DRC Evolution

The Differential Reaction Calorimeter is a very convenient calorimetri tool to investigate quickly and simply the potential of amine solutions for CO_2 capture and help in the development of new technologies in the field of Carbon Capture and Storage .

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