

Abstract

To mitigate the problems caused by CO₂ emissions, post-combustion capture using monoethanolamine (MEA) is one of the most appropriate solutions. In addition to the large energy penalty, one of the most important issues that prevent a large deployment of this technology is the oxidative degradation of MEA. A pilot plant sample showed degradation of MEA after 45 days when treating a flue gas containing about 5% O₂, at 40°C and atmospheric pressure^[1].

In order to study the various aspects related to the mechanism of degradation of the MEA within a reasonable time, operating conditions especially agitation rate are better controlled. This allows us to observe a significant degradation with similar reaction pathways compared to the real case (pilot plant).

Industrial vs. laboratory conditions

- A **base case** is identified for the study of MEA degradation under accelerated conditions (**Table 1**).
- By increasing the agitation rate, we could reduce the experiment duration for similar degradation rate (**figure 1**).
- Degradation products obtained at lab scale are similar to industrial scale (**figure 2**) and accelerated lab-scale degradation follows the same reaction pathways as degradation at industrial scale. This confirms the relevance of accelerated degradation experiments.

Table 1. Comparison between industrial and lab scale conditions

	Unit	Industrial conditions	Lab conditions (G.Leonard ^[2])	Lab conditions (base case)
Time	days	45	7	2
Degradation rate	Wt% / day	0,026	0,9	0,88
P _{O₂}	Pa	6000	25000	25000
T	°C	40-60	120	120
Agitation rate	RPM	-	600	800
K _L a	s ⁻¹	0,01<K _L a<0,04	~0,003	~ 0.0045
Gas feed	%	6%O ₂ /68%N ₂ /14% CO ₂ /12% H ₂ O	5%O ₂ /95%N ₂	5%O₂/95%N₂

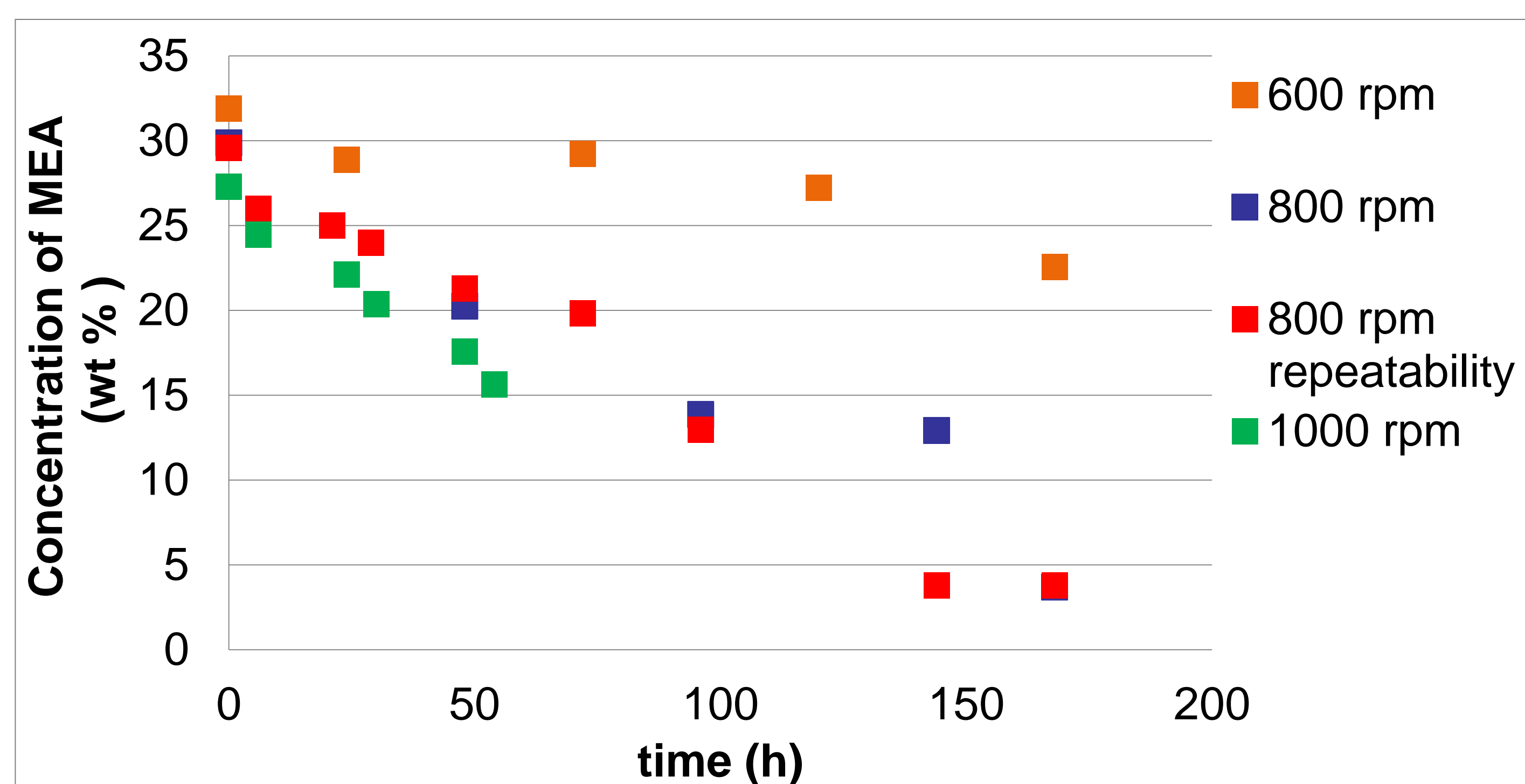


Figure 1. Influence of the agitation rate on the degradation of the MEA over time.

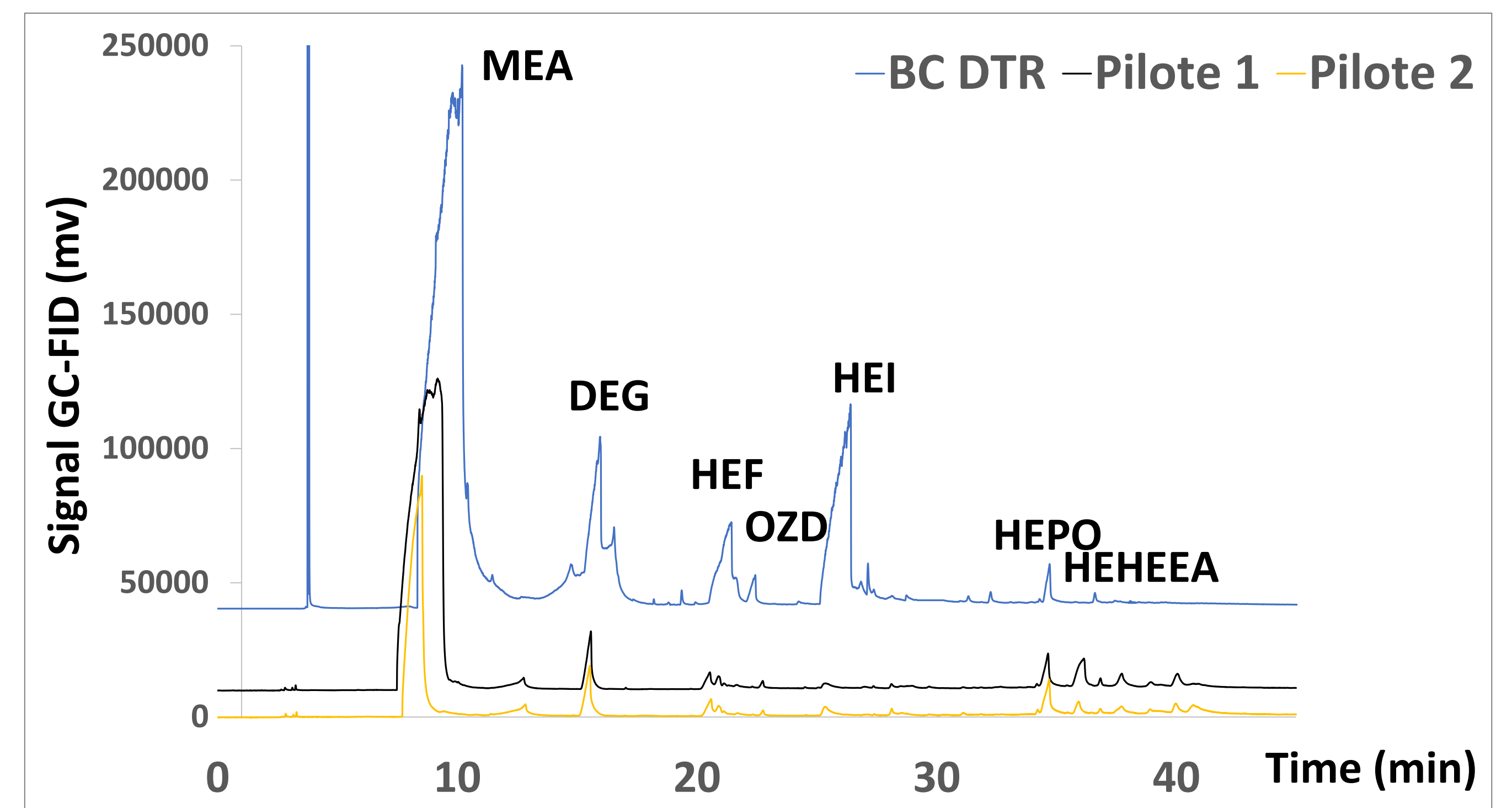


Figure 2. Comparison of GC-FID spectra between samples degraded at lab scale (BC DTR) and at industrial scale (pilots 1 and 2).

Kinetics of MEA degradation

- We propose a kinetic model of the MEA degradation under two different agitation rate (800 and 1000 rpm).

Case 1: 800 rpm

$$-r_{MEA} = 3.9 \times 10^5 e^{-48.116/RT} [O_2]^1$$

Case 2: 1000 rpm

$$-r_{MEA} = 5.3 \times 10^5 e^{-48.116/RT} [O_2]^1$$

- Larger agitation rate → higher overall mass transfer coefficient.
- As a consequence, more oxygen is transferred to the gas/liquid interface → acceleration of the degradation (**figure 3**)

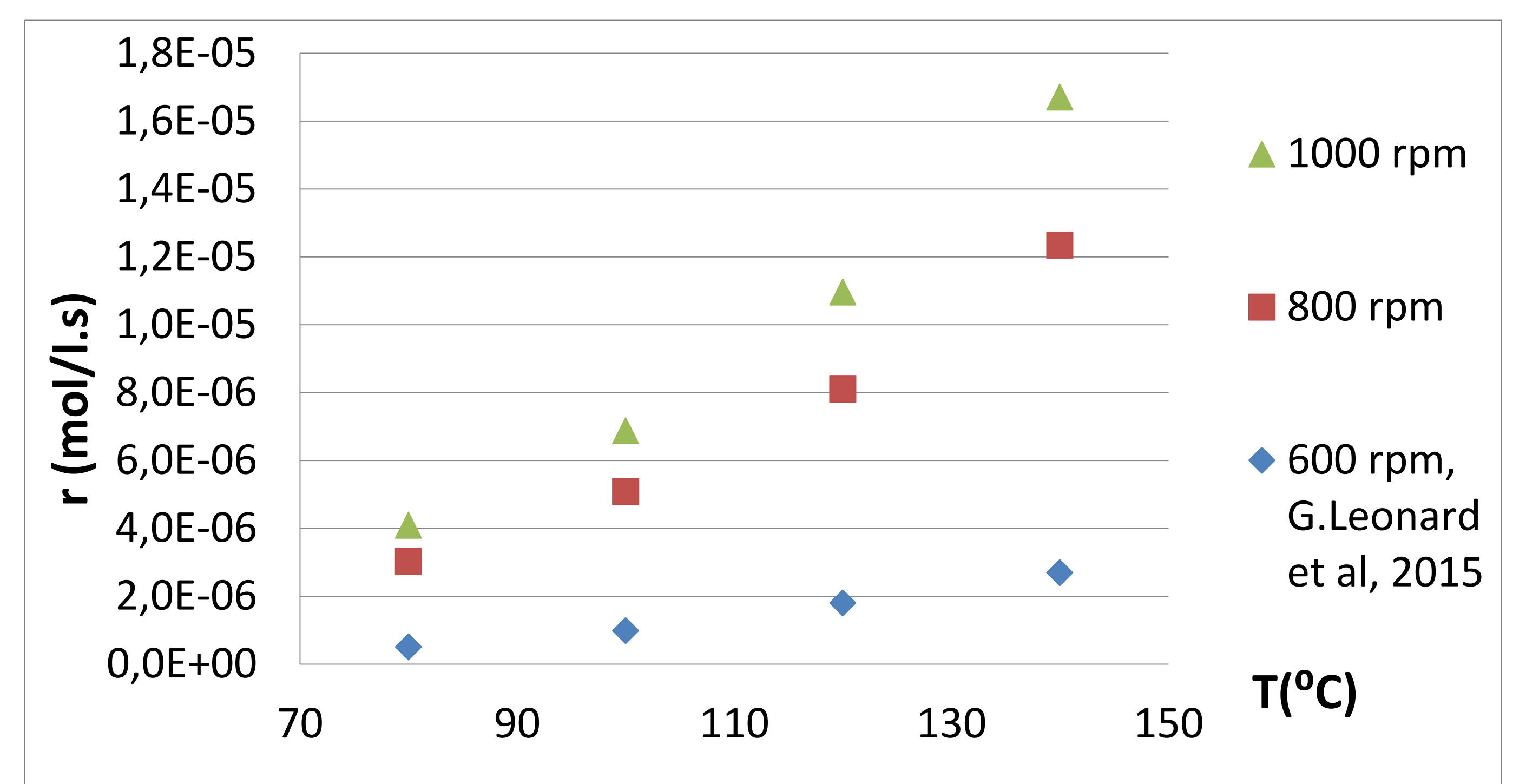


Figure 3. influence of temperature and agitation rate on degradation rate of MEA

Conclusion and perspective

- In addition to the temperature and the pressure, the improvement of the gas / liquid transfer also accelerates the degradation
- Based on the results, the goal of the next study is to establish a kinetic model that considers both the chemical and the physical kinetics separately instead of usual apparent kinetics

$$r = k_0 * e^{-\frac{E_a}{RT}} \left(1 + \frac{2K_L a - k_0 * e^{-\frac{E_a}{RT}}}{2K_L a + k_0 * e^{-\frac{E_a}{RT}}} \right) * [O_2]^n$$

References

- [1] Lepaumier h. Etude des mécanismes de dégradation des amines utilisées pour le captage du CO₂ dans les fumées. Phd thesis 2008. University of Savoie.
- [2] Leonard G, Crosset C, Dumont M-N, Teye D. Oxygen solubility and mass transfer in amine solutions for applications in post-combustion CO₂ capture. Presentation at the 3rd Post-Combustion CO₂ Capture Conference, Regina, Canada, 2015.