

Understanding solvent degradation: A study from three different pilot plants within the OCTAVIUS project

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Abstract

Degradation of solvent is one of the most important issue to be addressed for absorption-desorption based post-combustion CO₂ capture [1], [2]. Several laboratory studies have been performed to identify the degradation products and understand the mechanisms of both, oxidative and thermal degradation [3]–[5]. However, there seems to be a gap in knowledge from translating the lab scale studies to observations from the pilot campaigns. Moreover, the observations from the different pilot plant campaigns can be quite different. The objective of this study is to compare the solvent degradation behaviour from the different campaigns and highlight their causes in terms of degradation products, solvent metal content and ammonia emissions.

Results from the following different pilot plants are evaluated; (a) TNO's CO₂ capture plant at Maasvlakte, the Netherlands, (b) EnBW's CO₂ capture plant at Heilbronn, Germany and (c) ENEL's CO₂ capture plant at Brindisi, Italy. Each pilot plant receive their flue gas from coal fired power plants, however, the type of coal used and the flue gas treatment train prior to the CO₂ capture plant are different. At each pilot plant MEA has been used as the solvent. Figure 1 shows a picture of the different pilot plants.



(a)



(b)



(c)

Figure 1. Pictures of the different pilot plants; (a) TNO’s CO₂ capture plant at Maasvlakte, the Netherlands, (b) EnBW’s CO₂ capture plant at Heilbronn, Germany, and (c) ENEL’s CO₂ capture plant at Brindisi, Italy.

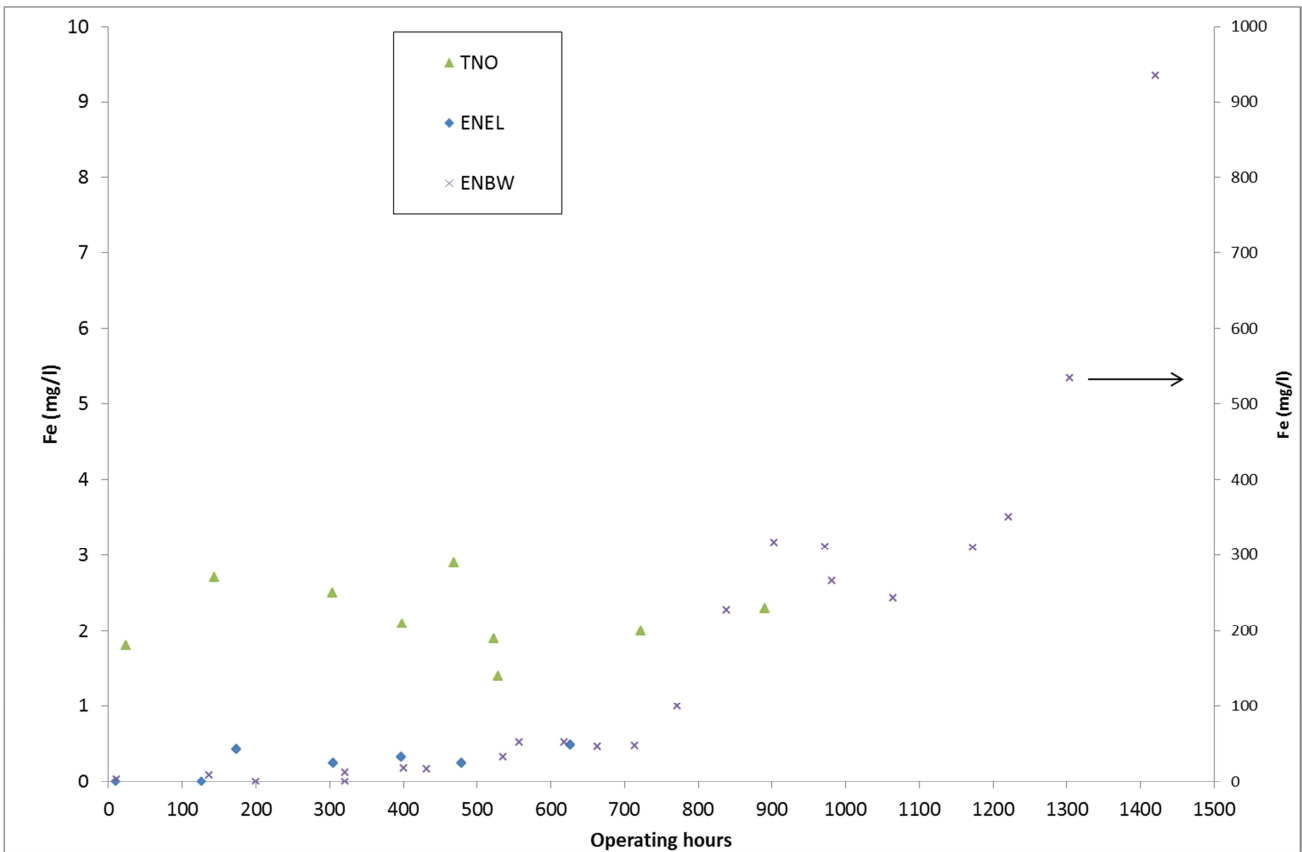


Figure 2. Solvent iron content over time at the different campaigns.

The presence of metals in solution is not only an indicator of corrosion but also of increased degradation as some of the primary and secondary degradation products are known to be corrosive [6]. The solvent iron concentration over the campaign duration was as shown in Figure 2. A similar trend was observed for other metals such as Cr, Ni and Mn. The measured solvent metal content at TNO and ENEL campaign remains constant throughout the campaign. However, there is an increasing trend at the EnBW campaign especially after 500 operating hours [7]. A corresponding

trend in the degradation products and ammonia emissions was also observed, which will be presented at the conference.

The observed degradation products were mainly linked to oxidative degradation mechanisms. The observation of degradation behavior can be expected to be due to the different rate of oxidative degradation observed at the different campaigns. As can be expected for any rate based processes, temperature and time plays an important role. Therefore, the temperature and the residence time of the solvent in the oxygen containing zone such as the absorber sump and the cross heat-exchanger also determine the rate of oxidative degradation. Moreover, the presence of heavy metals such as Fe^{2+} , Cr^{3+} , and Ni^{2+} which can act as a catalyst can drastically alter the rate of oxidative degradation [8].

The different rate of solvent degradation can be correlated to the different rates of oxidative degradation in the different pilot plant campaigns. Along with these results, recommendations for minimizing solvent degradation for full scale CO_2 capture plants will be presented. Moreover, experimental studies to understand the observed phenomena in the pilot plants will also be outlined.

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