



# Analytical methods for the monitoring of post-combustion CO<sub>2</sub> capture process using amine solvents: A review

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## ABSTRACT

Post-combustion CO<sub>2</sub> capture is considered to be the most promising technology to limit the CO<sub>2</sub> emissions from existing fossil fuel power plants. One of the main problems associated with the CO<sub>2</sub> capture process is the degradation of amine solvents, which can negatively impact both human health and the environment. Degradation products are formed in the liquid phase of the solvent, but can also be emitted with the gaseous effluents, increasing the need for monitoring strategies. The present review proposes a critical analysis of the literature concerning the analytical strategies developed in the field of post-combustion capture to identify and quantify the main classes of degradation products formed; specifically amines, amides, aldehydes, nitrosamines and organic acids. Regarding the liquid phase, the principal analytical methods involved are Liquid Chromatography (LC) and Gas Chromatography (GC) for the analysis of amines and Ionic Chromatography (IC) for the analysis of organic and inorganic acids. Concerning aldehydes, the most described method is derivatization of the compounds with 2,4-dinitrophenylhydrazine prior to LC analysis. In order to monitor the gaseous effluents, four methods have been described: FTIR, implementation of impingers, online MS analysis and sampling on solid sorbents.

## 1. Introduction

In 2015, the average concentration of CO<sub>2</sub> was 40% higher compared to the pre-industrial period, with an average increase of 2 parts per million (ppm)/year in the last ten years ("IEA 2016," 2016). Twenty-five percent of these emissions originated from electricity and energy production associated with the combustion of fossil fuels ("Intergovernmental Panel on Climate Change 2014," 2014). To mitigate future climate change due to CO<sub>2</sub> emissions, the International Energy Agency (IEA) proposes CO<sub>2</sub> capture as one of the key technologies to be developed and utilized (International Energy Agency, 2016). In the power production sector, three technologies of CO<sub>2</sub> capture can mitigate this increase: post-combustion CO<sub>2</sub> capture, pre-combustion CO<sub>2</sub> capture and oxy-fuel combustion (Kanniche et al., 2010). Currently, post-combustion CO<sub>2</sub> capture by amines-based chemical absorption is the most mature technology to reduce CO<sub>2</sub> emissions (Boot-Handford et al., 2013; Dutcher et al., 2015; Rochelle, 2009). The process is based on the reversible absorption of CO<sub>2</sub> at low temperature (40–70 °C) and atmospheric pressure by the amine through the formation of a carbamate when using primary and secondary amines (Fig. 1).

In the case of sterically hindered amines (e.g. 2-amino-2-methylpropan-1-ol, AMP) or tertiary amines (e.g. *N*-methyldiethanolamine, MDEA), the reaction with CO<sub>2</sub> will lead to the formation of the protonated amine and the bicarbonate ion (Chowdhury et al., 2011; Zhang et al., 2016). The amine is then regenerated at high temperature (100–150 °C) and pressure (between 1 and 5 bar) to emit pure CO<sub>2</sub> expected for storage (Rochelle, 2012, 2009).

Post-combustion CO<sub>2</sub> capture process using amines has been extensively studied due to its possible application on existing CO<sub>2</sub> sources and can recover up to 99% of CO<sub>2</sub> present. The main drawbacks of the capture process are the high energy penalty (around 20% of the power plant efficiency) and the irreversible degradation of the amine (Gouedard et al., 2012; Oexmann et al., 2012) which is responsible of around 10% of the total CO<sub>2</sub> capture cost (Rao and Rubin, 2002). In addition to reacting with CO<sub>2</sub> and O<sub>2</sub>, amines also react with NO<sub>x</sub> and SO<sub>x</sub> which are likely to be present in the flue gas. Indeed, even after gas purification (particulate removal, denitrification and desulfurization), NO<sub>x</sub> and SO<sub>x</sub> can still be present in the ppm range (Adams, 2010). The high temperature used during the regeneration step is also involved in the thermal degradation of the solvent (Rochelle, 2012; Vega et al.,

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