An overview of solvent management and emissions of amine-based CO₂ capture technology

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ABSTRACT

Increasing global carbon dioxide (CO₂) emissions are a rising concern for the global climate change. Amine-based post-combustion CO₂ capture (PCC) technology is one of the mature options to contribute to the mitigation of these emissions. The technology is approaching toward its commercialization. However, there are two important problems, which should properly be addressed, solvent management and the amine-based PCC emissions. Major losses in amines are due to the oxidative and thermal degradation. Concentration of oxygen (O₂) is the driving force for the oxidation. Temperature, CO₂ loading and amine concentration affect both thermal and oxidative degradation. This manuscript reviews solvent selection, thermal and oxidative degradation of amines used for CO₂ capture. Furthermore, amine-based PCC emissions have also been highlighted, with some of their concerns. Based on literature reviewed and discussions provided, conclusions are made. In addition, some of the future work is also directed in form of suggestions.

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1. Introduction

1.1. Carbon dioxide emissions and environment

Global warming is a well-known, worldwide concern, most probably caused by increasing concentrations of CO₂ and other greenhouse gases in the earth’s atmosphere, due to human activities. Power sector, mainly relies on coal, gas and heavy oil. Coal is widely known as the most intensive of the fossil fuels, and hence is amplifying its share in the global warming. The report of international energy agency (IEA) revealed that the highest rate of CO₂ emissions of 71.5% has been observed in electricity and heat sector for last two decades, from 1990 to 2010 (IEA, 2012). Global CO₂ emissions can raise up to 29% by the year 2035, which are nearly double to that of, which were in 1990 (BP, 2014). Another report claimed that the global energy-related CO₂ emissions have been predicted to increase up to 46% by 2040, approaching 45 billion metric tons (Sieninski, 2013). As a result, ecosystems may fail and about 15–40% of all of the species may get destroyed (Shao and Stangeland, 2009). In order to limit long-term global average temperature rise between 2 and 2.4 °C by the year 2050, it would be necessary to mitigate CO₂ emissions up to 50%, based on the emissions of 2005 (IPCC, 2013).

1.2. Technologies of choice for CO₂ capture

Carbon dioxide capture technologies are a valuable way to achieve an important reduction in CO₂ emissions. There are a number of technologies which are being evaluated for the capture of industrial CO₂ emissions. Generally, three technology choices are widely known as viable for large scale development in coming times, like post-combustion CO₂ capture using amine solvents, oxyfuel combustion and calcium looping technologies (MacDowell et al., 2010). Amine scrubbing may be a more feasible technology of for CO₂ capture from coal-fired power plants due to its retrofit approach for capturing CO₂ from existing power plants (Rao and Rubin, 2002). The estimated energy requisite for an advanced amine scrubbing process may be up to 2.6 MJ/tons CO₂, with an overall thermodynamic efficiency of 50% (Rochelle et al., 2011).

1.3. CO₂ capture through amine scrubbing technology

Carbon dioxide absorption by chemical technology refers to the counter-current, gas–liquid contact, in a separating column known as absorber. Stripper in parallel is configured with absorber for the regeneration of the solvent, which is later on recycled to the absorber. Additional amine is added to the absorber as solvent make