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Progress in hydrotalcite like compounds and metal-based oxides for CO_2 capture: a review

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ABSTRACT

Sorption Enhanced Reaction (SER) concepts for H_2 production and removal of CO_2 from hot flue gas/syngas are two emerging areas of CCS technology. In recent years, these applications are receiving increased research interest due to their potential energy efficiency and cost-effectiveness. The separation technologies such as absorption, membrane separation and cryogenic cannot meet the requirements of SER process due to their inherent limitations, making adsorption technology as the only viable option. Among numerous state-of-the art solid sorbents, HTlcs and metal-based oxides have been considered as promising candidates for these applications. The present article attempts to review HTlcs, alkaline ceramics, CaO based sorbents, and MgO based sorbents as high temperature CO_2 adsorbents. The performances of these sorbents under the conditions of intended applications and recent progress made in their research are reviewed in present article. Further, the various pros and cons of property enhancement methods are discussed. Based on this review and discussion, conclusions are made along with suggestions for future work.

1. Introduction

Carbon dioxide capture and storage (CCS) technology is a promising option in the portfolio of mitigation actions for stabilization of atmospheric greenhouse gas concentration as fossil fuels continue to be a major source of energy in foreseeable future (Metz et al., 2005; IEA, 2010). It is best applied to large point sources including fossil fuel power plants, fuel processing plants, and industrial plants (Iron and steel, cement, and petrochemicals) (IEA ETSAP, 2010). Today, the range of CCS technologies at various stages of research, development, demonstration and deployment is wide and diverse (Kargari et al., 2012). However, none of these is completely matured enough for large-scale commercial deployment. The identified major challenges for complete commercialization of CCS include the reduction of energy penalty on the host power plant, reasonable capital and operating expenditure, acceptable plant footprint, and CO_2 production of high purity to meet the requirements of subsequent transport/storage (D'Alessandro et al., 2010; Drage et al., 2012).

CCS technology comprises three main steps: CO_2 capture, transportation, and utilization/storage. Among these, CO_2 capture is the most critical one as it accounts for 70–90% of the total operating costs (Spigarelli and Kawatra, 2013; Smith et al., 2009). Precombustion, post-combustion, and modified combustion (oxy fuel and chemical looping) are the three technological pathways to achieve CO_2 capture. For all the pathways, the four prominent technological areas that are in either use or under development are absorption, adsorption, membranes, and cryogenic distillation systems (Figueroa et al., 2008; Songolzadeh et al., 2012; Yang et al., 2008). Table 1 provides general advantages and disadvantages/challenges of these separation technologies (Kargari et al., 2012; Olajire, 2010; Kenarsari et al., 2013; Harrison, 2004).

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