Industrial wastes derived solid adsorbents for CO$_2$ capture: A mini review

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A B S T R A C T

Coal combustion in thermal power plants throughout the world produces large amounts of fly ash. Disposal of fly ash is a serious threat to the environment and hence is a worldwide concern for conversion of these wastes into useful products. Synthesis of mesoporous silica materials from coal fly ash has already been proposed as an option which can be utilized as an adsorbent. Adsorption is considered to be one of the more promising technologies for capturing CO$_2$ from flue gases. This paper reviews the recent development of solid adsorbents from industrial waste materials with special reference to fly ash for post-combustion capture of CO$_2$.

Keywords: Greenhouse gas; Fly ash; Adsorption; CO$_2$ capture

1. Introduction

Human activities result in the generation of greenhouse gases (GHGs) into the atmosphere. Greenhouse gases composed of mainly carbon dioxide (CO$_2$), methane (CH$_4$), chlorofluorocarbons (CFCs), and nitrous oxide (N$_2$O) that are contributing to the global warming phenomena considerably. The global warming caused by the increased levels of these gases is one of the most serious environmental threats to the human race at present. Out of these GHGs, the contribution of CO$_2$ is maximum. CO$_2$ emitted into the atmosphere is assumed to cause the greatest adverse impact on the observed green house effect accounting for approximately 55% of the observed global warming. The flue gas emitted from the thermal power plants (TPPs) is growing because 30% of the total global fossil fuel is being used for power generation that emits considerable amount of CO$_2$ (Bandyopadhyay, 2010).

The emissions of anthropogenic CO$_2$ have increased the CO$_2$ concentration on the atmosphere with over 30% compared to pre-industrial levels (Keeling and Whorf, 1998). Furthermore, it is estimated that future global CO$_2$ emissions will increase from ~7.4 GtC (billion tons of atmospheric carbon)/year in 1997 up to ~26 GtC/year in 2100 (Mercedes et al., 2004). Carbon dioxide sequestration provides a mid-term solution to mitigate environment impacts and allows human continue to use fossil energy until renewable energy technology mature. Carbon capture and sequestration (CCS) is one of the most suitable techniques for long term technology policies (Riahi et al., 2004). Since the CO$_2$ separation is the first and most energy intensive step of CCS, many researches have targeted at improving the current technologies or developing new approaches of CO$_2$ separation and capture (Yang et al., 2008a).

Carbon dioxide capture is widely studied with a view to its application in energy generation systems as a means of reducing greenhouse gas emissions; solid sorbents, capable of being regenerated, could provide an effective means for carrying out various operation (Felice et al., 2011; Harrison, 2008; Florin and Harris, 2008). CO$_2$ capturing from flue-gas streams is an essential parameter for the carbon management for sequestration of CO$_2$ from our environment. Current technologies being considered for CO$_2$ sequestration include: disposal of CO$_2$ in deep oceans; depleted oil and gas fields; deep saline formations (aquifers); and recovery of enhanced oil, gas, and coal-bed methane. However, the current cost for the utilization of these types of technologies has proven to be too expensive. Consequently, reducing the cost for the capture of CO$_2$ will be a critical step in the overall carbon management program. The physical and chemical adsorption of CO$_2$ can be achieved by using solvents chemical (gas–liquid) absorption,