



A review on carbon dioxide capture and storage technology using coal fly ash



Jung-Ho Wee *

Department of Environmental Engineering, The Catholic University of Korea, 43 Jibong-ro, Wonmi-gu, Bucheon-si, Gyeonggi-do 420-743, Republic of Korea

HIGHLIGHTS

- ▶ The potential of the CCS technology using coal fly ash (FA) is reviewed.
- ▶ Alkali species in FA are dissolved and consumed to sequester CO₂ in the wet process.
- ▶ FA can be used as a support or as a raw material of dry sorbents to capture CO₂.
- ▶ The technology can stabilize the harmful components in FA during the process.
- ▶ Therefore, the technology may be another option of CCS to a limited extent.

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ABSTRACT

This work reviews the availability and the potential of the carbon capture and storage (CCS) technology using coal fly ash (FA). Because the technology can be effectively applied on-site to coal fired power plants and as FA contains sufficient alkali components, the technology may be another option of CCS technology to a limited extent.

The technology can be divided into wet and dry processes. In the former, the available components for CCS in FA are leached into solution by the solvent where they are subsequently consumed for carbonation to store CO₂. Particularly, the CO₂ storage capacity of CaO-enriched FA solution mixed with brine under high pressure may be equal to or greater than the true CO₂ emission reduction achieved by applying FA as a cement additive.

In the dry process, FA can be used as a direct support or as the raw material of the sorbent supports for CO₂ capture. The dry process is effectively applied for CO₂ capture rather than storage because the sorbents should be regenerated. Another advantage of the technology is the stabilization of the harmful components present in FA, which are mostly co-precipitated with carbonated FA during the process.

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1. Introduction

The amount of solid waste residue (SWR) generated from the large-scale industrial processes such as coal fired power plant (CFPP), cement plant, steel, paper, oil shale industry and solid waste incinerator is increasing every year and some SWRs are substantially harmful to the environment. Therefore, the SWR disposal situation has been intensively aggravated to become an important issue [1–5]. Considering that most of the processes that generate SWR emit a great amount of CO₂, SWR can be directly or indirectly used as a material for on-site CO₂ capture and storage (CCS), which is another option of CCS technology [6–13].

This potential is based on the following reasons. Firstly, because industrial SWRs contain substantial alkali and alkali earth metals

[14–17], the mineral carbonation with SWR is readily achieved to store CO₂ and which may be a permanent solution compared to geological and ocean storage. In addition, CO₂ can be partially recovered from the instable carbonated (or bi-carbonated) SWR products. Secondly, they are geochemically instable and reactive because they are generally formed at very high temperature (over 1200 °C) and subsequently produced by rapid cooling [7]. Finally, they are porous materials with relatively high surface area.

The first study on CCS using SWR was conducted by Reddy et al. group with alkaline byproduct of oil shale combustion process in the mid-1980s [18] and they proposed the technology to increase the reaction rate of former process in the early 1990s [19]. Both works had inspired a number of subsequent literatures dealt with mineral carbonation with various SWRs [8,20–22].

Among industrial SWRs, interest has focused on coal fly ash (FA) generated from the pulverized CFPP because the CO₂ emissions from CFPP and the FA portion are the largest [23–28]. Although

* Tel.: +82 2 2164 4866; fax: +82 2 2164 4765.

E-mail addresses: jhwee@catholic.ac.kr, jhwee@korea.ac.kr