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Review Article

Review on bacteria fixing CO_2 and bio-mineralization to enhance the performance of construction materials

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ABSTRACT

Excessive CO_2 in the atmosphere can cause the greenhouse effect, increase the environmental temperature, cause natural disasters, and affect the safety of people's lives and properties. This article summarizes how to use CO_2 to reduce carbon emissions from the field of building materials, so as to achieve the global carbon neutral goal. In the presence of calcium or magnesium ions, carbon-capturing bacteria can adsorb and transform CO_2 into carbonates, and the entire mineralization/carbonization process is environmentally friendly. In the presence of carbon-capturing bacteria and CO_2, calcium or magnesium sources in cement-based materials, steel slag, and waste concrete can be mineralized/carbonized to stable carbonates. This microbial method can be used to capture carbon and improves anti-efflorescence and durability of cement-based materials, mechanical properties of recycled concrete aggregates, and suppressing dust on construction sites. These potential applications provide important reference value in large-scale applications of CO_2 in construction materials.

1. Introduction

Global carbon reduction and neutrality are a worldwide topic, and all countries need to work together to use carbon emission technologies and carbon compensation methods to achieve zero carbon footprint. The sources of CO_2 emissions in the atmosphere are mainly from transportation, energy, housing and industry, which account for 22%, 42%, 6% and 21% respectively [1]. Due to the continuous use of fossil fuels, the concentration of CO_2 in the global atmosphere will continue to increase. Today, the concentration of CO_2 in the air is higher than 400 ppm [2]. Compared with methane, nitrous oxide, water vapor and other gases, CO_2 is the main greenhouse gas, contributing 60% of the greenhouse effect [3,4]. The CO_2 emitted by cement mainly comes from the burning of fossil fuels and the decomposition of limestone, accounting for about 8–9% of global carbon emissions [5]. Thermal power emissions CO_2 mainly come from the burning of fossil fuels, accounting for about 7% of global carbon emissions. The amount of neutralization and storage of CO_2 by cement-based materials (concrete, cement mortar, cement-based wallboard) and waste alkaline earth oxides (steel slag) mainly depends on the content of CaO and MgO, the contact area and time of CO_2 [6–9]. The concrete neutralizes and stores approximately 30%–80% of the CO_2 produced during the entire raw material production process during the entire life cycle [6]. Oxides (calcium oxide, magnesium oxide, aluminum oxide, etc.) in steel slag account for about 60%, and these oxides can capture carbon dioxide to form stable carbonates [10]. Therefore, the carbon capture efficiency of steel slag is about 47% calculated as calcium oxide. By using waste cement-based materials and alkaline earth oxides to actively capture CO_2, it reacts with the calcium and magnesium-containing substances in the materials to form stable carbonates to achieve the purpose of carbon sequestration and improve the performance of building materials can also effectively reduce its emissions in the air.

The methods of capturing and storing carbon dioxide mainly include physical, chemical and biological methods. The physical method of capturing and storing carbon dioxide is mainly through mechanical capture and injecting high-concentration CO_2 into underground rock formations (mined oil and gas wells, coal seams and deep seas) for long-term storage. It is suitable for large-scale capture and storage of carbon dioxide and the entire process is relatively expensive [11,12]. In the case of crustal movement, CO_2 stored in deep rock formations for a long time may leak, which is fundamentally risky and the capture and storage are more expensive. The chemical method to capture and store CO_2 is

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