Development of Synthesis Technology for Carbon-Neutral Flooring Composites Based on Recycled Waste Materials

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Abstract

As global efforts to achieve carbon neutrality accelerate, the construction and building materials sectors are under growing pressure to reduce greenhouse gas emissions. Conventional flooring materials such as cement and polyvinyl chloride (PVC) significantly contribute to carbon emissions and environmental degradation throughout their life cycles. In particular, the disposal of waste PVC—widely used in construction due to its flexibility, durability, and insulation properties—has become a critical environmental challenge [1]. Owing to its complex composition and hazardous additives, most waste PVC is either landfilled or incinerated, resulting in toxic by-products such as dioxins and microplastic pollutants. Mechanical recycling under mild conditions offers a promising, eco-friendly alternative that preserves PVC's chemical integrity while reducing environmental risks [2-4]. This study focuses on the development of sustainable, high-performance artificial granite block composites by recycling waste PVC plastic powder, waste stone powder, and fly ash. These composite materials not only provide a viable solution to waste accumulation but also serve as carbon-neutral substitutes for traditional flooring materials. Fly ash, a by-product of coal combustion, and waste stone powder from quarrying activities, both present environmental disposal issues yet possess functional properties beneficial for composite reinforcement. The integration of these industrial by-products helps reduce the reliance on virgin materials and lowers the overall carbon footprint.

The research begins with a comprehensive analysis of the physicochemical properties of conventional cement and an assessment of its carbon emissions during production. Based on these findings, a novel composite formulation was designed by partially replacing cement with industrial by-products—fly ash and waste stone powder. To further enhance mechanical strength and bonding capability, calcium oxide and a PVC-based reinforcement agent were introduced into the mixture. The optimized composite material was then combined with gravel and molded into paving blocks using a high-capacity compression system.

This process not only reduces reliance on virgin cement and lowers carbon emissions but also offers a high-value pathway for recycling waste PVC and mineral residues. The resulting paving bricks demonstrate improved durability, strength, and sustainability, providing a viable solution for low-carbon construction applications.

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