Development of High-Performance Multilayer Water and Sewage Pipes Based on Reinforced Recycled Polyethylene

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Abstract

The global plastics industry is currently facing significant challenges due to fluctuations in crude oil prices and supply chain instability, particularly influenced by ongoing geopolitical conflicts in the Middle East. These factors have led to a substantial increase in the cost of virgin polymer resins, including polyethylene (PE), which is widely used in infrastructure applications such as water supply and sewage pipelines. Consequently, there is a growing need to develop sustainable and cost-effective alternatives through the recycling and valorization of waste plastics [1,2].

Among various thermoplastic materials, polyethylene (PE) is particularly suitable for recycling due to its excellent chemical resistance, corrosion durability, low density, and superior processability [3]. These inherent advantages make recycled PE a promising candidate for use in civil infrastructure applications, especially in water and sewage piping systems where long-term durability and environmental resistance are critical. However, recycled PE typically suffers from degraded mechanical properties, limiting its direct application in high-performance structural products.

To address these limitations, this study proposes the development of high-performance multilayer water and sewage pipes using recycled polyethylene as the primary matrix material. The mechanical performance of recycled PE is enhanced through the incorporation of reinforcing additives, including carbon fiber reinforced polymer (CFRP) and fly ash. CFRP serves as a high-strength reinforcement phase, significantly improving tensile strength and stiffness, while fly ash acts as a functional filler that enhances dimensional stability and cost efficiency [4].

Furthermore, an optimized blending ratio and multilayer extrusion design are employed to maximize the overall performance of the pipe structure. The proposed multilayer configuration enables the strategic distribution of materials, where each layer is tailored to achieve specific functional requirements such as mechanical strength, durability, and resistance to environmental stress. Through this approach, the study aims to develop a sustainable, high-performance piping system that not only reduces dependence on virgin plastics but also promotes circular economy practices by effectively utilizing waste polyethylene.

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