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Physicochemical Properties of Basalt Fiber Waste

Jalilov Raximjon Ravshanbek o'g'li [1]

[1] PhD student of the Department of Materials Science and Technology of New Materials Andijan Machine Building Institute (Andijan, Andijan region, 170100, Republic of Uzbekistan)

Annotation:

Basalt fiber, a material derived from natural volcanic rock, is increasingly utilized in industries such as construction, aerospace, and automotive manufacturing due to its remarkable mechanical properties, including high strength and durability. However, the growing use of basalt fiber leads to the generation of significant amounts of waste. To promote sustainable practices and recycling, it is essential to understand the physicochemical properties of basalt fiber waste, which determine its potential reuse and environmental impact. This article explores the critical physicochemical characteristics of basalt fiber waste.

Keywords: Basalt fiber, waste, high strength, durability, aerospace, environmental impact, silicon dioxide, aluminum oxide, resistance, magnesium Oxides, geopolymers, flexibility, adhesion.

INTRODUCTION

Basalt fiber waste typically exists in the form of thin, thread-like filaments with a diameter ranging from 10 to 20 microns. The fibers are often stiff, with little flexibility, and can have sharp, rough surfaces. The fiber length can vary, depending on how the waste is generated, with short fibers (micrometers to millimeters) being common in processing waste.

The surface morphology of basalt fiber waste is rough and irregular, which can enhance mechanical interlocking in composite materials. This feature makes it a suitable candidate for reinforcement in concrete, polymers, and other composite structures. Basalt fiber waste is inert and non-reactive under typical environmental conditions. It resists corrosion and does not degrade easily when exposed to moisture, UV radiation, or chemicals. These properties make it a low-maintenance material in applications such as concrete reinforcement or soil stabilization. Additionally, basalt fiber waste does not release harmful substances into the environment, which is a significant advantage for sustainable practices.While basalt fiber waste is resistant to chemical degradation, it has a moderately hydrophilic surface, meaning it can absorb a small amount of moisture. This can be beneficial in certain applications, such as composite materials, where the adhesion between fiber and matrix is critical. However, the hydrophilic nature of basalt waste might limit its use in environments with excessive moisture exposure, as it can affect the fiber's bonding with hydrophobic materials.

Chemical composition. Basalt fiber waste is primarily composed of silicate minerals. The main constituents are silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), calcium oxide (CaO), and magnesium oxide (MgO), all of which are present in varying proportions depending on the basalt rock source. Silicon Dioxide (SiO_2): A major component, typically accounting for around 45-50% of the waste. It contributes to the fiber's strength and resistance to high temperatures. Aluminum Oxide (Al_2O_3): Present in the range of 10-15%, it enhances the thermal stability and mechanical properties of basalt fibers. Iron Oxide (Fe_2O_3): Generally around 5-12%, iron oxide impacts the fiber's density and contributes to its heat resistance. Calcium and Magnesium Oxides (CaO, MgO): These oxides, constituting 10-15%, play a role in modifying the viscosity and melting behavior of the basalt, influencing its fiber-forming ability. The chemical stability of basalt fiber waste is one of its most prominent attributes, allowing it to maintain its properties over time and under various environmental conditions. This stability also makes basalt waste suitable for applications in construction, geopolymers, and composite materials.

Thermal properties. Basalt fiber waste exhibits high thermal resistance, which is a critical aspect of its physicochemical profile. It can withstand temperatures up to 600°C without significant degradation, making it suitable for high-temperature applications such as insulation and fire-resistant materials. Additionally, the melting point of basalt fiber is around 1400°C, giving it an edge over other fibers like glass in high-temperature environments. The mechanical properties of basalt fiber waste are influenced by its composition, processing methods, and the resulting fiber structure. Some key mechanical characteristics include: High Tensile Strength: Basalt fibers have a tensile strength ranging from 2.8 to 4.0 GPa, which remains significant even in waste forms. This strength makes basalt fiber waste useful as a reinforcing material. Elastic Modulus: The modulus of elasticity for basalt fibers is approximately 85-90 GPa. The waste form retains much of this stiffness, making it suitable for applications where rigidity is needed. Durability: Basalt fiber is highly durable and resistant to chemical attack, especially from alkalis, acids, and salts, which enhances the longevity of the material when reused or recycled.

Hydrophilic Nature. While basalt fiber waste is resistant to chemical degradation, it has a moderately hydrophilic surface, meaning it can absorb a small amount of moisture. This can be beneficial in certain applications, such as composite materials, where the adhesion between fiber and matrix is critical. However, the hydrophilic nature of basalt waste might limit its use in environments with excessive moisture exposure, as it can affect the fiber's bonding with hydrophobic materials.

Potential applications of basalt fiber waste. Given its unique physicochemical properties, basalt fiber waste has several potential applications across industries:

1. Construction: The waste can be used as reinforcement in concrete and asphalt, providing increased strength, durability, and thermal resistance. Its rough surface also enhances the bond with the matrix, improving the overall performance of composite materials.
2. Composites: Basalt fiber waste can be incorporated into polymers and resins to create durable, lightweight composites suitable for automotive, aerospace, and infrastructure applications.
3. Insulation: The high thermal stability and resistance of basalt fiber waste make it suitable for use in thermal and acoustic insulation materials, especially in high-temperature environments.

4. Geopolymer Applications: Basalt fiber waste can be used as a raw material in the production of geopolymers, a class of inorganic polymers known for their durability and environmental friendliness.

It resists chemical weathering but can break down slowly through hydrolysis, particularly in the presence of water and carbon dioxide, which can alter its minerals into clays or other secondary minerals.

CONCLUSION

Basalt fiber waste, characterized by its robust chemical composition, high thermal resistance, mechanical strength, and environmental stability, represents a valuable resource for recycling and reuse in various industries. Its unique physicochemical properties allow it to be repurposed in applications ranging from construction to advanced composite materials. As industries continue to embrace sustainable practices, understanding and leveraging the properties of basalt fiber waste will play a crucial role in reducing environmental impact and enhancing material efficiency.

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