AEROSPACE APPLICATIONS OF ALUMINA FIBER REINFORCED ALUMINA MATRIX COMPOSITES

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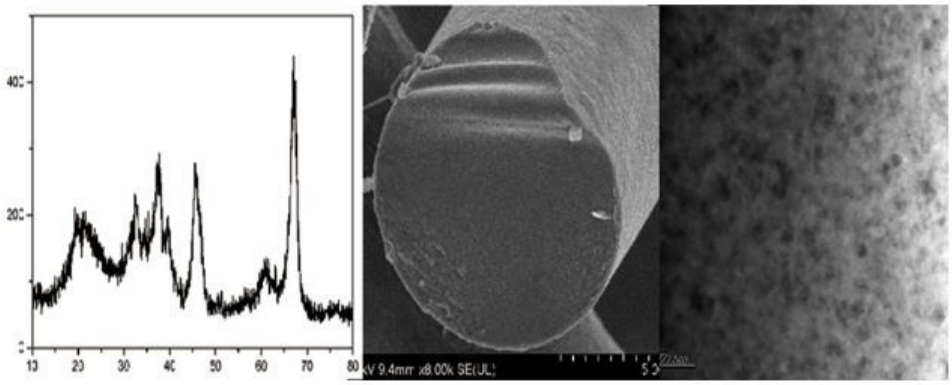
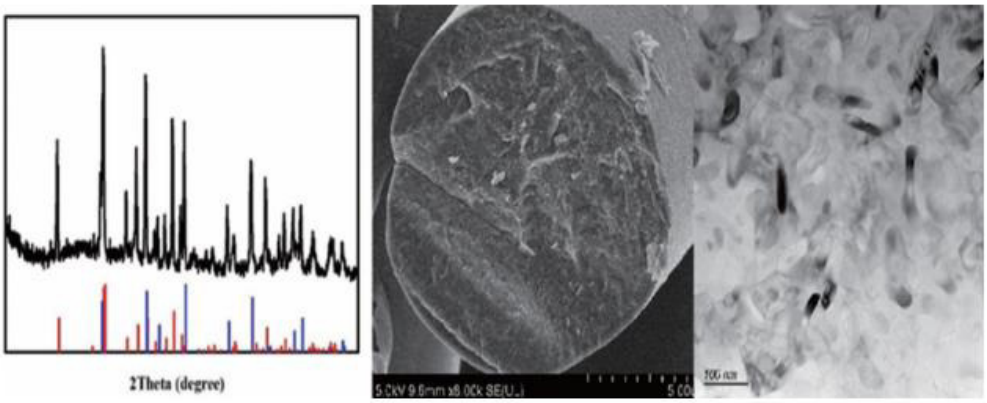
ABSTRACT: Alumina fibers are high-performance ceramic fibers made from aluminum oxide (Al2O3). This article focuses on the latest developments and advances in alumina fibers and their composites, focusing on their synthesis, properties, fabrication, and applications. The review covers a brief introduction to alumina fibers and their properties.

Various routes including hydrothermal or solvothermal, sol-gel techniques, electrospinning and extrusion, template techniques [19,20], chemical vapor deposition in flame[30], and mercury mediated technique [29] have been developed for producing Al2O3 nanofibers.

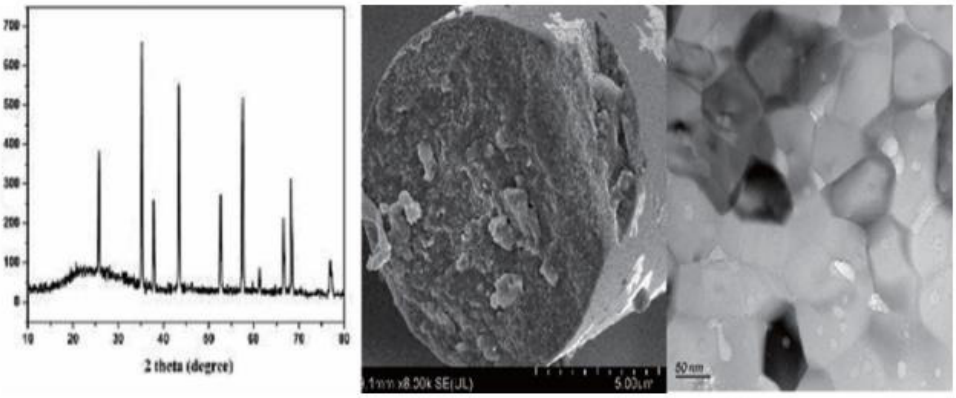
AF17 FIBER: The fiber is composed of microcrystalline polycrystalline (γ-Al2O3) with a diameter ranging from 9 to 12 micrometers. It boasts an impressive tensile strength of over 2.0 GPa at room temperature and can endure service temperatures exceeding 1200□. Additionally, it exhibits excellent resistance to high temperatures and demonstrates remarkable creep resistance.





AF18 FIBER: The fiber exists in a microcrystalline state (α-Al203 + mullite), with a diameter ranging from 11 to 14 μm. It demonstrates an exceptional tensile strength exceeding 2.0 GPa at room temperature while being able to withstand service temperatures surpassing 1300°C. Alumina fiber currently exhibits the highest level of resistance against creep deformation. Up to 1100°C, the strength remains relatively unchanged. Even at 1200°C, it retains over 90% of its room temperature strength, and at 1300°C, it retains more than 80% of its room temperature strength.

AF19 FIBER: The fiber is characterized by a microcrystalline state (α-Al203) with a diameter ranging from 11 to 14 μm. It exhibits an impressive tensile strength exceeding 3.0 GPa at room temperature and is capable of withstanding service temperatures exceeding 1000□. With its high strength and favorable mechanical properties, it serves as an excellent reinforcement material for composites. However, it should be noted that the fiber's creep resistance at high temperatures is relatively poor.



PROPERTIES OF ALUMINA FIBER: The properties of alumina fiber vary depending on the manufacturing process and the type of aluminum used. However, in general, alumina fiber has the following properties:

1. Density: Alumina fiber has a density of about 3.9 g/cm3, which is about twice the density of steel. This makes alumina fiber a relatively heavy material.
2. Melting point: The melting point of alumina fiber is about 2,024°C (3673°F). This means that alumina fiber can withstand high temperatures without melting.
3. Electrical conductivity: Alumina fiber is a good conductor of electricity. It has an electrical conductivity that is about 10% of that of copper.
4. Thermal conductivity: Alumina fiber is a good conductor of heat. It has a thermal conductivity that is about twice that of steel.
5. Corrosion resistance: Alumina fiber showcases a high resistance to corrosion from the majority of chemicals. This makes it an exceptional choice for applications that demand corrosion-resistant materials.
6. Oxidation resistance: Alumina fiber is resistant to oxidation. This means that it can withstand high temperatures without oxidizing.
7. Strength: Alumina fiber is strong. It has a tensile strength that is about 2,000 MPa.
8. Stiffness: With a modulus of elasticity measuring around 370 GPa, alumina fiber possesses remarkable stiffness.
9. Toughness: Alumina fiber is characterized by high impact strength, indicating its ability to withstand substantial force.

AEROSPACE APPLICATIONS OF ALUMINA FIBERS:

1. Alumina continuous fiber finds its applications in hypersonic aircraft, radomes, and radar radomes. It has emerged as a promising material for fulfilling the elevated temperature demands of next-generation technologies. European and American countries have already incorporated this material into space shuttles, starships, and various weapons and equipment, where it excels in temperature resistance and heat insulation properties.
2. Alumina continuous fiber ceramic matrix composites possess exceptional high-temperature strength, making them suitable for various critical applications. They can be employed in insulation layers, nozzle outlet cones, and other related components of rocket motor combustion chambers. Furthermore, they serve as an ideal material for thermal structure insulation connections between nozzles and combustion chambers in solid motors. Additionally, these composites find utility in the hot end components of aviation turbojet engines.
3. Aluminum oxide continuous fiber reinforced metal matrix composites are employed in mechanical parts that bear high loads and operate under high temperatures, as well as in high-speed rotating components like transmission devices in helicopters. Furthermore, these composites find application in solid rocket motor nozzles.
4. Alumina continuous fiber reinforced light alloy finds valuable applications in the military industry. It serves as an ideal material for pistons in armored vehicles and tank engines, providing enhanced strength and performance. The U.S. Army utilizes continuous alumina fiber reinforced composites to manufacture tank track shoes, resulting in a significant weight reduction from 544 kg of cast steel to 272-363 kg. Moreover, these composites can be utilized for the fabrication of solid motor shells for air-launched missiles. They possess comparable bursting pressure to steel while being 11% lighter than aluminum alloy, offering a favorable balance between strength and weight.

FUTURE APPLICATIONS: Some of the specific trends that are expected to drive the growth of the alumina fiber market include:

1. Increasing demand for lightweight materials: Industries such as automotive and aerospace are increasingly seeking lightweight materials to enhance fuel efficiency and performance. Alumina fiber, with its lightweight nature, is well-positioned to fulfill these requirements.
2. Growing demand for corrosion-resistant materials: Chemical and industrial processing industries place a premium on materials that can withstand corrosive environments. Alumina fiber's exceptional resistance to corrosion positions it as an ideal choice for such applications.
3. Rising demand for electrical insulation materials: The electronics and electrical industries require effective electrical insulation materials. Alumina fiber's impressive electrical insulation capabilities make it an attractive option for these sectors.

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