Green Specialty Alumina for Greener Energy Products

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https://doi.org/10.71659/icsoba2024-aa026

Abstract

Alumina and their derivatives were researched and engineered with different formulations using advanced processes for the last 4 decades, offering a wide spectrum of applications in aerospace, automobile, energy, petrochemical, steel, defence, solar, and mining segments. Amongst various efforts to address, the challenges of optimum energy utilization, materials selection and design play a crucial role in energy-related engineering applications. Special grades of Alumina (including hydrates), as a raw material, offer numerous advantages for energy conservation and efficiency having a potential more than 12 000 kt global market in 2030.

As the world shifts towards green and renewable energy, lithium-ion batteries (LiBs) play a significant role. Hindalco has developed high quality alumina and offered for very high-end applications, for example, Sub-Micron Alumina (SMA) and Ultra Fine Boehmite (UFB) are used as a separator coating on polyolefin films for Li-ion batteries to enhance performance and safety. High purity alumina (IC : Industrial Ceramic) is used in thermal interface materials to dissipate heat faster from batteries and other electronic devices, ensuring safety and longevity. In applications like spark plugs and insulators, High Crystalline Alumina (HCA) offers electrical insulation and high-temperature stability. It's also crucial in high-voltage insulators due to its low dielectric constant and high dielectric breakdown voltage.

Additionally, Super Fine Hydrate (SFH) of trihydrates and the UFB are finding applications as catalyst support materials in petroleum refining, indirectly aiding the energy sector.

On the other hand, by effective utilization of red mud it is possible to develop sustainable and green aluminium company. Advanced R & D and fully automated process control enable the development of a wide range of calcined alumina for various applications. The cumulative impact of green alumina refining process and products contributes significantly to achieving sustainability goals.

Keywords: Alumina, Boehmite, Energy, Green product, Specialty alumina.

1. Introduction

Amongst various industrial ceramics, alumina is one of the most important engineering materials due to its diverse and beneficial properties, which result in a wide range of applications [1, 2]. In industry, there is always a high demand for suitably designed materials due to their ease of application and high performance [3]. In some cases, this high performance leads to energy-saving processes, which is also a factor in designing materials for a greener approach.

Electric vehicles and rechargeable electronic gadgets heavily rely on the use of Li-ion batteries [4]. Ramasubramanian et al. [5] described major challenges for the sustainability of the Li-ion battery in their paper. They discussed the main criteria for the sustainability of Li-ion batteries, including maximizing battery performance and prolonging battery life with safety. Alumina and boehmite play very important roles here [6, 7]. While improved cathode materials and electrolytes

are being designed to improve current density coating a suitable separator on the polypropylene or polyethylene film can also enhance current density. Both alumina and boehmite improve the performance (current density), safety, and prolonged cycle life of Li-ion batteries [8, 9]. Due to the use of such ceramic coated separator thermal runaway can be prevented, and also ensure thermal stability at high working temperature. Additionally, separator coating improves the mechanical strength and wettability of the separator. Therefore, use of alumina and boehmite help to meet the sustainable criteria of Li-ion battery.

EV (Electric Vehicle) batteries and other electronic devices face problems due to heat generation during operation. The device's performance and safety are at substantial risk due to the generation of excessive heat. Therefore, heat dissipation is the most significant factor for to safely using the device for a prolonged life cycle. Alumina with high dielectric strength and moderate thermal conductivity can resolve this issue [10–12]. For Thermal Interface Materials (TIMs), Alumina is used a filler in the resin matrix (silicone, Epoxy, Nylon) to remove the generated heat from the devices. It helps to efficiently transfer heat away from the components, reducing the risk of overheating and ensuring stable operation. In power electronics, alumina substrates are widely used to mount semiconductor devices, enhancing their thermal management and reliability.

Thermocouples are used to measure the temperature from ambient to elevated conditions. The wire of the thermocouple needs thermal protection during the operations at high temperature. Alumina being thermally stable and inert can provides such protection to thermocouple wires [13–16]. Heat loss can be minimized if the temperature measurement is accurate. Accurate temperature measurement is needed to minimize heat loss, which ensures accuracy of the system. In this way, the use of alumina is a greener approach which helps to reduce energy loss. Alumina can withstand very high temperature (1600–1800 °C) temperatures without degradation makes it suitable as refractory materials in industries such as metallurgy, glass manufacturing, and chemical processing, where temperature control heat loss is crucial.

Sparkplugs are used for the ignition of fuel in engine of the cars. Alumina with thermal and electrical insulations can host the high-temperature spark and minimize the damage. Alumina due its effective electrical insulation properties prevent electrical leakage, ensuring generation of spark for ignition [17, 18]. Use of Alumina ensure the lifespan of the sparkplug with any degradation over the application period. This helps the internal combustion engine to run with better fuel economy and low emission of green-house gases.

High dielectric strength is required for the transmission of high voltage lines. Porcelain bodies with Alumina as a filler material can attain such high dielectric strength required for the transmission. Alumina containing insulators helps long distance transmission without any leakage and failure [19]. Their durability and resistance to environmental factors such as moisture and temperature variations make the alumina containing insulators ideal for outdoor applications.

Alumina is a significant raw material for the refractory industry, the use of alumina has significantly increased for the clean steal production. Alumina provides high-temperature insulation, inertness, strength, and stability [20, 21]. Effective insulation saves a significant amount of energy at high temperature and completes processes in minimal time. Therefore, alumina as one of the major components of refractory raw materials, helps in energy saving [22]. Alumina based refractories finds applications in industries like steelmaking, cement production, and glass manufacturing where for lining furnaces, kilns, and reactors [23]. These alumina containing refractories withstand high temperatures and provide protection from the corrosive environments, ensuring process efficiency and longevity of the kiln, furnace and equipment, leading to reduced energy consumption and operational costs.

6. References

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