

Effect of Binders on the Processing of α -Alumina in Tunnel Kiln

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Abstract



In today's scenario, most extensively employed binder systems for monolithic refractories are high alumina cements and chemical binders. The ability to choose and apply the best suited binder is critical to the monolithic product's performance. The effects of several types of binders on α -alumina were investigated in this study using a simple technique. It was developed in a two-step method without the involvement of saggars. For greater α -alumina purity, three types of binders were chosen, with PVA (Polyvinyl Alcohol) proving to be the most effective. Effect of binders and increase in temperature are some of the crucial parameters in terms of the purity of alumina. The XRD (X-Ray diffraction) technique was utilised to distinguish between α -alumina and γ -alumina and revealed a structural phase change from gamma- Al_2O_3 to alpha- Al_2O_3 in nano-porous structure. Electron microscopy images indicated the formation of near spherical shape with a diameter roughly to be 25 nm. Further, from the surface morphological studies it was observed that the synthesized α -alumina was at the higher side, although the porosity decreased with temperature. Our research revealed that the synthesized α -alumina has a high purity of 99.9 %, implying that it has the potential for future industrial uses, especially while its production using a tunnel kiln in an economical manner.

Keywords: Aluminium oxide, Binder, Nanomaterial, Phase transition, Synthesis.

1. Introduction

Alumina (Al_2O_3) is a raw material used in the production of many different types of ceramic materials, catalyst supports and refractories. Most commercial alumina is produced according to the "Bayer Process", a well-known process for the production of alumina from bauxite [1]. Alumina has high strength and excellent heat resistance, and they are used in the form of moulded articles [2]. In particular, these products are obtained by moulding and/or mixing alumina together with various binder components and different matrixes having small bulk density and so they are lightweight [3]. In addition, they have a large insulating effect, and therefore they are suitable for high-temperature insulating materials. Having said that, alumina and its applications are effectively applied in various industries for its supremacy in physical and chemical properties which is high heat resistance, excellent electrical isolation, abrasion resistance and high corrosion resistance [4]. In recent years, the demand of high purity alumina is expanding in fields which are expected to show a high growth rate i.e., display materials, energy, automobiles, semiconductors and computers [5,6,7]. The term "high-purity" refers to alumina that is 99.6 % -99.9 % pure and composed of uniformly sized fine particles. When the purity is lower than this level, chemical stability is poor, and the objective of the present invention cannot be achieved. In this connection, alumina blocks prepared with absolute zero dilution with any other external products other than

a binding agent [8,9]. The Bayer processing of bauxite to produce smelter grade alumina involves digestion of the bauxite ore at temperatures in the range of 135-250 °C. The digestion produces a saturated sodium aluminate liquor from which ATH (Aluminium Tri-hydroxide) is crystallized (as gibbsite) by cooling in the presence of large quantities of seeds [10, 11].

In this context, a poor bauxite as defined by commercial practice [12] would have a Total Available Alumina/ reactive silica (TAA/reactive SiO₂) ratio of alumina products are not for smelter use [13]. Alternative processes (non-Bayer) have been developed in efforts to recover alumina from bauxite in an attempt to reduce the cost and energy required for the production of specialty alumina (low soda, fine and high purity alumina). Other processing techniques have been developed in order to produce these more valuable specialty alumina or sodium aluminate etc, [14,15]. New research has also been conducted to develop alternative processes to recover alumina from “hard to treat” bauxites, including those containing high soluble silica or diaspore, aluminogothite ores or calcium aluminate slags, which pose technical difficulties during Bayer processing [16]. Boehmite (aluminium monohydroxide or alumina monohydrate, Al₂O₃.H₂O or γ-AlOOH) can be synthesized by hydrothermal processing at > 160 °C [17], or via crystallization from saturated sodium aluminate liquors by cooling [18,19]. Dash et al. reported that boehmite could be precipitated from a sodium aluminate solution having an A/C_{Na2O} of 1.0-1.1 at 85-93 °C (which is higher than the conditions for gibbsite precipitation) using > 300 g/L boehmite seeds. The addition of additives such as tartaric acid (50-300 mg/L) or precipitation at lower temperatures would favour the formation of gibbsite. A higher super-saturation also favours gibbsite formation [20]. Wang et al. used CO₂ to precipitate a mixture of gibbsite and boehmite from a sodium aluminate liquor as a method to recover aluminium hydroxide [21]. The use of flash calcination at 400-600 °C was applied to pre-treat a bauxite containing high aluminogothite [22]. A thermal-chemical activation process was also developed by Smith and his co-workers to deal with high reactive silica bauxite [23,24]. The process involves the roasting of bauxites containing high reactive silica to ~950 °C or above to decompose the kaolin component into amorphous silica and transitional alumina. Roasting bauxite before its digestion can also potentially destroy most organic matter, which exist in the ore up to 0.5% w/w carbon [25]. While calcination of alumina at higher temperature is known its operational issues while processing is often not economical when processed in a tunnel kiln.

Moreover, the tunnel kilns are mostly used by the ceramic industries for heating refractory and ceramic products [26]. Basically, a tunnel kiln is a long stationary insulated furnace made of refractory bricks or pressed ceramic wool blankets. It has a rail track provision inside the kiln for the travel of trolleys. The material is loaded on the trolleys and enters from the feed end of the tunnel kiln [27]. It comes out on the other end by travelling inside the kiln with a prefixed speed. In these kilns, the material passes through different temperature regimes of preheating, and reduction as in beneficiated but with stationary bed of material [28]. Therefore, one has the flexibility with raw material. Another major advantage is that it utilizes beneficiated fines directly without induration. Low upkeep and maintenance are required. Unlike rotary kiln, heating is external and therefore it permits the use of different carbon source for heating. The only drawback of this process is low productivity which is even less compared to rotary kiln due to operational problems of charging powder alumina in the tunnel kiln using several containers or saggars which breaks due to thermal expansion during calcination at higher temperatures. This resulted frequent stoppages of kiln, new saggarr replacements, loading and unloading issues etc. making business uneconomical.

2. Materials and Methods

Alumina was collected from the NALCO alumina refinery. PVA (Polyvinyl alcohol) was purchased from HIMEDIA. In the current research paper, we have tried to synthesize α-alumina by developing a suitable clot (pellets) by using of a suitable binder (which is a challenge) so that

5. References

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