Bayer process

The **Bayer process** is the principal industrial means of refining bauxite to produce alumina (aluminium oxide). Bauxite, the most important ore of aluminium, contains only 30–54% aluminium oxide, (alumina), Al_2O_3, the rest being a mixture of silica, various iron oxides, and titanium dioxide.[1] The aluminium oxide must be purified before it can be refined to aluminium metal.

Process

The **Bayer process**
In the Bayer process, bauxite ore is heated in a pressure vessel along with a sodium hydroxide solution at a temperature of 150 to 200 °C. At these temperatures, the aluminium is dissolved as sodium aluminate in an extraction process. The aluminium compounds in the bauxite may be present as gibbsite($Al(OH)_3$), boehmite(AlOOH) or diaspore(AlOOH); the different forms of the aluminium component will dictate the extraction conditions. After separation of the residue by filtering, gibbsite (aluminium hydroxide) is precipitated when the liquid is cooled and then seeded with fine-grained aluminium hydroxide.

The extraction process converts the aluminium oxide in the ore to soluble sodium aluminate, $2NaAlO_2$, according to the chemical equation:

$$Al_2O_3 + 2\ NaOH \rightarrow 2\ NaAlO_2 + H_2O$$

This treatment also dissolves silica, but the other components of bauxite do not dissolve. Sometimes lime is added at this stage to precipitate the silica as calcium silicate. The solution is clarified by filtering off the solid impurities, commonly with a rotary sand trap and with the aid of a flocculant such as starch, to remove the fine particles. The undissolved waste after the aluminium compounds are extracted, bauxite tailings, contains iron oxides, silica, calcia, titania and some unreacted alumina. The original process was that the alkaline solution was cooled and treated by bubbling carbon dioxide through it, a method by which aluminium hydroxide precipitates:

$$2\ NaAlO_2 + CO_2 \rightarrow 2\ Al(OH)_3 + Na_2CO_3 + H_2O$$

But later, this gave way to seeding the supersaturated solution with high-purity aluminium hydroxide ($Al(OH)_3$) crystal, which eliminated the need for cooling the liquid and was more economically feasible:

$$2\ H_2O + NaAlO_2 \rightarrow Al(OH)_3 + NaOH$$

Some of the aluminium hydroxide produced is used in the manufacture of water treatment chemicals such as aluminium sulfate, PAC (Poly aluminium chloride) or sodium aluminate; a significant amount is also used as a filler in rubber and plastics as a fire retardant. Some 90% of the gibbsite produced is converted into aluminium oxide, Al_2O_3, by heating in rotary kilns or fluid flash calciners to a temperature in excess of 1000 °C.

$$2\ Al(OH)_3 \rightarrow Al_2O_3 + 3\ H_2O$$

The left-over or 'spent' sodium aluminate solution is then recycled. This, however, allows

gallium and vanadium impurities to build up in the liquors, so these can be extracted.

For bauxites having more than 10% silica, the Bayer process becomes uneconomic due to insoluble sodium aluminium silicate being formed, which reduces yield, and another process must be chosen.

Over 90% of the aluminium oxide produced is used in the Hall–Héroult process to produce aluminium.