



Detailed production steps of alumina from coal ash in china

In China, the production of alumina from coal ash involves several detailed processing steps, tailored to handle high-alumina fly ash from coal-fired power plants, especially in regions like Shanxi and Inner Mongolia. The adopted technologies vary, but commonly include acid leaching, alkali sintering, hydrothermal processes, and roasting methods, each designed to maximize alumina recovery and minimize environmental impact. ^{[1] [2] [3] [4]}

Detailed Production Steps

1. Raw Material Preparation

- **Coal fly ash** is collected from thermal power plants and typically ground to increase surface area. ^[3]
- Drying is performed (often at $\sim 105^{\circ}\text{C}$) to remove moisture prior to processing. ^[5]

2. Activation/Pre-Treatment

- **Calcination:** The fly ash is calcined (heated, typically $600\text{--}900^{\circ}\text{C}$) to modify mineral phases and improve reactivity, a key step before chemical extraction. ^{[4] [3]}
- Desilication may be performed to remove excess silica, which can interfere with later recovery steps. ^[6]

3. Chemical Leaching

Acid Leaching Route (e.g., H_2SO_4 or HCl)

- Ground and calcined coal ash is mixed with concentrated acid (commonly sulfuric or hydrochloric acid). ^[3]
- Roasting: The mixture is roasted further to facilitate extraction reactions. This step can reach temperatures of $600\text{--}800^{\circ}\text{C}$. ^[3]
- Leaching: Roasted residue is leached with hot water, dissolving aluminum salts (usually as aluminum sulfate or chloride). ^{[1] [3]}
 - For example, Shenhua Group uses one-step HCl leaching: fly ash is treated with 20% HCl at $130\text{--}150^{\circ}\text{C}$ for 2 hours, achieving high yields. ^[1]
- Solution handling: The resulting aluminum salt solution is concentrated and cooled, allowing aluminum salt crystals to precipitate. ^[3]

- Crystal dehydration: Aluminum salt crystals are heated to produce anhydrous aluminum salts.^[3]

Alkali Hydrothermal Route

- A solution of sodium hydroxide (NaOH) and sometimes lime ($\text{Ca}(\text{OH})_2$) is prepared.^[5]
- Fly ash mixture is processed in an autoclave at high temperature (up to 260 °C) and pressure; alumina is extracted into solution as sodium aluminate.^{[7] [5]}
- Solid-liquid separation: Filter to separate insoluble residues from sodium aluminate solution.
- Precipitation: Alumina is recovered from solution by cooling/neutralization (precipitation of aluminum hydroxide).^{[2] [7]}
- Calcination: The precipitated hydroxide is calcined (heated ~1200 °C) to yield pure alumina powder.^[5]

Ammonium Sulfate Roasting

- Fly ash is roasted with ammonium sulfate and then leached with water. Alumina-containing complexes are formed and separated.^{[8] [4]}

4. Purification and Product Finishing

- Filtration, washing, further calcination, and solid-liquid purification steps are employed to yield high-purity alumina, suitable for aluminum smelting or industrial use.^{[4] [5] [3]}
- Secondary by-products (e.g., silica) may also be extracted in parallel with alumina.^[7]

Example: Stepwise Process (from Chinese practices)

Step	Process Detail
Raw ash handling	Collection, grinding, drying
Calcination	600–900 °C heating for phase modification
Acid/alkali leaching	Sulfuric/HCl (acid) or NaOH (alkali) at 130–260 °C, under agitation
Roasting	High-temperature treatment for activation
Liquid separation	Filtration to obtain aluminum-rich solution
Precipitation	Cooling/concentration to form aluminum salt/hydroxide crystals
Calcination	1200 °C heating to produce final alumina
Waste/byproduct handling	Management and possible utilization of silica, unreacted residue

Equipment Used

- Ball mills or grinders
- Rotary kilns or fluidized bed furnaces for calcination
- Autoclaves and reactors for hydrothermal/chemical leaching
- Roasting furnaces
- Industrial filters and separation units
- Crystallizers and sedimentation tanks
- Calcination units for final product processing ^[4] ^[5] ^[3]

Summary

China employs integrated acid, alkali hydrothermal, and roasting processes to extract alumina from coal ash, typically involving steps of drying, calcination, chemical leaching, solution handling, precipitation, and calcination to yield high-purity alumina. These practices not only help meet domestic demand, given limited bauxite resources, but also creatively utilize coal ash waste streams for value-added production. ^[2] ^[1] ^[5] ^[4] ^[3]



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