Extraction of Aluminium and High Quality Aluminium Oxide from Coal Ash and Production of Liquid Fuels from Methane

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In this article, few ideas on extraction of aluminium and high quality aluminium oxide from coal ash and production of liquid fuels from methane, in a cost effective way with optimum use of resources are given. Attempt has been made to provide these ideas in simple manner to understand easily. The author at his age of ninety two is interested only to see that the said views reach many in different walks of life and put in to action as appropriate.

The Ideas

At present, bauxite is used as the raw material for the extraction of aluminium and pure aluminium oxide. Innumerable attempts were made in the last century to utilize clay as a substitute raw material for bauxite and also for avoiding the use of consumable carbon anode in Aluminium production. Till date, these attempts have not been commercially successful.

I recommend the utilization of high ash content (up to 40%) of low grade coal in place of clay as raw material, which is far cheaper than clay, because:

1. Cost of mining clay is avoided
2. The clay is used for other purposes as a successful raw material and
3. Heat treatment of clay at 750 – 800 degree centigrade which is essential for the leaching of aluminium, as chloride by reaction with Hydrochloric acid is avoided

The low grade powdered coals are subjected to latest methods of physical separation to get

1. Cleaned coal powder fraction and
2. Coal powder containing all ash and sulphur (even up to 4.5%) contents

Coal powder from fraction (2) is subjected to chemical treatment in which the chemicals ferrous sulphate-sulphuric acid are regenerated and used in the cyclic process. The ferrous sulphate–sulphuric acid solution is converted into ferric sulphate by air and bacterial oxidation. A required portion is used in the cyclic process. The excess ferric sulphate solution is reacted with ammonia gas and then filtered to remove good quality ferric hydroxide. The ammonium sulphate solution is used as fertilizer.

After removing the sulphur content, the ash rich coal fraction is subjected to circulating fluidized bed combustion, a commercially established technology of Bharat Heavy Electrical Limited (BHEL), Tiruchirapalli (Tamil Nadu, India) to generate steam and from it mechanical and electrical energy. The resulting ash is used as a raw material in place of clay for the production of aluminium metal and pure aluminium oxide.

Any attempt to avoid liberation of oxygen at the anode, which consumes the carbon anode, must produce chlorine as anode product at graphite anode through the electrolysis of suitable mixtures chlorides of sodium, potassium and aluminium at proper temperatures. The production of pure anhydrous aluminium chloride from clay its feeding in to electrolytic cells in an inert atmosphere and also maintaining proper conditions during electrolysis have met with considerable difficulties in commercial operations.

Hence I recommend production of pure aluminium chloride solution from coal ash converting it into pure and easy to handle sodium cryolite in a cyclic process and electrolysis of suitable mixtures of

sodium cryolite, sodium and potassium chlorides at about 850 degree centigrade, to get aluminium metal with chlorine liberation at graphite anode. The success of this procedure depends upon economic:

1. Production of sodium cryolite from coal ash in a cyclic process and
2. Utilization of chlorine.

It is well established on a commercial scale that purified methane obtained from any source such as natural gas, bio gas, coal bed methane, can be reacted with chlorine to get methyl chloride with the expulsion of hydrochloric acid and from methyl chloride liquid fuels can be produced employing suitable catalysts under proper conditions with the expulsion of the hydrochloric acid gas. I recommend the use of chlorine obtained as co-product in aluminium metal production for obtaining methyl chloride. The success of this process of producing liquid fuels from methane depends upon the economic utilization of hydrochloric acid co product resulting (a) methyl chloride production and (b) in the production of liquid fuels from methyl chloride. I recommend these two sources of hydrochloric acid in the production of pure aluminium chloride solution from coal ash.

The coal ash is reacted with concentrated hydrochloric acid solution (and if need be along with very small required amount of mild steel scrap filings to reduce any ferric iron solution to ferrous) in a plastic lined vessel and filtered. The acid filtrate is reacted with HCl gas to precipitate out pure aluminium chloride hydrate and centrifuged employing plastic lined vessel and filtered. The acid filtrate from this step is utilized in a cyclic process for treating coal ash.

In the continuous production of aluminium metal and chlorine depleted electrolyte is withdrawn at regular intervals fortified and fed at regular intervals to the cell. Fortification of depleted electrolyte is done by reacting calculated amounts of depleted electrolyte and pure aluminium chloride hydrate in the presence of required amount of water. The least soluble sodium cryolite is precipitated out leaving behind concentrated sodium and potassium chloride solutions.

$$Alcl3 + 6\ NaF \text{ ----------} \rightarrow Na3\ AlF6 + 3\ NaCl$$

To this mixture required amount of makeup sodium fluoride, sodium and potassium chlorides are added, evaporated to get solid and the resulting solid is melted and fed in to the electrolyte cell at regular intervals. A required portion of molten aluminium is retained at the cell for use as cathode and the rest is removed at regular intervals and utilized for various purposes. The chlorine co product is utilized as indicated earlier.

Production of Pure Aluminium Oxide

Pure aluminium oxide can be obtained from pure aluminium chloride hydrate by thermal decomposition in the presence of steam at suitable high temperatures out of contact with air to get pure aluminium oxide as a residue with expulsion of HCl. The hydrochloric acid along with small required amount of makeup hydrochloric acid is used in a cyclic process to get pure aluminium chloride hydrate from coal ash as indicated earlier.

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