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# Studies on ferric oxide based anodes for aluminium production

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Extensive use of electrocatalytic processes call for the development of cheap and easily available materials for use as anodes in electrowinning operations. From energy and pollution considerations, replacing the existing carbon anodes with stable anodes are thought of and mixed oxides based composites have been identified as suitable anodes. The preparation of $NiFe_2O_4$ and $CoFe_2O_4$ compacts and their physical characteristics such as density and electrical conductivity are presented in this paper.

**Key words: Ferric oxide anode, aluminium production, electrocatalysis**

## INTRODUCTION

The search for a suitable alternate anode for Al production is being carried out. Aluminium is produced world over by the electrolytic decomposition of purified alumina dissolved in cryolite melt at 1243K between carbon block cathode and carbon or carbonaceous materials as consumable anode. Even though the technology has been in existence for a century, no major change has taken place. Recently, an awareness has been created in the aluminium industry to improve the technology of aluminium production and some work has been initiated.

One of the improvements thought of is the identification and application of nonconsumable anodes in place of consumable carbon. Earlier communication [1] discusses the role of anode, main disadvantages of the present anodes and some of the alternate materials. Actual consumption of carbon is about 450 kg per ton of Al produced. This consumption of carbon accounts for 10% of production cost. Besides the quantity, the quality of carbon also must be high in order to get a pure metal. Though a minimum of 1.2 V is essential for the electrolytic decomposition of alumina, in practice due to large inter electrode gap the cells operate at about 4 to 5 V, resulting in a high energy consumption of 14,000 to 15,000 kWh/T of metal. The use of inert anodes with stable cathodes will result in about 30% energy saving and a net reduction of 15% in cost of production.

The development of the nonconsumable anodes will result in complete elimination of prebaked or Soderberg anodes and handling of large volume of $CO_2$. At the inert anode, the product is only concentrated oxygen—a valuable byproduct. Pots with reduced stable interpolar gap lowers the energy consumption. Above all a compact closed clean and higher energy efficient cell could be foreseen by the introduction of inert electrodes in the pots.

After testing several materials, mixed metallic oxides were found to be suitable material as anode [2,6]. This paper deals with the method of fabrication of pellets, sintering and some of the characterisation of two important ferrite anodes –$NiFe_2O_4$ and $CoFe_3O_4$.

## EXPERIMENTAL

### Fabrication

The oxide composites are prepared by mixing 30-32%, NiO/CoO with 1% niobium pentoxide and the remaining $Fe_2O_3$.

In the first method, the oxides were thoroughly ground and their particle size analysis was done using Malvern Particle Sizer which was essential, as the size of the starting materials plays a major role in the property of the end product. They were mixed, blended and average size was again measured. Then compacted to get pellets of 2.2 cm dia and 1.5 to 2 cm height at a pressure of 4 $T/cm^2$ in a hydraulic press. In the second method, the individual powders were preheated to a temperature of 973K and kept at that temperature for 3 to 5 hrs and then size was measured and compacted under identical conditions.

The green density was calculated and they were sintered upto 1523K in stages, holding at 673K and 1173K for 2-3 hrs. Sintering was done to impart higher density,mechanical strength and electrical conductivity. After heating for over 24 hrs intermittently and slow cooling the density of the sintered samples were calculated and electrical resistance measured. The pellets were tightly pressed in between two Pt plates and resistance was measured using digital microohm meter. The measurements were done continuously from room temperature to 1273K controlling the tempertures by an electrically heated resistance furnace. The results are given in Fig. 1.

 

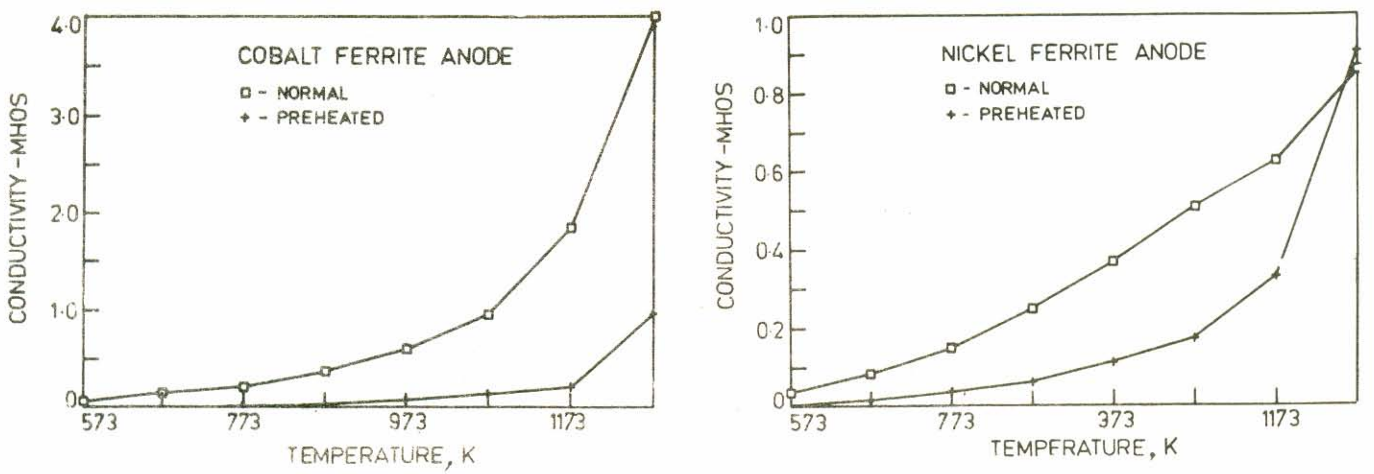


*Fig. 1: Variation of electrical resistivity with temperature*

## RESULTS AND DISCUSSION

The pellets obtained are hard enough to withstand the normal mechanical handling of cell operation. The density is in the order of 4.0 to 4.5 $g.cm^{-3}$. From Fig. 1, it can be seen that both ferrites have got higher conductivities than the present anodes of Al pot and among them the cobalt ferrite has got a four fold higher conductivity than Ni ferrite. Preheating was not advantageous but had an adverse effect on the cobalt ferrite. In Ni ferrite, the effect is distinct at lower temperature, but the electrical conductivity at higher temperature is maintained. Preheating did not have much effect on the particle size distribution. The size of the individual powders were 1,0-20 micrometre and a slight size reduction has been observed during blending.

## CONCLUSION

Among the two ferrites studied, cobalt ferrite seems to be more suitable. But considering the electrical conductivity alone, both are better than prebaked or Soderberg electrodes. Actual cell operation using this anode material has to be carried out before arriving at a final conclusion.

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