

Reduction of Bauxite through Hydrogen

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Abstract

The present investigation aims at beneficiating the run of the mined bauxite mineral for enhancing the purity of alumina which can be subsequently treated for aluminium extraction. The present process involves reduction of the bauxite mineral by molecular hydrogen, non-thermal hydrogen plasma and thermal hydrogen plasma respectively followed by magnetic separation. The products are characterized after each stage of operation for their chemical composition, XRD (X-ray Diffraction) analysis and microscopic analysis. The results revealed that hydrogen could reduce iron oxide present in the bauxite and subsequently these iron bearing constituents can be removed from the bauxite mineral through magnetic separation. It was observed that alumina of moderate purity can be obtained through the above process used in the present study. The separated alumina after hydrogen reduction of bauxite mineral and subsequent magnetic separation was reduced further by hydrogen plasma which could yield aluminium of moderate purity.

Keywords: Bauxite, alumina, aluminium, hydrogen plasma, reduction, magnetic separation.

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Contents

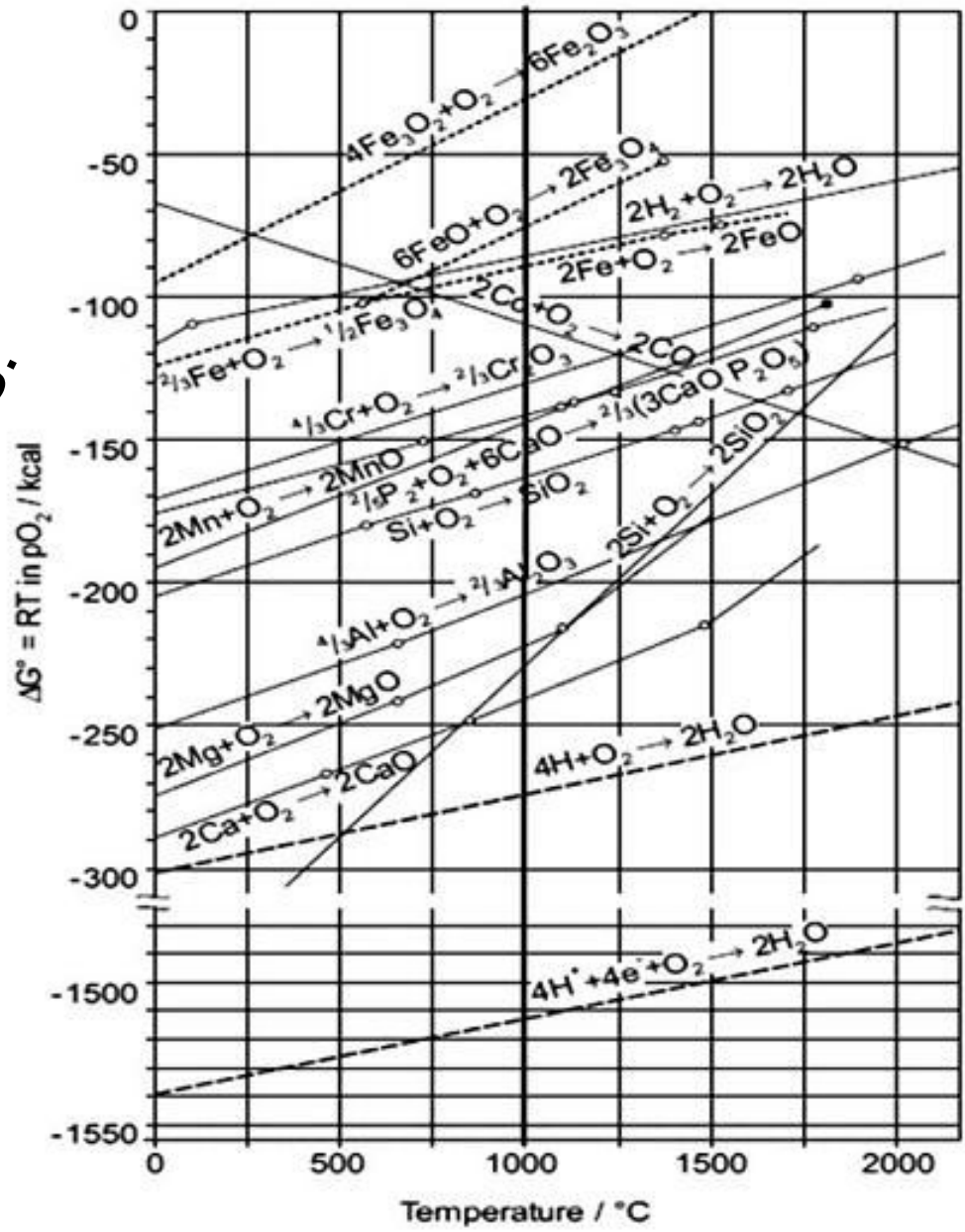
- Introduction
- Objectives
- Experimental Details
- Results and Discussion
- Summary

Introduction

Hall-Heroult Process (Disadvantages):

1. The hydrometallurgical effluents from the Bayer process and the fumes generated by the Hall-Heroult process constitute a major cause of environmental pollution. For example during the Bayer process a large no. of sodium ions are introduced during NaOH leaching and these ions are discharged from the system into the natural water resources. Similarly, the disposal of red mud is a serious problem.
2. The electrolysis process uses large amounts of energy in the extraction and makes aluminium very expensive to produce.
3. Electrodes are made up of graphite & are very expensive and also large number of electrodes are being used for the extraction of aluminium by Hall-Heroult process.

Ellingham Diagram for Metal-oxides.



Advantages of Hydrogen Reduction:

1. The reaction of metal oxides with hydrogen is far more environmentally friendly, as the by-product being water rather than carbon dioxide.
2. Hydrogen in the form of plasma (consisting of H and H⁺) is a very powerful reductant that can reduce most metal oxides at temperatures below the melting point of metals.
3. Thermodynamically it should be easier to reduce alumina by H or H⁺ as these lines are present well-below the Al-Al₂O₃ line.

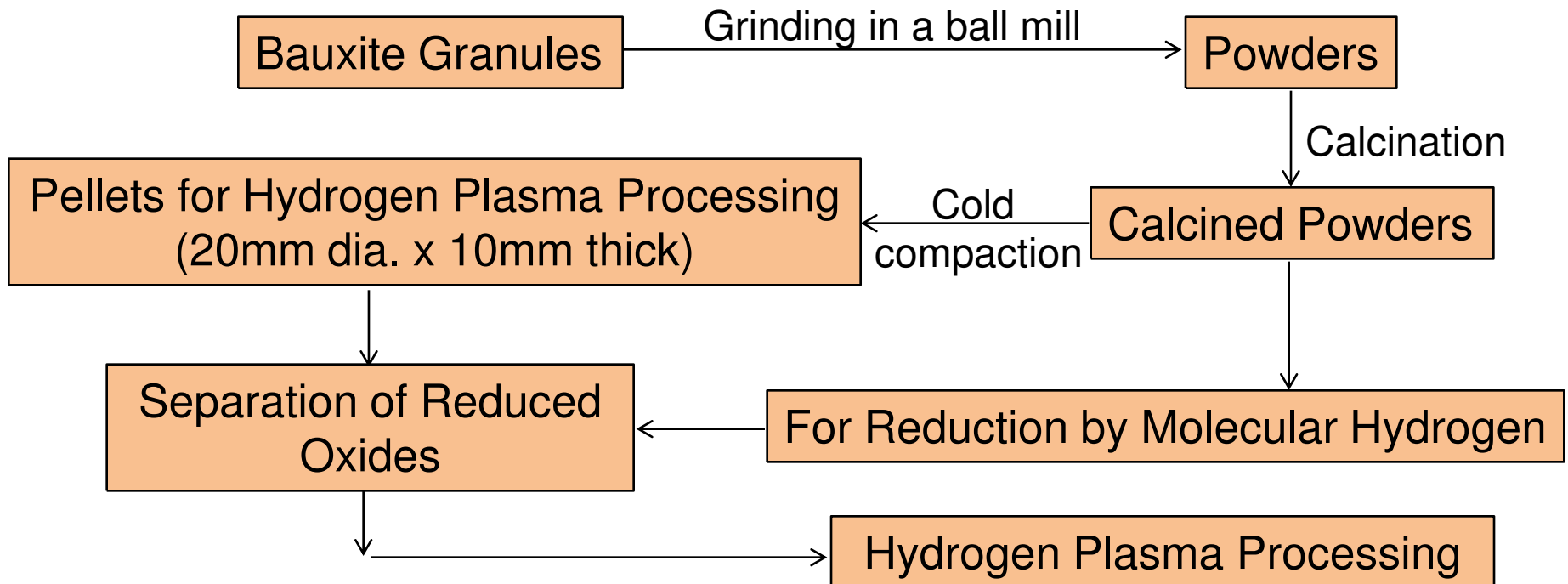
Objectives

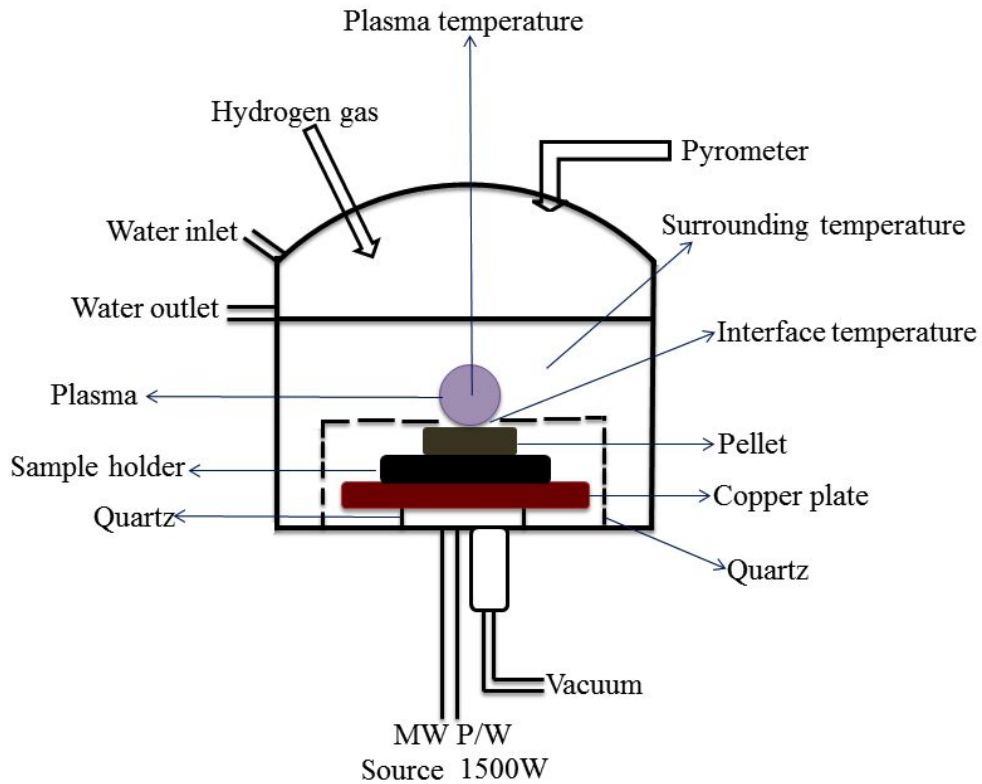
- Employing hydrogen (H_2 , H and H^+) to reduce oxide minerals present in bauxite.
- Extent of reduction of the oxide minerals present in bauxite will be established.
- Extraction of alumina through the process of hydrogen reduction.
- Extraction of aluminium through the process of hydrogen reduction.

Experimental Details

Chemical composition (in wt.%) of Bauxite (received from NALCO) used in the present work:

Al_2O_3	Fe_2O_3	TiO_2	SiO_2	LOI
43	27	3	4	22.5



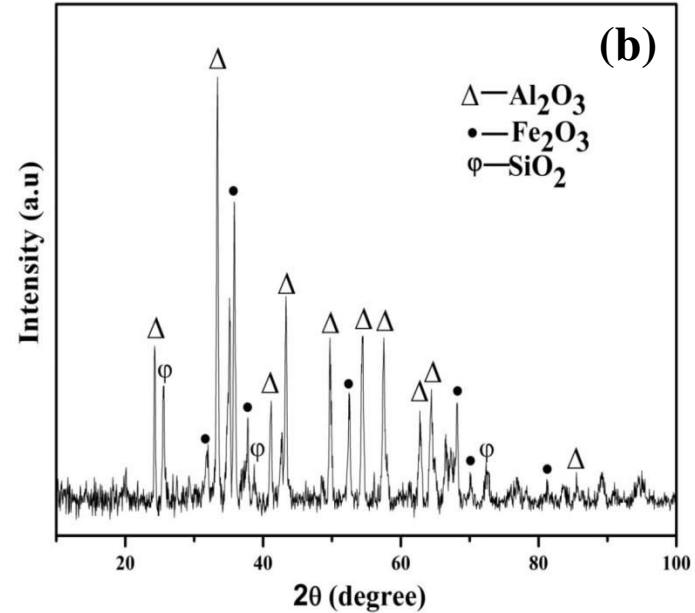
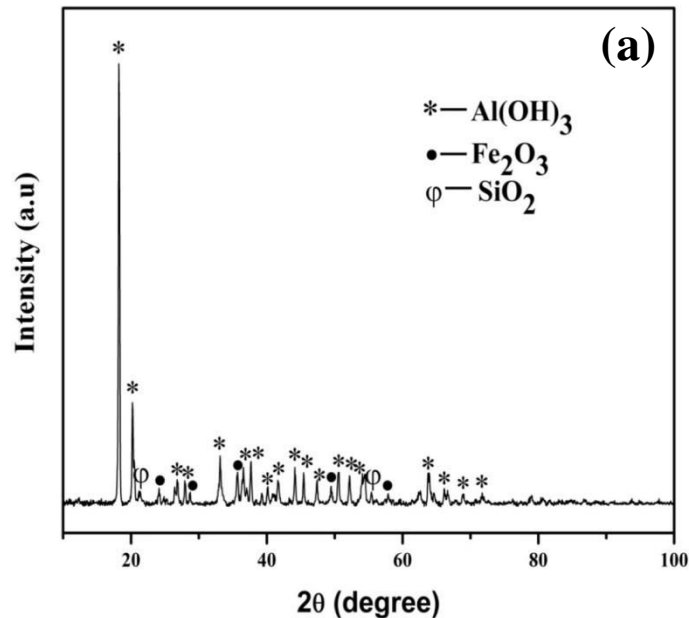


microwave hydrogen plasma reactor



hydrogen plasma smelter

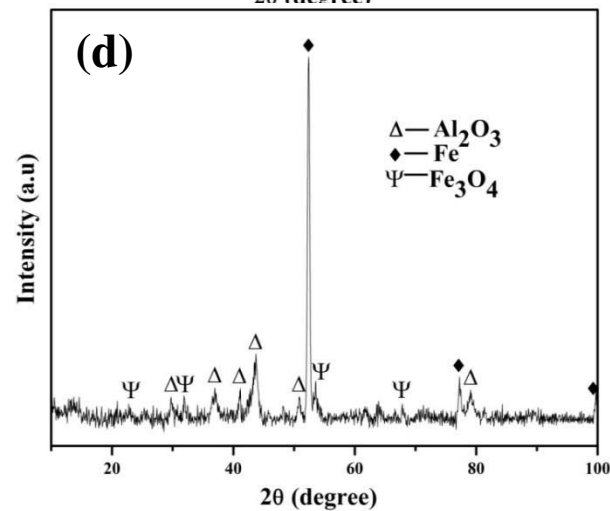
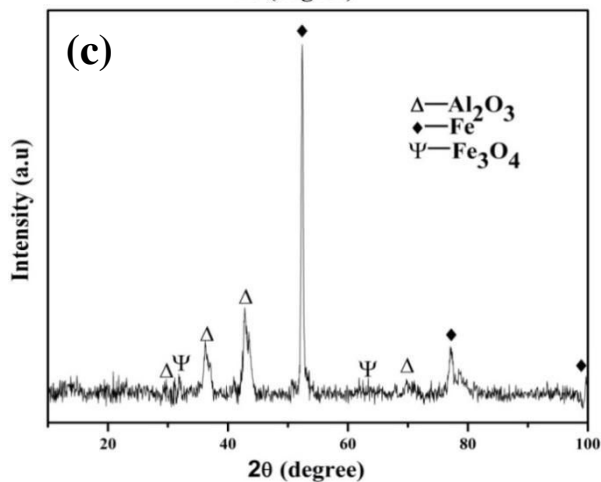
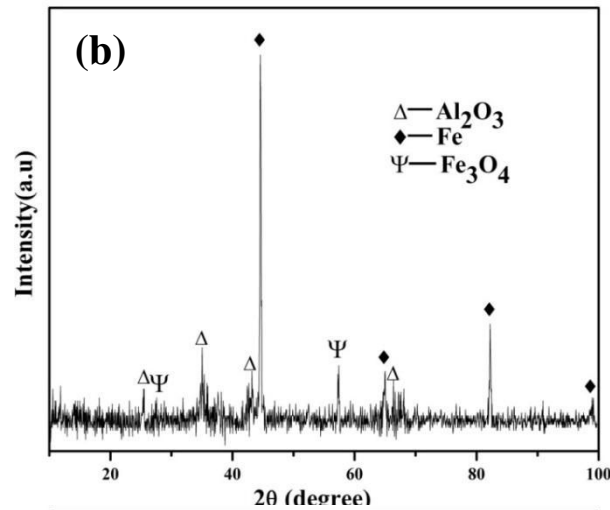
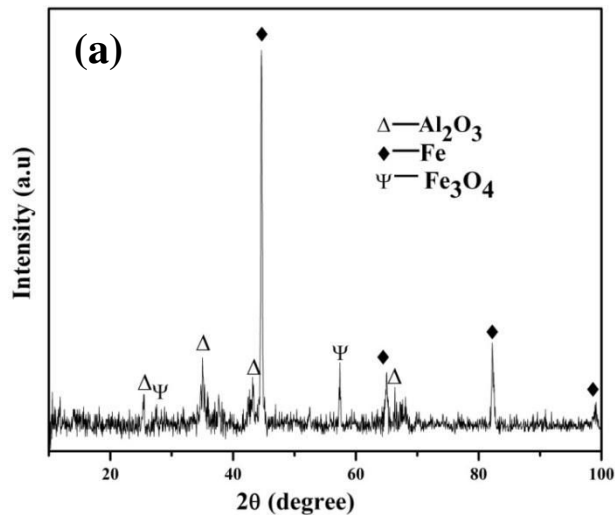
Results and Discussion



XRD pattern of (a) raw and (b) calcined bauxite sample.

Chemical composition (in wt.%) of calcined bauxite

Al_2O_3	Fe_2O_3	SiO_2	TiO_2
59.48	29.97	5.16	3.8

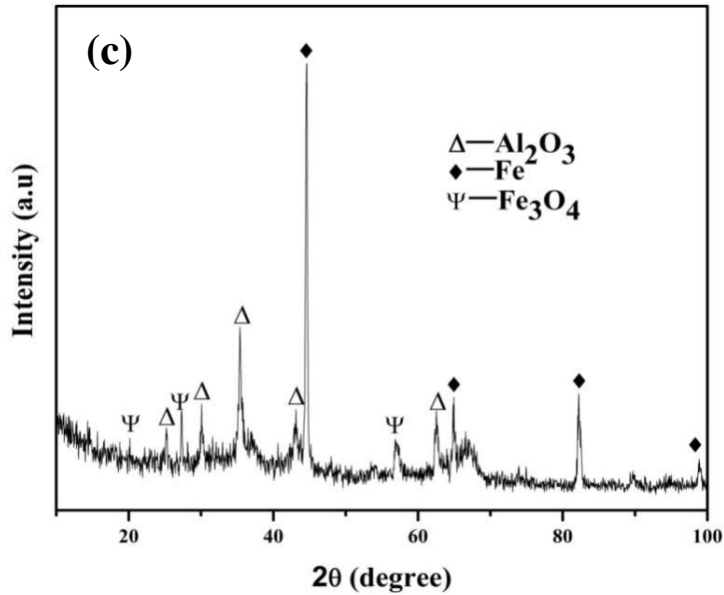
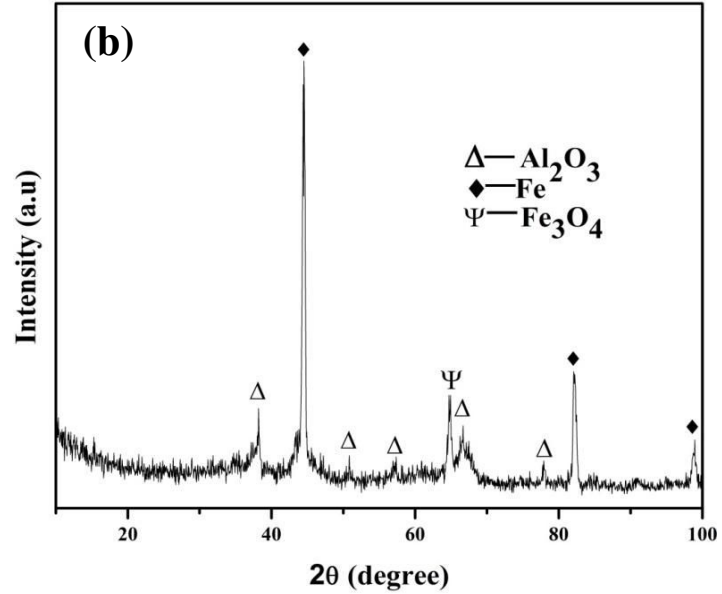
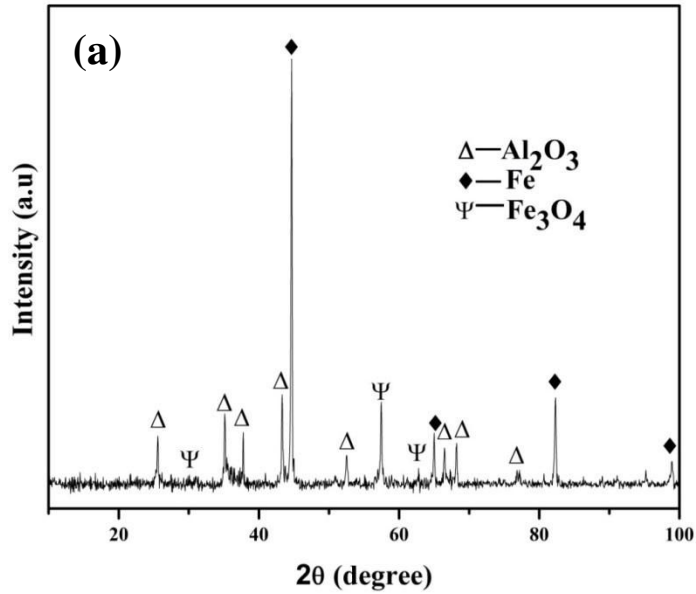


Chemical composition (in wt. %) of bauxite after reduction through hydrogen.

Al_2O_3	Fe_3O_4	Fe	SiO_2	TiO_2
57.87	2.74	23.21	4.26	3.72

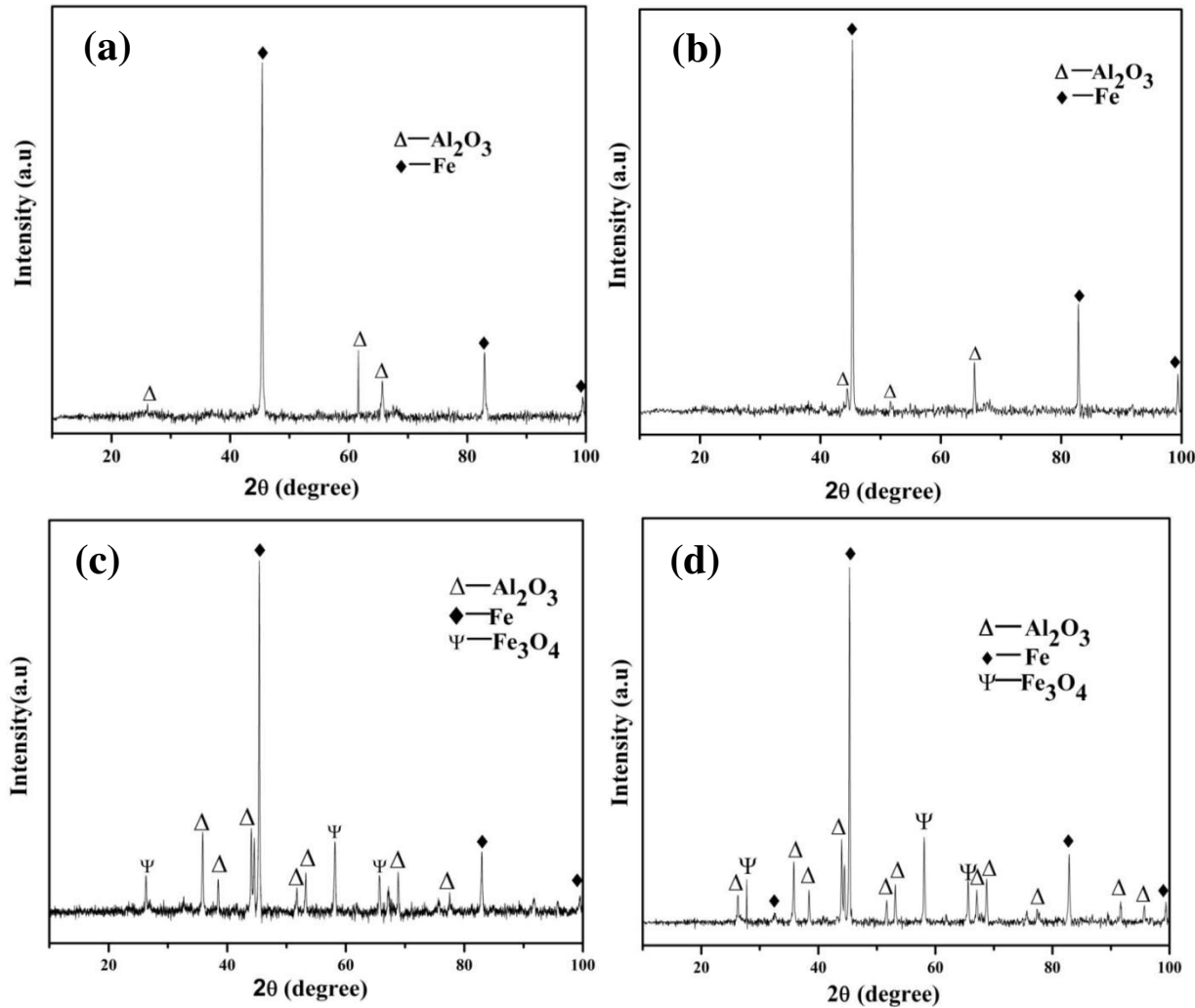
XRD patterns of reduced bauxite after processing through hydrogen

Reduction through Hydrogen



XRD plots of bauxite reduced through microwave assisted hydrogen plasma processing at different flow rate of hydrogen.

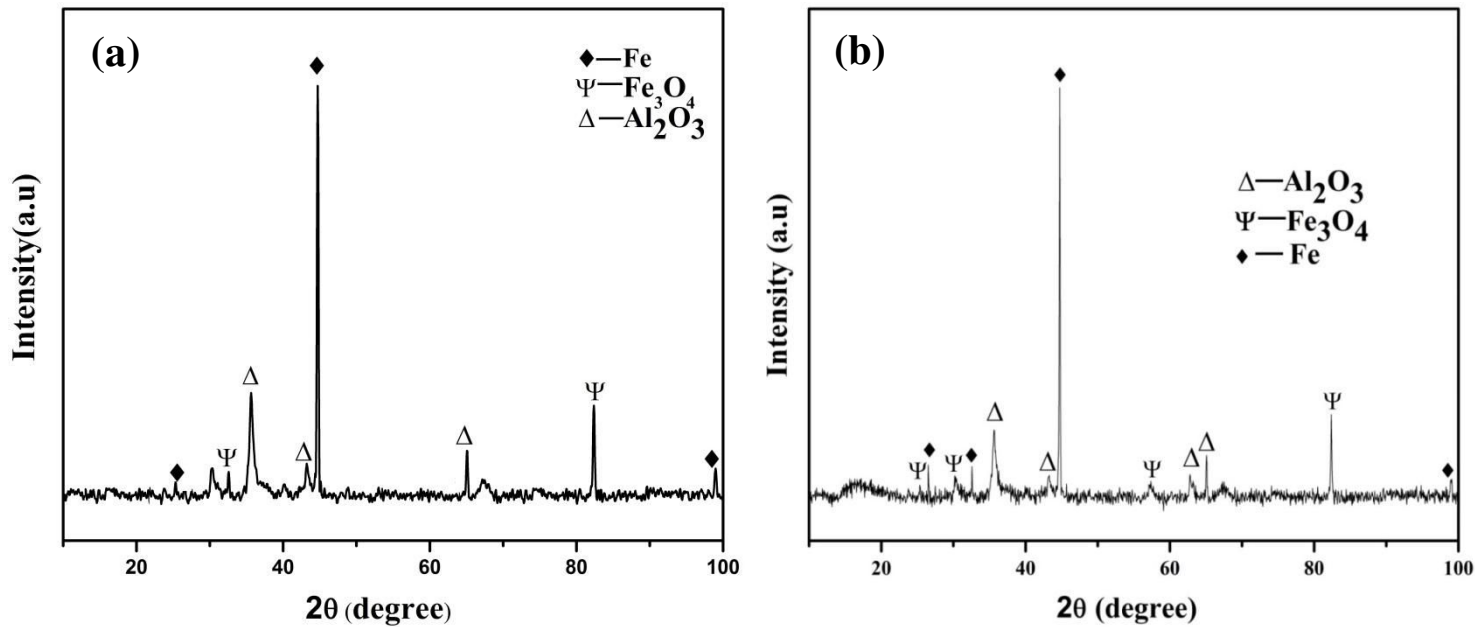
Reduction through microwave assisted hydrogen plasma



XRD plots of bauxite samples after reduction through hydrogen plasma.

Chemical composition (in wt.%) of bauxite reduced by microwave hydrogen plasma at 1200 °C.

Al ₂ O ₃	Fe ₃ O ₄	Fe	SiO ₂	TiO ₂
58.06	2.03	25.21	4.26	3.55

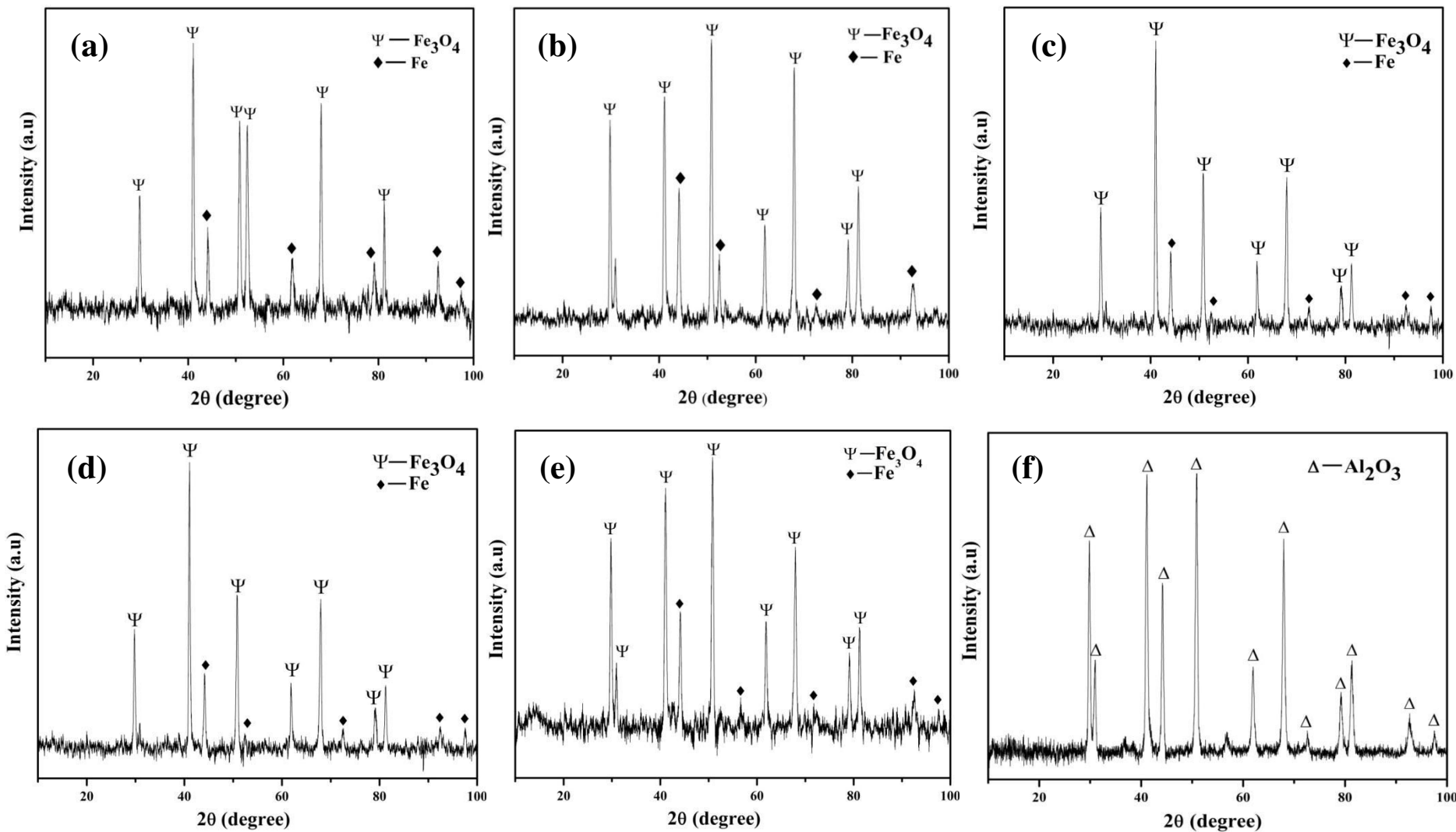


XRD plots of reduced bauxite by hydrogen plasma.

Chemical composition (in wt. %) of reduced bauxite by hydrogen plasma.

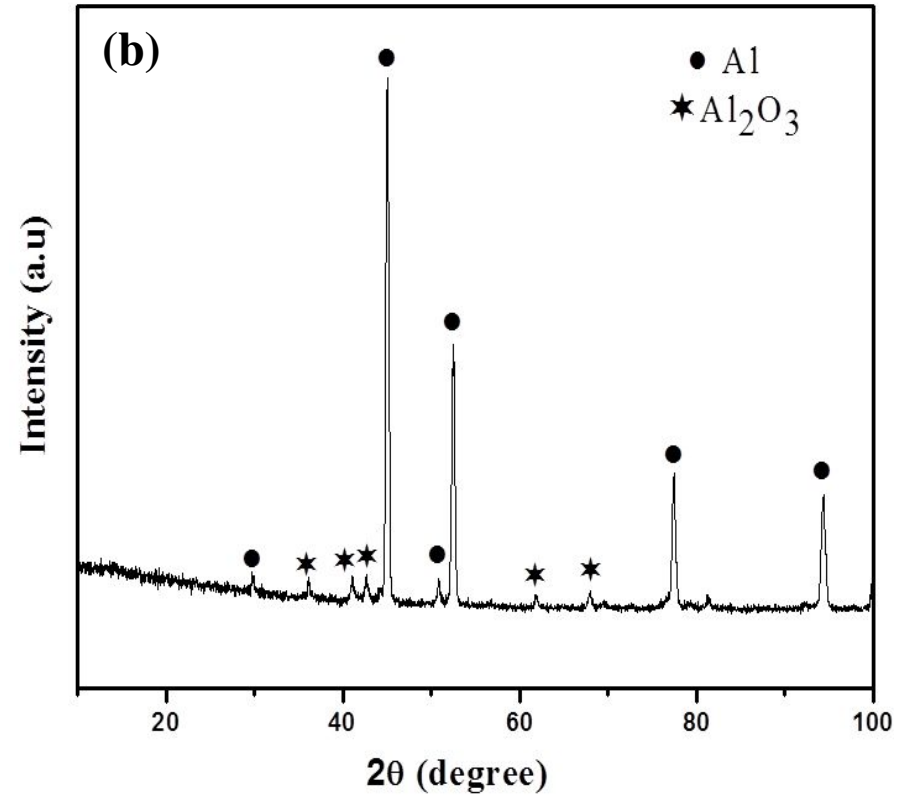
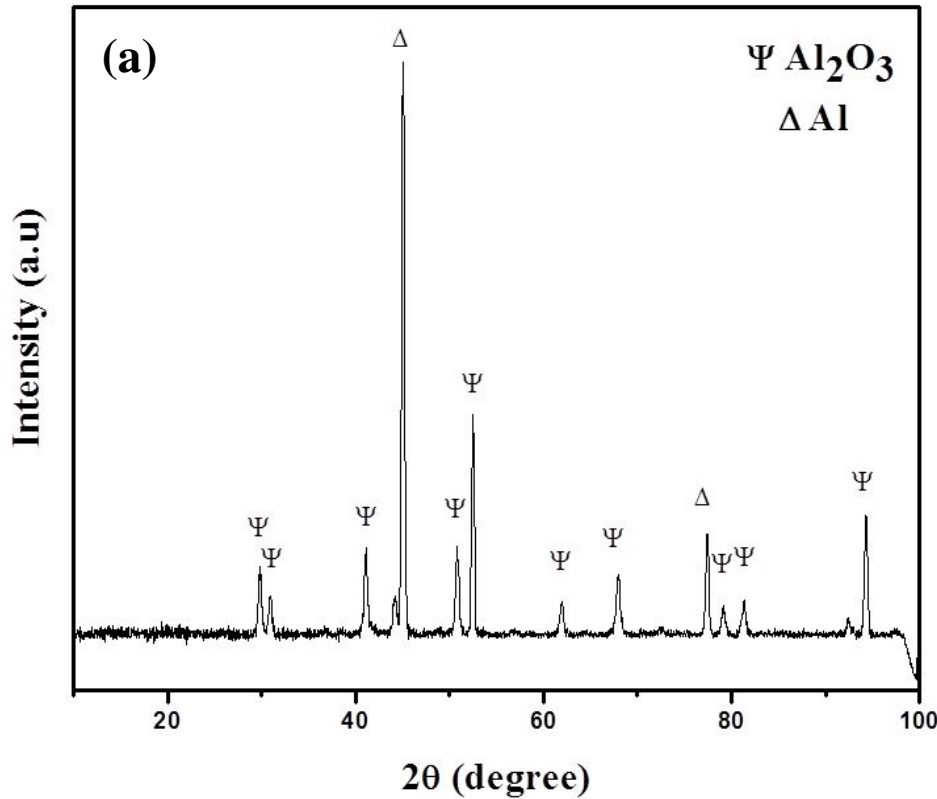
Al ₂ O ₃	Fe ₃ O ₄	Fe	SiO ₂	TiO ₂
58.33	2.01	26.61	3.26	2.89

Reduction by hydrogen plasma smelting



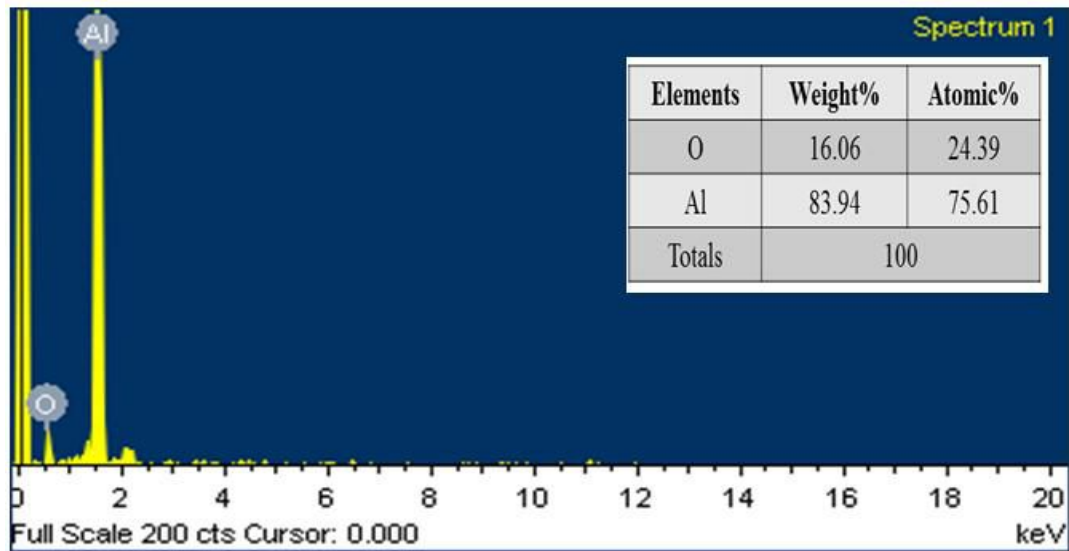
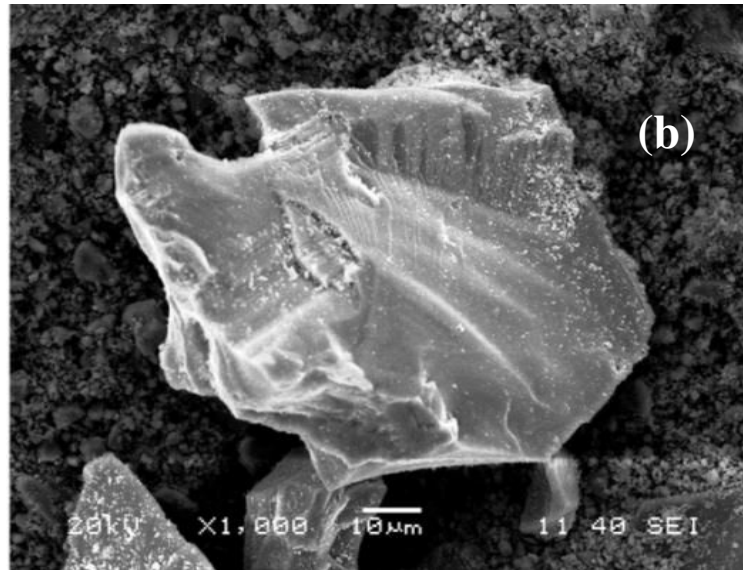
XRD patterns of magnetic fractions obtained at different magnetic field intensities.

Magnetic Separation after Reduction of Bauxite



XRD patterns of reduced alumina obtained from non-magnetic part after magnetic separation of reduced bauxite by hydrogen plasma smelting with flow rate of hydrogen.

Reduction of Alumina obtained after magnetic separation of reduced bauxite.



(a) SEM micrograph and (b) EDX spectrum of metallic aluminium obtained from reduction of alumina

Summary

It was observed that during the reduction of bauxite through hydrogen in the form of molecular, atomic and ionic hydrogen, only iron oxide present in the bauxite mineral was reduced to magnetite and metallic iron, under the processing conditions used in the present study.

As revealed from chemical composition and XRD analysis of the samples after magnetic separation, the non-magnetic portion consisted of alumina whereas the magnetic portion exhibited considerable enrichment of an iron bearing constituents.

Aluminium of moderate purity was obtained through the process of reduction of alumina through hydrogen plasma smelting.

The process can be a futuristic process for the extraction of aluminium.

Thank you!