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Letter to Editor

SYNTHESIS OF IRON OXIDE FROM METALLURGICAL WASTES

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Abstract

Waste materials like slags, mill scale and lean ores from steel plants were chemically beneficiated. The alpha Iron oxide obtained was subjected to solvent extraction and then converted to gamma iron oxide by combustion method. The raw materials and the as synthesized gamma iron oxide were characterized by X-Ray Diffraction and Fourier Transform Infrared Spectroscopy. In few cases, the intermediate products were amorphous in nature, but transformed to the crystalline state in the final product.

Keywords: Wastes; Minerals; Slags; Scale; Ferrites; Spectroscopy

1. Introduction

Industrial operations such as mining and smelting produce useful minerals and metals, but at the same time lead to the generation of large quantities of waste materials such as ore tailings, slags and mill scale. These waste materials need to be used / recycled in a constructive manner. The most voluminous utilization, so far, has been the production of blended cements from blast furnace slag. Efforts have been made towards the production of value added materials such as ferrites from lean ores and have been reported in the literature [1 – 3]. An attempt has been made, in this work, to produce iron oxide from waste materials such as slags, iron ore and mill scale. The preliminary findings [4] are reported here.

2. Experimental Details

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Five waste materials (Table 1) were chosen including three iron ore samples (from three steel plants), one slag from copper extraction and one sample of mill scale from a steel plant.

Table 1: Samples used for synthesis of iron oxide

Sl. No.	Samples	% Fe_2O_3	% SiO_2	% Al_2O_3	% FeO	Total
1	SI iron ore	77.67	10.74	4.3	----	92.71
2	SU iron ore	45.46	20.34	10.52	----	76.32
3	JL iron ore	48.5	30.04	15.24	----	93.78
4	ML mill scale	84.68	7.22	4.34	----	96.24
5	CU copper slag	1.04	15.91	20.01	33.25	70.21

The treatment procedure was similar to that reported in the literature [1 – 3]. The waste materials (sample weight of about one gram) were chemically beneficiated by acid extraction, followed by precipitation with ammonia. The thermal product of these precipitates was mainly alpha iron oxide. This was typically separated from the system by treatment with Methyl isobutyl ketone (MIBK). This was used as a precursor, in the combustion route, for the synthesis of gamma iron oxide by treating with Poly ethylene glycol (PEG). The absence of silica and alumina in the final product was confirmed in a few cases – indicating the formation of relatively pure iron oxide. The determination of chemical composition by XRF has been initiated and the data (indicative) obtained from wet analysis have been included. The waste materials and the synthesized products were characterized by FT – IR spectroscopy [5] and X- ray diffraction.

3. Results and Discussion

The FT – IR spectra (Table 2) reveal the formation of α - Fe_2O_3 and in some cases, the formation of FeOOH also - after treatment with MIBK. In one sample, the final product has been identified as a mixture of γ-Fe_2O_3 and α - Fe_2O_3.

Table 2: Spectral data from the phases synthesized

Sl. No.	Sample	Phases	Band regions (cm^{-1})	
			Obtained	Expected
1	SI	α-Fe_2O_3 MIBK	478	477 - 484
		γ-Fe_2O_3 PEG	465	464 - 466
			559	560
2	SU	α-Fe_2O_3 MIBK	585	570 - 579
		γ-Fe_2O_3 PEG	465	464 - 465
			563	560
3	JV	α-FeOOH MIBK	800	802
		γ-Fe_2O_3 PEG	465	464 - 465
			558	560
4	ML	α-Fe_2O_3 MIBK	473	477 – 484
		γ-Fe_2O_3 PEG	465	464-465
			560	560
5	CU	α-Fe_2O_3 MIBK	485	477 – 484
			570	570 – 579
		γ-Fe_2O_3 PEG	464	464-465
			554	560

The X-ray diffraction patterns reveal the presence of amorphous materials in some stages and the presence of crystalline materials in some other stages. Six indicative diffraction patterns are provided in Figures 1 to 6.

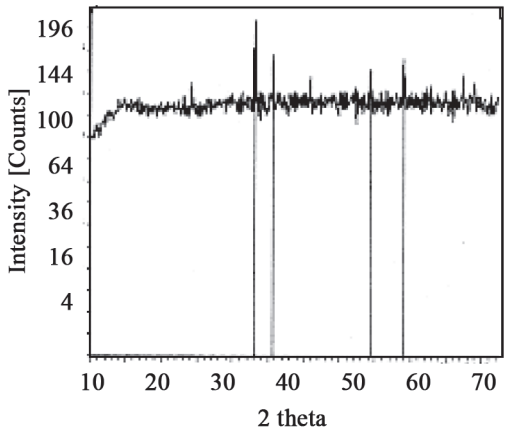

Fig. 1. XRD pattern for iron ore corresponding to sample No: 1

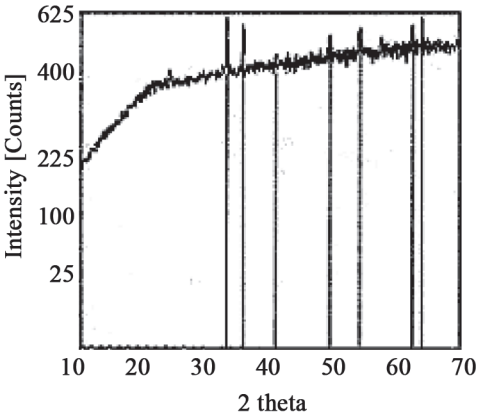

Fig. 4. XRD pattern for iron ore corresponding to sample No: 2

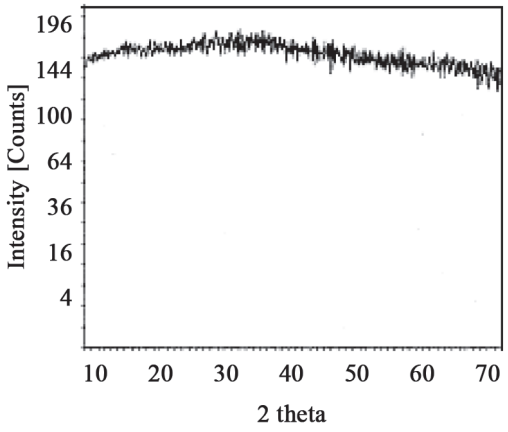

Fig. 2. XRD pattern for iron oxide from sample No: 1, after MIBK treatment

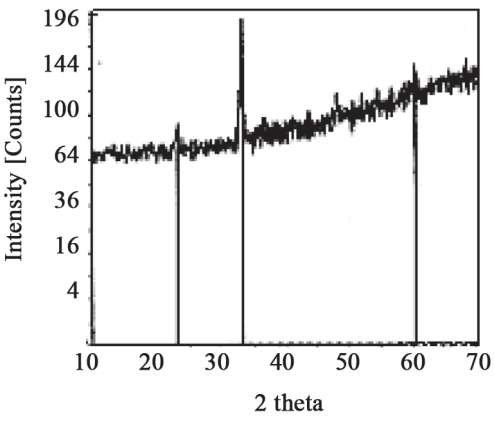

Fig. 5. XRD pattern for iron oxide from sample No: 2, after MIBK treatment

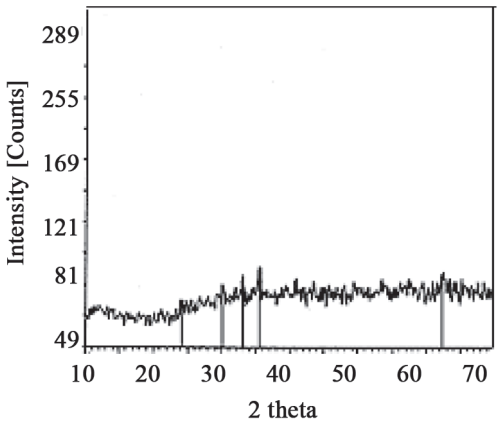

Fig. 3. XRD pattern for iron oxide from sample No: 1, after PEG treatment

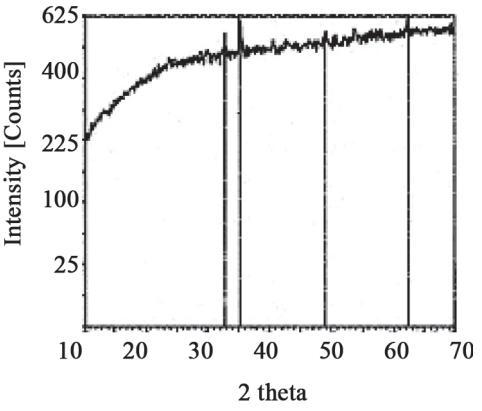

Fig. 6. XRD pattern for iron oxide from sample No: 2, after PEG treatment

Two of the five samples changed from crystalline state to amorphous state upon MIBK treatment and then reverted back to crystalline state upon PEG treatment. One sample was amorphous to begin with, remained amorphous with MIBK treatment, but became crystalline with PEG treatment. It appears that synthesis of amorphous iron oxide from waste materials has not been reported so far in the literature and the amorphous products obtained here can lead to many interesting applications. The transformation involving the crystalline and amorphous phases can lead to the development of novel materials and novel sensors. The phenomenon is being investigated further – in terms of larger sample sizes and related characterization.

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