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Nano-particle synthesis of titanium oxides from ilmenite in a thermal plasma reactor

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ABSTRACT

Nano-particle of titanium oxides was synthesised from the precursor ilmenite powder in an argon plasma jet at atmospheric pressure. The decomposition of ilmenite concentrates was investigated in a non-transferred arc thermal plasma reactor. Argon and Argon–Nitrogen were taken as plasma gases in the plasma torch. The effect of input power, plasma gases and particle size was carried out on the quality and yield of the product. Nano-powders were characterized using various techniques, viz., XRD, SEM, and TEM. Thermal equilibrium diagram was plotted to predict the thermodynamic behaviour of the system under various operating conditions. The present investigation shows significant segregation of titanium and iron-rich products in thermal plasma processing. Average particles diameters are from 10 nm to 200 nm.

Keywords: Thermal plasma; Ilmenite; Decomposition; Nano-particle; Synthesis

1. Introduction

Ilmenite, with the chemical formula $FeTiO_3$ is an economically important and interesting mineral. This is an opaque mineral, black to brownish-red in color, with a metallic or submetallic luster. This belongs to hematite–ilmenite–magnetite group in the oxide and hydroxide class. Ilmenite is the major source of titanium dioxides, TiO_2 (Nuilek et al., 2008). Titanium is usually found in igneous and metamorphic rocks as ilmenite ($FeTiO_3$), rutile (TiO_2) and titanomagnetite (Fe_2TiO_4–Fe_3O_4). About 85% of titanium bearing minerals is used in making titanium dioxide for the pigment industry. Titanium dioxide is used in manufacturing paints, varnishes, lacquer, paper, paperboard, printing inks, rubber, floor covering, ceramics, food and pharmaceuticals (Samal *et al.*, 2008, 2009). Titanium is usually produced from Ilmenite ($FeTiO_3$) and rutile (natural TiO_2) the two minerals, which are rich sources of titanium. The availability of rutile is very rare and scarce in nature and economically expensive. So natural ilmenite is considered as the basic raw material for this purpose and the demand for ilmenite is increasing gradually. Ilmenite, as raw material is easily available and lower in cost. Earlier production of titanium dioxide (TiO_2) has been carried out from ilmenite concentrates in high temperature furnaces and plasma reactor using reductants like carbon, hydrogen and methane (Taylor et al., 1995). The general processes are wet chemical processes like leaching of ilmenite with chloride or sulfate medium. Chloride medium is safer compared to sulfate medium due to less waste production as well as easier over the conventional methods, which involve the use of electrically heated furnaces (Skrivan and Chase, 1974).

The present paper investigates the fundamental thermodynamic and experimental studies on thermal decomposition of ilmenite powder in a non-transferred arc plasma reactor. This deals with a one-step process to synthesize TiO_2 from ilmenite powder. For this purpose several experiments were carried out by varying the input power, keeping the flow rate of powder fixed at 1 atm. pressure. Nano-powders obtained in these experiments were characterized using XRD, SEM and TEM techniques.

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