

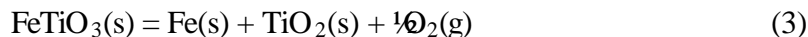
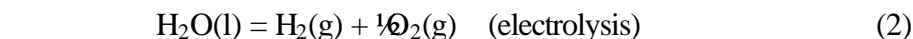
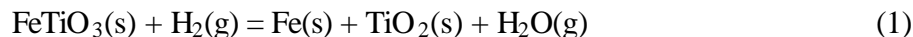
KINETICS OF ILMENITE (FeTiO_3) REDUCTION WITH HYDROGEN

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Iron (II) titanate (FeTiO_3), more commonly known as ilmenite, is abundant in nature and a major constituent in the production of titanium dioxide pigment. Ilmenite undergoes reduction to form TiO_2 and elemental iron and a leaching process yields a final TiO_2 product of 88-92% purity. The reduction of ilmenite, in addition to manufacturing pigment, has also been used for the production of titanium and steel alloys. Metallic titanium has superior chemical and thermal resistance.

More recently, investigations have been concentrated on the reduction of ilmenite for producing Lunar Liquid Oxygen (LLOX). A major challenge facing lunar colonization is providing oxygen to form a livable environment. Consequently, it is important to develop technologies that utilize the raw materials present on the moon for oxygen production. One of the promising process concepts for lunar oxygen production is ilmenite reduction with hydrogen. Ilmenite is an abundant mineral found in lunar regolith. The proposed overall reactions for producing oxygen are:



The reduction kinetics of synthetic ilmenite by hydrogen was studied. Investigations were performed using virgin ilmenite and ilmenite catalyzed with alkali metal salts. The weight loss was measured (as a function of time) isothermally using

thermogravimetric analysis over a temperature range of 700-1015 °C. Weight loss data were converted to fractional conversions based on the complete reduction of iron oxide. An Arrhenius plot of the initial rates indicates the presence of different rate-controlling mechanisms. Phase transitions, as determined from existing phase diagrams for Fe-Ti-O, occur during the reduction of ilmenite. These phase changes further complicate the reduction kinetics of ilmenite. Temperatures above 900 °C yielded fractional conversions that exceed the complete iron oxide reduction indicating that the reduction of titanium dioxide is beginning to occur. An activation energy of 18.8 kcal/mole was estimated from the Arrhenius plot. Experimental results were in good agreement with those reported in the literature.

Potassium chloride and potassium carbonate were added as catalysts to the ilmenite reduction reactions. Results for the potassium chloride catalyzed reduction showed a 100-170% increase in initial rates compared to those determined from non-catalyzed ilmenite. The activation energy for ilmenite with potassium chloride, based on the method of initial rates, was estimated to be 28.1 kcal/mole from an Arrhenius plot. Results for the potassium carbonate catalyzed reduction showed a 164-276% increase in initial rates, but only for temperatures greater than 807 °C. Experiments conducted at temperatures below 807 °C did not provide appreciable rate increases in rates over non-catalyzed samples at the same experimental conditions. Temperatures greater than 807 °C resulted in rates much higher than non-catalyzed and KCl catalyzed ilmenite. The activation energy for potassium carbonate addition, based on the method of initial rates, was estimated to be 50.9 kcal/mol.