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Morphological Changes in Rutile Reduced by Liquid Petroleum Gas

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Reduction of rutile (TiO_2) by liquefied petroleum gas (LPG) hydrogen gas mixture was carried out in the range of temperature 1100-1200°C. Based on standard change in Gibbs (ΔG°) energy calculations, the reaction was favourable above 1000°C although reaction kinetics was slow. Pure rutile was reduced to titanium oxycarbide (TiC_xO_{1-x}), which is a solid solution of TiC and TiO. Formation of TiC from pure rutile started at 1100°C based on XRD and SEM/EDX analysis. The rate and extent of reaction increased with increasing temperature to 1200°C. An increase in LPG flowing time from 10-20 minutes resulted in the formation of titanium (III) oxide (Ti_2O_3) and TiC_xO_{1-x} formation. Reduction of TiO_2 to TiC_xO_{1-x} occurred in the following sequence where *x* was the molar fraction of TiC in the solid solution: $TiO_2 \rightarrow Ti_5O_9 \rightarrow Ti_4O_7 \rightarrow Ti_3O_5 \rightarrow Ti_2O_3 \rightarrow TiC_xO_{1-x}$. Morphological changes in TiO_2 from 1100-1200°C showed that after 3 hours of reduction, the surface became roughened with scattered porosity. With increasing reduction temperature, the grain surface degraded in terms of geometry and size indicating a shrinking core chemical reaction mechanism. The SEM/EDX images showed that when only hydrogen gas was used, a dense product layer was formed consisting of inter layers of Ti_2O_3 and TiC_xO_{1-x} which reduces the rate of diffusion of gaseous components. Based on the findings in this work, LPG is a viable reductant for TiO_2. LPG reduction of metal oxides to metal/carbide hold promising future in extractive metallurgy as it reduces CO_2 footprint and offers alternative pathways for H_2 gas generation.

Key words: Rutile, Titanium (III) oxide, Titanium oxycarbide, Reduction, LPG

Biography:

Dr. Sheikh Abdul Rezan joined USM Engineering campus in 2010. He completed his PhD in Materials Engineering (Pyrometallurgy) from University of New South Wales, Australia in 2010. His undergraduate degree was from Alfred University (New York), USA and Master in Optical Engineering from UTM, Johor. He has published more than 80 journals and conference papers combined in the field of extractive metallurgy, steel making, marine corrosion and high temperature ceramics. He is an invited member to Malaysia Steel Institute (MSI) and SIRIM committee for Malaysian Standard for raw materials for iron, steel and intermediate products (TC/P/1). His research interest includes sacrificial zinc anode for cathodic protection (SACP), marine corrosion, steel making waste recycling and pyro-processing of titanium minerals.