Rare Earth Silicates Powder Synthesis for use as SOFC electrolyte

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Rare-earth apatite type materials (general formula $A_{10\text{-}x}M_6O_{26\pm y}$; where A=rare earth, M=Si, Al, Ge or P) have been investigated as alternative solid electrolyte materials for SOFC (Solid Oxide Fuel Cells) [1]. This is because of their higher ionic conductivity than conventional zirconia electrolytes, at temperatures between 600ºC and 700ºC. Among apatite rare-earth silicates, the lanthanum silicates, exhibit the highest values of oxide ion conductivity at intermediate temperatures. Lanthanum silicates with general formula $La_{9.33+x}(SiO_4)_6O_{2+1.5x}$ $(0 \leq x \leq 0.67)$ exhibit high ionic conductivity and low activation energy values at intermediate temperatures (500–700°C). Therefore, they are considered as promising electrolytes for intermediate temperature SOFCs (IT-SOFCs) [2]. Doping into La or Si sites can enhances the ion conductivity of apatite-type lanthanum silicates (ALS). It was observed, for example, to the Mg-doped lanthanum silicate, $La_{9.533}(Si_{5.7}Mg_{0.3})O_{26}$ [3]. The main effort to the actual application of ALS as IT-SOFC electrolyte remains in the difficulty to prepare dense ceramics. High temperatures (1600–1800 °C) and prolonged time are required to obtain a relative density of 90% for ALS prepared by conventional solid-state synthesis route. Secondary phases, such as $LaSi_2O_5$ and $La_2Si_2O_7$ could also remain in the system. Those phases deteriorate the conductivity of the ceramic electrolyte. To synthesize powders with higher sinterability wet-chemical routes, such as, sol–gel, modified sol-gel, molten salts, freeze-drying, co-precipitation and acid citric methods has been practiced. In his work, pure lanthanum silicate $La_{9,56}(SiO_4)_6O_{2,34}$ and Mg-doped lanthanum silicate, $La_{9,8}Si_{5,7}Mg_{0,3}O_{26,4}$ were successfully synthesized by using the sol-gel followed by precipitation method. The crystalline apatite phase of $La_{9,56}(SiO_4)_6O_{2,34}$ and $La_{9,8}Si_{5,7}Mg_{0,3}O_{26,4}$ was obtained by calcination at 900ºC. The density measurements revealed that the samples have a density of higher than 90%.

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