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Influence of excess alumina on mullite synthesis with pyrophyllite-alumina by spark plasma sintering process

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Aluminosilicate has been widely used in mullite ceramic industries due to its unique properties. However, the use of pyrophyllite ($Al_2O_3.4SiO_2.H_2O$) in the production of mullite ceramic is very much restricted. This is probably because the mineral seldom occurs in its pure state which can influence its properties and behavior. Meanwhile, the presence of the glassy phase in mullite prepare from aluminosilicate ceramics are detrimental to it mechanical properties. This study focusses on the influence of excess alumina on 3:2 mullite synthesized using alpha alumina and pyrophyllite powder mined in South Africa by spark plasma sintering (SPS). The stoichiometric 3:2 mullite was prepared with 40 wt% dehydroxylated pyrophyllite and 60 wt% alumina while the sample with excess alumina was prepared with 28 wt% dehydroxylated pyrophyllite and 72 wt% alumina. The powders were mixed in an Attritor mill. The milled powders were consolidated by spark plasma sintering at 1600°C under a pressure of 50 MPa with heating rate of 100°C/min and holding time of 10, 20 and 30 minutes. The samples were heat treated at 1350°C and held for 2 h in order to determine the influence of the excess alumina on the microstructure. The SEM micrograph of mullite sample containing 60 wt% alumina sintered in SPS at 20-minute holding time revealed large amounts of glassy phase. However, a glassy phase was not found in sample containing 72 wt% alumina sintered under the same conditions. The sample with 72 wt% alumina showed higher value of hardness and fracture toughness compared to 3:2 mullite. The highest hardness and fracture toughness of 12.43 GPa and 2.71 MPa.$m_{0.5}$ respectively were obtained in sample containing 72 wt% alumina.

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