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Alumina-mullite composites prepared from calcined alumina and colloidal silica by uniaxial pressing

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Aqueous grades of colloidal silica (CS) are commonly employed in high-alumina refractory castables as liquid medium and binding agent, due to their straightforward processing, good flowability and workability, and faster and safer drying. They also attain their maximum strength levels at low temperatures due to the high reactivity of silica nanoparticles. Despite such technological interest in castable systems, using CS in its liquid form as a uniaxial pressing additive was not explored. In this study, fine calcined alumina particles (D50=0.6 mm) were sprayed with different quantities of thin droplets of a colloidal silica suspension (D50=30 nm). The mixture was vigorously homogenized with a brush and uniaxially pressed as rectangular prisms (70?20?10 mm, 40 MPa, 60 s) and, after demolding, samples sintered (1500ºC). Reference samples prepared with distilled water were tested under the same conditions. Physical properties (solid density, total porosity, flexural Young's modulus and of rupture, linear thermal dimensional variation), crystalline phases, and microstructure were investigated. Differently from systems prepared to cast flowable suspensions, the pressing-based processing route employed produced spherical domains of silica-rich aggregates surrounded by calcined alumina particles' continuous matrix. During thermal treatment, the initially amorphous silica nanoparticles reached their glass transition temperature and crystallize before reacting with alumina forming mullite. The final microstructure contains portions of unreacted sintered alumina connecting needle-like mullite crystals and irregular grains of cristobalite. The levels of total porosity (15 %) and flexural strength (30 MPa) attained after sintering suggest such structures could be employed as semi-insulators bricks for cement ovens or petrochemical lines.