RECENT DEVELOPMENTS IN GEOPOLYMER COMPOSITES AND THEIR POTENTIAL APPLICATIONS

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Geopolymers are a class of ceramic-like materials which are aluminosilicate inorganic polymers and cured at ambient temperatures from calcined clay and an aqueous, alkaline, metasilicate solution precursor. The strained nature of the 5-coordination aluminum cation polyhedra is identified as the reason why metakaolin-based geopolymer ceramics are made from solution, rather than with high temperature diffusion as for typical ceramics. Geopolymers essentially behave as a refractory glue. The microstructure of alkali based geopolymers is nanoporous and nanoparticulate, having 40 vol% porosity and ~1.5 g/cc density. Intrinsic mechanical properties as well as those of geopolymer composites have been measured for composites containing both ceramic, polymeric as well as biological reinforcements. Such geopolymer composites exhibit significant graceful failure and fracture toughness such as three times those of alumina. Glass frit-containing geopolymer composites, or appropriate intrinsic compositions of geopolymer undergo amorphous self-healing upon heating above the melting point of the glass. Depending on their compositions, geopolymers melt at temperatures up to 1900°C.

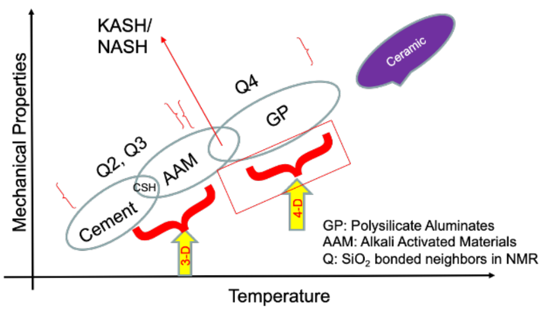

Fig. 1. Schematic description of relationship between cements, alkali activated cements, geopolymers and ceramics. Geopolymers are scalable and made under ambient temperatures like a cement, but can have mechanical properties, like a ceramic.

Potential applications of geopolymer composites include: fire resistant coatings and fire breaker panels; nuclear radiation shielding against gamma rays and neutron rays with ~98% attenuation to date; low level radioactive waste encapsulation; porous water purification filters for removing heavy metals such as arsenic, cadmium, mercury etc.; corrosion and acid resistant coatings; refractory adhesives between stainless steel, metals, glass, ceramics and wood to at least 1150°C; thermal shock resistant coatings having tailorable thermal expansion coefficients; “smart” coatings containing embedded piezoelectric sensors; porous insulators and refractories having tailorable porosity; porous aerogels; alternative and scalable processing routes to iso-chemical ceramics made from organic alkalis; high temperature resistant, airplane runways (1500 °C); scalable molten salt containment for thermal energy storage and electricity generation from solar heat rather than from burning coal; coatings e.g. as roof tiles; fire breaker panels; alternatives to cements for geothermal wells; a potential partial solution to global warming as a potential replacement for Portland cement when made from revalorized mine tailings.