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"Geopolymers and their Composites"

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Abstract

"Geopolymer" is a charge balanced, aluminosilicate, ceramic-like gel made by from a liquid suspension undergoing dissolution, polycondensation or precipitation under ambient conditions. It has a nominal chemical composition of $M_2O•Al_2O_3•4SiO_2•11H_2O$ where M could be Group I elements of Li, Na, K, Rb or Cs. The water content may be varied, depending on particle size, and specific surface area of the starting powder, such as metakaolin. The inorganic polysialate polymer is made by mixing metakaolin ($Al_2O_3•2SiO_2$) with waterglass (an alkali metasilicate solution). The resulting microstructure is impervious, nanoporous (of diameter~6.8 nm), contains 40% porosity by volume, and is nanoparticulate (5-40 nm diameter depending on composition),

Alternative aluminosilicate sources are waste materials such as fly ash, slag, or other minerals such as kaolinite, halloysite or bentonite. The cross-linked product shares the brittle nature of ceramics, but can be reinforced with platelets, particulates, chopped fibers, uniaxial fibers, or fiber weaves yielding a strong and touch composite, which has additional properties of fire and corrosion resistance. Geopolymers also have refractory adhesive properties up to 1,000°C whereupon they crystallize into a ceramic. They are nanoporous, nanoparticulate materials which can also be made meso- and macro porous of tailorable porosity.

Geopolymer composites have been make with chopped graphite fibers (60 μm and 100 μm in length); carbon nanoplatelets; chopped Saffil alumina; basalt (1/2 inches) or polypropylene fibers (0.5", 1", 1.5"); alumina platelets; uniaxial fibers of carbon, corn husks; and weaves of Nextel 610 alumina and Nextel 720 mullite plus alumina as well as natural fibers of corn husks, jute, Colombian fique and Amazonian malva. The mechanical properties of various ceramic particulate, chopped fiber and fiber-reinforced composites are summarized as a function of temperature, both post-heat treatment, or in situ at high temperatures to 1400 °C.

While the manufacture of one ton of Portland cement releases ~0.95 tons of carbon dioxide into the atmosphere, the synthesis of geopolymer liberates only 0.25 tons of carbon dioxide. The mechanical properties of geopolymer concretes are about twice the compressive strength and three times the flexural strength of cement concretes. Geopolymers have a density of ~1.4 g/cc which is approximately half that of Portland cement, and set in 1-2 days as compared to 28 days for Portland cement. With the use of waste produces such as fly ash and slag, geopolymers present a viable pathway to retard the effects of global warming. Thus geopolymer composites expand the field of sustainable construction materials.

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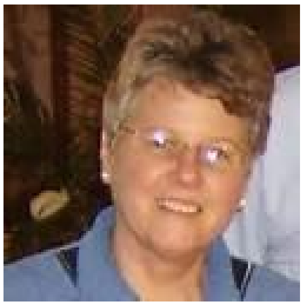
Condensed Resume of Prof. Waltraud (Trudy) M. Kriven

http://www.matse.illinois.edu/faculty/Kriven.html



Prof. Waltraud M. Kriven received a Ph. D in 1976 in Solid State Chemistry from the University of Adelaide in South Australia. The B.Sc. (Hons) and Baccalaureate degrees were in Physical and Inorganic Chemistry, and Biochemistry, also in Adelaide. She spent three years (1977-1980) jointly at the University of California at Berkeley, and at the Lawrence Berkeley Laboratory. There, Dr. Kriven conducted post-doctoral research in transmission electron microscopy of ceramics and was a Lecturer in the Dept. of Materials Science and Mineral Engineering. For almost four years (1980-1983) Dr. Kriven was a Visiting Scientist at the Max-Planck-Institute in Stuttgart, Germany. Since 1984, Professor Kriven has been at the University of Illinois at Urbana-Champaign. She is a Full Professor in the Department of Materials Science and Engineering, and an Affiliate Professor in the Department of Mechanical Science and Engineering at UIUC. She has written or co-authored more than 300 research publications and edited or co-edited 22 books. Professor Kriven has been elected as an Academician to the World Academy of Ceramics (2005), Fellow of the American Ceramic Society (1995) and Fellow of the Australian Ceramic Society (2009) and won the Brunauer Award twice (in 1988 and 1991) from the American Ceramic Society Cements Division, for co-authoring the best research papers of the year. Four US patents have been granted.

Professor Kriven was a Past-Chair and Counselor to the Engineering Ceramics Division of the American Ceramic Society and Symposium Organizer of the Focused session on Geopolymers at the ACERS Annual Meetings, the Cocoa Beach and Daytona Beach Conferences and Expositions on Advanced Ceramics and Composites from 2003 to 2014. Professor Kriven is also a co-organizer of a new symposium on Phase Transformations in Ceramics to be held at the Annual Meeting of Materials Science and Technology, in Oct 2014 in Pittsburgh, PA.

Research areas:

- *In situ*, in air high temperature (2000°C) sychrotron XRD and Rietveld studies of oxide ceramics
- Martensitic and phase transformations, and thermal expansions in ceramics
- Geopolymers and hybrid inorganic polymers
- Low energy synthesis of oxide ceramic powders
- Structural ceramic composites and oxide fibers
  (design, fabrication, characterization and mechanical evaluation)
- Microstructure characterization by scanning and transmission by electron microscopy (SEM, TEM, EDS, HVEM, HREM, XPS)