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ALKALI SILICATE ACTIVATED, SLAG-FLY ASH BINDERS

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Sodium silicate activated, slag-fly ash binders (SFB) and slag-metakaolin binders (SMKB) are room temperature hardening binders that have excellent mechanical properties and a significantly lower carbon footprint than does Ordinary Portland cement (OPC). The aim of this study was three-fold. The first aim was to study the properties of precursors. Fly ash, slags and commercial metakaolins were characterized using energy dispersive x-ray fluorescence (EDXRF), X-ray diffraction (XRD), laser diffraction, Fourier transform infrared (FTIR) spectroscopy as well as magic-angle spinning, nuclear magnetic resonance (MAS-NMR) spectroscopy. The second aim was to develop a method to identify and quantify all poorly-ordered phases (unreacted precursors and products) present in SFB and SMKB. This was achieved by selective chemical extractions and MAS-NMR spectral subtraction of binders and extraction residues. The third aim was to observe the nanostructural evolution of the product phases with time, temperature and slag/fly ash ratio in SFB. This was accomplished by deconvoluting the MAS-NMR spectra. It was observed that the proportion of true geopolymer present was only 0-15 % and higher in SMKB when compared to SFB. Although C-N-A-S-H and geopolymer coexisted in SFB and SMKB, C-N-A-S-H was the major product phase formed. The mean chain length (MCL) and structure of C-N-A-S-H gel were estimated as a function of time, temperature and slag/fly ash ratio. The MCL decreased with increasing slag/fly ash ratio and decreased with increasing temperature. While increasing the slag/fly ash ratio accelerated the strength development, the cure time was decreased due to the formation of calcium silicate hydrate (C–S–H), calcium aluminum silicate hydrate (C–A–S–H), and (Ca, Na) based geopolymer. No new crystalline phases evolved through 28 days in ambient- or heat-cured binders. Furthermore, the early age properties of slag - fly ash binders namely, set time, and heats of reaction were investigated. Set time was investigated using a combination of the ASTM C403 penetration testing, and s-wave ultrasonic wave reflectometry (SUWR). The discrepancy in set time identified by these two methods suggested the presence of a soft gel which eventually hardened with time. The composition of this soft gel was analyzed by suspending the chemical reaction of the binder after the soft gel formed, but before it hardened. In order to analyze the composition of the soft gel, selective chemical extractions were performed on the binder. 29Si MAS-NMR and FTIR spectroscopy were performed on binders and extraction residues. The soft gel contained a modified calcium silicate hydrate gel (C-N-S-H where N=Na), with a short mean chain length and no observable Al incorporation. Orthosilicate units were also found to be present in relatively high proportions when compared to hardened binders at later ages

Biography

Waltraud M. Kriven is a Full Professor and has held joint faculty positions in the Materials Research Laboratory (initially) and the Department of Materials Science and Engineering. She received her 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. Professor Kriven has internationally recognized expertise in the areas of geopolymers, phase transformations in inorganic compounds and their applications in structural ceramic composites, and low temperature synthesis of oxide ceramic powders. In addition she has made extensive contributions to oxide composites design, microstructure characterization by electron microscopy techniques and phase equilibria. The Kriven group has developed a new technique for in situ, hot stage (up to 2000°C) synchrotron studies of ceramics in air, including an image plate detector capable of taking a high resolution, diffractometry spectrum within 20 seconds. She has written or co-authored 282 journal and 56 conference publications, as well as given or co-authored over 432 conference presentations. Prof. Kriven has edited or co-edited 26 books to date. She has given 34 keynote/plenary lectures at international meetings, as well as 218 invited lectures both nationally and internationally, including the US, Japan, Germany, United Kingdom, Switzerland, Spain, Turkey, Egypt, Korea, Italy, Ukraine, France, Australia, Colombia, Brazil. Professor Kriven has won the James A. Mueller Award (2017) from the Engineering Division of the American Ceramic Society for her research in ceramics. She was awarded the Brunauer Award twice (in 1988 and 1991) from the American Ceramic Society for co-authoring the best research papers of the year.

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