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Nano-cement composite with graphene oxide produced from epigenetic graphite deposit

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Abstract

This study presents the development of a nano-cement composite with graphene oxide (GO) carbon-based nanomaterials synthesized from a high-purity epigenetic graphite deposit. Diamond drill sampled graphite mineralization was upgraded through beneficiation and purification to recover a high-purity graphite product (99.9% graphitic carbon "Cg"). An alternate and improved chemical oxidation process based on the Modified Hummers method was adopted for the synthesis of GO from high-purity graphite. Microstructural analysis were performed to characterize GO. The GO consists of –OH, -C=O, -COOH, and C-O-C functional groups with a layer thickness of 1.2 nm, 2 to 3 layers of graphene, an interlayer distance of 0.89 nm and a Raman (I_D/I_G) ratio of 0.79. The effect of 0.02, 0.04, and 0.06 wt.% GO of cement on the composite workability, hydration, microstructure, mechanical and transport properties was determined. Increasing the concentration of GO in the composite decreased the workability due to the hydrophilic nature of the 2D planar surface. The rate of hydration accelerated and the cumulative hydration heat increased with the increasing proportions of GO in the composite. GO dosages about 0.02 and 0.04 wt.% of cement in the composites resulted the maximum enhancement of compressive and flexural strength by 83 and 26%, respectively, compared to the control mix (0 wt.% GO). The microstructural investigation shows that GO enhanced the hydration of calcium hydroxide (CH) and calcium silicate hydrate (C-S-H) during the nucleation and growth stages, filled pores, bridged micro-cracks and created interlocking between the cement hydration products. Collectively, these effects ultimately improved the mechanical properties of the composites. Also, in this process, the 0.02 and 0.04 wt.% GO cement composite increased the electrical resistivity by 11.5%, and decreased the sorptivity by 29%, respectively, both of which improved the overall performance of the composite.

Keywords: high-purity graphite, carbon-based nanomaterials, graphene oxide (GO), functional groups, micro-crack bridging.

1. Introduction