Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Strength improvement of cement pastes with cellulose nanocrystals via short circuit diffusion

Youngblood, Jeffrey; Cao, Yizheng; Zavattieri, Pablo; Weiss, Jason, Purdue University, United States; Moon, Robert, US Forest Service, United States

ABSTRACT

The influence of cellulose nanocrystals (CNCs) addition on the performance of cement paste is investigated. Our mechanical tests show an increase in the flexural strength of ~30% with only 0.2% volume of the as-received CNCs with respect to cement. However, the strength decreases at the high concentration region due to the agglomeration of CNCs. The ultrasonication is performed to disperse the CNCs and a maximum strength improvement of up to 50% is achieved. The relationship between the dispersion of CNCs and the strength of the cement paste is examined with rheological measurements. Isothermal calorimetry and thermogravimetric analysis show that the degree of hydration (DOH) of the cement paste is increased when CNCs are used. The first mechanism that explains the increased hydration is the steric stabilization, which is supported by rheological, heat flow rate measurements, microscopic imaging, and nanoindentation. A second mechanism is proposed as short circuit diffusion (SCD) to explain the increased hydration. SCD appears to increase cement hydration by increasing the transport of water from outside the hydration product shell (i.e., through the high density CSH) on a cement grain to the unhydrated cement cores. The DOH and flexural strength are measured for cement pastes with water reducing agent and CNC to verify this theory. Our results indicate that SCD is more dominant than steric stabilization.