Effect of UH-Biosurfactant on Hydration Heat of Nanoparticles Modified Smart Oil Well Cement

J. Liu and C. Vipulanandan
Texas Hurricane Center for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX, 77204-4003
Tel: (713)743-4278; Email Address: jliu@mail.uh.edu, cvipulanandan@uh.edu

Abstract
The ability of UH-biosurfactant to reduce hydration heat during cement hydration was studied. Addition of 1% biosurfactant into smart cement can reduce the hydration heat by about 12% with peak temperature reduced 18.5 °F, and increase the final setting time by 0.6 h.

1. Introduction

Cement hydration is an exothermic reaction. During cement hydration, substantial heat is released in cement. As lower heat of cement hydration is preferred in high temperature oil well, the use of additives or supplementary cementitious materials on cement hydration heat have been studied (Langan et al. 2002; Jones and McCarthy 2006). Surfactant has been used to reduce hydration temperature and delay setting time of cement (Liu and Vipulanandan 2013; Mohamad et al. 2006). Compared to widely used chemical surfactants in oil well cement, usage of biosurfactant is more environmental friendly with higher biodegradability and lower toxicity compared to chemical surfactants. Using semi-adiabatic calorimeter to measure cement heat of hydration has been widely used (Livesey 1991).

2. Objective

To test UH-biosurfactant's effect on hydration heat and setting time of oil well cement composite.

3. Materials and Methods

Biosurfactant (1%) was added to class H oil well cement with 0.075% CF and 0.075% Fe/Ni nanoparticles. A superior insulation, high-performance semi-adiabatic calorimeter (P-CAL 1000, Calmetrix Inc.) was used to record the temperature change during early hydration (7 days) of the cement composite. The volume of the specimen tested was 1.47 L. Peak temperature and time to reach the peak temperature were compared for samples with and without biosurfactant. Volumetric specific heat capacity C_v for cement composite during hydration at room temperature was tested using the KD2 Pro thermal property meter (Decagon Devices) with and without biosurfactant. SH-1 sensor was used after setting of cement composite to test the volumetric specific heat capacity of the cement composite. Temperature change during cement hydration was converted to heat from beginning to the peak temperature and from the peak temperature to 96 h after recording using the equation $Q = C_v V \Delta T$. Where Q is heat (J), C_v is volumetric specific heat capacity (J/cm^3/K), V is volume of the material (cm^3), and T is temperature of the material (K).

4. Results and Discussion

Addition of 1% biosurfactant modified cement reduced the C_v of the cement composite from 2.76 J/cm^3/K to 2.53 J/cm^3/K. Addition of 1% biosurfactant reduced the peak temperature by 21.5 ºF (12.5%), and it delayed the time to arrive peak by 0.6 h. This delay also contributed to the reduced peak temperature. As the time reached the peak temperature was correlated to the time of final setting of the cement, addition of biosurfactant could effectively delay the final setting of cement composite. With 1% biosurfactant addition, the heat before peak temperature was reduced by 11.8% to 1111.38 kJ compared to the modified cement. Heat before the peak temperature was comparable to the heat after the peak

temperature. Biosurfactant brought foam into the composite during mixing, the existence of air voids in cement composite may be the reason for the heat reduction.

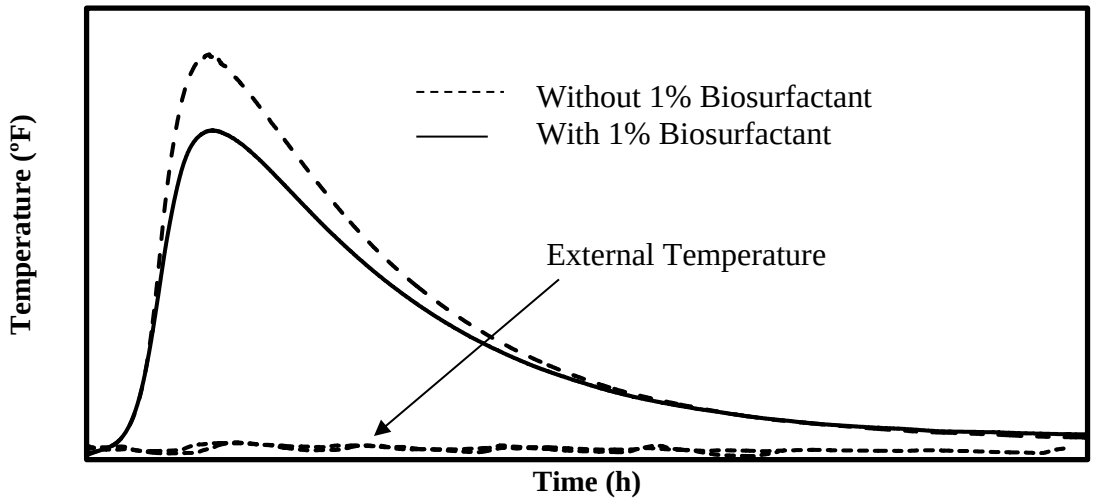

Figure 1 Hydration Temperature Change with Time for a Modified Class H Oil Well Cement with or without Addition of 1% Biosurfactant Recorded by Calorimeter

Table 1 Thermal Properties of Class H Oil Well Cement with or without 1% Biosurfactant

Additives	Peak Temperature (°F)	Volumetric Specific Heat Capacity (J/cm^3/K)	Heat Before Peak Temperature (kJ)	Heat After Peak Temperature (kJ)	Peak Time (h)
Without BSF	168.7	2.76	1253	1245	20.6
With BSF	150.2	2.53	1111	1101	21.2

5. Conclusions

From the experiment, it can be concluded that addition of 1% biosurfactant can reduce heat generation of cement composite at the same time to retard hydration for cement composite.

6. Acknowledgments

This study was supported by CIGMAT and THC-IT with funding from DOE/NETL/RPSEA (Project 10121-4501-01).

7. References

[1] M. Heikal, M. S. Morsy, I. Aiad (2006). Effect of polycarboxylate superplasticizer on hydration characteristics of cement pastes containing silica fume. Ceramics Silikáty. 50 (1) 5-14

[2] M.R. Jones, A. McCarthy (2006). Heat of hydration in foamed concrete: Effect of mix constituents and plastic density. Cement and Concrete Research. 36(6): 1032–1041

[3] B.W. Langana, K. Wengb, M.A. Warda (2002). Effect of silica fume and f ly ash on heat of hydration of Portland cement. Cement and Concrete Research 32: 1045–1051

[4] J. Liu, C. Vipulanandan, D. Richardson (2014). Effect of UH-Biosurfactant on the Smart Oil Well Cement Hydration and Piezoresistive Behavior. CIGMAT-2014 Proceedings.

[5] P. Livesey, A. Donnelly, C. Tomlinson (1991). Measurement of the Heat of Hydration of Cement. 13:177-185