Journal of Petroleum Science and Engineering 169 (2018) 553–559

Contents lists available at ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: www.elsevier.com/locate/petrol

Dilatometric behavior and crystallographic characterization of Portland-polyurethane composites for oilwell high-temperature cementing applications

Ítalo Batista da Silva[a,b,*], Antônio Eduardo Martinelli[a], Wendell Rossine Medeiros de Souza[a,c], Júlio Cezar de Oliveira Freitas[a], Marcos Alysson Felipe Rodrigues[a]

[a] Laboratório de cimentação de poços, Universidade Federal do Rio Grande do Norte – UFRN, Natal, Rio Grande do Norte, CEP: 59064-970, Brazil
[b] Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte - IFRN, Campus Caicó, CEP: 59015-300, Brazil
[c] Universidade Federal Rural do Semi-árido - UFERSA, Campus Angicos, CEP: 59625–900, Brazil

ARTICLE INFO

Keywords:
Oilwell cementing
Portland cement
Polyurethane and thermal expansion

ABSTRACT

In order to improve the behavior of Portland-based oilwell sheath to high-temperature applications and the corresponding thermal gradients, polymeric admixtures can be added. Steam injection, for instance, raises the cement sheath-steel casing interface temperature to ∼300 °C which can be deleterious to the mechanical stability and zonal isolation provided by the cement sheath as a result of cracking of the cement. Polyurethane can be added to the cement to improve its plastic behavior and reduce the thermal expansion mismatch between casing and sheath. However, the use polymeric admixtures, especially as aqueous dispersion, can affect the kinetics of the hydration reactions and, as a consequence, the crystallographic composition and coefficient of thermal expansion of the material. Therefore, the present study aimed at evaluating the effects of the addition of different concentrations of polyurethane on the thermomechanical properties of Portland cement pastes cured at 300 °C from 14 to 90 days. Formulations containing 1 gpc (0.052 kg), 2 gpc (0.102 kg) and 3 gpc (0.153 kg) of polyurethane, respectively named PU1, PU2 and PU3 were prepared according to the American Petroleum Institute guidelines. A standard PU-free slurry was also prepared. X-ray diffraction and dry dilatometric tests were carried out. The results revealed that the curing time does affect the kinetics of hydration of Portland-polyurethane composites, retarding the formation of high-temperature stable phases, i.e., tobermorite and xonotlite. Moreover, longer curing times were necessary to reveal the improved expansion of the composites with respect to the standard sample. The addition of polyurethane can be pointed as an approach to high-temperature oilwell cement applications, since it reduces the thermal mismatch between cement sheath and steel casing for and retards but do not prevent the formation of xonotlite.

1. Introduction

Thermal methods have been widely used worldwide to improve the production of heavy oils. Downhole heaters (Lund, 2003), *in situ* combustion (Zhao et al., 2015), injection of hot fluids, such as continuous (Pernites and Santra, 2016) or cyclic vapor injection (Ichim and Teodoriu, 2017) are some of the techniques used to reduce viscosity and enhance production. Cyclic vapor injection takes place in three stages, *i.e.,* vapor injection, soaking, and production (Alvarez and Han, 2013). Vapor is usually injected at ∼300 °C, which can damage the naturally brittle cement sheath, either during injection or cooling, as a result of the thermal expansion mismatch between the cement sheath and steel casing. The typical thermal expansion coefficients of steel casings is about 13×10^{-6} °C^{-1} whereas that of oilwell cement is ∼ 9–10 $\times 10^{-6}$ °C^{-1} at the water-saturated state (Chougnet-Sirapian et al., 2011). Cracking and loss of adherence due to thermomechanical stresses affect both the mechanical integrity and zonal isolation of the well (Bu et al., 2017).

Increasing the coefficient of thermal expansion and improving the plastic behavior of cement pastes can be achieved by the addition of temperature-resistant plastic materials, such as lattices, including polyurethane (Artioli and Bullard, 2013; Jiang et al., 2016; Zhang and Sum, 2018; Souza et al., 2018).

The addition of polymeric admixtures to Portland cement is known to affect the kinetics of hydration (Kong et al., 2015; Jinhui et al., 2017), thereby extending the setting time and the formation of

* Corresponding author. Laboratório de cimentação de poços, Universidade Federal do Rio Grande do Norte – UFRN, Natal, Rio Grande do Norte, CEP: 59064-970, Brazil.
E-mail addresses: italo.batista@gmail.com, italo.batista@ifrn.edu.br (Í. Batista da Silva).

https://doi.org/10.1016/j.petrol.2018.06.014
Received 25 May 2018; Accepted 4 June 2018
Available online 06 June 2018
0920-4105/ © 2018 Elsevier B.V. All rights reserved.

Table 1
Concentration of the material used in the formulations of cement slurries.

Composition	Material (g)					w/c ratio
	Cement	Silica (40%)	Water	Antifoam	Polyurethane (PU)	
PU0	561.33	224.53	334.92	0.76	0	59.67
PU1	559.03	223.61	286.53	0.76	52.62	51.25
PU2	556.74	222.7	238.52	0.76	102.83	42.84
PU3	554.48	221.79	190.91	0.76	153.61	34.43

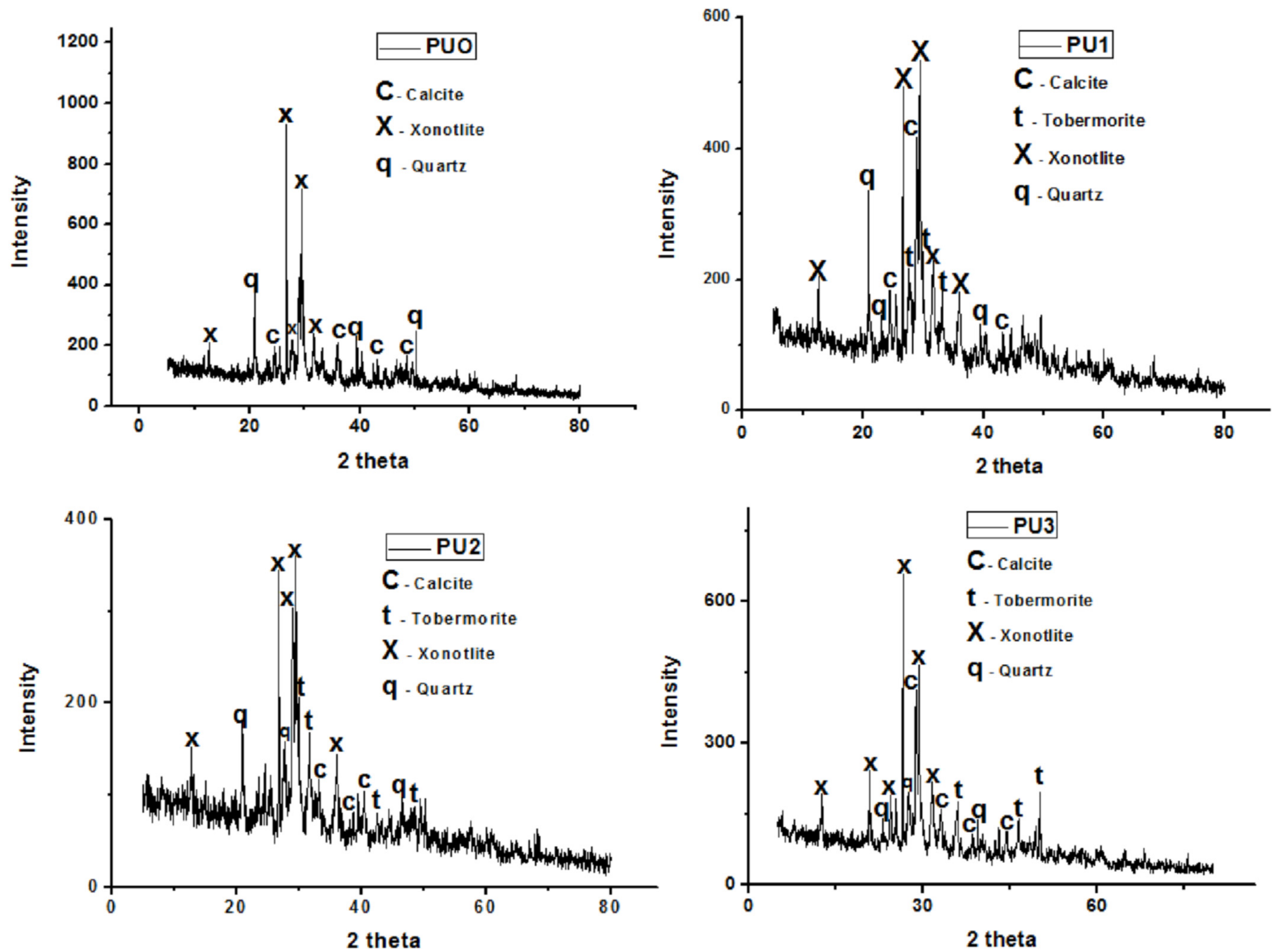

Fig. 1. X-ray diffractograms of formulations (a) PU0, (b) PU1, (c) PU2 and (d) PU3 after curing for 14 days.

crystalline phases responsible, for instance, for high temperature strength, as in the case of tobermorite and xonotlite. This can also have an effect on the thermal expansion behavior of cement pastes, as the presence of a latex in the mix affects moisture content, internal humidity, porosity and the development of cement hydration products (Bu et al., 2017).

Therefore, the objective of the present study is to evaluate the effect of the addition of different concentrations of polyurethane on the expansion behavior of Portland-polyurethane slurries hardened at 300 °C under pressure to simulate pumping conditions (3 kpsi). The crystallographic composition of the composites was evaluated by X ray diffraction. For high temperature applications, the cementing materials must develop strength values to overcome the retrogression effect. To that end, all compositions included 40% silica flour to assure the formation of the crystallographic phases responsible for high-temperature strength (Costa et al., 2017;Pernites and Santra, 2016). Literature on the dilatometric behavior of thermally-cycled Portland-polymer composites is scarce. The thermal expansion of hardened cement materials can be evaluated by conventional dilatometry, which allows real time monitoring of the dimensional changes that occur in a sample submitted to a thermal cycle, however under dry conditions (Bu et al., 2017). A standard polyurethane-free composition was also mixed and characterized under the same conditions to assess the changes in thermal mismatch resulting from the addition of polyurethane.

Download English Version:

https://daneshyari.com/en/article/8124632

Download Persian Version:

https://daneshyari.com/article/8124632

Daneshyari.com