Desalination and Water Treatment
www.deswater.com

doi no:10.5004/dwt.2017.0336

69 (2017) 163–172
March

A comparative performance ranking of some phosphonates and environmentally friendly polymers on $CaCO_3$ scaling inhibition by NACE protocol

Konstantin Popov*, Galina Rudakova, Vladimir Larchenko, Mariya Tusheva, Elena Afanas'eva, Svetlana Kombarova, Semen Kamagurov, Natalya Kovaleva

PJSC "Fine Chemicals R&D Centre", Moscow, 107258, Russia, Tel. +7 916 29174 81; emails: ki-popov@mtu-net.ru (K. Popov), rudakova@travers.su (G. Rudakova), larchenkove@mail.ru (V. Larchenko), tusheva@travers.su (M. Tusheva), lenaafanasyeva@mail.ru (E. Afanas'eva), kombarsv@yandex.ru (S. Kombarova), kamagurov@mail.ru (S. Kamagurov), n.e.kovaleva@gmail.com (N. Kovaleva)

Received 24 March 2016; Accepted 16 June 2016

ABSTRACT

A comparative ability of industrial samples of four phosphorus-free polymers (polyaspartate [PASP]; polyepoxysuccinate [PESA]; polyacrylic acid sodium salt [PAAS]; and copolymer of maleic and acrylic acid [MA-AA]) and of two phosphonates (aminotris(methylenephosphonic acid), ATMP; 1-hydroxyethane-1,1- bis(phosphonic acid), HEDP) to inhibit calcium carbonate precipitation is tested following the National Association of Corrosion Engineers (NACE) Standard TM0374-2007 for the dosages ranging from 1 to 25 $mg \cdot dm^{-3}$. In a parallel way, an aqueous phase is studied by dynamic light scattering (DLS), while the solid calcium carbonate is characterized by scanning electron microscopy and powder X-ray diffraction (XRD). The following ranking ATMP > HEDP > PESA (400–1,500 Da) ~ PASP (1,000–5,000 Da) > PAAS (3,000–5,000 Da) ~ MA-AA is found. DLS exhibits the formation of $CaCO_3$ particles with a particle size around 300–400 nm in the blank solution as well as in presence of all antiscalants immediately after a supersaturated solution preparation with negative ζ-potential around –5 mV for all reagents. Only for MA-AA the bigger aggregates are formed. XRD analysis revealed calcite formation at low dosages of all antiscalants, although the crystal shapes are distorted. At a higher concentration of some antiscalants, aragonite (PAAS, ATMP) and vaterite (PASP) are found to be the dominating crystal modifications. The differences between the blank experiments and scaling in the presence of inhibitor are attributed neither to $CaCO_3$ particle size nor to electrostatic charge, but to the number of particles formed. In presence of an antiscalant, the number of solid phase particles is sufficiently less, than in a blank solution. Thus, both the polymers and phosphonates prevent mostly the formation of initial crystallization centers under NACE protocol conditions.

Keywords: Scale inhibition; Calcium carbonate; Biodegradable polymers; Phosphonates; NACE; DLS; SEM; XRD

*Corresponding author.

Presented at the EDS conference on Desalination for the Environment: Clean Water and Energy, Rome, Italy, 22–26 May 2016.