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ORIGINAL PAPER

Acrylic acid–allylpolyethoxy carboxylate copolymer as an environmentally friendly calcium carbonate and iron(III) scale inhibitor

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Abstract A novel environmentally friendly type of calcium carbonate and iron(III) scale inhibitor AQ*n* was synthesized. The anti-scale property of the AQ*n* copolymer toward $CaCO_3$ and iron(III) in the artificial cooling water was studied through static scale inhibition tests. The observation shows that both calcium carbonate and iron(III) inhibition increase with increasing the degree of polymerization of AQ*n* from 5 to 15, and the dosage of AQ*n* plays an important role on calcium carbonate and iron(III) inhibition. The effect on formation of $CaCO_3$ was investigated with combination of scanning electronic microscopy, transmission electron microscopy, X-ray powder diffraction analysis, and Fourier-transform infrared spectrometer, respectively. Inhibition mechanism is proposed that the interactions between calcium or iron ions and polyethylene glycol are the fundamental impetus to restrain the formation of the scale in cooling water systems.

Keywords Scale inhibitor · Environmentally friendly · Calcium carbonate · Disperse

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Introduction

Open recirculating cooling water systems are frequently used because they not only provide economical heat removal but also recirculation of water conservation is accomplished with substantial cost reductions. The cooling water circulates to operating units where it picks up heat and the resulting warm water is cooled through vaporization by returning to the cooling tower. Dissolved and suspended matter contained in the water is concentrated in cooling water recirculation. The precipitation of calcium carbonate scale on heat transfer surfaces widely occurs, which involves the deposition of an insulating layer onto the internal walls owing to its inverse temperature-solubility characteristics (Xyla et al. 1992; Saleah and Basta 2008; Ben Amor et al. 2004). Deposits formation may cause severe corrosion and deterioration of heat exchange. The study of the mechanism of calcium carbonate crystal growth inhibition is an important theme for developing an effective technique to prevent scale formation. The most common and effective method of scale controlling is the use of chemical additives as scale inhibitors that retard or prevent scale formation even in very small concentrations (Kjellin 2003). Several studies about calcium carbonate scale formation in the absence and presence of inhibitors have been carried out (Kumar et al. 2010; Zhou et al. 2011; Liu et al. 2011; Suharso et al. 2011; Al Nasser et al. 2011; Zhang et al. 2010).

Copolymer has been used satisfactorily as a specific scale inhibitor in the circulating cooling water systems developed in the late 1970s (Reddy and Nancollas 1973) because of its strong complexation of multifunctional groups and superior dispersion characteristic of macromolecule. This kind of chemical inhibitors is applied widely in circulating cooling water treatment contribute to their excellent performances