



Fundamental Characterization and Technical Aspects of a Chelating Surfactant

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Abstract. The purpose of this study was to investigate the fundamental characteristics of a chelating surfactant in terms of solution behaviour, chelation of divalent metal ions, and interaction in mixtures with different foaming agents and divalent metal ion, as well as examining its prospects in some practical applications. Chelating surfactants are functional molecules, with both surface active and chelating properties, which are water soluble and therefore suitable for chelation in many aqueous environments. The dual functionality offers the possibility to recover the chelating surfactant as well as the metals.

The DTPA (diethylenetriaminepentaacetic acid)-based chelating surfactant 4-C₁₂-DTPA (2-dodecyldiethylenetriaminepentaacetic acid) was synthesized at Mid Sweden University. In the absence of metal ions, all eight donor atoms in the headgroup of 4-C₁₂-DTPA are titrating and the headgroup charge can be tuned from +3 to -5 by altering the pH. The solution properties, studied by surface tension measurements and NMR diffusometry, were consequently found strongly pH dependent. pH measurements of chelating surfactant solutions as a function of concentration was used to extract information regarding the interaction between surfactants in the aggregation process.

Small differences in the conditional stability constants ($\log K$) between coordination complexes of DTPA and 4-C₁₂-DTPA, determined by competition measurements utilizing electrospray ionization mass spectrometry (ESI-MS), indicated that the hydrocarbon tail only affected the chelating ability of the headgroup to a limited extent. This was further confirmed in hydrogen peroxide bleaching of thermomechanical pulp (TMP) treated with 4-C₁₂-DTPA.

Interaction parameters for mixed systems of 4-C₁₂-DTPA and different foaming agents were calculated following the approach of Rubingh's regular solution theory. The mixtures were also examined with addition of divalent metal ions in equimolar ratio to the chelating surfactant. Strong correlation was found between the interaction parameter and the phase transfer efficiency of Ni²⁺ ions during flotations. Furthermore, a significant difference in $\log K$ between different metal complexes with 4-C₁₂-DTPA enabled selective recovery of the metal ion with the highest $\log K$.

The findings in this study contribute to the understanding of the fundamental characteristics of chelating surfactants, which can be further utilized in practical applications.

Keywords: chelating surfactant, DTPA based surfactant, pH-responsive, characterization, surface tension, NMR diffusometry, conditional stability constants, interaction parameter, ion flotation