ENHANCEMENT EFFECTS OF SURFACTANTS IN FLAME ATOMIC ABSORPTION ANALYSIS

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INTRODUCTION

The use of surfactants in flame atomic absorption has been reported previously (1-7). Surfactants in dilute solutions below their critical micellar concentration (CMC) act as strong electrolytes. Above their CMC they exhibit unique solvent property changes such as apparent molar volumes, density, specific heat, electrical conductance, electromotive force, surface tension, vapor pressure, microfluidity or viscosity, and the temperature coefficient of solubility (9). It was the purpose of these studies to ascertain whether or not these changes in the solvent properties of water would effect atomic absorption signals. A review of the literature on this subject results in apparent inconsistencies in the final results and the theories that explain this phenomena. In the original papers some confusion might have resulted because the enhancement of signals had been reported three different ways. For ease in comparison these values have been recalculated as ratios of the signal studied compared to their aqueous solutions. For example a value of 1.10 could have previously been reported as a 10% enhancement or 110% of the aqueous signal.
In 1959 Foster and Hume used a total consumption burner and determined that variations in surface tension by the non-ionic surfactant Tergitol NPX had no significant effect in the analysis of sodium (1). It was believed that these solutions would behave like organic cosolvents which have lower surface tensions compared to water. Therefore more of the solution would be aspirated by the capillary tube and smaller droplets would be generated during the nebulization process, resulting in an increase in efficiency an enhancement in sensitivity. In 1960 Dean reported that small amounts of surfactants resulted in the enhancement of emission signals using a premix burner, but he recanted that statement in 1969 after reports by Lockyer in 1961 and Pungor in 1963 refuted those earlier findings (2). In 1974 Venable and Ballad reported on the effects of surfactants on the flame atomic absorption analysis of copper and nickel (3). Using sodium dodecyl sulfate (SDS) and tetradecylpyridinium bromide above their critical micellar concentrations (CMC) they found that SDS caused an enhancement in signal while tetradecylpyridinium bromide actually caused a decrease in the signal. Another effect noted was that SDS solutions prevented the formation of precipitates and stabilized colloidal dispersions over an extended pH range from 1 to 9 compared to solutions without SDS which had a pH range of 1 to 5.3. However, in their conclusions they warned against using surfactants because they might give erroneous results.

Kodama reported on the enhancement of chromium signals in the presence of SDS in flame atomic absorption spectroscopy (FAAS) using a premix burner (4). Later experiments focused on the droplet size distributions of water and aqueous micellar systems which exhibited proof that the surfactants produced a finer aerosol due to the surface tension lowering of these solutions above their CMC. Both SDS and dodecyltrimethylammonium chloride enhanced chromium (VI) absorbances up to a factor of 2.00. Other metals studied exhibited enhancement between 1.05 to 1.40 in the order: Fe>Ni>Mn>Cu>Zn. These results follow the decreasing order of analytical sensitivity and seem to indicate that the metals that form more stable solid particles in the flame are influenced by the size of the droplets (5). Armstrong studied the effects of SDS, ammonium dodecylsulfate and Aerosol OT, which all gave similar enhancements for copper flame atomic absorption