

Physico-chemical characterization of non-ionic polyoxazoline surfactants

S. SULTANA, T. ZUBERI AND M. J. LAWRENCE

Department of Pharmacy, King's College London, Manresa Road, London SW3 6LX

Living cationic polymerization is widely recognized as an important tool for the synthesis of hydrophilic oxazoline polymers (POz) with narrow polydispersities (Chujo et al 1989). Despite the wide spread interest in the synthetic aspects of these molecules, very little has been reported about the physico-chemical properties of these polymers, and in particular, their surface active derivatives. This is surprising as polyoxazoline-based surfactants comprising a flexible linear hydrophilic polyoxazoline chain and a long hydrophobic amine chain are readily synthesized. Furthermore, as these surfactants can be considered as polymeric analogues of the solvent dimethylacetamide, the aggregates these surfactants form may exhibit potential as a means of solubilizing water-insoluble drugs.

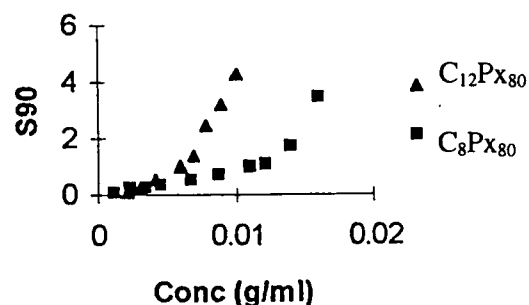
The present study examines the potential of a series of polyoxazoline-based surfactants to form micellar aggregates. Two series of polymers have been prepared using the method of Chujo et al (1989), varying both in the length of the hydrophobic amine and the number of oxazoline units, designated as $C_nP_{x_8}$. The physico-chemical properties of two of the surfactants prepared are reported here, namely $C_8P_{x_8}$ and $C_{12}P_{x_8}$. In particular the surfactants have been evaluated for their ability to form aggregates using dynamic light scattering (Malvern 4700c series light scatterer) and surface tension measurements (Wilhelmy plate method).

However it is of interest to note that the shorter hydrophilic chain surfactants (ie $C_8P_{x_n}$ and $C_{12}P_{x_n}$ where n is less than or equal to 60) produced cloudy, birefringent one-phase solutions when present in water at concentrations of 1.0 wt%, while in contrast, the longer hydrophilic chain derivatives at the same surface concentration produced clear solutions. Encouragingly aqueous solutions (concentrations of 1.0 wt%) of $C_8P_{x_8}$ and $C_{12}P_{x_8}$ failed to exhibit a cloud point over the temperature range 20-90°C, giving these surfactants a significant advantage over the commonly used non-ionic polyoxyethylene-based surfactants.

Evaluation of the dynamic light scattering data (Figure) suggested that the aggregates were growing in size above a critical concentration, designated the critical micelle concentration (cmc). The cmc obtained for each of the surfactants from light scattering experiments (2.3×10^{-3} g/g for $C_{12}P_{x_8}$ and 8.3×10^{-3} g/g for $C_8P_{x_8}$) agreed closely with those obtained from surface tension measurements (Table). The area per molecule obtained from the surface tension data for these surfactants was unexpectedly very low (around 43 \AA^2) and may explain the continuous nature of association, as a small area per molecule is often indicative of this behaviour. Interestingly to date only a few polyoxyethylene nonionic surfactants with relatively short hydrophilic head groups have been reported to exhibit similar aggregation behaviour.

Surface properties of $C_{12}P_{x_8}$ and $C_8P_{x_8}$

Surfactant	γ_{\min} (mN/m)	cmc (10^{-3} g/g)	Area per molecule (\AA^2)
$C_{12}P_{x_8}$	31	2.5	42
$C_8P_{x_8}$	32	3.0	43

Light scattering behaviour of $C_{12}P_{x_8}$ and $C_8P_{x_8}$ 

The existence of continuously associating aggregates may have important implications in the use of these surfactants as drug delivery vehicles to solubilize drug.

Chujo, Y., Ihara, E., Ihara, H., Saegusa, T. (1989) *Macromolecules*, 22, 2040-2048.