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APPLICATION NOTE

WP4005: Determination of critical micelle concentration by dynamic light scattering

Introduction

Detergents have been characterized in solution by a variety of methods, including surface tension measurements, light scattering, gel permeation chromatography, and fluorescence and absorbance spectroscopy. Spectroscopic methods depend on spectral changes of a probe molecule which is able to intercalate into a micelle structure upon its formation. Unfortunately, such a perturbation in a detergent system can easily influence the CMC and aggregation number.

Matrix adsorption can be problematic in GPC approaches, and surface tension measurements are generally time consuming and tedious to perform. Light scattering on the other hand, has the advantages of being non-perturbing, rapid, and easy to perform, while providing meaningful physical properties.

Materials and Methods

Wyatt's DynaPro™ DLS/SLS instrument, configured with separate, optimized dynamic and static light scattering detectors both at 90° scattering angle, was used to determine the critical micelle concentration (CMC) for Triton X-100 in the absence of salt. All measurements were made using a 45 µL quartz cuvette, after filtering the sample through a 0.1 µm Whatman Anodisc filter.

Beyond the hydrodynamic size and scattering intensity results presented here, a DynaPro NanoStar provides size distributions and polydispersity, molecular weight and particle concentration data. With an intuitive touchscreen app and data quality assessments that provide actionable recommendations, the NanoStar can be used with very little training by everyone in the lab.

Results and Discussion

Figure 1 shows the total scattering intensity and apparent hydrodynamic radius as a function of surfactant concentration for the marked TX100 system. As seen here, there is a marked deviation in the slope of the intensity curve at ~0.26 mM. Concomitant with an increase in scattering intensity is the detection of a particle with an effective radius of ~3.8 nm, indicating the formation of micelles for TX100 concentrations > 0.27 mM.

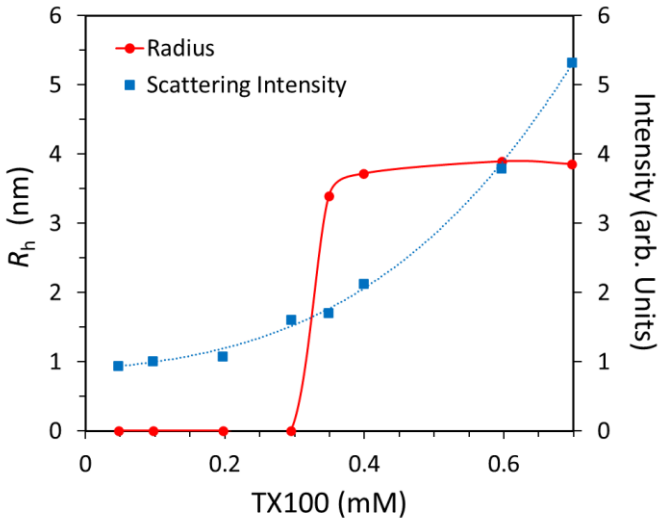

Figure 1. Influence of TX100 concentration on the radius (J, red) and total scattering intensity (B, blue). Solid plots are only meant as a guide to the eye.

A comparison of the properties of TX100 micelles determined using various instrumental techniques is shown in Table 1, where N is the aggregation number. In the dynamic light scattering technique (DynaPro), the molecular weight of the TX100 micelle was estimated using a MW-vs.-R_h calibration curve constructed from globular protein standards. As evident in Table 1, the CMC, MW,

and aggregation numbers determined using the DynaPro are consistent with those determined using fluorescence and ultracentrifugation techniques.

Table 1. Properties of TX100 Micelles

	Fluorescence	Centrifugation	DynaPro
CMC (mM)	0.22 – 0.3	-	0.27
R_H (nm)	-	-	3.8
MW (kDa)	-	63- 97	74
N		100- 134	119

Conclusions

By simultaneously providing total scattering intensity, hydrodynamic radius, polydispersity, and estimated MW as a function of surfactant concentration, the DynaPro enables one to study CMC, aggregation number, size, and system homogeneity. Its ease of use and applicability to a wide range of solution phenomena, without the introduction of system perturbation, gives it an appealing advantage in the exploration of macromolecular interactions in solution.

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