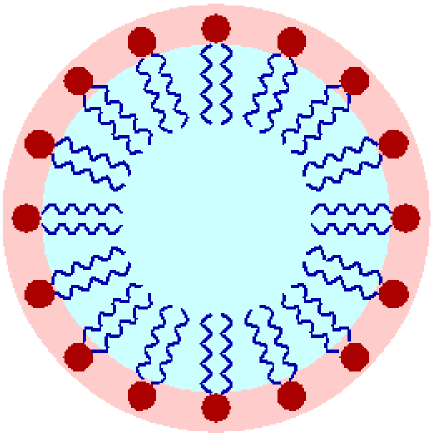
Determination of the critical micellar concentration of a detergent using a fluorescent probe



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Smart_Drugs Teacher Guide

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Summary

In this experimental activity the aim is to estimate the micellar concentration in detergents through the behaviour of surfactants in a liquid environment. Due to their properties they will aggregate into micelles, the interior of which is a hydrophobic environment where the Nile Red, a fluorescent dye, will migrate to and thereby increase its fluorescence emission.

Introduction

The determination of the critical micellar concentration (CMC) is of paramount importance for any processes involving surfactants, substances that lower the surface tension of a liquid or influence the interface between two liquids. The effect of these compounds is greater when a significant concentration of micelles is present. Micelles are spherical in shape, having a dimension of 1.5 to 3 nm in radius and having about 200 units, and on their surface there are polar zones that function as a "shield" which minimizes hydrophobic interactions. Their formation is not static; the dynamics of micellar dissociation is important because it participates in numerous solubility reactions of solutes or insoluble species. The concentration at which the CMC occurs, at a given temperature, is a characteristic of each surfactant. The CMC is influenced by three factors: the nature of the surfactant, the temperature and the ionic strength. The CMC is usually determined by graphs that are based on the sudden change in physical and chemical properties, such as: conductivity, interfacial tension, surface tension, osmotic pressure, etc.

The aim of this work is to determine the CMC of a detergent, sodium dodecyl sulfate (SDS), through the fluorescence emission from a dye, Nile Red, which migrates to hydrophobic environments created by the detergent's molecules when aggregated into micelles. Thus, Nile red can be used as a probe to detect the CMC through the variation of the intensity of its fluorescence spectrum.

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Curriculum/subjects

Biology - year 10 and 11

Biophysics

Chemistry - year 12

Material

- Nile Red solution
- - Sodium dodecyl sulfate (SDS) detergent
- 12 volumetric flasks of 50 ml
- Pasteur pipettes
- 12 cuvettes
- Spectrofluorimeter

Experimental procedure

Prepare 12 Nile Red solutions with different concentrations of detergent (SDS) in 50ml volumetric flasks.

Transfer the solution into cuvettes with Pasteur pipettes. Each cuvette is analyzed in the spectrofluorimeter to measure the fluorescence spectra of the aqueous solutions, in the wavelength range from 590 to 700 nm.

With the values obtained, create a graph of the fluorescence intensity of the Nile Red according to the different detergent concentrations.

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Data collection and analysis

The CMC values by absorption spectroscopy in the visible zone were determined by behavioural changes in the absorption curve. This change in behaviour happens due to changes in the environment in which these molecules meet. By increasing the concentration of SDS, micelles are formed and, as a result, the dye is incorporated into the micelle, until the dye is completely solubilized in the micelle, thus obtaining the maximum point of the curve. The maximum point represents the value of the CMC.

In table 1, the values of the fluorescence intensity of the Nile Red in the different concentrations are shown.

Concentration (mol/L)	Fluorescence Intensity
3,00E-03	2,00
4,00E-03	3,75
5,00E-03	5,50
6,00E-03	25,30
6,50E-03	50,60
7,00E-03	59,80
7,50E-03	64,80
8,00E-03	61,80
9,00E-03	65,00
1,00E-02	65
1,20E-02	63,20

(Table1 - fluorescence intensity of the Nile Red in the different concentrations)

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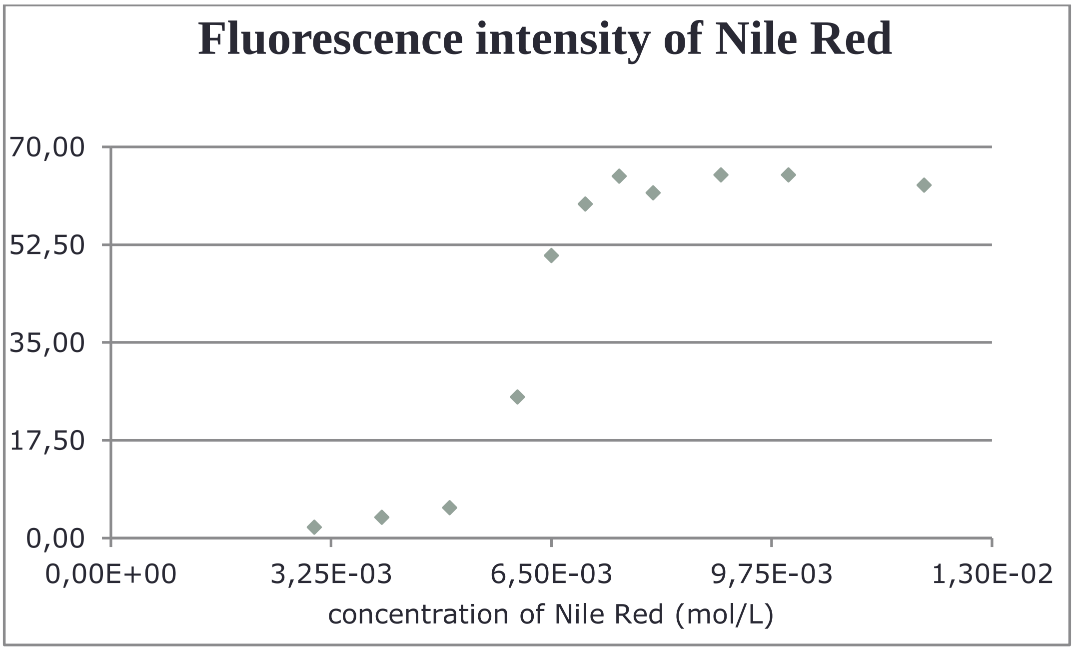
In figure 1, it is possible to observe that by increasing the concentration of SDS in the solutions, there is a resulting increase in the fluorescence intensity of the Nile Red.



(Figure 1- graphical representation of fluorescence intensity values in different concentrations)

The intensity levels become stable, in this case, between the concentrations of 7.50E-03 mol / L and 1.20E-2 mol / L.

The mean of the intensity values comprised between the concentrations mentioned above, which will result in the critical micellar concentration of SDS, in this case, is 9.0 E-3 mol / L.

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Conclusion

This process enabled us to plot the fluorescence intensity of the Nile Red according to the detergent concentration and the resulting estimate of the critical micelle concentration of 9.0 E-3 mol / L.

We can observe that the higher the concentration of the detergent (SDS), the greater fluorescence intensity will be.

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