

The Effects of Heat Treatment on the Drug Loading of Poloxamer Micelle Structures

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Research Motivation and Methods:

The motivation for this project was to determine the effects of heat treatment on the drug loading of poloxamer (Pluronic) micelle structures. Methods included using spectrophotometry and dynamic light scattering (DLS) to analyze micellar structures heated at different temperatures and using solid and liquid Pluronics to identify whether its physical form has a significant impact on the effects of heat treatment.

Introduction:

Micelles are polymer structures with amphiphilic components that self-assemble when present above the critical micelle concentration (CMC)

Spectrophotometry is a technique for finding the light absorbance of a chemical substance in solution

DLS is a technique for determining the size of particles in solution

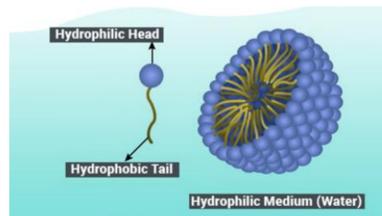


Fig. 1: Structure of a Micelle [1]

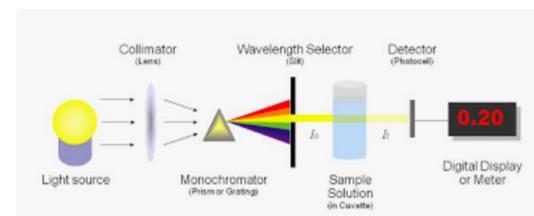


Fig. 2: Schematic of a spectrophotometer [2]

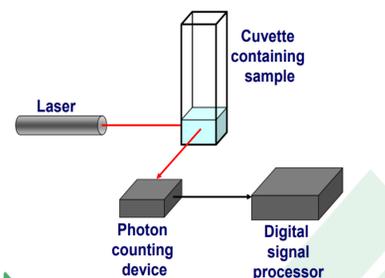


Fig. 3: Schematic of a DLS instrument [3]

Procedure:

Micellar solutions were formed using Pluronic F-127 or Pluronic L-121 and deionized water, and PBS buffer and pyrene, which served as the drug analog, were added when required. Solutions were heated at 35, 45, and 55°C for 10 minutes with stirring (solutions at 25°C served as the control). Spectrophotometry was then utilized to measure the absorbance of the solutions, and DLS was used to determine the size of the micellar structures.

Results and Analysis:

Pyrene Absorbance Data

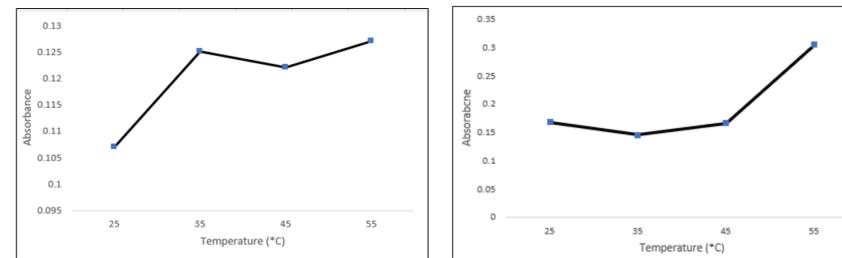


Fig. 4: Line plot of the absorbance of pyrene in Pluronic F-127 (left) and Pluronic L-121 (right) solutions in accordance with temperature

Figure 4 demonstrates that the absorbance of pyrene begins to significantly increase when heat treatment is applied at 35°C for Pluronic F-127 and at 55°C for Pluronic L-121 solutions. Pluronic L-121 solutions have greater pyrene absorbance than Pluronic F-127 with an average absorbance of 0.20 compared to 0.12.

Environment and Time Effects

Table 1: Micelle absorbance based on the environment and temperature for Pluronic F-127

Temperature (°C)	Absorbance		
	DI Water (Short-term)	DI Water (Long-term)	DI Water and PBS
25	0.001	0.001	0.003
35	0.002	0.001	0.004
45	0.001	0.002	0.003
55	0.002	0.001	0.003

Table 1 demonstrates that time did not affect the absorbance of the Pluronic F-127 solutions with the same environment although the environment did affect the micelle absorbance.

Table 2: P-values for hypothesis tests on the slope of the regression lines

Environment	P-value
DI Water (Short-term)	0.553
DI Water (Long-term)	0.742
DI Water and PBS	0.742

Table 2 highlights that there is not a significant relationship between micelle solution absorbance and temperature for any of the scenarios tested.

Citations:

- [1] *Micelle*, Byju's: The Learning App, byjus.com/chemistry/micelle/.
- [2] *Spectrophotometry*, The University of Queensland, <https://di.uq.edu.au/community-and-alumni/sparq-ed/sparq-ed-services/spectrophotometry>.
- [3] Shaw, R., *Dynamic Light Scattering Training: Achieving Reliable Nano Particle Sizing*, ATA Scientific, 1-132. <https://www.chem.uci.edu/~dmityrf/manuals/Fundamentals/DLS%20concept.pdf>.

Heat-treatment Effects on Micelle Size

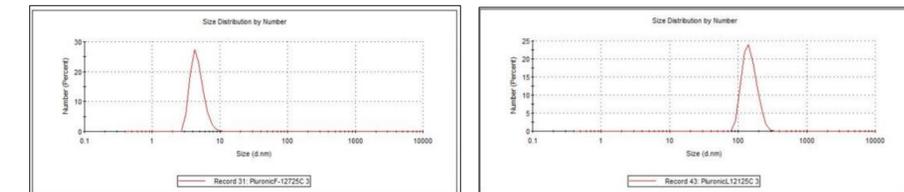


Fig. 5: Size distribution plots for Pluronic F-127 (left) and Pluronic L-121 (right) micelles from DLS at 25°C

Table 3: Average size data for Pluronic F-127 and Pluronic L-121 from DLS

Pluronic	Average Size (nm)
F-127	6.6±1.8
L-121	250±30

Figure 5 and Table 3 illustrates that the Pluronic F-127 micelles are significantly smaller than the Pluronic L-121 micelles on average.

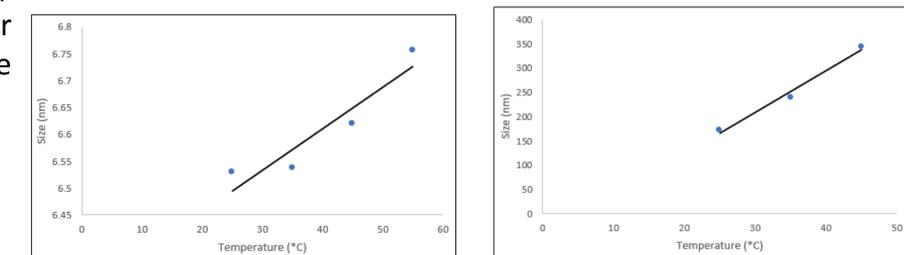


Fig. 6: Size with respect to temperature for Pluronic F-127 (left) and L-121 (right)

Figure 6 suggests an upward trend in the size of the micelles as temperature increases.

Table 4: P-values for hypothesis tests on the slope of the regression lines

Pluronic	P-value(s)
F-127	0.065
L-121	0.083

Based on the p-values, there is not a significant relationship between the size of the micelles and the temperature at which they were heat treated with the current number of points.

Future Work:

- Create a calibration curve to determine the concentration of pyrene based on the absorbance in order to calculate the drug loading capacity
- Replicate results and collect data at additional temperatures to verify trends found