Effect of surfactant addition on dynamics of gellan gum gels: Non-ergodic approach

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ABSTRACT SUMMARY
The dynamics of gellan gum hydrogels with addition of surfactant was studied by dynamic light scattering. A non-ergodic treatment was used for analysis. Results reveal that CMC plays a vital role in determining diffusion coefficients. The present study highlights the scope of studying structural properties of gel so that they can be tailored to suit drug delivery applications.

INTRODUCTION
Hydrogels have gained potential interest in recent decades both in industries for their versatile applications and in research to understand the structure and fundamental features. Hydrogels are of great importance in wide variety of applications including food industries, personal care, pharmaceutics, drug delivery etc¹. Regardless of all these applications their use in drug delivery formulations is still emergent. Sometimes in order to suit specific applications, additives such as surfactants can be added. Surfactants allow modification of structure, solubilization capacity and drug release profiles of hydrogels. Thus to understand polymer surfactant interaction better, in the present study we report dynamic light scattering study of effect of sodium dodecyl sulfate (SDS) surfactant addition on dynamics of gellan gum hydrogels.

EXPERIMENTAL METHODS
To study the dynamics of gels, non-ergodic treatment was used. Time averaged intensity correlation function (ICF) \( g_T^{(2)}(q,t) \) was measured for 30 minutes at a single position which also gives \( \langle I(q) \rangle_T \) using a 7004- ALV multitau correlator. Ensemble averaged scattered intensity \( \langle I(q) \rangle_E \) was measured by rotating the sample cell at a speed of 6rpm using a stepper motor. In the case of hydrogels because of the presence of non-ergodicity time averaged ICF is not equal to ensemble averaged ICF, the ensemble-averaged dynamic structure factor \( f(q,t) \) was determined from \( g_T^{(2)}(q,t) \) using Pusey and van Megan method ².

\[
f(q,t) = \frac{Y - 1}{Y} + \frac{(g_T^{(2)}(q,t) - \sigma_I^2)^{1/2}}{Y}
\]

Where \( \sigma_I^2 \) is the mean square intensity fluctuation and \( Y = \langle I(q) \rangle_E / \langle I(q) \rangle_T \)

RESULTS AND DISCUSSION
The ISF \( f(q,t) \) was constructed using equation 1 and is plotted in figure 1. The ISF for all the hydrogel samples decays from an initial value of 1 at short time. However at long times, due to the presence of frozen-in structures a non-decaying component is seen and the value saturates to different values. The long time ISF \( f(q,\infty) \) which is a measure of frozen in component is analyzed with varying surfactant concentration.

All the curves are fitted with the standard equation. The values obtained from the fitting are tabulated for further analysis. The fast relaxation time is seen to shift to smaller values with increase in SDS concentration but below critical micellar concentration in this case. However above CMC, relaxation times increases. But for stretched exponential function a clear comparison is not possible due to the value of \( \beta \). Nonetheless below CMC slow relaxation time decreases.

CONCLUSION
The interaction of gellan gum hydrogels with SDS was studied by use of dynamic light scattering. It was seen that surfactant as well as CMC plays a vital role in deciding the dynamics of hydrogels.

REFERENCES

ACKNOWLEDGEMENTS
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1. INTRODUCTION

Factors effecting hydrogel structure
- Polymer concentration
- Crosslinking density
- Solution pH
- Solvent quality
- Aging of gels
- Temperature
- Presence of salts

Why Gellan gum?
- One of the most potential in-situ gelling polymers in human body.
- Used in drug delivery vehicles.
- Used in food industry.
- Used in protein immobilization media.
- Biocompatible.
- Non-toxic.
- Structure can be altered to suit specific applications

Applications of Hydrogels
- Drug delivery
- Toe Implants
- Wound dressing
- Healing
- Ophthalmic
- Cancer therapy
- Medicine
- Food industry

Objectives
- To synthesise hydrogels with relatively homogeneous structure.
- To study the effect of surfactant addition on structure and dynamics of hydrogels

2. MATERIALS AND METHODS

Dynamic light scattering (DLS)

The intermediate scattering function (ISF) \( f(q,t) \) was determined from \( g_{I}^{(2)}(q,t) \) by Pusey and van Megan method
\[
f(q,t) = \frac{1}{Y} - \frac{(g_{I}^{(2)}(q,t) - \sigma_{I}^{2})^{1/2}}{Y}
\]
Where \( \sigma_{I}^{2} \) is the mean square intensity fluctuation & \( Y = \langle I(q) \rangle / \langle I(q) \rangle_{T} \)
The short time expansion is given by
\[
f(q,t) = 1 + D\sigma_{I}^{2}t^{2} \ldots
\]
\( D \) -corrected diffusion coefficient
\( D_{A} \)-apparent diffusion coefficient

3. RESULTS AND DISCUSSION

- The intermediate scattering function \( f(q,t) \) was constructed using equation from measured time averaged ICFS.
- The ISF for all the hydrogel samples decays from an initial value of 1 at short time.
- However at long times, due to the presence of frozen-in structures a non-decaying component is seen and the value saturates to different values.
- This result is a clear indication of the non-ergodicity of the hydrogel samples.

- The cooperative diffusion coefficient increases when surfactant is added below CMC.
- But after CMC on further increasing surfactant concentration the diffusion coefficient decreases.
- The slow diffusion coefficient also follows a similar trend but clear comparison is not possible because of \( \beta \), however diffusion coefficient increases below CMC.

- The long time ISF \( f(q,\infty) \) which is a measure of frozen in component is plotted in above figure with varying surfactant concentration.
- The incomplete decay arising due to frozen in structures is clearly seen.
- They arise due to constraints imposed on the diffusion of particles by gel network.
- Below CMC the frozen in structures increases however above CMC the trend is reversed.

- The fast relaxation time is seen to shift to smaller values with increase SDS concentration but below CMC
- However above CMC, relaxation times increases.
- But for stretched exponential function a clear comparison is not possible due to the value of \( \beta \). Nonetheless below CMC slow relaxation time decreases.

4. CONCLUSION

- The dynamics of gellan gum hydrogels with addition of surfactant SDS was studied by dynamic light scattering.
- A non-ergodic treatment was used for analysis.
- Results reveal that CMC plays a vital role in determining diffusion coefficients.
- The present study highlights the scope of studying structural properties of gel so that they can be tailored to suit drug delivery applications.

5. FUTURE WORK

- The Effect of other surfactants on the dynamics of hydrogels can be studied.
- The mechanical properties of the prepared hydrogels can be evaluated by the rheological measurements.

6. REFERENCES

7. ACKNOWLEDGEMENTS
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