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Comparative studies of ultrasound and membrane emulsification for the production of stable Perfluorocarbon-in-water nanoemulsions

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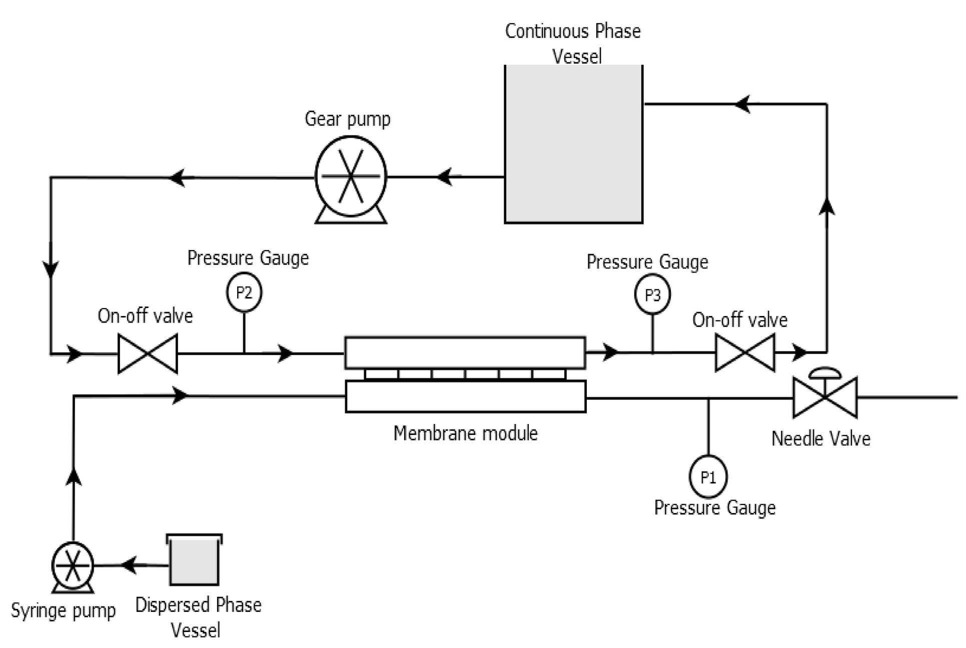
Introduction

- Low-molecular weight perfluorocarbons (PFCs) are usually chemically and biologically inert, clear, colorless liquids, presenting a high affinity for many gases, which turn them particularly suitable in various biomedical applications involving gas capture, transport and release.
- The use of PFC-in-Water emulsions as blood substitutes and for O_2/NO therapeutics, have still problems related to low emulsion stabilities, wider size distributions and reduced shelf-lives [1].
- In a comparative study, PFC-in-Water nanoemulsions were produced by the traditional ultrasound emulsification method and the low energy–intensive membrane emulsification method [2] by using Nadir UC 500 regenerated cellulose membrane.

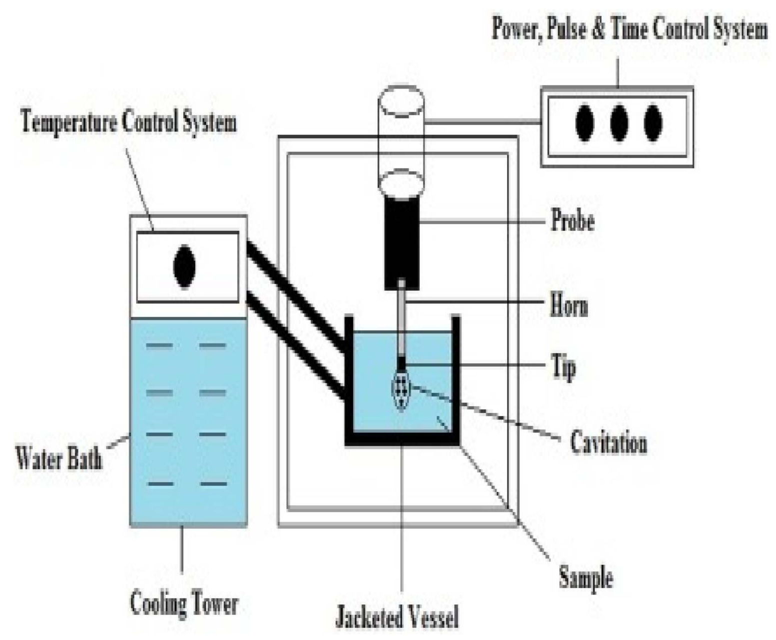
Objective

The main objective of this work is to produce monodisperse perfluorocarbon (PFC) nanoemulsions presenting larger surface-to-volume ratios, enhanced stabilities and more efficient gas capture/delivery properties.

Experimental Set-up



Membrane Emulsification unit

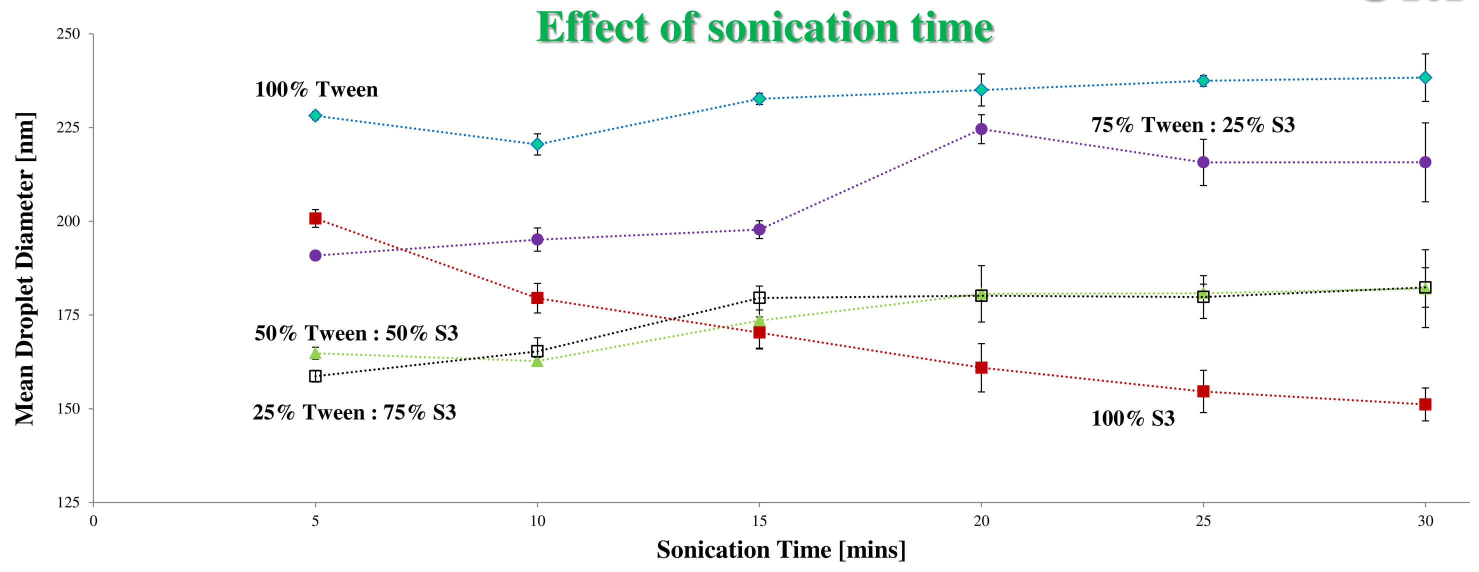


Ultrasound Emulsification unit (500 W)

Results

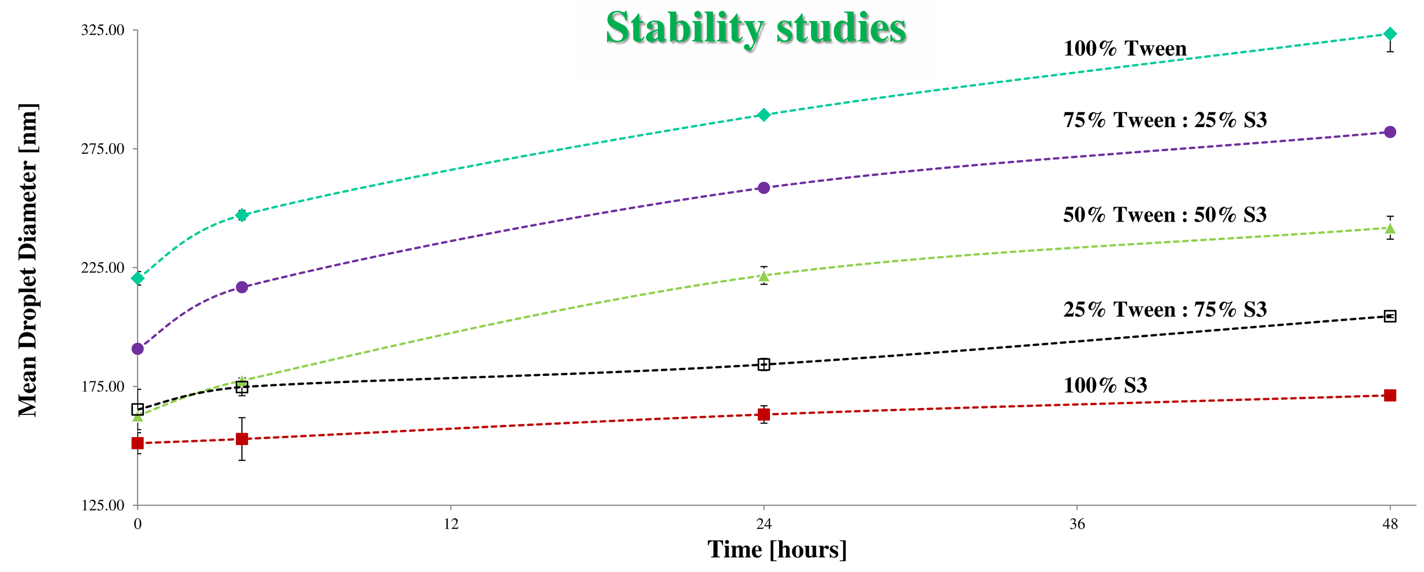
Ultrasound Emulsification

Effect of sonication time



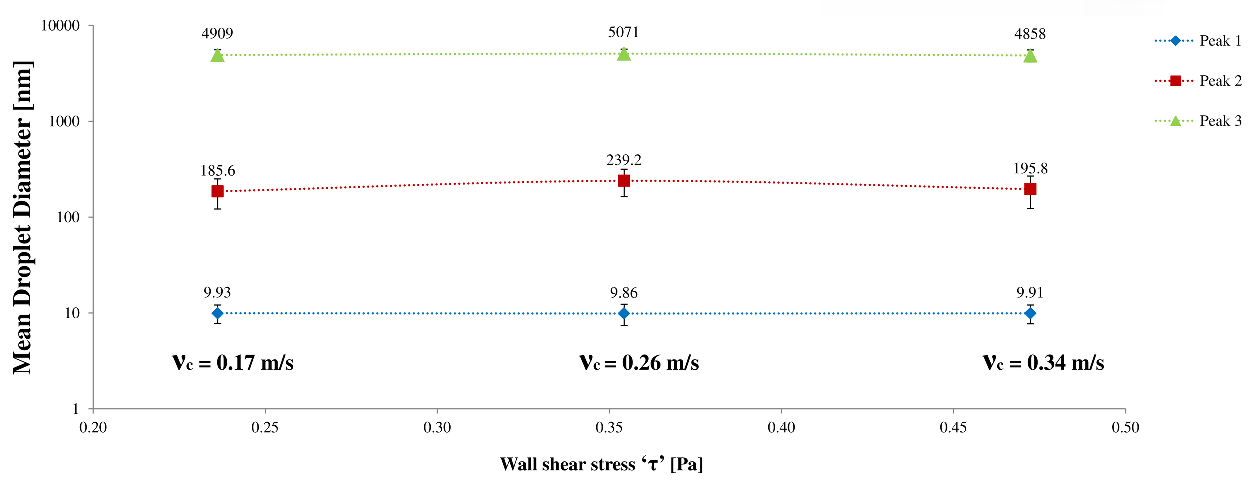
Surfactants used : Tween 80 and perfluorooctyl phosphocholine 'S3'

Stability studies



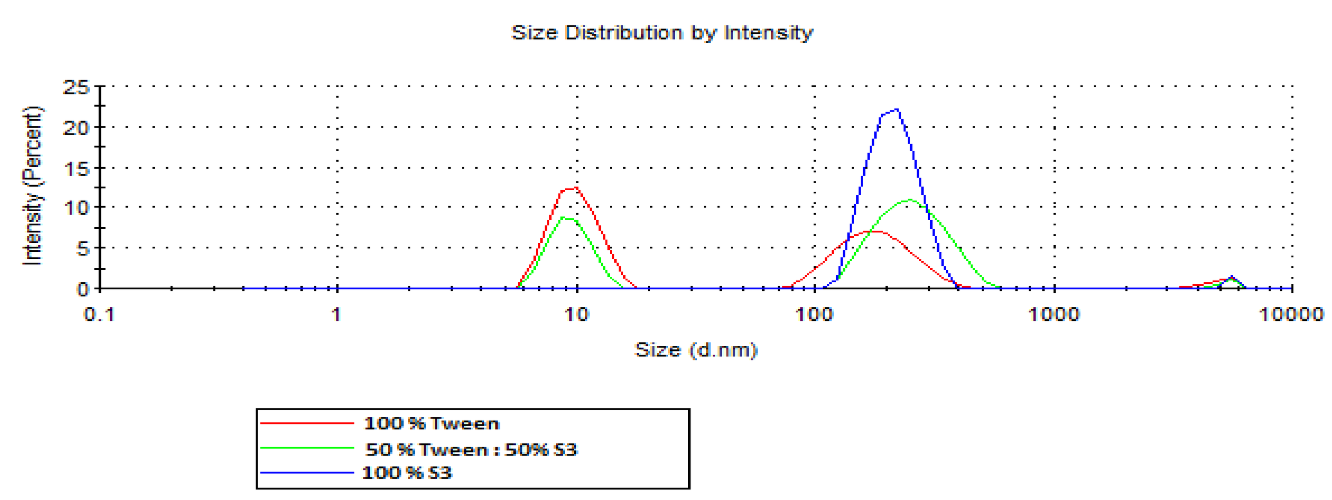
Membrane Emulsification

Effect of continuous phase cross-flow velocity 'vc'

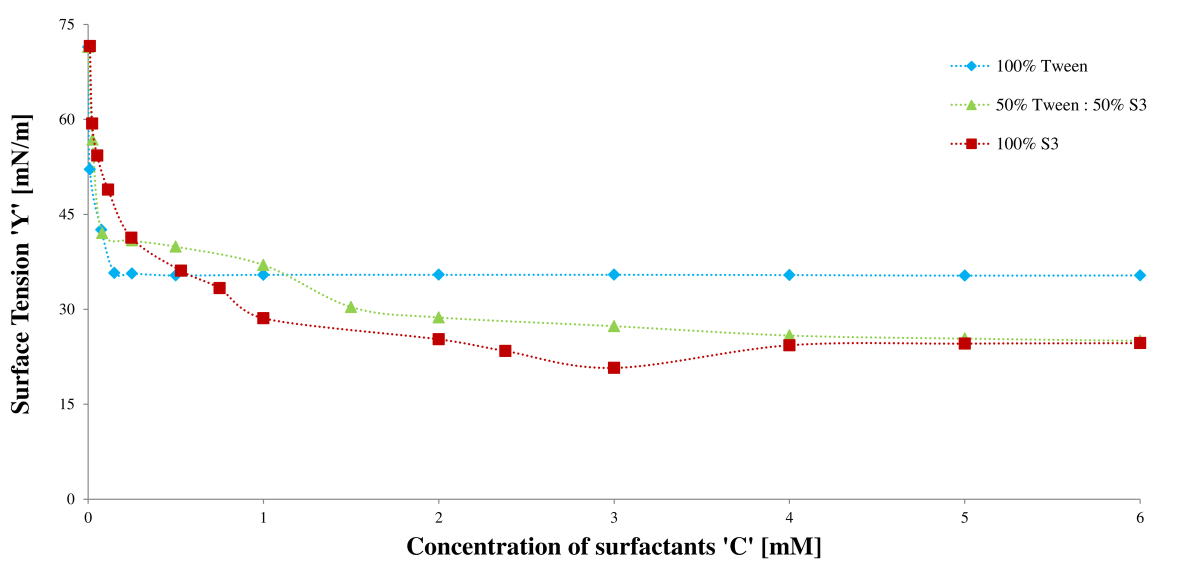


Dispersed phase flowrate 'Qd' = 55 ml/min, emulsifier is Tween 80 and 'Vc' is the cross-flow velocity of the continuous phase

Effect of surfactants

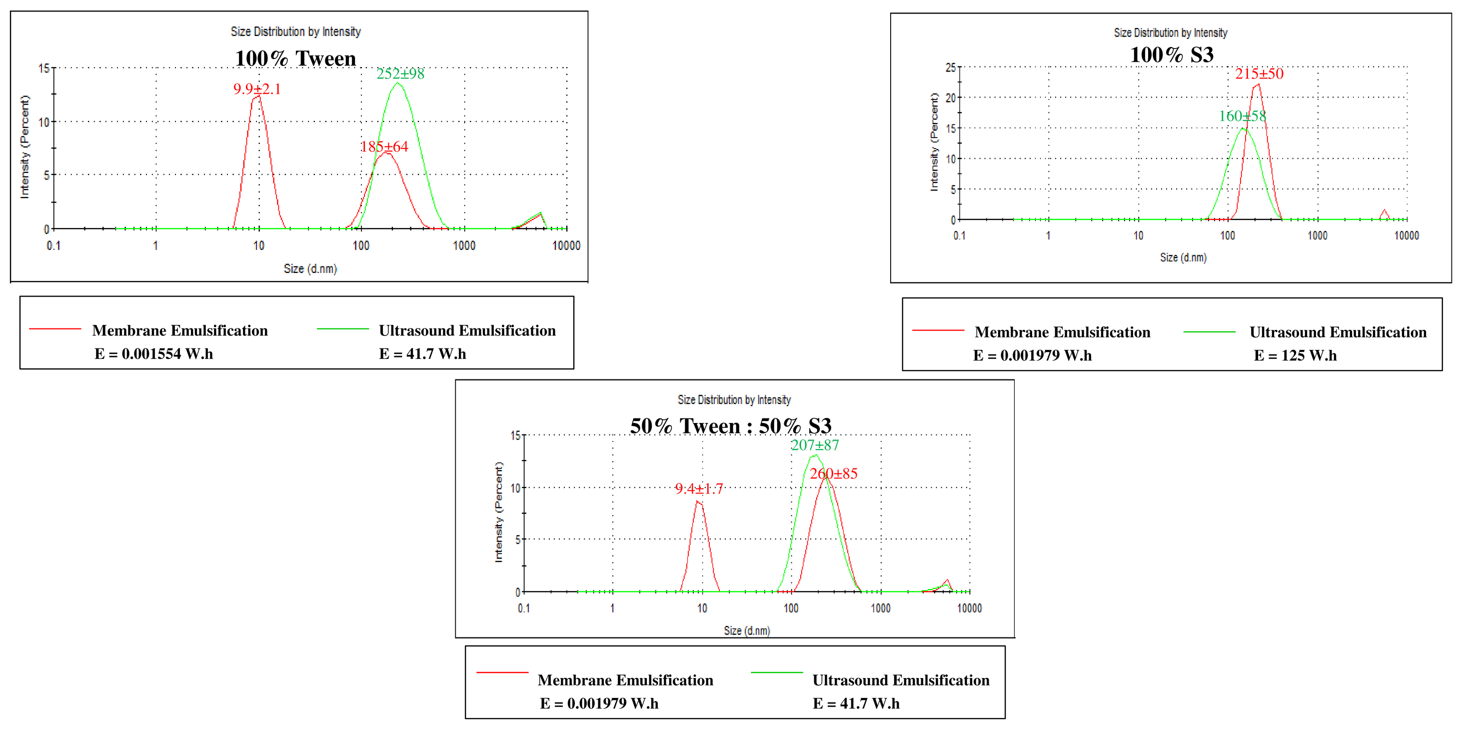


Surface Tension Measurement



Since perfluorooctyl phosphocholine 'S3' is a fluorinated surfactant, it has lower surface tension compared to Tween 80. Interestingly, by using the mixture of S1 and S3 (50/50%), low surface tension values can also be achieved leading to reduced cost of operation.

Comparative Analysis



Membrane Emulsification - Dispersed phase flowrate 'Qd' = 55ml/min. Continuous phase cross-flow velocity 'Vc' = 0.17 m/s. 'S3' is perfluorooctyl phosphocholine surfactant

Conclusions

- In each case, the concentration of surfactants used to prepare emulsions- 100% Tween, 100% S3 and 50%Tween : 50%S3, are above their critical micellar concentration (c.m.c.).
- With mixture of surfactants, process is cost-effective and emulsions are quite stable.
- Low energy-intensive membrane emulsification produces narrower distribution of emulsions. However, it needs further screening of membranes and operating parameters.

References

[1] M.P. Krafft, A. Chittofrati, J.G. Riess, Emulsions and microemulsions with a fluorocarbon phase. Curr Opin in Colloid Interface Sci., 8 (2003) 251–258

[2] E. Piacentini, E. Drioli, L. Giorno, Membrane Emulsification technology: Twenty-five years of inventions and research through patent survey. J. of Membr. Sci., 468 (2014) 410–422

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