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Usman Taqui Syed
LAQV/Requimte, Department of Chemistry, Faculty of Science and Technology, NOVA University of Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal, s.taqui@campus.fct.unl.pt

Sylvia Sousa
EPQPF, Department of Chemical Engineering, FCTUC, University of Coimbra, Pólo II - Pinhal de Marrocos, 3030-790 Coimbra, Portugal

Ana M. A. Dias
EPQPF, Department of Chemical Engineering, FCTUC, University of Coimbra, Pólo II - Pinhal de Marrocos, 3030-790 Coimbra, Portugal

Hermínio C. de Sousa
EPQPF, Department of Chemical Engineering, FCTUC, University of Coimbra, Pólo II - Pinhal de Marrocos, 3030-790 Coimbra, Portugal

Joao Crespo
LAQV/Requimte, Department of Chemistry, Faculty of Science and Technology, NOVA University of Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal

See next page for additional authors

Authors
Usman Taqui Syed, Sylvia Sousa, Ana M. A. Dias, Hermínio C. de Sousa, Joao Crespo, and Carla Brazinha

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

Usman Taqui Syed[a], Sylvia Sousa[b], Ana M. A. Dias[b], Hermínio C. de Sousa[b], Joao Crespo[a], Carla Brazinha[a]

[a] LAQV/Requimte, Department of Chemistry, Faculty of Science and Technology, NOVA University of Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal

[b] CIEPQPF, Chemical Engineering Department, FCTUC, University of Coimbra, Rua Sílvio Lima, Pólo II - Pinhal de Marrocos, 3030-790 Coimbra, Portugal

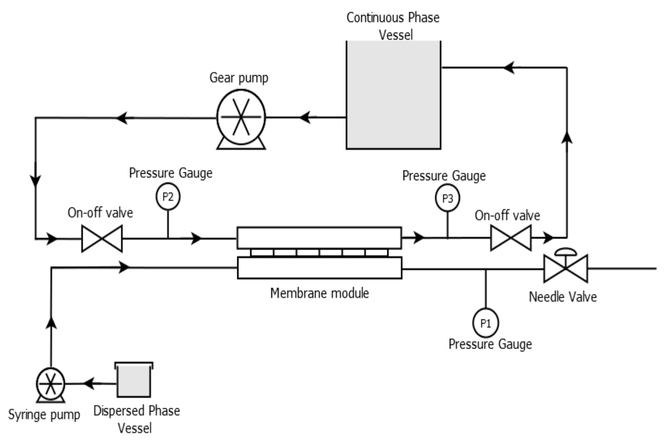
Introduction

- 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.

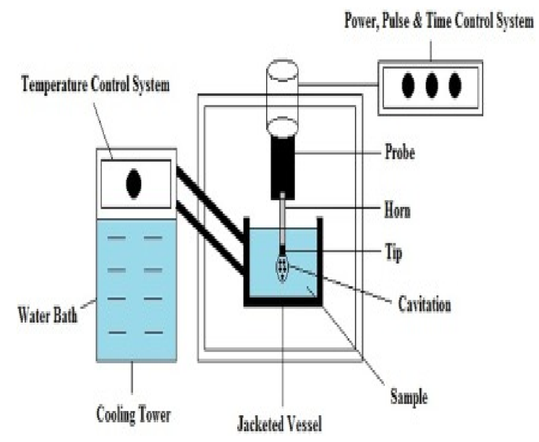
Objective

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

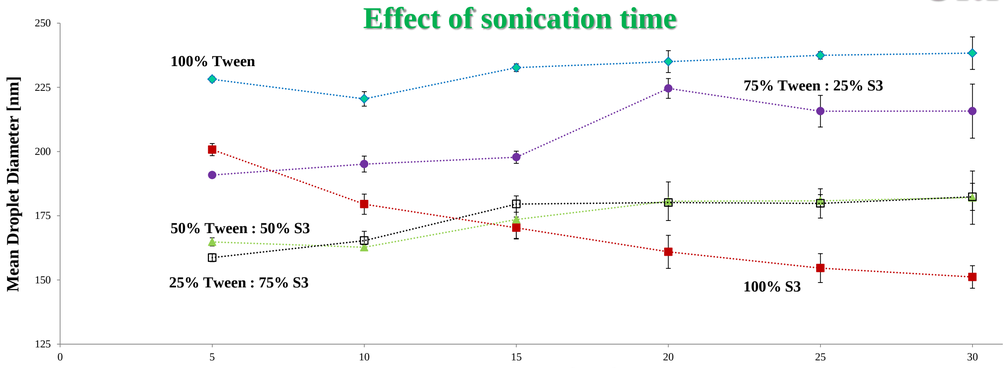


Ultrasound Emulsification unit (500 W)

Results

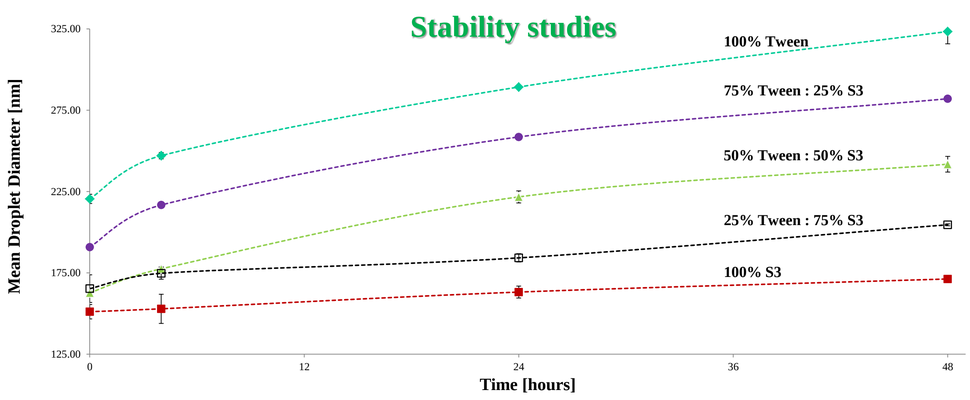
Ultrasound Emulsification

Effect of sonication time



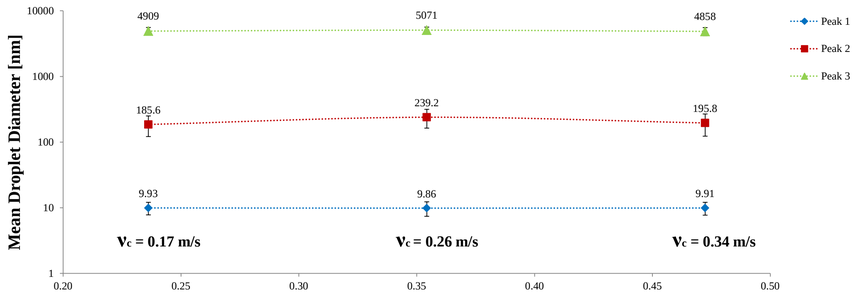
Surfactants used : Tween 80 and perfluorooctyl phosphocholine 'S3'

Stability studies



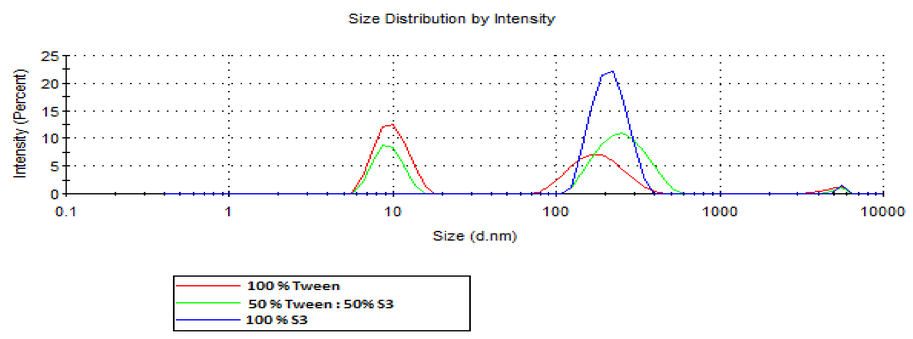
Membrane Emulsification

Effect of continuous phase cross-flow velocity 'v_c'

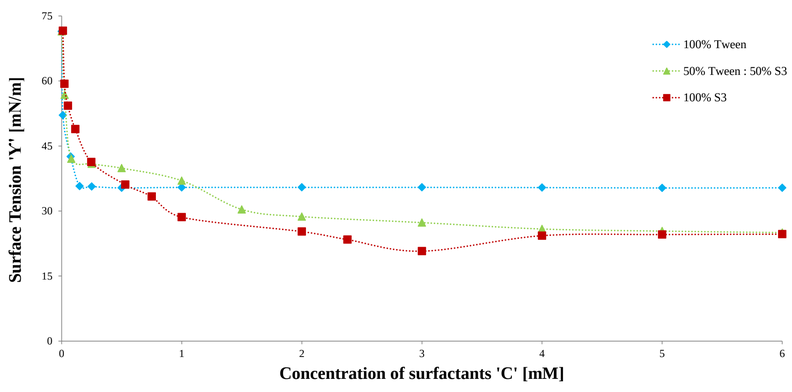


Dispersed phase flowrate 'Q_d' = 55 ml/min, emulsifier is Tween 80 and 'v_c' is the cross-flow velocity of the continuous phase

Effect of surfactants

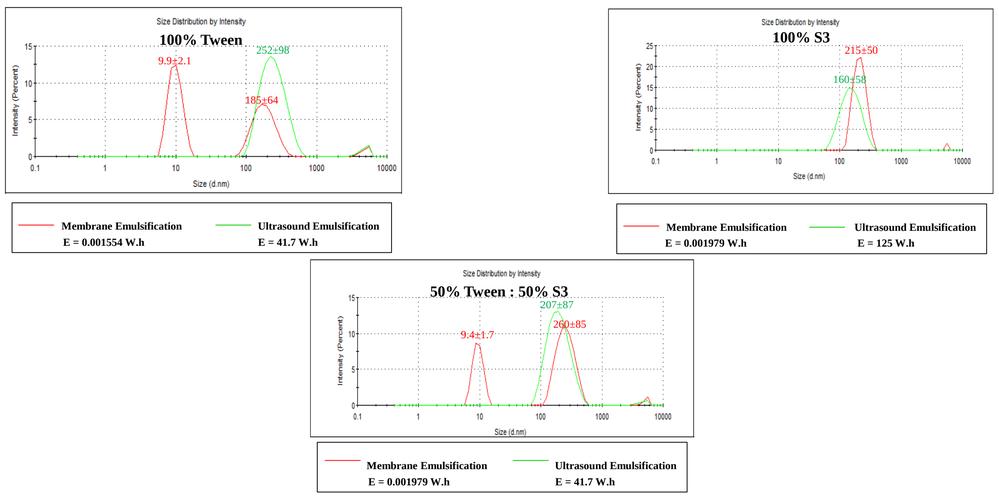


Surface Tension Measurement



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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