COMPARATIVE STUDIES OF ULTRASOUND AND MEMBRANE EMULSIFICATION FOR THE PRODUCTION OF STABLE PERFLUOROCARBON-IN-WATER NANOEMULSIONS

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Low-molecular weight perfluorocarbons (PFCs) are usually chemically and biologically inert, clear, colorless liquids, presenting a high affinity for many gases, namely for O$_2$, NO and CO$_2$, which turn them particularly suitable in various biomedical applications involving gas capture, transport and release. In fact, PFC-in-Water emulsions were one of the two major classes of systems proposed as blood substitutes and for O$_2$/NO therapeutics. However there are still some important issues concerning this type of systems which have limited their efficiency, approval and commercial success, namely those related to emulsion stability, hydrodynamic size distribution and reduced shelf-lives. Stability issues can easily lead to PFC diffusion in water, to aggregation and to the consequent hydrodynamic size increase and emulsion degradation [1].

Nanoemulsions (typically within a range of hydrodynamic sizes of 10-100 nm) exhibit various advantages over typical microemulsions [2]. Hence, our aim is to produce monodisperse PFC nanoemulsions presenting larger surface-to-volume ratios, enhanced stabilities and more efficient gas capture/delivery properties. A first approach to achieve these goals is to prepare and to study a mixed surfactant system based on Tween 80 and on a perfluorinated surfactant (perfluorooctyl phosphocholine) at different relative compositions.

PFC-in-Water nanoemulsions were produced by using the traditional ultrasound emulsification method (500W). The effects of co-surfactants relative compositions on CMC values, on the kinetics of emulsion formation and on the corresponding stabilities of prepared nanoemulsions were evaluated. Hydrodynamic sizes and Zeta-potentials were also assessed, being able to obtain stable nanoemulsions with hydrodynamic sizes between 150 and 200 nm. In a comparative study, PFC-in-Water nanoemulsions were also produced by membrane emulsification. This low energy-intensive technique has received increasing interest as it allows more flexible operating conditions. Regenerated cellulose membranes such as Nadir UC500 and Millipore Ultraceil RC100, polyethersulphone membranes such as Nadir UP150 and Millipore PBHK04310, and a promising polycarbonate Whatman Track-etched 30 nm Nuclepore membrane, were employed to produce nanoemulsions, and using the same mixed surfactant system and relative compositions. The energy inputs of these two methods were compared and discussed along with their efficiencies in terms of producing nanoemulsions presenting improved stabilities, smaller hydrodynamic sizes and narrower hydrodynamic size distributions.

References