Experimental report

07/01/2016

Proposal: **9-10-1422**

Council: 10/2014

Title: Insertion of perfume molecules in pluronic micelles

Research area: Soft condensed matter

This proposal is a new proposal

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Jerome COMBET

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Samples: 1,8-cineol, $C_{10}H_{18}O$
Anethol, $C_{10}H_{12}O$
linalool, $C_{10}H_{18}O$
limonene, $C_{10}H_{16}$
menthol, $C_{10}H_{20}O$
linoleic acid, $C_{18}H_{23}O_2$
oleic acid, $C_{18}H_{34}O_2$
Pluronic F127,$C_{290}H_{1192}O_{266}$

Instrument	Requested days	Allocated days	From	To
D22	0	1	28/06/2015	29/06/2015
D33	1	0		

Abstract:

The focus of this proposal is on the influence of model perfumes on the shape and size of nonionic micelles. Since the middle ages, essential oils have been widely used for bactericidal, fungicidal, antiparasitical, insecticidal, and other medicinal properties. Their nano-encapsulation in drug delivery systems has been proposed for their capability of decreasing volatility, improving the stability, water solubility, and efficiency of essential oil-based formulations. Pluronics meet a number of essential requirements for drug delivery. They are bio-compatible and have a low toxicity. We propose to perform a SANS experiment at different contrasts to understand how the position of the perfume molecules into the core-shell F127 micelles drives the change of shape and size of the micelle.

Insertion of perfume molecules in pluronic micelles

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Prop 9-10-1442, D22, 28-29/06/2015

Essential and vegetal oils are complex blends of a variety of volatile molecules such as terpenoids, phenol-derived aromatic components and aliphatic components having a strong interest in pharmaceutical, sanitary, cosmetic, agricultural, and food industries. Since the middle ages, essential oils have been widely used for bactericidal, virucidal, fungicidal, antiparasitical, insecticidal, and other medicinal properties such as analgesic, sedative, anti-inflammatory, spasmolytic, and locally anaesthetic remedies. Their nano-encapsulation in drug delivery systems has been proposed for their capability of decreasing volatility, improving the stability, water solubility, and efficiency of essential oil-based formulations, by maintenance of therapeutic efficiency. A series of 9 essential oils (EO) has been selected: fennel, thyme, lemon, rosemary, lavender, palmarosa, tea tree, pepper mint and gaultherie. In parallel, the insertion of the main molecules present in the EO is compared (anethol, thymol, lemonen, 1,8 cineol, linalol, geraniol, 4-terpinol, menthol, methyl salicylate).

Among the wide variety of surfactants, the triblock copolymers of poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide) (PEOx-PPOy-PEOx) kown as Pluronics meet a number of essential requirements for drug delivery. They are bio-compatible and have a low toxicity. They have low critical micellar concentration, (around 10^{-5} mol/L) and micelle formation is strongly dependent upon temperature. F127 (EO100-PO65-EO100) is an attractive candidate as pharmaceutical vehicle for drug delivery through different oral or parenteral route of administration. It is also used in cosmetic products.

The ternary systems (F127/EO/D_2O) are first characterized by optical observation to identify the single phase domains and the insertion limits. MicroDSC is used to determine the CMT. Finally, the compositions retained are Φ_{F127}= 1% Φ_{EO} =0.2% and Φ_{F127}= 3% Φ_{EO} =0.2% and 0.6%. The temperature is fixed at 37°C, above the CMT.

The SANS experiment has been performed on D22. The wavelength was fixed at 6 Å and 2 detector distances, 2 and 14 m with a detector offset of 400 mm were used to cover a q –range from $3x10^{-3}$ to 0.4 $Å^{-1}$. In parallel, x-ray measurements on ID2 at the ESRF has been performed on the same samples.

The scattering curves obtained for Φ_{F127}= 3% and Φ_{EO} =0.2% are shown in Figure 1a for the EO, and Figure 1b for the corresponding chemicals. An increase of the scattering at low q and the shift of the oscillation toward lower q is the direct evidence of the growth of the micelles. The scattering length profile for neutron and x-ray, before and after the oil loading is presented in Figure 2a and b. Due to the high hydration of the ethylene oxide groups, the polar part of the F127 micelles is almost not visible with neutrons. Inversely, x-rays are more sensitive to the shell. A combined SANS and SAXS analysis in absolute scale allows a detailed characterisation of the micelles.

The data analysis of hairy micelles has been developed in [1-3]. In addition to a standard core-shell model, the scattering of the small PEO polymer that gives the characteristic q^{-2} behaviour at high angle is taken into account. The SANS data fitting of the pure F127 micelle in D_2O is presented in Figure 3a. An example SANS after the addition of lavender is shown in Figure 4. Table 1 summarizes the fitting parameters.

Lemon is a very highly hydrophobic molecule and does not enter the F127 micelles. For the almost all the other essential oils and related molecules a swelling of the hydrophobic core and a decrease of the SLD is observed. On the contrary, the shell thickness is not significantly affected and the SLD remains constant. The strongest swellings are also related to the most important decrease of the CMT.

The data analysis for the concentration Φ_{F127}= 1% and Φ_{EO} =0.2% and Φ_{F127}= 3% and Φ_{EO} =0.6% is under progress.

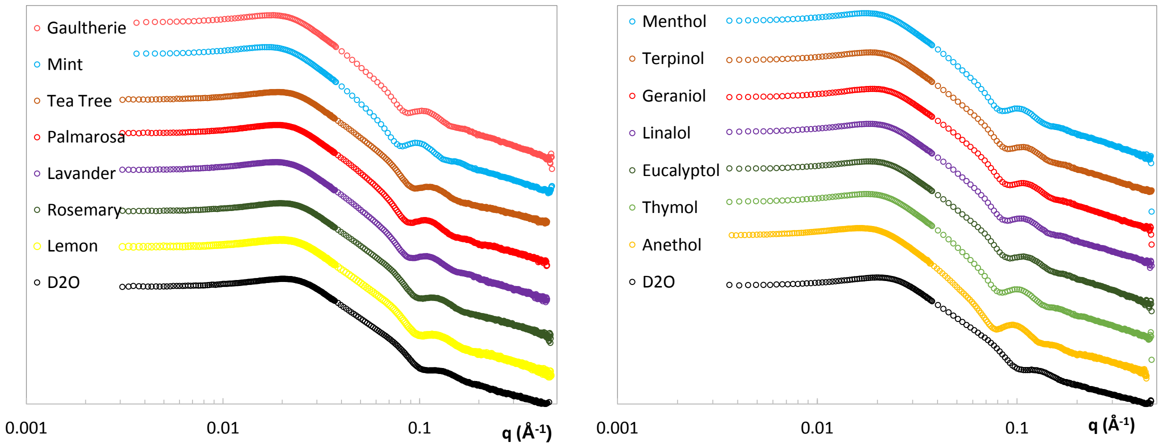


Figure 1: SANS scattering curves for the composition Φ_{F127}= 3% and Φ_{EO} =0.2%. Left: essential oils; Right: corresponding chemicals. The curves are shifted in intensity for clarity reasons. The shift of the oscillation toward lower q is the evidence of the swelling of the micelles.

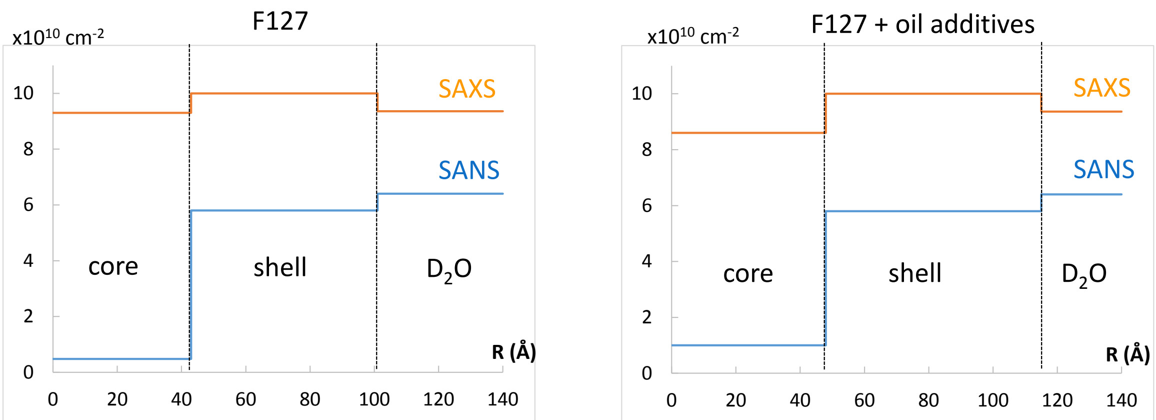
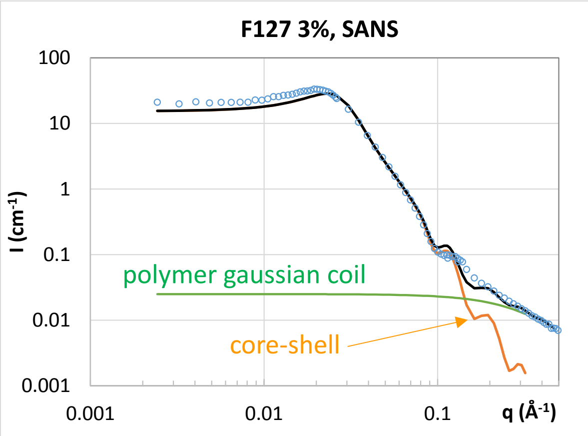


Figure2: Comparison of the scattering length density profiles of neutron and x-ray, before and after the loading with hydrophobic molecule that enter the micellar core.



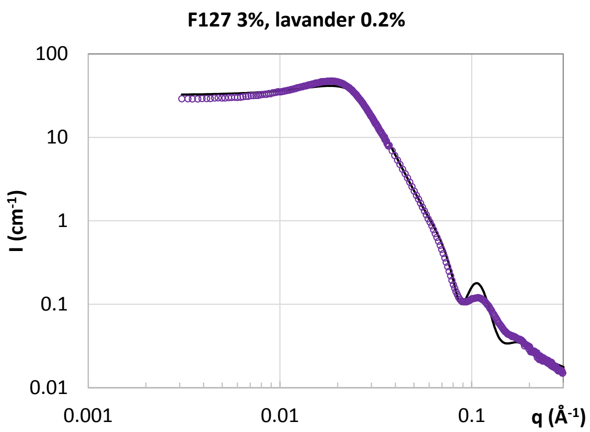


Figure3: Data analysis of the SANS scattering of pure F127 micelles (Φ_{F127}= 3%) (Left) and after addition of EO of lavender (Φ_{EO} =0.2%) (Right)

Table 1: summary of the SANS fitting parameters for (Φ_{F127}= 3% and Φ_{oil} =0.2%).

	Rc(Å)	e_{shell}(Å)	Φ HS	ρ_{core}(cm^{-2})	ρ_{shell}(cm^{-2})
D_2O	45	60	0.13	0.95 10^{10}	5.87 10^{10}
Lemon	46	61	0.13	0.98 10^{10}	5.83 10^{10}
Rosemary	48	62	0.14	1.07 10^{10}	5.85 10^{10}
Lavender	51	62	0.13	0.87$10^{10}$	5.38 10^{10}
Palmarosa	53	64	0.15	1.22 10^{10}	5.83. 10^{10}
Tea tree	51	64	0.13	0.94 10^{10}	5.84 10^{10}
Pepper mint	59	68	0.13	0.88 10^{10}	5.79 10^{10}
Gaultherie	54	64	0.12	0.89 10^{10}	5.75 10^{10}

	Rc(Å)	e_{shell}(Å)	Φ HS	ρ_{core}(cm^{-2})	ρ_{shell}(cm^{-2})
D_2O	45	60	0.13	0.95 10^{10}	5.87 10^{10}
Anethol	58	68	0.13	1.19 10^{10}	5.71 10^{10}
Thymol	57	64	0.13	1.05 10^{10}	5.75 10^{10}
1,8 cineol	53	64	0.13	0.84 10^{10}	5.78 10^{10}
Linalol	54	64	0.14	0.88 10^{10}	5.80 10^{10}
Geraniol	53	64	0.14	0.88 10^{10}	5.84 10^{10}
4-terpinol	52	64	0.15	0.92 10^{10}	5.92 10^{10}
menthol	56	66	0.13	0.84 10^{10}	5.81 10^{10}

<u>References:</u>

[1] Mortensen K., Pedersen J.S., Macromolecules (1993) 26, 805

[2] Pedersen J.S., Gerstenberg M.C., Macromolecules (1996) 29, 1363

[3] Pedersen J.S., Gerstenberg M.C., Colloids and Surfaces A: Physicochem. Eng. Aspects (2003) 213, 175