Elaboration and time stability study of capsules made of double emulsions

Maxime Nollet[1] Eric Laurichesse[1], Olivier Soubabère[2], Samantha Besse[2] and Véronique Schmitt[1]
1 Centre de Recherche Paul Pascal Université de Bordeaux, CNRS 115 Av. A.Schweitzer, 33600 Pessac, 2 Natural Plant Protection, Arysta LifeScience's group, Parc d'activités Pau-Pyrénées, 35 avenue Léon Blum, 64000 Pau, France
Contact Email: veronique.schmitt@cnrs.cnrs.fr

Double water-in-oil-in-water emulsions are interesting systems for encapsulation of hydrophilic drugs (see Figure 1) as vitamin B12 or a suspension of *Cydia pomonella Granulovirus*, used in organic agriculture to protect fruits against the Carpocapse insect. Using rotor-stator mixers, monodisperse double emulsions were prepared in a two-step process that may impact the encapsulation efficiency. Using both classical UV-Vis spectroscopy and, more originally, rheology we assessed the encapsulation efficiency and water exchanges during emulsification [1]. We showed that encapsulation reached high levels, close to 100% and that this encapsulation decreased only if two conditions are fulfilled simultaneously: (i) during the second emulsification step, the flow is turbulent and (ii) it leads to excessive fragmentation inducing formation of too small drops. We also discuss the effect of a deliberate osmotic pressure unbalance on the encapsulation and characterize the induced water fluxes.

Once prepared, these capsules could also release their content or exchange water between inner and external aqueous phases. Using the same techniques, rheology and UV-Vis spectroscopy, we built a lipophilic stabilizer concentration-inner droplet volume fraction diagram highlighting the domains where the double emulsion is stable towards encapsulation and/or water fluxes [2]. We showed the important role of non-adsorbed stabilizer concentration in the intermediate oil phase on the emulsion stability. In the non-stable domains, we describe the observed phenomena and we determine the mechanisms responsible for release.

We conclude that by a judicious choice of the composition, double emulsion may act as efficient capsules over a large period of storage.

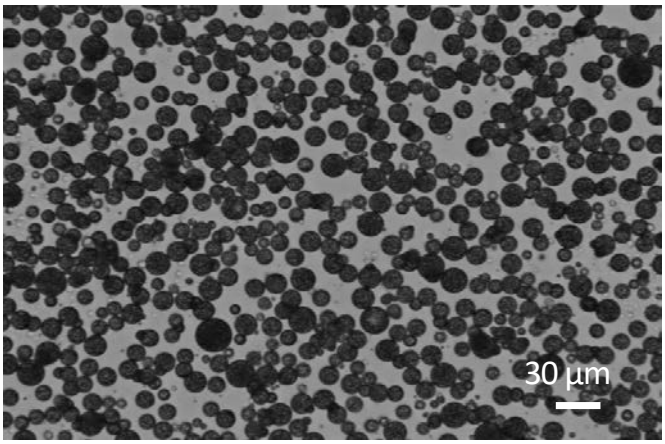

Figure 1: Microscopy image of the double emulsion: the high amount of inner aqueous droplets are responsible for the dark appearance of the oily globules.

References

[1] M. Nollet, M. Mercé, E. Laurichesse, A. Pezon, O. Soubabère, S. Besse, and V. Schmitt, *Soft Matter*, **12** 2016, 3412-3424.

[2] M. Nollet, E. Laurichesse, S. Besse, O. Soubabère, and V. Schmitt *Langmuir* **34** 2018 2823-2833.

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