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Quinoa starch particles as a new technology to stabilize and encapsulate lipophilic components

Poster #441

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INTRODUCTION

New pathways in formulation, like **Pickering emulsion**, lead to breakthrough innovations in texture, tolerance, and sustainability. **Starch** from **Quinoa** can meet these needs perfectly.

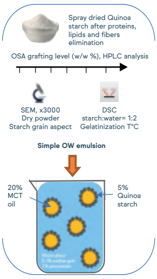
Micron-sized **Quinoa starch** have additional benefit of creating systems of superior stability due to a **higher energy of detachment** while promoting small droplets compared to other starches.[1-2]

To increase the lipophilicity of Quinoa starch, octenyl succinic anhydride (OSA) was grafted to some hydroxyl groups of the starch backbone by esterification.

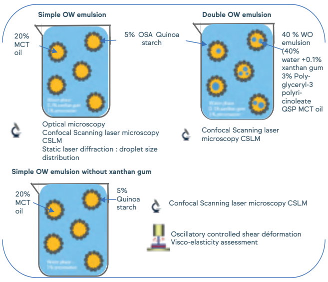
Interactions and compatibilities with other ingredients can affect the mechanisms of stabilization and the properties of the Pickering agent in negative or positive ways; **understanding the microstructure** of modified quinoa starch emulsions **in real-life cosmetic environment**[3] is key to formulate and optimize its use.

MATERIALS & METHODS

Powder characterization

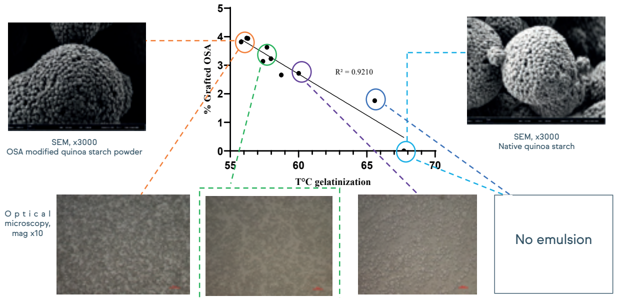


Emulsion microstructure investigation



RESULTS AND DISCUSSION

OSA GRAFTING LEVEL



SEM, x3000
OSA modified quinoa starch powder

SEM, x3000
Native quinoa starch

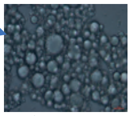
Optical microscopy, mag x10

No emulsion

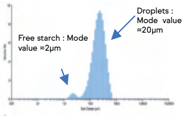
Starch grains
Quinoa OSA starches exhibited significantly lower T°C gelatinization than their native counterparts, a feature emphasized as the DS increases. This is attributed to a disruption of the crystalline structure of amylopectin upon modification with OSA. The OSA modified grains maintain a microscopic aspect despite a shift in gelatinization temperature.

Simple OW emulsion
The OSA grafting level enhances the performance of the particle, until a substitution degree optimum point is reached (green level).

Micron-size OSA quinoa grains can be clearly observed at the oil droplet interface, showing good coverage. Droplets can be seen to exhibit a flocculated state.



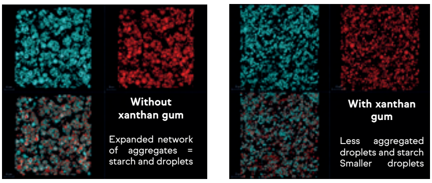
Optical microscopy, mag x100



Laser diffraction sizing

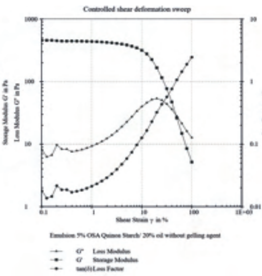
Simple OW emulsion features with optimum OSA level
As compared to a surfactant-based emulsion, the droplet size distributions were quite large (3 - 60 µm in diameter). Consequently, these emulsions creamed readily if the formula did not contain a gelling agent, but **otherwise were extremely stable to coalescence**, with no significant change in droplet size distributions over several months. This can be explained by the high interface anchoring energy of micron-size Pickering particles, and probably also by **the flocculation state** of the emulsion.

SIMPLE EMULSION OW MICROSTRUCTURE WITH AND WITHOUT XANTHAN GUM



Two-color CLSM pictures of OSA quinoa starch-stabilized emulsions, in volume style pictures. Top: the starch appears in blue and the oily phase in red; Bottom: combined image. The scale bar corresponds to 50 µm.

The droplets were covered at all depths by starch particles. Especially without xanthan gum, they are clearly aggregated, and the aggregates were associated to droplets surfaces. **The idealized model involving the stabilization of a Pickering emulsion by a monolayer of uniform spherical particles is rarely realized in practice**[4]. Due to the tendency towards flocculation, three-dimensional networks of closely packed emulsion droplets seem to have formed after emulsification.

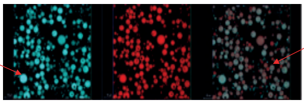


Before the yield point, **the storage modulus dominated and was dramatically higher than the loss modulus, as highlighted by the very low value of the loss factor.** This confirmed that the emulsion microstructure formed a strong three-dimensional network thanks to the connection of starch particles and oil droplet in clusters.

G' was also influenced by the interfacial elasticity resulting from the strong adhesion between solid particles adsorbed at the oil–water interface compared to surfactant-based emulsions[5].

MULTIPLE WOW EMULSION MICROSTRUCTURE

The oil droplets of the secondary OW emulsion are fully and homogenously covered by OSA quinoa starch granules.



The water droplets of the primary WO emulsion are clearly observed as black holes in the red-stained droplets of the secondary OW emulsion.

Two-color CLSM pictures in vertical section of OSA quinoa starch-stabilized WOW emulsion. The starch appears in blue and the oily phase in red; the resulting coupled images are displayed on the right. The scale bar corresponds to 10 µm.

This multiple emulsion didn't exhibit flocculation behavior or any starch/droplets clusters. As above, this could be explained by the presence of xanthan gum in the outer water phase. Furthermore, a larger amount of OSA quinoa starch grains were involved at the interface, since the quantity of WO emulsion emulsified here oil 40% (vs. 20%).

The stability of the WOW emulsion over several months met cosmetic industry expectations. Widely known as difficult to stabilize with surfactants, the production of multiple emulsions in cosmetic area is unlocked here through the combination of amphiphilic molecules and particles, stabilizing respectively OW and WO emulsions through two different stabilization mechanisms.

CONCLUSION

- OSA Quinoa starch produces emulsions aligned with cosmetic industry needs (easy to formulate, sustainable, highly stable) and with unique texture
- Key factors of performance understanding
- Full emulsion interface coverage
- Easy formulation of multiple emulsions
- Encapsulation applications throught a barrier treatment

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