

Synthesis of Tunable Janus-type Transesterified Cellulose Nanoparticles – an Eco-friendly Emulsifier

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Introduction

What is an emulsion ?

Oil-in-water Emulsion Without an emulsifier, separation occurs to form two layers

What is the role of an emulsifier ?

Stable mixture/ Emulsion Emulsifiers stabilise the oil-water interface and prevent droplet coalescence

Surfactant-stabilised emulsions vs Pickering emulsions

a. A surfactant molecule **b. Oil in water emulsion stabilized by molecules** **c. Particle** **b. Oil in water emulsion stabilized by particles**

water-soluble end Highly mobile, rapidly exchangeable Size $\approx 1-2$ nm Not mobile or exchangeable, Greater stability Size $\approx 50-500$ nm

Pros	Cons
Prevent droplet coalescence by forming a physical barrier between droplets, ensuring long-term stability	Use of nano-material
Offer eco-friendly and biocompatible alternatives to molecular surfactants (petrochemicals)	High production cost
Possibility of recovery and reuse	Require higher energy to form and emulsion
Do not generate foam/ acts as an anti-foaming agent	Particles generally do not possess inherent amphiphilicity

Background / Previous work^[1,2]

Spherical Cellulose Nanoparticles (SCNP) Emulsion formation Oil-in water emulsion Lipophilicity modifier Janus-type SCNP n= 6, 10 or 14 n= 4, 8 or 12

Advantages of Janus type particles

- Provides amphiphilic properties by introducing hydrophilic and hydrophobic faces, which allow the particles to possess more effective surfactant action
- Amphiphilic particles possess greater affinity for the oil/water interface

Current Research Objectives

- Develop a method for making spherical cellulose nanoparticles sustainable way that is amenable to scale-up
- Replace alkyl bromide with vegetable oil or plant-based derivatives
- Develop a method to make a range of particles with varying Janus balance and compare to HLB scale

Synthesis^[3]

Spherical Cellulose Nanoarticles (SCNPs) Canola Oil Trans-esterification Pickering Emulsion formed 0.05-0.1 M NaOH Partial Cleavage Janus-type SCNP Emulsion formation Tunable Janus balance

Particle Characterisation^[3]

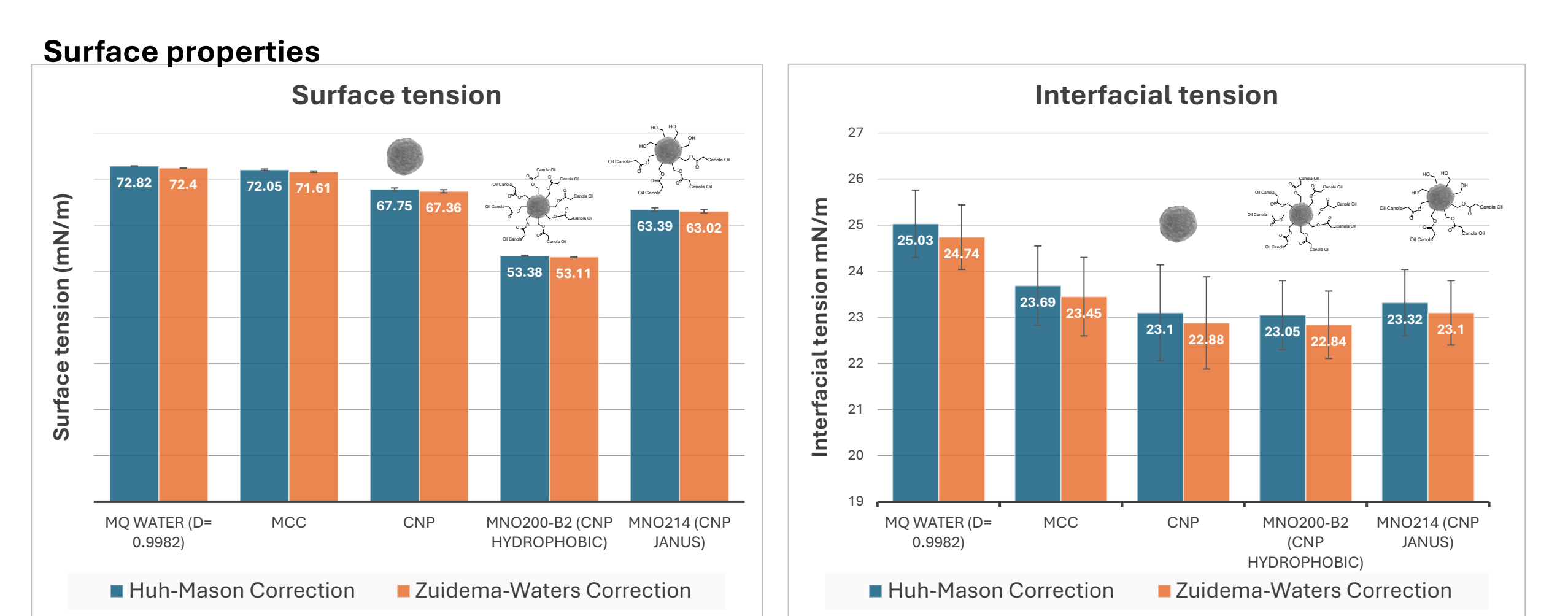
Reaction followed by IR analysis

SCNP Hydrophobic SCNP Janus-SCNP Carbonyl peak

No wetting, on water Dispersed in water

HLB was determined using a method by Campos and Domingo^[4]

Compound	Nature of Particle	Cleaving Time (min)	NaOH (mol L ⁻¹)	Structure	HLB
MNO200B2	Hydrophobic SCNPs	-	-		1-2
MNO216	Janus SCNPs	30	0.1		16-18
MNO217	Janus SCNPs	30	0.05		14-16



Behaviour as an Emulsifier

Emulsification properties (canola oil/water 1:1, 0.5% w/w JSCNP)

SCNP HSCNP JSCNP 0 min 30 min No change even after 3 weeks

Microscopic Image of Pickering emulsion and molecular-based emulsions

MNO216 MNO217 Tween 80 + GMO

- The size of the oil droplets is very large compared to emulsions stabilised by standard molecular-based surfactants
- An overall lower interfacial area means a smaller amount of particles is required to stabilise the emulsions

Recovered particles

After breaking the emulsion using centrifugation Janus-SCNP stays at the interface and can be recovered

Summary and Conclusions

- A method has been developed to produce spherical cellulose nanoparticles
- A novel method was developed to access Janus-type spherical cellulose particles, where the Janus balance can be varied and the performance of the final particles correlated to hydrophobic-hydrophilic balance (HLB).
- The Janus particles were synthesised from cellulose and vegetable oil and thus can be considered an eco-friendly synthesis
- As the size of the oil droplets in the resulting Pickering emulsions is bigger, stable emulsions require a lower amount of particles compared to standard molecular-based surfactants
- Particles can be recovered and re-used and thus has lower impact on environment
- There is the possibility of recirculating all other materials that are used in the process

References

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