

Vienna, 16/10/2023



Dr. Rita Mota

# Cyanobacterial polymer towards the cosmetic industry

**Netzwerk Algen 2023**

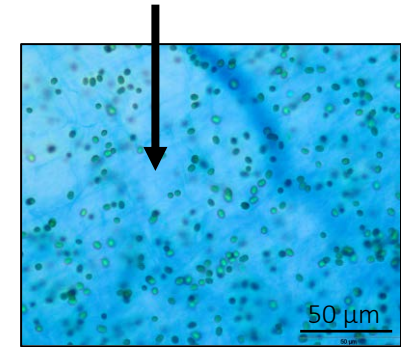
# *Crocospaera chwakensis* CCY0110



- Marine unicellular cyanobacterium
- Efficient RPS producer: 1.4 g/g DW biomass
- Easy to isolate and purify
- RPS production not affected by culture conditions

**Cyanoflan**

RPS - Released Polysaccharides



Optical Microscopy -  
Alcian Blue staining

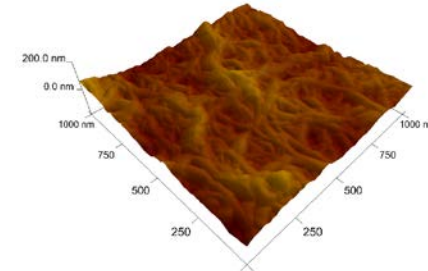
Mota *et al* (2013) *Carbohydr Polym* 92:1408-15

# Cyanoflan characteristics

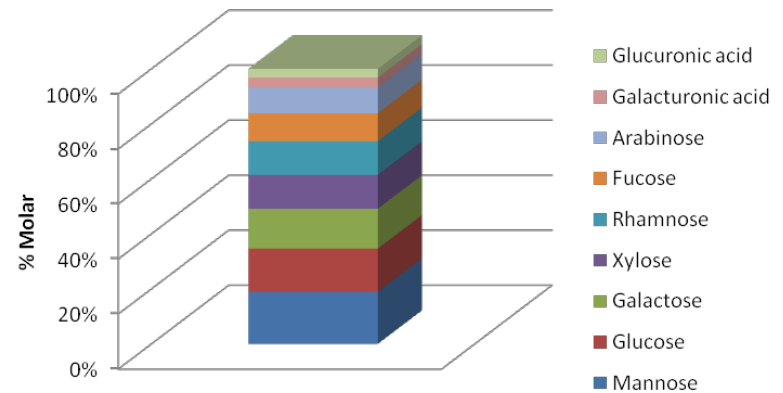
- 9 different monosaccharides (2 uronic acids)
- Proteins (4%) and sulfate groups (10%)
- Thermostable up to 250 ° C
- Molecular mass > 2 MDa
- Complex chemical structure

**Complex and versatile  
biomaterial**

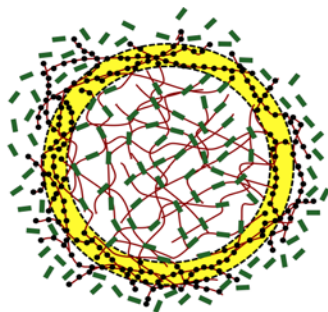
Mota *et al* (2020) *Carbohydr Polym* 229:115525






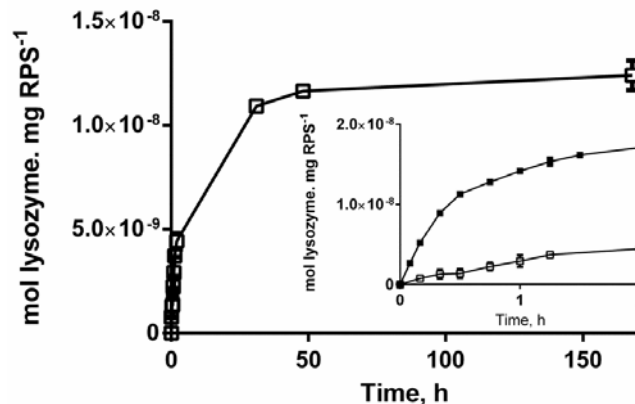
AFM



# Drug delivery



-  Negatively charged RPS chains
-  Positively charged protein
-  Cation



- Modulation through addition of divalent cations, delaying the proteins diffusion rate

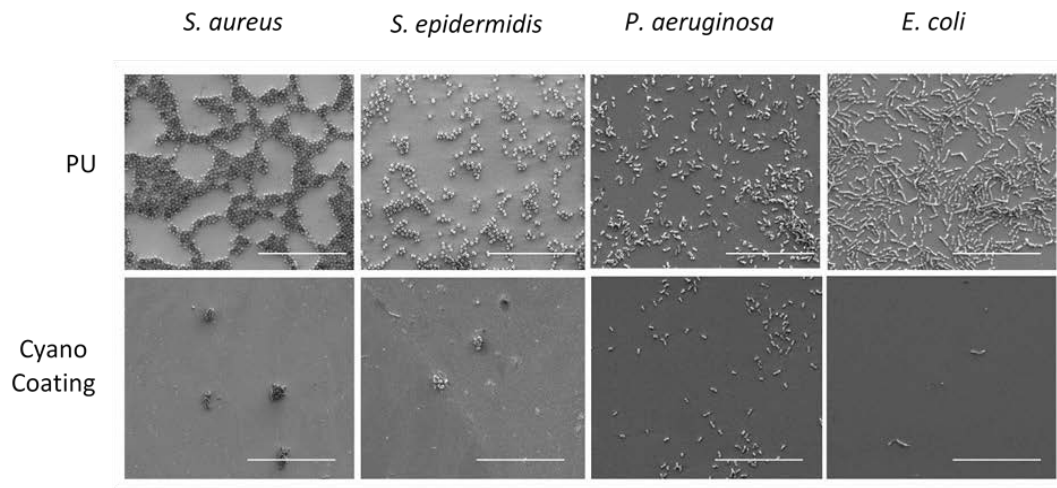
**Vehicle for topical or oral administration  
of therapeutic macromolecules**

Leite *et al* (2017) *Macromol Biosci* 17:1600206 | Estevinho *et al* (2019) *Powder Technol* 644-51 | US11458202B2

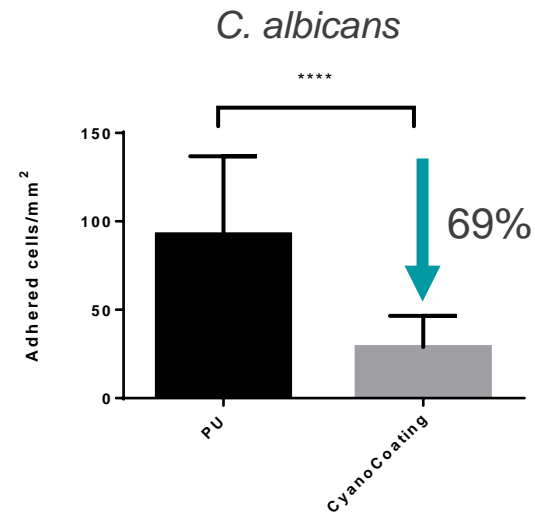
# Anti-adhesive coating



Anti-infective urinary catheter without antibiotics or biocides



80-96% reduction



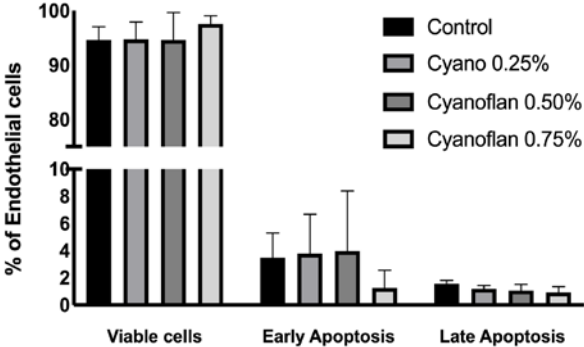
**Broad-spectrum anti-adhesive coating**

Costa *et al* (2019) *Mar Drugs* 17:243 | Costa *et al* (2020) *Mar Drugs* 18:279 | Cardoso *et al* (2021) *J Mater Chem B* 9:3705-15 | EP3762054B1

# Wound healing

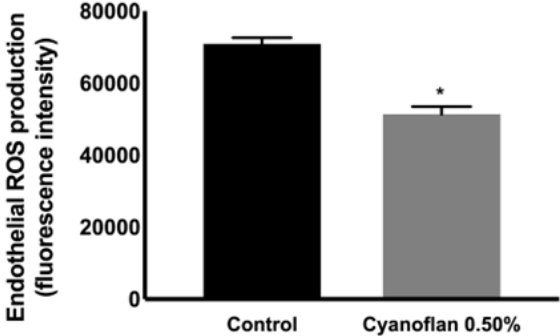


## Analysis of viability and cell death in human dermal cell lines by flow cytometry



➤ Biocompatible

## Reactive Oxygen Species (ROS) Formation



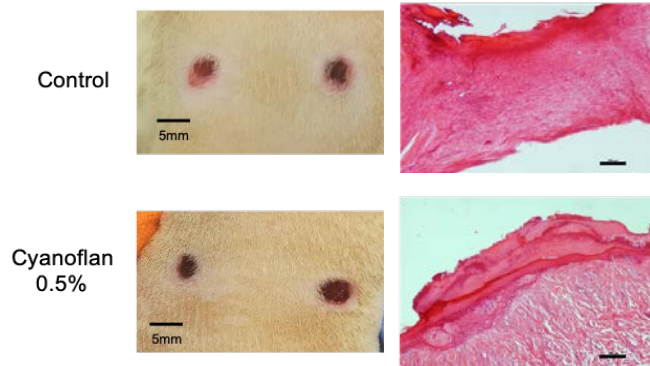
➤ Antioxidant activity

Costa et al (2021) *Mar Drugs* 19:147 | US11458202B2

# Wound healing

## *In vivo* assay: Wistar rats

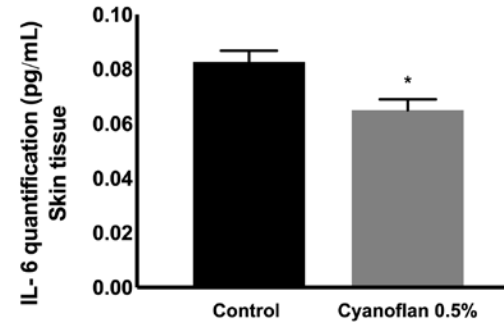
Day 6



- Less inflammatory cells and more scar tissue

Costa *et al* (2021) *Mar Drugs* 19:147 | US11458202B2

## Pro-inflammatory cytokine Interleukin-6 quantification by ELISA



- Anti-inflammatory activity

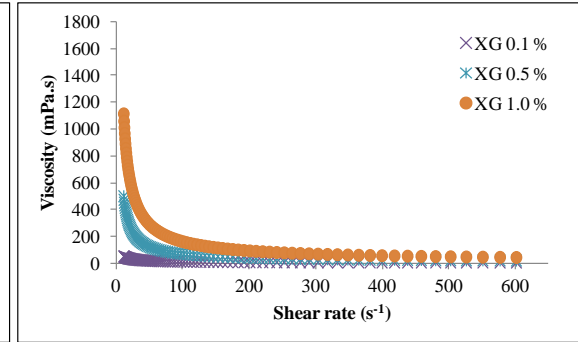
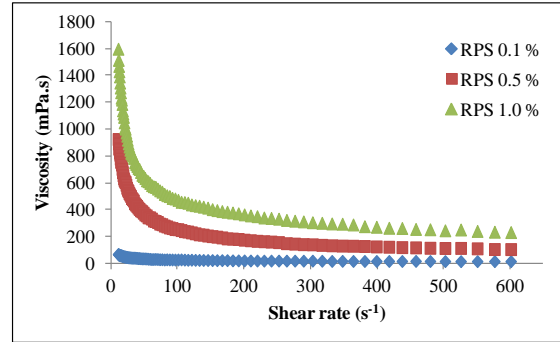
**Novel dressing for skin  
wound healing**

# Rheology modifier

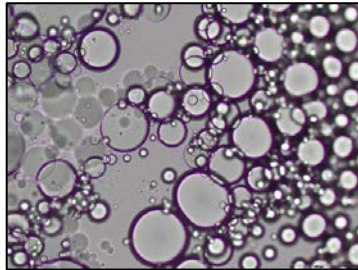
High viscosity  
1.5x higher than Xanthan gum



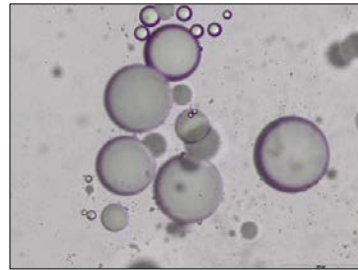
Non-Newtonian fluid with  
pseudoplastic behavior



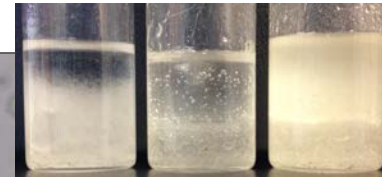
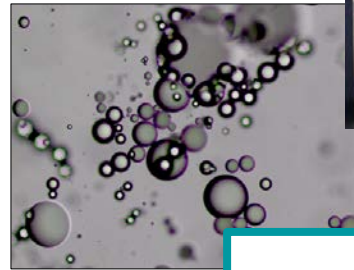
n-hexane



Liquid paraffin



Vegetable oil



Mota *et al* (2020) *Carbohydr Polym* 229:115525 | US11458202B2

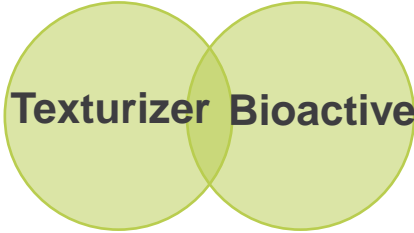
**Rheology modifier for  
pharma, cosmetic & food industries**



# Cosmetic ingredient



Natural ingredients for cosmetics & personal care industry



Environmentally conscious society  
Carbon neutral beauty

CyanoCare

Validation by a CRO



- ❖ Consulting services
- ❖ Safety tests
- ❖ Performance tests

# Safety: Ocular irritation potential test

## *In vitro* Hen's Egg Test - Chorioallantoic Membrane (HET-CAM)

0 min

5 min

SDS 1%



If lysis, hemorrhage and/or coagulation:  
Index > 9

index of  $10 \pm 0$   **Severely irritating**

Cyanoflan 1%  
(= 0.5% & 0.75%  
w/v H<sub>2</sub>O)



index of  $0 \pm 0$   **Non-severely irritating**

ICCVAM, NIH Pub. No.10-7553, 2010

# Safety: Acute cutaneous irritation potential

## In vivo 48 h patch test



Time-point:	30min After patch removal			24h after patch removal		
Subject ID	Erythema	Oedema	Other symptoms	Erythema	Oedema	Other symptoms
2	0	0	ADE	0	0	-
3	1	0	PRU	0	0	-
5	0	0	-	0	0	-
7	0	0	-	0	0	S
8	0	0	ADE	0	0	PRU
9	0	0	S, PRU, ADE	0	0	PRU
10	0	0	-	1	0	-
12	1	0	ADE	0	0	-
13	0	0	-	0	0	-
14	1	0	ADE	1	0	PRU, S

Non-irritating ( $\leq 0.2$ )  
 Slightly irritating ( $0.2 \leq 0.5$ )  
 Moderately irritating ( $0.5 \leq 1$ )  
 Irritating ( $> 1$ )

Cyanoflan 0.5%: index of 0.20  
 Cyanoflan 0.75%: index of 0.10  
 Cyanoflan 1%: index of 0.10

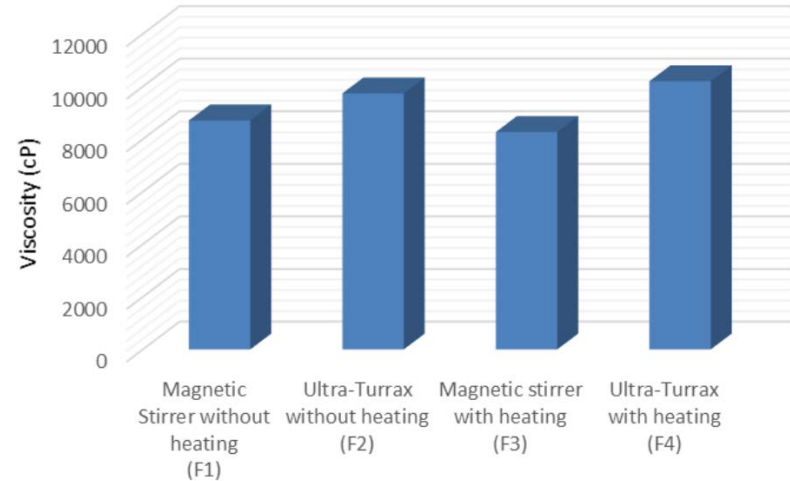
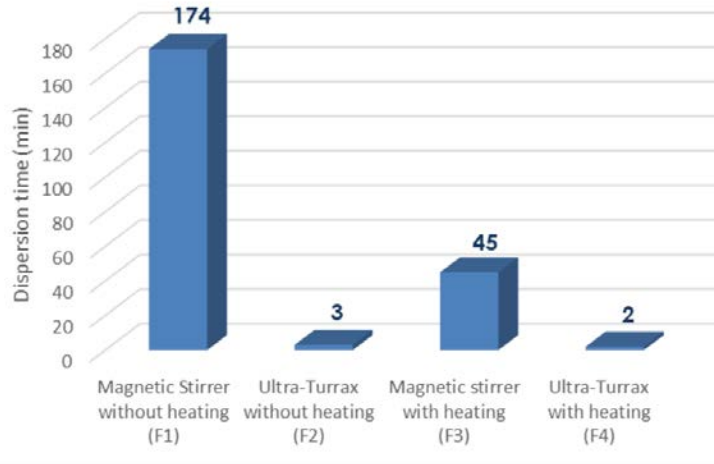


**Non-irritating**

ISO 14155:2011

# Performance Tests

## Water dispersion of Cyanoflan 1% (w/v)



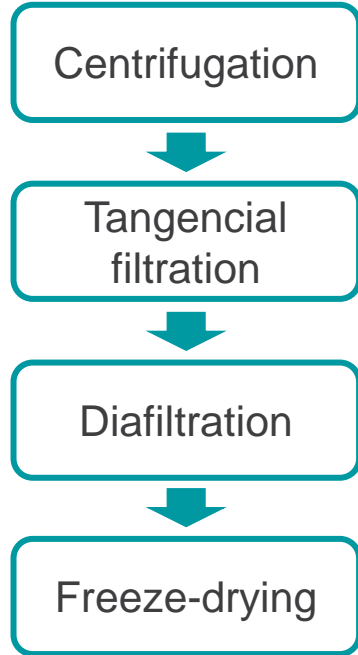
- Easily dispersible in water (up to 1%)
- Cold and hot (~75 °C) processable
- Solutions produced with gel-like texture

**Suitable to work as a safe thickener ingredient**

# Pilot scale production



Panel  
Photobioreactor



(biomass separation)

(supernatant concentration)

(salt removal)



Matinha-Cardoso *et al* (2023) *Algal Res* 69, 102939

# Pilot scale production



Panel  
Photobioreactor

## Biomass surplus



Balanced nutritional potential

Blue pigment phycocyanin

- ❖ Proteins 54% DW
- ❖ Lipids 8% DW
- ❖ Carbohydrates 18% DW
- ❖ Fat-soluble vitamins (A & E)
- ❖ Minerals (potassium, magnesium & iron)

Matinha-Cardoso *et al* (2023) *Algal Res* 69, 102939

# On going

- Further Cyanoflan physicochemical characterization (after enzymatic degradation)
- Cyanoflan as bioactive cosmetic ingredient (further validation studies & formulations)
- Pilot scale production optimization



Tubular Photobioreactor 1.2 m<sup>3</sup>



# Acknowledgments



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**Thank you for your attention**

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