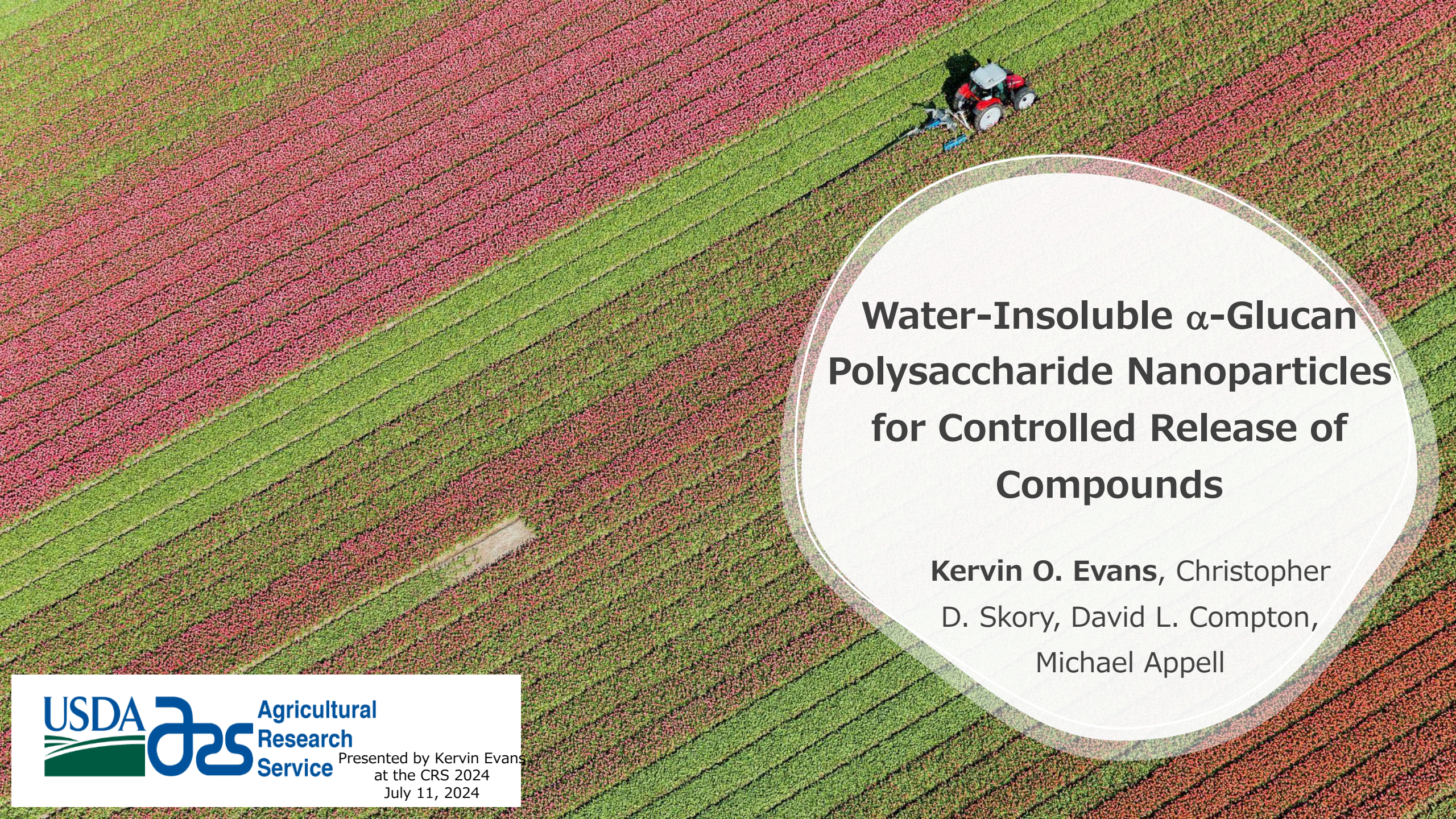


Water-Insoluble α-Glucan Polysaccharide Nanoparticles for Controlled Release of Compounds

Kervin O. Evans, Christopher D. Skory, David L. Compton, Michael Appell

USDA Agricultural Research Service

Presented by Kervin Evans at the CRS 2024 July 11, 2024

Thanks to the Following:

David Compton – ARS Chemist, Feruloyl Soy Glycerides synthesis

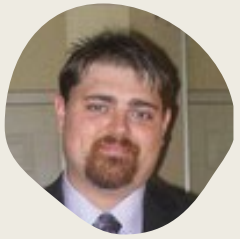
Michael Appell –ARS Chemist, molecular modeling

Greg Cote – Retired ARS Chemist, , α-glucan polysaccharide synthesis & purification

Chris Skory – ARS Microbiologist, α-glucan polysaccharide synthesis & purification

Suzanne Unser – High pressure homogenization, α-glucan polysaccharide synthesis & purification, Technical Assistance

Leslie Smith
Retired, Technical Assistance



Ryan Cormier, former ARS, Catalent Pharma Solutions, α-glucan nanoparticles & films

National Program 306 – Product Quality and New Uses

Problem Statement 1.B – New Bioactive Ingredients and Health-Promoting Foods

Problem Statement 2.B – Enable technologies to produce new/expand marketable non-food, non-fuel biobased products derived from agricultural feedstocks

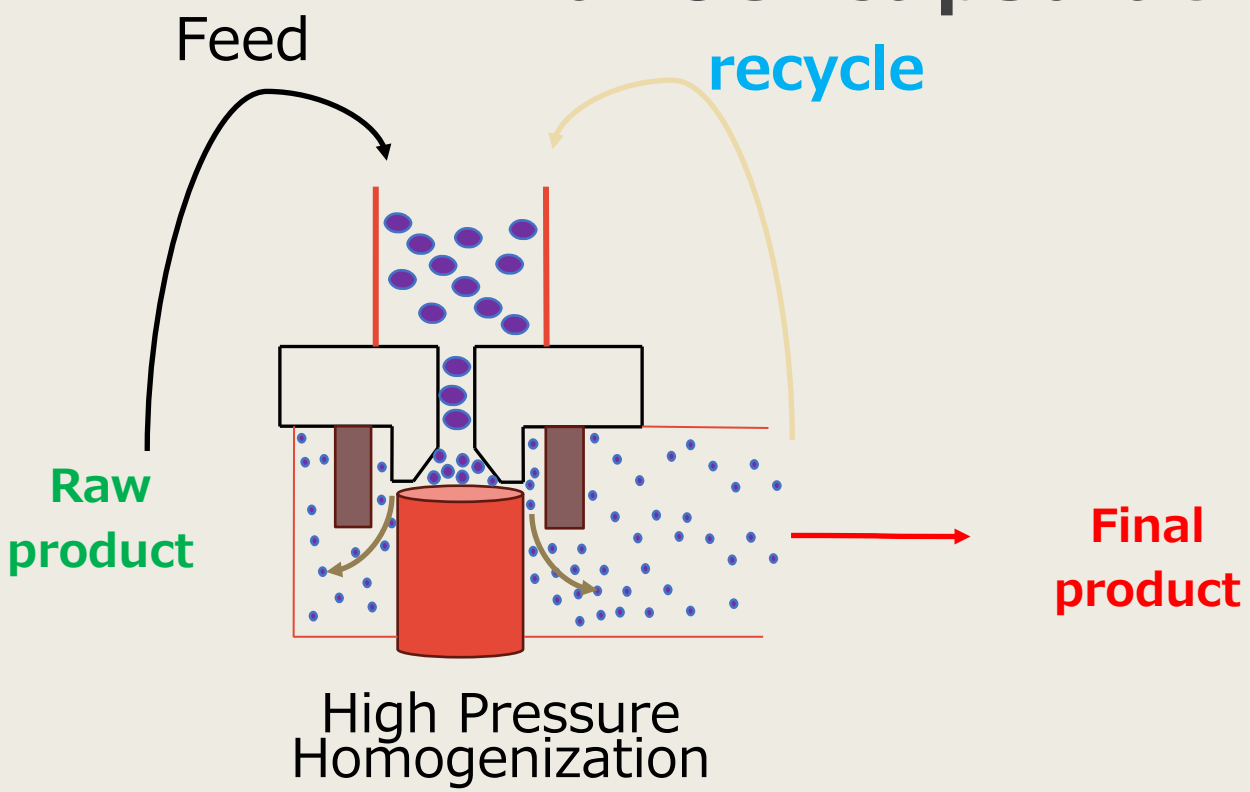
CRIS – Technologies for Producing Marketable Bioproducts

***Objective 2*. Develop innovative lipid and biopolymer-based encapsulation systems for delivering, preserving, or promoting the activity of bioactive ingredients.**

USDA ARS Agricultural Research Service

Presented by Kervin Evans
at the CRS 2024
July 11, 2024

Nanoparticles via High-Pressure Homogenization for Nanoencapsulation



High pressure homogenizer

Sample solutions forced through small openings via high pressure shear forces (MegaPascal) to form small particle (<600 nm diameter)

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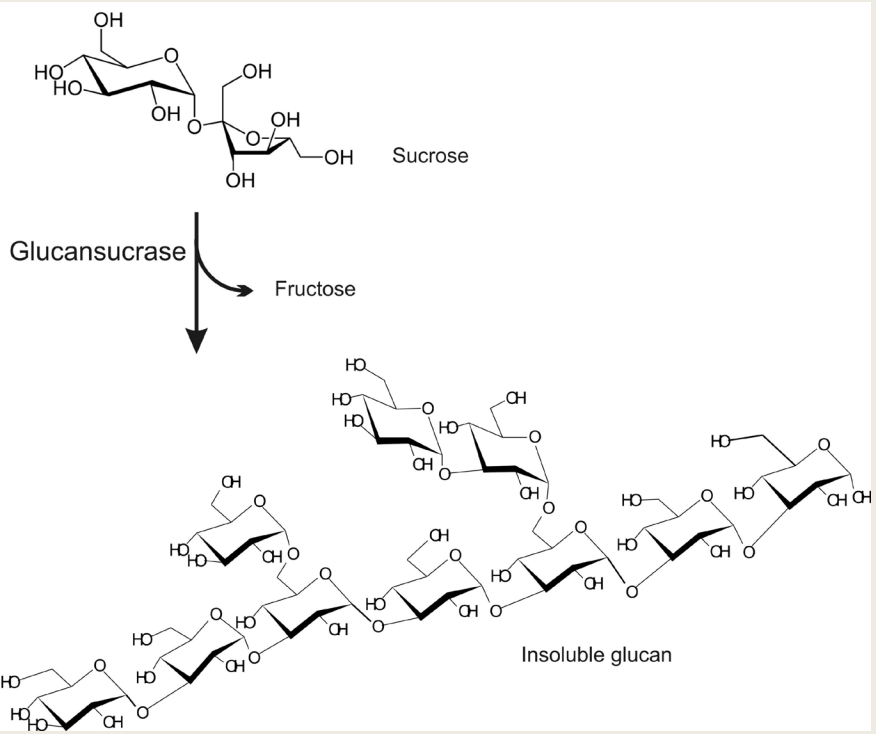
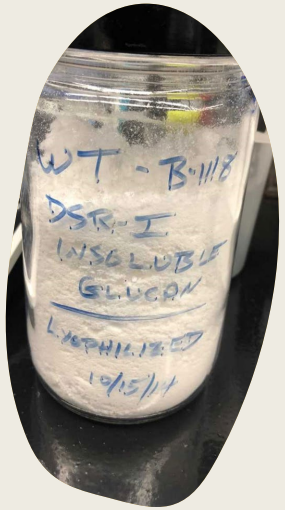
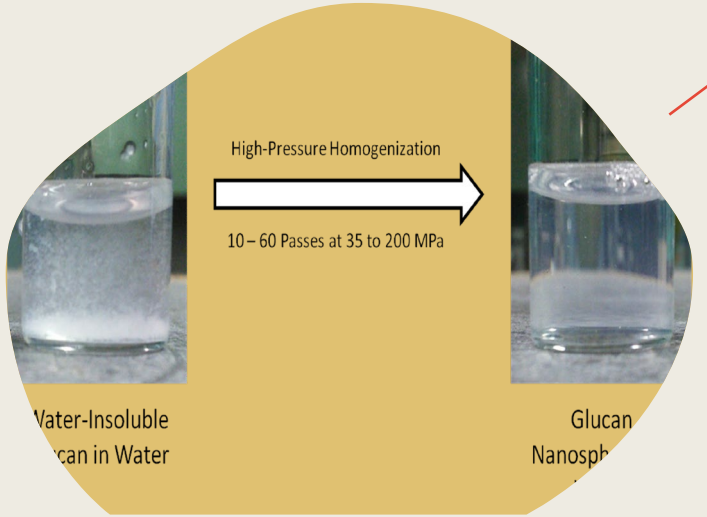
Water-Insoluble Glucan Nanoparticles Formation

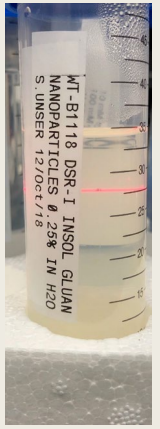




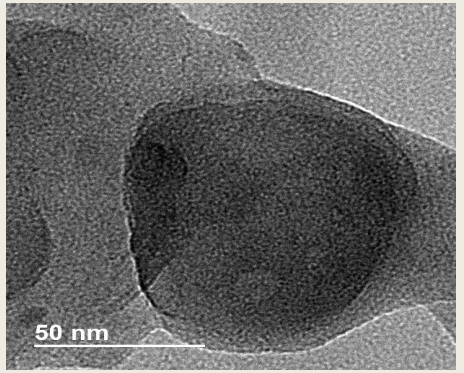
Cote et al, 2013, Applied Microbiology and Biotechnology 97: 7265-7273



MW ~ 1.2 Mega Dalton
(polymer ~ 1.4 Mega Dalton)



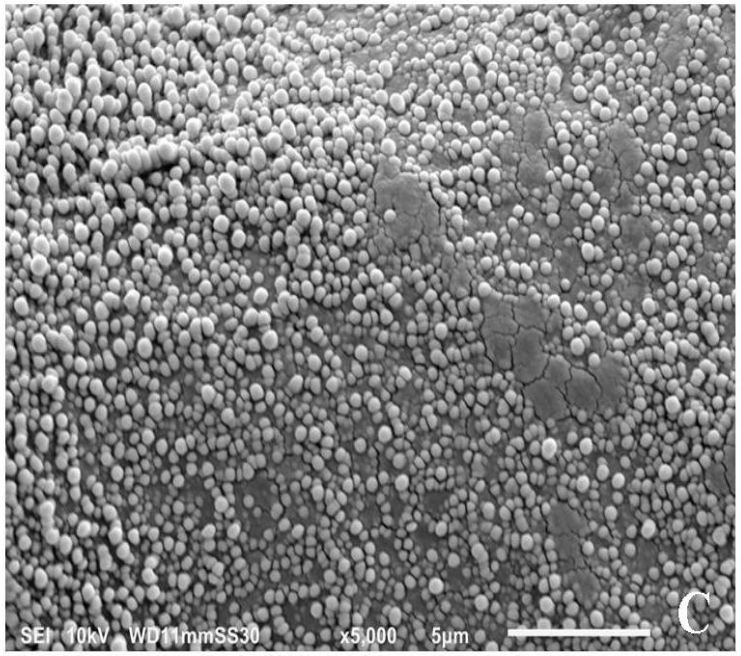
Example of alpha-glucan nanoparticles scattering red laser light



Cryo-TEM

Evans et al, 2020, Molecules 25 (17): 3807

α-Glucan Nanoparticles Physical Properties

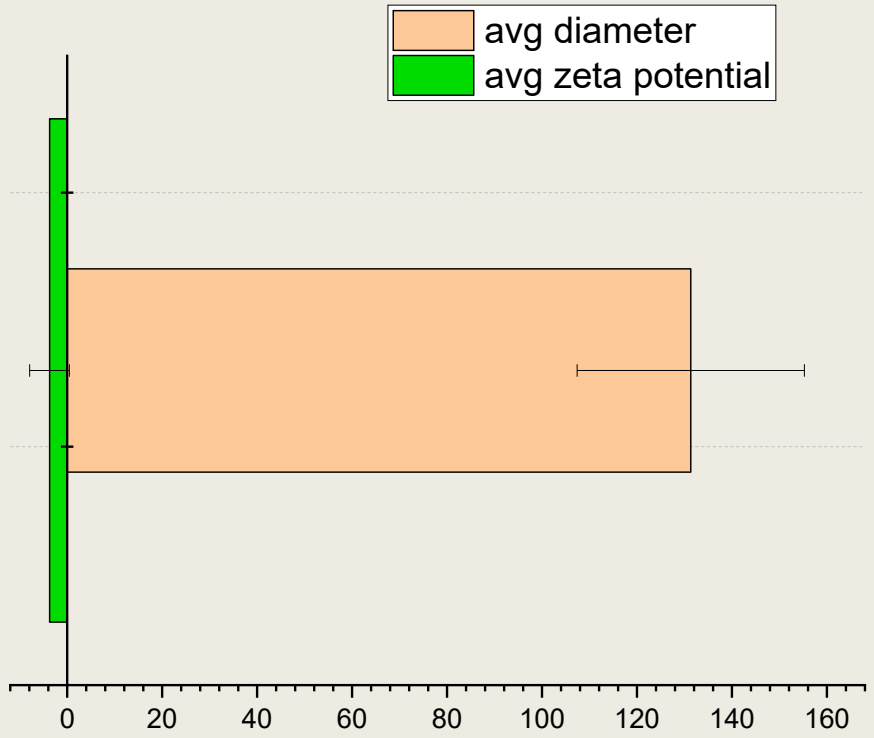


SEM image shows the spherical nature of freeze-dried polysaccharides after high-pressure homogenization

Cormier et al, 2017, US Patent 9,708,417 B2

Average α-glucan nanoparticles

- **106-160 nm in diameter**
- **~-4 mV zeta potential**



Presented by Kervin Evans
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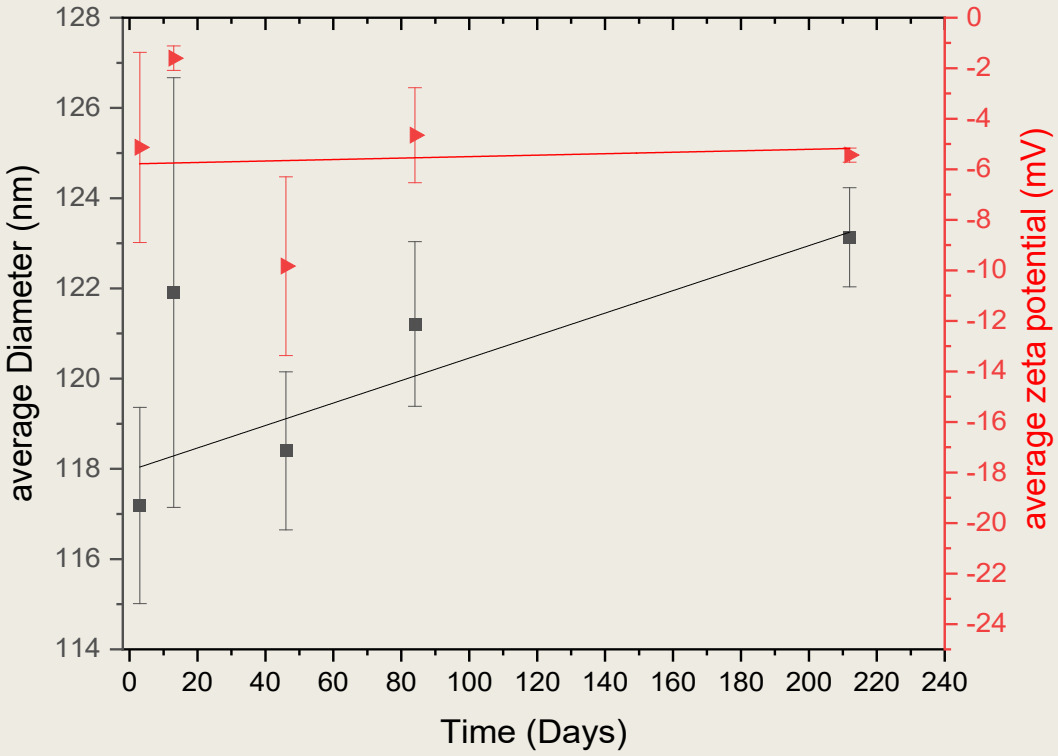
July 11, 2024

α-Glucan Nanoparticles Stability

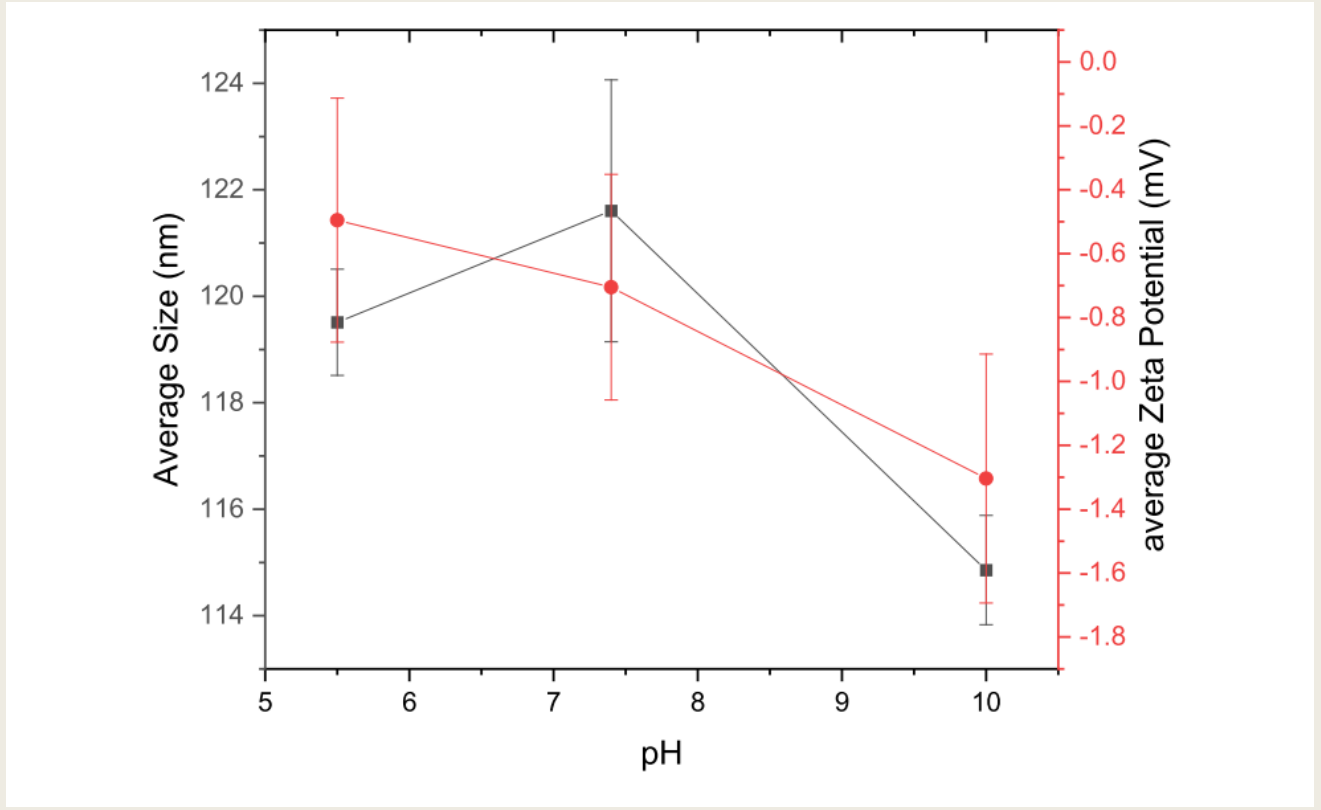
- α-Glucan Nanoparticles show stability for more than 7 months
- Likely due to steric hindrance of highly dense particle



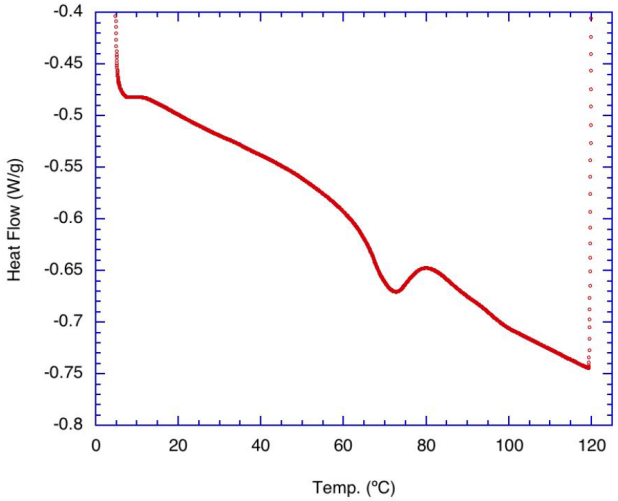
Stability suggests α-glucan nanoparticle can be used for long term controlled-release system

α-Glucan Nanoparticles Under Slightly Acidic and Basic Conditions

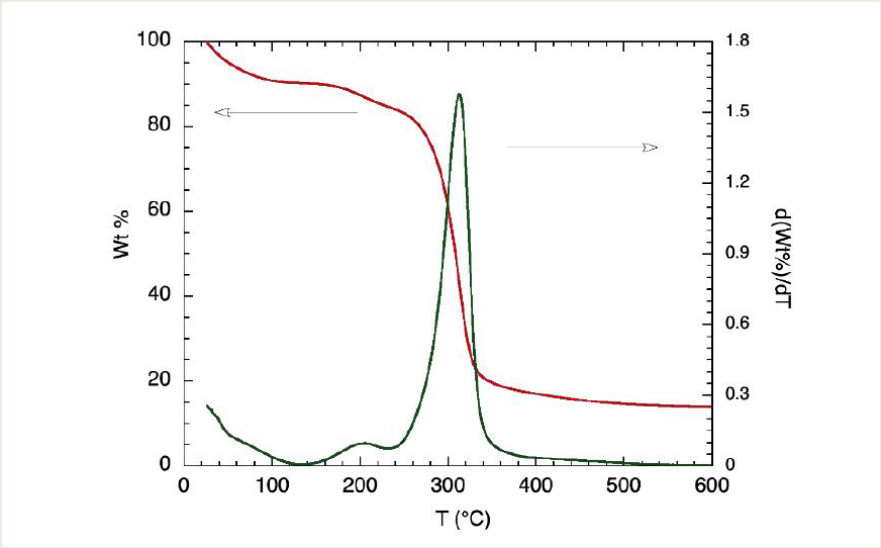
- **Alpha-glucans can be made into nanoparticles at pH 5.5, 7.4 and 10 under buffered conditions.**



What are Thermal Properties of α-Glucan Nanoparticles

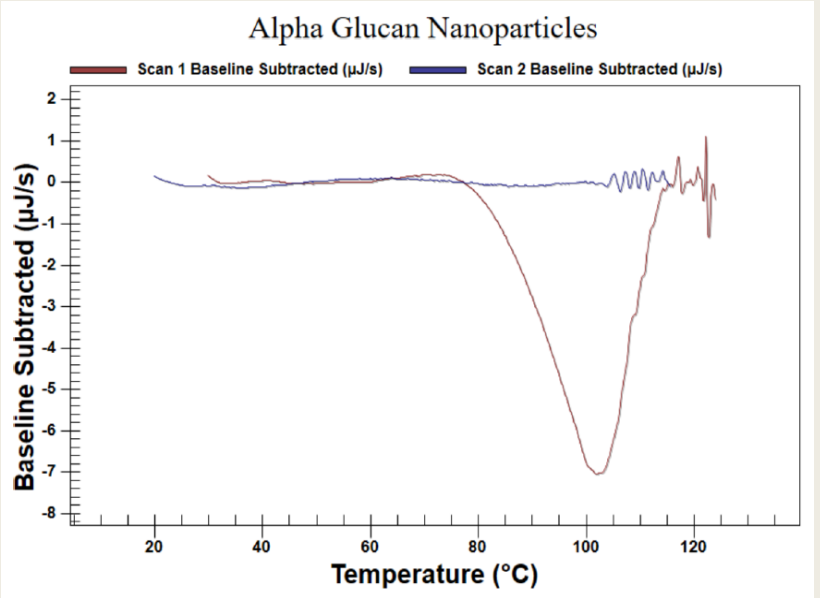


DSC Thermal analysis of α-glucan show structural changes likely to occur ~ 70° C.



TGA shows that α-glucan thermally degrades between 160° C and 340° C.

Nano DSC shows that nanoparticles start to unravel at ~70° C and completely unravel at ~ 104° C.



Evans et al, 2020, Molecules 25(17), 3807

Evans et al, 2023, Biotechnology Reports 40, e008107

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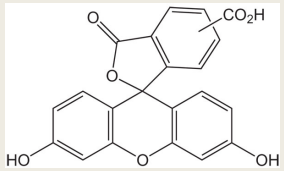
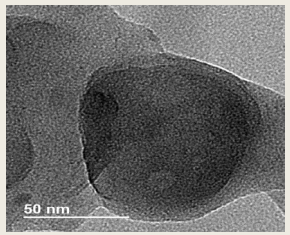
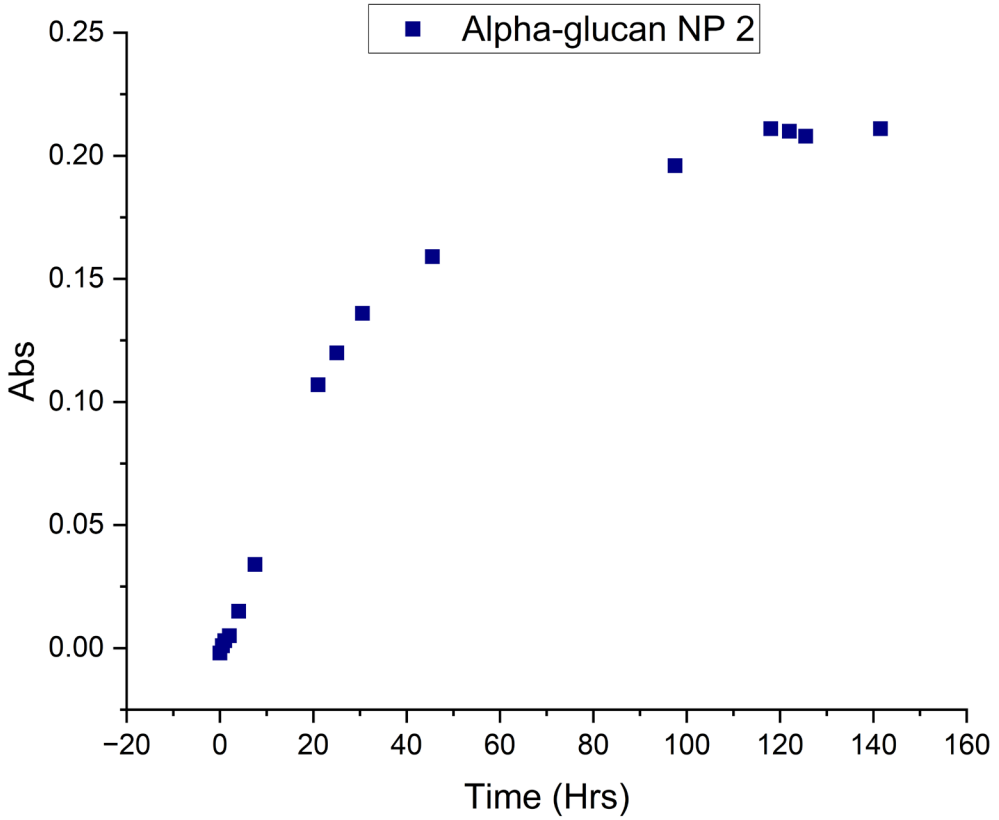
Hydrophilic Encapsulation within α-Glucan Nanoparticles



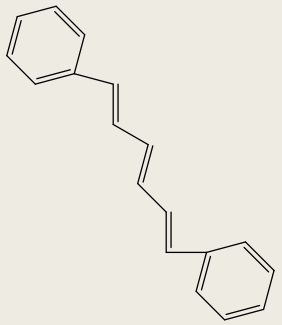
5 (6)-carboxyfluorescein



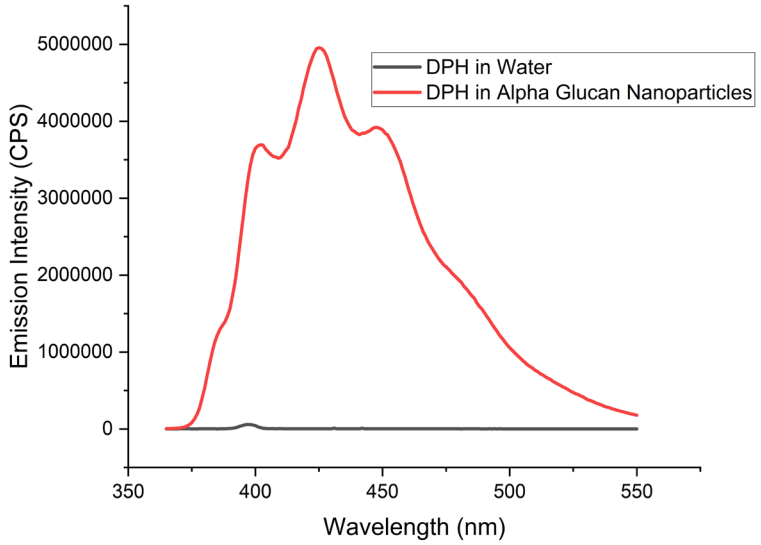


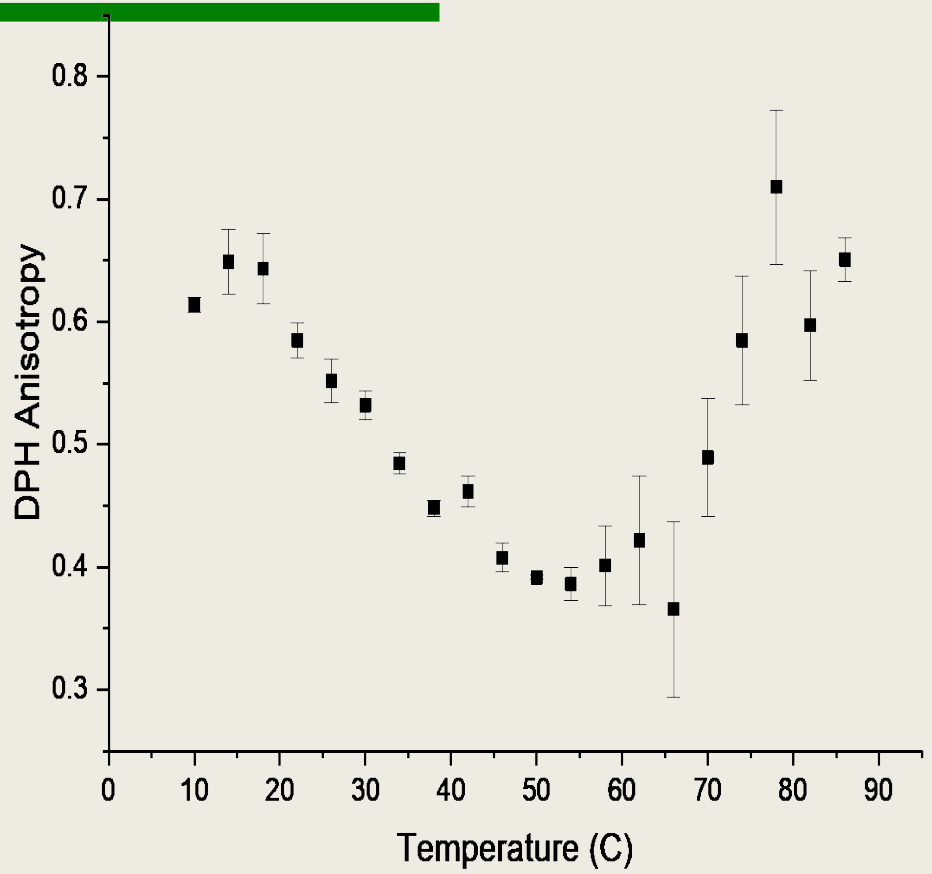
- **Alpha-glucans nanoparticles show release of carboxyfluorescein for up to 120 hr during 6-day dialysis.**

Hydrophobic Encapsulation within α-Glucan Nanoparticles



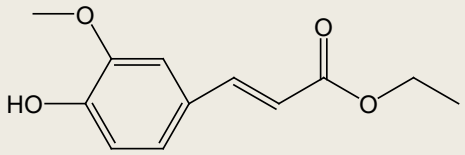
1,6 Diphenyl-1,3,5-hextriene (DPH)



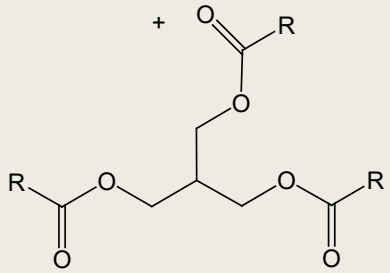


- **Alpha-glucans nanoparticles have internal hydrophobic regions**
- **Anisotropy measurement show structure changes but not complete degradation.**

Can Feruloyl Soy Glycerides (FSG) Encapsulate within α-Glucan Nanoparticles???



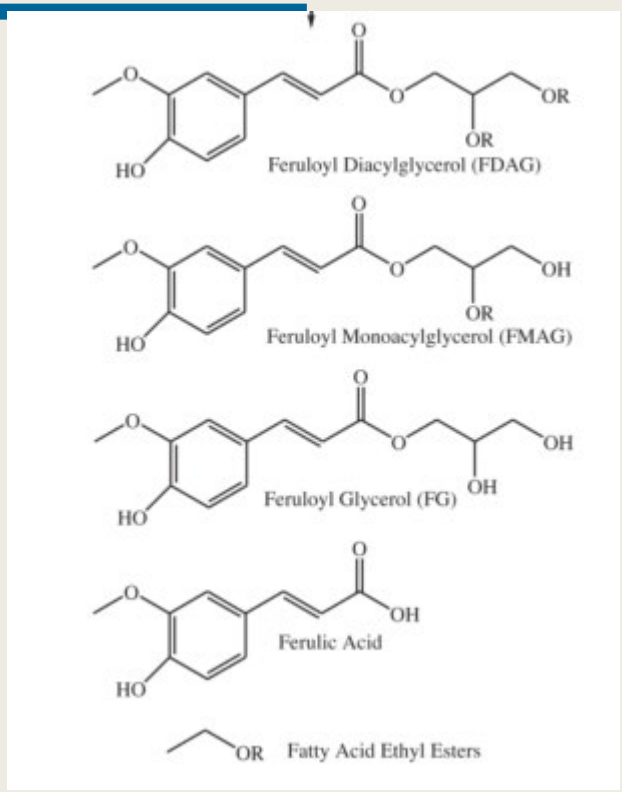
Ethyl ferulate, 1 mole
(CAS # 40446-02-0)



Soybean oil, 1 mole
(from *Glycine max*)

trace amount of H_2O

Candida antartica lipase B (Novozym 435)
60° C, 144 h

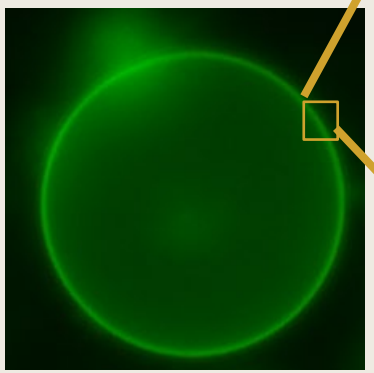


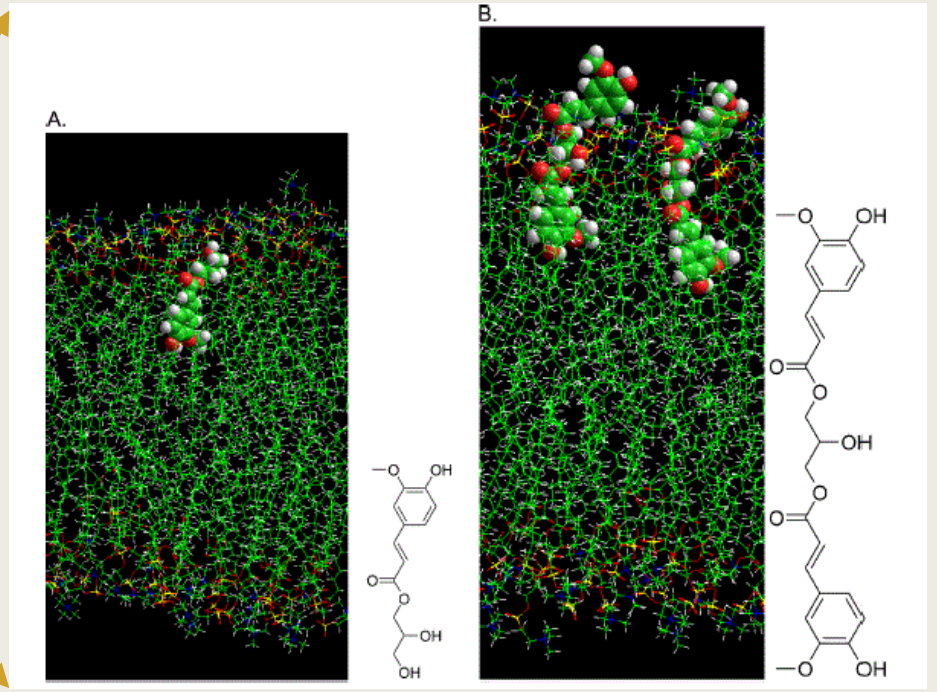
Compton et al, 2015, Industrial Crops and Products 77:787-794

Isolated Components of Feruloyl Soy Glycerides Encapsulate within Liposomal Bilayer. Will they encapsulate within dense α-Glucan nanoparticles?

1-Feruloyl glycerol

1,3-Diferuloyl glycerol



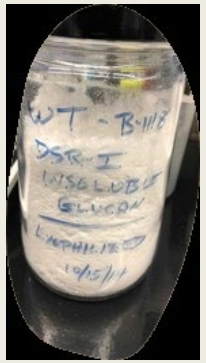


1-Feruloyl glycerol within lipid bilayer

1,3-Diferuloyl glycerol within lipid bilayer

Evans et al, 2016,Chem. Phys. Lipids 195:1–11

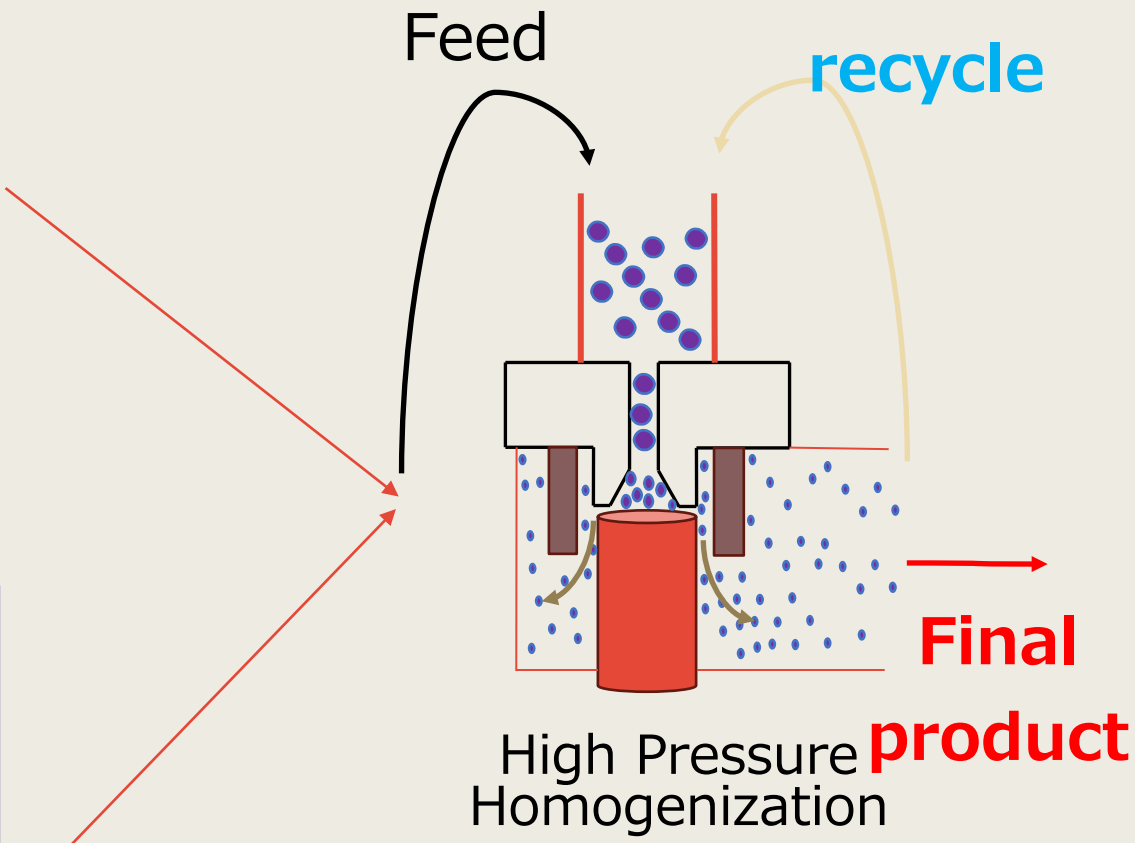
Can Feruloyl Soy Glycerides (FSG) Encapsulate within α-Glucan Nanoparticles???

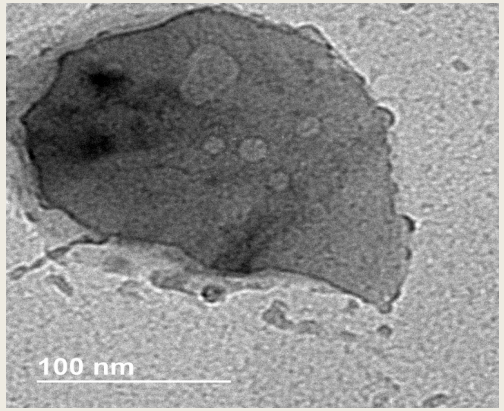


α-glucan

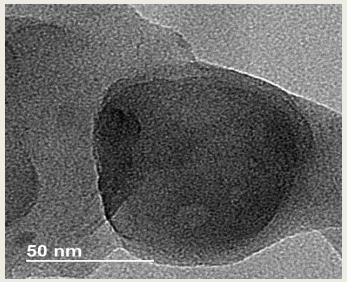
+

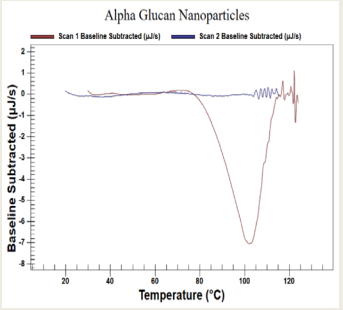
FSG





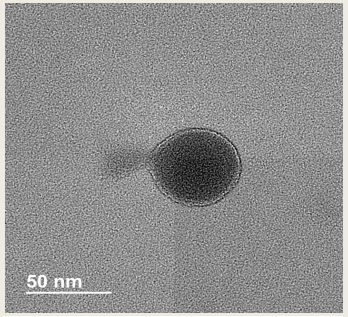
How Do FSG/Alpha-Glucan Nanoparticles Compare???

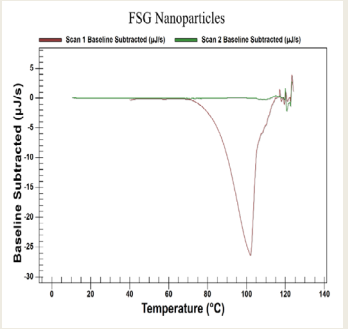




Alpha-glucans nanoparticles

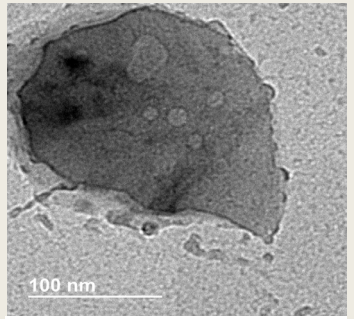
- ~ 126 nm diameter
- ~ -5 mV
- ~ 75° C – 102° C irreversible unraveling

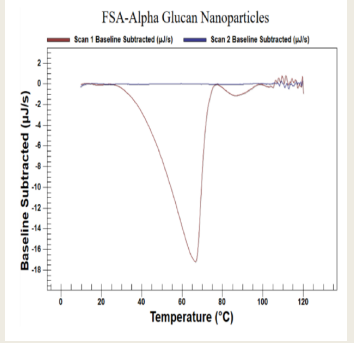




FSG nanoparticles

- ~ 190 nm diameter
- ~ -25 mV
- ~ 70° C – 115° C irreversible degradation





FSG/Alpha-glucans nanoparticles

- ~ 216 nm diameter
- ~ -15 mV
- ~ 98% encapsulation
- ~ FSG release 26° C – 66° C

Conclusions

- Insoluble α-glucan forms nanoparticles stable up to 7 months and 80° C under neutral conditions; can be made at pH 5.5 – 10;
- α-Glucan nanoparticles can encapsulate and release hydrophilic and hydrophobic materials;
- α-Glucan nanoparticles encapsulate 98% of 5% (w/v) feruloyl soy glycerides;
- α-Glucan nanoparticles release feruloyl soy glycerides between 26° C and 66° C;
- α-Glucan nanoparticles may be good release system for oils.

Thank You for Your Attention!!!

Questions???