Doping feruloylated arabinoxylan covalent hydrogels with cellulose nanocrystals

Carole Antoine-Assor, Martin In, Céline Moreau, Valérie Micard, Denis Cassan

Doping feruloylated arabinoxylan covalent hydrogels with cellulose nanocrystals

Carole Assor Antoine [(1)]*, Martin In [(2)], Denis Cassan [(1)], Céline Moreau [(3)] and Valérie Micard [(1)]

[(1)] Univ. Montpellier, INRAE, Institut Agro, U.M.R. IATE, Montpellier, France; [(2)] L2C, Univ. Montpellier, CNRS, Montpellier, France; [(3)] UR1268 Biopolymères Interactions Assemblages, INRAE, 44316 Nantes, France.

*carole.assor@inrae.fr

CONTEXT

WHEAT

1 T

milling process

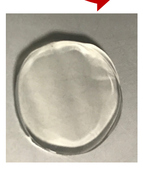
BRANS

0.25 T

FLOUR

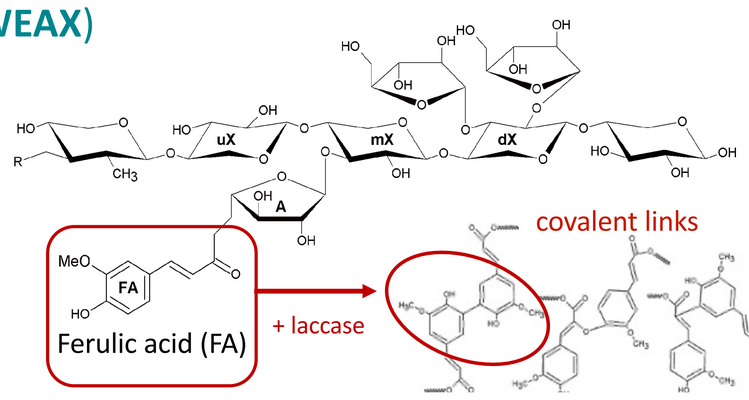
French milling process
4.7 Mt of wheat in 2022

60% MS



covalent hydrogel

Feruloylated **W**ater-**E**xtractable **A**rabinoxylans (**F-WEAX**)



- ✓ thermostables
- ✓ swelling capacity (100 - 300 g water. g^{-1} F-WEAX)
- ✓ stability/ pH
- ✓ macroporous : 200 - 500 nm for bioactive molecule encapsulation
- ✓ resistant to digestive enzymes
- ✗ mechanical (from 10 to 100 Pa)

AIM OF THE STUDY

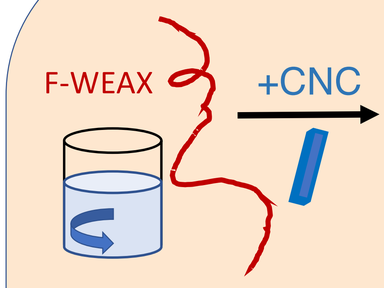
Improvement of mechanical strength of F-WEAX covalent gel by addition of cellulose nano crystals (CNC) combining two networks, a covalent and a reinforced physical one

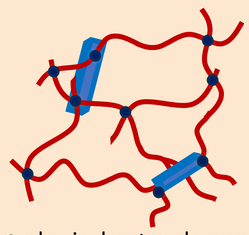
HYPOTHESIS

- strong physical interactions between CNC and F-WEAX
- CNC content modulate viscoelastic and structural properties of the mixed gels
- preservation of gel swelling capacity

EXPERIMENTAL STRATEGY

MIXED SUSPENSIONS



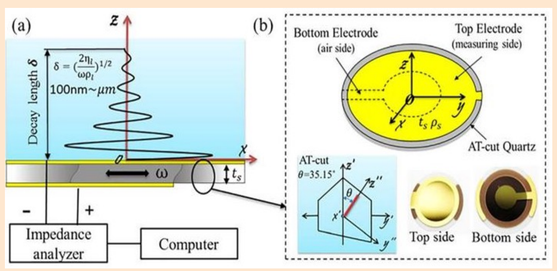


- physical entanglements

F-WEAX solution: 20 $g.L^{-1}$
+ CNC suspension: 0 to 15 $g.L^{-1}$
+ strong mechanical stirring

F-WEAX content: 10 $g.L^{-1}$
CNC/ F-WEAX ratio:
0; 0.5; 1; 1.5

F-WEAX/ CNC interactions



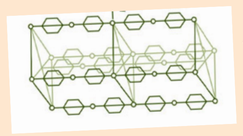
Quartz Mirco Balance (QCM)

Molecular properties

F-WEAX

A/X : 0.58
AF : 1.61 microg. mg^{-1} F-WEAX
Purity : 63 %
M_w : 438 kDa
approximatively 1258 xyloses
R_g : 600 Å

CNC



2.3 - 4.5 nm (AFM)

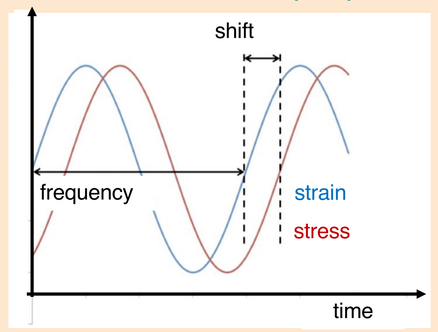
44 -108 nm
~ 81-200 glucoses [(1)]
R_g = 202 (70/(√12)= 202 Å

[(1)] *Reid et al., Langmuir 2017, 33, 1583–1598.*

MIXED GELS

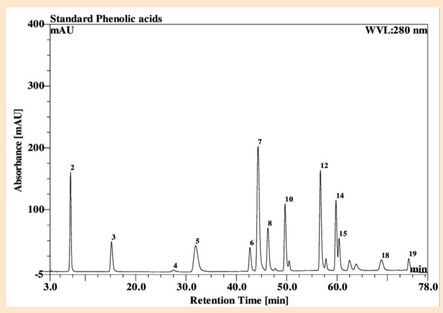
Viscoelastic properties

enzymatic gelation



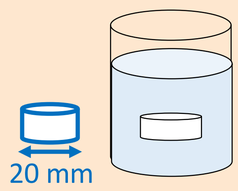
+ laccase [(2)]

Structural properties



FA; di-FA contents
covalent cross-link density

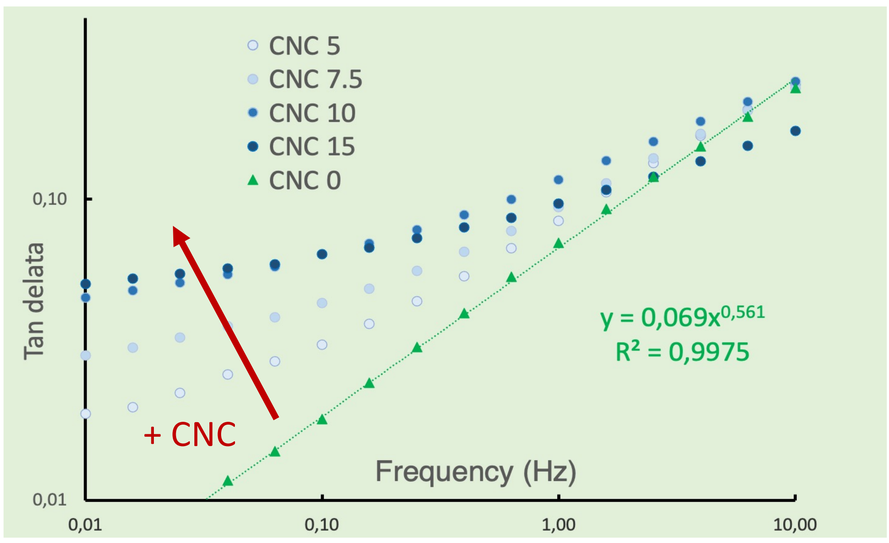
Swelling capacity

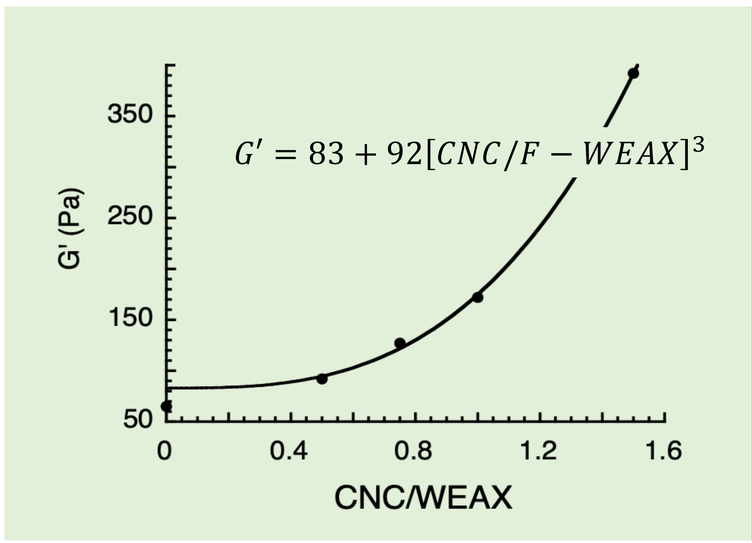


swelling equilibrium: H_20 + 0.02 % azide, 20 h, 20°C

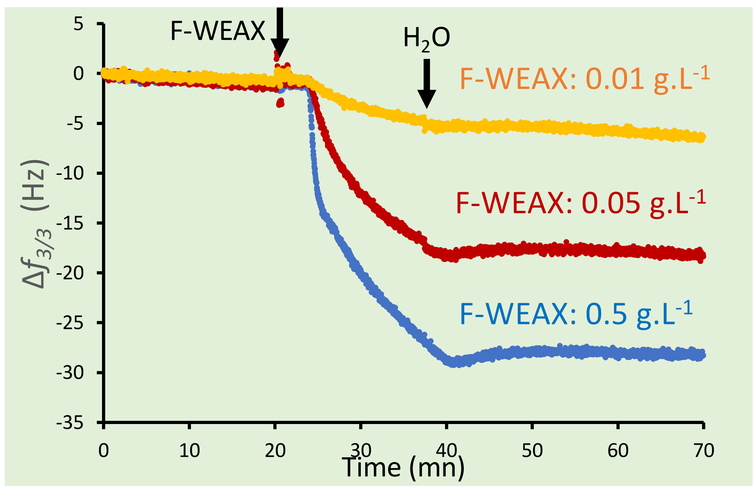
$q = (W_s - W_{F\text{-}WEAX})/W_{F\text{-}WEAX}$

RESULTS





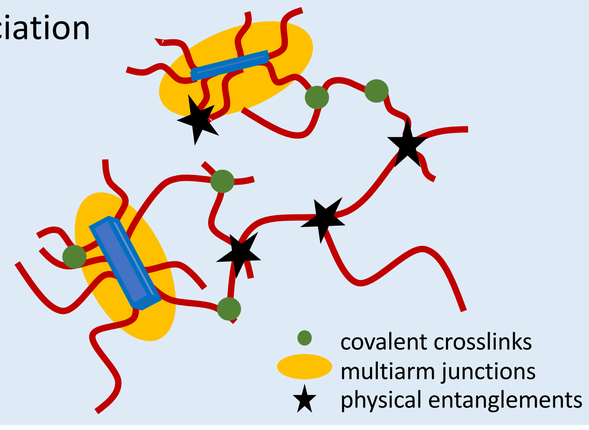
CNC/ F-WEAX ratio	FA oxidized %	di-FA µg. mg^{-1} F-WEAX	FA recovered %	q g H2O. g^{-1} F-WEAX
0.00	92 ± 1	0.44 ± 0.04	25 ± 2	199 ± 00
0.50	85 ± 1	0.72 ± 0.04	48 ± 2	123 ± 14
0.75	83 ± 3	0.80 ± 0.03	55 ± 1	124 ± 12
1.00	76 ± 7	0.74 ± 0.02	54 ± 4	121 ± 09
1.50	75 ± 6	0.73 ± 0.07	56 ± 9	134 ± 05



CONCLUSIONS

- F-WEAX interact strongly and irreversibly with CNC surfaces
- after gelation, % of FA recovered under di-FA forms is two times higher in presence of CNC
- G' and G'' increase with CNC/ F-WEAX ratio with a cubic power law
- swelling capacity of mixed gels is link to it covalent crosslink density

Structural model of CNC/ F-WEAX association



[(2)] The authors would like to thank JRU Biotechnologie des Champignons Filamenteux (INRAE, Aix- Marseille Université, Marseille, France) for supplying the laccase (EC 1.10.3.2) from *Pycnoporus cinnabarinus* (Uniprot ID: Q9UVQ2), and the Transform department of INRAe for funding this work.