Fibres de lin pour renforcer des polymères. Spécificités

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Nancy le 26 nov2013

Sommaire

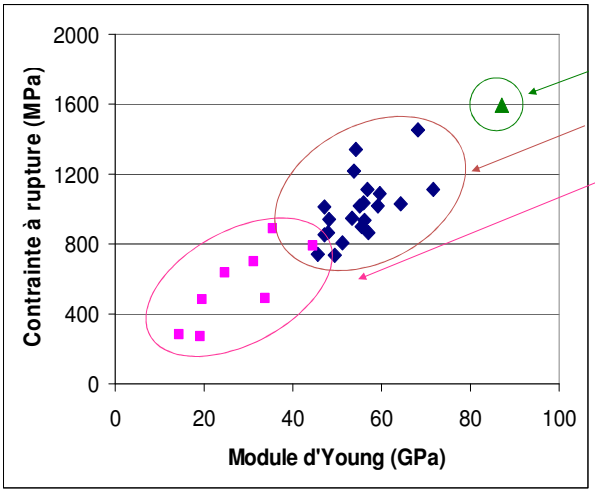
- Introduction
- Une tige de lin = Matériau composite
- Une fibre élémentaire = Nanocomposite
- Remarques sur les biocomposites
- Bilan

Introduction

1/2 produits / Optimun?

Des fibres performantes, durables et biodégradables

Propriétés mécaniques en traction



Ortie (Urtica Doïca)

Lin

Chanvre

Densité:

Fibres de verre d=2,54

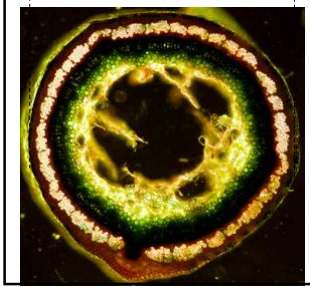
Fibres végétales d = 1,4 – 1,5

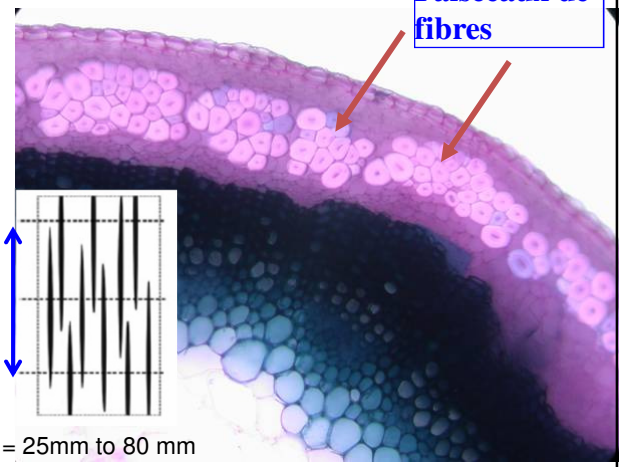
Traction sur fibres unitaires
Protocole identique
Conditions de caractérisation identiques

Tige = un matériau composite

Lin / Analyse d'une tige

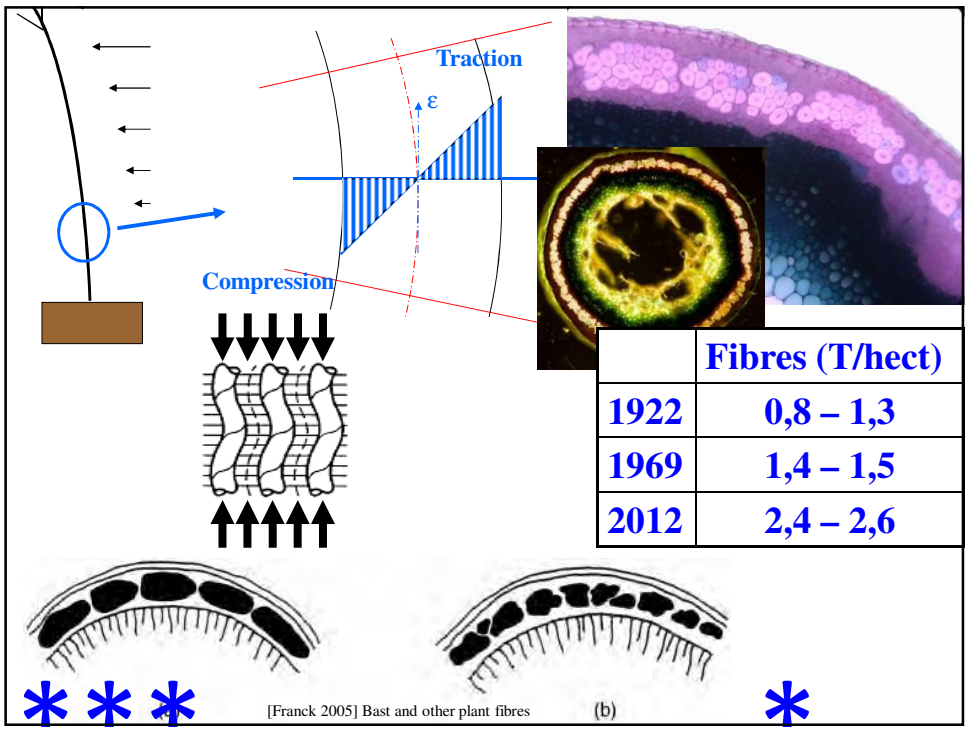
Diamètre d'une tige ~ 2 mm





L = 25mm to 80 mm

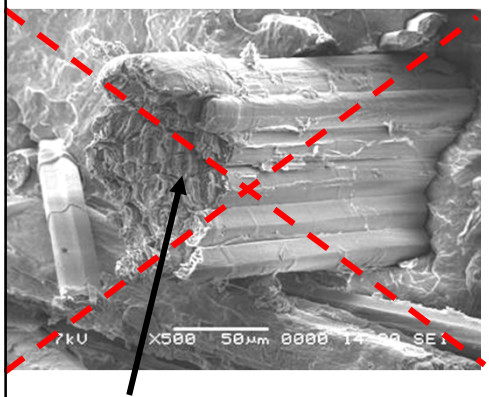
- Les fibres renforcent la tige,
- Une tige est un matériau composite,
- La cohésion entre les fibres est très forte (fonction assurée par les lamelles mitoyennes),
- La tige est renforcée par des fibres courtes.



	Fibres (T/hect)
1922	0,8 – 1,3
1969	1,4 – 1,5
2012	2,4 – 2,6

De la tige au matériau composite

Extraction, division, nettoyage des surfaces, modification de la compatibilté fibre/matrice….

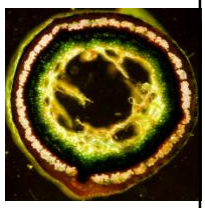
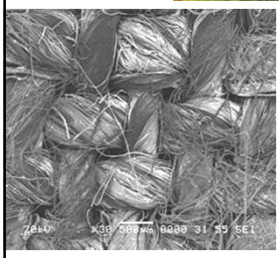
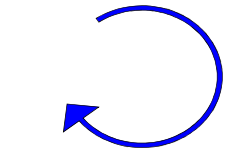


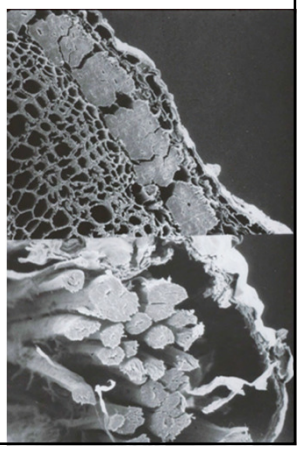
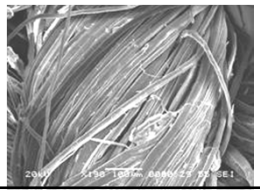
Faisceau de fibres de lin

<u>But</u>: une distribution régulière des fibres dans la matrice ↘

Etapes de production des fibres de lin



Teillage, peignage

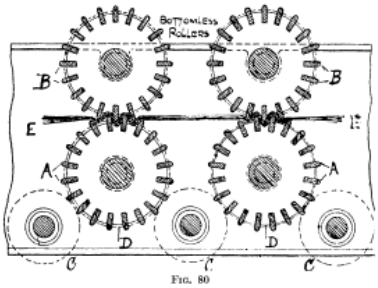


Fig. 80

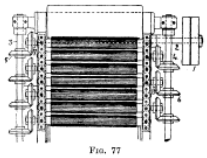
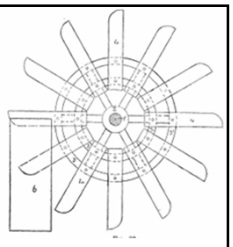


Fig. 77



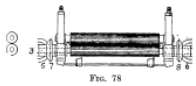


Fig. 78

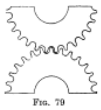


Fig. 79



Influence du rouissage sur les propriétés

Rouissage faible → **Rouissage optimun**

Rouissage optimun pour des applications textiles

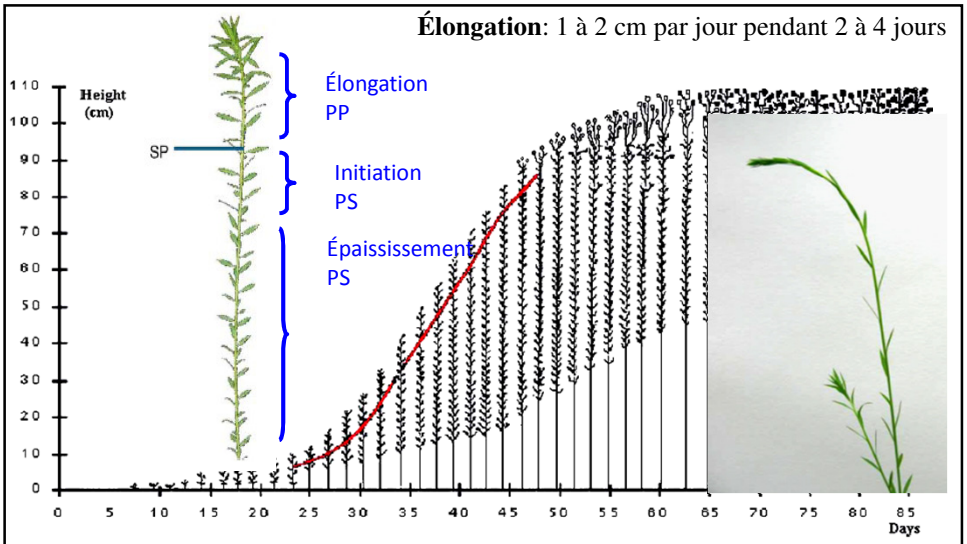
[Martin et al. 2013]

Lots	E (GPa)	σ (MPa)	A (%)
R1	38.6	792	2.2
R3	48.6	935	2.2
R6	55.6	1036	1.9

Influence du temps de rouissage sur les propriétés mécaniques en traction de fibres élémentaires

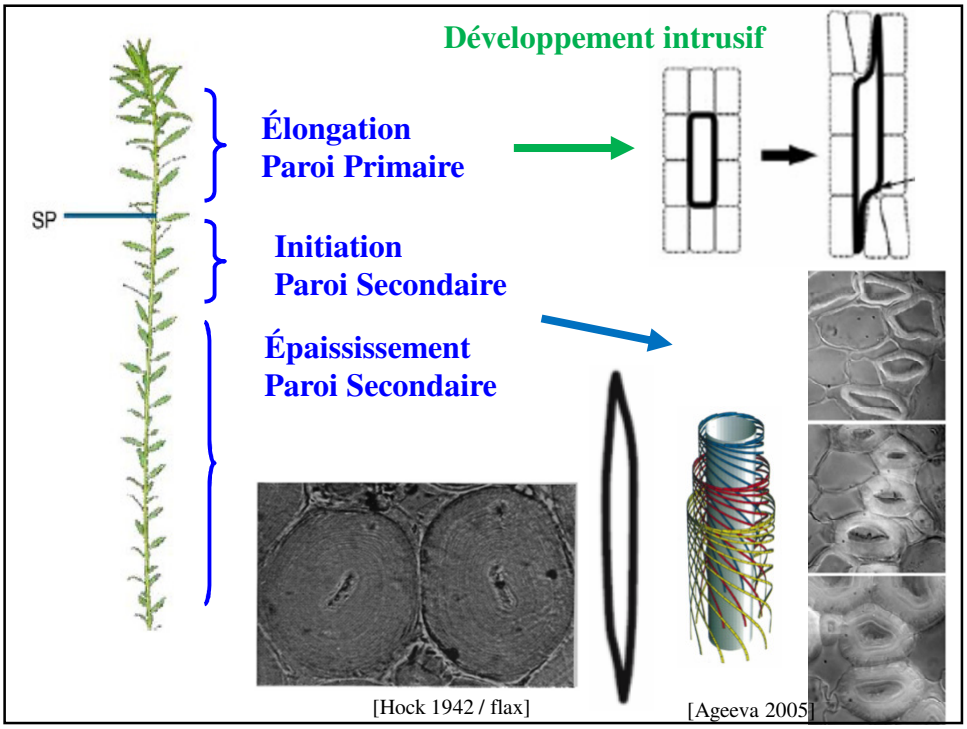
Fibre élémentaire

Élongation: 1 à 2 cm par jour pendant 2 à 4 jours

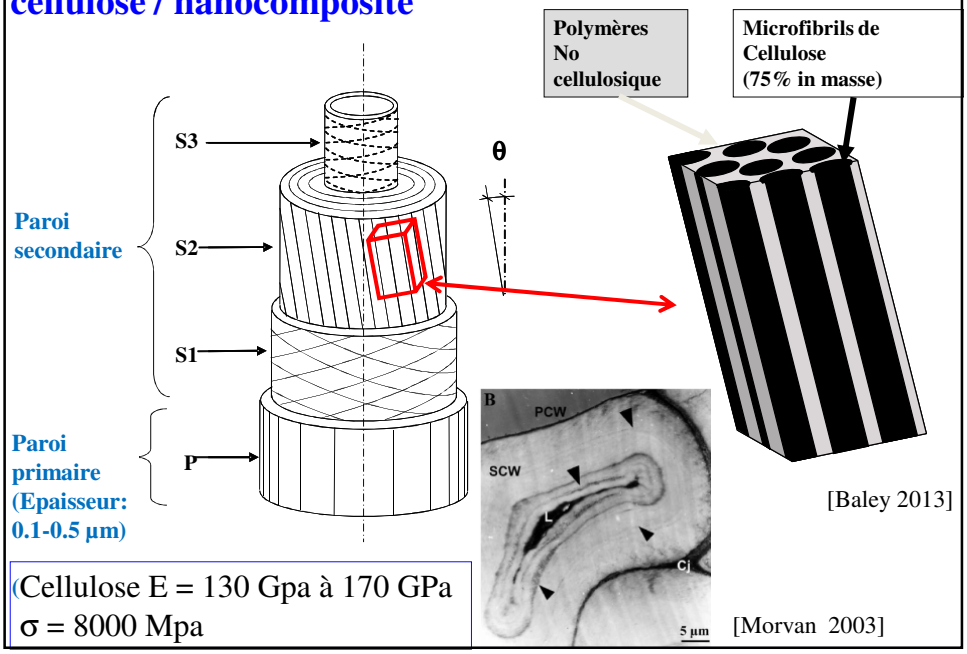


Scheme of snap point position (red line) on flax stem in the course of plant development (Gorshkova et al. 2003)

Lors de la période de croissance, la plante réagit en fonction des conditions pedo-climatiques qu'elle subit.
Paramètres: Sol / les précipitations/ la température/ le nombre de graines au m² / vent / variété/ apport azote / traitements / la période d'arrachage…



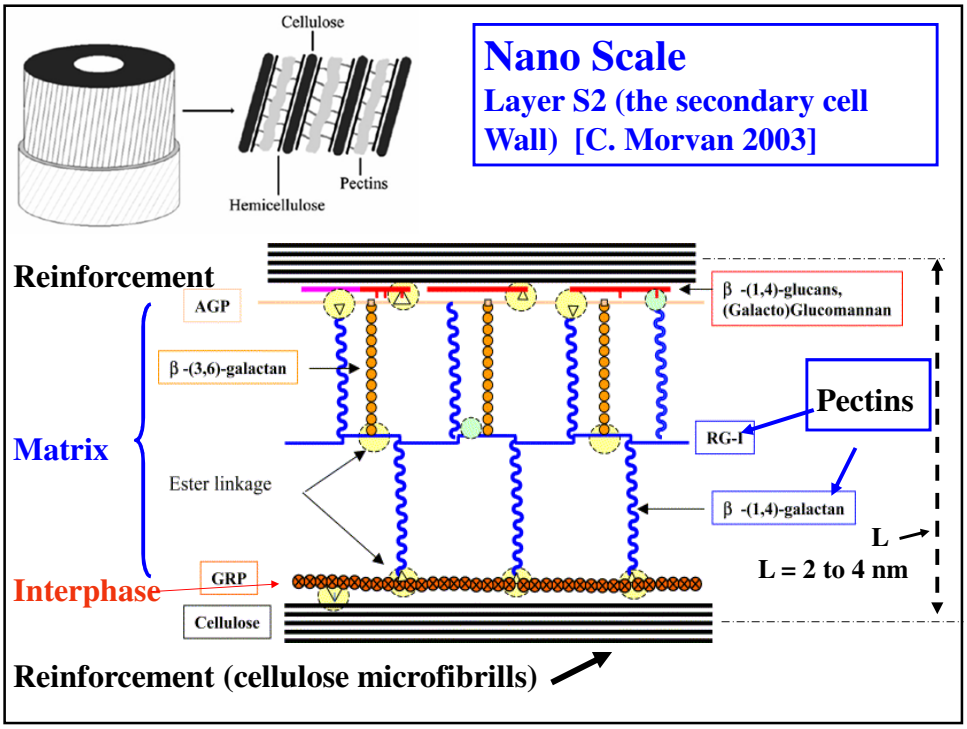
Une fibre = un empilement renforcé par des fibrilles de cellulose / nanocomposite



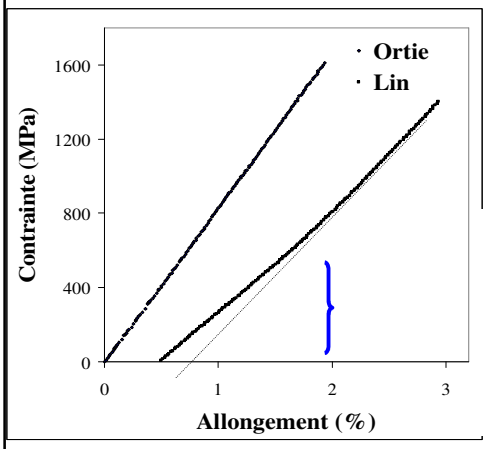
[Baley 2013]

(Cellulose E = 130 Gpa à 170 GPa
σ = 8000 Mpa

[Morvan 2003]



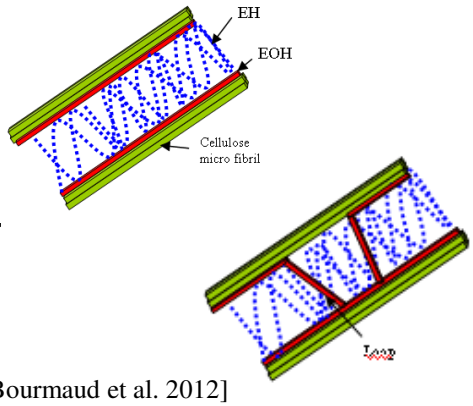
Influence de l'angle microfibrillaire ?



Courbes types contrainte-allongement.
Essai de traction fibre d'ortie et de lin.
(Baley, 2002) (Bodros et Baley, 2008)

Angle microfibrillaire

	MFA (°)
Lin (Bourmaud 2012)	**9°**
Chanvre (Placet 2011)	**11°**



[Bourmaud et al. 2012]

Composition d'une fibre de lin

Composition d'une fibre de lin
65 – 75% de cellulose + 11-17 % hémicellulloses + 2-3 % pectines + 6-8 % eau + cires + lignine

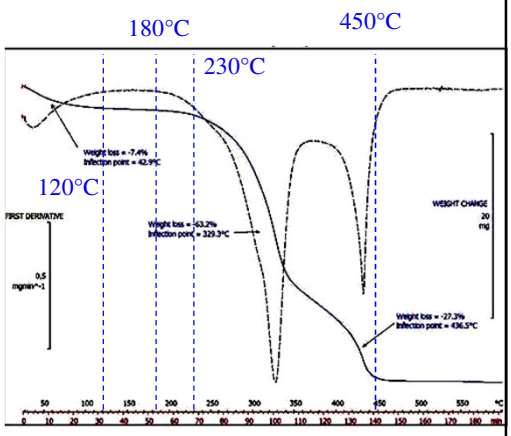
Et si on chauffe ?

Libération de l'eau

A 120 °C il n'y a plus d'eau + dégradation des cires,

A 180°C dégradation des pectines

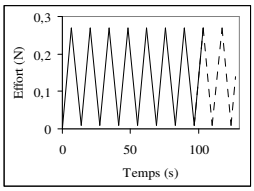
A 230°C on note une dégradation des hémicelluloses et cellulose



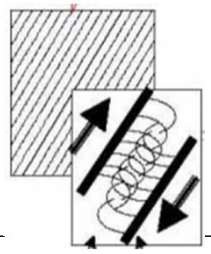
Paramètres: temps et température

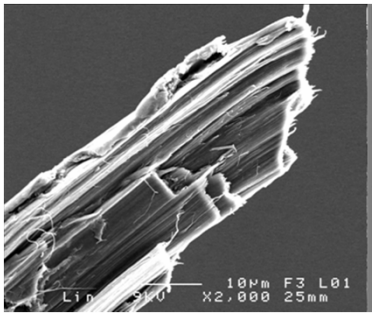
Evolution des performances avec un cycle thermique

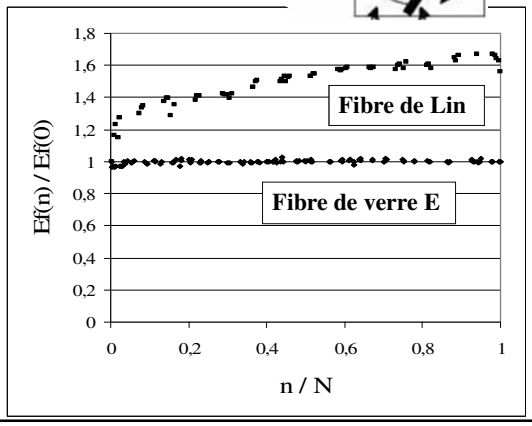
Comportement en fatigue

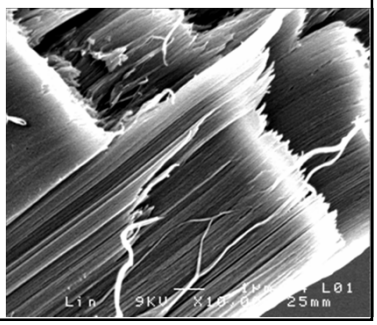


(Baley 2002)



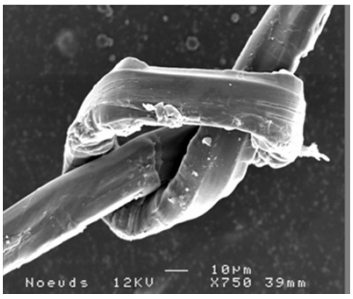


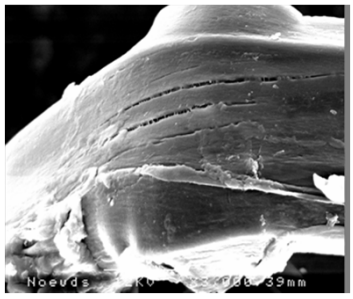




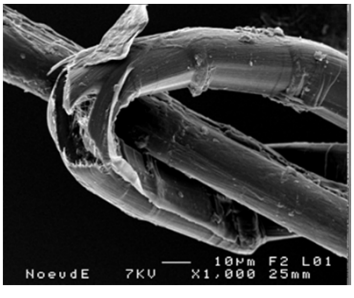
Fibre de lin - Influence de l'eau absorbée

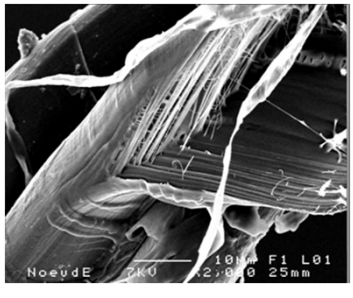
Fibre avec 7% d'eau absorbée



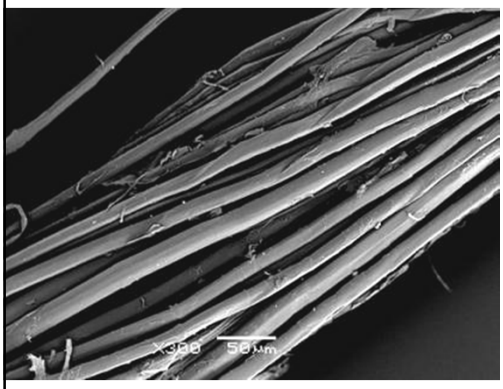


Fibre de lin après un traitement thermique de 12h à 105 C

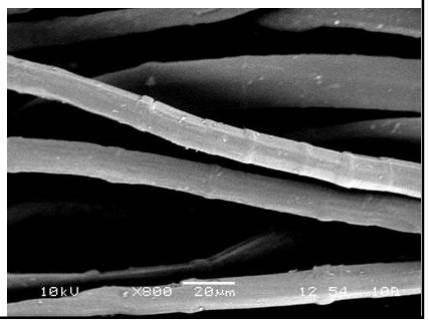




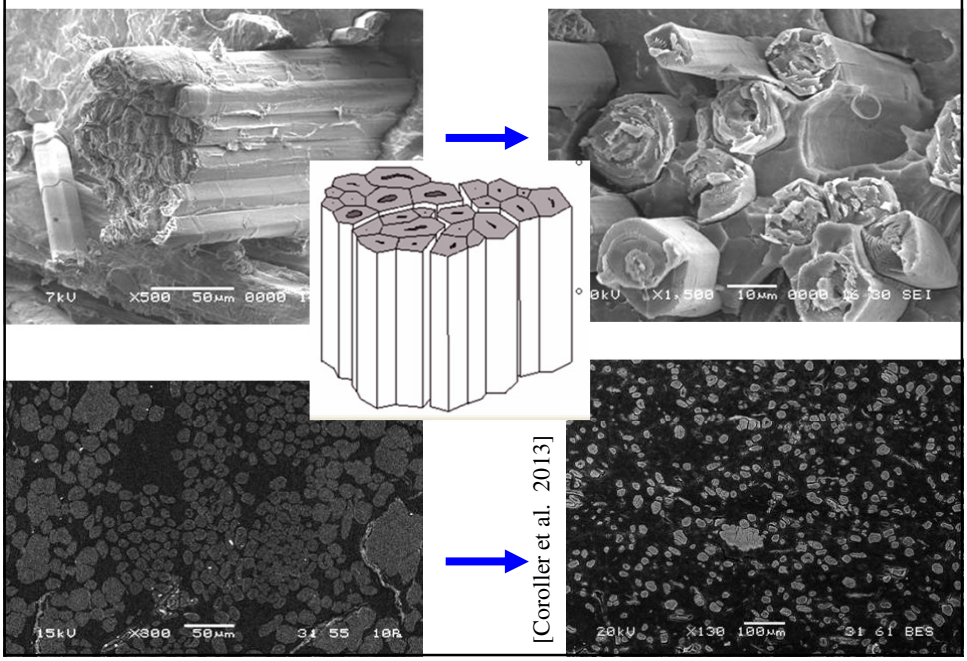
Remarques sur les biocomposites



Un fil de lin est composé de fibres élémentaires torsadées

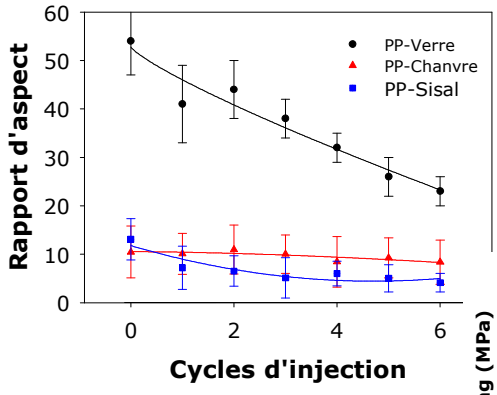


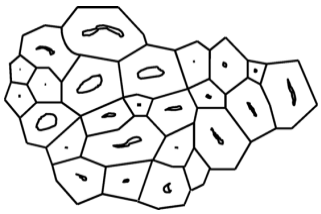
Bundle of fibers or no? Individualization?

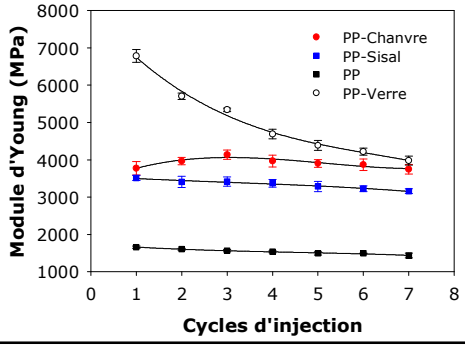


[Coroller et al. 2013]

Recyclage PP/fibres végétales (Injection)

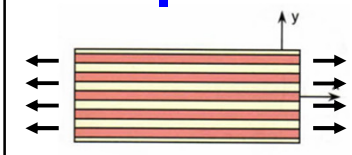






[Bourmaud et al. 2011]
[Bourmaud et al. 2009]
[Bourmaud et al. 2007]

Unidirectionnel en traction longitudinale



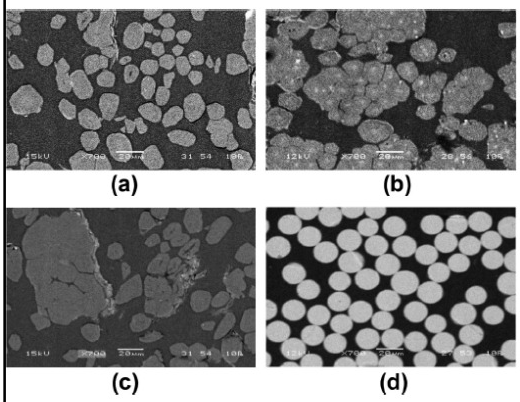
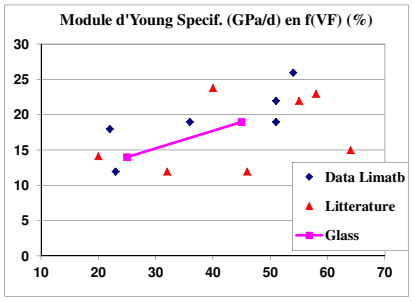
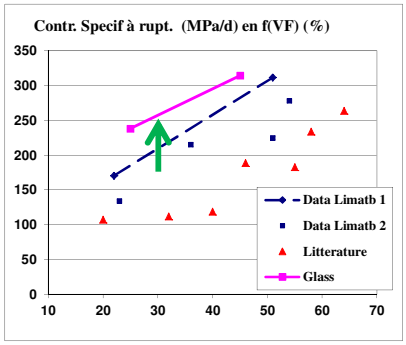


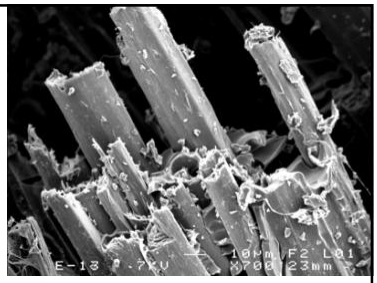
Fig. 5. Composites SEM images: (a) Hermes, (b) Andrea, (c) Marylin and (d) glass.

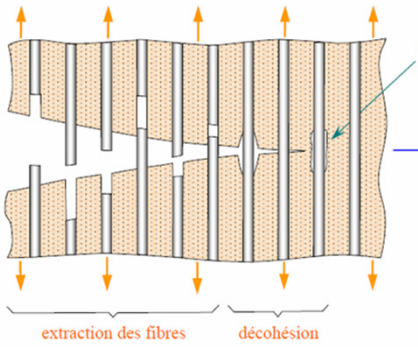


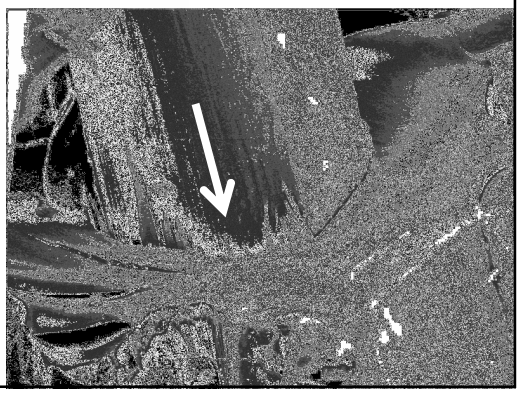


[Coroller et al. 2013]

UD lin/époxy





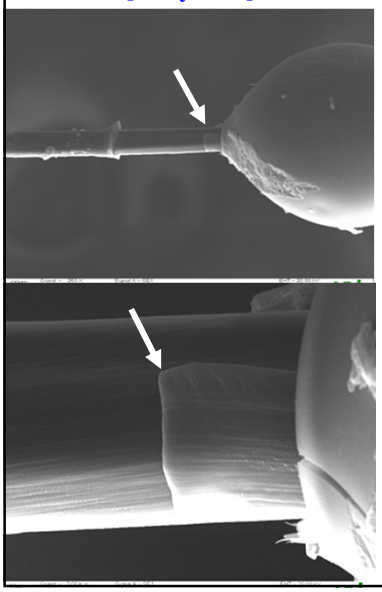


Habituellement: rupture de fibres, de matrice, d'interface + déchaussement de fibres

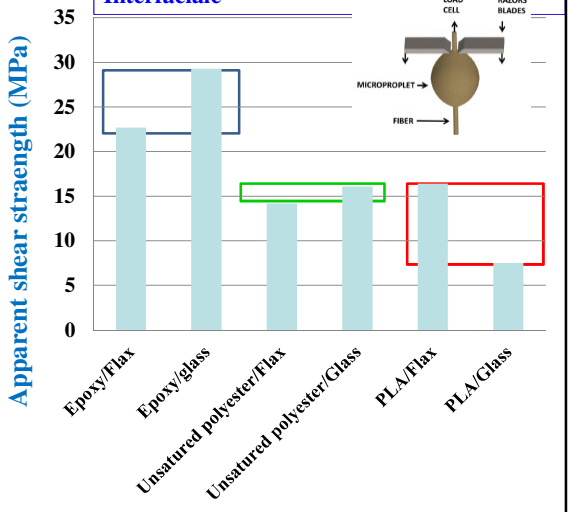
Fibre végétale = empilement

Remarque sur la notion d'interface

Conséquence d'un traitement thermique maladroit [Baley 2013]

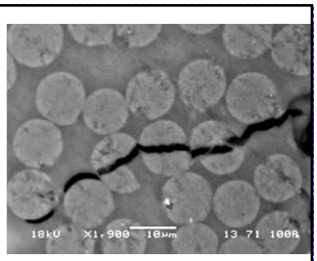


Essais de déchaussement d'une microgoutte
Contrainte apparente de cisaillement
Interfaciale

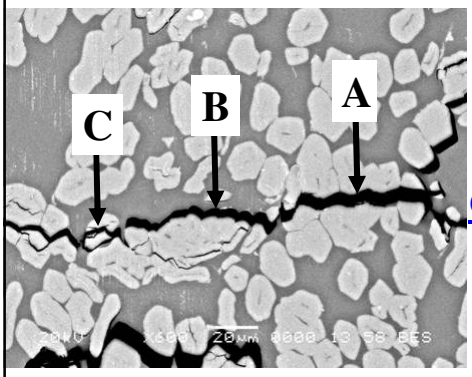


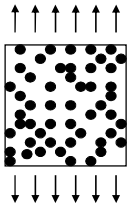
[Baley et al. 2006] [Le Duigou et al. 2010 / A] [Le Duigou et al. 2010 / B]

Unidirectional Transverse behavior



Pitch carbon fibers





Crack propagation:

(A) Between fibers

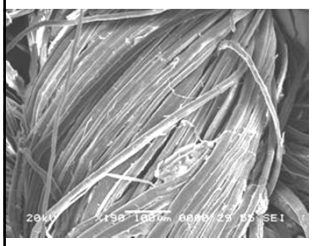
(B) Between fiber and matrix

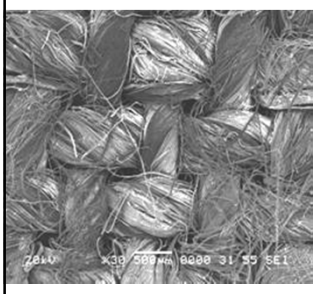
(C) In fiber

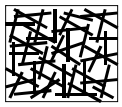
[Baley et al.2006]

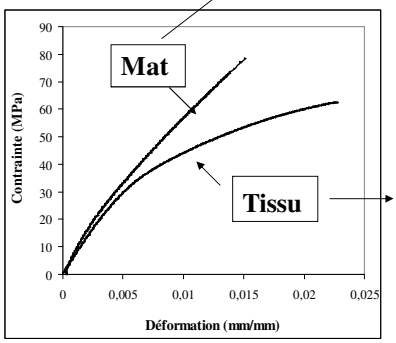
The cohesion (stickiness, toughness) of a cell wall is function : biochemical composition, percentage of absorbed water, thermo-mechanical cycle during the process… + retting

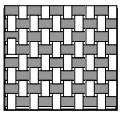
Présentation des fibres

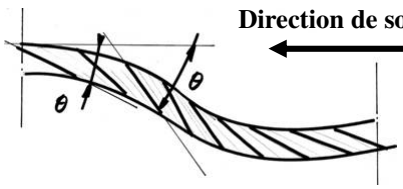








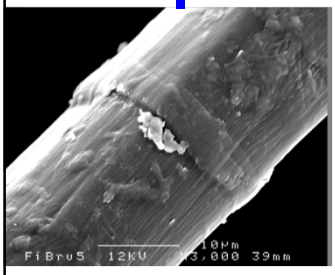


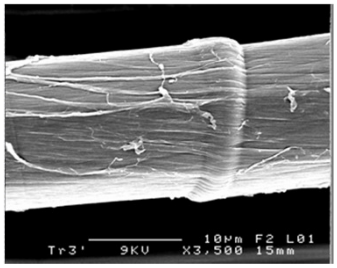


Direction de sollicitation

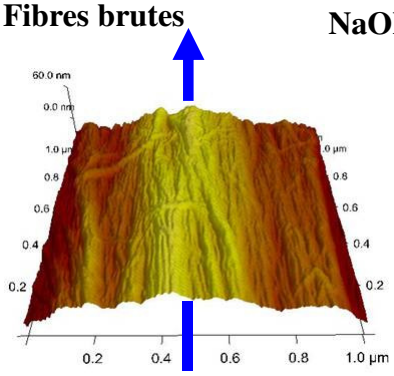
Traitements des fibres

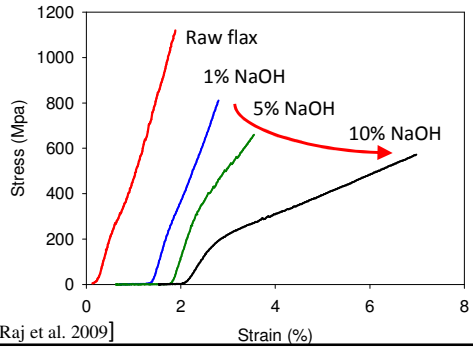
[Baley et al. 2006]





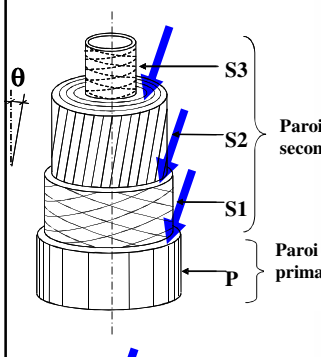
Fibres brutes **NaOH** **Enzymatique**

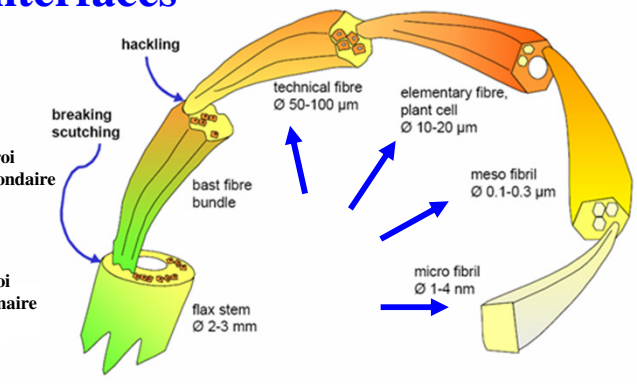


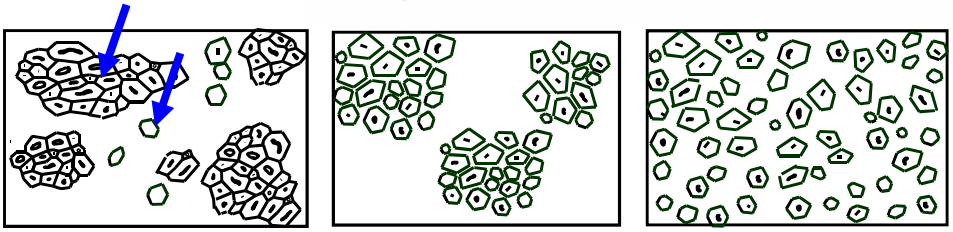


[Raj et al. 2009]

Des interfaces

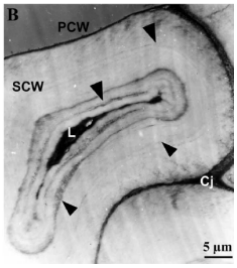


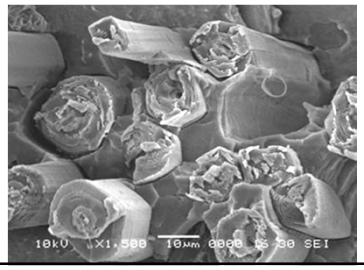




[Baley et al. 2014]

Bilan





Points abordés

- Une fibre de lin a un rôle structurel

- Une tige = un matériau composite
- Fibres ont un rôle de soutien, elles sont assemblées en paquet
- Nécessité d'un rouissage pour les extraire

- Un fibre élémentaire et un empilement nanostructuré
- Le développement et la composition des cellules influencent leurs propriétés et leurs géométries
- Les fibres de lin sont anisotropes
- Il est nécessaire de tenir de compte de leur composition

- Pour optimiser le renforcement il faut tenir compte des spécificités des fibres. Présentation optimale?
- Il existe des interfaces

- Début de l'histoire (polymères renforcés par des fibres végétales),


Merci de votre attention.
« Ce n'est pas seulement du blé qui sort de la terre labourée, c'est une civilisation toute entière. »
Lamartine