20T2060

Tecnologia de Biopolímeros

Bruno Las-Casas Chaves
brunochaves@usp.br

Profa. Talita M. Lacerda

HÁ ALGUNS ANOS ATRÁS ...

Cyperus papyrus

Discovery of fire (~ 300 mil anos atrás/Homo erectus)

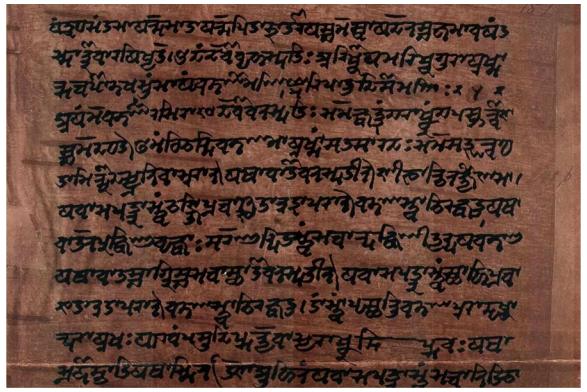
Cordas (4500 BC/China)

Roupas (4000 BC)

Papiro (3000 BC – Egito/Nilo)

Manuscritos Hindus sobre cultivo de algodão (1500 BC)

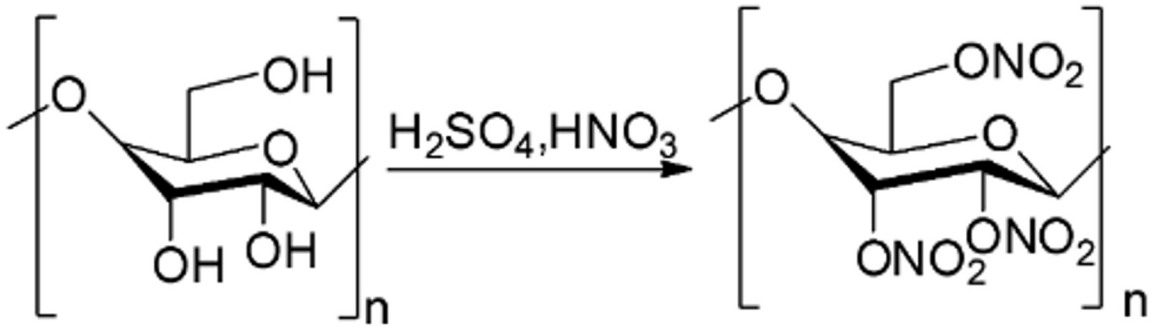
Mumificação no antigo Egito (300 a 500 BC)



HISTÓRIA RECENTE

Anselme Payen (1795-1871)

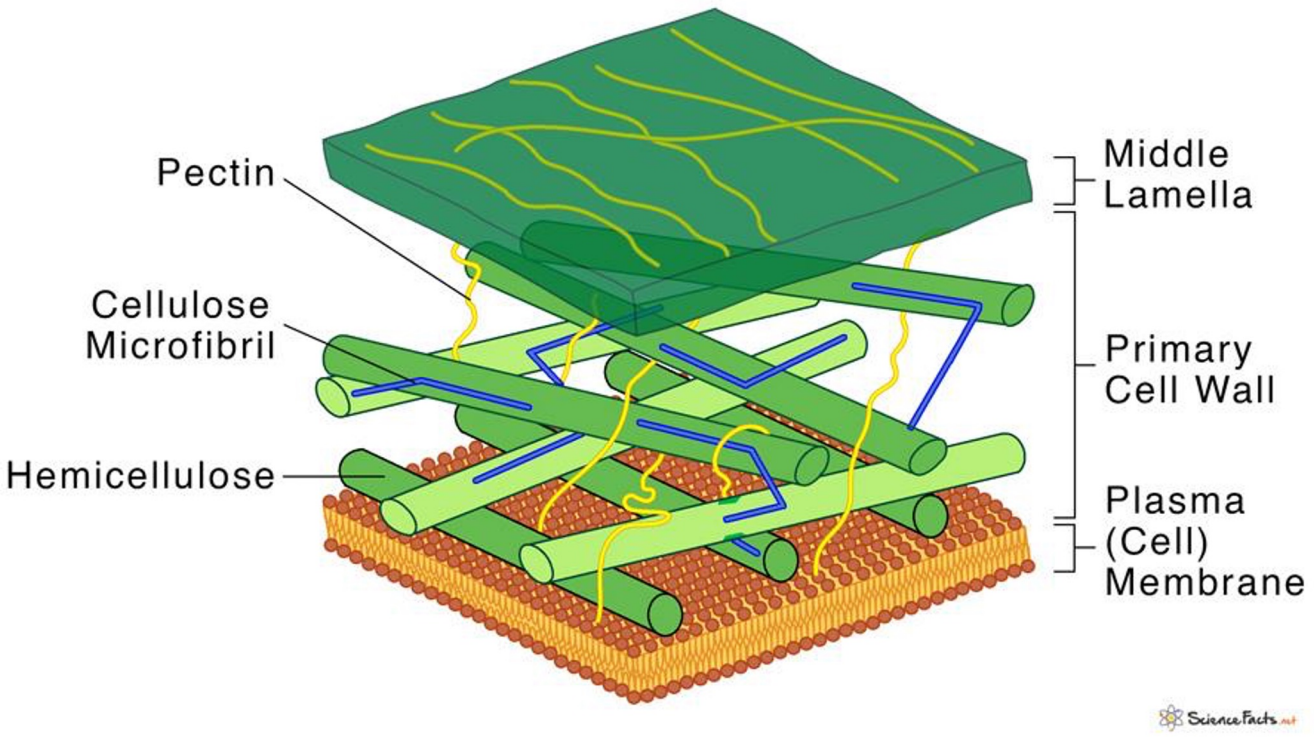
- Extração de celulose por tratamento com ácido nítrico. Obtenção de um material fibroso.

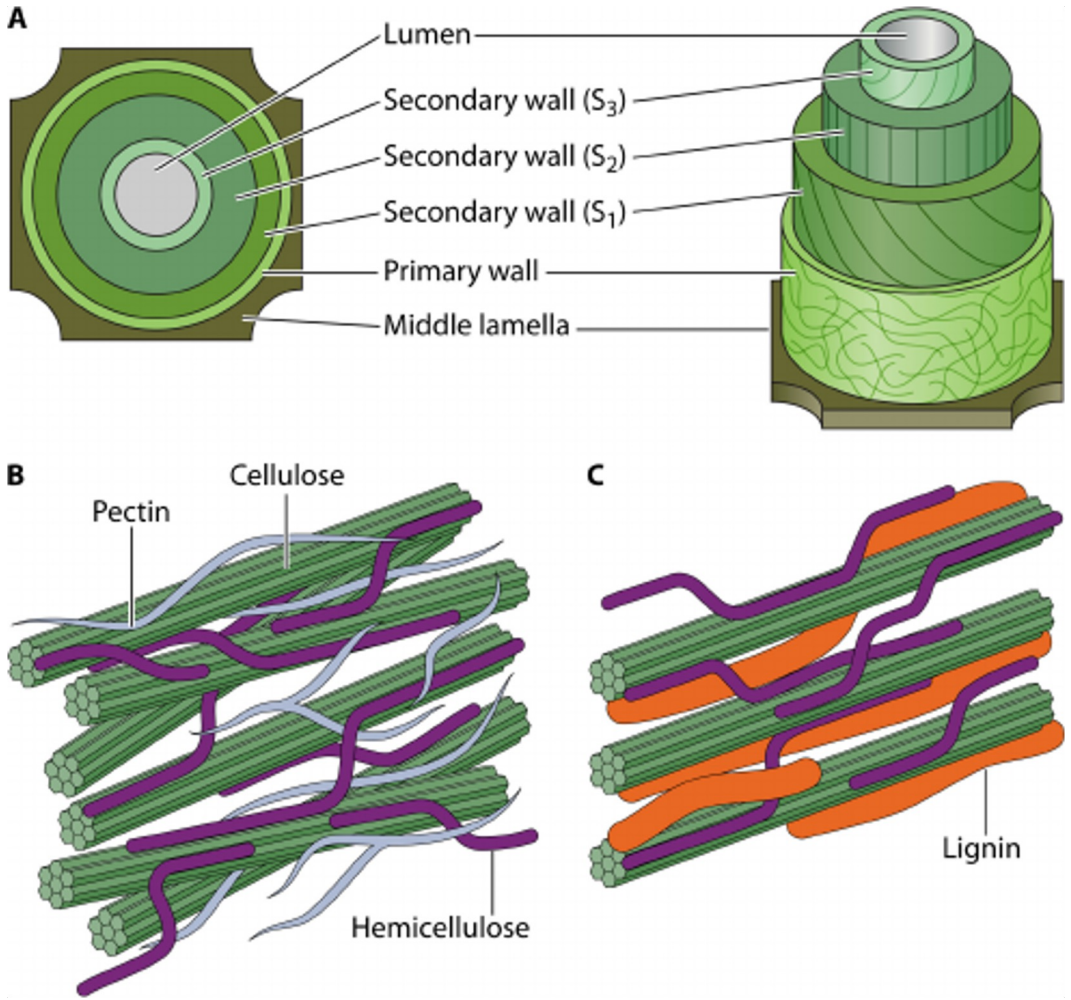


CONCLUSÕES:

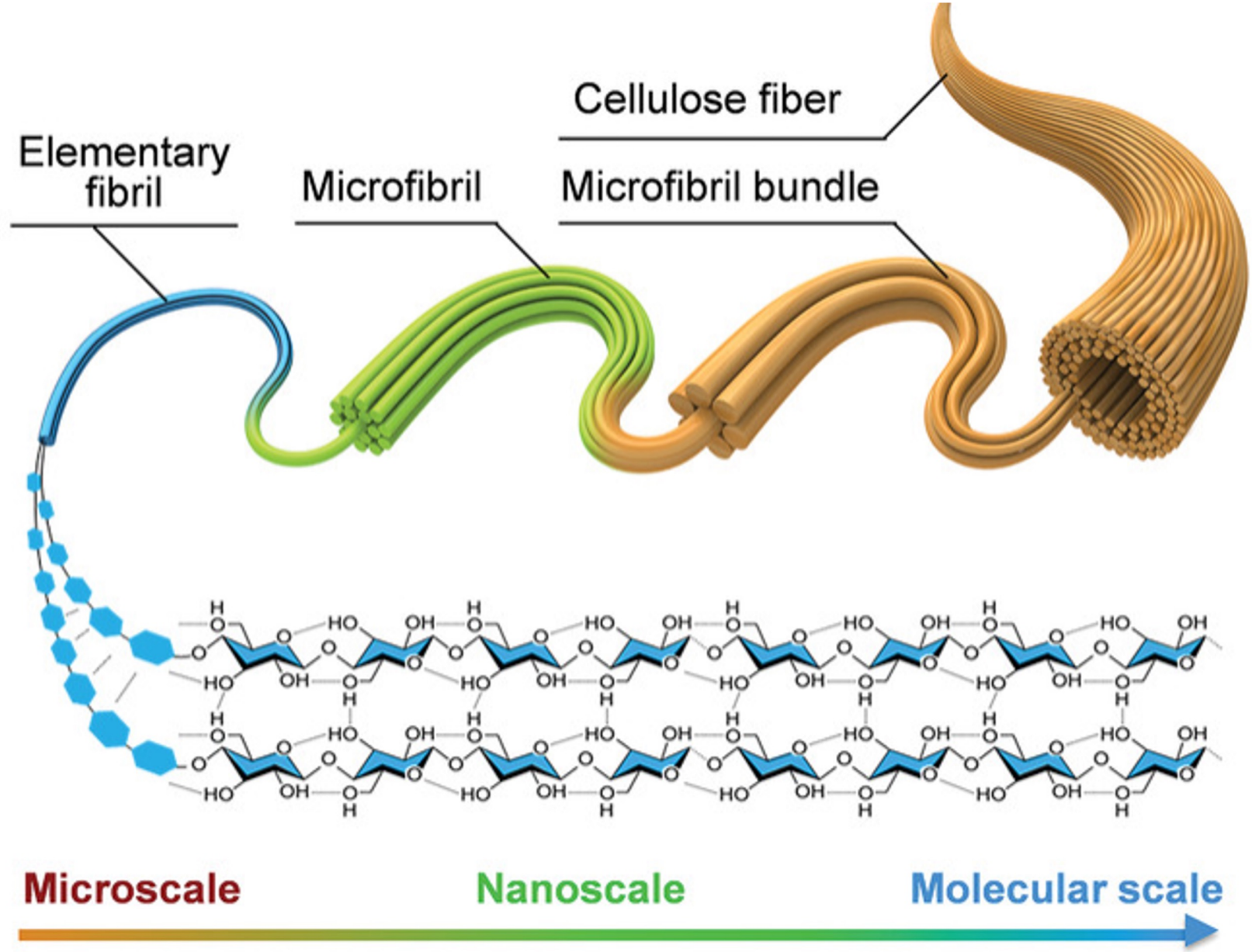
- Cellulose – *cellule* (pequena célula) + ose (açúcar)
- A MESMA COMPOSIÇÃO DO AMIDO;
- A COMPOSIÇÃO DA CELULOSE ERA A MESMA PARA DIFERENTES FONTES;
- PODERIA SER REPRESENTADA PELA FÓRMULA $C_6H_{10}O_5$;
- MATERIAIS INCRUSTANTES (“*LES MATIERES ENCRUSTANTES*”)

TUDO COMEÇA NA PAREDE CELULAR VEGETAL .....

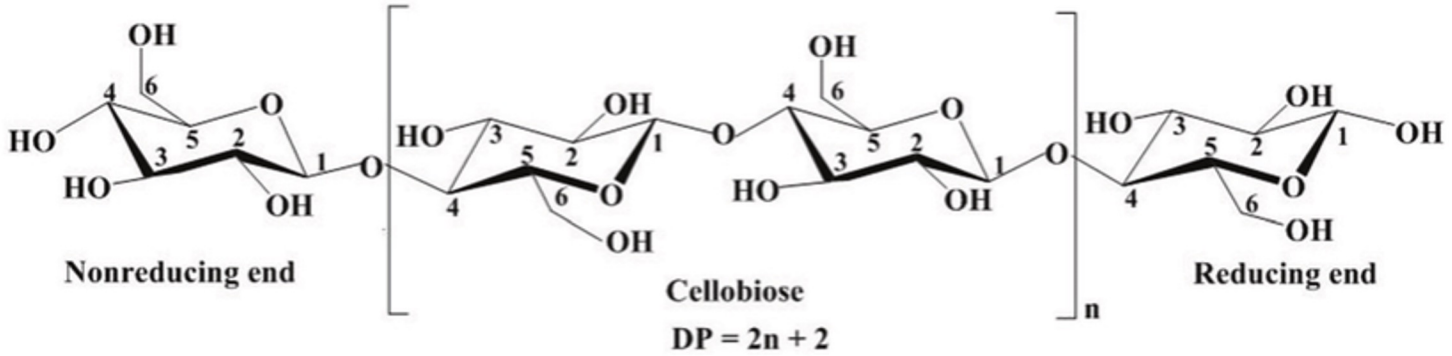


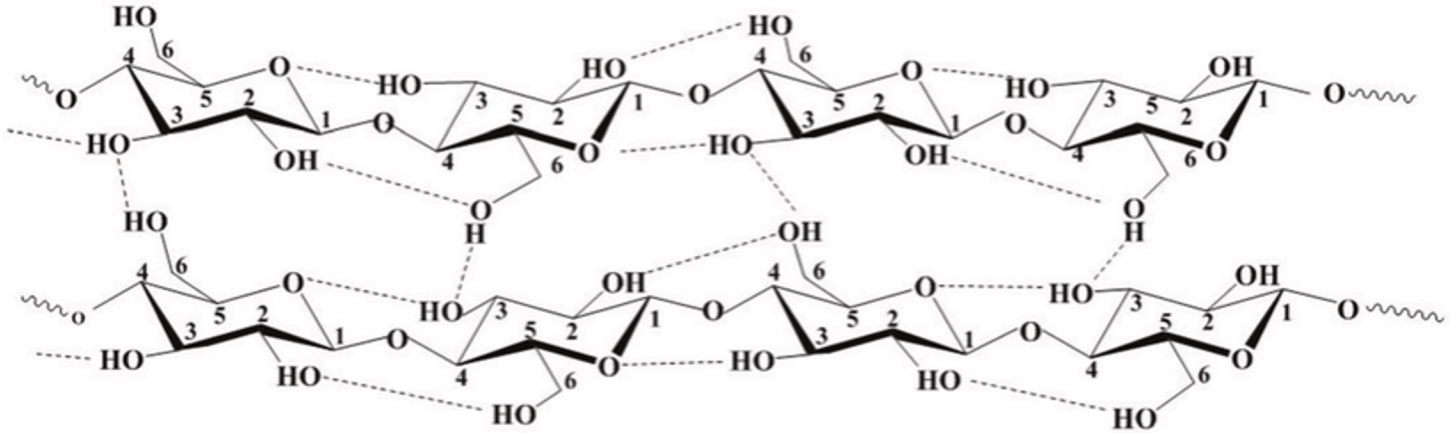


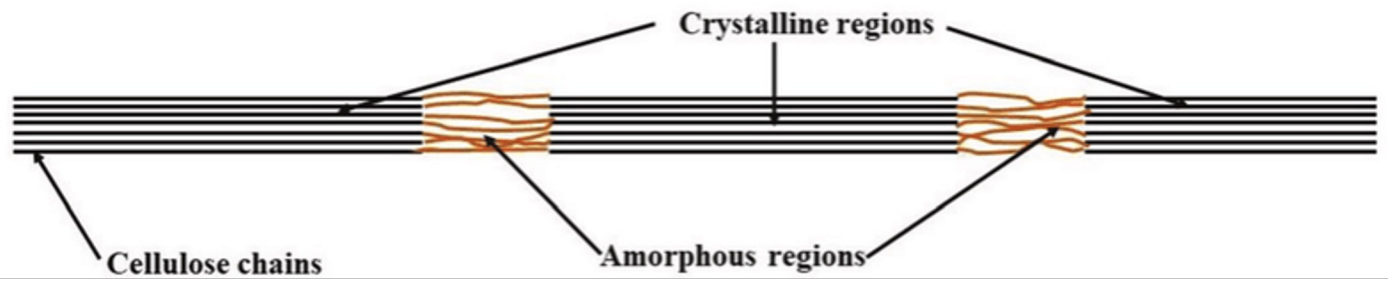
MAIS UM POUCO DE ZOOM .....



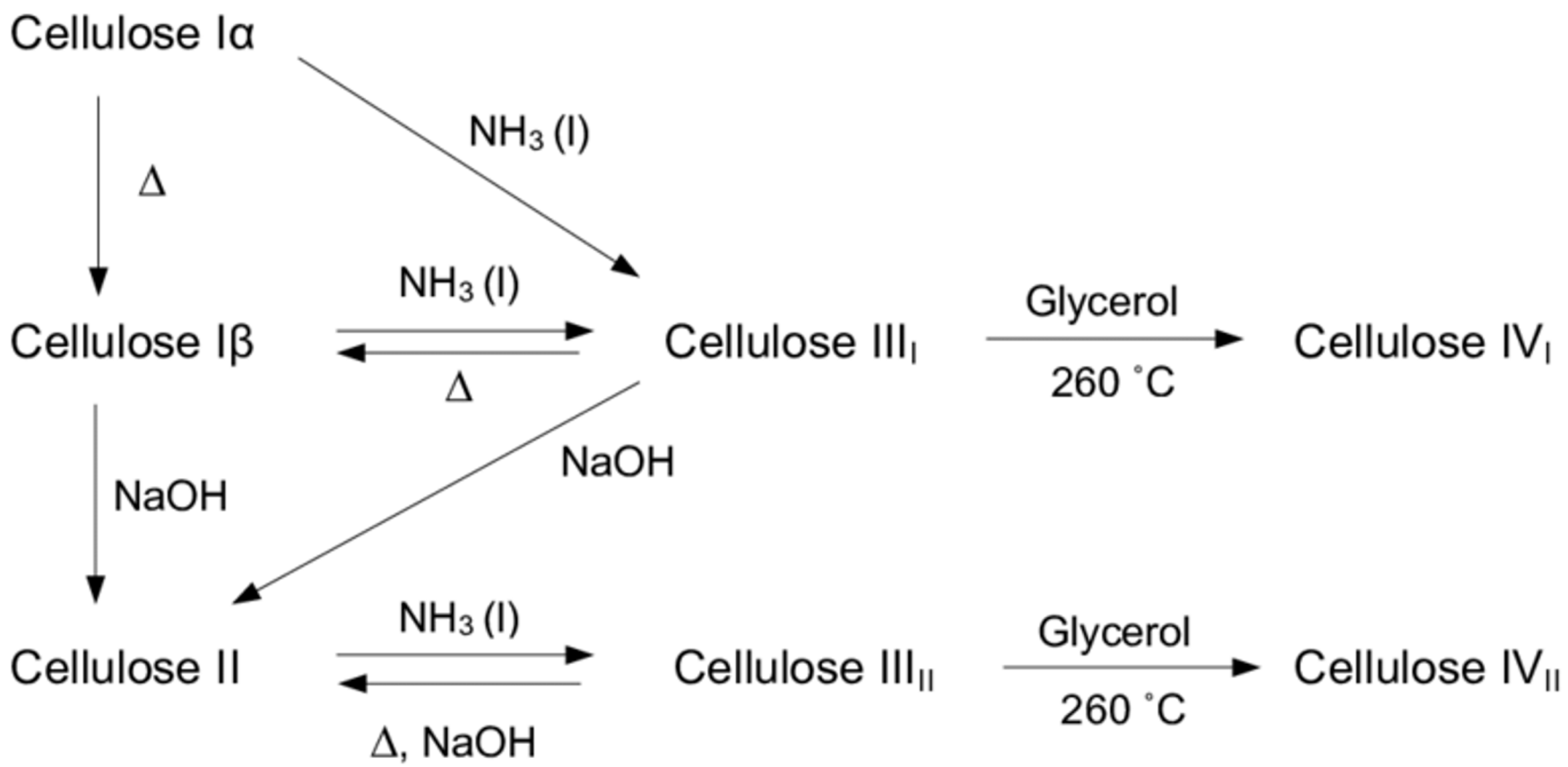
SÓ MAIS UM POUQUINHO DE ZOOM .....







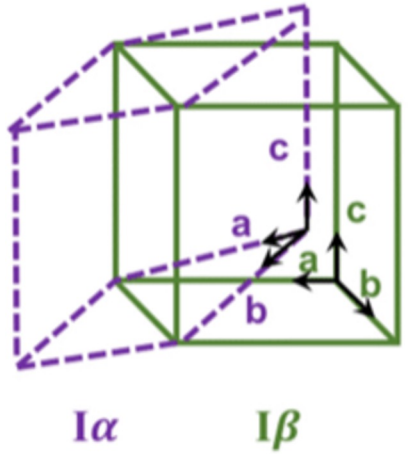
POLIMORFISMO CRISTALINO DA CELULOSE

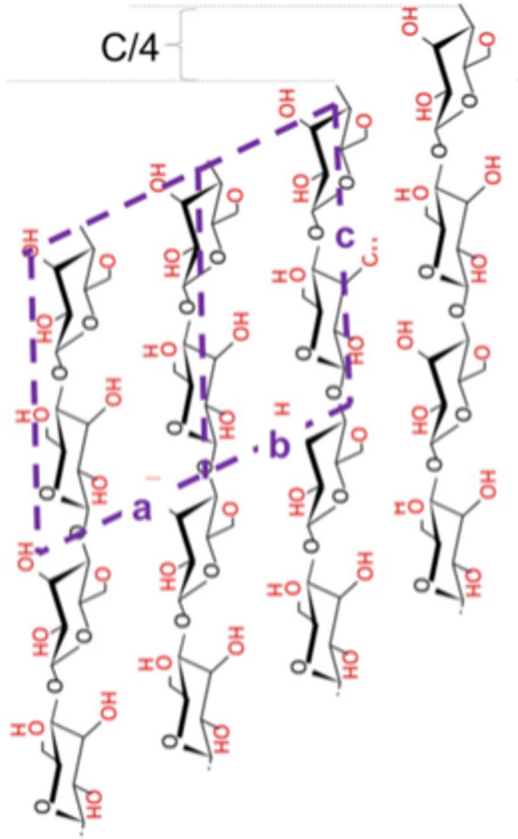


POLIMORFISMO CRISTALINO DA CELULOSE

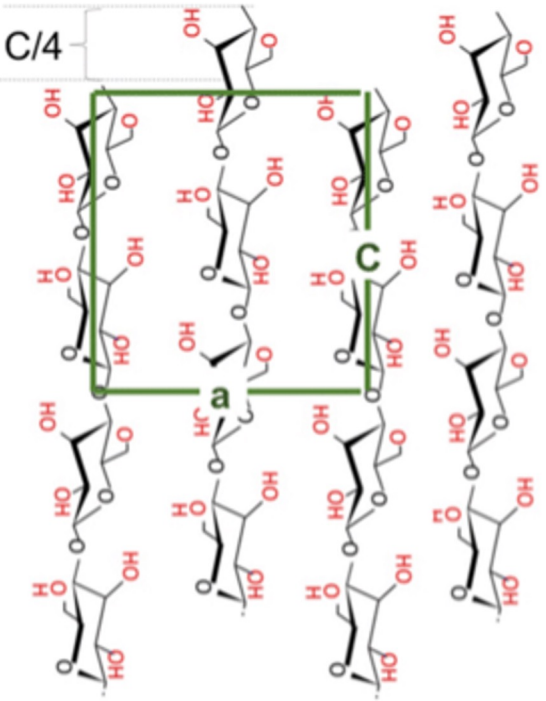
Native Cellulose: A Composite of Two Distinct Crystalline Forms

Abstract. *Multiplicities in the resonances of chemically equivalent carbons, which appear in the solid-state carbon-13 nuclear magnetic resonance spectra of native celluloses, have been examined at high resolution. The patterns of variation are consistent with the existence of two distinct crystalline forms. One form is dominant in bacterial and algal celluloses, whereas the other is dominant in celluloses from higher plants.*





Cellulose structure
Iα Triclinic

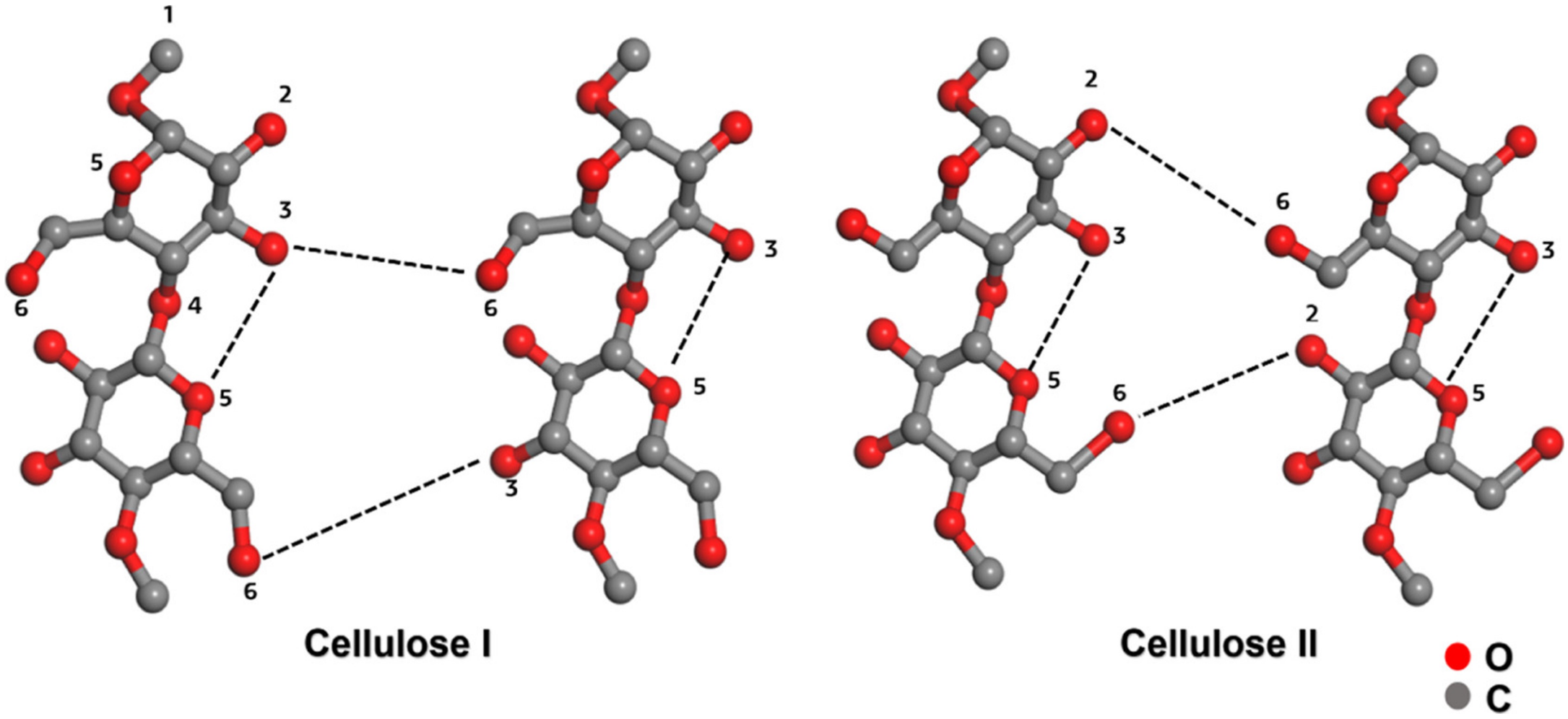


Cellulose structure
Iβ Monoclinic

Bactérias e algas

Plantas

POLIMORFISMO CRISTALINO DA CELULOSE



Fontes de celulose

Plantas

Tunicados

Microrganismos

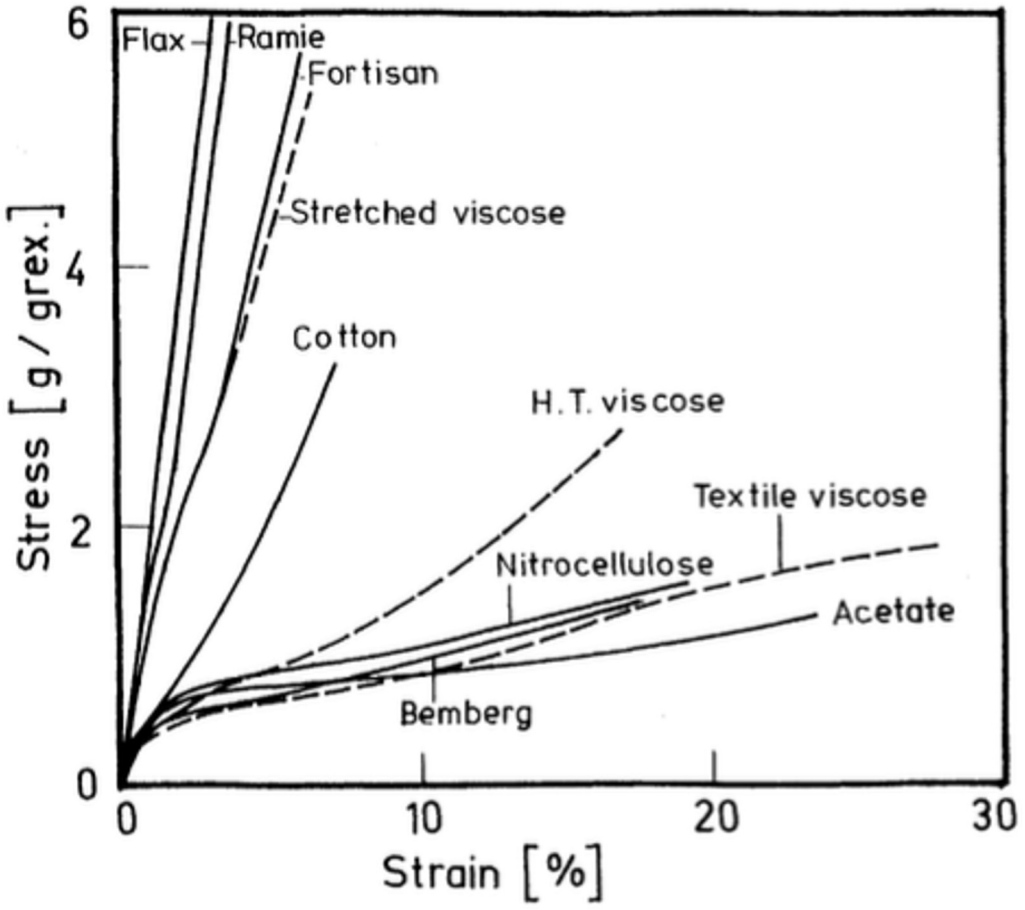
Table 1. Typical chemical composition of the dry biomass

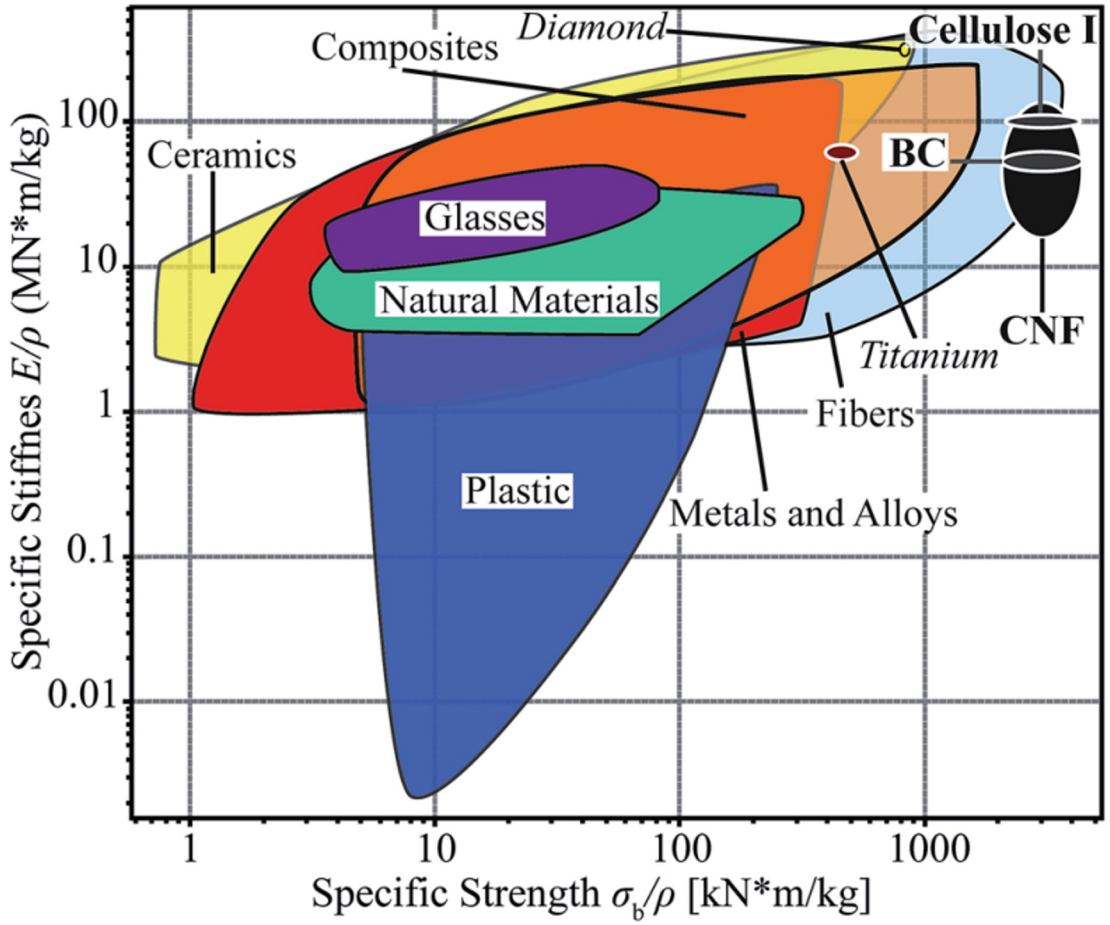
Biomass	Cellulose, %	Hemicelluloses, %	Lignin, %
White cotton	94-96	1-2	<1
Brown cotton	85-88	2-3	5-7
Flax	85-88	5-6	3-5
Softwood	46-48	20-23	27-28
Hardwood	44-46	25-27	22-25
Bagasse	37-39	23-25	19-21
Corn stalks	35-37	24-26	18-20
Corn cobs	34-36	36-38	9-11
Corn stover	35-37	28-30	18-20
Wheat straw	34-36	28-30	15-17
Rice straw	34-36	25-27	7-9
Switchgrass	36-38	26-28	17-19

Source of Cellulose	MW (g/mol)	Fiber Size (mm)	DP
Sugarcane bagasse	157,800–168,000	1.0–1.5	974–1,039
Hardwood	648,000–891,000	1.25	4,000–5,500
Softwood	648,000–891,000	3.0	4,000–5,500

PROPRIEDADES DA CELULOSE

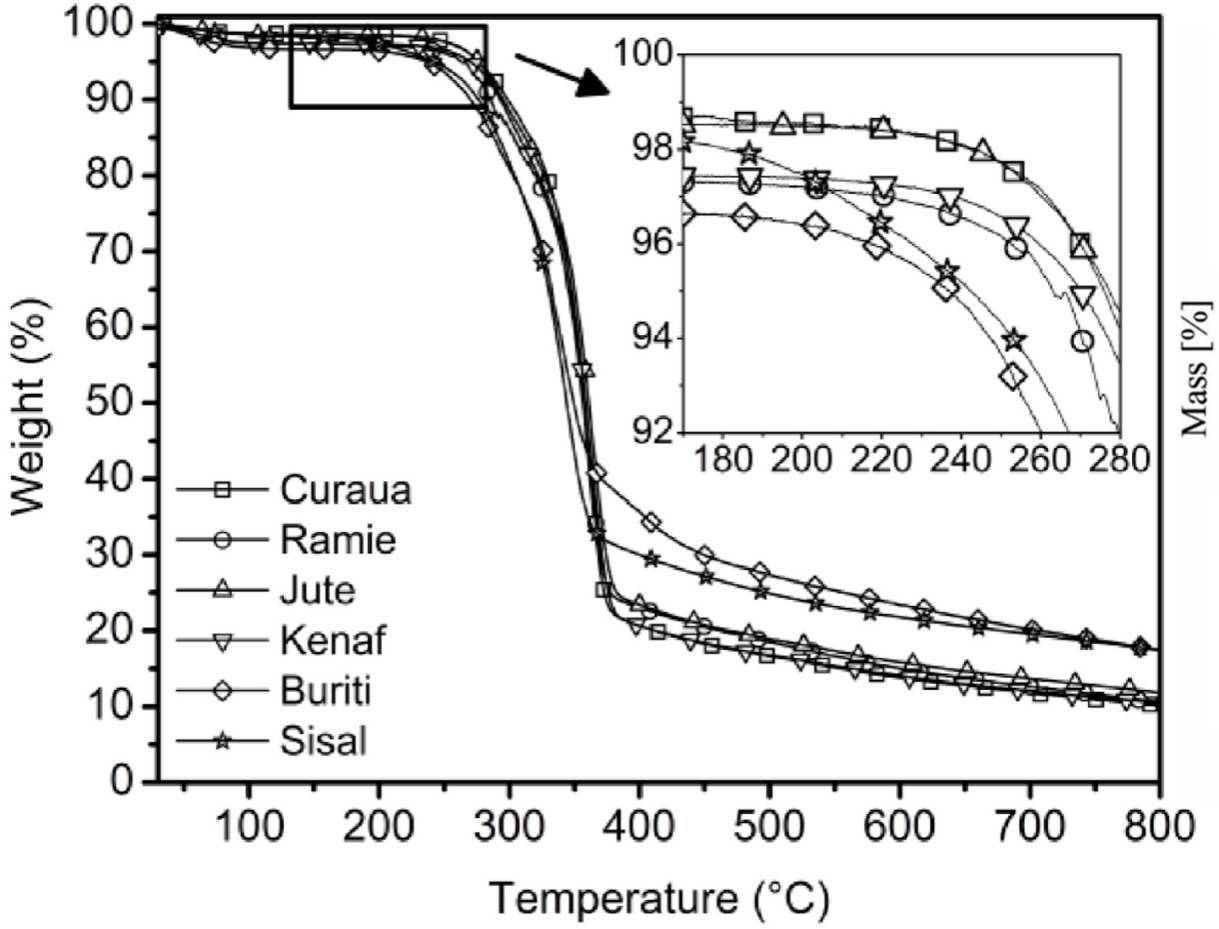
PROPRIEDADES MECÂNICAS

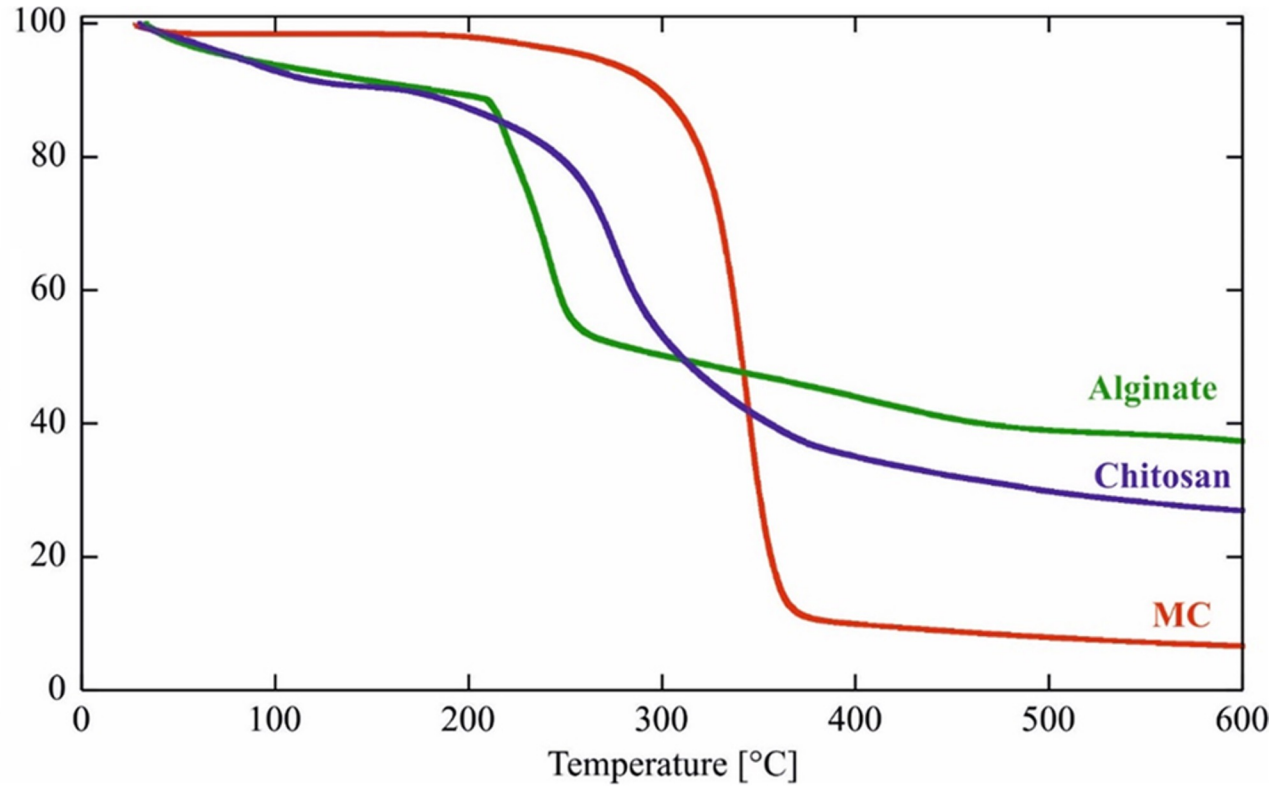




PROPRIEDADES DA CELULOSE

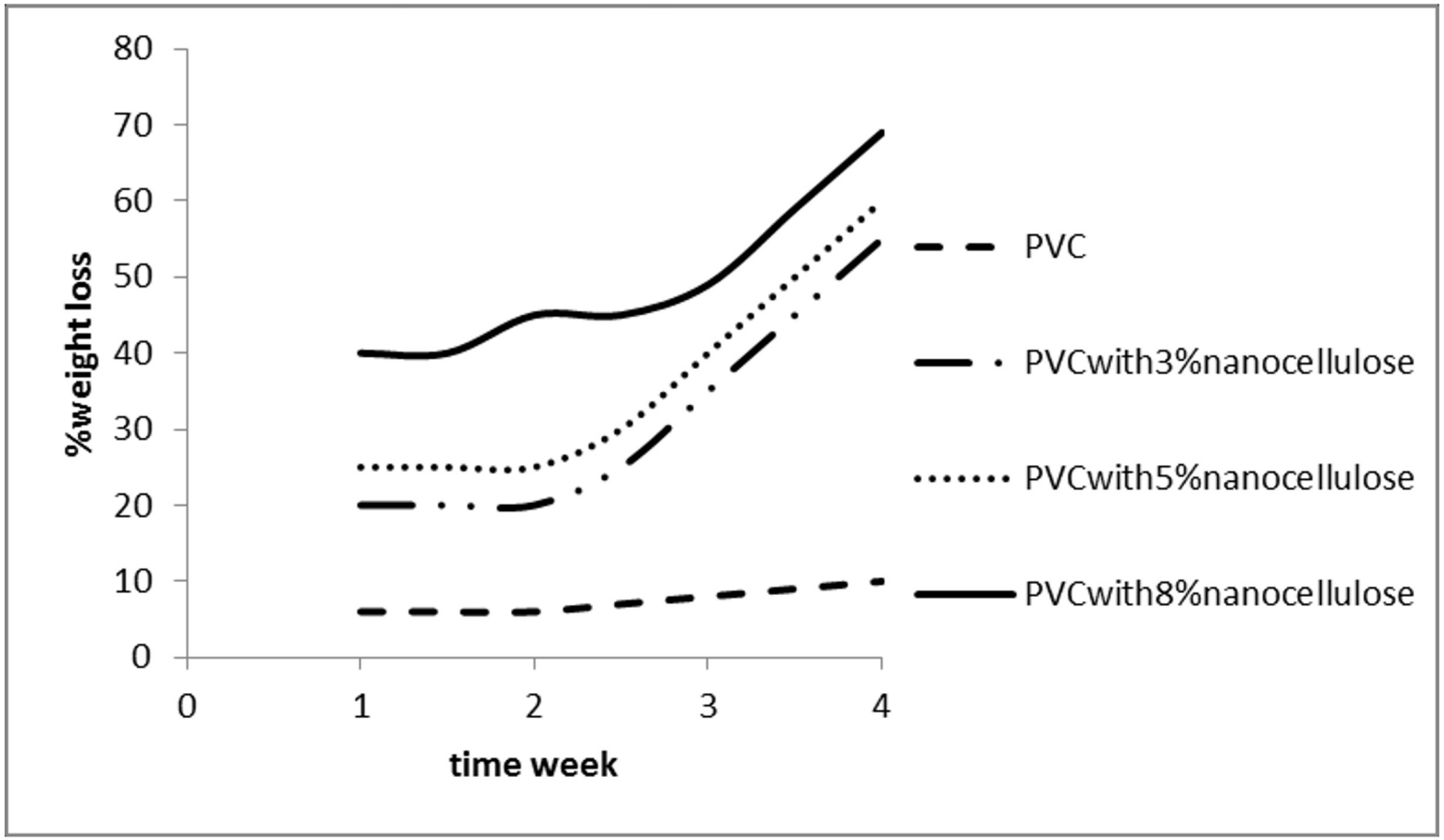
PROPRIEDADES TÉRMICAS





PROPRIEDADES DA CELULOSE

PROPRIEDADES GERAIS



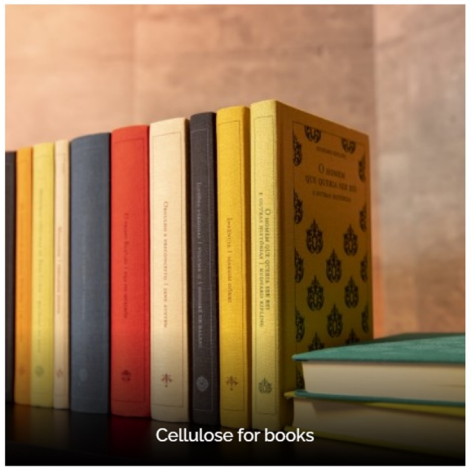
PROPRIEDADES DA CELULOSE

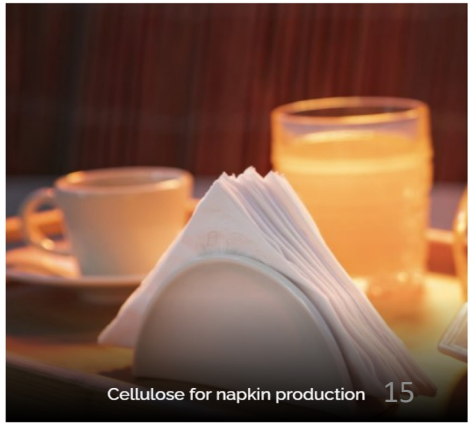
PROPRIEDADES GERAIS

Material	Tensile strength (MPa)	Elasticity modulus (GPa)	Density (g/cc)
Cellulose nanocrystals	7500	120-143	1.50
Glass fiber	4800	86	2.50
Steel wire	4100	207	7.85
Graphite whisker	21	410	1.80
Carbon nanotubes	11-63	270-970	1.33
Kevlar	3.5	124	1.40

APLICAÇÕES DA CELULOSE

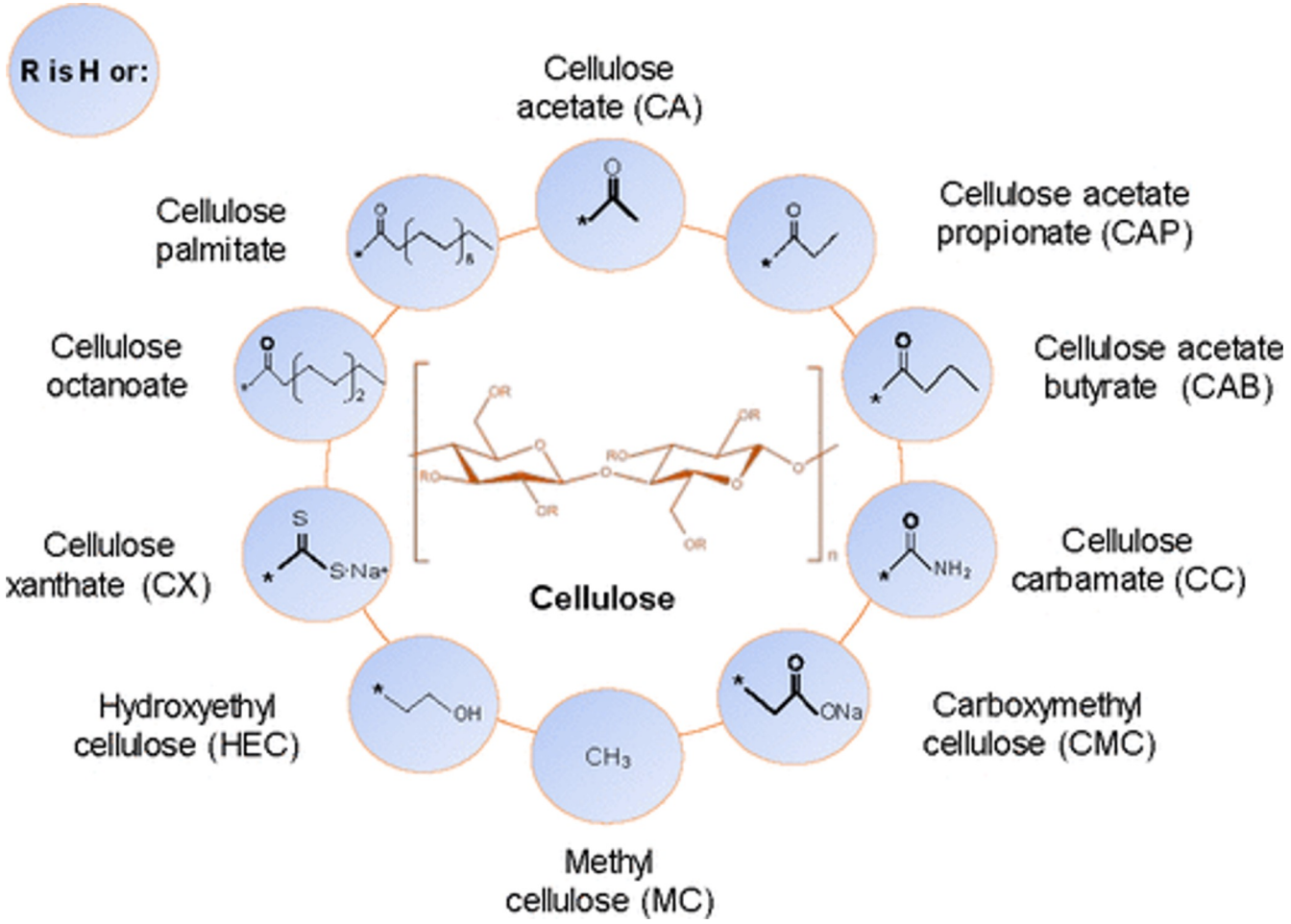
Klabin



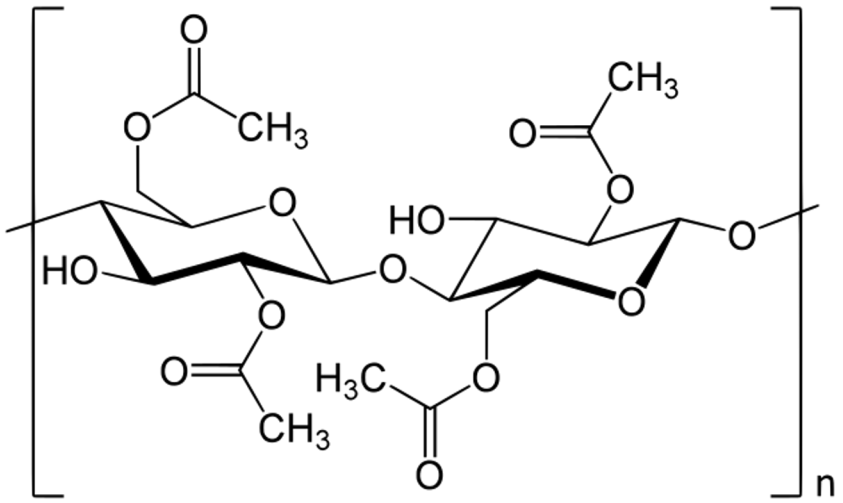


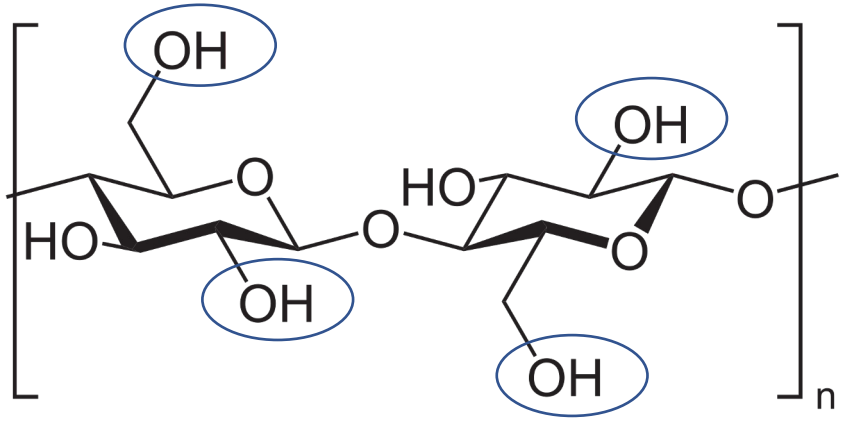
É POSSÍVEL AUMENTAR O CAMPO DE APLICAÇÕES DA CELULOSE? COMO?

DERIVADOS DE CELULOSE

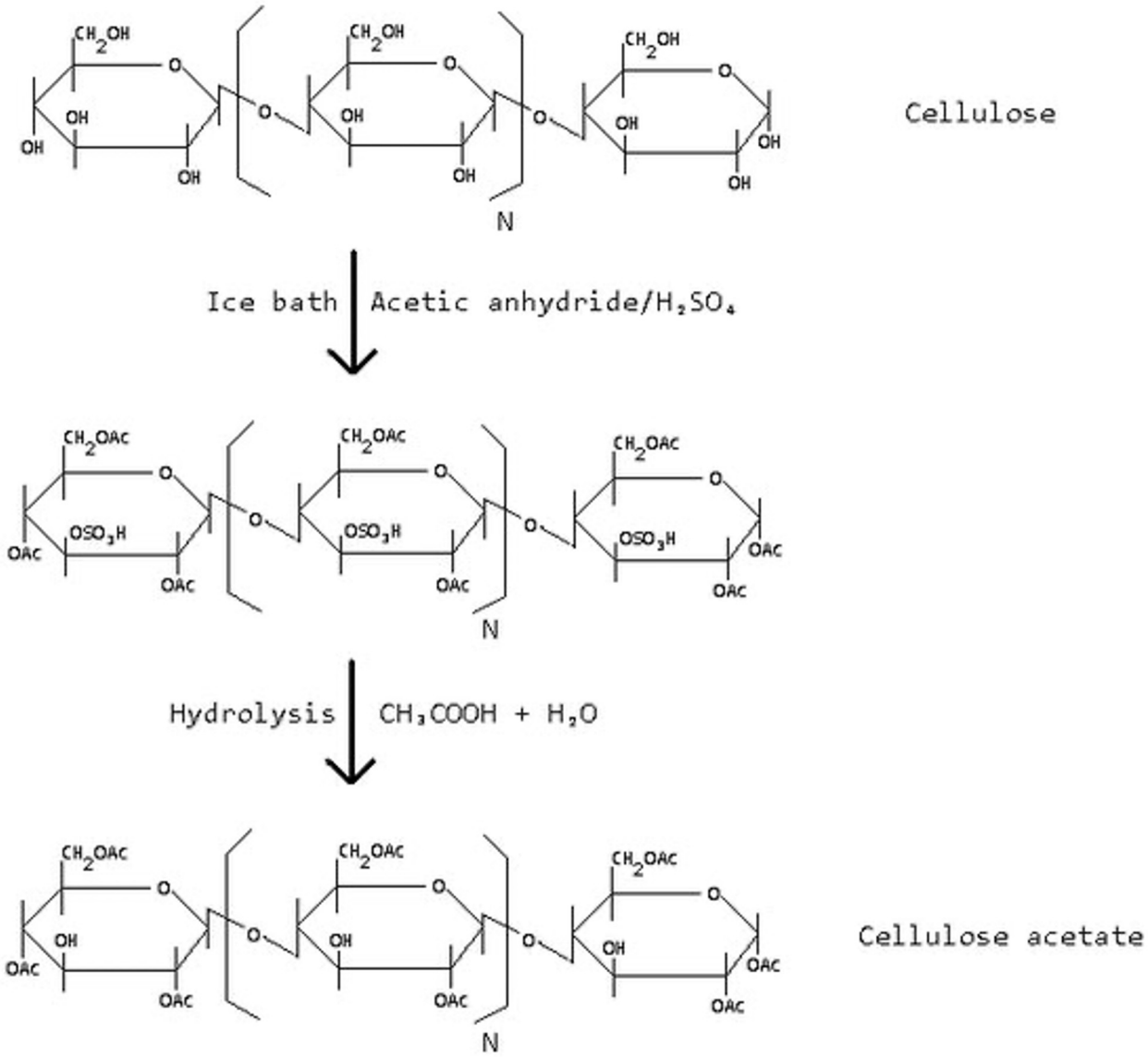


ACETATO DE CELULOSE





Celulose nativa



POLARIS MARKET RESEARCH

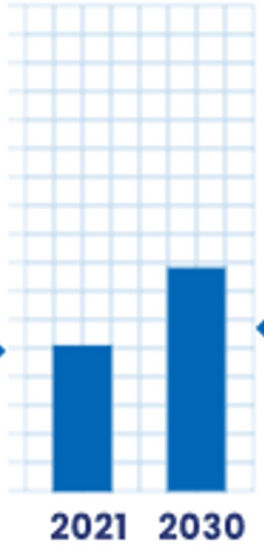
CELLULOSE ACETATE MARKET

+1-929 297-9727 | +44-203-287-6050
sales@polarismarketresearch.com

CAGR FROM 2022 - 2030

5.0%

MARKET SIZE VALUE IN 2021 USD 5.07 BILLION



REVENUE FORECAST IN 2030 USD 7.80 BILLION

KEY COMPANIES

- Biosynth Carbosynth,
- Carbomer, Inc,
- Celanese Corporation,
- Cerdia International,
- Chemos,
- China National Tobacco,
- Daicel Corporation,
- Dongguan He-Hong Plastic Co Ltd,
- Eastman Chemical Company,
- Mitsubishi Chemical,
- Others

BY TYPE

- Fiber
- Plastics

BY PRODUCT

- Cellulose acetate filament
- Cellulose ester plastics
- Cellulose acetate tow
- Cellulose acetate flakes
- Other

BY APPLICATION

- Cigarette Filters
- Textiles & Apparel
- Photographic Films
- Tapes & Labels
- Others

BY REGION

ACETATO DE CELULOSE - APLICAÇÕES

Qual a composição do Carduran XL?

Cada comprimido de liberação prolongada de Carduran® XL 4 mg contém:

Mesilato de doxazosina equivalente a 4 mg de doxazosina base.

Excipientes: óxido de polietileno, hipromelose, óxido férrico vermelho, estearato de magnésio, cloreto de sódio, acetato de celulose, macrogol, Opadry® branco (hipromelose, macrogol e dióxido de titânio) e tinta preta.

ACETATO BUTIRATO/PROPIONATO DE CELULOSE (CAB/CAP)

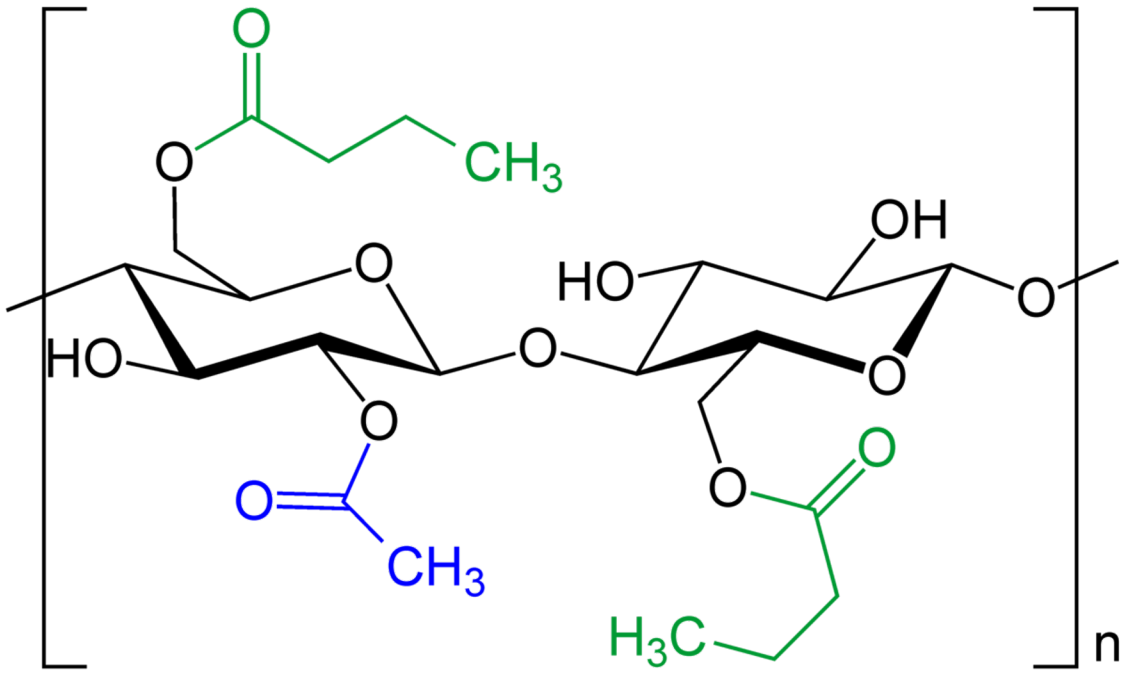


Figure 3. Benefits of using Eastman cellulose esters as additives or modifiers in coating and ink applications

Due to their rapid viscosity build, cellulose esters prevent:

- Film distortions and craters
- Sags and runs
- Picture framing
- Poor metal flake orientation
- Color separation in multipigment systems
- Pigment flooding and floating
- Inconsistent gloss control with matting agents
- Poor holdout

Due to their near-Newtonian rheology, cellulose esters improve:

- Flow and leveling
- Rheology control
- Appearance (reduction of surface defects such as pinholes and craters)
- Spraying (atomization)
- Roll-coat application
- Curtain coat application (reduction of holes)

Due to their high T_g, cellulose esters provide:

- Rapid dry-to-touch times (reduced dirt pickup)
- Excellent hardness and hardness development

Due to their cellulosic polymer nature and pendant groups, cellulose esters have:

- Good UV stability
- Excellent dimensional stability (cold-crack resistance)
- Heat and moisture stability (exterior durability)
- Increased intercoat adhesion (attributed to the good wetting properties of CAB and the controlled level of solvent attack on one coat by a subsequent coat)

EASTMAN

Eastman Chemical Company

Figure 1. Code designation of Eastman cellulose esters, using Eastman CAB 381-0.1

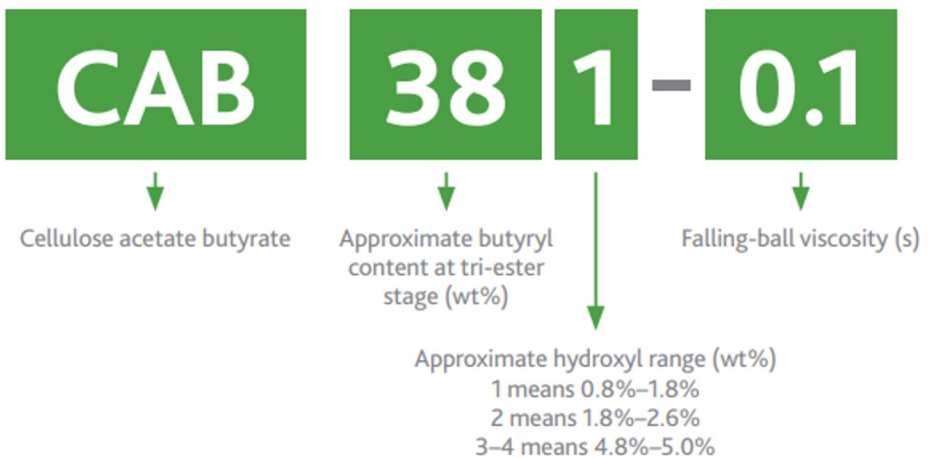
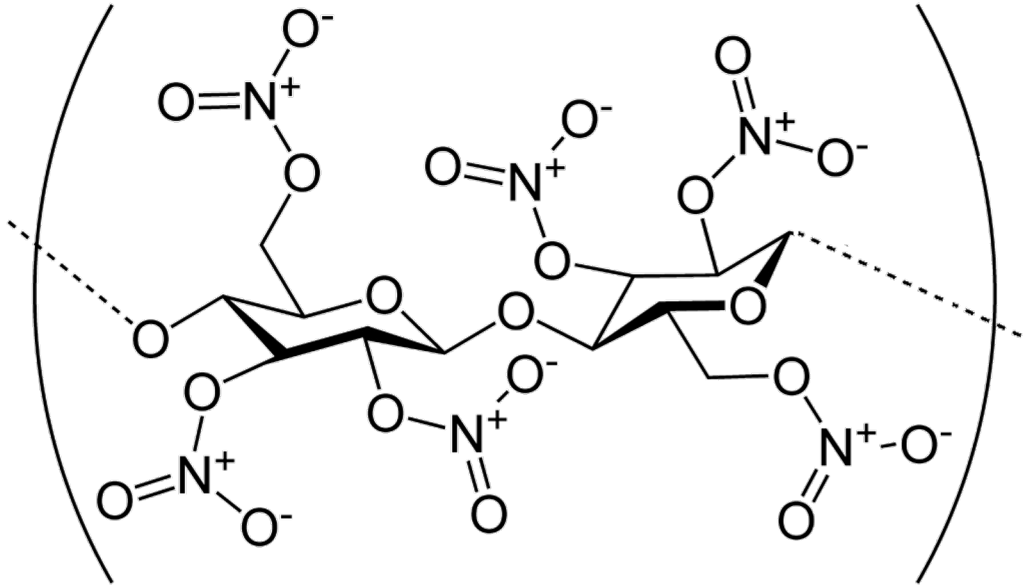
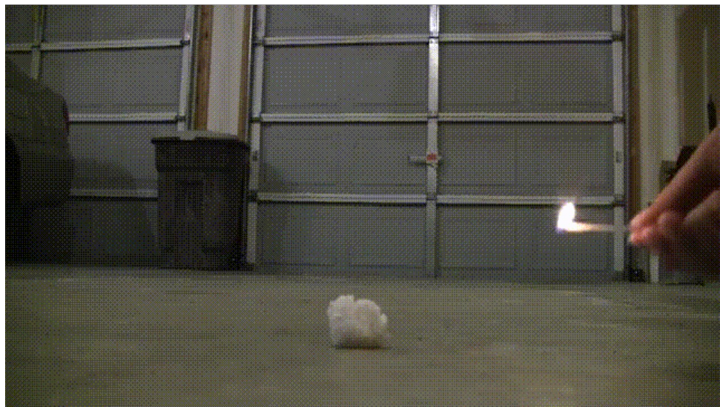


Table 1. Typical properties[a]

Product	Viscosity[b] poise	Viscosity[b] sec	Intrinsic viscosity	Acetyl wt%	Butyryl wt%	Propionyl wt%	Hydroxyl wt%	Specific gravity	T_g,[c] °C	Melting range, °C	MW_n[d]
Cellulose acetate butyrate											
CAB 171-15	57.37	19	—	29	18	—	1.1	1.26	161	230–240	65,000
CAB 321-0.1	0.38	0.1	—	17.5	32	—	1.3	1.2	127	165–175	12,000
CAB 381-0.1	0.38	0.1	—	13.5	38	—	1.5	1.2	123	155–165	20,000
CAB 381-0.1, food contact	0.38	0.1	—	13.5	38	—	1.5	1.2	123	155–165	20,000
CAB 381-0.5	1.9	0.5	—	13.5	38	—	1.5	1.2	130	155–165	30,000
CAB 381-0.5, food contact	1.9	0.5	—	13.5	38	—	1.5	1.2	130	155–165	30,000
CAB 381-2	8	2	—	13.5	38	—	1.3	1.2	130	171–184	40,000
CAB 381-2, food contact	8	2	—	13.5	38	—	1.3	1.2	130	171–184	40,000
CAB 381-2 BP	8	2	—	14.5	35.5	—	1.7	1.2	133	175–185	40,000
CAB 381-20	76	20	—	13.5	37	—	1.8	1.2	141	195–205	70,000
CAB 381-20, food contact	76	20	—	13.5	37	—	1.8	1.2	141	195–205	70,000
CAB 381-20BP	20.8	16	—	15.5	35.5	—	0.8	1.2	128	185–195	70,000
CAB 500-5	19	5	—	3	51	—	1	1.18	96	165–175	57,000
CAB 531-1	5.6	2	—	3	50	—	1.7	1.17	115	135–150	40,000
CAB 531-1, food contact	5.6	2	—	3	50	—	1.7	1.17	115	135–150	40,000
CAB 551-0.01	0.038	0.02	—	2	52	—	2	1.16	85	127–142	16,000
CAB 551-0.01, food contact	0.038	0.02	—	2	52	—	2	1.16	85	127–142	16,000
CAB 551-0.2	0.76	0.2	—	2	52	—	1.8	1.16	101	130–140	30,000
CAB 551-0.2, food contact	0.76	0.2	—	2	52	—	1.8	1.16	101	130–140	30,000
CAB 553-0.4	1.14	0.3	—	2	47	—	4.8	1.2	136	150–160	20,000
CAB 553-0.4, food contact	1.14	0.3	—	2	47	—	4.8	1.2	136	150–160	20,000
Cellulose acetate propionate											
CAP 482-0.5	1.53	0.5	—	1.5	—	45	2.6	1.23	142	188–210	25,000
CAP 482-0.5, food contact	1.53	0.5	—	1.5	—	45	2.6	1.23	142	188–210	25,000
CAP 482-20	76.5	20	—	1.3	—	48	1.7	1.22	147	188–210	75,000
CAP 482-20, food contact	76.5	20	—	1.3	—	48	1.7	1.22	147	188–210	75,000
CAP 504-0.2	0.76	0.2	—	0.5	—	42.5	5	1.26	159	188–210	15,000
CAP 504-0.2, food contact	0.76	0.2	—	0.5	—	42.5	5	1.26	159	188–210	15,000
Cellulose acetate											
CA 394-60LF	228	34	—	40	—	—	4	1.32	180	240–260	—
CA 398-3	11.4	3	—	39.8	—	—	3.5	1.31	180	230–250	30,000
CA 398-3, food contact	11.4	3	—	39.8	—	—	3.5	1.31	180	230–250	30,000
CA 398-6	22.8	6	—	39.8	—	—	3.5	1.31	182	230–250	35,000
CA 398-30	114	30	—	39.7	—	—	3.5	1.31	189	230–250	50,000
Eastman Solus™ performance additives											
Solus 2100	—	—	0.08	2	53	—	1.6	1.2	75	—	—
Solus 2100, food contact	—	—	0.08	2	53	—	1.6	1.2	75	—	—
Solus 2300	—	—	0.095	19	30	—	1.6	1.22	~110	—	—
Solus 3050	1.02	0.3	—	1.9	46.7	—	2.8	—	130	—	—

NITROCELULOSE – O DERIVADO DE CELULOSE “ESQUENTADINHO”





NITROCELLULOSE GROUP

The New York Times

Tianjin Explosions Were Result of Mismanagement, China Finds

Give this article

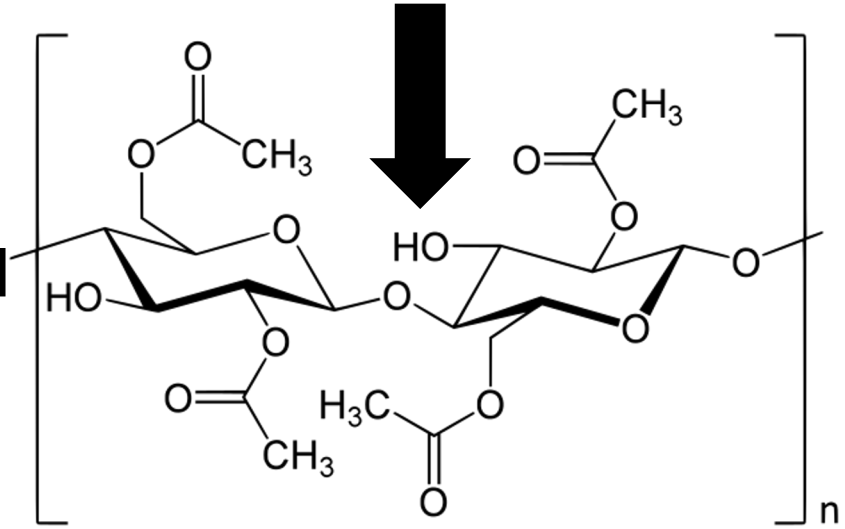
The aftermath of explosions in Tianjin, China, in 2015. A new report described the blasts as a man-made disaster that caused $1.1 billion in damage. Ng Han Guan/Associated Press

The report said the explosions had occurred when an improperly stored chemical became too dry and ignited, setting fire to nearby containers full of explosive substances. The chemical, nitrocellulose, is used in nail polish and lacquer. It was near containers of ammonium nitrate, a highly explosive chemical commonly used in fertilizers.

LUZ, CÂMERA, EXPLOSÃO, VINAGRE E AÇÃO

Utilização da nitrocelulose em carretéis de filme

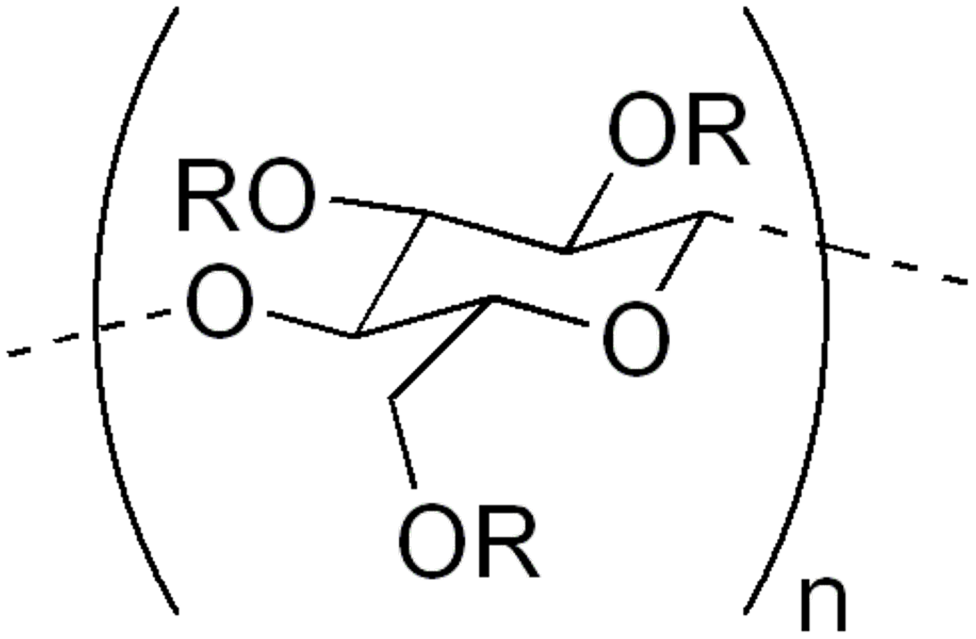
Explosão na produtora Lubin em 1914, Filadélfia (USA)



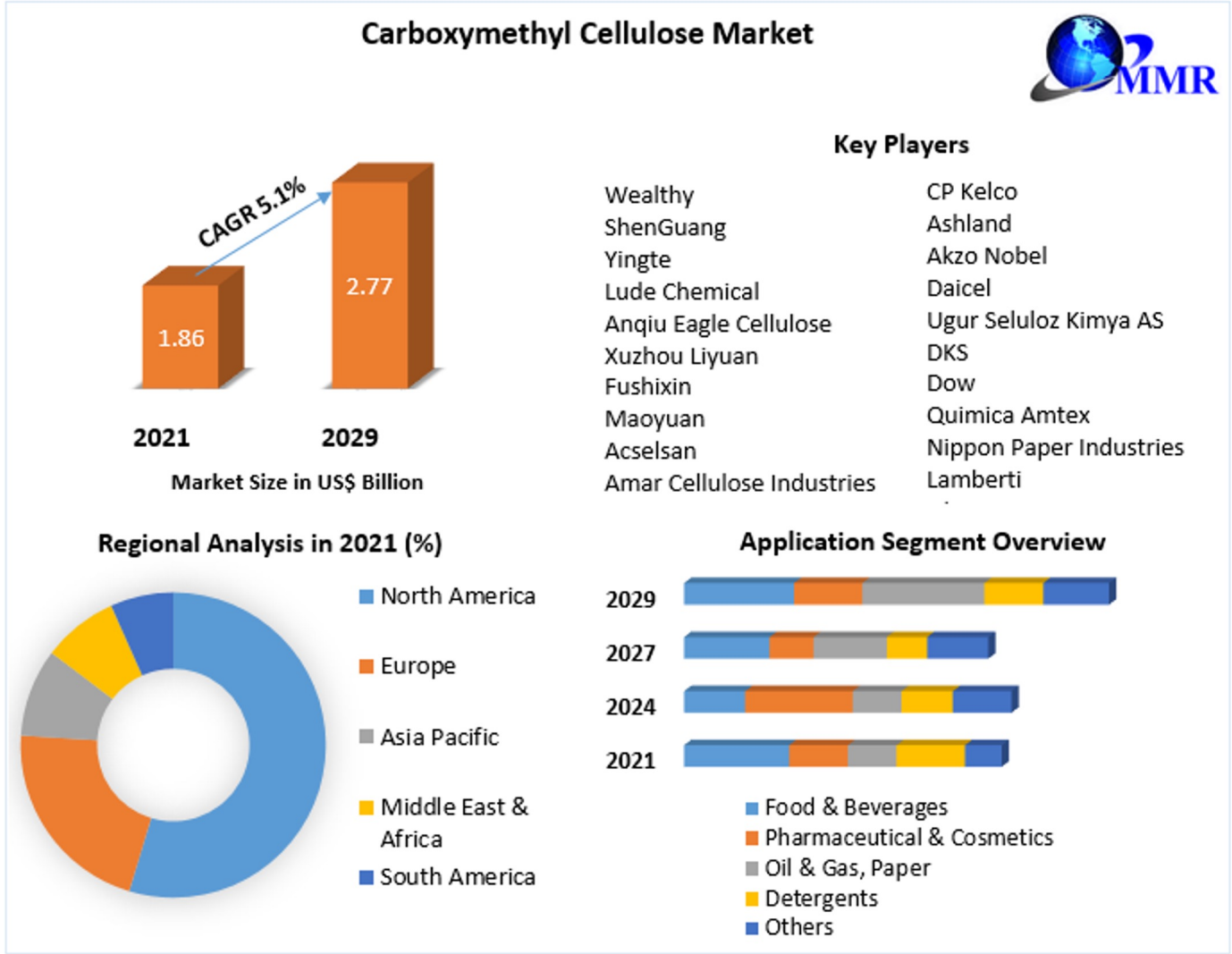
Fabricação de filmes com acetato de celulose (1950)

"Vinegar syndrome"

CARBOXIMETILCELULOSE (CMC)



$R = H \text{ or } CH_2CO_2H$



APLICAÇÕES DA CMC

ALIMENTOS

CREME DENTAL

INGREDIENTES

Sorbitol, aqua, hydrated silica, sodium lauryl sulfate, aroma, cellulose gum, sodium fluoride, sodium saccharin, zinc sulfate, sodium hydroxide, synthetic fluorphlogopite, titanium dioxide, ci 42090, limonene. Contém sacarina sódica. Ingrediente ativo: contém fluoreto de sódio (1450 ppm ion flúor).

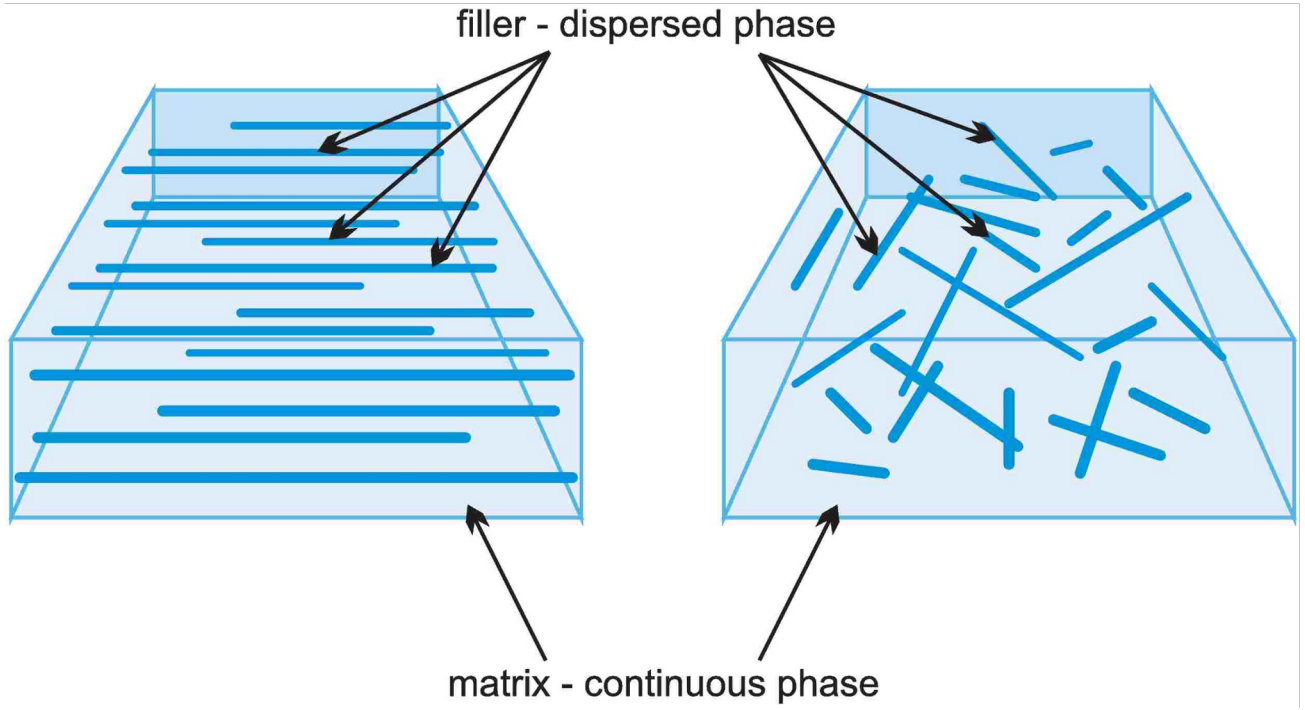
COLÍRIO

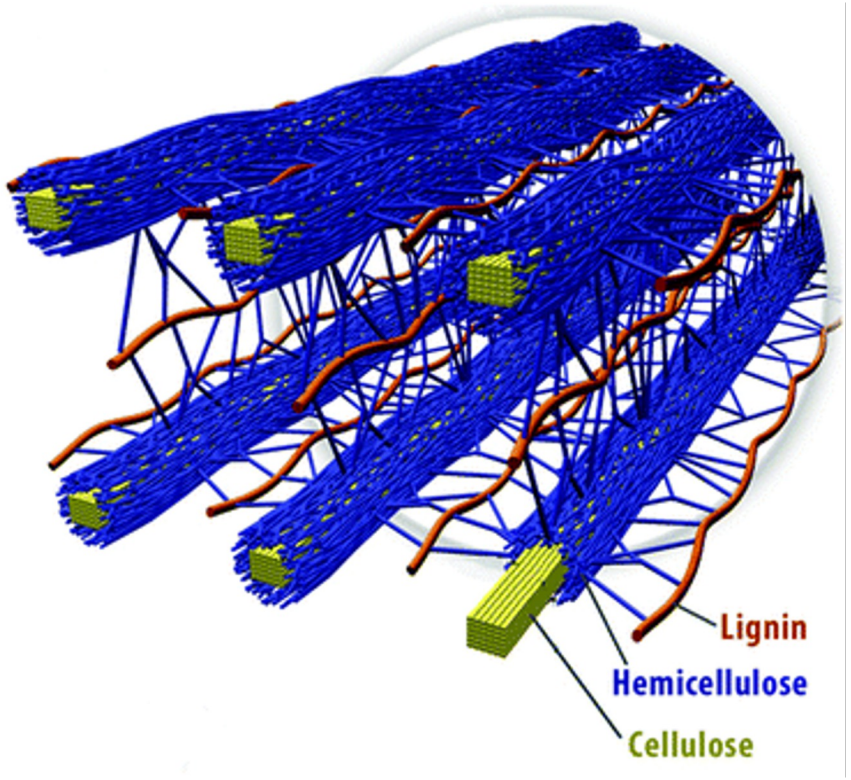
Ingredientes:

Tomate, vinagre, água, açúcar, sal, cebola, espessantes carboximetilcelulose sódica e goma xantana, acidulante ácido cítrico, conservador ácido sórbico e aromatizantes.

COMPÓSITOS COM CELULOSE

- Um compósito é composto por uma fase contínua (matriz) e uma fase dispersa;
- As propriedades de um compósito são superiores e únicas em comparação as propriedades dos componentes individuais;





COMPÓSITOS COM CELULOSE - CONCRETO

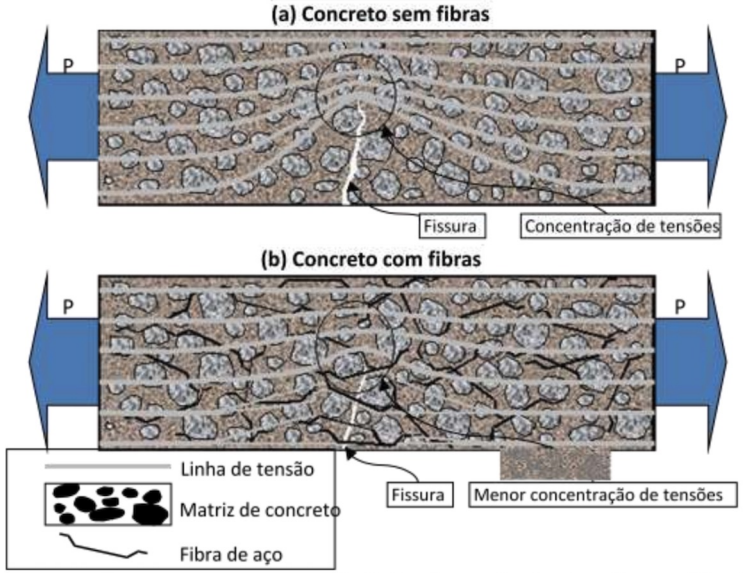


Figura 2.15 – Esquema de concentração de tensões para um concreto sem (a) e com reforço de fibras (b) (Figueiredo, 2000).

Materials Today Communications 22 (2020) 100818

Contents lists available at ScienceDirect

Materials Today Communications

journal homepage: www.elsevier.com/locate/mtcomm

Mechanical properties and engineering application of cellulose fiber-reinforced concrete

Weili Ma[a,b], Yuan Qin[a,b,*], Yanlong Li[a,*], Junrui Chai[a,b], Xianwei Zhang[a], Yingbiao Ma[a], Haimin Liu[b]

[a] State Key Laboratory of Eco-hydraulics in Northwest Arid Region of China, Xi'an University of Technology, Xi'an 710048, PR China
[b] Qinghai Huanghe Electric Power Technology Co., Ltd., PR China

Table 2
Mix designs of PC and CFRCs.

Type	Water	Cement	Sand	Aggregate	Fly ash	Water reducers	Fiber content
Unit (kg/m^3)							
PC	120	253	694	1287	63	2.53	–
CFRC-0.6	125	263	687	1276	66	2.63	0.6
CFRC-0.9	125	263	687	1276	66	2.63	0.9
CFRC-1.2	125	263	687	1276	66	2.63	1.2
CFRC-1.5	125	263	687	1276	66	2.63	1.5

COMPÓSITOS COM CELULOSE - CONCRETO

Materials Today Communications 22 (2020) 100818

Contents lists available at ScienceDirect

Materials Today Communications

journal homepage: www.elsevier.com/locate/mtcomm

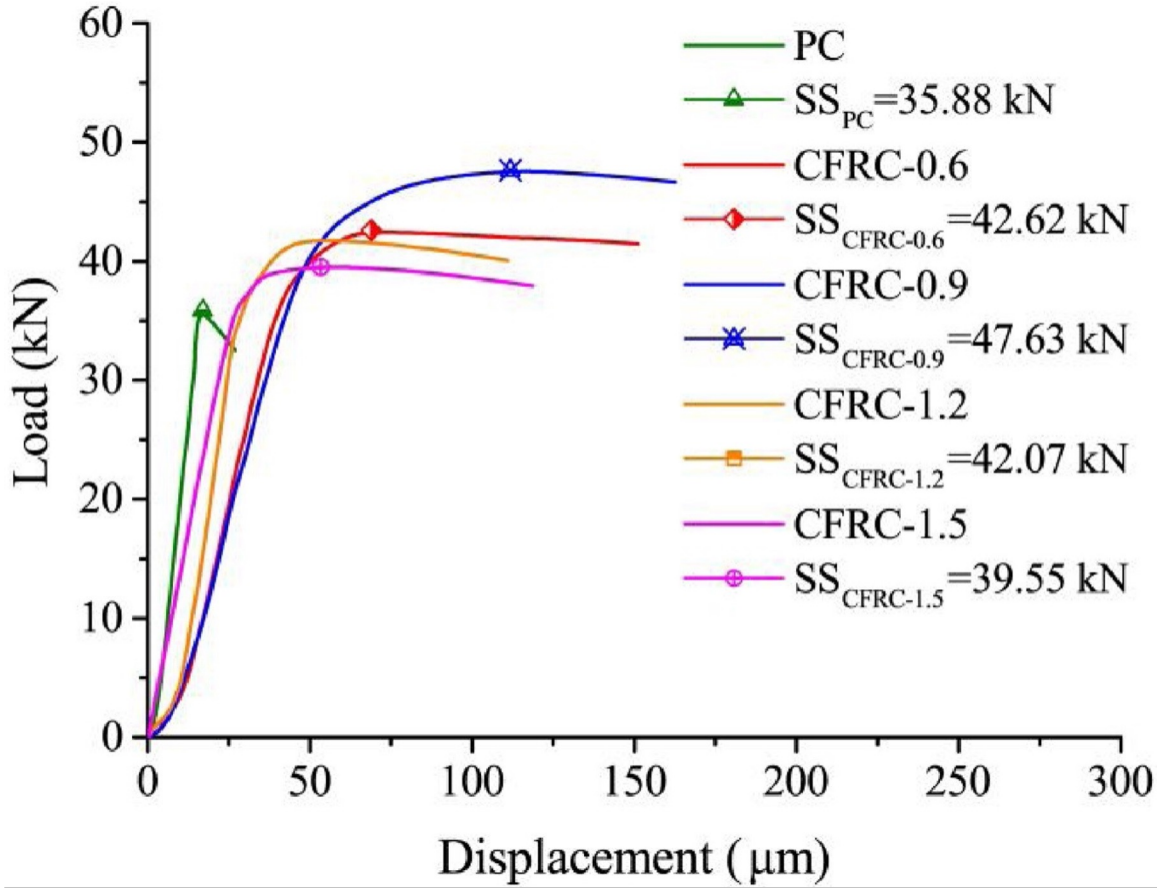
Mechanical properties and engineering application of cellulose fiber-reinforced concrete

Weili Ma[a,b], Yuan Qin[a,b,*], Yanlong Li[a,*], Junrui Chai[a,b], Xianwei Zhang[a], Yingbiao Ma[a], Haimin Liu[b]

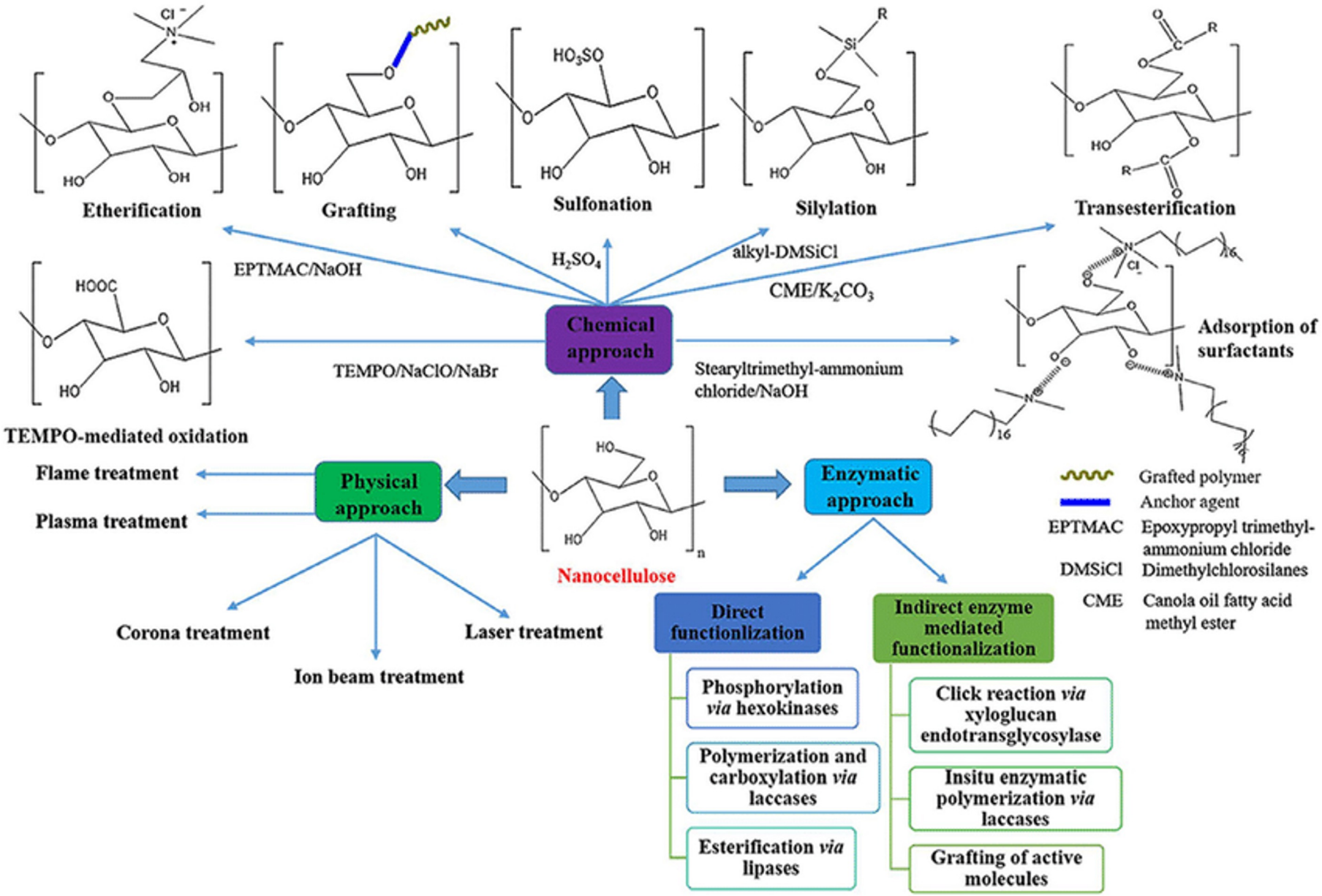
[a] State Key Laboratory of Eco-hydraulics in Northwest Arid Region of China, Xi'an University of Technology, Xi'an 710048, PR China
[b] Qinghai Huanghe Electric Power Technology Co., Ltd., PR China

Table 2
Mix designs of PC and CFRCs.

Type	Water	Cement	Sand	Aggregate	Fly ash	Water reducers	Fiber content
Unit (kg/m^3)							
PC	120	253	694	1287	63	2.53	–
CFRC-0.6	125	263	687	1276	66	2.63	0.6
CFRC-0.9	125	263	687	1276	66	2.63	0.9
CFRC-1.2	125	263	687	1276	66	2.63	1.2
CFRC-1.5	125	263	687	1276	66	2.63	1.5



COMPÓSITOS COM CELULOSE (COMPATIBILIDADE)



Article

JOURNAL OF COMPOSITE MATERIALS

Journal of Composite Materials
2017, Vol. 51(13) 1807–1815

DOI: 10.1177/0021998316665241
journals.sagepub.com/home/jcm
SAGE

Cellulose fiber-reinforced high-density polyethylene composites—Mechanical and thermal properties

Daniella R Mulinari[1], Herman JC Voorwald[2], Maria OH Cioffi[2] and Maria LCP da Silva[3]

Table 3. Mechanical properties of the composite materials.

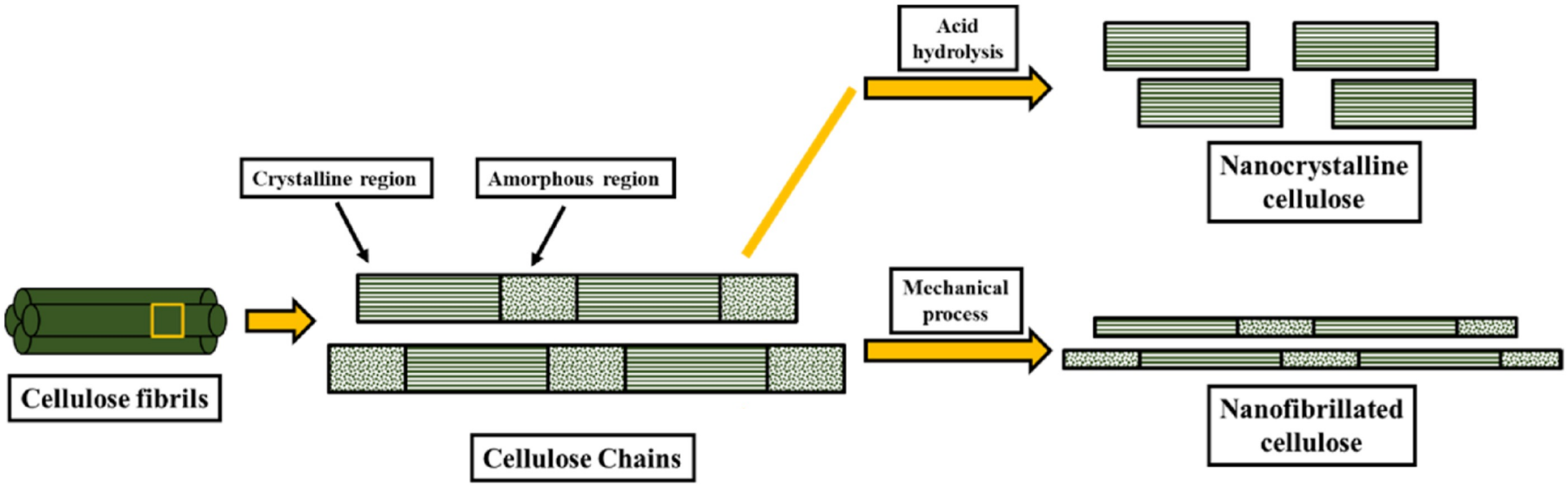
Samples	Elongation at break (%)	Tensile strength (MPa)	Tensile modulus (MPa)	Flexural strength (MPa)	Flexural modulus (MPa)	Impact strength ($kJ.m^{-2}$)
HDPE	8.9 ± 0.8	15.7 ± 1.1	732.5 ± 90.6	18.6 ± 0.2	794 ± 17	38.9 ± 0.5
CCB5%	5.4 ± 0.4	16.2 ± 0.7	942.5 ± 98.6	18.8 ± 0.4	1002 ± 32	45.9 ± 0.1
CCB10%	5.5 ± 0.2	15.6 ± 0.3	897 ± 27.5	20.1 ± 0.7	1107 ± 35	46.5 ± 0.1
CCB20%	5.7 ± 0.3	15.8 ± 0.3	1141 ± 62.5	20.4 ± 0.3	1087 ± 37	48.0 ± 0.2
CCB30%	6.0 ± 0.7	16.7 ± 0.8	1156 ± 178	21.9 ± 1.4	1176 ± 65	49.0 ± 0.3
CCB40%	5.7 ± 0.5	16.8 ± 1.3	1217 ± 191	22.1 ± 1.0	1238 ± 50	50.6 ± 0.1
CCM5%	7.2 ± 0.1	20.8 ± 0.4	1178 ± 25	18.8 ± 0.7	1294 ± 94	48.1 ± 0.7
CCM10%	7.4 ± 0.4	21.9 ± 0.6	1238.5 ± 41	22.1 ± 0.5	1244 ± 21	50.0 ± 0.1
CCM20%	6.5 ± 0.2	20.9 ± 0.4	1306 ± 27	21.3 ± 0.5	1241 ± 40	51.6 ± 0.1
CCM30%	5.5 ± 0.2	19.9 ± 0.4	1490 ± 71	23.2 ± 0.1	1303 ± 30	52.4 ± 0.1
CCM40%	5.9 ± 0.4	23.2 ± 0.6	1629 ± 109	23.1 ± 1.7	1304 ± 97	53.5 ± 0.1

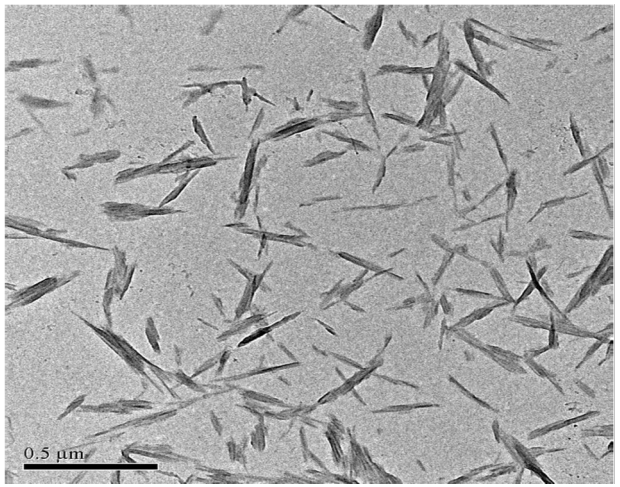
CCB%, HDPE composites reinforced with cellulose fibers non-modified %wt; CCM%, HDPE composites reinforced with cellulose fibers modified %wt.

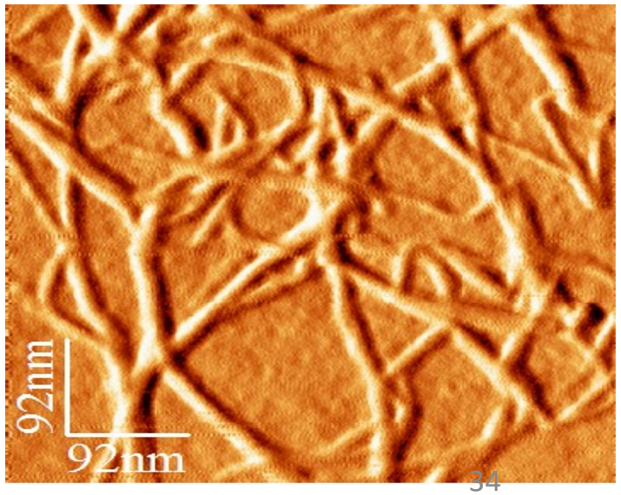

VOCÊ CONHECE A
NANOCELULOSE?
© 1980 Warner Bros. Inc.

NANOCELULOSE

DEFINIÇÃO: Partículas de celulose com pelo menos uma dimensão abaixo de 100 nanômetros.

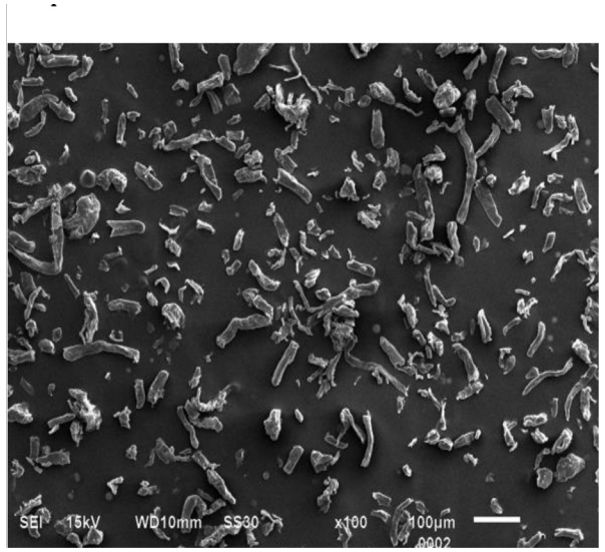






ENTRE O MACRO E O NANO TEM O MICRO ...

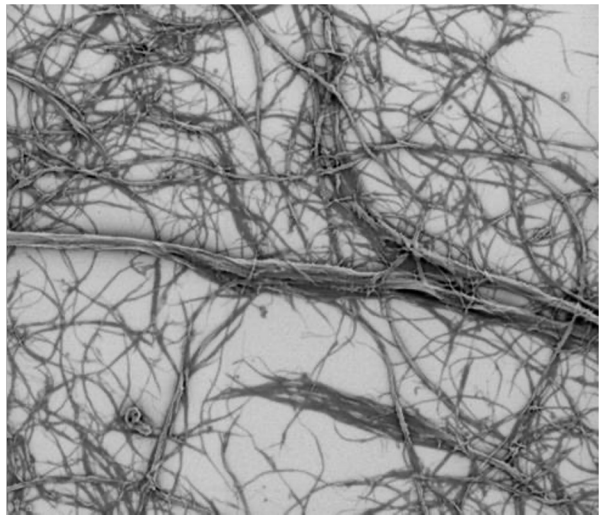
Celulose Microcristalina (MCC)



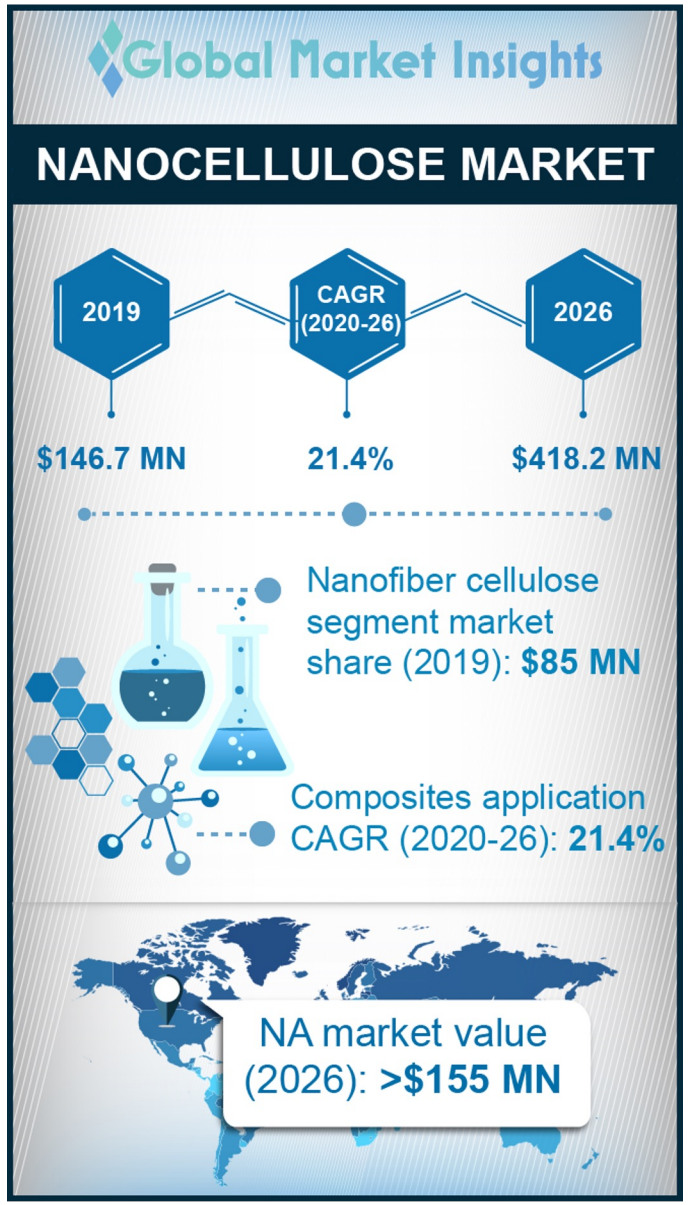
TAPPI WI3021

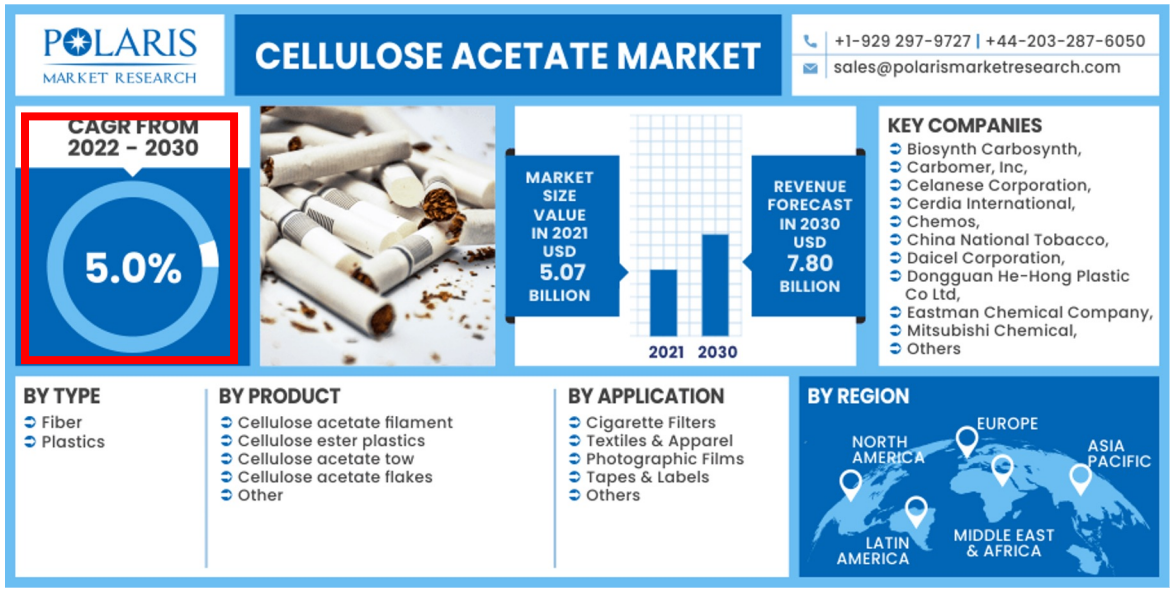
INGREDIENTES: Cafeína anidra, agente de massa celulose microcristalina, estabilizante polivinilpirrolidona, lubrificante estearato de magnésio e antiumectante dióxido de silício. **NÃO CONTÉM GLÚTEN.**

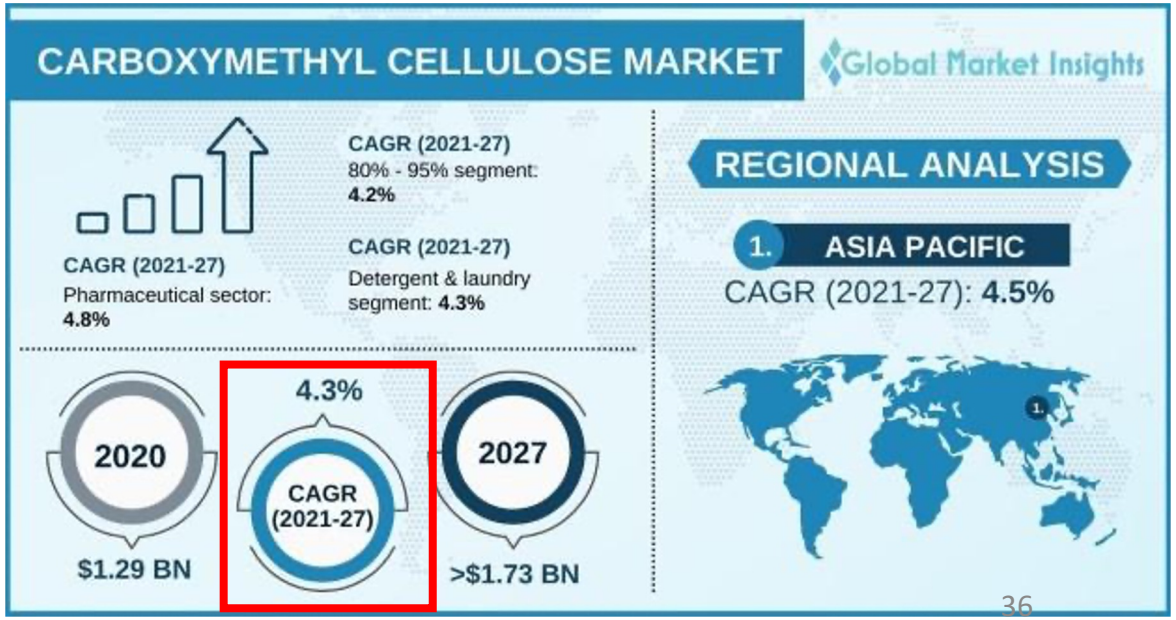
Celulose Microfibrilada (MCF)



NANOCELULOSE - MERCADO







NANOCELULOSE PELO MUNDO ...

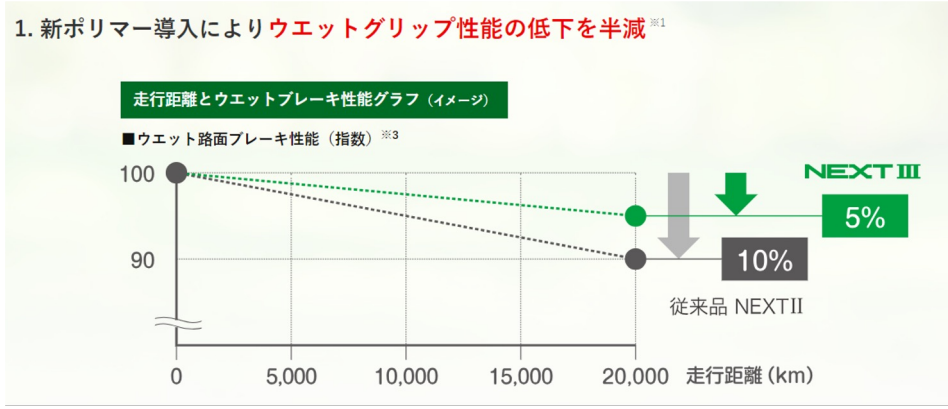
BIOSAKURA

asics

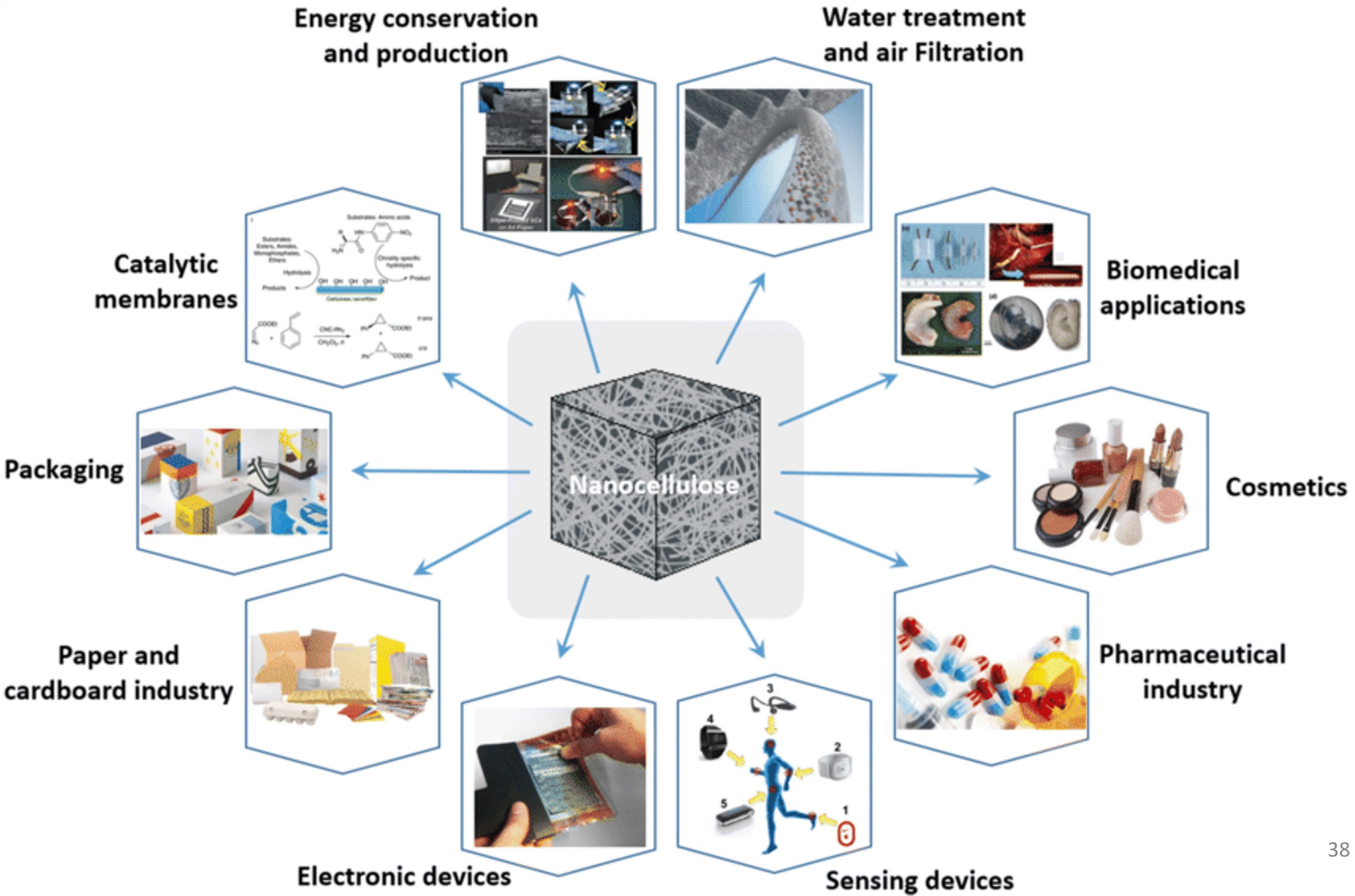
asics About ASICS Investor Relations Sustainability Press Career

INTRODUCING GEL-KAYANO 25: THE FIRST EVER SHOE TO FEATURE NEXT- GENERATION HIGH PERFORMANCE MATERIAL CELLULOSE NANOFIBER

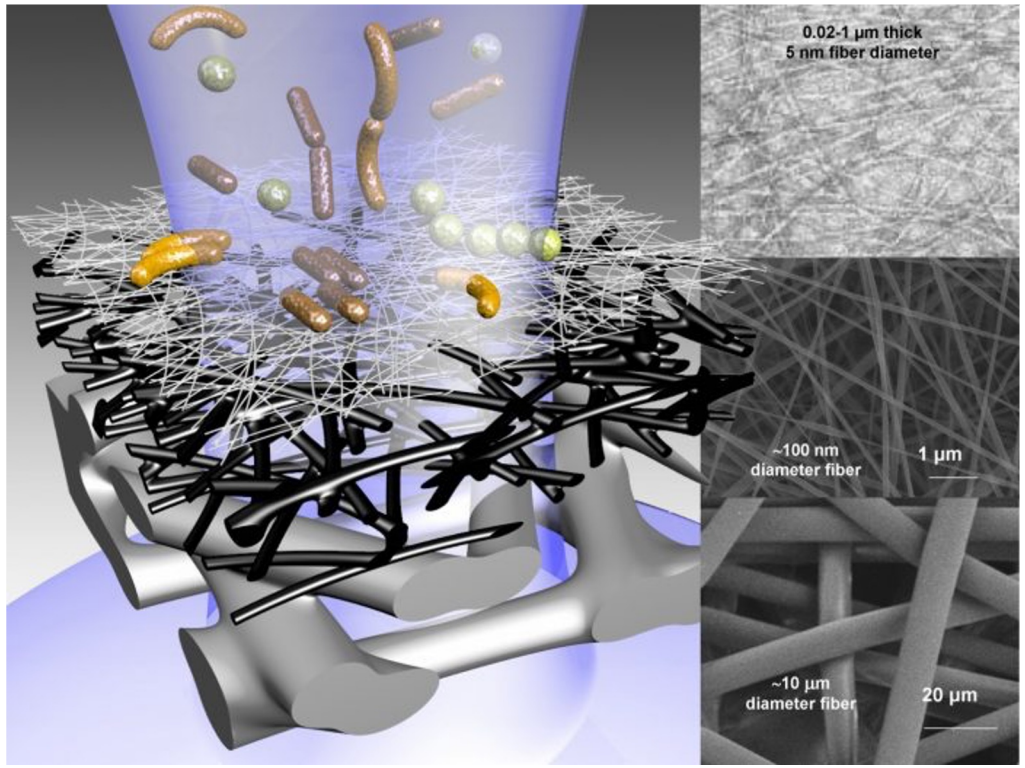
SUMITOMO RUBBER INDUSTRIES



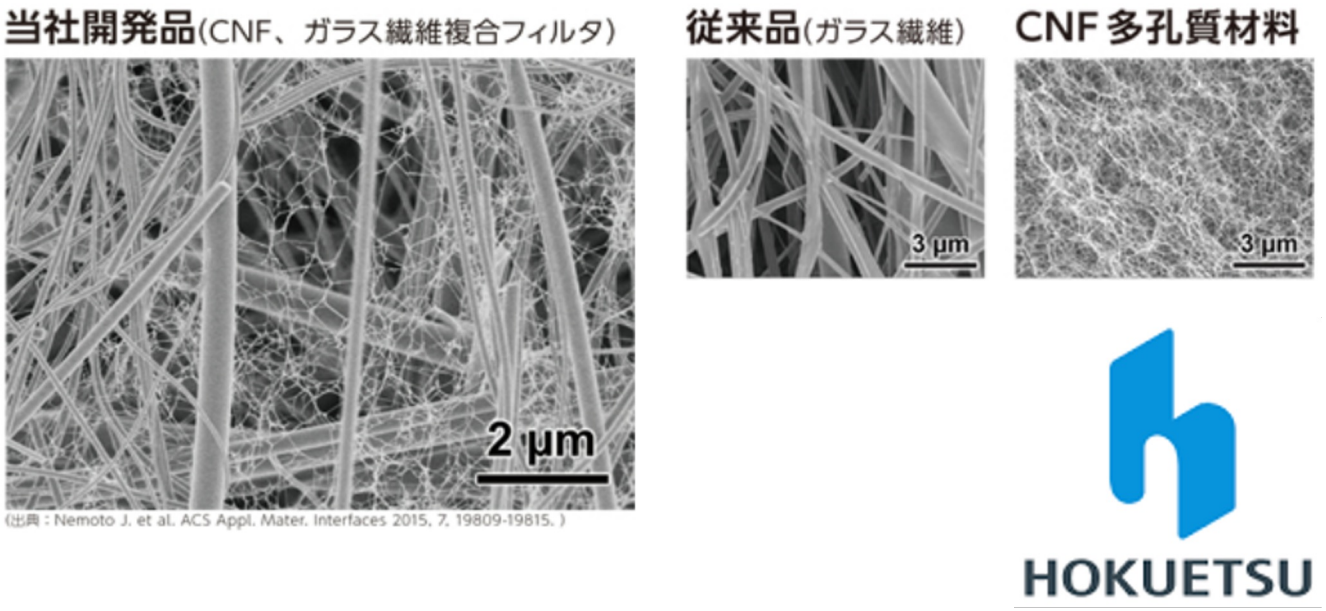
APLICAÇÕES DA NANOCELULOSE



APLICAÇÕES DA NANOCELULOSE – MEMBRANAS DE PURIFICAÇÃO



FILTRO DE AR COM FIBRAS DE VIDRO E CNF



(出典：Nemoto J. et al. ACS Appl. Mater. Interfaces 2015, 7, 19809-19815.)

CHEMICAL REVIEWS

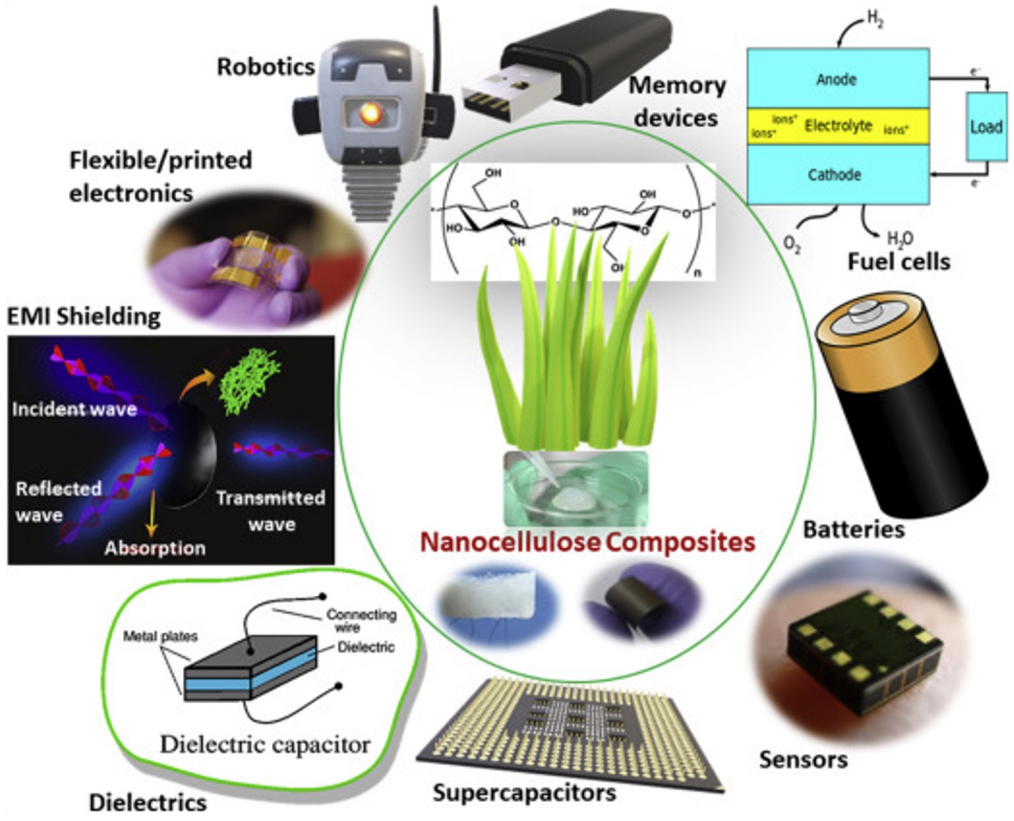
pubs.acs.org/CR Review

Nanocellulose for Sustainable Water Purification

Rasel Das, Tom Lindström,* Priyanka R. Sharma, Kai Chi, and Benjamin S. Hsiao*

Cite This: *Chem. Rev.* 2022, 122, 8936–9031 Read Online

APLICAÇÕES DA NANOCELULOSE – DISPOSITIVOS ELETRÔNICOS



frontiers in Chemistry

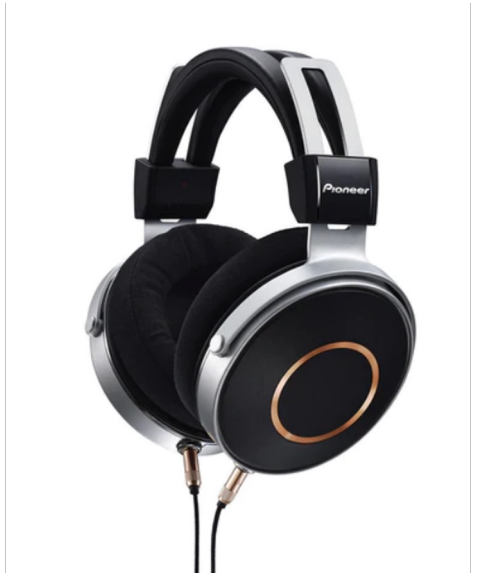
REVIEW
published: 21 May 2020
doi: 10.3389/fchem.2020.00420

Current State of Applications of Nanocellulose in Flexible Energy and Electronic Devices

Otavio Augusto Titton Dias[1], Samir Konar[1,2], Alcides Lopes Leão[3], Weimin Yang[4], Jimi Tjong[1,2] and Mohini Sain[1,2]*

[1] Centre for Biocomposites and Biomaterials Processing, University of Toronto, Toronto, ON, Canada, [2] Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, ON, Canada, [3] College of Agricultural Sciences, São Paulo State University (Unesp), São Paulo, Brazil, [4] College of Mechanical and Electrical Engineering, Beijing University of Chemical Technology, Beijing, China

SE-MONITOR5 HI-RES STEREO HEADPHONES

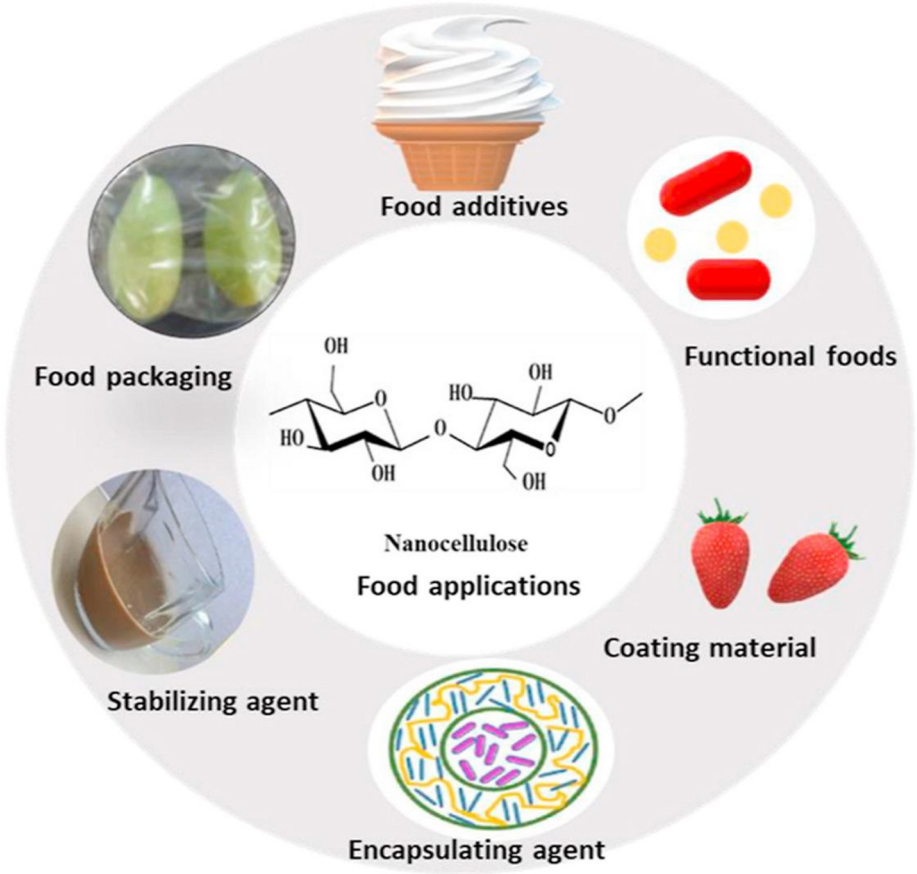


Pioneer

Audio Features

- 50 mm (1.96") Cellulose Nano-Fiber Wide-Spectrum Driver
- Magnesium Alloy Base and Housing to Reduce Resonance
- Advanced Double Chamber Construction with Ports for Bass Definition and Clarity
- Magnesium Alloy Housing with Original Diffuser to Reduce Distortion
- Copper-coated Aluminum Voice Coil and Large Magnet
- Full-frame Magnesium Alloy Basket with Screws
- Cable 3.0 m OFC litz wire
- Floating Structure with Rubber Insulators to Reduce Vibration and Cross-channel Interference

APLICAÇÕES DA NANOCELULOSE – ALIMENTOS



Dorayaki (185 ienes cada)

Ao amassar a nanofibra de celulose "Serenpia" desenvolvida pela Nippon Paper Industries Co., Ltd. na massa dorayaki, é possível criar uma massa "fofa e úmida"

御菓子庵 日子の月

ELSEVIER

Food Hydrocolloids
Volume 127, June 2022, 107484

Nanocellulose: Recent trends and applications in the food industry

Anand Babu Perumal [a c], Reshma B Nambiar [b d], J.A. Moses [a], C. Anandharamakrishnan [a]

APLICAÇÕES DA NANOCELULOSE – CARRO CONCEITO (TOKYO MOTOR SHOW 2019)