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"Nano Bio-mimetics; Materials for the future"



Our current materials, structures and machines



Our current materials and structures



3 billion years of evolution resulted in super performing materials and structures.



Sequoia trees; hundreds of tons for hundreds of years



in the sun and UV light









CNC; The future of the Industry







Alibaba.com

Pulp & Paper Industry Waste, a Perfect Source for CNC



Pulp & Paper Industry Waste, a Perfect Source for CNC



11M ton waste annually in Europe alone



Converting environmental problem to a goldmine



Microscope image of the CNC



SEM cross-section analysis of cross-linked vs normal CNC films

NORMAL

CROSS-LINKED



 $100,000 \times$

200,000 ×.

Tensile strength of Normal vs cross-linked and CNC films





CNC dramatically improves strength of cotton fibers



Photo: MizC / iStockphoto Photo: Brendan Hunter / iStockphoto

<u>CNC/CNT (Tortech CNT) composite conducting films</u>



Electric resistance: 29 Ω/sq



CNC Super hydrophilic coating

Spray coatings of CNC based formulation











Super hydrophobic aerogel











CatFleas Jumping Skills





Equivalent to Human Jumping 400 m High

Production of Recombinant Resilin Engineered With a Cellulose Binding Domain (CBD)



Adding a drop of resilin into a stiff CNC foam





JUMP HIGHER





Res-CBD-CNC film Super performing material !!! Tough, Elastic, Transparent

Stress-Strain curves of Instron tested NCC and Res-CBD-NCC containing films



• NCC + 0.5% glycerol: 1[MJ/m3]

Rivkin et al., 2015. Industrial Biotechnology. 11(1): 44-58.

Resilin-CBD impose long-range molecular order in CNC films

Polarized optical microscopy



Rivkin et al., 2015. Industrial Biotechnology. 11(1): 44-58.

Synthetic medical implants "screw and glue"



Synthetic materials fail to perform

In nature organisms are self assembled





Our body is made of **collagen**

TRIPLE COLLAGEN HELIX



ARTIFICIAL MENISCUS



AUTOGENOUS BLOCK GRAFT



BIOLOGICAL HEART VALVE



"Autogenous block graft" by Dental Specialty Group - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http:// commons.wikimedia.org/wiki/File:Autogenous_block_graft.jpg#mediaviewer/ File:Autogenous_block_graft.jpg "Carpentier-Edwards biological heart valve" by Stif Komar - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Carpentier-Edwards_biological_heart_ valve.jpg #mediaviewer/File:Carpentier-Edwards_biological_heart_ valve.jpg





Federal Register January 12, 2007: The FDA is proposing to prohibit the use of certain cattle material in drugs, biologics and medical devices intended for use in humans





Large scale Human collagen produced in tobacco plants



STATISTICS OF THE VIEW OF THE OWNER OWNE







Vergen x^mFG - Full wound closure at 4 weeks after a single treatment Clinical trial results

Study Design

- Single arm study
- 20 patients with lower limb ulcer
- One single treatment
- 4 week follow up
- End points Safety; wound reduction



Study Results

- Average wound closure rate of 80%
- Full wound closure was observed in nine of the 20 patients (45%)
 - Versus 24% of patients after 12 weeks with SoC¹



1. "The efficacy and safety of Grafix for the treatment of chronic diabetic foot ulcers: results of a multicenter, controlled, randomized, blinded clinical trial," Lavery et al, International Wound Journal, 2014.





Yaari et al., 2016. ACS Biomaterials Science & Engineering in press

Draw Ratio

Fiber Morphology Reflects Degree of Alignment Scanning Electron Microscopy of fibers



Yaari et al., 2016. ACS Biomaterials Science & Engineering in press

Fiber Mechanical Properties Versus Draw Ratio



Fiber	Strength [GPa]	Toughness [MJ/M ³]
rhCollagen wet spun		
fibers	0.4	44
Araneus MA silk	1.1	160
Araneus viscid silk	0.5	150
<i>Bombyx mori</i> cocoon silk	0.6	70
Tendon collagen Bone	0.15 0.16	7.5 4



Energy at Break [MJ/m^3]



Yaari et al., 2016. ACS Biomaterials Science & Engineering in press

Rat tenocytes alignment on drawn rhcollagen fibers





Collagen-Resilin Composite Fibers



Cytoskeletal organisation of the HDFs seeded on the scaffolds, cells were stained for F-actin using rhodaminephalloidin and nuclear staining using ethidium after 1, 4, and 7 days of incubation.

Sanami et al., 2015 Biomed Mater. 10(6): 1748-6041.



Stress Strain curves of 0 and 5% Resilin in Collagen Fibers

380% increase in toughness300% increase in strain at break

Collagen-Resilin artificial tendon and ligaments

Sanami et al., 2015 Biomed Mater. 10(6): 1748-6041.

Fabricate organs for transplantation



TGGGAGTGCGCCGAGCTGCTCAGCTAAAAAATGCATC GIGGCCGTGA STAN AL TTGGAAGTTTATGAGAAG GGAATG TCATGCTTCCCCCA 3 TAA CCACATAT GTGCTTCC GGAAGT TGCAAGGTCAAGA//GT IGG TT/ A/ CG TR ACI AC. JAGTAACAATATCTTAGGGGTTUCGA AGTTGCTCTAT .00. TGGGGAAICTCAAAGATCCAAG CGL JAGL JCTL JCTL NAAAL GCAT TO ICCTGCAC GTGG CGTG/ AAG TTTC CATC ACT ATCCCAGT TATGAL SETTO GTCA CCCT ITTO GGAATGCGA TAAAAAA GAGTAACAATATCT TAGGGGTT TGGGGTGAAAA CAAGAAG (I CAAAGAI (CAAGAGG STERGERECTECTEASETAAAAAATGEATE TTCATA

if you want a new idea, open an old book

