Odlični v znanosti 2013

SLOVENSKI 9. FORUM INOVACIJ

INOVATIVNI POTENCIAL SLOVENIJE

Functional patterning of biopolymer thin films using enzymes and lithographic methods

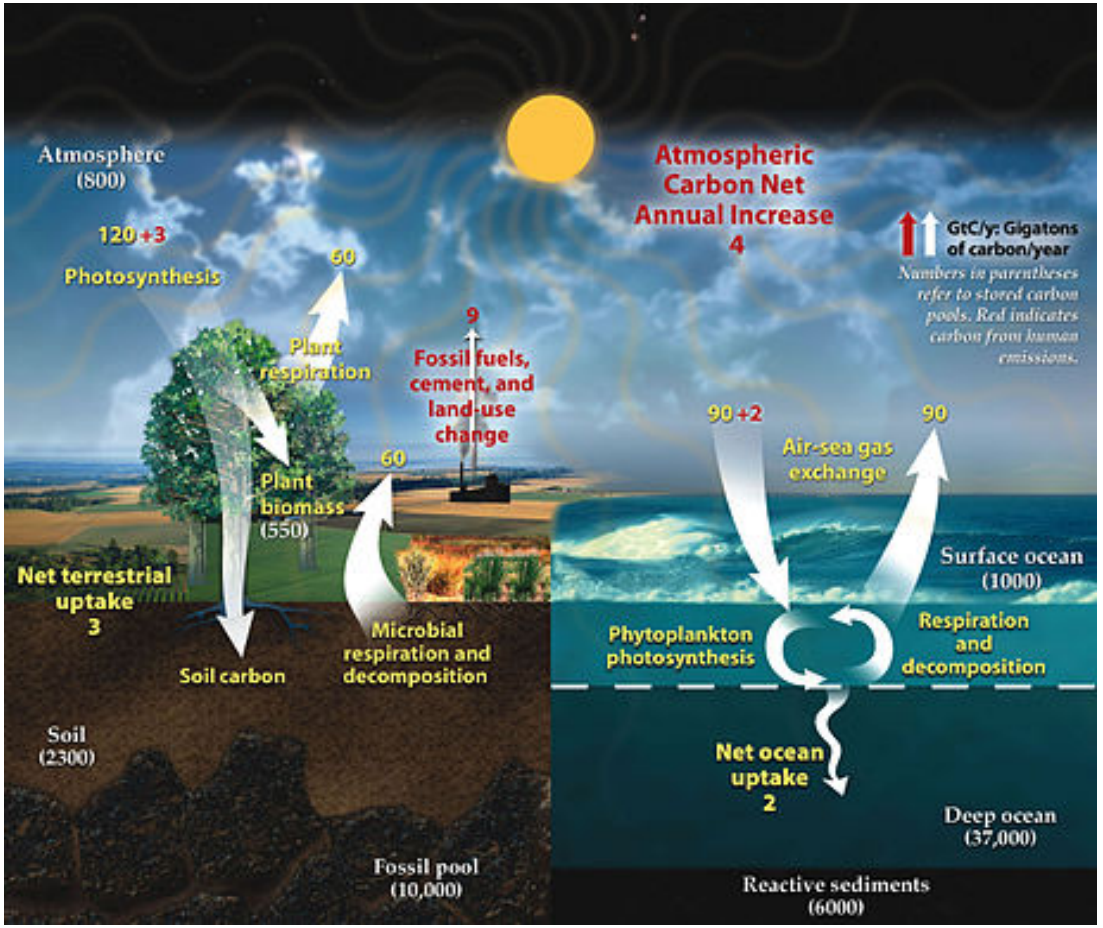
Rupert Kargl, Univerza v Mariboru

SPIRIT SLOVENIJA JAVNA AGENCIJA | I FEEL SLOVENIA

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA GOSPODARSKI RAZVOJ IN TEHNOLOGIJO

JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST REPUBLIKE SLOVENIJE

What Nature Produces for Free – The CO_2 cycle



What Nature Produces for Free – The CO_2 cycle

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Terrestrial plant biomass carbon stock 550 billion t

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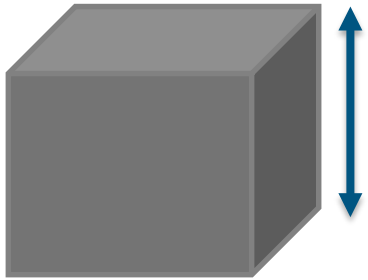

6.5 km (2t/m³ pure carbon)

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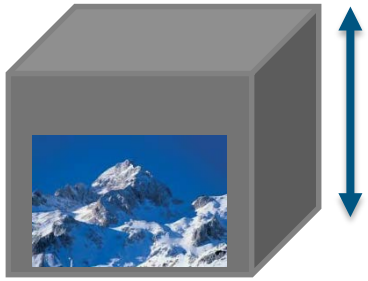

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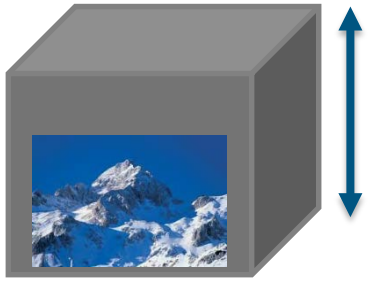
Vegetation binds net 59 billion t carbon per year from the atmosphere[1,2]



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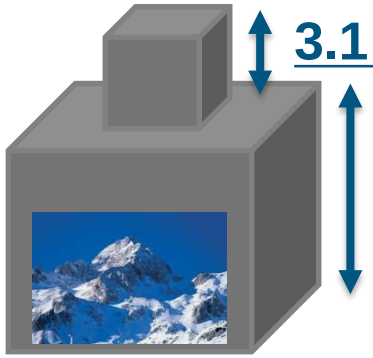

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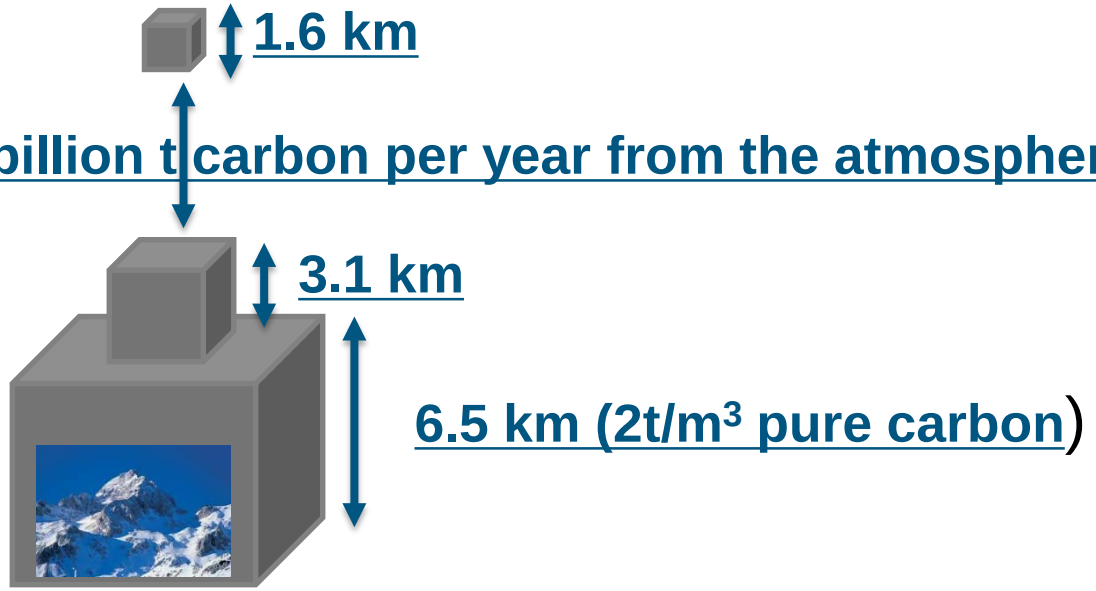
What Nature Produces for Free – The CO_2 cycle

All humans harvest 8 billion t carbon per year - *Wood & Food*[2]



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Fossil carbon used by humans per year 10 billion t
Coal - Oil – Gas - Cement[3]

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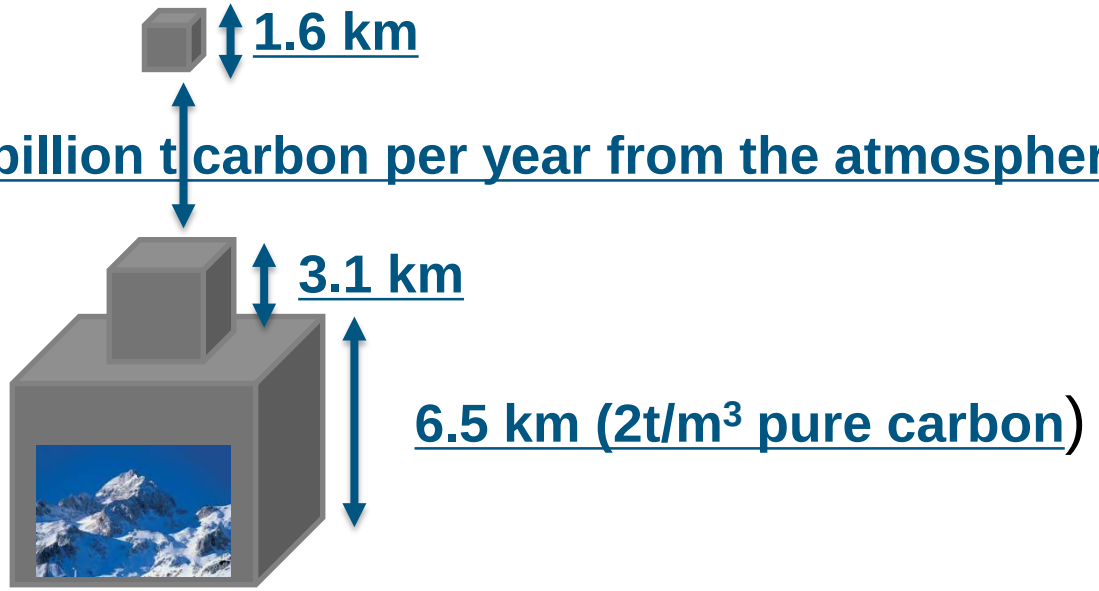

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Fossil carbon used by humans per year 10 billion t
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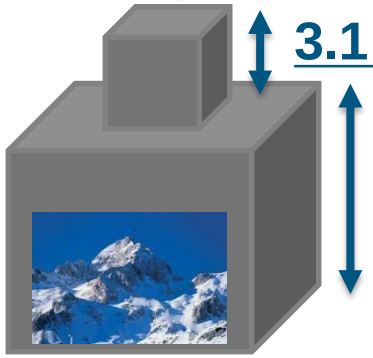
1.7 km

All humans harvest 8 billion t carbon per year - *Wood & Food*[2]

1.6 km

Vegetation binds net 59 billion t carbon per year from the atmosphere[1,2]



3.1 km

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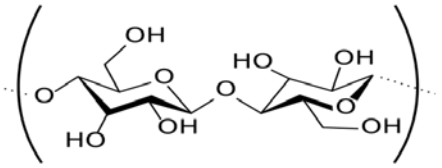
Are We Smart Enough in Using Plant Biomass?

Plant Biomass

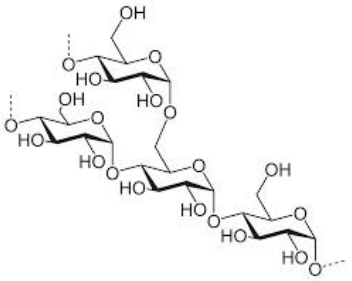
Fossil Biomass

Current: Food, Fuel and Materials from Plant Polysaccharides

Cellulose: Fuel, Housing, Clothing, Paper



Starch, Sugars: Food, Fuel



Future: Target → more efficient & **alternative applications** for plant biomass

A Contribution to the Use of Plant Biomass
Advanced Materials from Polysaccharides

A Contribution to the Use of Plant Biomass

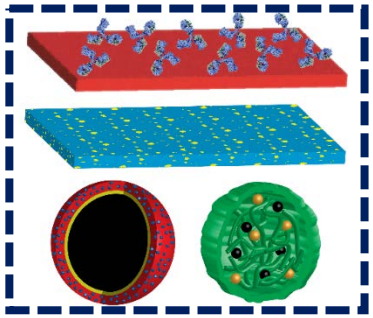
Advanced Materials from Polysaccharides

Application

Technical polymers

Biomedical areas

Biotechnological processes



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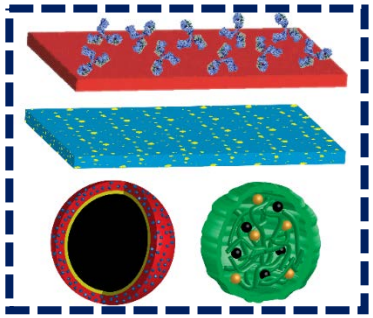

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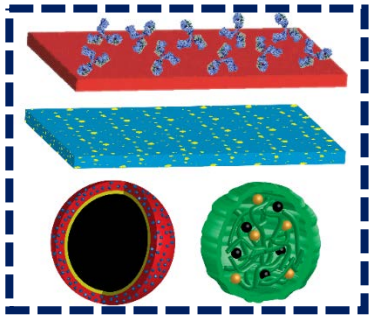
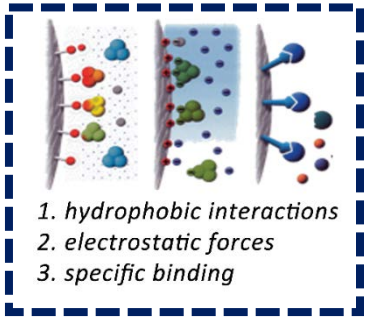


Interactions at Interfaces

Surface Modification and Characterization of Bio-Based-Materials



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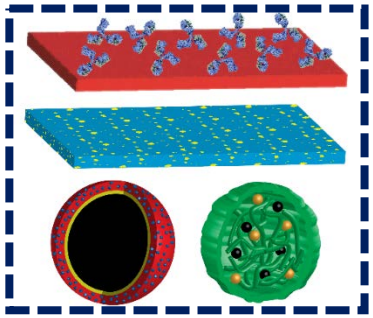

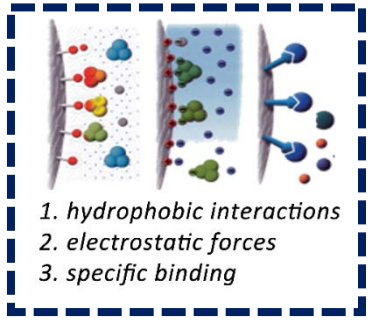

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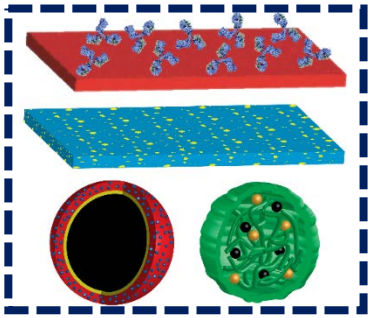

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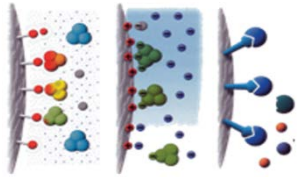


1. hydrophobic interactions
2. electrostatic forces
3. specific binding

Advanced Functional Materials Technologies and Products

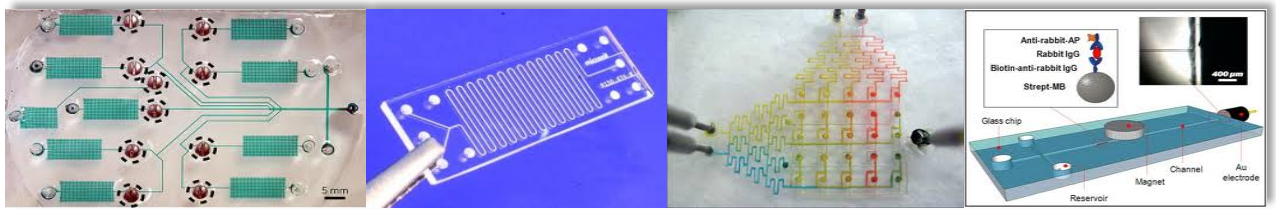
„Key enabling technologies (KET) in EU Horizon2020“

Biosensors

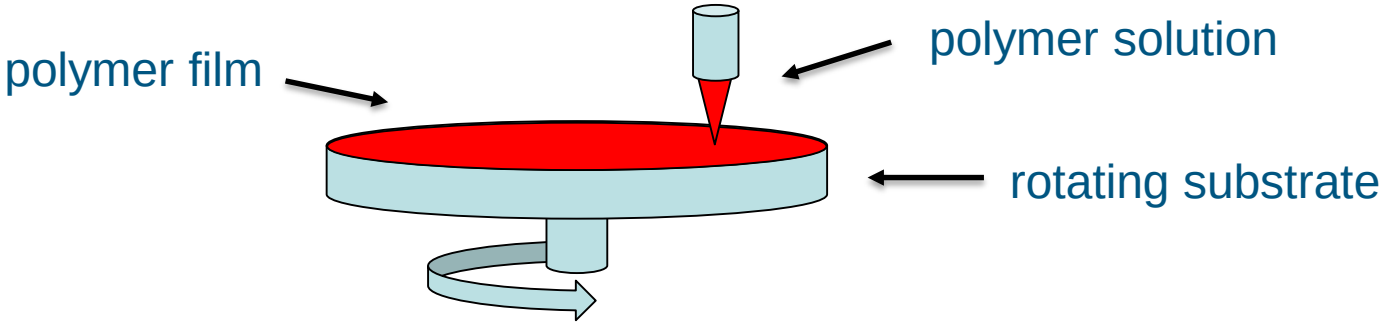
Organic electronics

Biosensors and Electronics often Require Patterned Surfaces

- Superhydrophobic surfaces (lotus-effect)
- Microreactors, Microfluidics
- (Bio)Sensors
- Microelectronics, organic electronics, organic thin film transistors (OTFT)



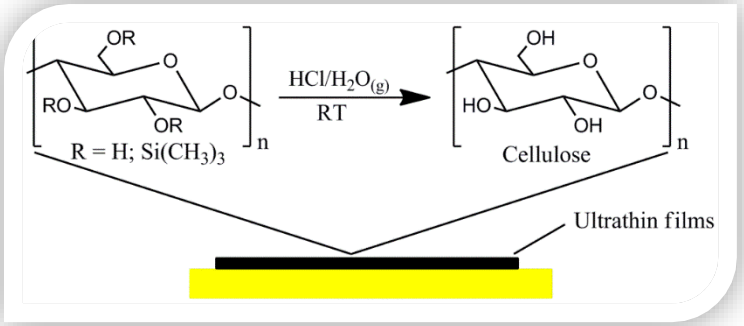
- Thin polymer substrates by spin coating



Patterning of Cellulose Thin Films by Enzymes

Patterning of Cellulose Thin Films by Enzymes

Spin coating of thin cellulose films → 30 nm thickness



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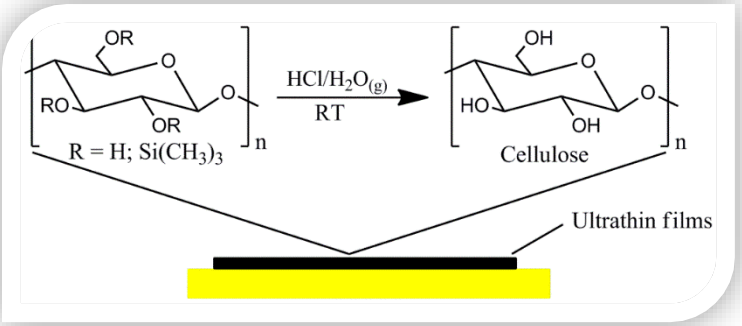

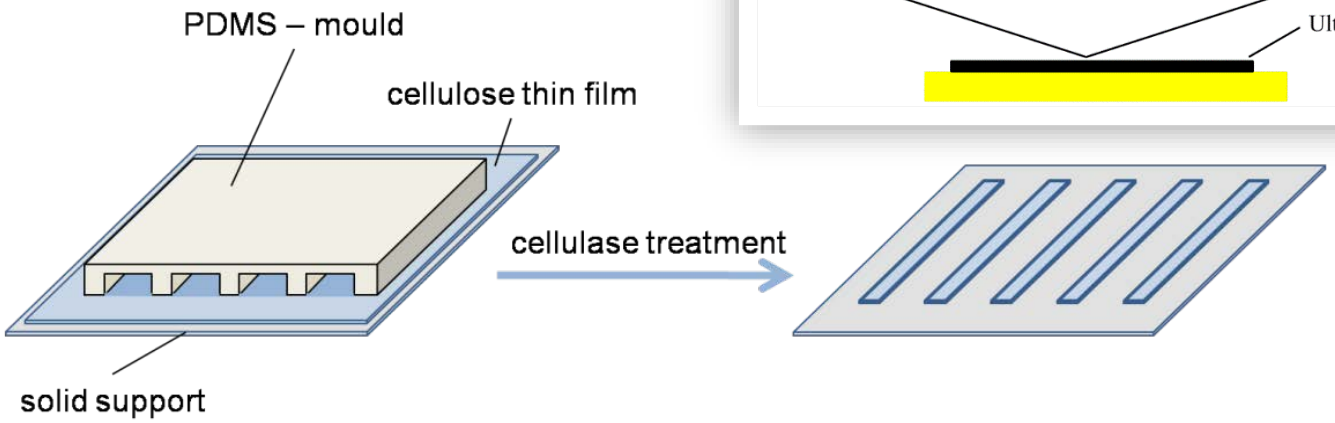

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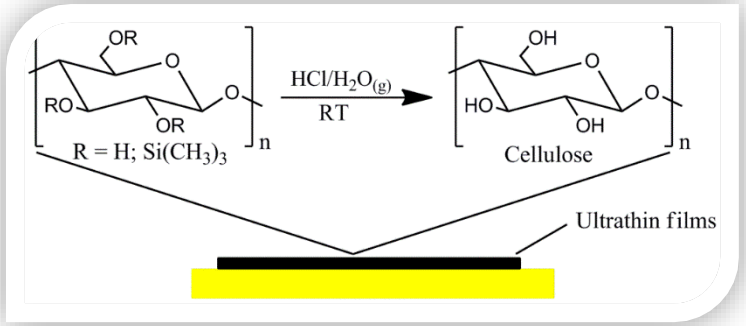

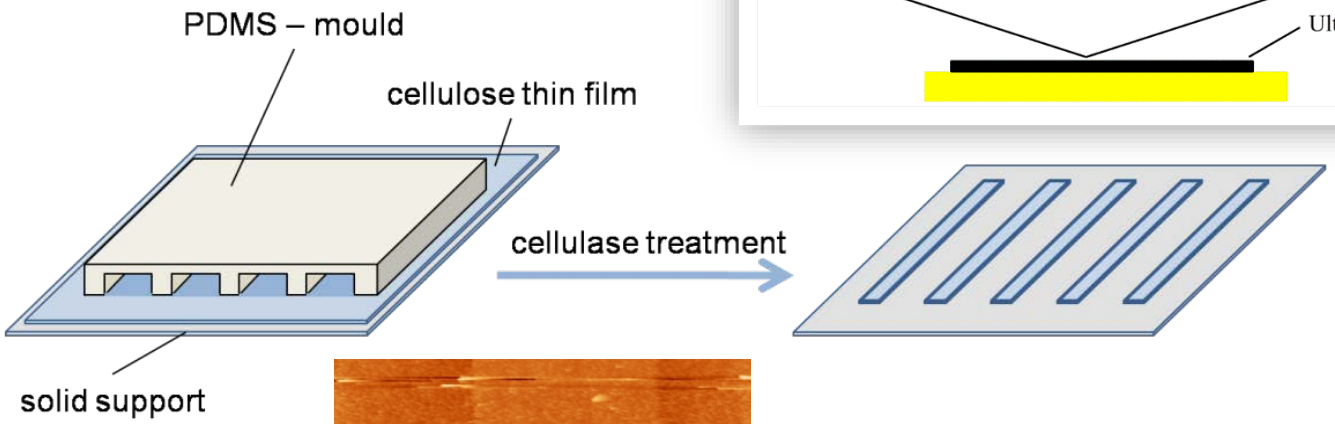

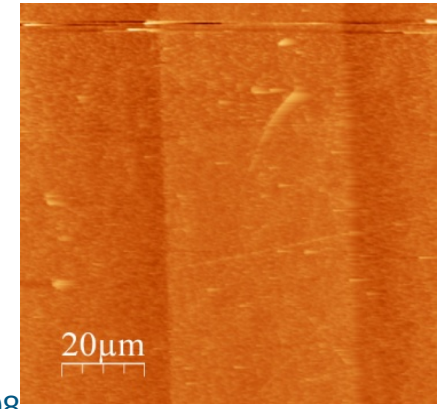

AFM image cellulose stripe

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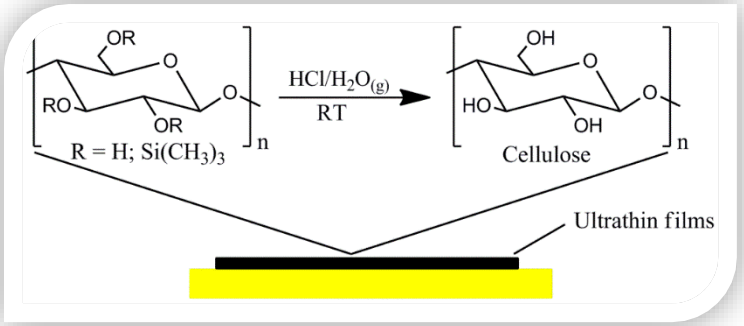

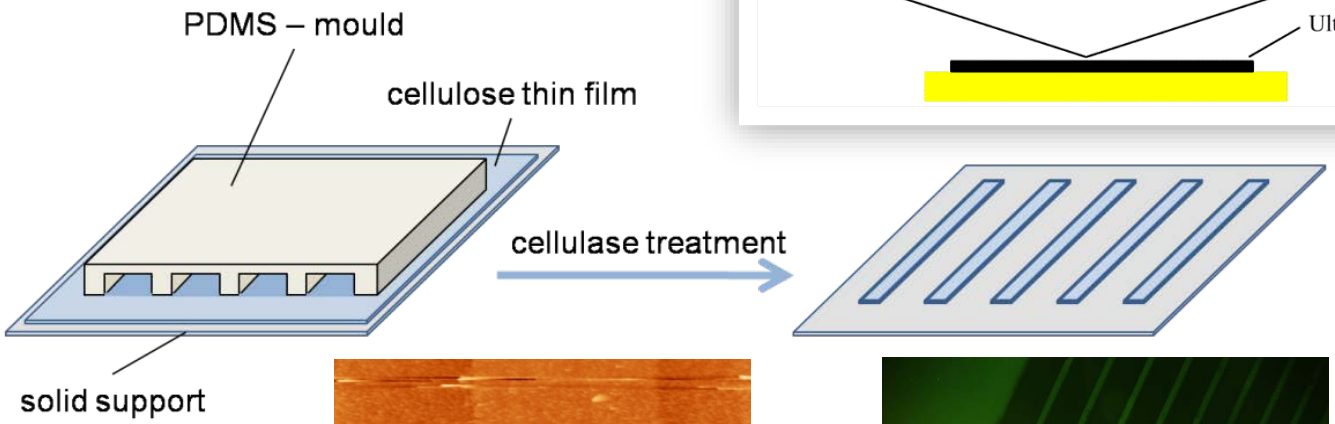

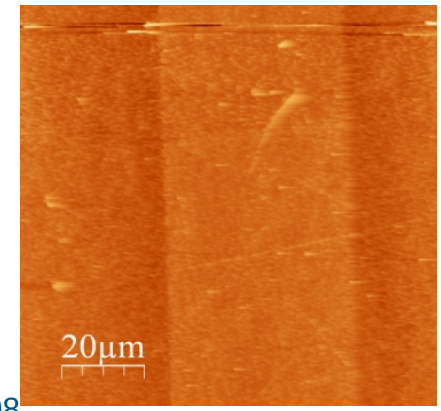

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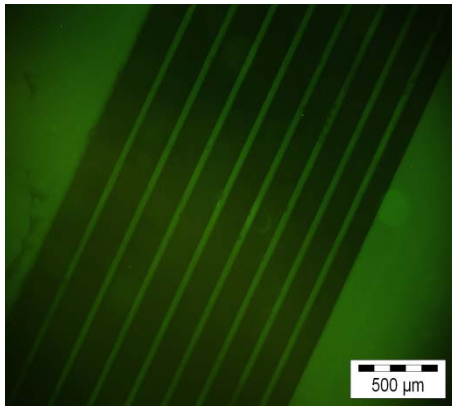

Fluorescence microscope image of a structured cellulose film

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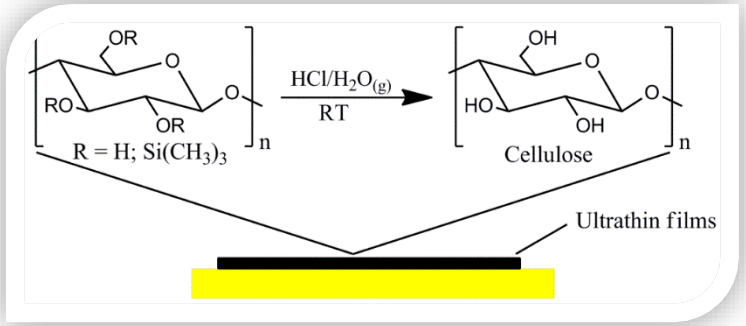

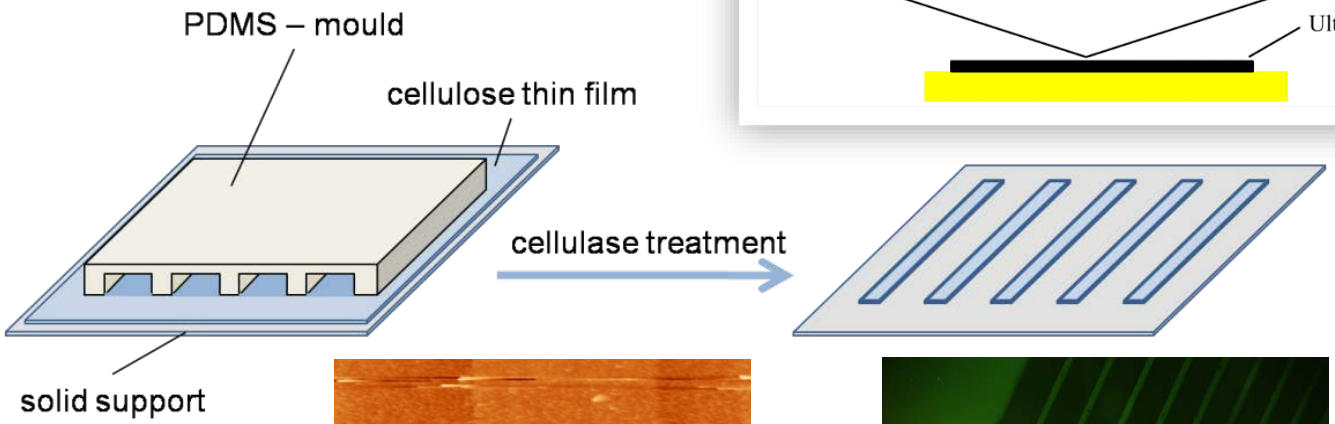

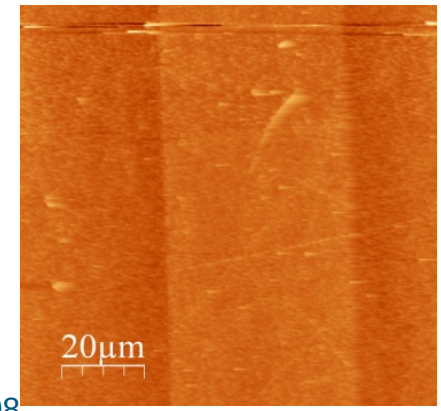

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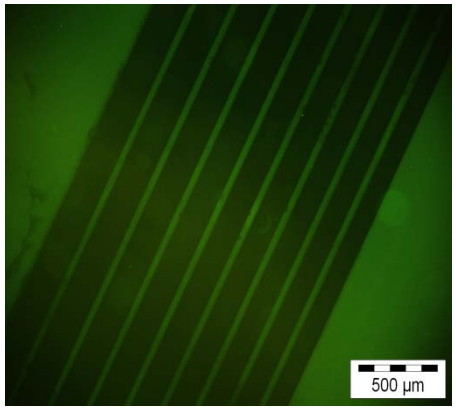

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100 µm resolution

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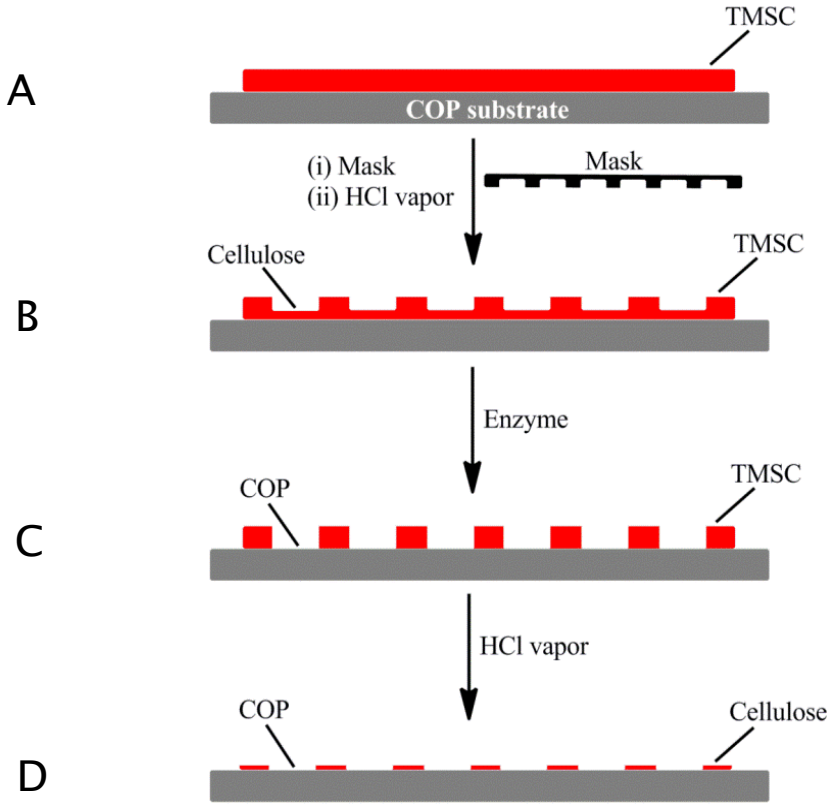
Patterning of Cellulose Films via Vapor Phase of HCl and Enzymatic Digestion



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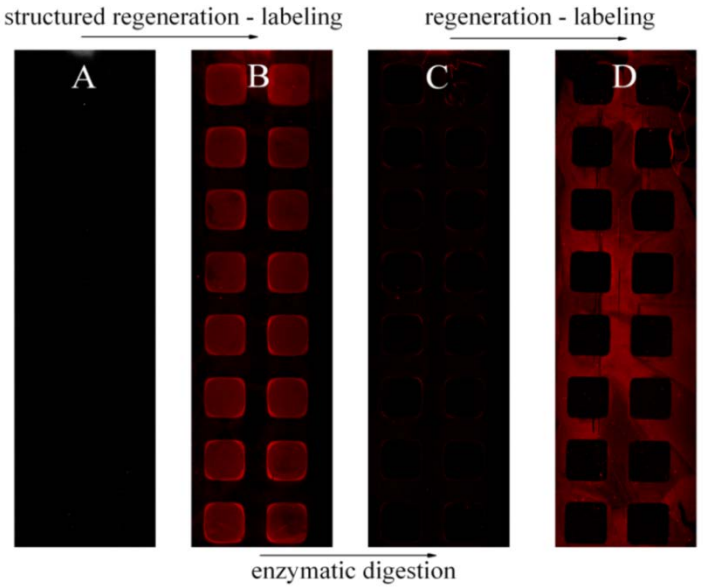

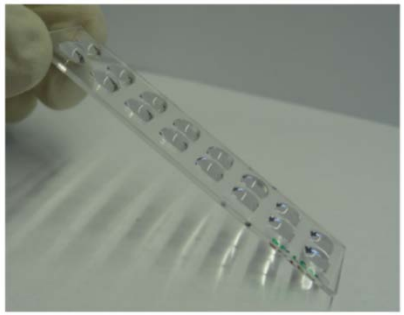

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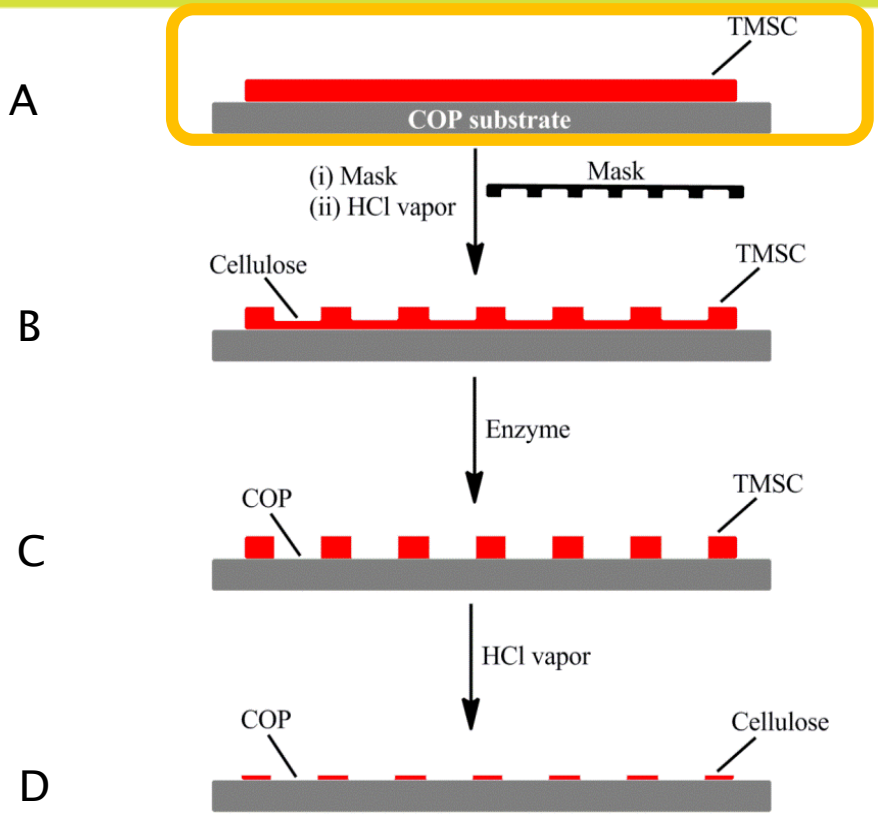

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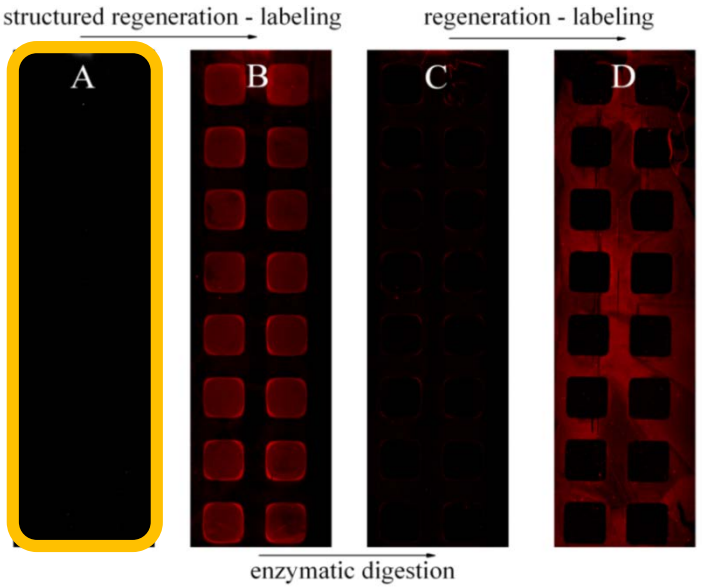

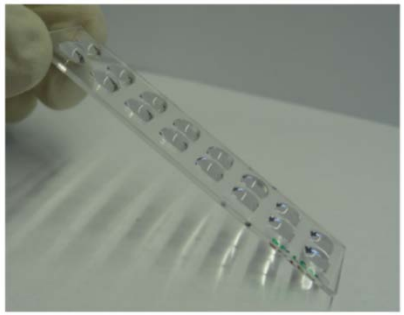

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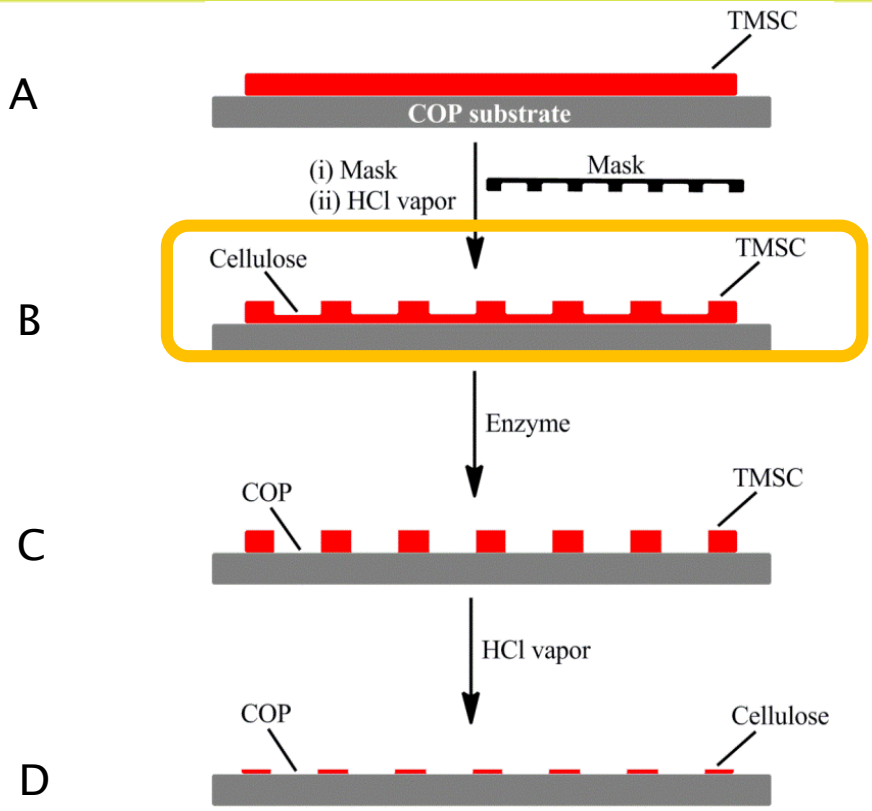

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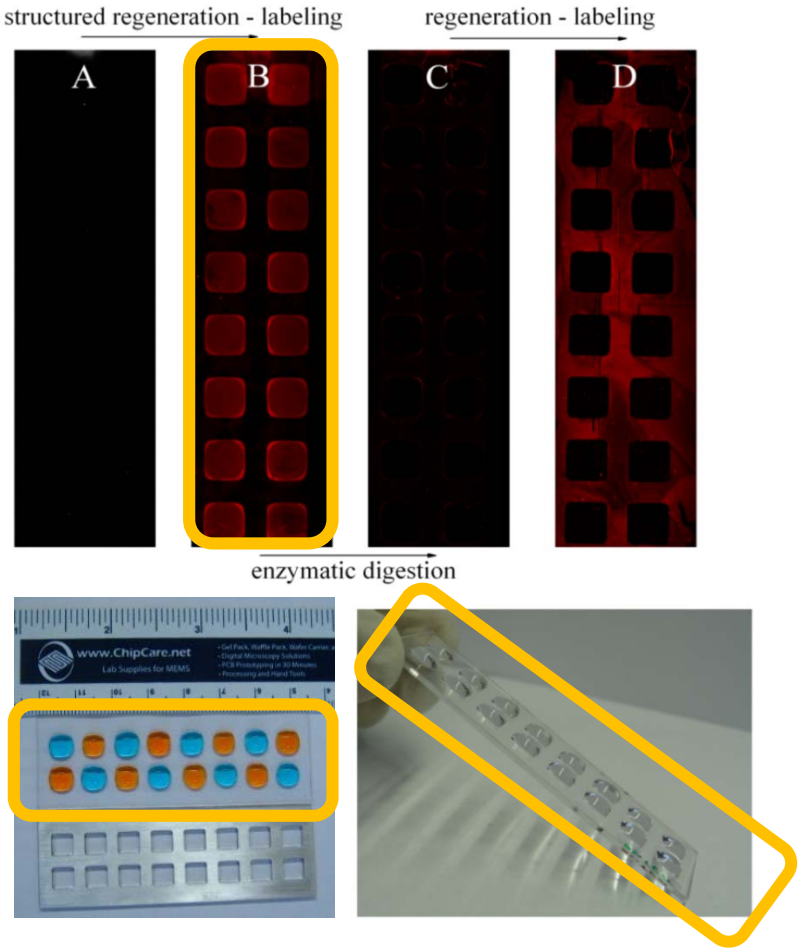

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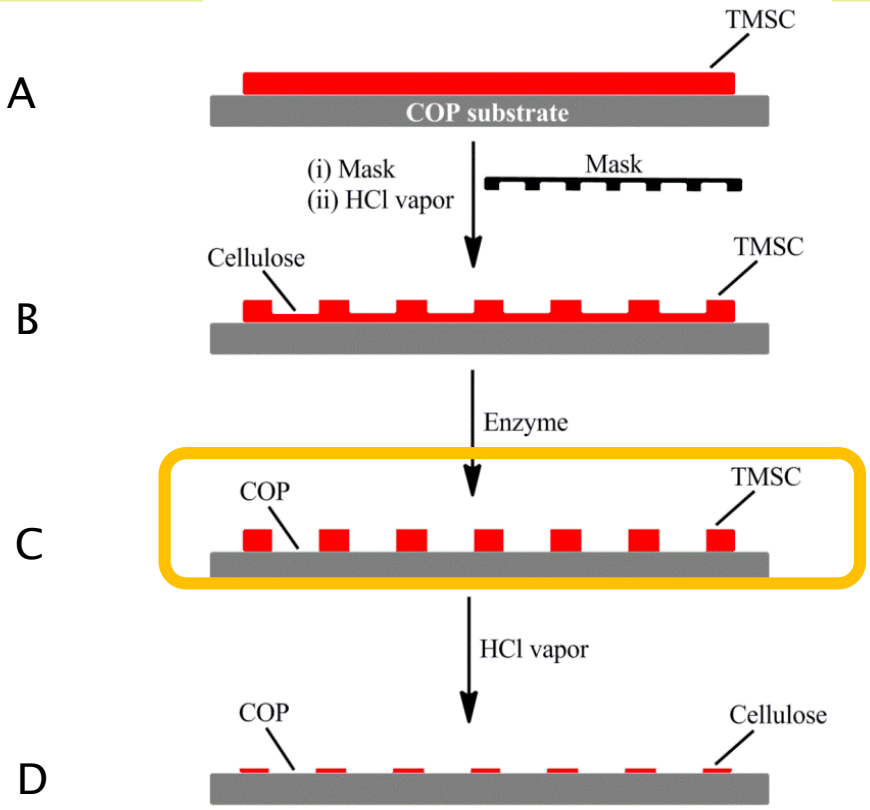

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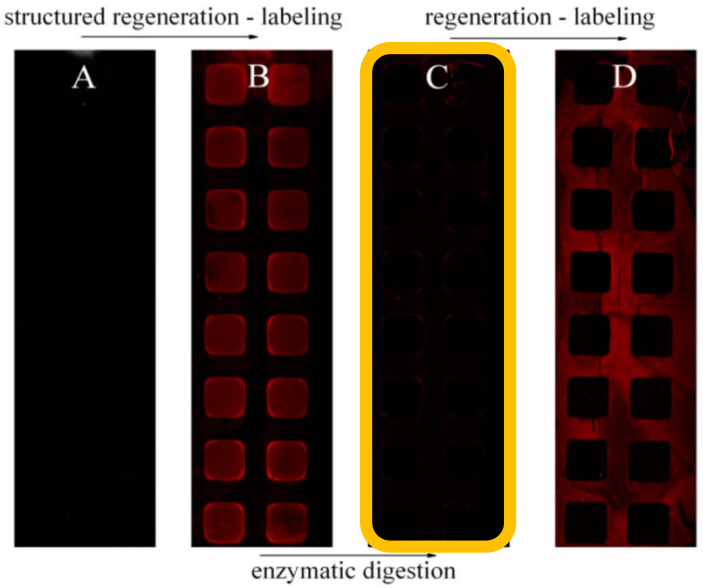
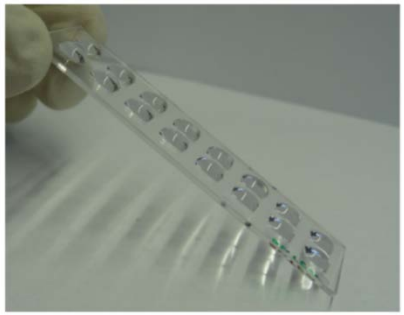
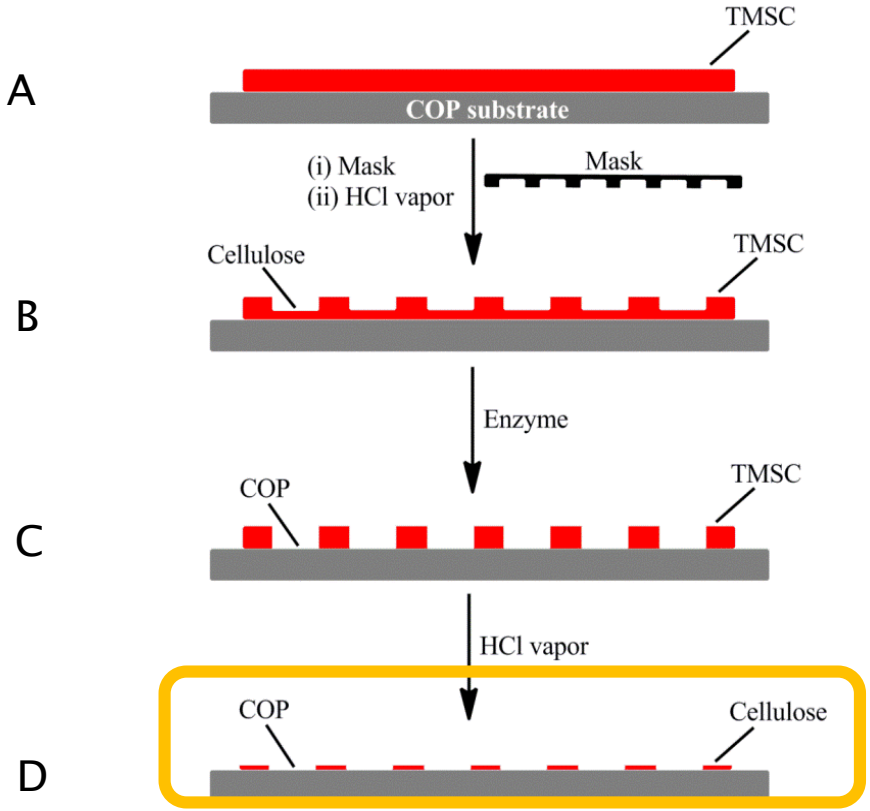


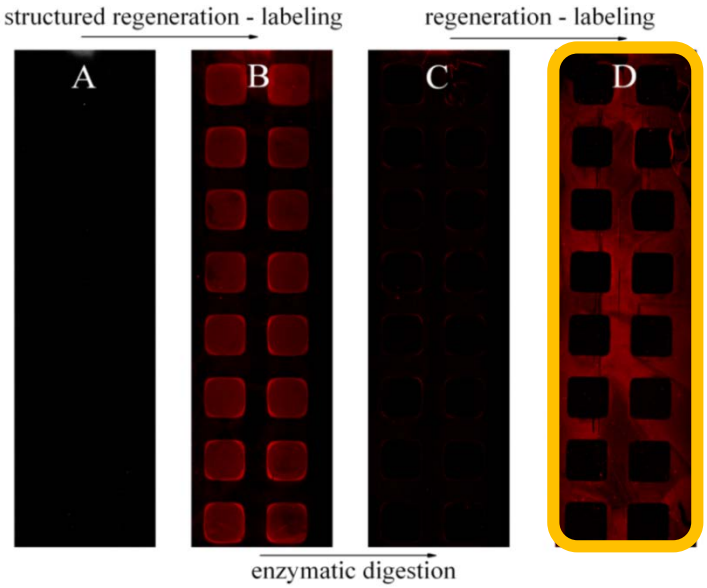


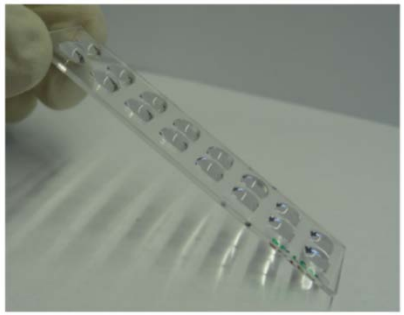
Adv. Funct. Mater., **2013**, 23, 308.

Patterning of Cellulose Films via Vapor Phase of HCl and Enzymatic Digestion



100 µm resolution





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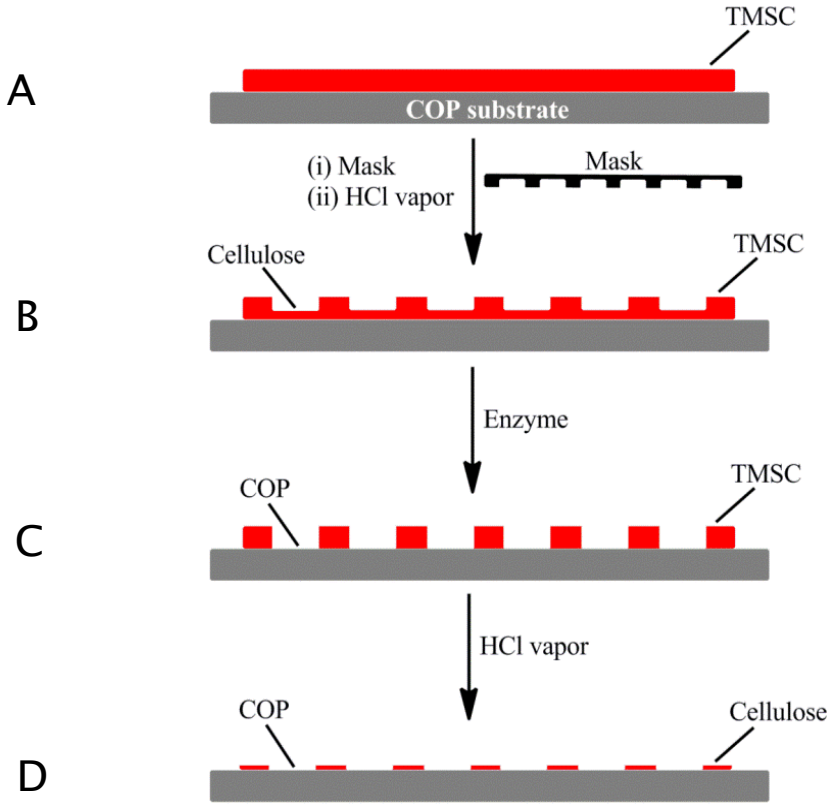
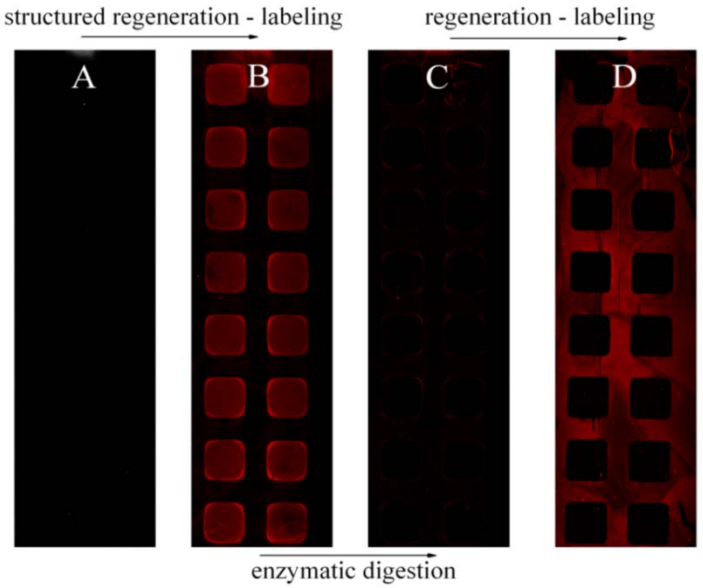
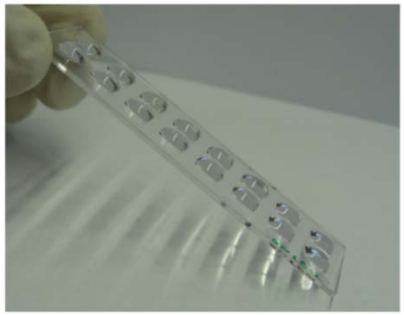


100 µm resolution





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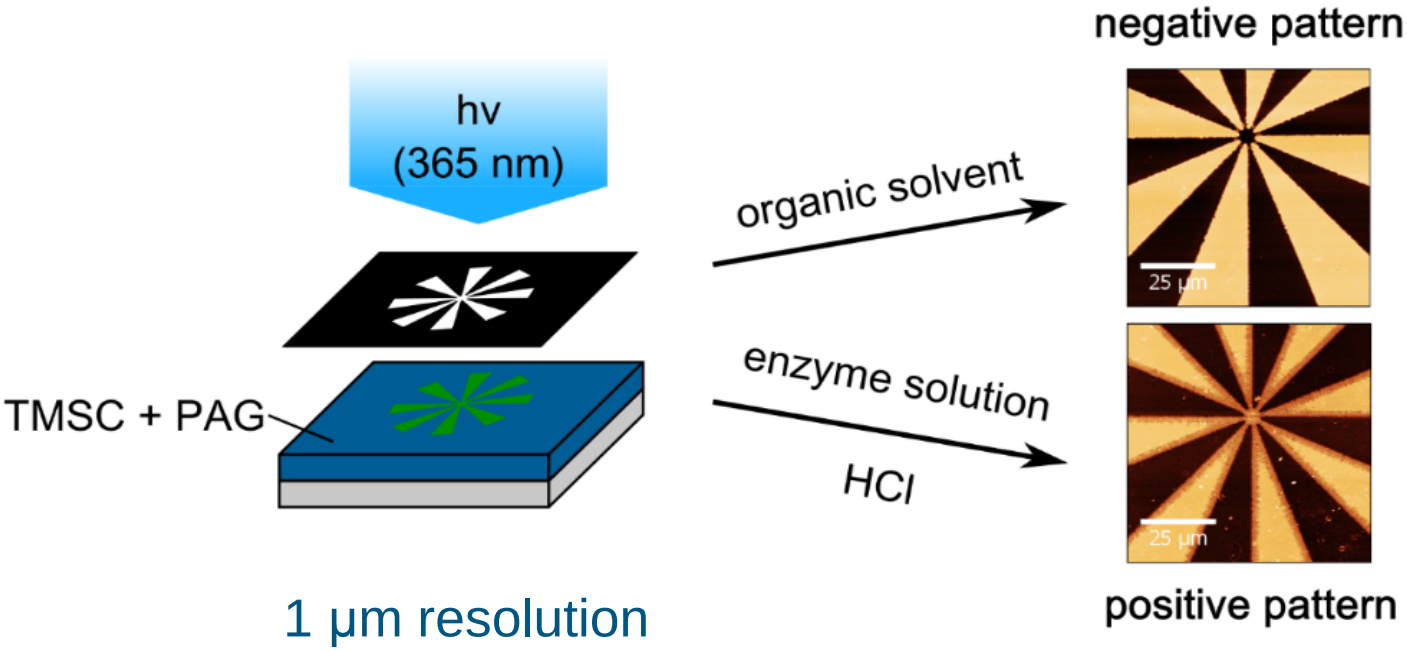
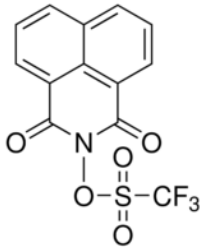
Photolithography for High Resolution Patterns



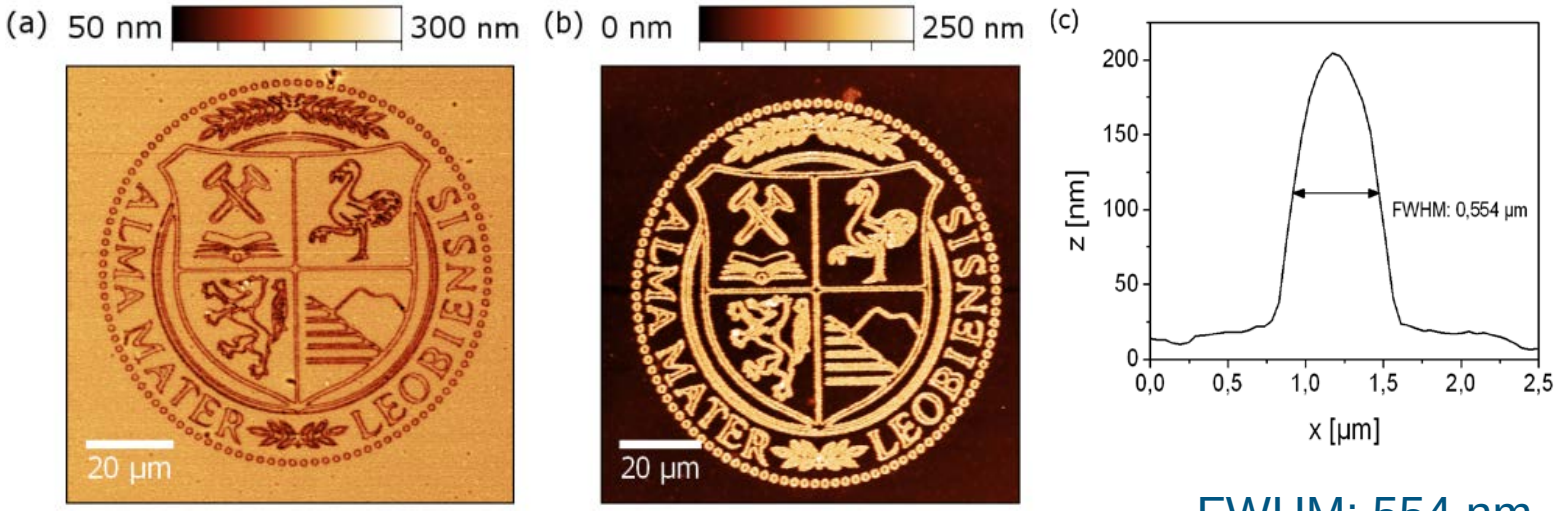
1 µm resolution

Wolfberger et al. Molecules 2014, 19, 16266-16273; doi:10.3390/molecules191016266

Patterning using Two Photon Absorption (TPA)



- PAG used for 2-D patterning also TPA active
- Submicron structures in 200 nm cellulose thin film



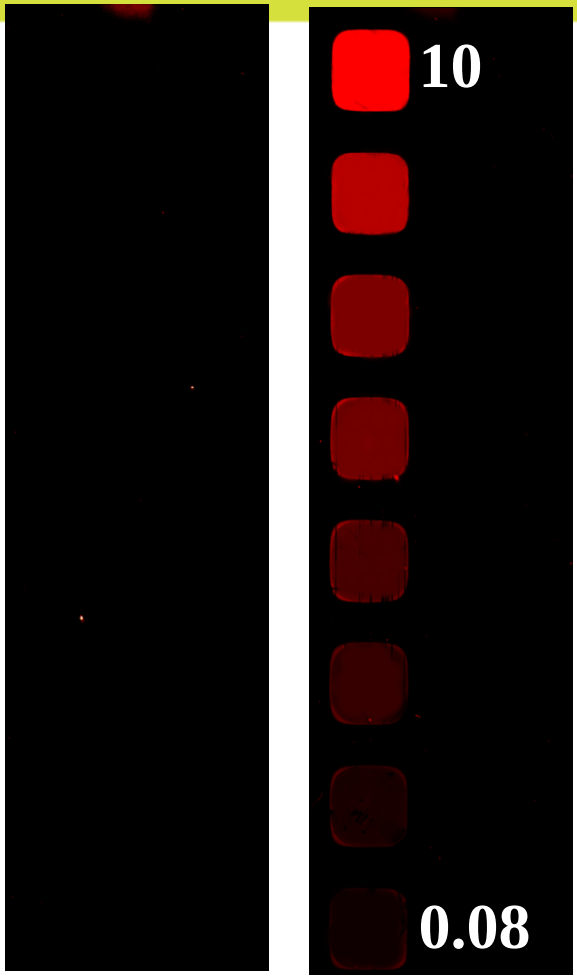
600 nm resolution

FWHM: 554 nm full width at half maximum

Wolfberger et. al. Cellulose, 2014 in press, DOI 10.1007/s10570-014-0471-4

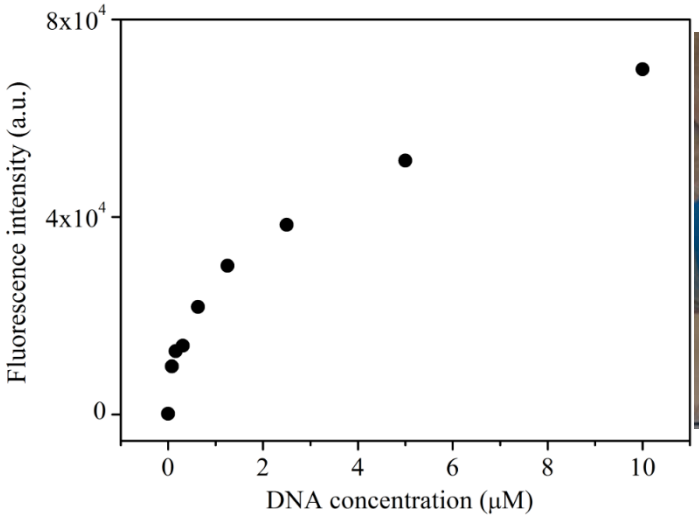
Application as DNA Biosensor

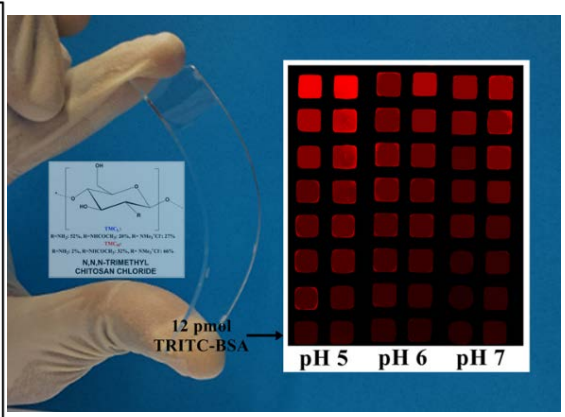
DNA/CMC/EDC DNA/CMC



Before Hybridization

After Hybridization

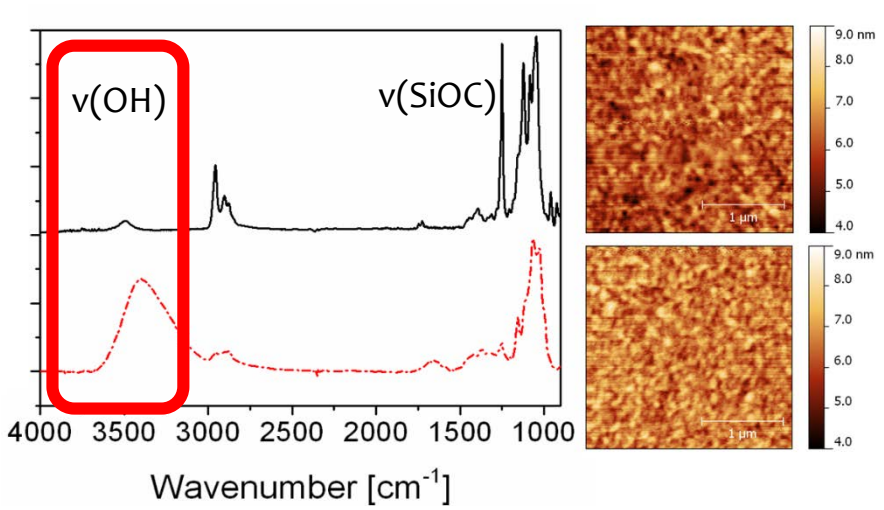




80 nM DNA can be detected – **0.8 mg per liter**

EU Project application:
Vircell - Spanish bio-diagnostics company

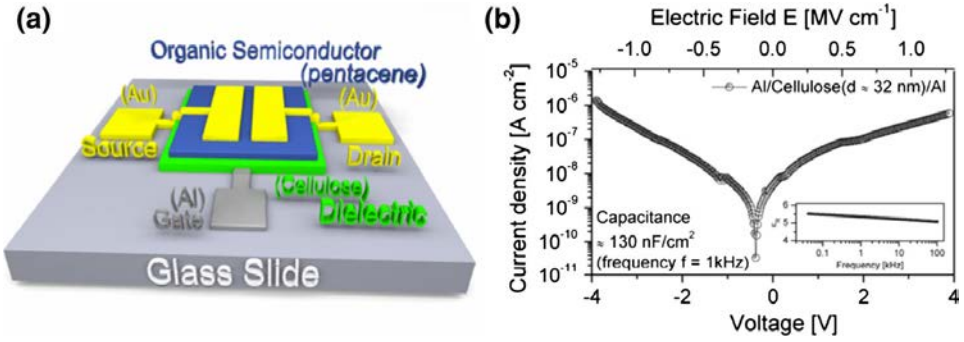
A Cellulose Thin Film as a Dielectric in Organic Thin Film Transistors



- Partial regeneration of TMSC for OTFTs
- Incompletely regenerated cellulose performs best regarding dielectric constant e
- e TMSC (with DS_{Si} = 0.5) = 4.8

Al_2O_3 = 4.5, SiO_2 = 3.9

Film thickness 32 nm, pentacene as organic semiconductor



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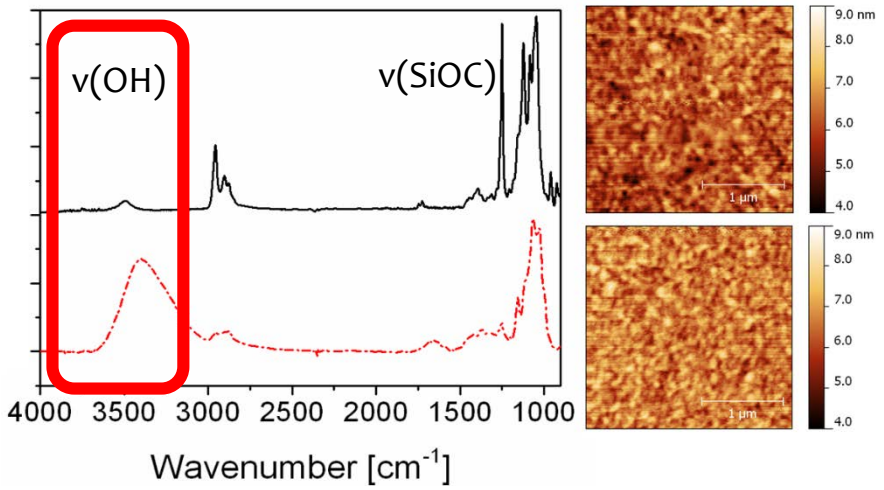

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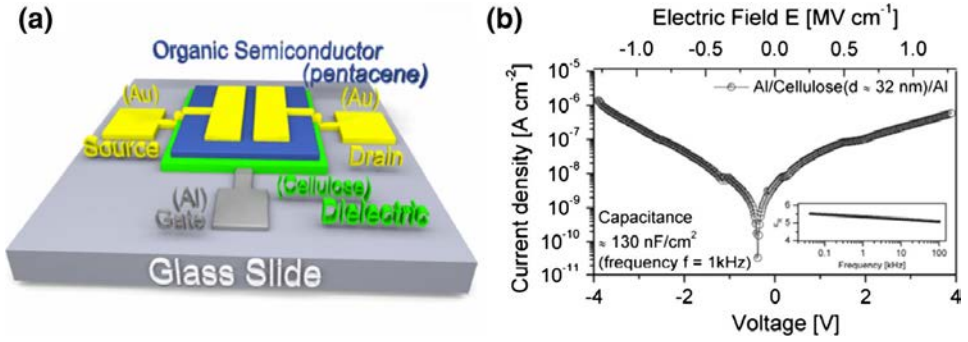

V_{on}: -0.8 V $V_{threshold}$: -1.25 V Gate leak currents: 80 pA

Wolfberger et. al. Cellulose, 2014 in press, DOI 10.1007/s10570-014-0471-4

The Team at LCPP – University Maribor

http://lcpp.um.si/

Program Group P1118 Textile Chemistry
Marie Curie Career Integration Grant; PHOTOPATTTOCELL

(FP7/2007-2013); 214653; SURFUNCELL

Marie Curie (FP7-PEOPLE-2012-IEF); POLY-INTER-FACES
Marie Curie; (FP7/2007-2013); 214015; STEP ITN

University Graz
TU Graz
Montan University Leoben

MARIE CURIE ACTIONS
SEVENTH FRAMEWORK PROGRAMME

SPIRIT SLOVENIJA | I FEEL SLOVENIA
REPUBLIKA SLOVENIJA MINISTRSTVO ZA GOSPODARSKI RAZVOJ IN TEHNOLOGIJO