Polysaccharide-Based Materials

OSCM*Lab – Laboratory of Organic Synthesis, Catalysis, and Materials*

Carlo Punta

Department of Chemistry, Materials, and Chemical Engineering «G. Natta»
carlo.punta@polimi.it

OSCM*Lab* – *Laboratory of Organic Synthesis, Catalysis, and Materials*




The fact: **Today, standard procedures for chemical processes require inexpensive reagents, used under the mildest possible conditions, in order to achieve the desired products in high chemical yields and high atom economy by following the common rules of "*Green Chemistry*".**

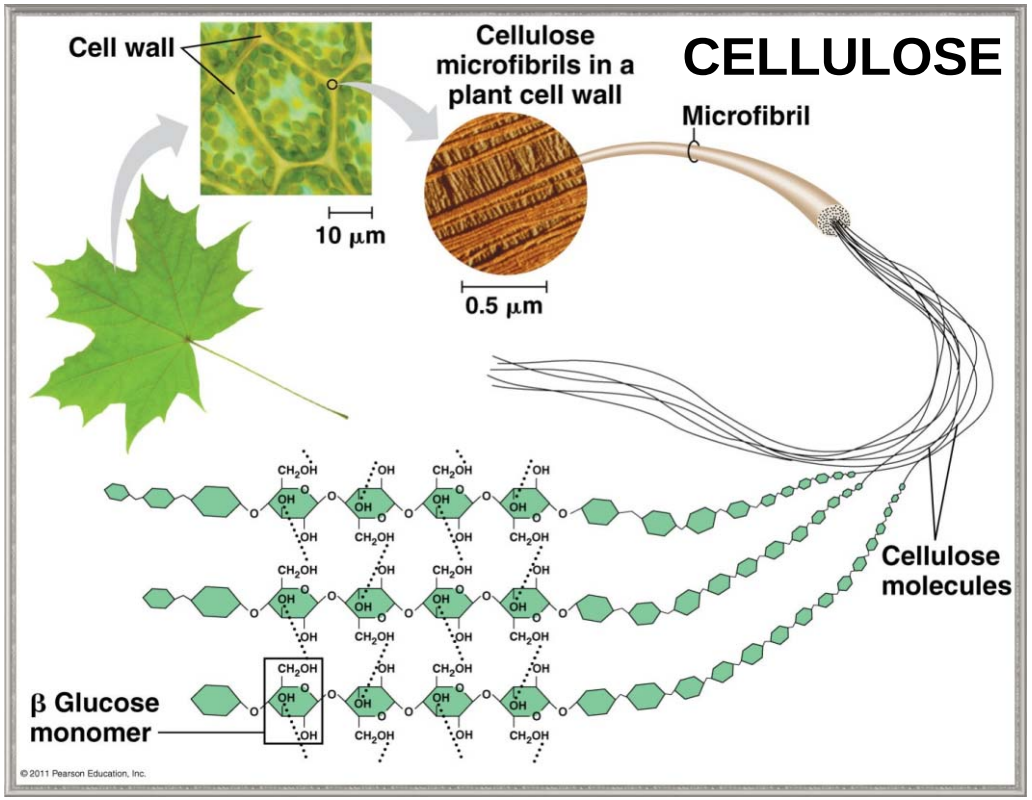
Group's aim: **To produce high added value organic products and materials for fine and basic chemistry and to meet growth, environmental and health expectations. This has to be obtained by a significant reduction of wastes and energy consumption with a consequent reduction in capital investment.**

How: **Our "motto" is *understanding chemistry for making chemicals*. Our approach consists in basic research, mechanism interpretation, and practical applications.**

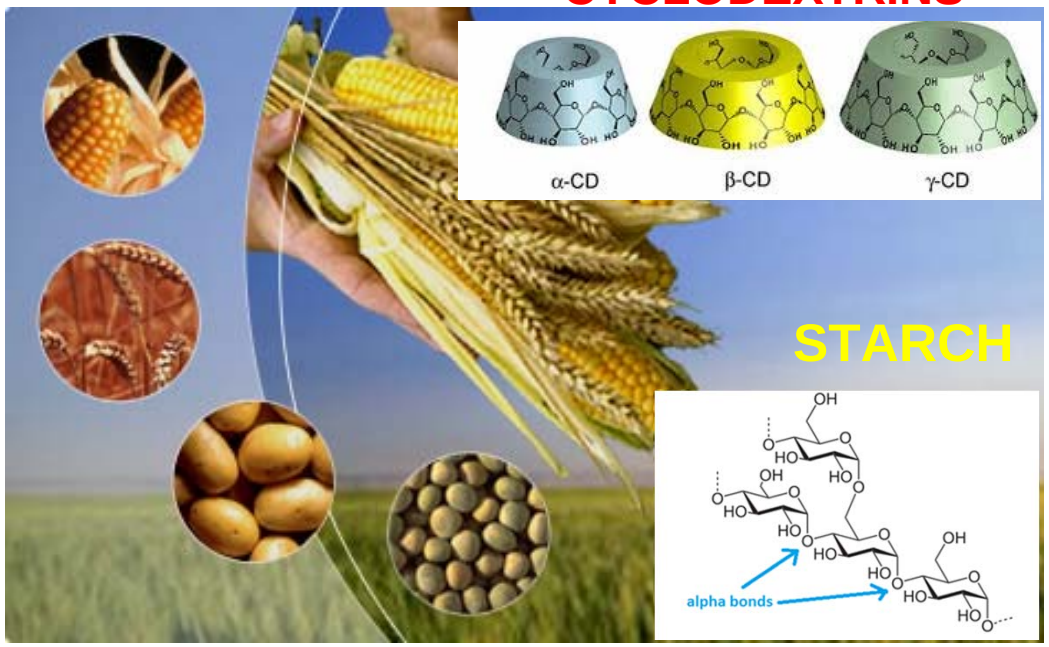
Research fields:

- **New catalytic systems for sustainable oxidations under mild conditions.**
- **Multicomponent reactions for advanced organic synthesis**
- **Organic vectors, gels, and materials for drug- and gene-delivery**
- **New sorbent materials for water, soil, and air decontamination**
- **Porous Coordination Polymers for novel applications**

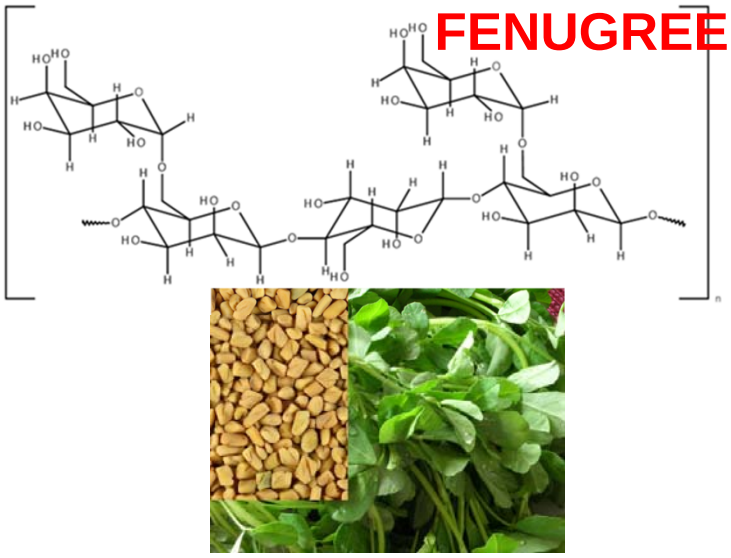
Polysaccharide-based materials

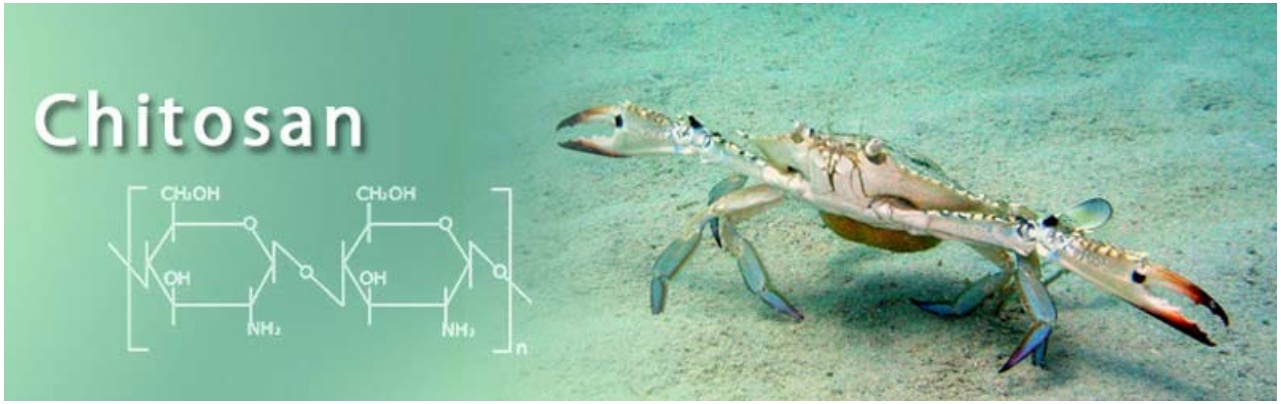


CYCLODEXTRINS



FENUGREEK





Polysaccharide-based materials




Carbohydrate Polymers **2017**, *165*, 71-85.
ChemPlusChem **2017**, *82*, 848-858.
Biomacromolecules **2016**, *17*, 564−571
ChemPlusChem **2015**, *80*, 1408-1415.
RSC Advances **2015**, *5, 83197*

CYCLODEXTRINS



Beilstein J. Org. Chem. **2017**, *13*, 182–194.
Exp. Opin. Drug. Deliv. **2017**, *14 (3)*, 331-340.
Phys.Chem.Chem.Phys. **2017**, *19*, 6022-6029.
Phys.Chem.Chem.Phys. **2017**, *19*, 22555-563.


Current Org. Chem. **2018**, *in press*.
PLoS One, **2010**, *5*, e13430.
Photochem. Photobiol. Sci., **2014**, *13*, 1680–1689.


Carbohydrate Polymers **2016**, *144*, 353.

Polysaccharide-based materials: Cellulose
From nano-sized to NANO-STRUCTURED materials

nano bond

Nanomateriali per la Bonifica associata a Dewatering di matrici ambientali

ACQUE INDUSTRIALI

BARTOLI
FIBREBOARDS FOR INDUSTRY
ITALY

REGIONE TOSCANA
MATE
Distretto Tecnologico Nuovi Materiali

BIOCHEMIE lab

INSTM

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Labromare s.r.l. LIVORNO

Ergo

Regione Toscana

NAIADI

NAno-cellulosa da fonti rInnovabili per la somministrAzione sostenibile Di fitofarmacI

SIPCAM

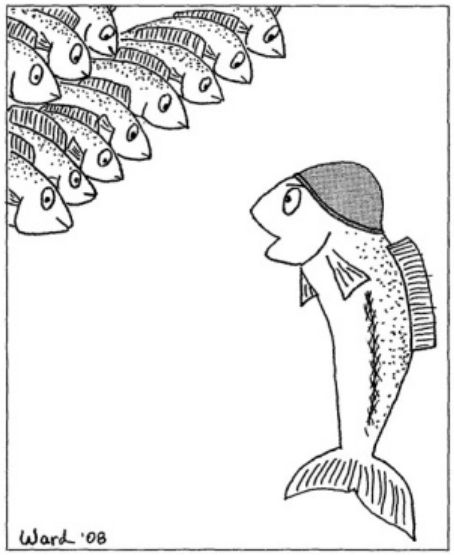
oxon ITALIA

UNIVERSITÀ DEL SALENTO

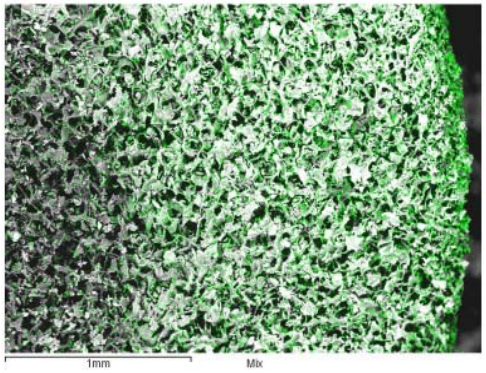
Regione Lombardia

INSTM

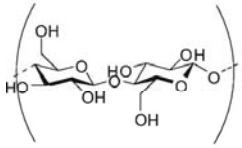
Polysaccharide-based materials: Cellulose
From nano-sized to NANO-STRUCTURED materials

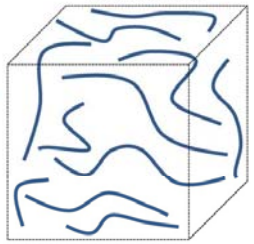


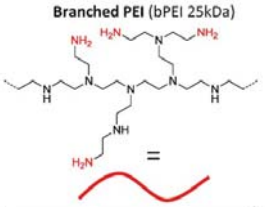
Listen up men. You are about to embark on a toxicity test to determine an LC50. Look left, look right – half of you won't be coming back.



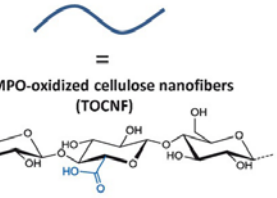
ILARIA CORSI

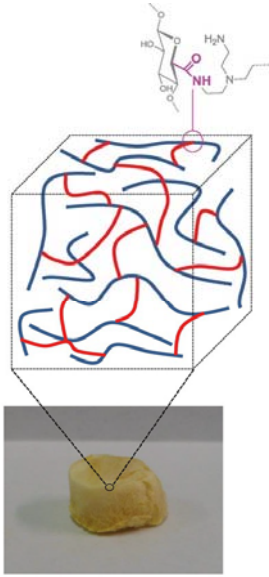


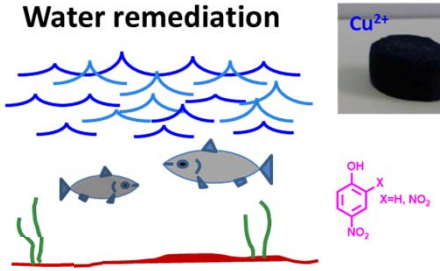




1) water, RT, 2h
2) Freeze-drying at -80°C, 24h
3) Heating up to 102°C, 10h



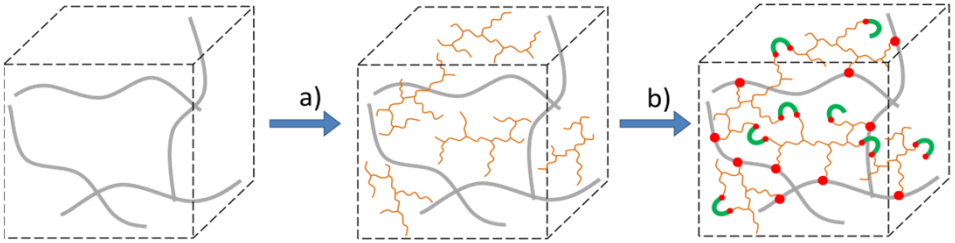


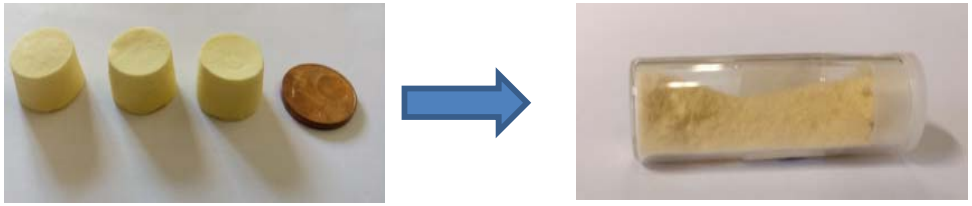


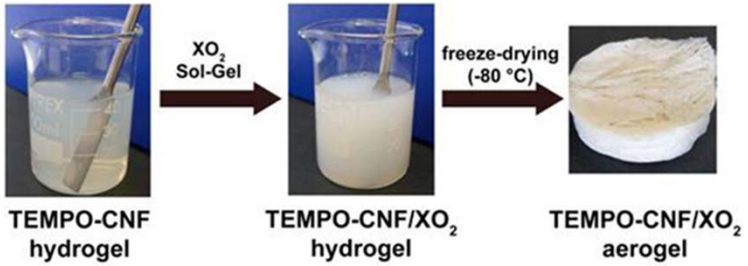
High- capacity adsorbent - Pulp wastes - Low cost - Easy scale up - Low environmental impact

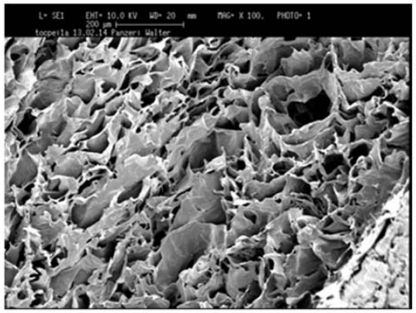
Carbohydrate Polymers **2017**, *165*, 71-85; *ChemPlusChem* **2017**, *82*, 848-858; *ChemPlusChem* **2015**, *80*, 1408-1415.

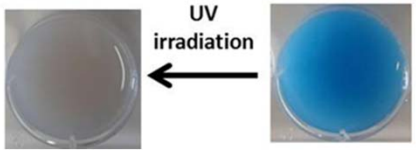
Polysaccharide-based materials: Cellulose
From nano-sized to NANO-STRUCTURED materials



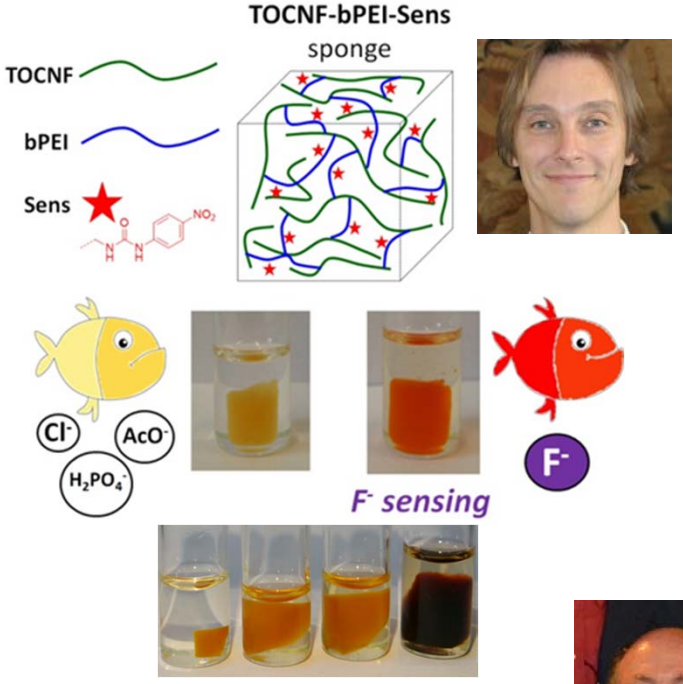




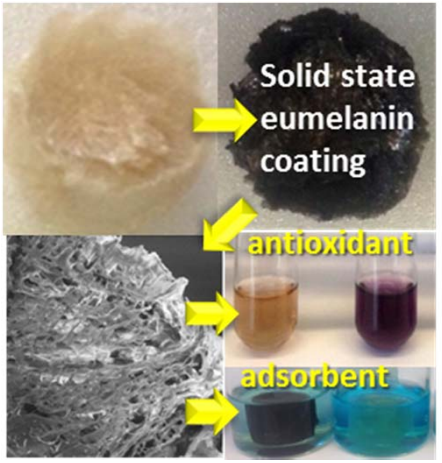


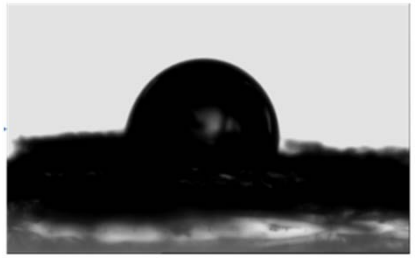


J. Photochem. Photobiol. A. **2013**, *261*, 53.



RSC Advances **2015**, *5*, *83197*

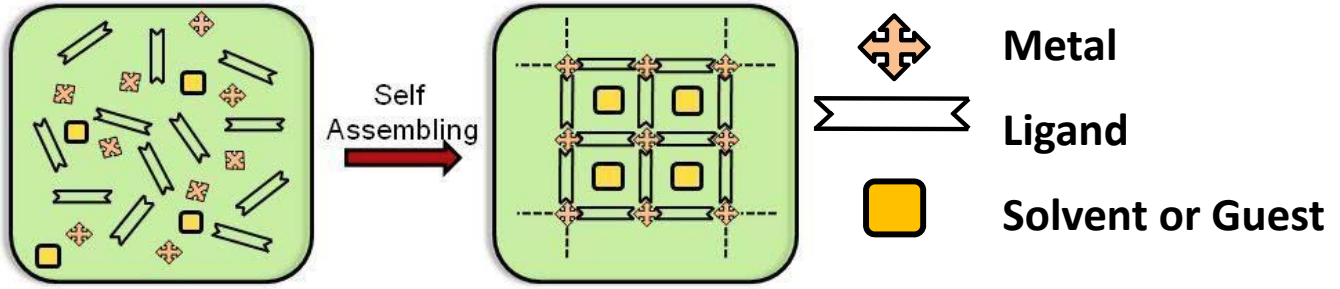


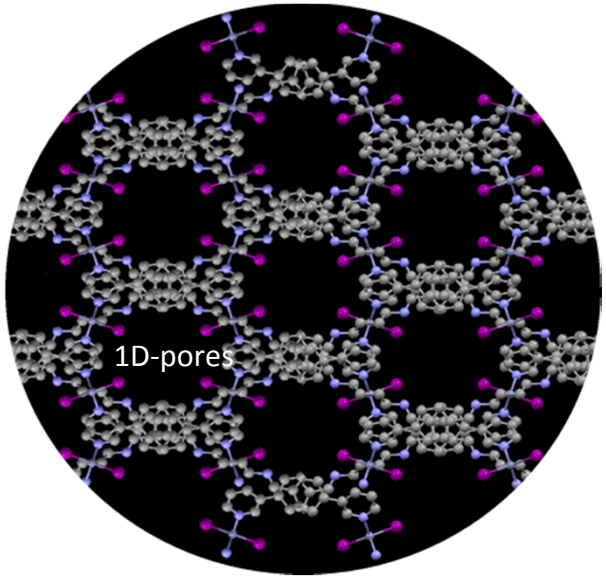


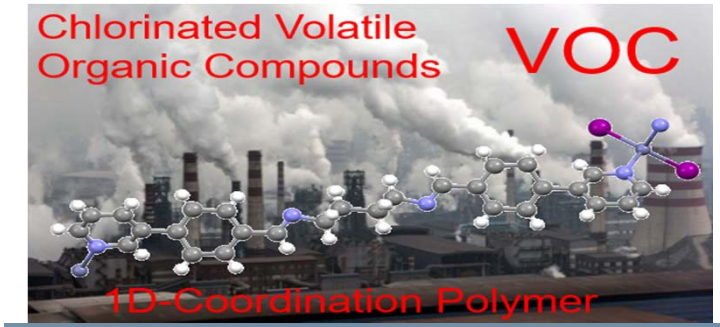
Biomacromolecules **2016**, *17*, 564−571

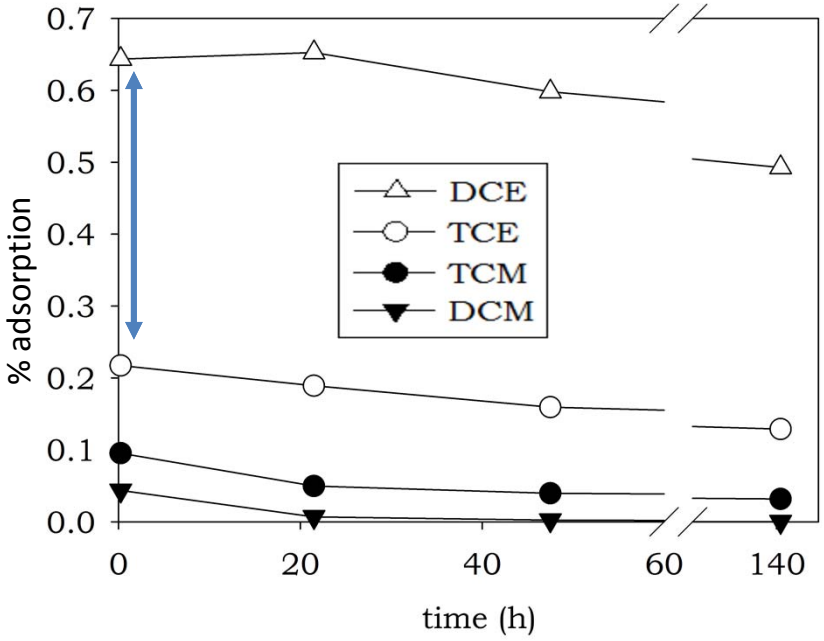
Porous Coordination Polymers for novel applications: Selective Adsorption of *Volatile Organic Compounds*.

Porous coordination polymers are a relatively new class of hybrid materials made by the self-assembly of organic ligands and metals ions.







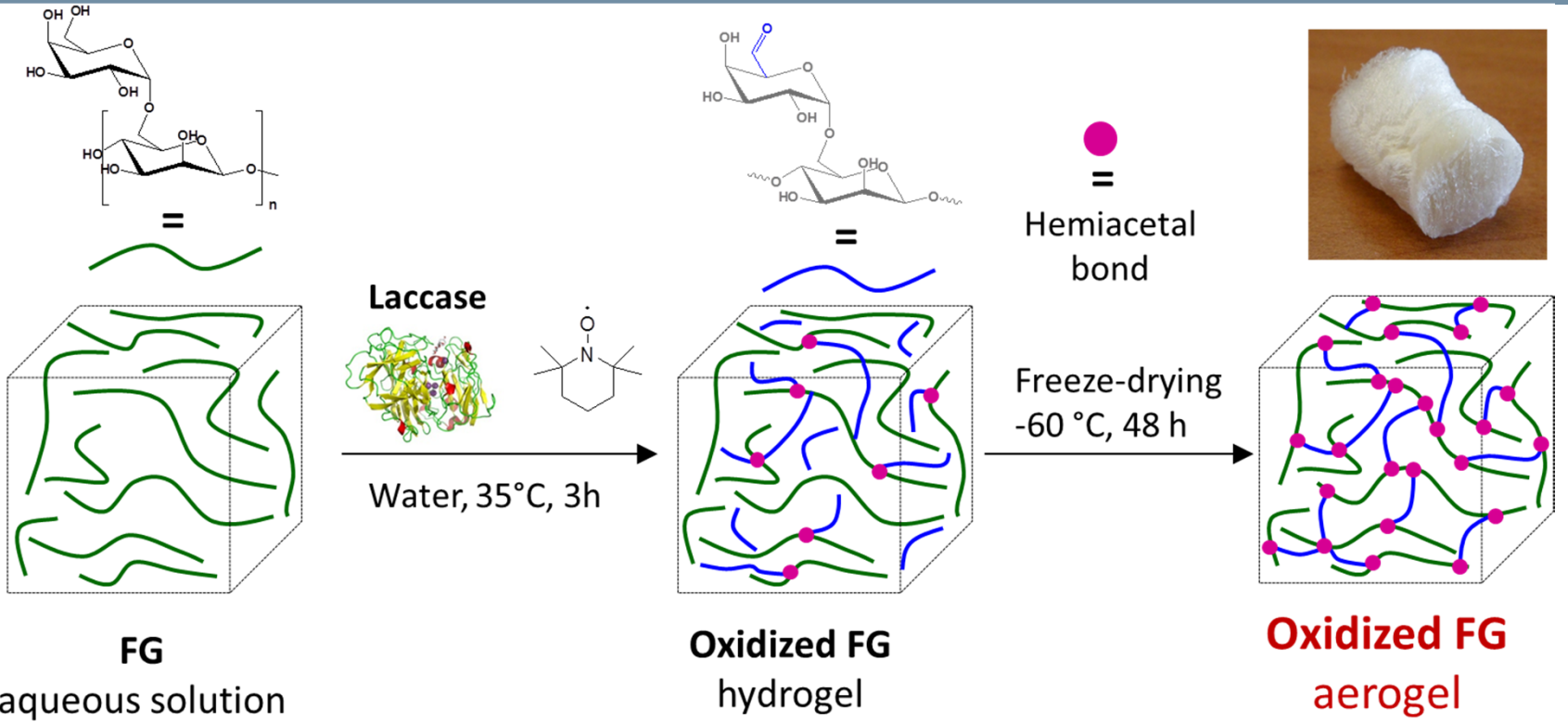


Selective adsorption of dichloro ethane (DCE) vapours over other chlorinated volatile organic pollutants under ambient conditions of T and P, and sustained retention.

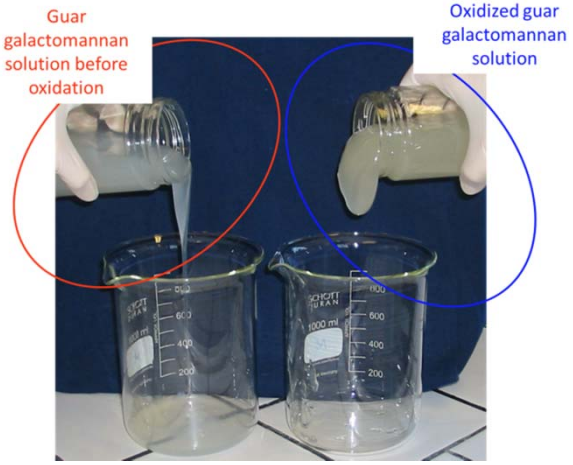
Dalton Trans., **2016**, 45, 18832
Dalton Trans., **2016**, 45, 1674
Chem. Commun., **2015**, *51*, 12357

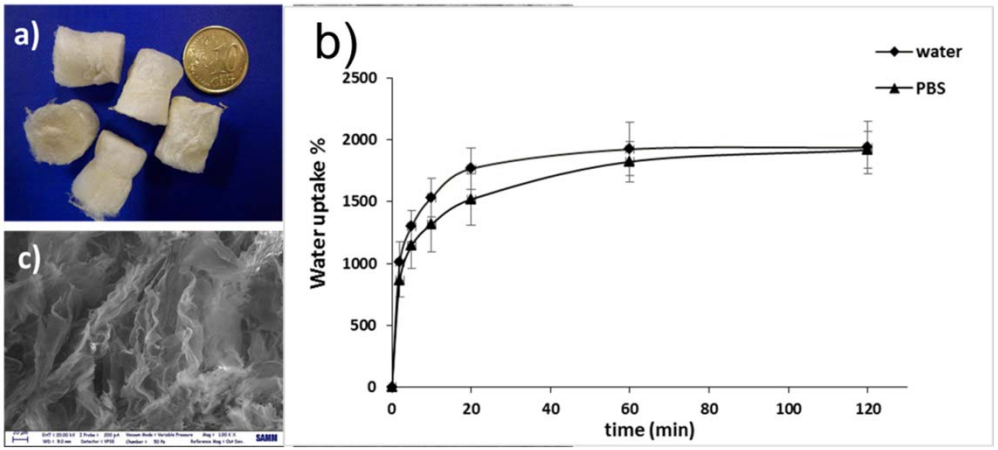
Potential applications for i) adsorption of nitro aromatics
ii) alkane/alkene/alkyne mixture separation

Polysaccharide-based materials: Galactomannans
From nano-sized to NANO-STRUCTURED materials



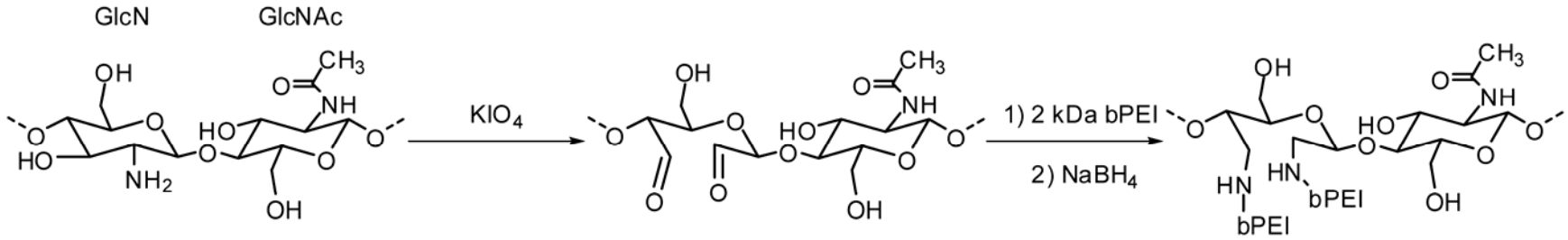
Carbohydrate Polymers **2016**, *144*, 353.





Polysaccharide-based materials: Chitosan

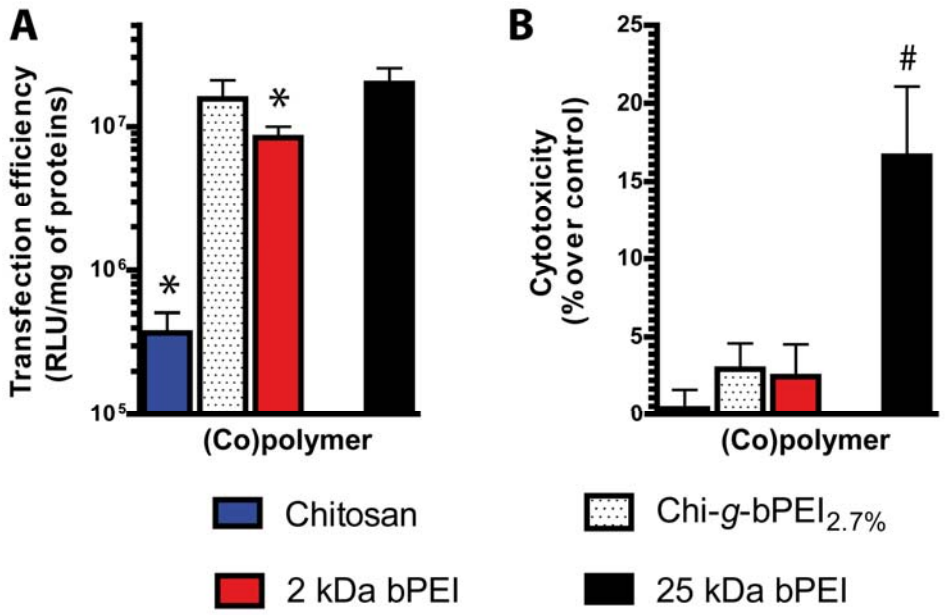
Chitosan-Graft-PEI: efficient, non-cytotoxic, non-viral gene delivery vectors



Chi-*g*-bPEI$_x$ copolymer	bPEI equiv of reaction	Degree of grafting (x)[a]
Chi-*g*-bPEI$_{0.6\%}$	1.27×10^{-2}	0.6±0.1%
Chi-*g*-bPEI$_{2.4\%}$	6.35×10^{-2}	2.4±0.1%
Chi-*g*-bPEI$_{2.7\%}$	1.27×10^{-1}	2.7±0.1%
Chi-*g*-bPEI$_{5.2\%}$	6.35×10^{-1}	5.2±0.3%
Chi-*g*-bPEI$_{7.0\%}$	2.54×10^{0}	7.0±0.2%
Chi-*g*-bPEI$_{8.7\%}$	1.27×10^{1}	8.7±0.1%
Chi-*g*-bPEI$_{8.8\%}$	6.35×10^{0}	8.8±1.3%

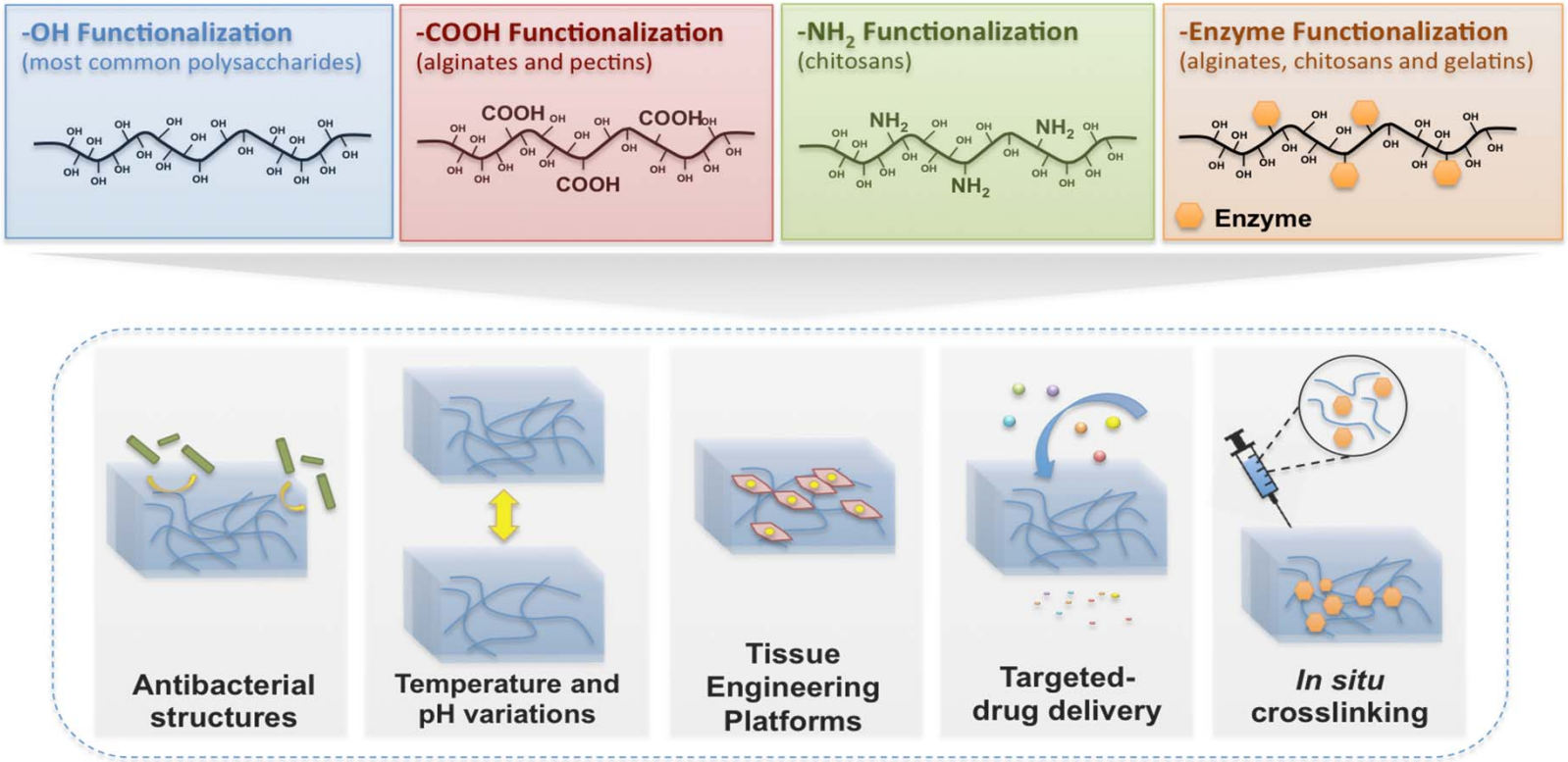
[a]"x" is the average percentage of D-glucosamine (GlcN) monomers grafted with branched polyethylenimine (bPEI). Results are expressed as mean ± standard deviation.

doi:10.1371/journal.pone.0034711.t001



PLoS One, **2010**, *5*, e13430; *Photochem. Photobiol. Sci.*, **2014**, *13*, 1680–1689

Polysaccharide-based materials: Chitosan



Current Org. Chem. **2018**, *in press*.

PLoS One, **2010**, *5*, e13430; *Photochem. Photobiol. Sci.*, **2014**, *13*, 1680–1689

Oligosaccharide-based materials: Cyclodextrin (CD) and Cyclodextrin Nanosponges (CDNS)

- ✓ **natural and biodegradable compounds**
- ✓ **low toxicity and hight versatility**

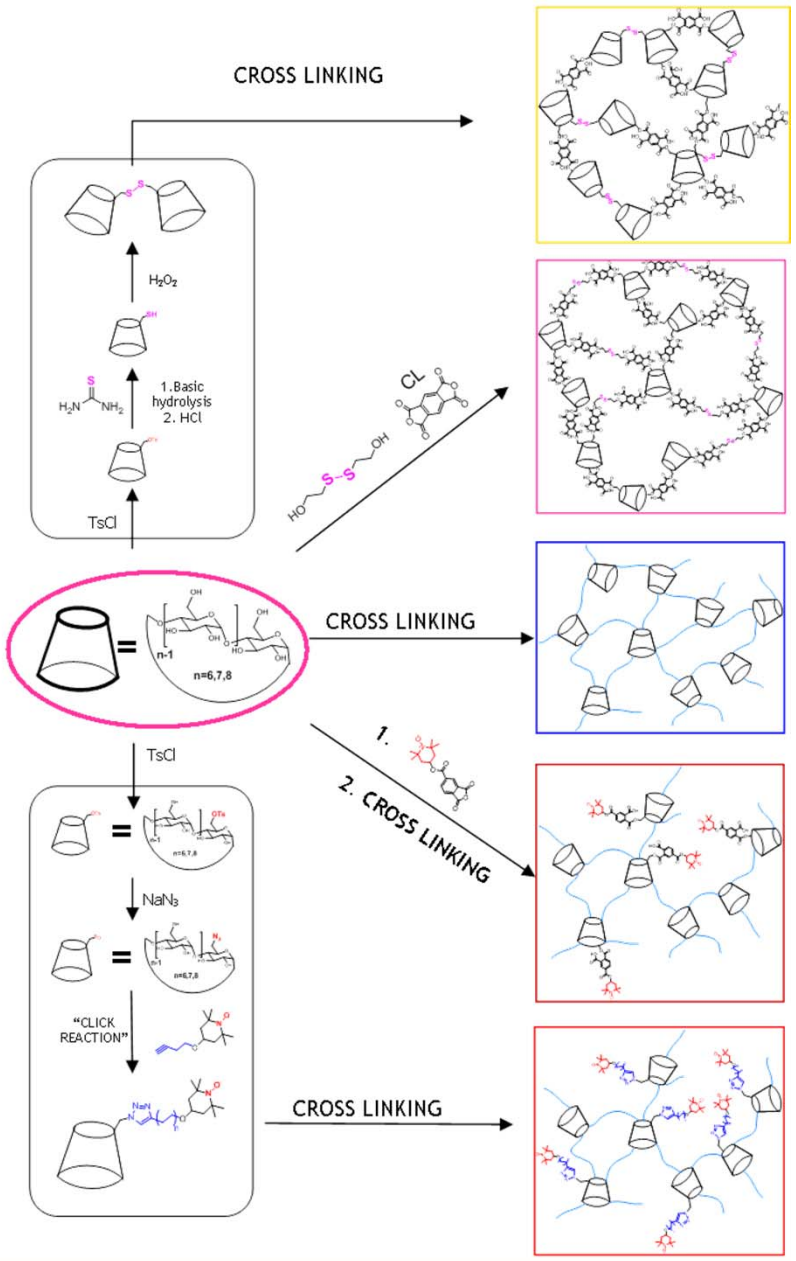
Home care

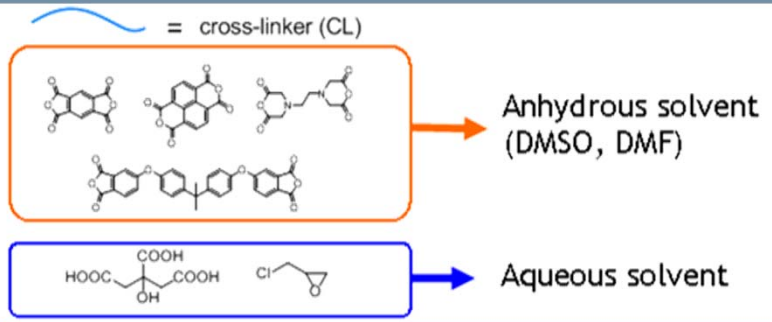
Food

Cosmetics

Drugs

Oligosaccharide-based materials: Cyclodextrin (CD) and Cyclodextrin Nanosponges (CDNS)

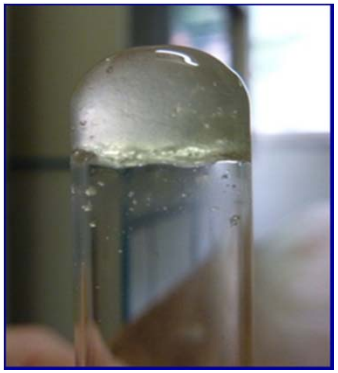




CDNS nanoporous cross-linked **polymers**

Intriguing properties:

- **increase** the dissolution rate, **solubility** and **stability of drugs**,
- mask **unpleasant flavors**,
- **convert liquid** substances **to solids** and to **prolong the release of drug**
- **Absorb** organic and inorganic pollutants
- They may form **stable hydrogels (e.g. drug loaded hydrogels)**



Soft Matter **2014, *10*, 2320**
***Beilstein J. Org. Chem*. 2014, *10*, 2715**
PCCP 2017, *19*, 6022
***Beilstein J. Org. Chem*. 2017, *13*, 182**

New catalytic systems for sustainable oxidations

Why: **oxidative processes of organic compounds represent some of the most important chemical transformations involved in many fundamental areas, including general synthesis, industrial processes, materials, energy, biology, and so on.**

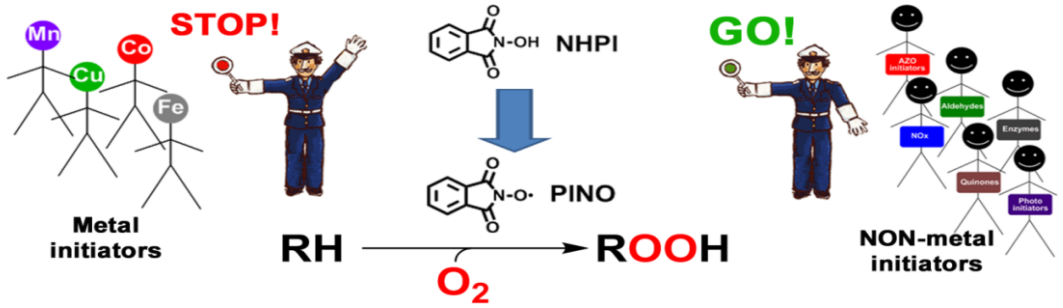
The oxidants: **the eco-friendly standards for the oxidative processes require oxidants able to combine a low environmental impact with an economical convenience. *Molecular oxygen and hydrogen peroxide* are the ideal oxidants from this point of view.**

Catalysis: **the use of these green oxidants strictly depends on the employment of catalytic systems, which allow operating with high selectivity under mild conditions.**

This group is specialized in the design of new – often metal-free – homogeneous catalytic systems for the selective oxidation of a wide range of substrates.

The developed processes based on this new catalysts often provide *promising "green" and more convenient alternatives to classical industrial procedures*

More than 20 papers on the field
4 book chapters edited by Wiley & Elsevier
5 international patents
2 national patents



***Beilstein J. Org. Chem.* 2013, *9*, 1296-1310.**

OSCM*Lab* – *Laboratory of Organic Synthesis, Catalysis, and Materials*

Prof. Alessandro Sacchetti

Prof. Alessandro Volonterio

Prof. Massimo Cametti

Prof. Carlo Punta

Dr. Melone, PhD

Dr. Fiorati, PhD

Dr. Petroselli, PhD

Dr. Pastori

Dr. Rossi, PhD

Dr. Pennetta

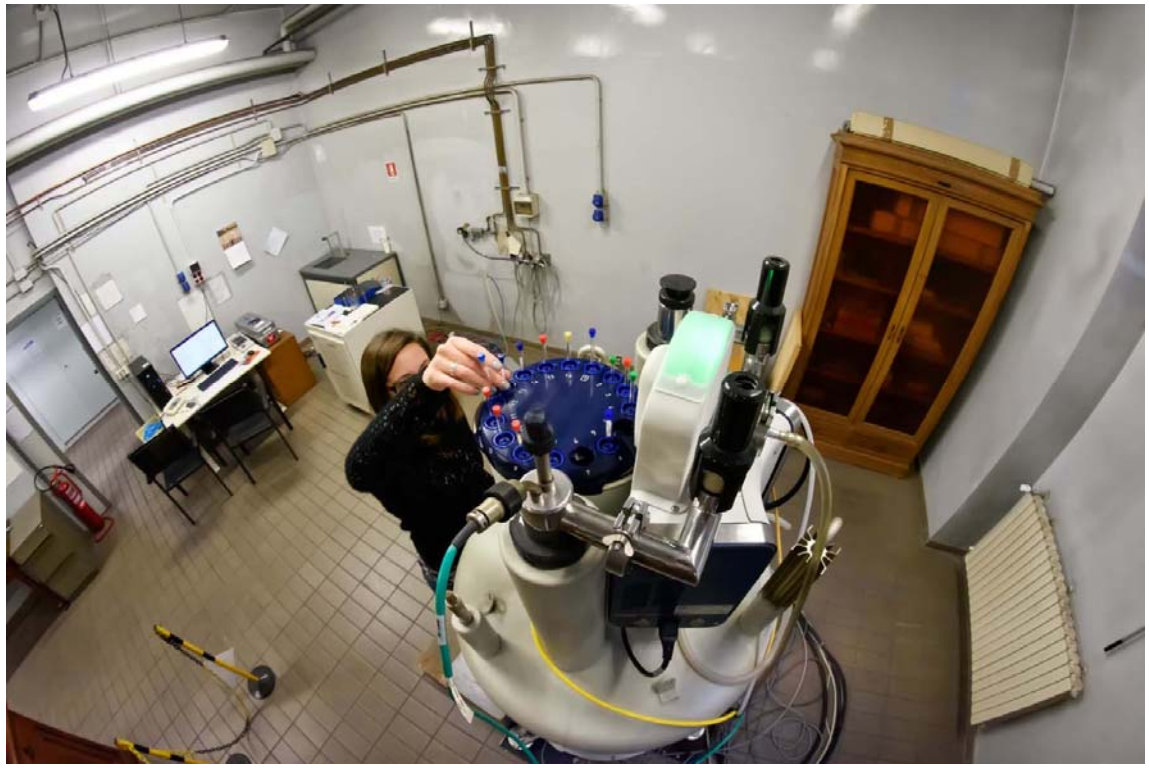
Dr. Rossetti

Dr. Colombo Dugoni

Dr. Caruso

Dr. Lippi

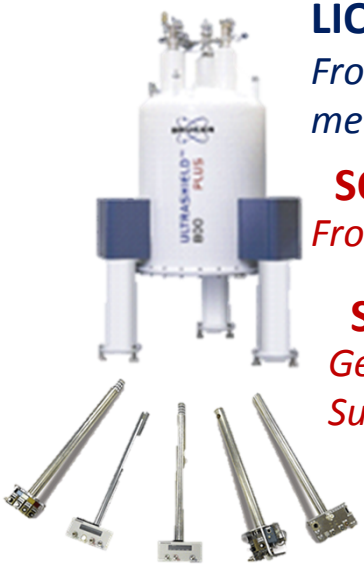
LGS – Laboratorio Grandi Strumenti



NMR spectroscopy
Mass Spectrometry
Powder X-ray Diffraction
FT-IR -UV-Vis
Freeze-drying equipment

Prof. Andrea Mele
Dipartimento CMIC "G. Natta"-
Via L. Mancinelli 7 - 20131 Milano Italy
Ph. +39 02 2399 3006
andrea.mele@polimi.it

LGS – What can NMR do for you?



LIQUID STATE

From molecular structure to metabolomics

SOLID STATE

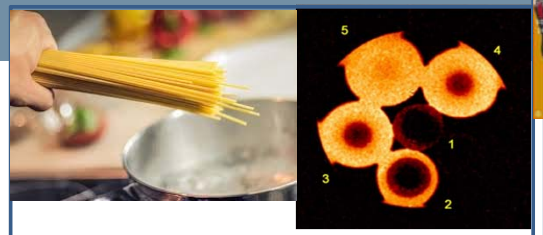
From materials to drug delivery

SOFT MATTER

Gels, Composites, Suspensions

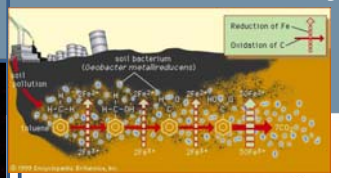
MICROIMAGING

From medicine to materials engineering

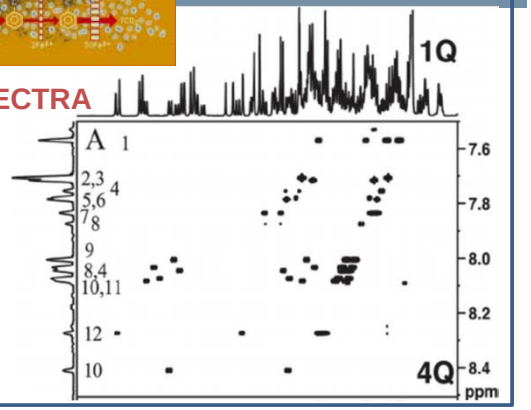


NMR microimaging of cooked pasta

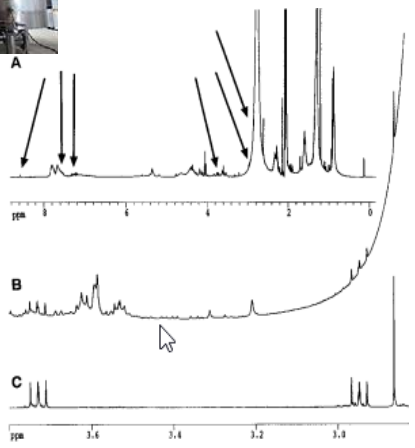
How to identify pollutants?



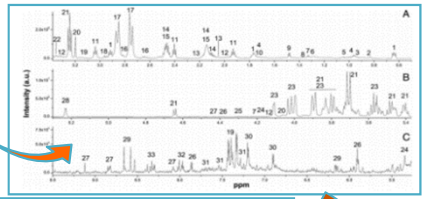
NMR SPECTRA



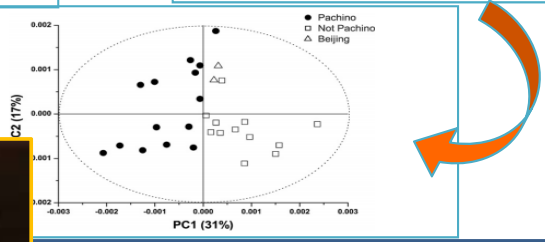
How to identify industrial byproducts?



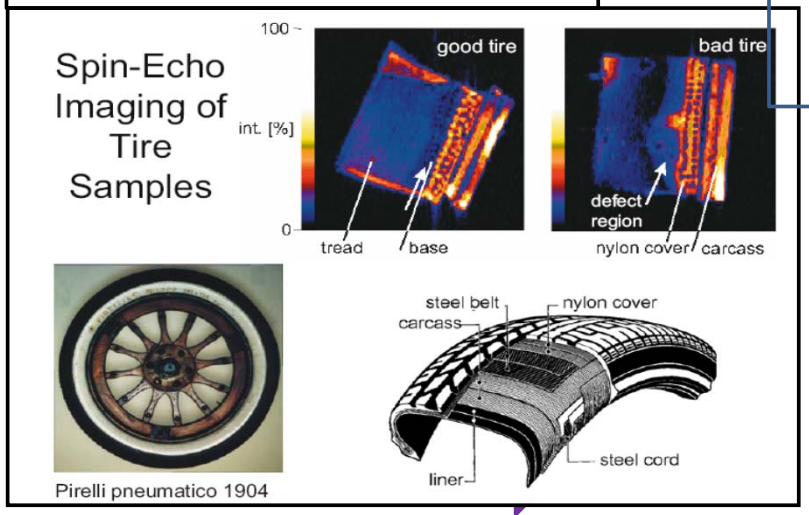
How to study food?
Metabolic profiling for food



MVA



How to evaluate materials?



What's inside a gel?
Cosmetics and Wellness Products