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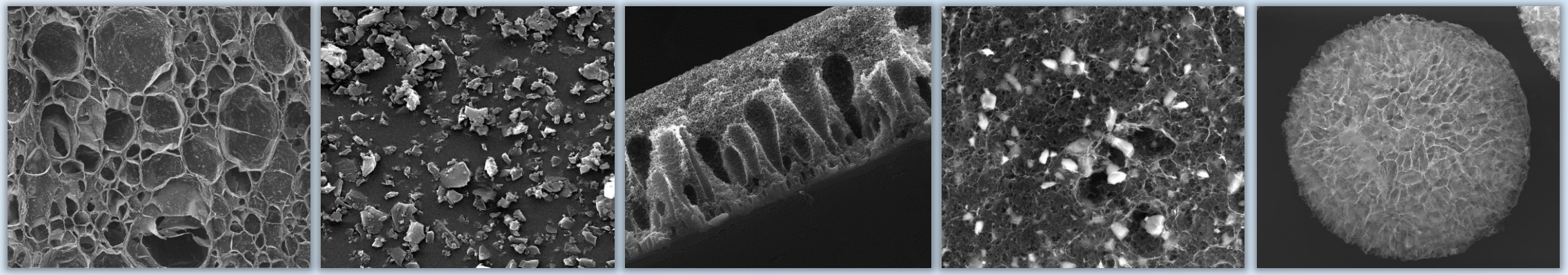
Dipartimento Scienze Chimiche e Tecnologie dei Materiali

Young Investigator Award 2019

ADVANCED MICROPOROUS SYSTEMS



FOR ENVIRONMENTAL APPLICATIONS

RACHELE CASTALDO

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ADVANCED MICROPOROUS SYSTEMS FOR ENVIRONMENTAL APPLICATIONS

water & air pollution

biological
chemical — approach
physical

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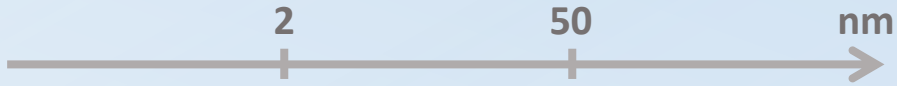
RACHELE CASTALDO

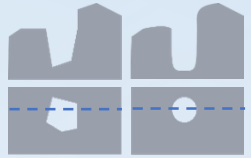
ADVANCED MICROPOROUS SYSTEMS FOR ENVIRONMENTAL APPLICATIONS

PHYSISORPTION

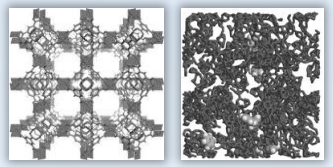
- spontaneous
- reversible
- favoured at low T
- multilayer
- non-specific
- non-site specific



- pore size : **micropores** / **mesopores** / **macropores**
- pore shape : **slit** / **cylindrical**



- pore level of order : **crystalline** / **amorphous**

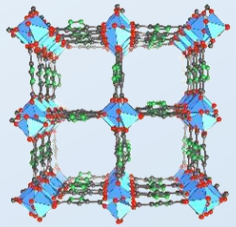


- pore size distribution:

  homogeneous / **heterogeneous** / **hierarchical** porosity

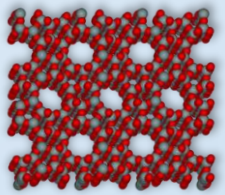
HIGH SURFACE AREA / MICROPOROUS MATERIALS

Metal Organic Frameworks

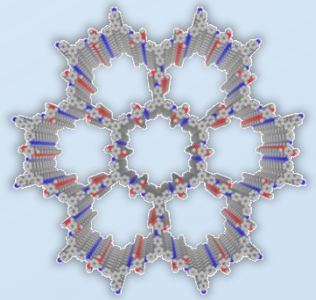


Activated Carbons

Zeolites

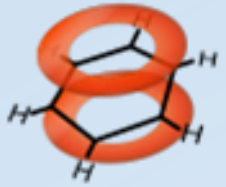


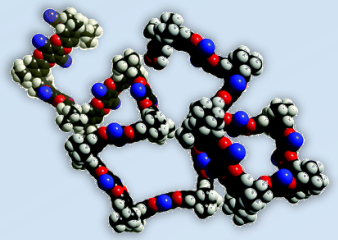
MICROPOROUS POLYMER



Covalent Organic Frameworks

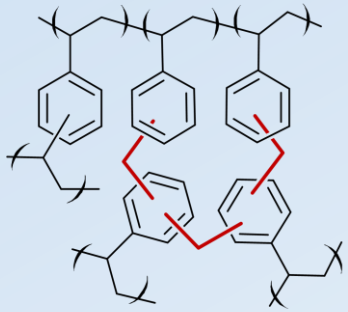
Conjugated Microporous Polymers





Polymers of Intrinsic Microporosity

Hyper-crosslinked Resins (HCLR)



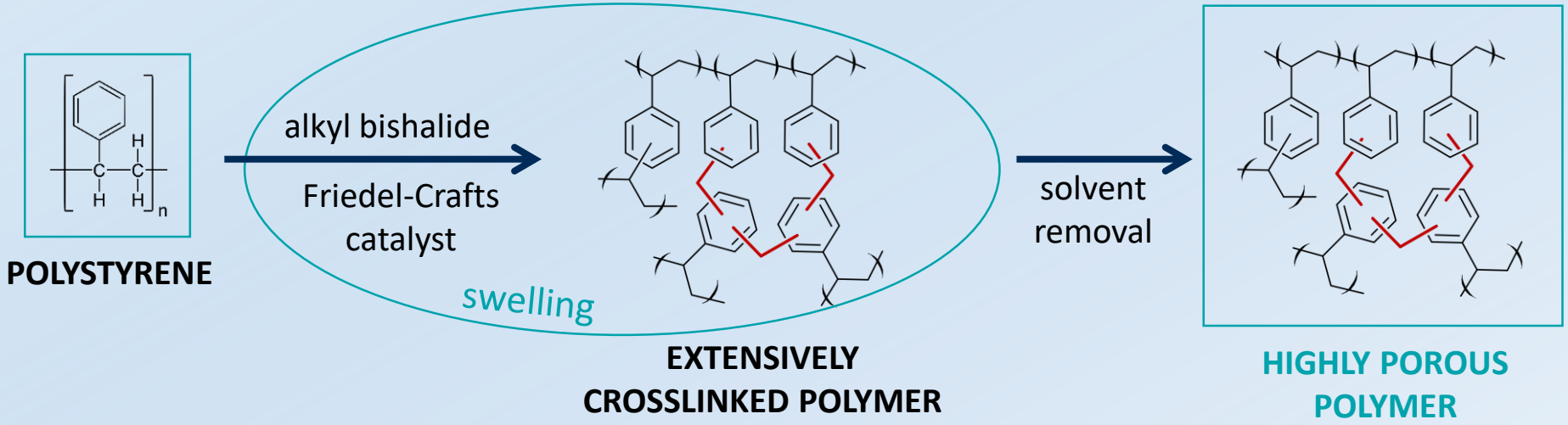
- ✓ high SSA
- ✓ low density
- ✓ tunable porosity and functionality

Hong Xu et al., 2015 Nature Chemistry
McKeown, et al., 2006 Chem. Soc. Rev
Castaldo et al., 2017, Polymers

HYPER-CROSSLINKED RESINS

- ✓ high SSA
- ✓ low density
- ✓ tunable porosity and functionality
- ✓ **high thermal & chemical resistance**

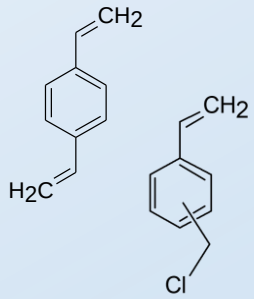
V.A. Davankov



HYPER-CROSSLINKED RESINS

NEW SYNTHETIC PROCEDURE

~~SUSPENSION POLYMERIZATION~~ → BULK POLYMERIZATION



HYPER-CROSSLINKING

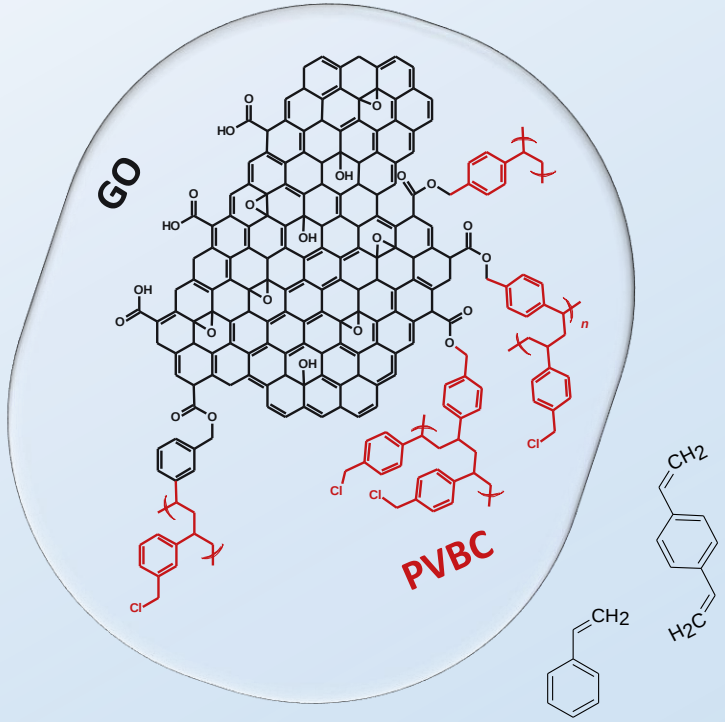
- ✓ high yield
- ✓ efficient dispersion of nanofillers

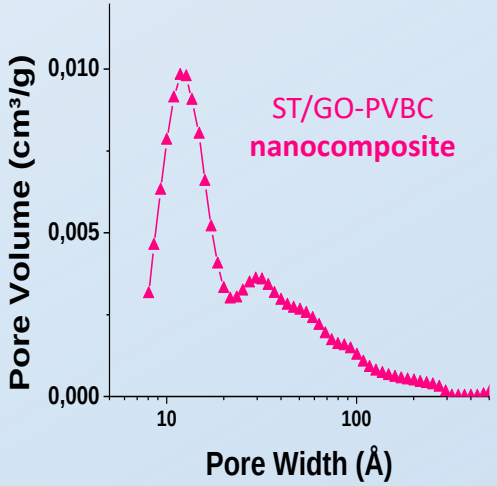
HIGH SURFACE AREA NANOCOMPOSITES

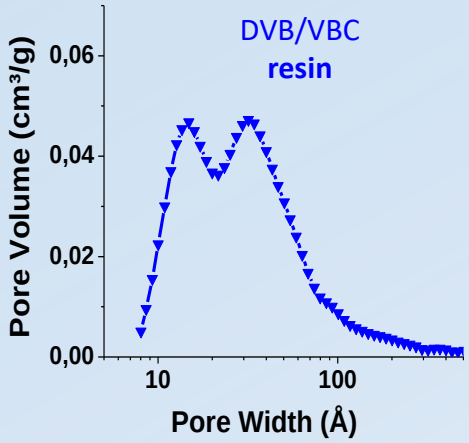
- graphene based materials
- mesoporous SiO_2
- TiO_2 nanoparticles
- metal nanoparticles
- …

Castaldo et al., *Macromolecules*, 2017, 50, 4132
Castaldo et al., *Nanomaterials*, 2019, 9, 1477

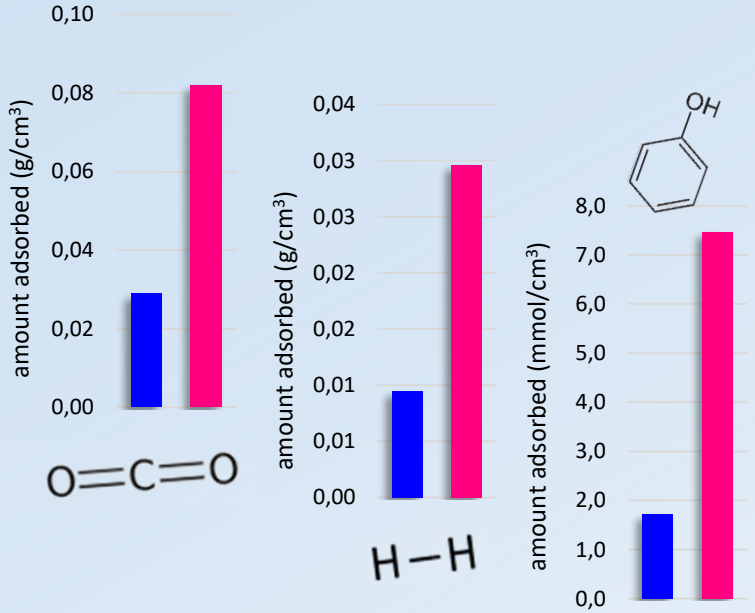
HYPER-CROSSLINKED NANOCOMPOSITES







adsorption capacity per pore volume



INTERFACIAL MICROPOROUS HCLN

Castaldo et al., *Macromolecules*, 2017, 50, 4132

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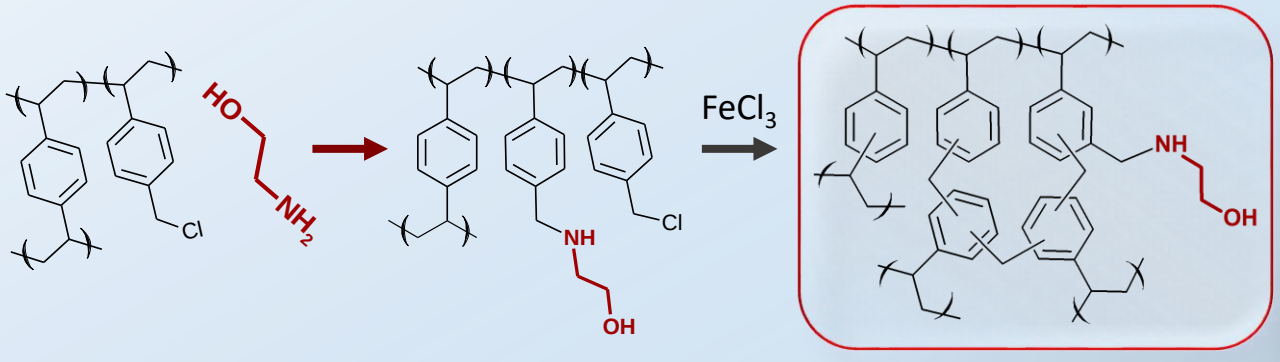
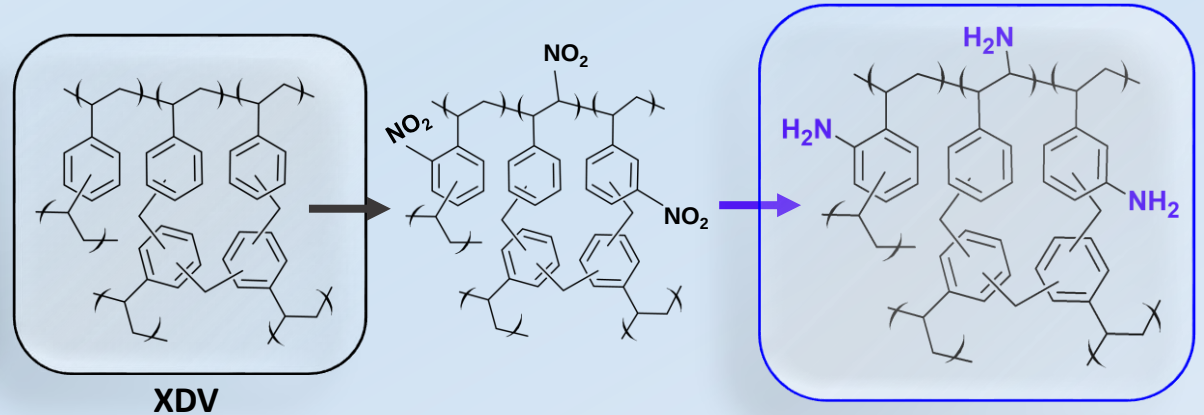
HYPER-CROSSLINKED RESINS WITH TUNABLE FUNCTIONALITY

ethanolamine-functionalized HCLR

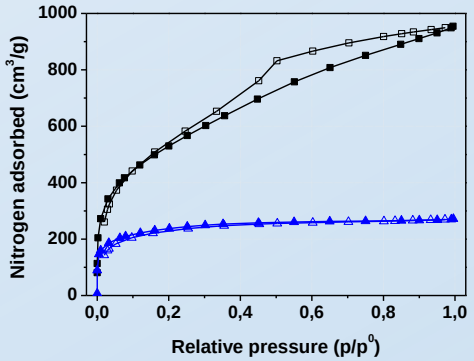


amino-functionalized HCLR



XDV

XDV-NH_2

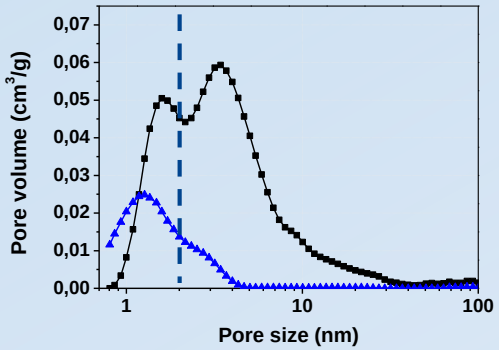


XDV

BET SSA: 2000 m^2/g

XDV-NH_2

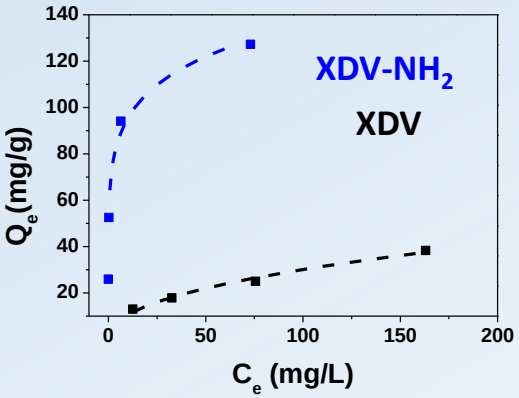
Langmuir SSA: 1200 m^2/g



indigo carmine adsorption

50% **100 %**

dye removal



Castaldo et al., *Chemical Engineering Journal*, 2019, 362, 497

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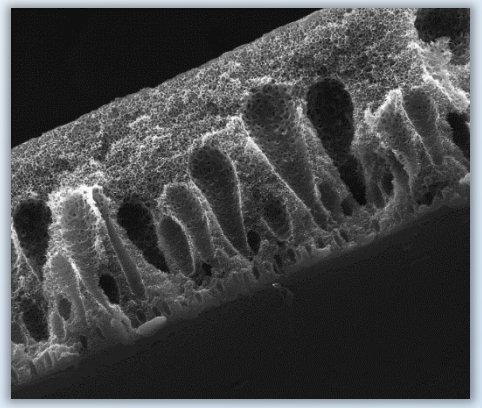
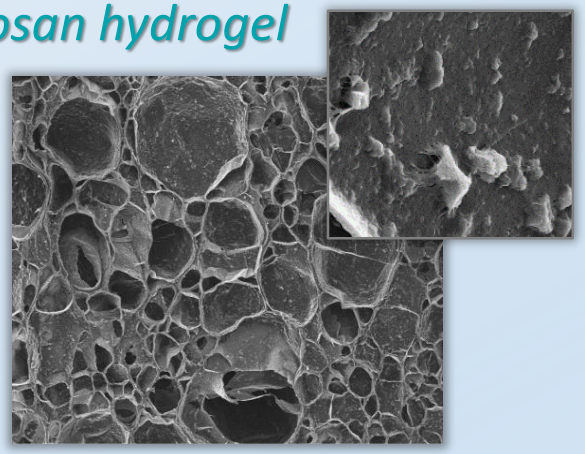
HYPER-CROSSLINKED RESINS IN MACROPOROUS SYSTEMS

polysulfone membranes



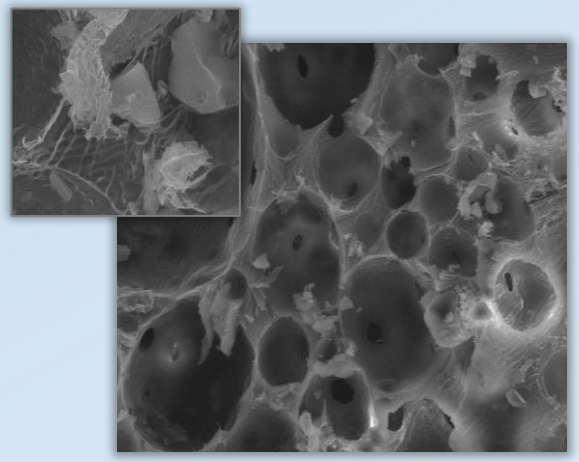
100 µm

chitosan hydrogel



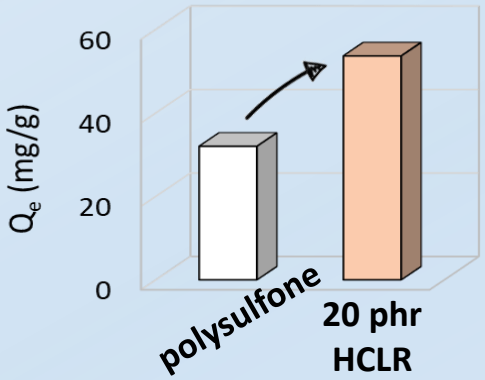
100 µm

poly(vinyl alcohol) foams

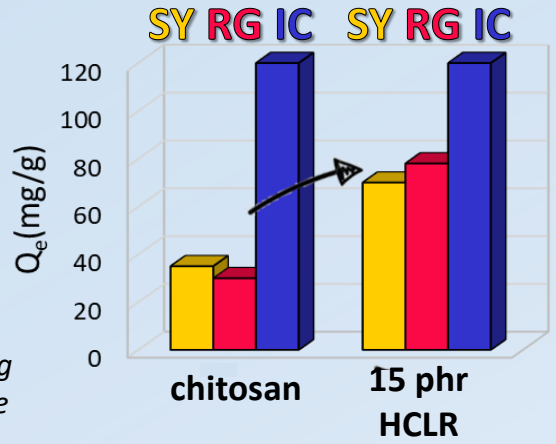


100 µm

phenol

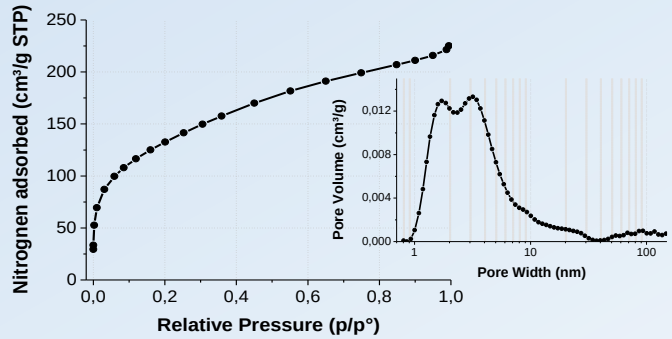


dyes



SY: Sunset Yellow
RG: Rhodamine 6g
IC: Indigo Carmine

> 80 % of HCLR porosity exposed



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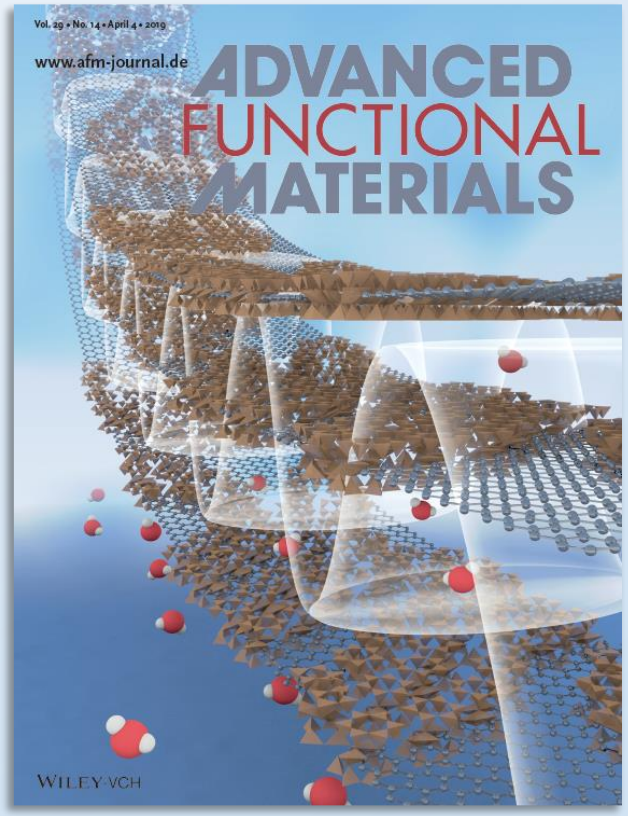
Castaldo et al., *Macromolecules*, 2017, 50, 4132
De Luna et al., *Carbohydrate Polymers*, 2017, 177, 347

HYPER-CROSSLINKED RESINS IN rGO/MMT HYDROGELS/AEROGELS



rGO / MMT / HCLR

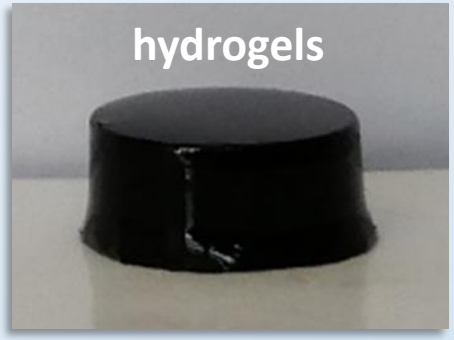
rGO / MMT / HCLR

rGO: Reduced Graphene Oxide, MMT: Montmorillonite

Castaldo et al., *Advanced Functional Materials* 2018, 1807744

HYPER-CROSSLINKED RESINS IN rGO/MMT HYDROGELS/AEROGELS

rGO / MMT / HCLR



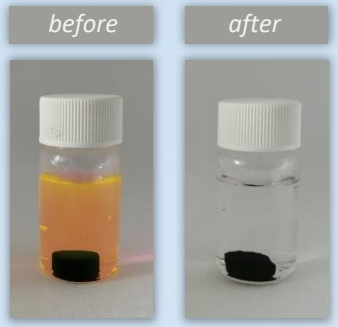
adsorption of organic pollutants from water

C_0 ~ 1500 mg/L

C_0 ~ 400 mg/L

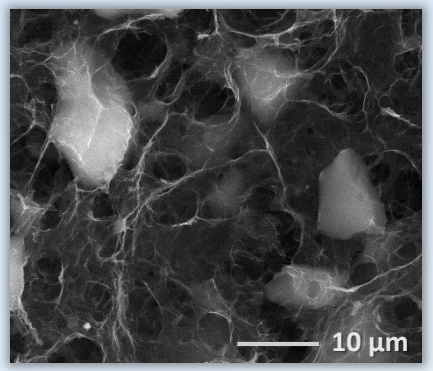
Rhodamine 6g

C_0 ~ 200 mg/L



adsorption of volatile organic pollutants

rGO / MMT / HCLR



CONCLUSIONS

High SSA microporous polymers were obtained through a **new high yield-high throughput synthetic procedure** based on the bulk polymerization of a gel-type precursor and following hyper-crosslinking

Through this procedure, a new class of high SSA **hyper-crosslinked nanocomposites** containing different functional nanofillers was developed, allowing to combine filler and matrix functional properties

Hyper-crosslinked resins and nanocomposites **functionalities** can be tuned by proper functionalization in order to induce the selective adsorption of specific pollutants

The embedding of **microporous hyper-crosslinked resins and nanocomposites**

in properly designed macroporous systems allows to obtain

highly performing hierarchical porous systems for adsorption applications

ONGOING ACTIVITIES

Microporous polymer composites for combined adsorption and photocatalytic applications

IPCF Istituto per i Processi Chimico Fisici

New hierarchical porous systems based on polyHIPE and HCLR by renewable resources

TECHNION Israel Institute of Technology

Adsorption of textile dyes released during washing processes

mermaids. OCEAN CLEAN WASH

Adsorption of volatile organic pollutants (VOC) for cultural heritage purposes

APACHE Horizon 2020

FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS INSTITUTE OF MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Adsorption of volatile organic contaminants emitted during plastic recycling

ECOBULK Horizon 2020

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