ISTITUTO DI CHIMICA DEI COMPOSTI ORGANOMETALLICI
Consiglio Nazionale delle Ricerche

Consiglio Nazionale delle Ricerche
Area della Ricerca di Pisa

SORPTION FRIENDS III - Workshop

2-4 May 20223, Taormina

Activities on sorption systems at CNR ICCOM-Pisa

Angelo Freni

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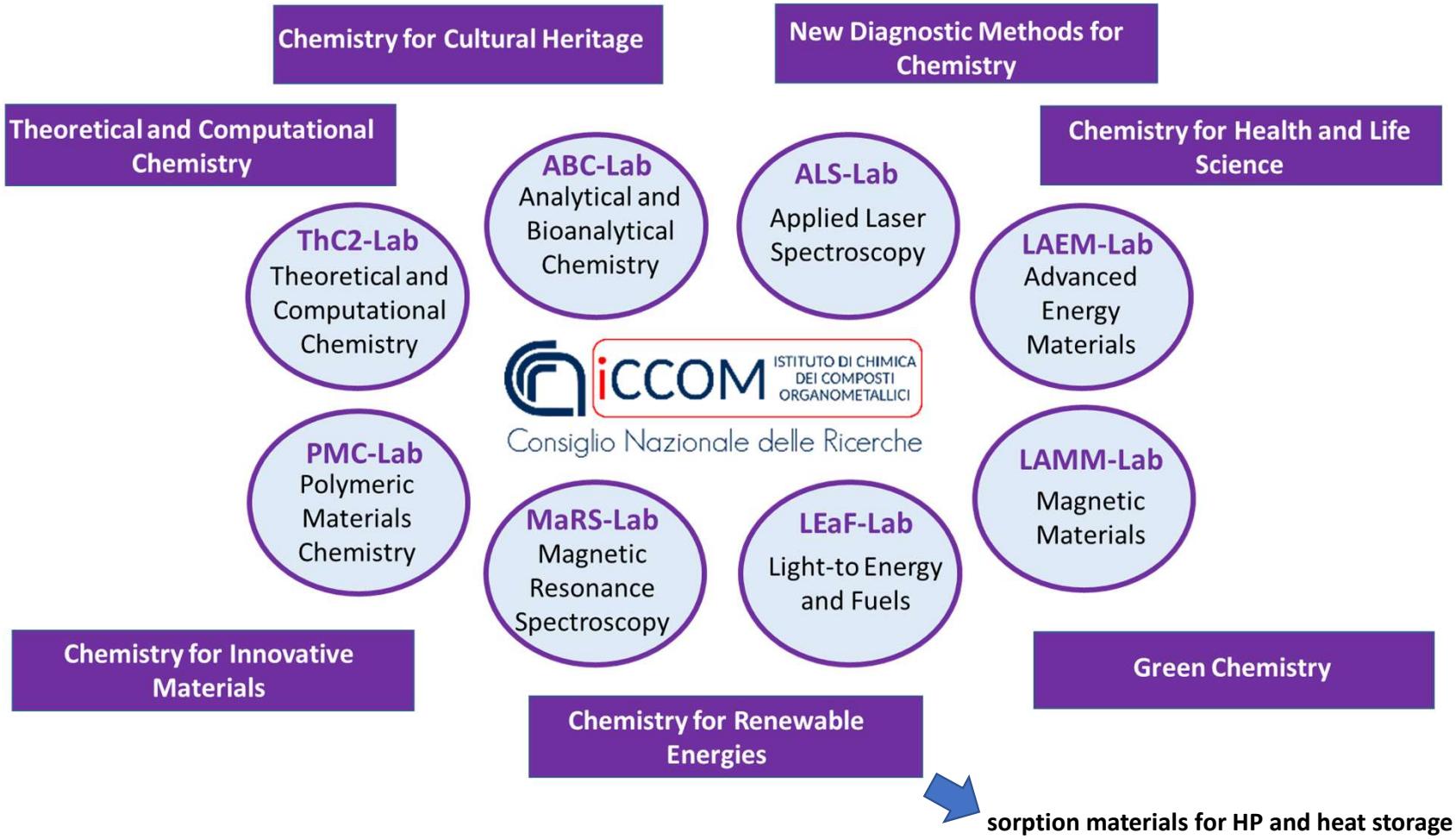
Florence (headquarter)

90	>3.400	>80
PERMANENT STAFF UNITS	PUBLICATIONS	PATENTS

Pisa site

Bari site

ICCOM SCIENTIFIC ORGANIZATION



Activities on sorption systems at CNR ICCOM-Pisa

- Polymeric adsorbent fibers by electrospinning for AHT
- Adsorbent layers for open cycles (dehumidification)
- Ionic liquids as heat storage fluid and for water sorption
- NMR studies on MOFs and ammonia salts
- Biochar for urban wastewater purification

Polymeric adsorbent fibers by electrospinning for AHT

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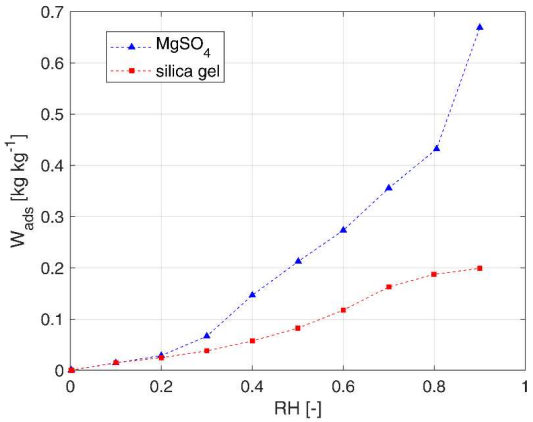
UNIVERSITÀ DEGLI STUDI DI REGGIO CALABRIA Mediterranea

Main features

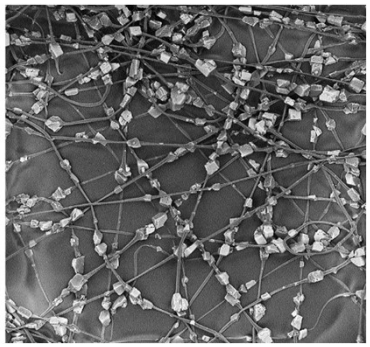
- ✓ High surface area
- ✓ High permeability
- ✓ High flexibility and mechanical strength
- ✓ Can fit various HEX geometries
- ✓ AdHEX with improved H&M transfer

Tailoring of adsorption properties

- ✓ Silica gel, SAPO34, hygroscopic salts,…
- ✓ Hydrophilic/hydrophobic polymers

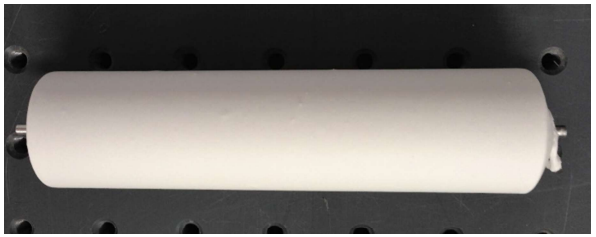


Adsorption isotherms at T=50°C



SEM of polymer/silica gel fibers

electrospun on an aluminum foil



electrospun on an aluminum pipe

L. Bonaccorsi et al., *Heat Powered Cycles Conference*, 3-6 Sept 2023 Edinburgh

A. Malara et al., *Heat Transfer Eng.*, 43(19), 1652-1663, 2022

E. Bramanti et al., *Materials Chemistry and Physics*, 287, 126248, 2022

A. Freni et al., *Energy*, 187, 115971, 2019

Adsorbent layers for open cycles

Main features

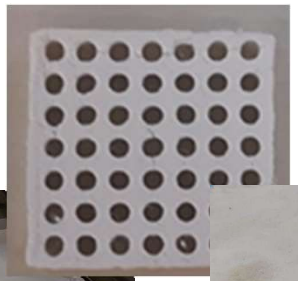
- ✓ Formulation based on a silica gel/polymer compound
- ✓ Different adsorbent configurations
- ✓ Can fit different HEX
- ✓ Tested a prototype for air dehumidification @POLIMI

Activities in progress

- ✓ Optimization of the formulation
- ✓ Use of different sorbents (salts, zeolites)
- ✓ Verification of hydrothermal stability

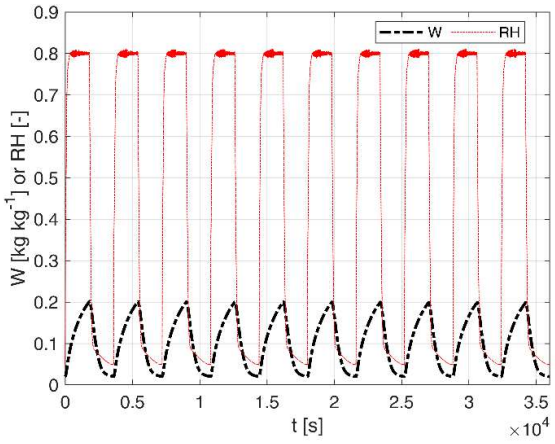
Slurry preparation

Layer drying



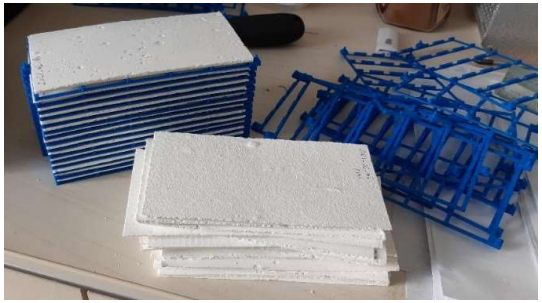
Monolith

Coating on Al

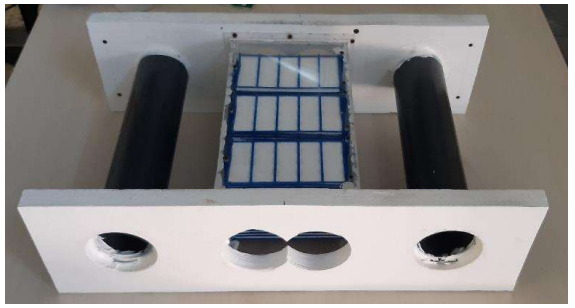


Repeated ad/desorption isotherms (45°C RH=5-80%)

Tensile test



Adsorbent layer stack preparation



Prototype for air dehumification

A. Freni et al., *Heat Powered Cycles Conference*, 3-6 Sept 2023 Edinburgh

S. De Antonellis et al., *Appl. Therm. Eng.,* 214, 118857, 2022

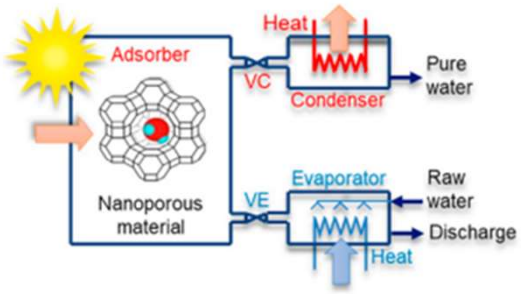
Ionic liquids as heat storage fluid and for water sorption

Activities

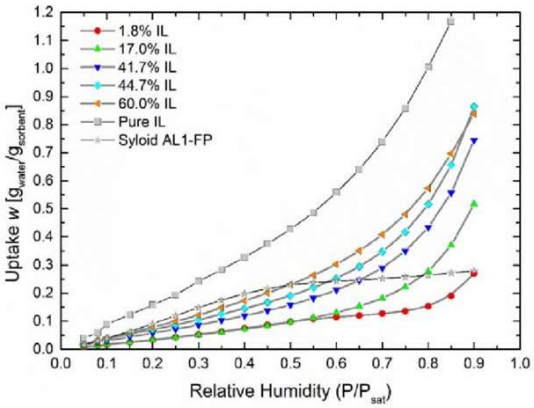
- ✓ Development and characterization of ILs with optimal thermo-physical properties (low viscosity, high thermal capacity, high density) for applications in the thermal storage sector at T = 100-400°C

- ✓ Verification of ILs thermal stability and resistance to corrosion by degradation tests in contact with metal at high T

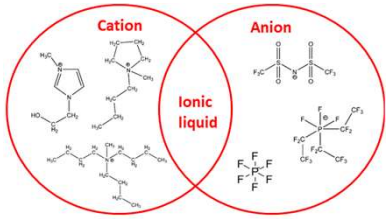
- ✓ Development of IL-based adsorbents for water desalination

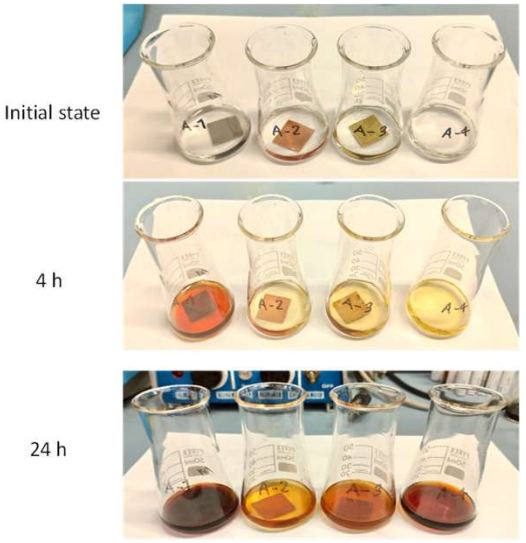


scheme of a single bed AD process



sorption isotherms at 25°C of a supported IL at different concentrations





Degradation of ILs in contact with metals at T=200C

F. Nardelli et al., *Materials*, 16 (5), 1762, 2023

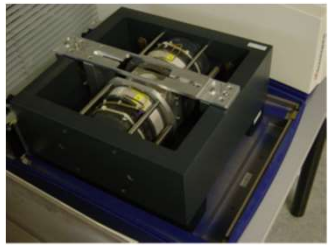
F. Nardelli et al., *Applied Sciences*, 12 (3), 1652, 2022

A.A. Askalany et al., *Desalination*, 452, 258-264, 2019

NMR studies on MOFs and ammonia salts

NMR Spectrometers

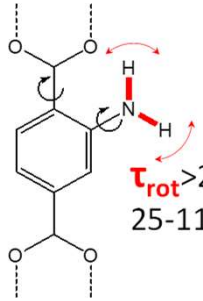
- ✓ Solid State NMR 400 MHz Varian Infinity Plus 400
- ✓ Solid State NMR 500 MHz, Bruker Avance Neo
- ✓ Fast Field-Cycling Relaxometer, Stelar SpinMaster 2000 (10kHz-42MHz)



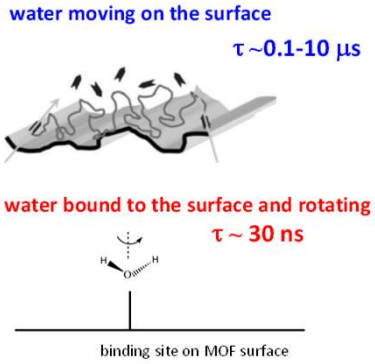
NMR Setups available at ICCOM

Activities

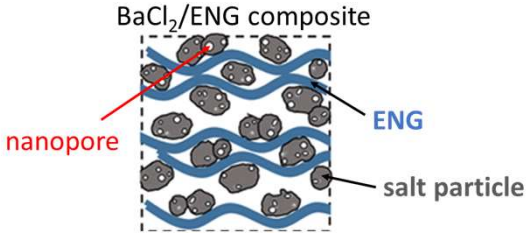
- ✓ NMR studies on MOFs (structural characterization, study the mobility of water inside the structure, adsorption behaviour)
- ✓ NMR studies on ammoniated $BaCl_2$ in expanded natural graphite – ENG (characterization of ammonia sorption into $BaCl_2$, study of aged samples)



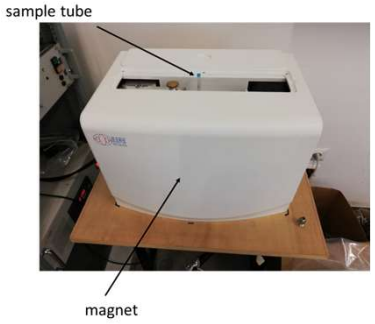
τ_{rot}>2.2 μs in the range 25-110 °C



Studies of framework flexibility and water mobility on NH2-MIL-125



$BaCl_2$/ENG composite



NMR setup to study the NH_3 absorbed

S. Pizzanelli et al., *Heat Transfer Engineering*, 43(19), 1652-1663, 2022

S. Pizzanelli et al., *The Journal of Physical Chemistry C*, 125(26), 14416–14429, 2021

S. Pizzanelli et al., *Physical Chemistry Chemical Physics*, 22, 15222-15230, 2020

Biochar for urban wastewater purification

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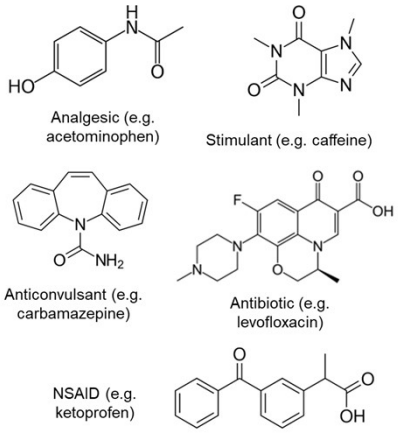
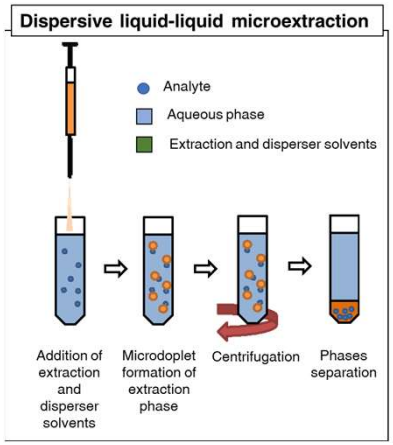
Eni

Activities

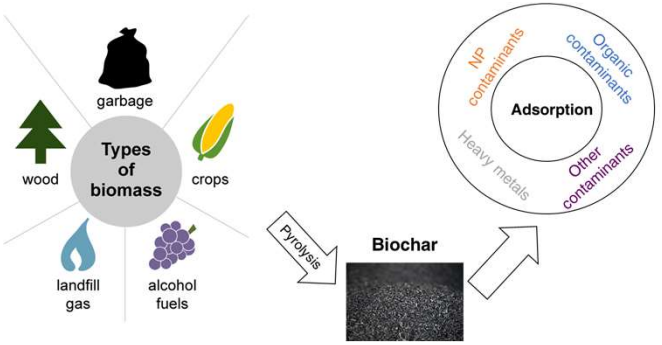
- ✓ Selection of organic adsorbents for contaminants removal
- ✓ Development of a HPLC method for the determination of emerging contaminants in urban wastewater treated with biochar and untreated

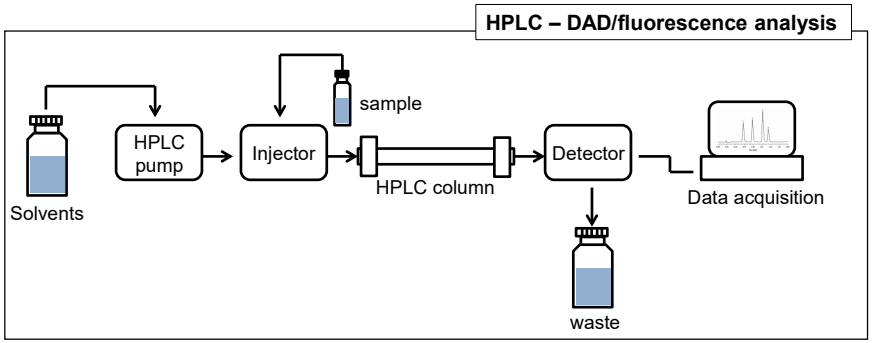


Some selected contaminants



sample preparation technique





The HPLC laboratory system

Instruments for elemental analysis available at ICCOM

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Elemental analysis:

- Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES Varian 720 ES)
- Inductively Coupled Plasma Mass Spectrometer (ICP-MS Agilent 7700x)
- Laser Induced Breakdown Spectrometer (LIBS Portable Modì Marwan Technology)

Molecular analysis:

- UV/Vis spectrometer (Jasco V700 from 190 to 1100 nm)
- FT-IR spectrometer (Perkin Elmer Frontier MIR Perf/KBr/DTGS)
- μ-Raman spectrometer (Renishaw InVia, lasers at 532, 633 and 750 nm equipped with xy-stage for 2D mapping)

Chromatography:

- Gas chromatography – mass spectrometer for liquid and headspace analysis (Agilent GC 6850 and Agilent MS 5795c)
- High performance liquid chromatography coupled with fluorescence and diode array detectors (Agilent Infinity 1260)

Thermo-analysis:

- Thermogravimetric analysis (TGA)
- Differential scanning calorimetry (DSC)

TG apparatus for water adsorption isotherms measurement: acquisition in progress

Thank you for your attention

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