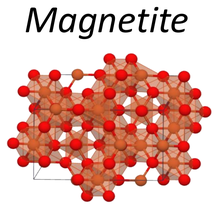
Magnetite functionalized with metal-organic frameworks (MOF) for perfluorooctanoic acid (PFOA) absorption

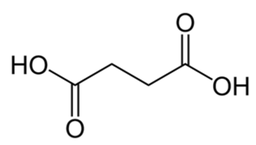
Davide Ceriotti[1*], Marco Pedrazzoli[1], Luca Magagnin[1,2], Maurizio Sansotera[1,2]

Magnetite

$$2FeCl_3 + FeCl_2 \xrightarrow[Water]{NaOH} Fe_3O_4\,(magnetite)$$

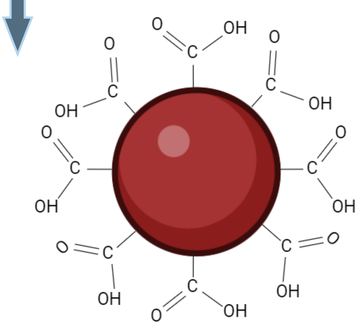
Magnetite + Succinic acid





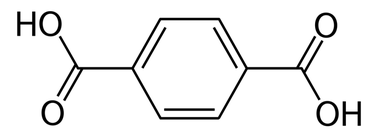
24h Water

$Fe_3O_4@(C_4H_6O_4)$



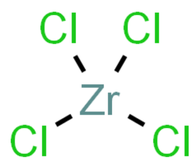
1- *WO/2015/177710, International patent.*

Functionalization

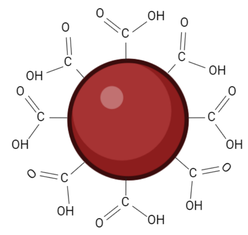


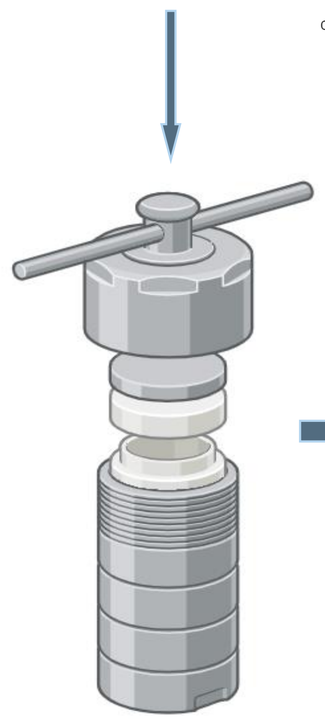
Terephthalic acid

Zirconium (IV) chloride



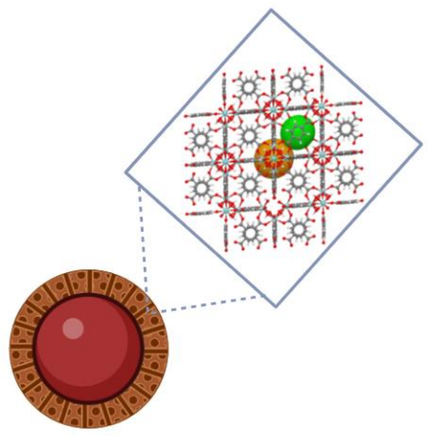
$Fe_3O_4@(C_4H_6O_4)$





Isopropanol

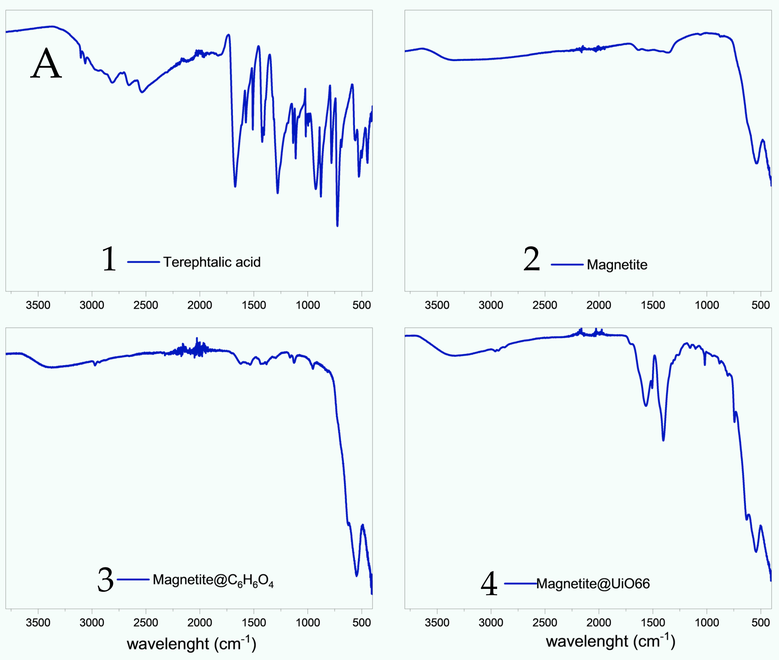
120°C
12h



Magnetite@UiO66

2- Michael J. Katz , Chem. Commun., 2013, 49, 9449-9451.

Characterization



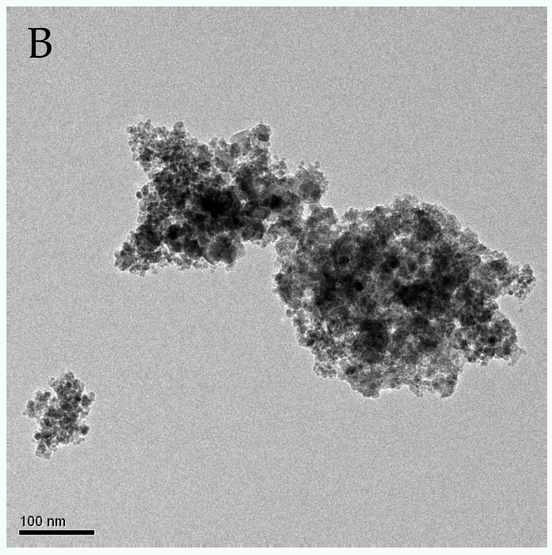


Fig 1. ***A****) FTIR-ATR peaks of 1-terephthalic acid; 2- Fe_3O_4; 3- $Fe_3O_4@(C_4H_6O_4)$; 4- Fe_3O_4@Ui66.* ***B****) TEM image of the powder.*

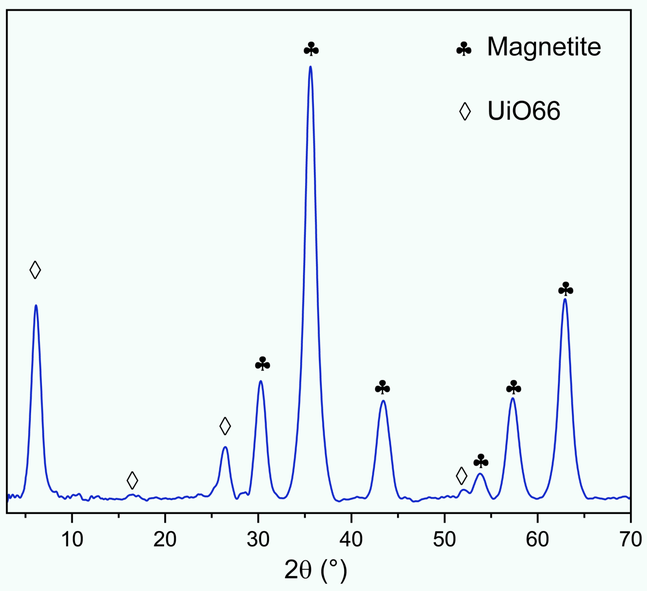


Fig 2. *XRD peaks of Fe_3O_4@Ui66*

- From FTIR-ATR spectra is possible to observe the presence of the peaks associated with the ester bonds that forms in the structure of the MOF (4) and the disappearance of the peak related to the acidic group present, instead, in the spectrum of terephthalic acid (1).
- The TEM image shows magnetite covered with crystalline MOF.
- XRD peaks show the presence of both magnetite and UiO66.

Magnetic MOF in water

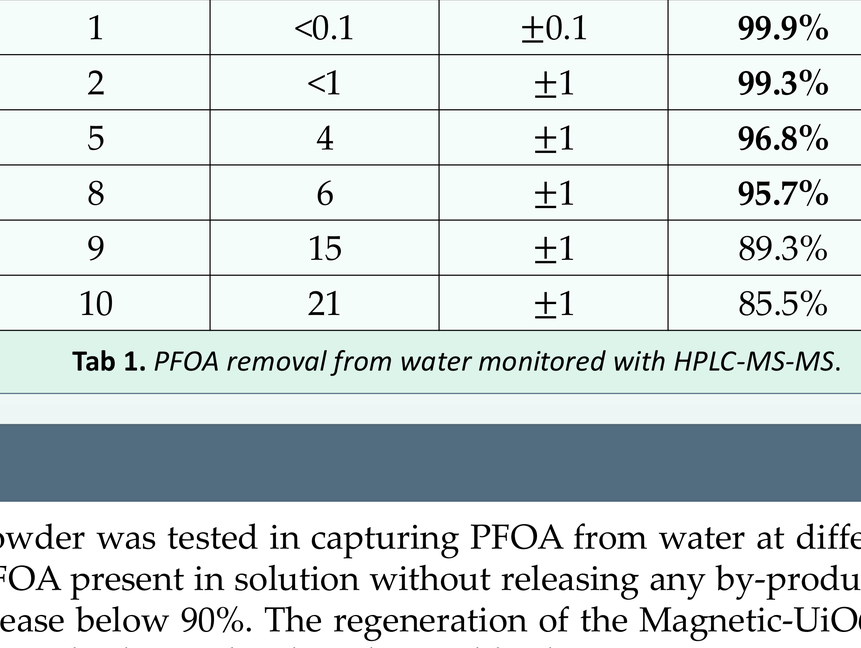


Fig 3. *Picture of Magnetic MOF in water, before (left) and after (center) the application of a magnetic field and the removal of the magnetic powder (right)*

PFOA absorption

Absorption tests conducted with 1000ppm of magnetic UiO66 to treat multiple 145ppb of PFOA solutions.

N° extraction	ppb PFOA	Error (ppb)	Extraction %
1	<0.1	±0.1	**99.9%**
2	<1	±1	**99.3%**
5	4	±1	**96.8%**
8	6	±1	**95.7%**
9	15	±1	89.3%
10	21	±1	85.5%

Tab 1. *PFOA removal from water monitored with HPLC-MS-MS.*

Conclusions

Magnetic Zirconium MOF has been successfully synthetized and characterized. The obtained powder was tested in capturing PFOA from water at different concentrations. In just 10 minutes of shaking, the magnetic MOF can capture up to 99% of the PFOA present in solution without releasing any by-product in the water system. Moreover, the powder can be reuse up to 9 times before its performance decrease below 90%. The regeneration of the Magnetic-UiO66 is currently under investigation through a desorption process. Aluminum and copper-based MOFs are also being developed as viable alternatives.

*Presenting author: **Davide Ceriotti**, davide.ceriotti@polimi.it

1. Dipartimento di Chimica, Materiali e Ingegneria Chimica, Politecnico di Milano, Via Mancinelli 7, 20131 Milano, Italy.
2. Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali (UdR-PoliMi), via G. Giusti 9, 50121 Firenze, Italy.

FLUORITECH
LABORATORY OF FLUORINE CHEMISTRY AND FLUORINATED MATERIALS