Investigation of Xe adsorbents in conditions relevant for IMS noble gas systems

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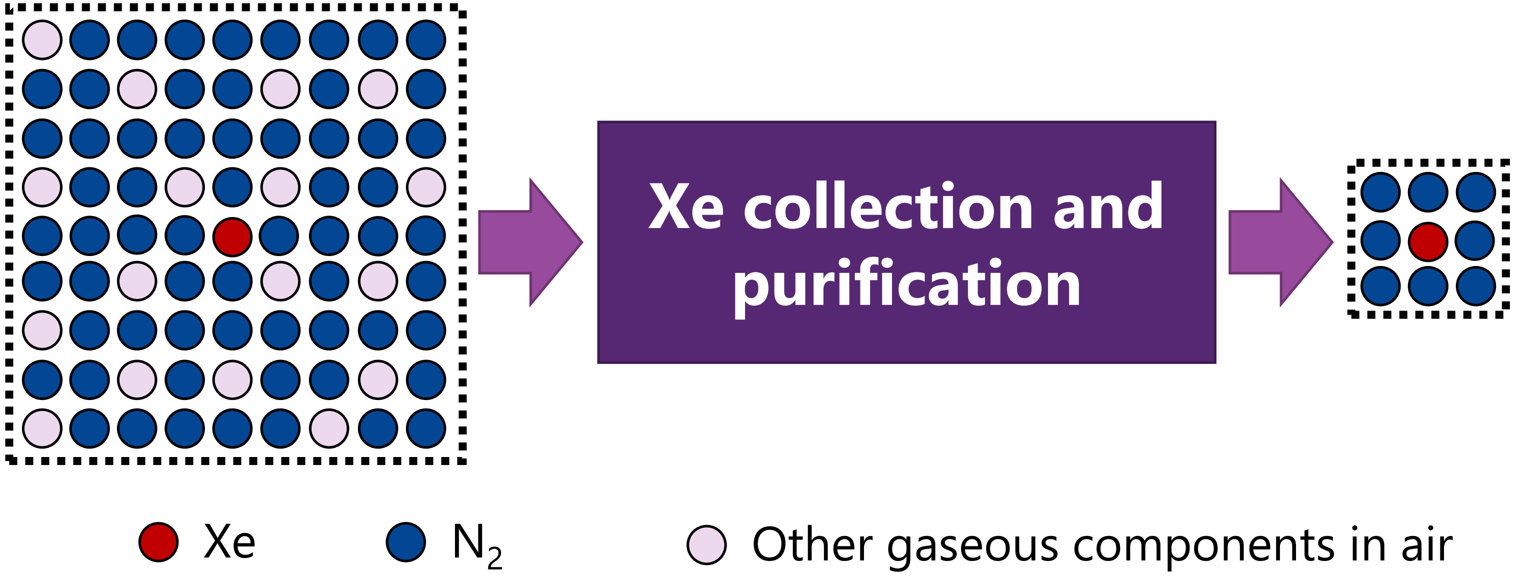
Content

- Introduction
- Selected adsorbents
- Xe collection
- Xe separation
- Durability
- Conclusions & perspectives

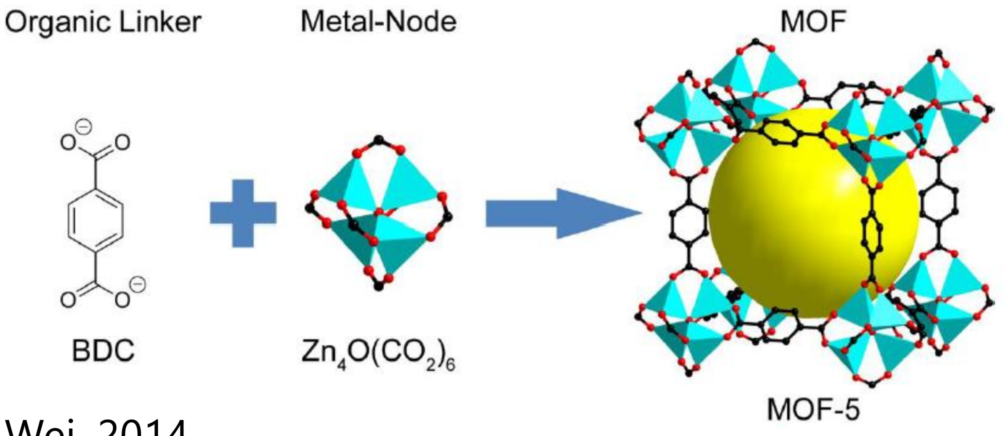


Introduction

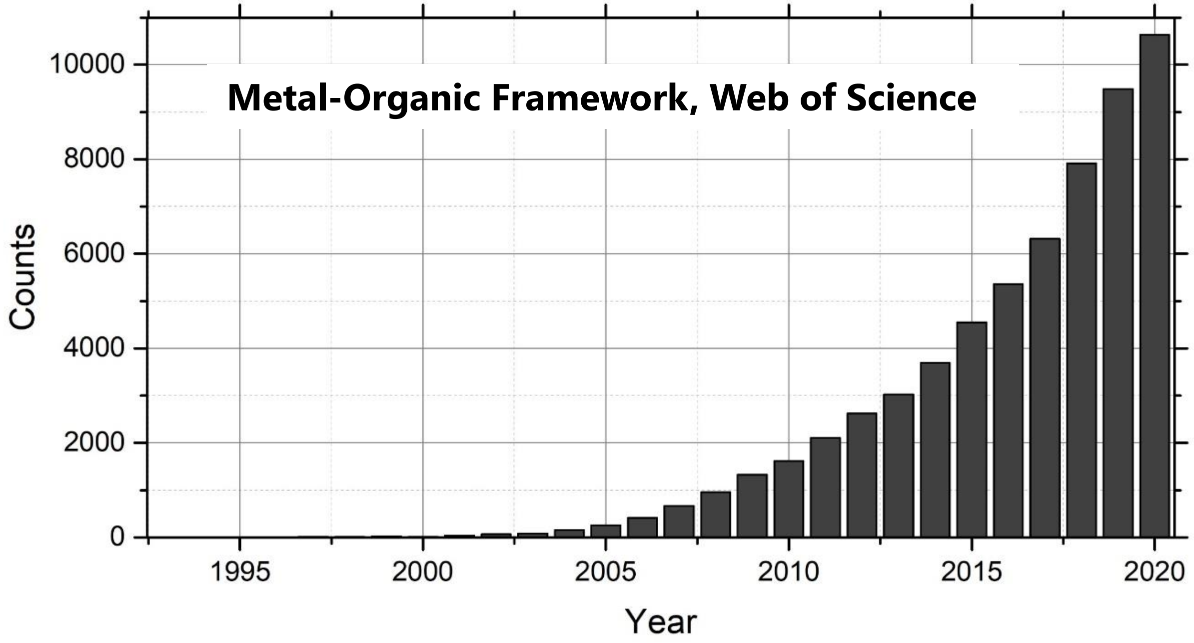
New class of adsorbents

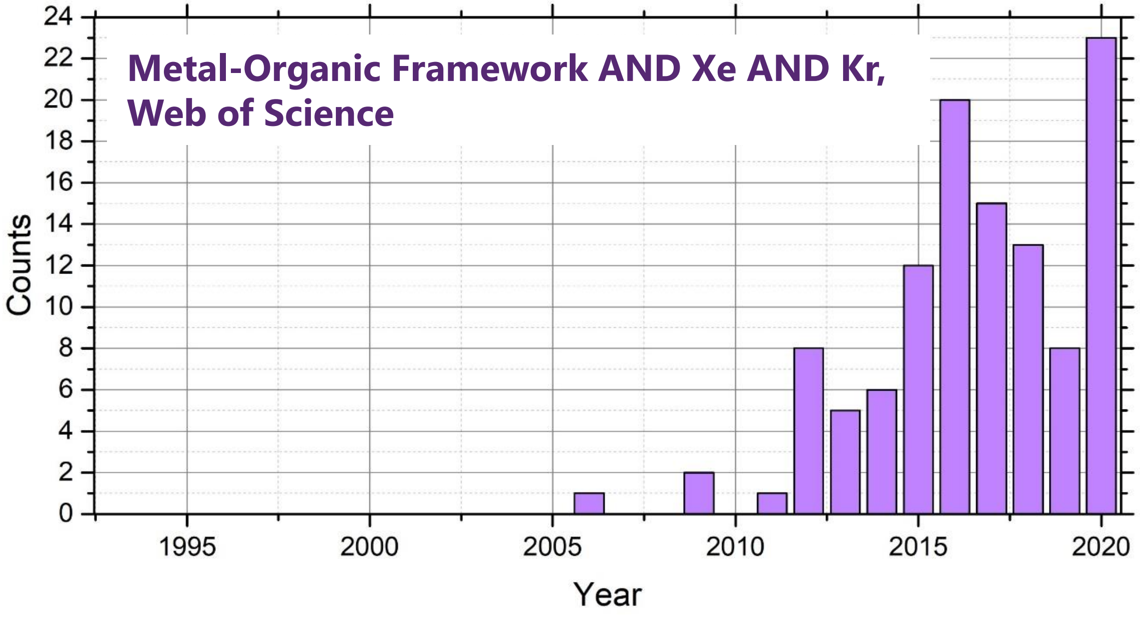
- Metal-Organic Frameworks
  - Promising adsorbents for various separation processes

Xe/Kr separation



Wei, 2014.

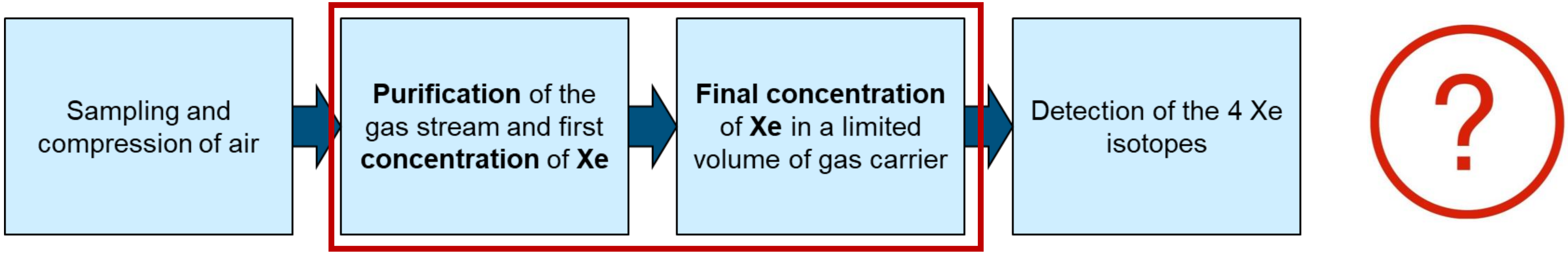




Wei, Z. New Design and Synthetic Strategies of Metal-Organic Frameworks. Ph.D. Thesis, Texas A&M University, 2014.

Introduction

- Could these MOFs have potential to enhance Xe collection and purification in IMS NG systems ?



- More specifically
  - Efficient Xe collection from air (adsorption) ?
  - Efficient separation of Xe from other gaseous components (desorption) ?
  - Durability against adsorption/desorption cycles ?

➡ **EU JA VII: Study of materials for improved adsorption of Xe**

➡ **Ongoing further research**

Selected adsorbents

- Reference adsorbents
  - Activated carbon: Nusorb GXK
  - Silver-exchanged zeolites: Ag-ETS-10 & Ag-ZSM-5

- MOFs – Selection criteria (end 2018)
  - Only commercially available MOFs
    - > 10 g
  - Hydrothermal stability
  - Xe adsorption properties (from Xe/Kr separation literature)

➡ **HKUST-1**, **Ni-DOBDC**, UiO-66 and ZIF-8

Activated Carbon (AC)

Nusorb GXK

Silver-exchanged Zeolite (AgZ)

Ag-ETS-10 (SAUNA III)

Ag-ZSM-5 (SPALAX-NG)

Metal-Organic Framework (MOF)

Ni-DOBDC

HKUST-1

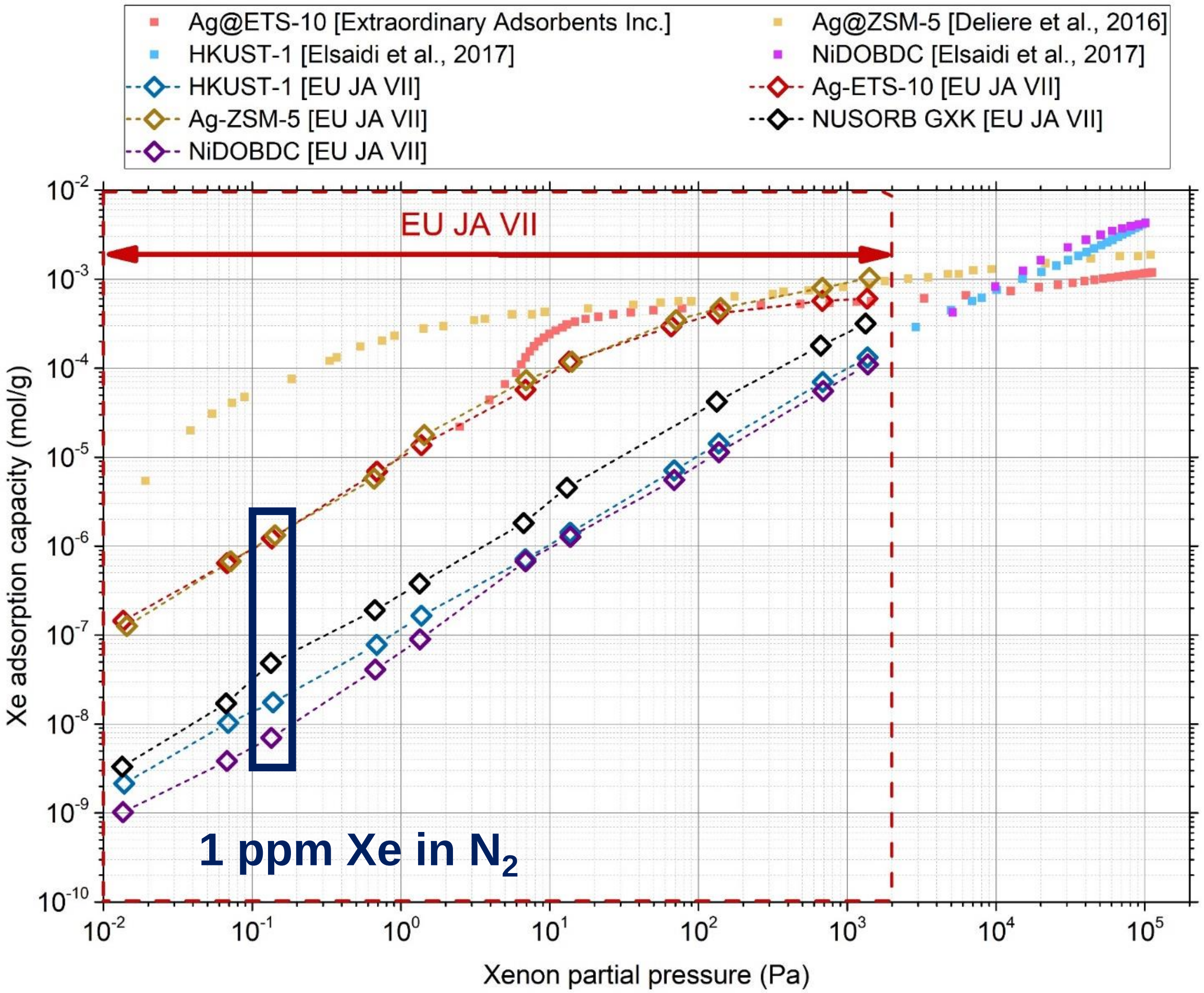
Xe collection

- Literature
  - Known pure Xe adsorption capacity for P_{xe} > 1000 Pa

Xe concentration in air = 87 ppb
8.7 mPa for air at 1 bar

?

- EU JA VII project
  - Xe adsorption capacity in N_2
    - 0.01 Pa to 1000 Pa
    - Much higher for AgZ at low P_{Xe}

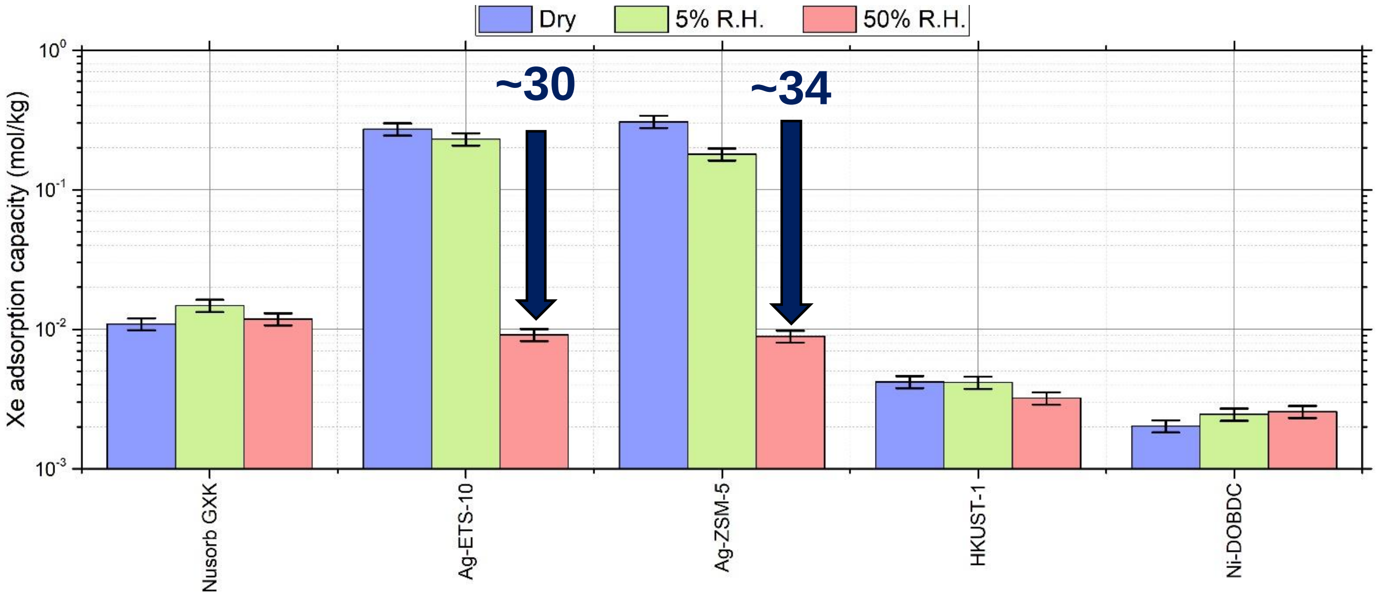


Material	Ratio to HKUST-1
Ag-ZSM-5	**76 (19)**
Ag-ETS-10	**70**
Nusorb GXK	2.7
HKUST-1	1.0
Ni-DOBDC	0.40

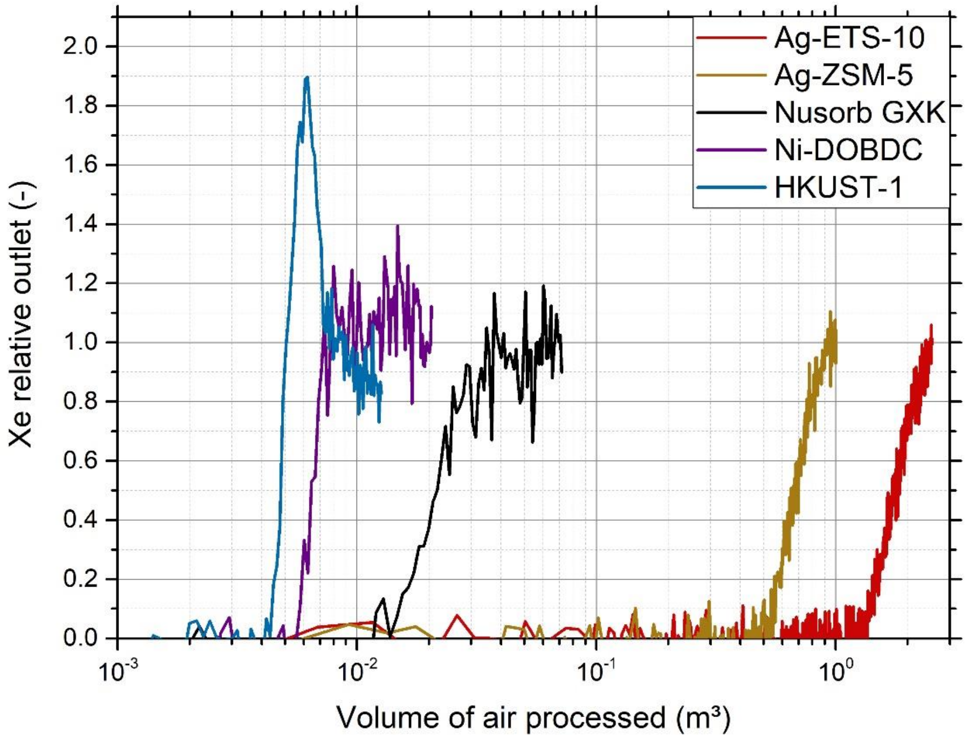
Deliere et al., 2016. Chemistry A European Journal 22 (28).
Elsaidi et al., 2017. Chemistry A European Journal 23 (45).

Xe collection

- Xe adsorption in air
  - >100 times higher for AgZ than MOFs
- Effect of moisture on Xe adsorption capacity
  - Significant decrease on AgZ



$V_{adsorbent}$ = 50 cm^3



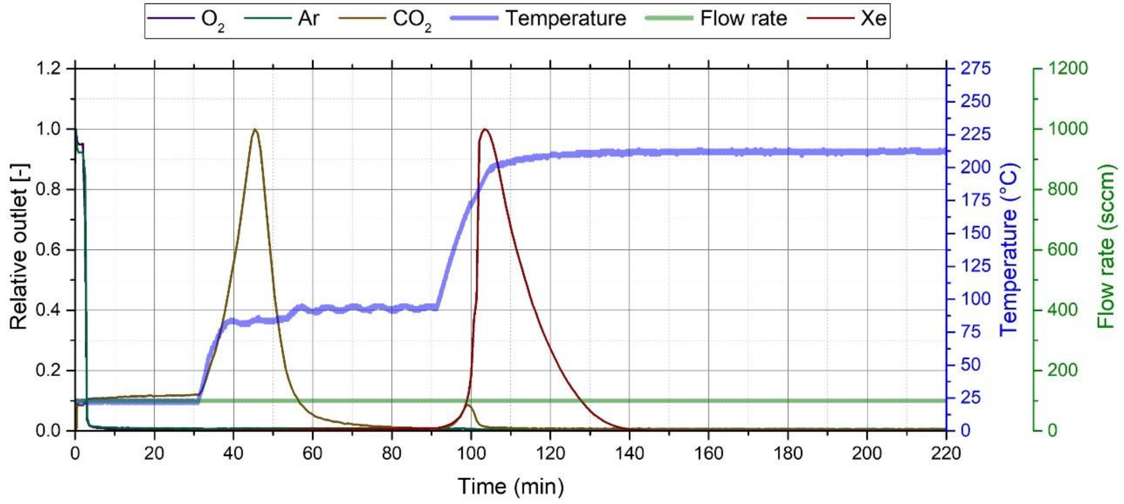
New measurements ongoing (time resolution, selectivities)

Xe separation

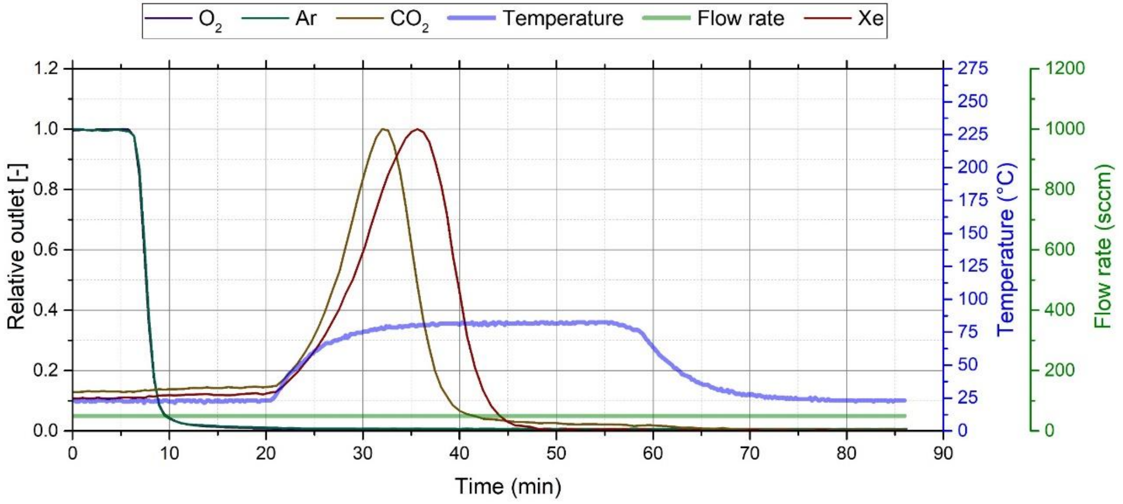
- Xe separation from O_2, Ar and CO_2
  - Desorption with varying T and F
  - Best results obtained on AgZs

Material	Xe (%)	O_2 (%)	Ar (%)	CO_2 (%)
Ag-ETS-10	91%	< 1%	< 1%	1%
Ag-ZSM-5	87%	< 1%	< 1%	**6%**
NUSORB	91%	2%	< 1%	**27%**
Ni-DOBDC	89%	**21%**	**12%**	2%
HKUST-1	90%	2%	1%	**86%**

Ag-ETS-10



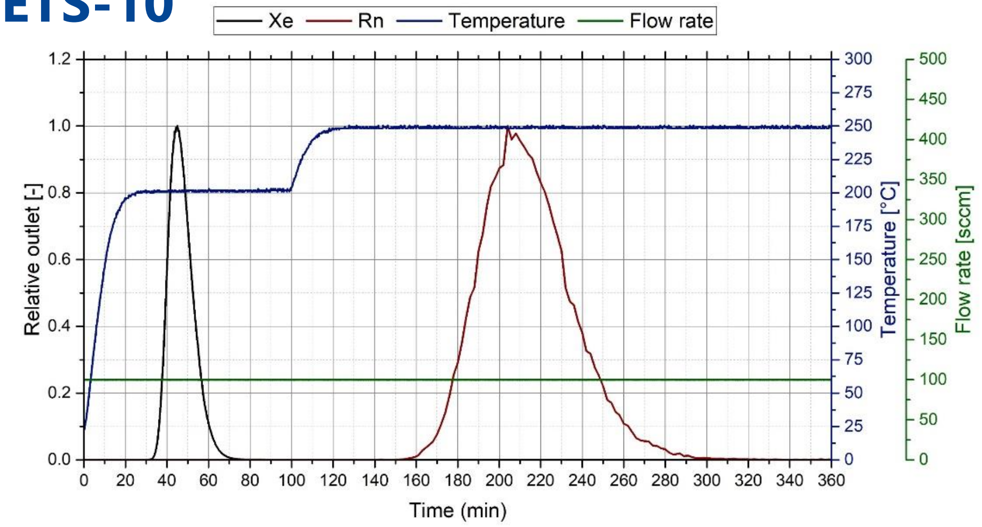
HKUST-1



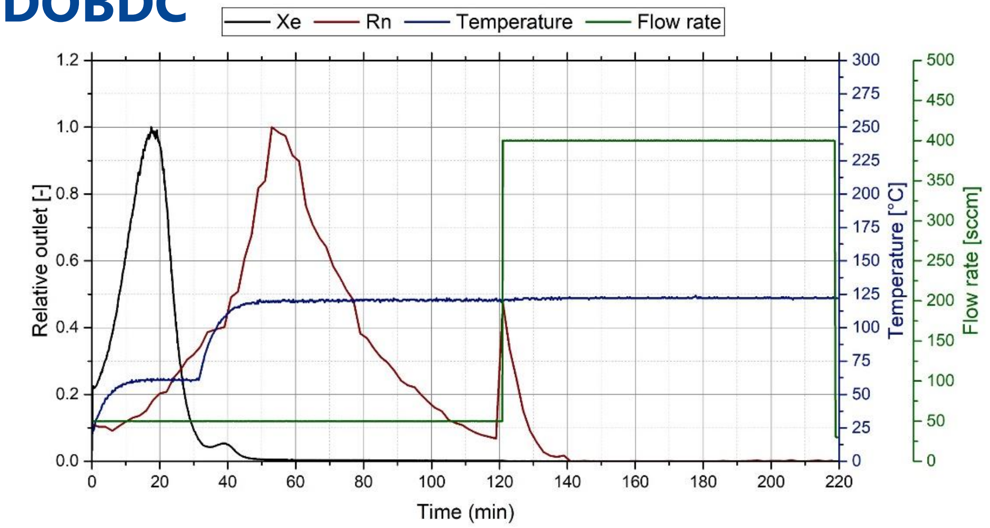
Xe separation

- Xe separation from Rn
  - Excellent separation on all adsorbents except Ni-DOBDC and Nusorb GXK

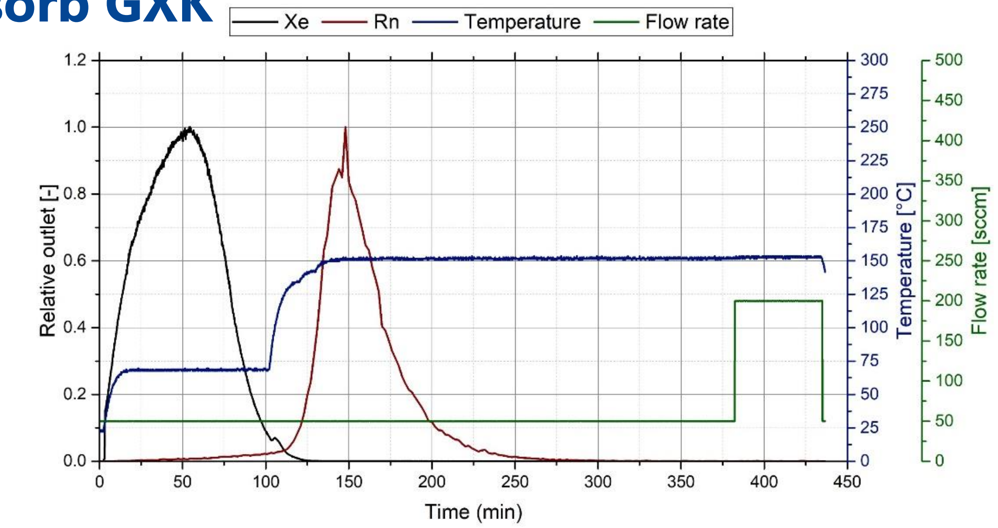
Ag-ETS-10



Ni-DOBDC



Nusorb GXK

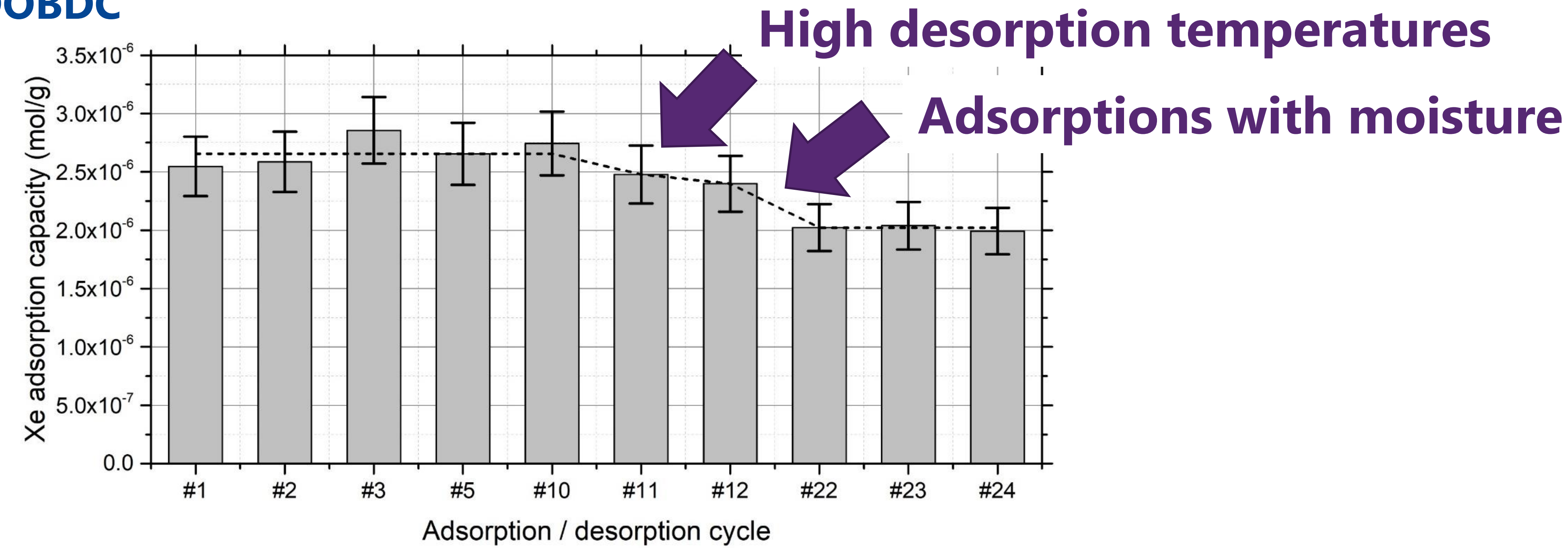


Durability adsorption/desorption cycles

- Followed-up through
  - 250 ppm Xe in air adsorption capacity

Material	# cycles	Max. T (°C)	Decrease in Xe adsorption ?
Ag-ETS-10	18	262	X
Ag-ZSM-5	13	254	X
Nusorb GXK	15	217	X
HKUST-1	12	154	X
Ni-DOBDC	**24**	**191**	**V**

Ni-DOBDC



Conclusions & perspectives

- The two AgZs are outperforming the two MOFs
  - BUT sensitive to moisture !
- First time that MOFs were investigated in these conditions

- Further research on the 5 adsorbents
  - Xe selectivity on N_2, O_2, Ar, CO_2 and Kr in air (ongoing)
  - Other characterizations ongoing (e.g. surface area, electron microscopy, …)
- Many other MOFs at laboratory scale
  - Should be monitored for their application in IMS NG systems