



HAL
open science

Metal Organic Framework scintillators for radioactive gas detection

Sharvane Mauree, Vincent Villemot, Guillaume H. V. Bertrand, Matthieu Hamel, Benoit Sabot

► **To cite this version:**

Sharvane Mauree, Vincent Villemot, Guillaume H. V. Bertrand, Matthieu Hamel, Benoit Sabot. Metal Organic Framework scintillators for radioactive gas detection. MOF 2022 - 8th International Conference on Metal-Organic Frameworks and Open Framework Compounds, Sep 2022, Dresden, Germany. cea-04904975

HAL Id: cea-04904975

<https://cea.hal.science/cea-04904975v1>

Submitted on 21 Jan 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Metal Organic Framework scintillators for radioactive gas detection

Sharvane Mauree, Vincent Villemot, Guillaume H.V. Bertrand, Matthieu Hamel, Benoît Sabot; Université Paris-Saclay, CEA, List, F-91120, Palaiseau, France;

Context

Since the discovery of radioactivity, the detection of radioactive gases (RG) has been of an utmost importance for radioprotection. The target gases in this project are ^{85}Kr , ^{133}Xe , and ^3H , whose productions are mainly anthropogenic. ^{85}Kr and ^{133}Xe are both fission products generated by nuclear fuel reprocessing plants¹. ^3H , on the other hand, is used in fusion bombs and in fusion reactors, whose implementation is predicted to increase with the upcoming ITER project².

One of the methods used for RG detection is liquid scintillation. A scintillator is a material that converts ionizing radiation into photons, which can easily be detected using photodetectors. Liquid scintillation, however, generates mixed waste and only allows for remote detection. Therefore, a gap for the online detection of radioactive gases exists, which is why a new class of porous scintillating materials, including Metal Organic Frameworks (MOF), are promising. The use of MOFs as scintillators for radiation detection was first experimentally demonstrated in 2009 and since then have only been theorized as potential candidates for RG detection³. We present here a library of MOF design and the first breakthrough results of MOF materials for RG detection.

Objectives

The choice of MOFs for this application was straightforward. They are the only class of porous materials to combine high surface areas of about $2000\text{ m}^2\text{g}^{-1}$ and a modular synthesis approach, which allows us to explore a large variety of fluorescent sponge-like materials. A solvothermal single crystal synthesis approach was chosen to ensure the purity of the MOF and hence accurate photophysical properties.

A unique gas bench experimental setup at the Laboratoire National Henri Becquerel (LNHB) is used to perform the gas detection experiments⁴. The radioactive gas is circulated through the MOF, where it is absorbed and concentrated. This maximizes the surface contact between the RG and detector material. The MOF will absorb the energy from the ionizing radiation produced by the disintegration of the RG and emit photons, which will be detected by three photomultiplier tubes in coincidence.

Part of this presentation will tackle the optimization of the detection by targeting specific fluorescence emission wavelengths and decay time.

Results

Figure II shows the results obtained for ^{85}Kr detection experiment, with the blank being a measurement without MOFs and scintillating microspheres being used as a known reference material in the field of scintillation.

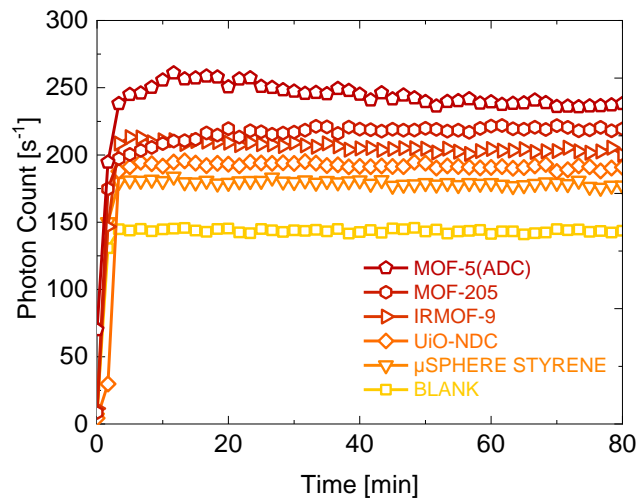


Figure I: Illustrating results for the ^{85}Kr detection experiment.

The MOFs shown here are able to absorb the ^{85}Kr within their pores and scintillate, as proven by the higher photon count with respect to the blank. The higher the photon count, the better the performance of the MOF as a scintillator.

Conclusion

To the best of our knowledge, this is the first proof of concept where the porous and scintillating nature of MOFs have been combined and used for radioactive gas detection. The search for MOFs producing higher scintillation yields is ongoing, as well as the improvement of the gas bench setup for accurate and reproducible metrological measurements. The next step is ^3H detection which is the most challenging target due to its low energy β ionizing radiation. It is in this configuration that the porosity of MOFs will become crucial, as it will maximize beta interaction within the scintillator.

- (1) Winger, K.; Feichter, J.; Kalinowski, M. B.; Sartorius, H.; Schlosser, C. A. *J. Environ. Radioact.* **2005**, *80* (2), 183–215.
- (2) ITER. Tritium Breeding <https://www.iter.org/mach/tritiumbreeding>.
- (3) Doty, F. P.; Bauer, C. A.; Skulan, A. J.; Grant, P. G.; Allendorf, M. D. *Adv. Mater.* **2009**, *21* (1), 95–101.
- (4) Sabot, B.; Rodrigues, M.; Pierre, S. *Appl. Radiat. Isot.* **2020**, *155*, 108934.