

Hongshan Zhu<sup>1,2,3</sup>, Stephan Heintz<sup>1</sup>, Steven Mullens<sup>2</sup>, Koen Binnemans<sup>3</sup>, Thomas Cardinaels<sup>1,3</sup>

<sup>1</sup>Belgian Nuclear Research Centre, SCK CEN, Mol, Belgium

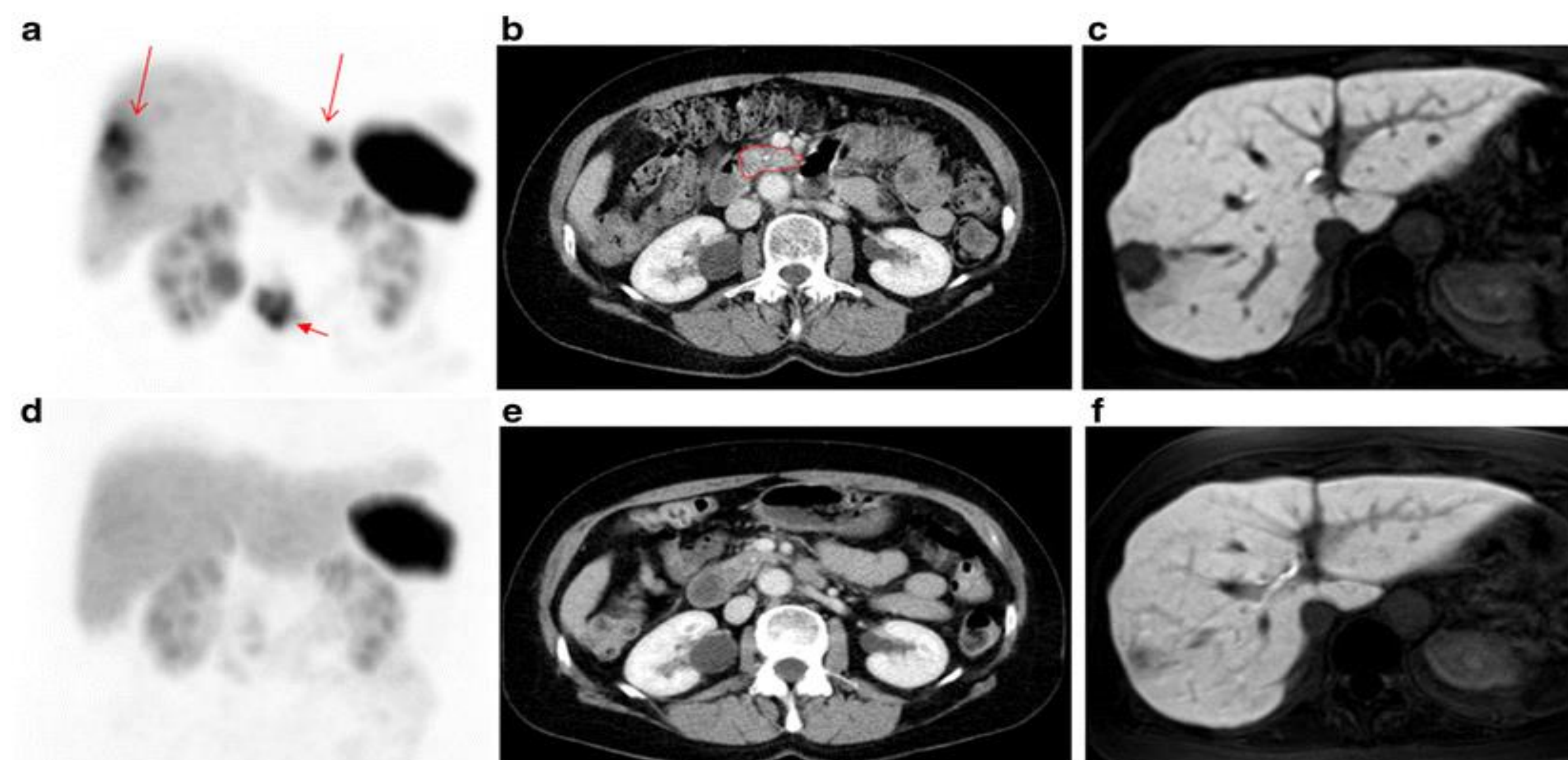
<sup>2</sup>Flemish Institute for Technological Research (VITO), Mol, Belgium

<sup>3</sup>KU Leuven, Department of Chemistry, Celestijnenlaan 200F, B-3001 Heverlee, Belgium

E-mail: Hongshan.zhu@sckcen.be

## Introduction

Targeted alpha therapy is a fast-growing area of cancer treatment and has attracted much attention over conventional therapies. Especially,  $^{213}\text{Bi}$  with a short half-life (45.6 min) is a very useful alpha-emitting radioisotope for targeted alpha therapy. However, choosing a suitable material for separating high activity  $^{213}\text{Bi}$  from its parent  $^{225}\text{Ac}$  is still an urgent and challenging task.



Patient 5 before therapy (a-c) and after three cycles of  $^{213}\text{Bi}$ -DOTATOC (d-f) to a dose of 4 GBq.<sup>1</sup>

The current in-house source of  $^{225}\text{Ac}$  is the long-lived  $^{229}\text{Th}$  (RCY group), which is unique in Belgium. Development of an alternative route for producing  $^{225}\text{Ac}$  via the  $^{226}\text{Ra}(\gamma, n)^{225}\text{Ra}(\beta^-)^{225}\text{Ac}$  reaction is ongoing and should significantly overcome the limitation of  $^{225}\text{Ac}$  availability in future.<sup>2</sup>

## Methodology

Carbon material and its derivatives first attracted our attention due to their high specific surface area, chemical stability, and high resistance against radiolysis. Usually, the sorption capacity of commercial activated carbon for radionuclides is relatively lower due to insufficient active sites. The acidic groups (e.g.,  $-\text{SO}_3\text{H}$ ,  $-\text{OSO}_3\text{H}$ ,  $-\text{PO}_3\text{H}$ ,  $-\text{OPO}_3\text{H}_2$ ,  $-\text{PO}_2\text{H}$ ,  $-\text{OPO}_2\text{H}$ ,  $-\text{COOH}$ ) are promising active sites for sorption cation ions in aqueous solution according to previous literature. Thus, developing the activated carbon through surface functionalization is a key way to improve its sorption performance.

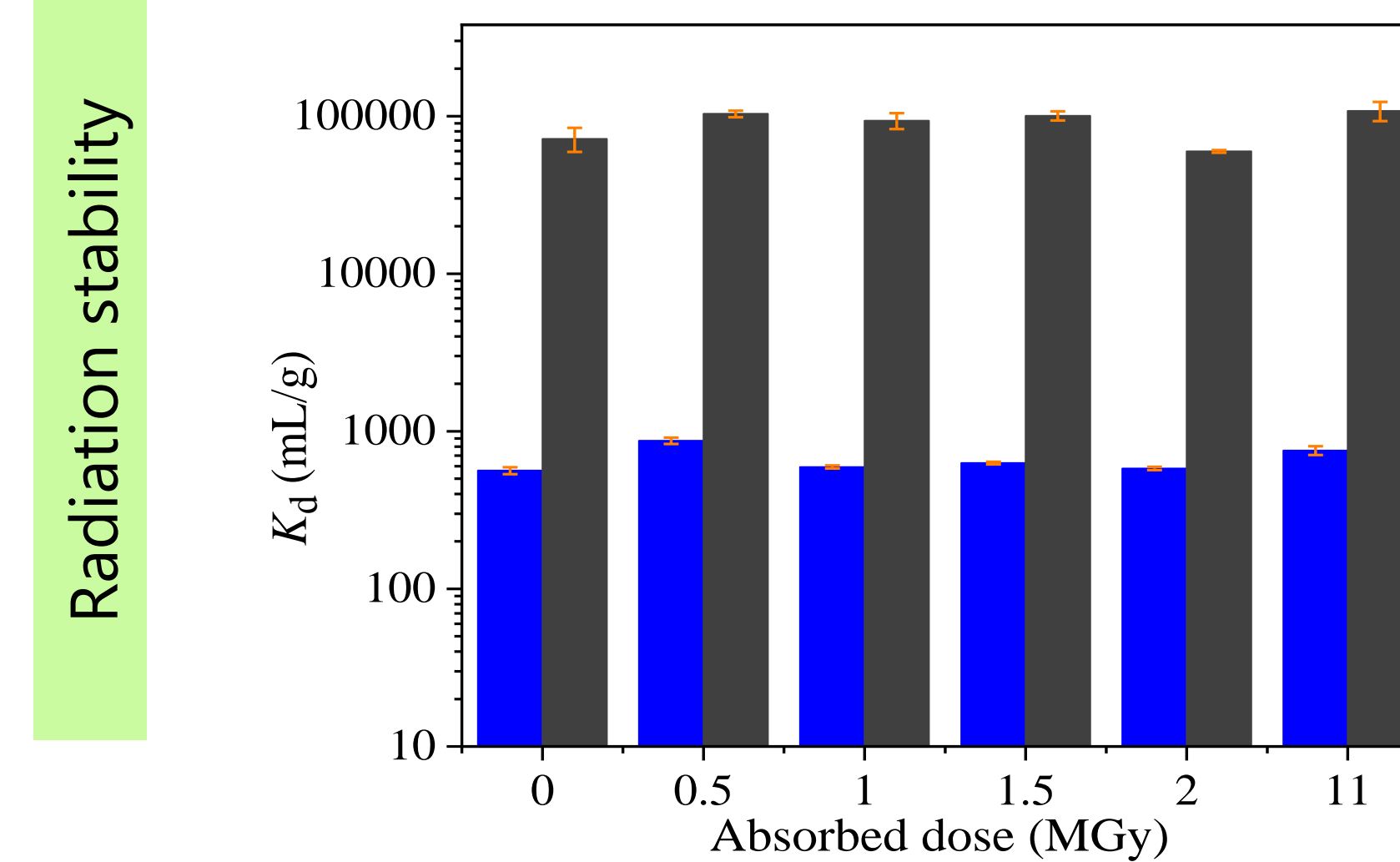
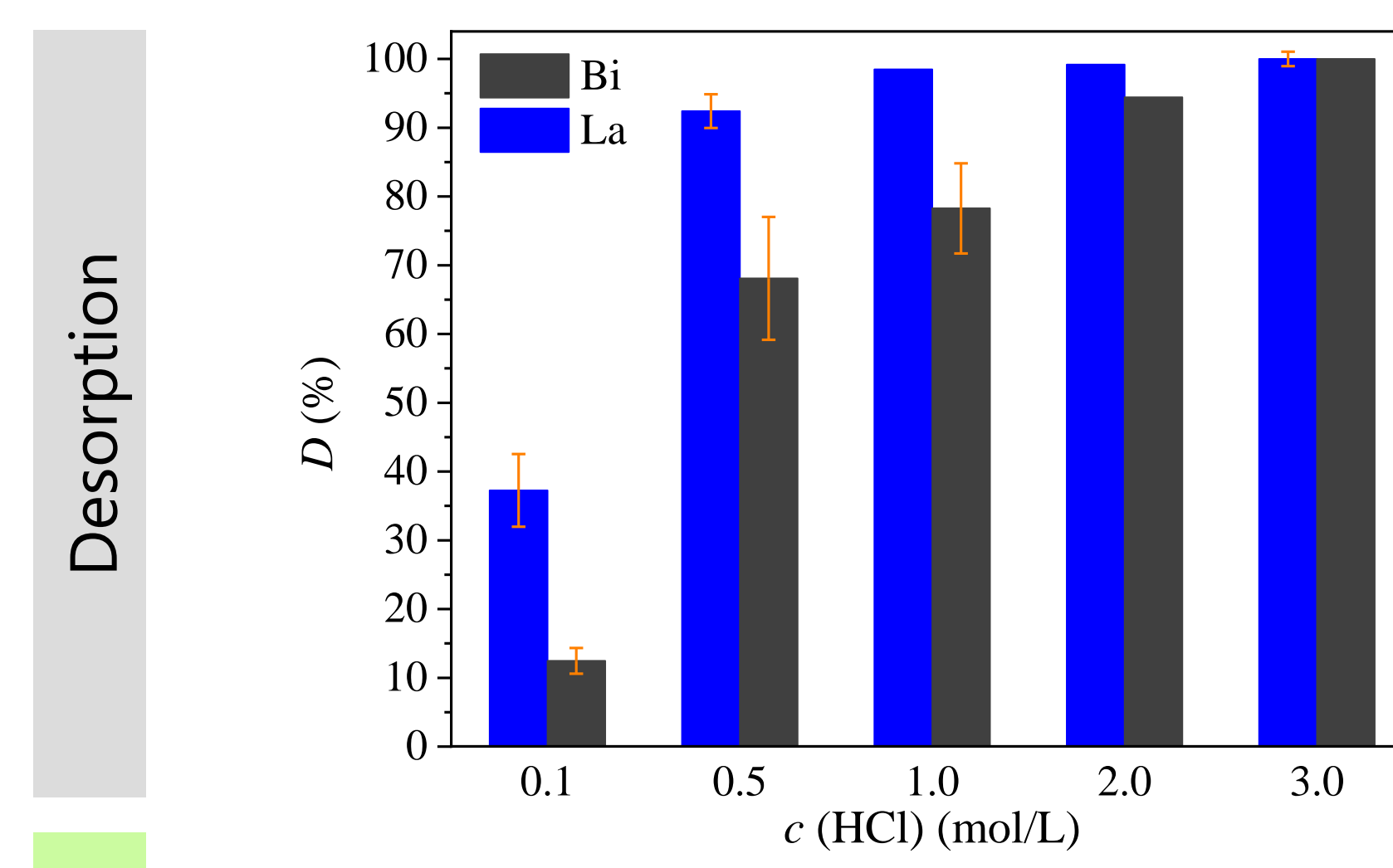
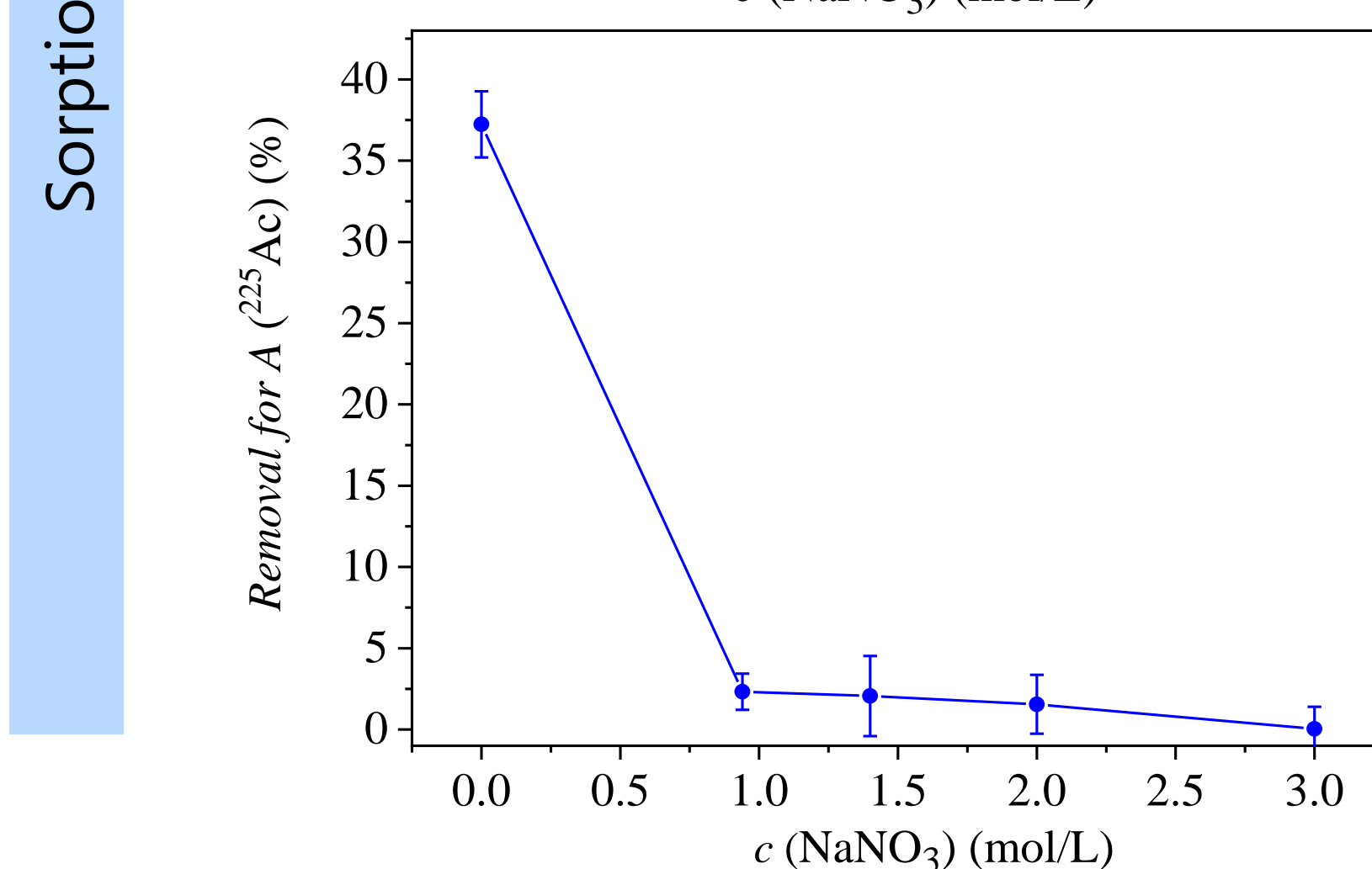
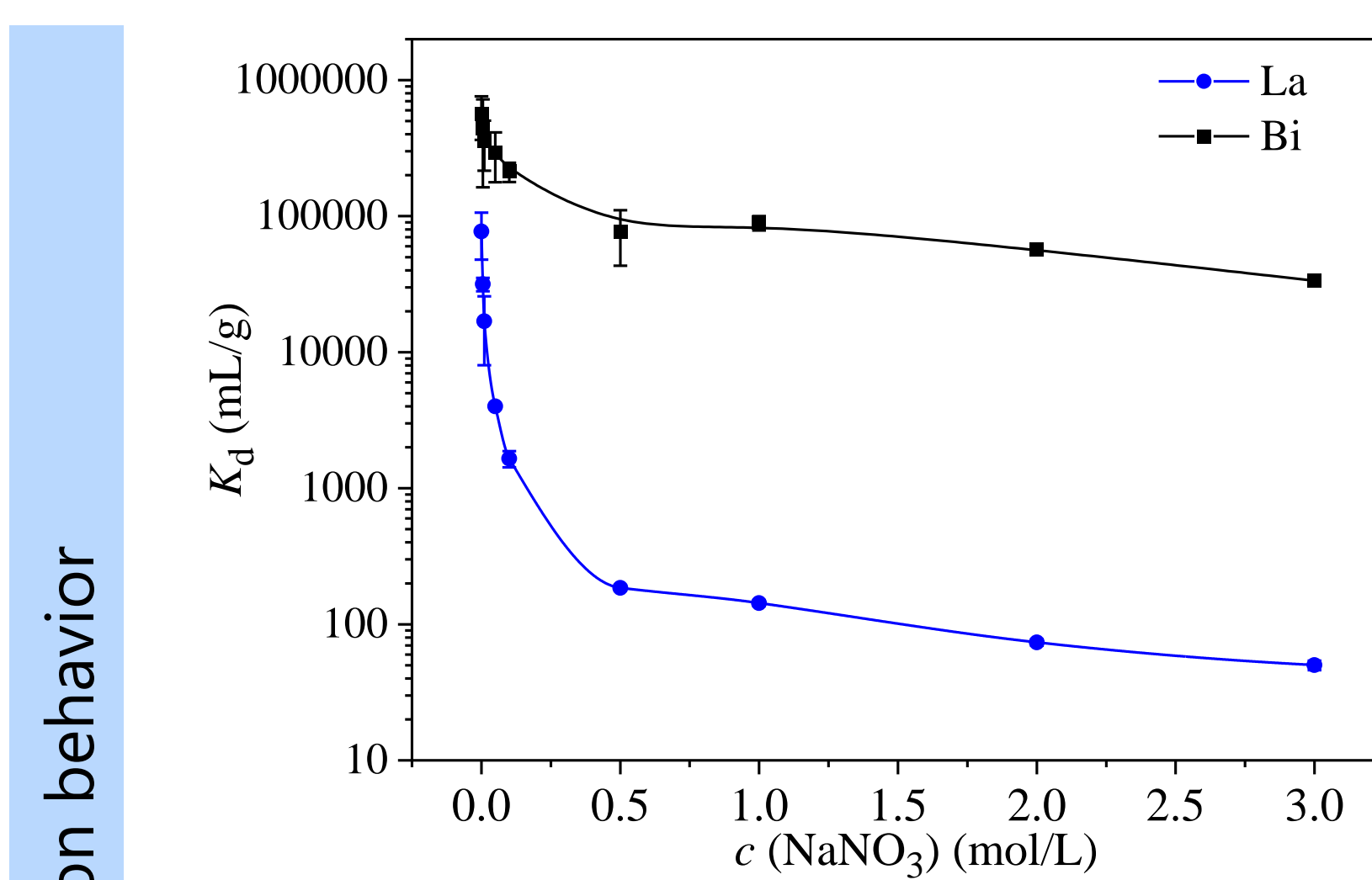
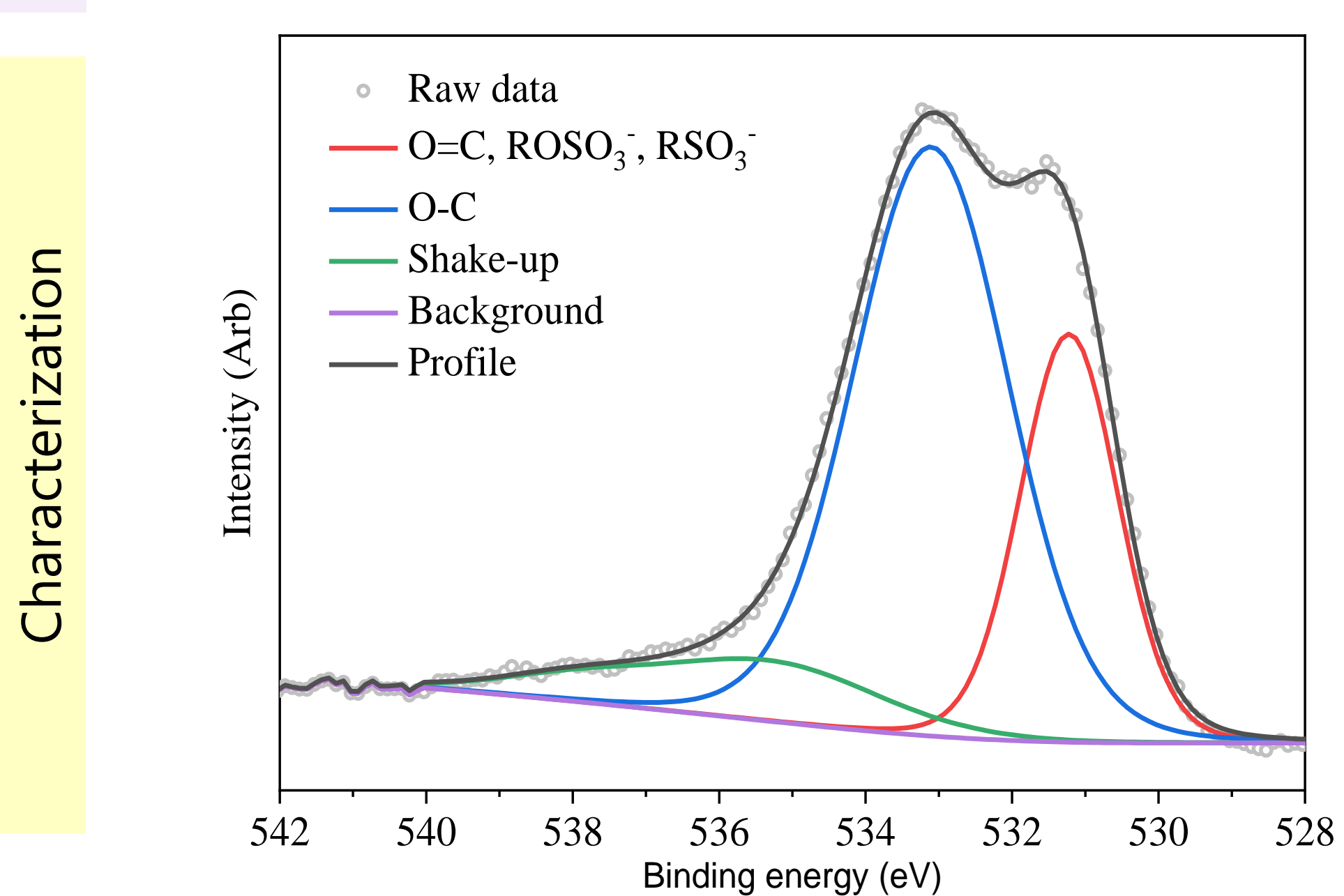
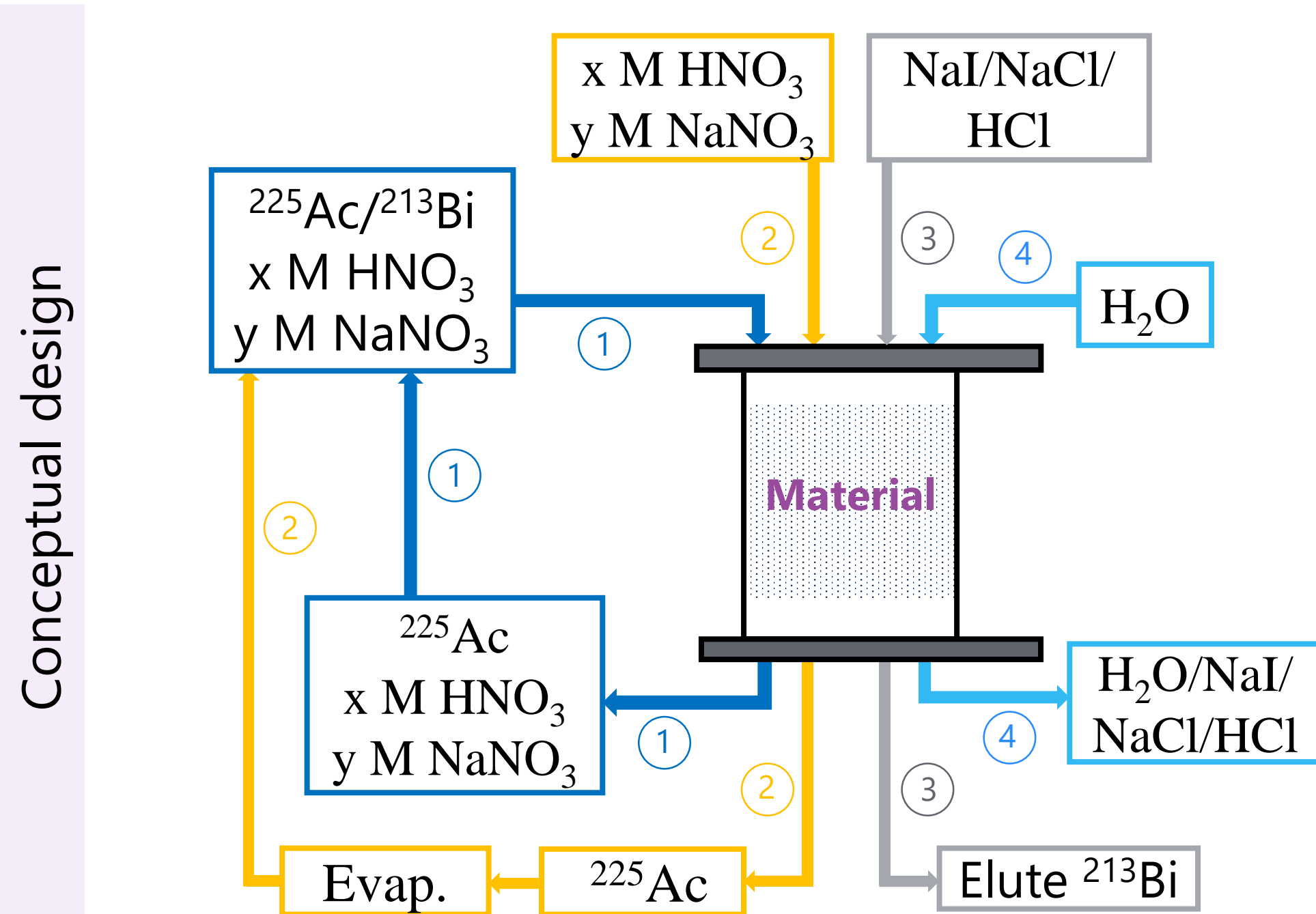
The radiation stability of prepared samples will be studied using  $\gamma$ -sources (either  $^{60}\text{Co}$  or spent fuel at BR2). The suitable materials will be shaped into spherical particles via different methods (e.g., pyrolysis or droplet coagulation).

## Objectives

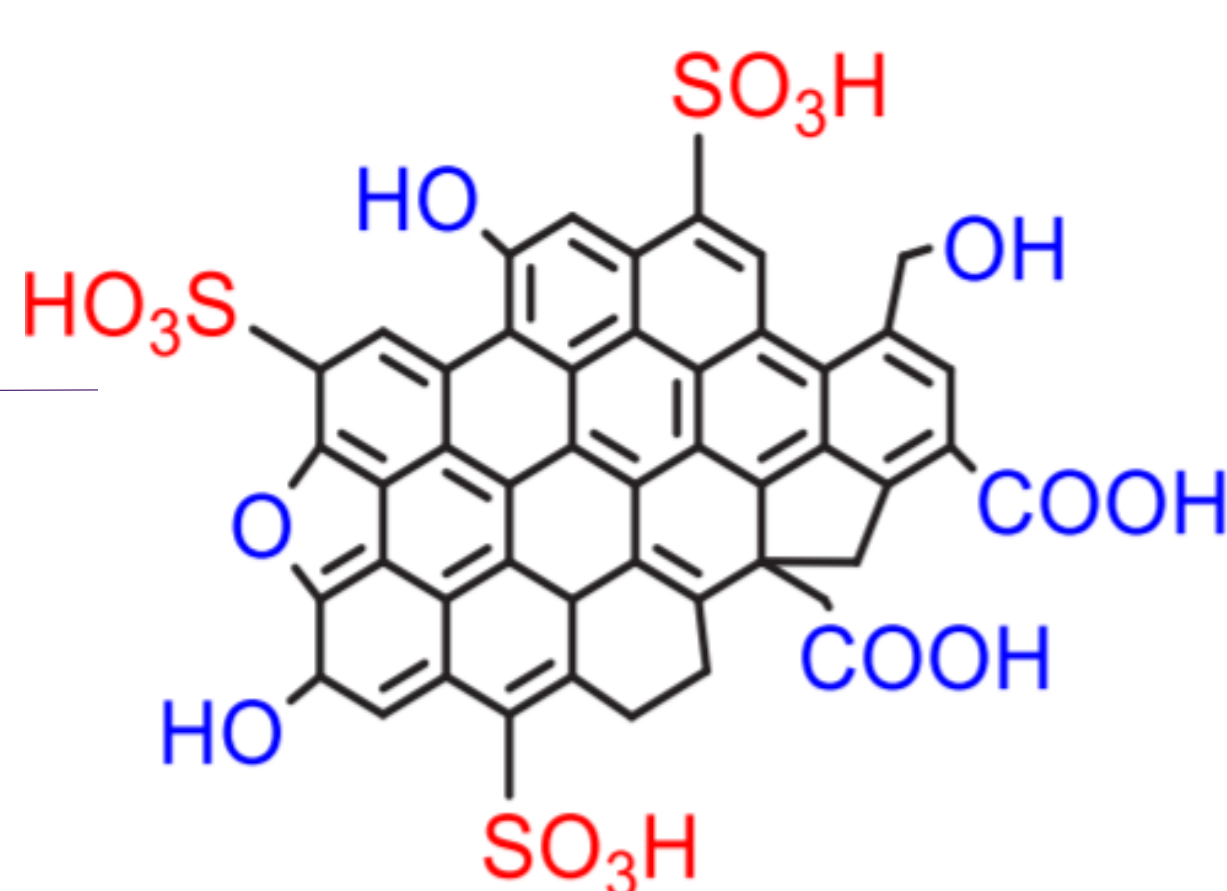
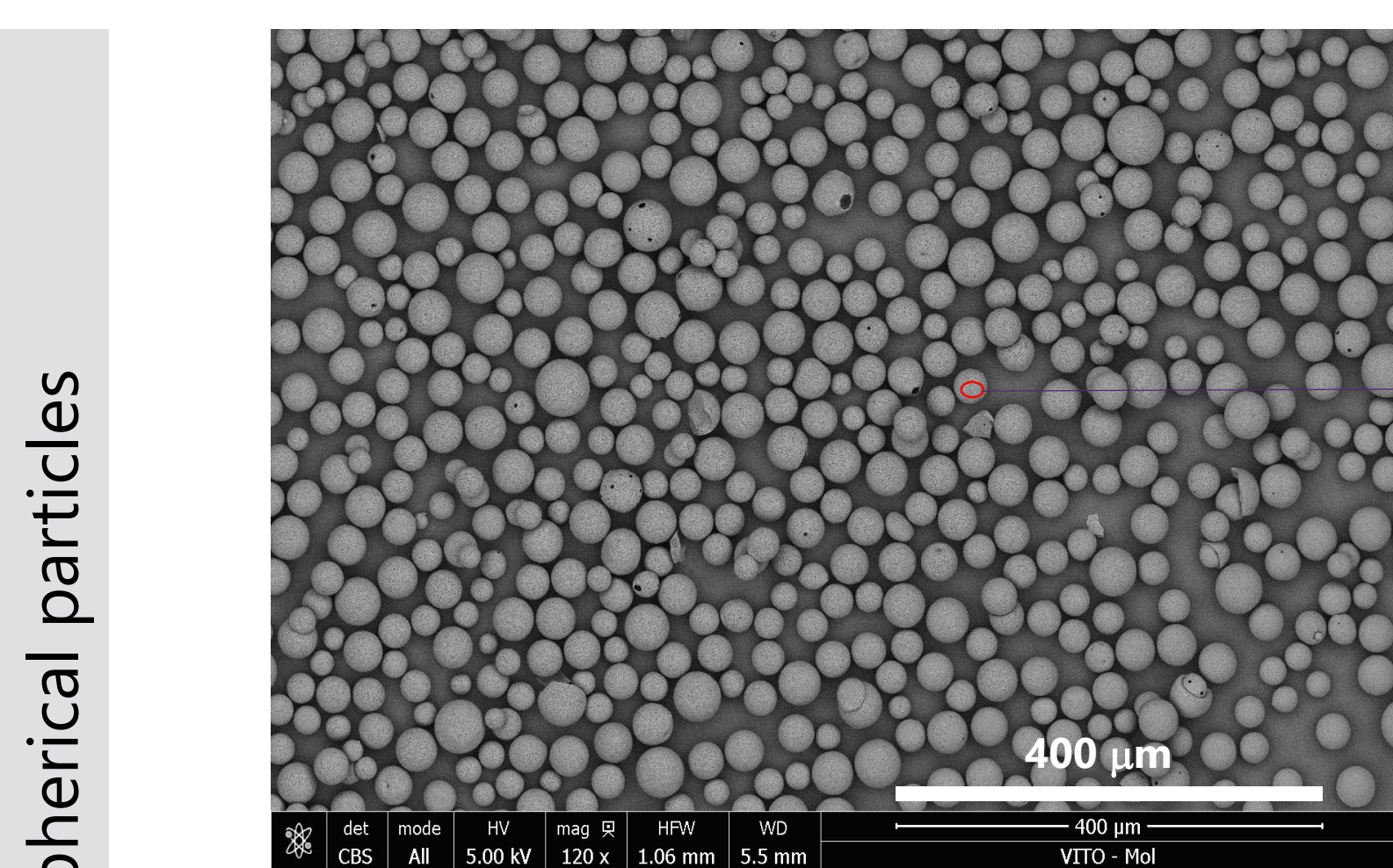
This research aims to develop suitable alternative inorganic sorbents to improve the lifetime of  $^{225}\text{Ac}/^{213}\text{Bi}$  radionuclide generators.

- ✓ High radiation resistance
- ✓ High sorption capacity
- ✓ High separation performance
- ✓ High acid stability
- ✓ Uniform spherical shape

## Results and Discussion



Unexpectedly, the sulfonated activated carbon exhibited high selective uptake of  $\text{Bi}^{3+}$  in the presence of  $\text{NaNO}_3$  at low pH, as even 2-3 mol/L  $\text{NaNO}_3$  does not significantly affect the sorption of  $\text{Bi}^{3+}$ . Inversely, the sorption capacity for  $\text{La}^{3+}/^{225}\text{Ac}^{3+}$  on the sulfonated Norit CA1 was more sensitive to the salt concentration and pH. Further, the sulfonated activated carbon showed high resistance against radiation radiolysis, and good chemical stability in a strong acid aqueous.



The spherical sulfonated carbon material was fabricated via the pyrolysis of spherical cellulose beads and then the sulfonation process.

## Conclusion and future work

- ✓ The functionalized carbon materials are potential sorbents for use in the inverse  $^{225}\text{Ac}/^{213}\text{Bi}$  radionuclide generators.
- ✓ Future studies would include column chromatography to determine the optimal operating conditions for the inverse  $^{225}\text{Ac}/^{213}\text{Bi}$  radionuclide generators.

## References

- [1] *Eur. J. Nucl. Med. Mol. Imaging* 2014, 41, 2106–2119.
- [2] *Nucl. Med. Biol.* 2021, 96–97, S80–S81.
- [2] *Chem. Rev.* 2019, 119 (2), 902–956.
- [3] *Chem. Rev.* 2019, 119 (22), 11576–11630.
- [4] *Solvent Extr. Ion Exch.* 2021, 39 (4), 353–372.