

# radiochimie et chimie sous rayonnement

## vivant et santé

Compléments à l'article « Les actinides, leur interaction avec les processus biologiques : où en sommes-nous ? », C. Den Auwer *et coll.* (*L'Act. Chim.*, 2021, 460-461, p. 68)

### Liste des autrices et auteurs de l'article

Claude ALBAN<sup>1</sup>, Jean AUPIAIS<sup>2</sup>, Maria Rosa BECCIA<sup>3</sup>, Catherine BERTHOMIEU<sup>4</sup>, Damien BOURGEOIS<sup>5</sup>, Jacques BOURGUIGNON<sup>1</sup>, Carole BRESSON<sup>6</sup>, Georges F. CARLE<sup>7</sup>, Virginie CHAPON<sup>4</sup>, Gaëlle CREFF<sup>3</sup>, Pascale DELANGLE<sup>8</sup>, Christophe DEN AUWER<sup>\*3</sup>, Christophe DI GIORGIO<sup>3</sup>, Thomas DUMAS<sup>9</sup>, Philippe GUILBAUD<sup>9</sup>, Agnès HAGÈGE<sup>10</sup>, Véronique MALARD<sup>4</sup>, Philippe MOISY<sup>9</sup>, Eduardo PAREDES<sup>6</sup>, Valérie PIERREFITE-CARLE<sup>7</sup>, Stéphane RAVANEL<sup>1</sup>, Sabine SANTUCCI-DARMANIN<sup>7</sup>, Sandrine SAUGE-MERLE<sup>4</sup>, Bruno SIBERCHICOT<sup>2</sup>, Pier Lorenzo SOLARI<sup>11</sup>, Anne VANDER MEEREN<sup>12</sup> et Claude VIDAUD<sup>13</sup>.



\* christophe.denauwer@univ-cotedazur.fr

1 Université Grenoble Alpes, CEA, INRA, CNRS, IRIG, PCV, 38000, Grenoble.

2 CEA, DAM, DIF, 91297 Arpajon, France.

3 Université Côte d'Azur, CNRS, Institut de Chimie de Nice, 06108 Nice, France.

4 Aix-Marseille Université, CEA, CNRS, BIAM, Institut de Biosciences et Biotechnologies d'Aix-Marseille, CEA-Cadarache, 13108 Saint Paul-lez-Durance, France.

5 ICSM, CNRS, CEA, 30207 Bagnols-sur-Cèze, France.

6 DES, Service d'Études Analytiques et de Réactivité des Surfaces SEARS, CEA, Université Paris-Saclay, 91191, Gif-sur-Yvette, France.

7 Université Côte d'Azur, CEA, Institut Joliot, TIRO-MATOS, 06107 Nice, France.

8 Université Grenoble Alpes, CEA, CNRS, IRIG, SyMMES, 38000 Grenoble, France.

9 CEA, DES, ISEC, DMRC, Université de Montpellier, 30207 Marcoule, France.

10 Université de Lyon, CNRS, Université Lyon 1, Institut des Sciences Analytiques, 69100 Villeurbanne, France.

11 Synchrotron SOLEIL, L'Orme des Merisiers, 91192 Gif-sur-Yvette, France.

12 CEA LRT, Université Paris-Saclay, 91297 Arpajon, France

13 BIAM, Institut de Biosciences et Biotechnologies d'Aix-Marseille, CEA-Marcoule, 30207 Bagnols-sur-Cèze, France.

### Références

- [1] Toxicologie nucléaire, environnementale et humaine, M.-T. Ménager, J. Garnier Laplace, M. Goyffon (coord.), Lavoisier, 2009.
- [2] P.E. Morrow, H. Witschi, M. Vore, P.E. Hakkinnen, J. Mac Gregor, M.W. Anders, C. Willhite, Harold Carpenter Hodge (1904-1990), *Toxicol. Sci.*, 2000, 53, p. 157-58.
- [3] T. Albrecht-Schmitt, Actinides in animals and man, in *The Chemistry of the Actinide and Transactinide Elements*, N. Edelstein, J.J. Katz, J. Fuger, L.R. Mors (eds), Springer, 4th ed., 2011.
- [4] E. Ansoborlo, O. Prat, P. Moisy, C. Den Auwer, P. Guilbaud, M. Carriere, B. Goujet, J. Duffield, D. Doizi, T. Vercouter, C. Moulin, V. Moulin, Actinide speciation in relation to biological processes, *Biochimie*, 2006, 88, p. 1605-18.
- [5] J. Rothe, C. Walther, M.A. Denecke, T. Fanghänel, XAFS and LIBD investigation of the formation and structure of colloidal Pu(IV) hydrolysis products, *Inorg. Chem.*, 2004, 43, p. 4708-18.
- [6] C. Madic, D.E. Hobart, G.M. Begun, Raman spectrometric studies of actinide(V) and -(VI) complexes in aqueous sodium carbonate solution and of solid sodium actinide(V) carbonate compounds, *Inorg. Chem.*, 1983, 22, p. 1494-503.
- [7] D.L. Clark, D.E. Hobart, M.P. Neu, Actinide carbonate complexes and their importance in actinide environmental chemistry, *Chem. Rev.*, 1995, 95, p. 25-48.
- [8] J. Aupiais, J.-C. Alexandre, R. Sicre, B. Siberchicot, S. Topin, P. Moisy, N. Dacheux, The Np<sup>V</sup> and Pu<sup>V</sup> carbonate systems: thermodynamics and coordination chemistry, *Eur. J. Inorg. Chem.*, 2020, 2, p. 216-25.

- [9] O.S. Pokrovsky, G.R. Choppin, Neptunium(V) complexation by acetate, oxalate and citrate, *Radiochim. Acta*, **1997**, 79, p. 167-71.
- [10] L. Mullen, C. Gong, K. Czerwinski, Complexation of uranium(VI) with the siderophore desferrioxamine B, *J. Radioanal. Nucl. Chem.*, **2007**, 273, p. 683-88.
- [11] S. Grison, D. Kereselidze, D. Cohen, C. Gloaguen, C. Elie, P. Lestaevel, A. Legendre, L. Manens, B. Habchi, M. Amine Benadjaoud, G. Tarlet, F. Milliat, J.-C. Martin, J.-M. Lobaccaro, M. Souidi, Applying a multiscale systems biology approach to study the effect of chronic low-dose exposure to uranium in rat kidneys, *Int. J. Rad. Biol.*, **2019**, 95, p. 737-52.
- [12] A. Garai, P. Delangle, Recent advances in uranyl binding in proteins thanks to biomimetic peptide, *J. Inorg. Biochem.*, **2020**, 203, 110936.
- [13] H.M. Baker, C.J. Baker, C.A. Smith, E.N. Baker, Metal substitution in transferrins: specific binding of cerium(IV) revealed by the crystal structure of cerium-substituted human lactoferrin, *J. Biol. Inorg. Chem.*, **2000**, 5, p. 692-98.
- [14] M. Sarthou, B. Revel, F. Villiers, C. Alban, T. Bonnot, O. Gigarel, A.-M. Boisson, S. Ravanel, J. Bourguignon, Development of a metalloproteomic approach to analyse the response of *Arabidopsis* cells to uranium stress, *Metalomics*, **2020**, 12, p. 1302-13.
- [15] J.R. Duffield, D.M. Taylor, S.A. Proctor, The binding of plutonium to transferrin in the presence of tri-n-butyl phosphate or nitrate and its release by diethylenetriamine penta-acetate and the tetrameric catechoylamide ligand LICAM(C), *Int. J. Nucl. Med. Biol.*, **1986**, 12, p. 483-87.
- [16] C. Basset, O. Averseng, P.-J. Ferron, N. Richaud, A. Hagège, O. Pible, C. Vidaud, Revision of the biodistribution of uranyl in serum: is fetuin-A the major protein target?, *Chem. Res. Toxicol.*, **2013**, 26, p. 645-53.
- [17] A. Jeanson, M. Ferrand, H. Funke, C. Henning, P. Moisy, P.-L. Solari, C. Vidaud, C. Den Auwer, Role of transferrin in actinide(IV) uptake: comparison with iron(III), *Chem. Eur. J.*, **2010**, 16, p. 1378-87.
- [18] F. Brulfert, J. Aupiais, Topological speciation of actinide-transferrin complexes by capillary isoelectric focusing coupled with inductively coupled plasma mass spectrometry: evidence of the non-closure of the lobes, *Dalton Trans.*, **2018**, 47, p. 9994-10001.
- [19] M.P. Jensen, D. Gormen-Lewis, B. Aryal, T. Paunesku, S. Vogt, P.G. Rickert, S. Seifert, B. Lai, G.E. Woloschak, L. Soderholm, An iron-dependent and transferrin-mediated cellular uptake pathway for plutonium, *Nature Chem. Biol.*, **2011**, 7, p. 560-65.
- [20] T.N.S. Huynh, D. Bourgeois, C. Basset, C. Vidaud, A. Hagège, Assessment of CE-ICP/MS hyphenation for the study of uranyl/protein interactions, *Electrophoresis*, **2015**, 36, p. 1374-82.
- [21] B.P. Aryal, T. Paunesku, G.E. Woloschak, C. He, M.P. Jensen, A proteomic approach to identification of plutonium-binding proteins in mammalian cells, *J. Proteomics*, **2012**, 75, p. 1505-14.
- [22] A. Dedieu, F. Berenguier, C. Basset, O. Prat, E. Quemeneur, O. Pible, C. Vidaud, Identification of uranyl binding proteins from human kidney-2 cell extracts by immobilized uranyl affinity chromatography and mass spectrometry, *J. Chromatogr. A*, **2009**, 1216, p. 5365-76.
- [23] S. Sauge-Merle, F. Brulfert, R. Pardoux, P.L. Solari, D. Lemaire, S. Safi, P. Guilbaud, E. Simoni, M.L. Merroun, C. Berthomieu, Structural analysis of uranyl complexation by the EF-hand motif of calmodulin: effect of phosphorylation, *Chem. Eur. J.*, **2017**, 23, p. 15505-17.
- [24] F. Brulfert, S. Safi, A. Jeanson, H. Foerstendorf, S. Weiss, C. Berthomieu, S. Sauge-Merle, E. Simoni, Enzymatic activity of the CaM-PDE1 system upon addition of actinyl ions, *J. Inorg. Biochem.*, **2017**, 172, p. 46-54.
- [25] S. Sauge-Merle, D. Lemaire, R.W. Evans, C. Berthomieu, J. Aupiais, Revisiting binding of plutonium to transferrin by CE-ICP-MS, *Dalton Trans.*, **2017**, 46, p. 1389-96.
- [26] G. Creff, S. Safi, J. Roques, H. Michel, A. Jeanson, P.L. Solari, C. Bassat, E. Simoni, C. Vidaud, C. Den Auwer, Actinide(IV) deposits on bone: potential role of the osteopontin-thorium complex, *Inorg. Chem.*, **2016**, 55, p. 29-36.
- [27] L. Qi, C. Bassat, O. Averseng, E. Quémeneur, A. Hagège, C. Vidaud, Characterization of  $\text{UO}_2^{2+}$  binding to osteopontin, a highly phosphorylated protein: insights into potential mechanisms of uranyl accumulation in bones, *Metalomics*, **2014**, 6, p. 166-76.
- [28] S. Kumar, G. Creff, C. Hennig, A. Rossberg, R. Steudtner, J. Raff, C. Vidaud, F.R. Oberhaensli, M.-Y. Dechaoui Bottein, C. Den Auwer, How do actinyls interact with hyperphosphorylated yolk protein phosvitin?, *Chem. Eur. J.*, **2019**, 25, p. 12332-41.
- [29] E. Kläning, B. Christensen, E. Sørensen, T. Vorup-Jensen, J.K. Jensen, Osteopontin binds multiple calcium ions with high affinity and independently of phosphorylation status, *Bone*, **2014**, 66, p. 90-95.
- [30] E. Paredes, E. Avazeri, V. Malard, C. Vidaud, P.E. Reiller, R. Ortega, A. Nonell, H. Isnard, F. Chartier, C. Bresson, Impact of uranium uptake on isotopic fractionation and endogenous element homeostasis in human neuron-like cells, *Sci. Rep.*, **2018**, 8, p. 17163-73.
- [31] E. Paredes, E. Avazeri, V. Malard, C. Vidaud, P.E. Reiller, R. Ortega, A. Nonell, H. Isnard, F. Chartier, C. Bresson, Evidence of isotopic fractionation of natural uranium in cultured human cells, *Proc. Natl. Acad. Sci.*, **2016**, 113, p. 14007-12.
- [32] C. Vidaud, M. Robert, E. Paredes, R. Ortega, E. Avazeri, L. Jing, J.-M. Guigonis, C. Bresson, V. Malard, Deciphering the uranium target proteins in human dopaminergic SH-SY5Y cells, *Arch Toxicol.*, **2019**, 93, p. 2141-54.
- [33] C. Vidaud, D. Bourgeois, D. Meyer, Bone as target organ for metals: the case of f-elements, *Chem. Res. Tox.*, **2012**, 25, p. 1161-75.
- [34] V. Pierrefite-Carle, S. Santucci-Darmanin, V. Breuil, T. Gritsenko, C. Vidaud, G. Creff, P.L. Solari, S. Pagnotta, R. Al-Sahlanee, C. Den Auwer, G.F. Carle, Effect of natural uranium on the UMR-106 osteoblastic cell line: impairment of the autophagic process as an underlying mechanism of uranium toxicity, *Arch. Toxicol.*, **2017**, 91, p. 1903-14.
- [35] L. Hurault, G. Creff, A. Hagège, S. Santucci-Darmanin, S. Pagnotta, D. Farlay, C. Den Auwer, V. Pierrefite-Carle, G.F. Carle, Uranium effect on osteocytic cells in vitro, *Toxicol. Sci.*, **2019**, 170, p. 199-209.
- [36] T. Gritsenko, V. Pierrefite-Carle, T. Lorivel, V. Breuil, G.F. Carle, S. Santucci-Darmanin, Natural uranium impairs the differentiation and the resorbing function of osteoclasts, *Biochim. Biophys. Acta Gen. Subj.*, **2017**, 1861, p. 715-26.
- [37] L. Miccoli, F. Ménétrier, P. Laroche, O. Grémy, Chelation treatment by early inhalation of liquid aerosol DTPA for removing plutonium after rat lung contamination, *Radiat. Res.*, **2019**, 192, p. 630-39.
- [38] F. Lahrouch, B. Siberchicot, J. Fèvre, L. Leost, J. Aupiais, P.L. Solari, C. Den Auwer, C. Di Giorgio, Carboxylate- and phosphonate-modified polyethylenimine: toward the design of actinide decoration agents, *Inorg. Chem.*, **2020**, 59, p. 128-37.
- [39] J.R. Duffield, D.M. Taylor, S.A. Proctor, The binding of plutonium to transferrin in the presence of tri-n-butyl phosphate or nitrate and its release by diethylenetriaminepenta-acetate and the tetrameric catechoylamide ligand LICAM(C), *Int. J. Nucl. Med. Biol.*, **1986**, 12, p. 483-87.