

Determination of Cl-36 in various radioactive waste

Céline Gautier^{1*}, Christèle Colin¹, Margaux Giuliani¹, Elodie Laporte¹,
René Brennetot¹, Laëtitia Kasprzak¹, Pascal Fichet¹

¹ Université Paris-Saclay, CEA, Service d'Études Analytiques et de Réactivité des Surfaces,
91191, Gif-sur-Yvette, France.

* Corresponding Author, E-mail: celine.gautier@cea.fr

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Introduction

In the context of radioactive waste management, Cl-36 is a key radionuclide to be measured due to its long half-life (3.01×10^5 years) and its high mobility in the environment. In particular, its mass activity must be lower than 5 Bq/g in France in the packages stored in the disposal facility dedicated to low and intermediate level nuclear waste. Presence of Cl-36 in radwaste mostly results from neutron activation of stable chlorine which can be contained as an impurity in fuels, fuel claddings, graphites and construction materials (steels and concretes).

Different strategies developed to extract and purify Cl-36 in radioactive waste

Cl-36 decays by emitting a beta particle (98.1 % yield - $E_{\max}=708.6$ keV) and electron capture (1.9 %). Consequently, this radionuclide can be measured by beta counting techniques, mainly liquid scintillation counting (LSC) for routine analysis of radwaste. As LSC has a poor energy resolution, Cl-36 has to be extracted and isolated from matrix and interfering elements through a selective radiochemical method before any LSC measurement. Radiochemical procedures are generally based on chlorine extraction followed by its precipitation with silver as AgCl and dissolution of this AgCl precipitate with ammonia or implementation of ion-exchange chromatography or extraction chromatography [1]. The method based on AgCl precipitation is relevant for radwaste with low beta- and gamma-emitters and with no other halogens such as iodine (which also precipitates with silver). LASE laboratory (Operator Support Analysis Laboratory) has developed an alternative radiochemical protocol in order to achieve higher decontamination factors required for Cl-36 analysis of high level radioactive samples [2]. After chlorine extraction with various decomposition methods, the following selective purification steps are applied: chlorine precipitation with silver, organic synthesis (chlorine fixation on octadecene), purification of the chlorinated molecule, then its destruction and an ultimate liquid-liquid extraction. Cl-36 is finally measured by LSC whereas stable chlorine is analyzed by ion chromatography to determine the separation yield.

The presentation will give an overview of the different strategies developed to extract and purify Cl-36 in various radioactive waste. The validation of the radiochemical method will first be performed using in-house reference samples spiked with Cl-36 and the participation in interlaboratory comparisons. Different methods applied to extract Cl-36 from various radioactive matrices will then be presented. In particular, implementation of micro-wave digestion, pyrolysis or acid digestion or leaching assisted with digital autoradiography will be explained depending on the studied matrices: ion exchange resins, graphites, concretes, irradiated or surface-contaminated steels and magnesium claddings. Finally, the presentation will discuss with the adaptation of the radiochemical procedure to measure Cl-36 by accelerator mass spectrometry (AMS) in order to achieve a detection limit lower than 5 Bq/g.

Conclusion

Cl-36 can be determined with accuracy and high sensitivity in different types of radioactive waste. The performances achieved for Cl-36 are largely suitable for the monitoring of nuclear waste in disposal facilities.

References

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