Development of a fast method using PSresins for the determination of ^{210}Pb in environmental samples

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^{210}Pb is a naturally occurring radionuclide that originates from the decay chain of ^{238}U and can be found in environmental samples. Due to its high radiotoxicity, as indicated by the very low permissible activity levels in natural waters (0.2 Bq/L according to the 213/51 EU Directive and 2/2023 Spanish Royal Decree), monitoring its presence in environmental samples or Naturally Occurring Radioactive Materials (NORM) is essential. Analytical strategies for ^{210}Pb must address two key challenges: its low-energy beta/gamma emissions and the need for extremely low detection limits (0.02 Bq/L). These requirements necessitate prolonged counting times, complex chemical separations, and/or the handling of large sample volumes, which complicates the efficient processing of a high number of samples. Plastic scintillation resins (PSresin) have recently emerged as an innovative strategy for analyzing beta-emitting radionuclides. By combining separation and measurement, this approach streamlines the analysis process. Additionally, the use of a small amount of scintillator (1 g) results in low background levels, thereby improving the limit of detection. These factors collectively suggest a promising new strategy for the rapid analysis of ^{210}Pb in environmental samples.

This research presents the development of a novel plastic scintillation resin (PSresin) based on a crown ether and an ionic liquid for the rapid analysis of ^{210}Pb. Two primary challenges were addressed: enhancing the impregnation of the extractant onto the plastic scintillator to reduce extractant stagnation, thereby allowing high sample volumes; and achieving efficient contact between the sample and extractant at high flow rates to minimize analysis time. To this end, various polymeric supports were studied, ranging from classical scintillating microspheres made of polystyrene to porous particles combining monomers of different polarity.

The results obtained indicate that classical PSresin cannot handle sample volumes greater than 50 mL. Despite achieving high efficiency (>80%), the analysis time remains lengthy (>12 hours/sample). Conversely, the combination of styrene, acrylic acid, and a phosphonic moiety yields scintillators with good efficiency (50-60%), low quenching (SQP of 630), low background (>1 cpm), and a stagnation volume exceeding 1L with quantitative retention. This new PSresin has been applied to the analysis of environmental samples, demonstrating compatibility with fast analysis requirements in terms of accuracy, detection limits, and analysis time for both water samples and complex matrices such as NORM lixiviates.