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Definition and optimization of a procedure for obtaining crosslinked plastic scintillation microspheres

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The measurement of alpha and beta radioactivity is something common in several fields (i.e. environmental monitoring, medicine, research···) although there is still a necessity for more environmentally respectful methods with a low generation of residues and new strategies for complex scenarios, like continuous monitoring or fast methods for the analysis of difficult to measure radionuclides (DTM). Following these aims, plastic scintillators in form of microspheres (PSm) has been proposed in the last years as an alternative to liquid scintillation. The use of plastic scintillators avoids the generation of mixed wastes, allow high selectivity in the determination of DTM radionuclides when these are combined with extracting agents (PSresins) as well as provide high viability for applications in continuous detection systems.

Previous experience of the authors on PSm based on linear polystyrene and prepared by evaporation/extraction method has shown that PSm provide a high detection efficiency in the determination of alpha and medium or high energetic beta emitting radionuclides. However, these can be used in a framework of limited conditions since the polymer is soluble in organic solvents in which the PSm are dissolved or the fluorescent solutes leached. This situation can be solved by the use of microspheres including a crosslinking agent, divinylbenzene, which is copolymerized with styrene creating a crosslinked scintillating microsphere (CPSm). These CPSm allow, according to their structure of chains of polymer linked one to another in different points, to be used in aggressive conditions, such as organic matrices, opening the possibility to measure organic samples or treat it with organic solvents to modify its structure (addition of pores) or its surface (adding functional groups on its surface) creating advanced PS systems.

The objective of the present study was to define and optimize a methodology to obtain CPSm by polymerisation of styrene and DVB, and to evaluate the morphological, resistance and scintillation properties of CPSm. The polymerization method used is a free radical polymerisation in a dispersant medium with the presence of a surfactant (PVA). Initially, the effect of the styrene-DVB ratio was verified. It was proved that a higher proportion of DVB produces a reduction in the medium size of the CPSm without significantly altering the radiometric properties. Values of detection efficiency are comparable to those PSm prepared by the evaporation/extraction method which demonstrate the low effect of crosslinking with DVB in the scintillation mechanism. In terms of resistance properties, melting point and extraction of fluorescent solutes encapsulated with different organic solvents was studied. Results shown that temperature resistance increases with the increase on the DVB proportions. Moreover, no morphological and scintillation properties changes were produced when the CPSm were treated with several organic solvents, highlighting the effect of the crosslinker agent. In contrast, it was determined that a high fraction of solutes encapsulated in CPSm were extracted by dichloromethane, acetone and toluene whereas in methanol and hexane the extraction was lower.

As a conclusion, a procedure for the preparation CPSm has been developed. The CPSm present comparable scintillation properties to that of lineal polystyrene PSm but with higher resistivity to temperature and organic solvents which increases the ranges of application and enables further structural modifications.

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