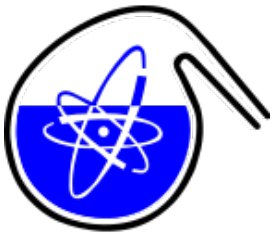

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Separation of 213Bi via an inverse 225Ac/213Bi radionuclide generator based on sulfonated carbon materials

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Bismuth-213 (213Bi) is an alpha-emitting radioisotope with large potential in nuclear medicine for cancer treatment. Several clinical trials of 213Bi-based radiopharmaceuticals have provided evidence for its therapeutic efficacy. 213Bi is produced from the relatively long-lived parent nuclide actinium-225 (225Ac) and then separated in a radionuclide generator. The patient dose of 213Bi is estimated to be 1 mCi/kg body mass, and the optimal 225Ac/213Bi radionuclide generator should separate 213Bi from 100-150 mCi 225Ac. However, previously used sorbent materials (e.g. Dowex 50W-X8, AG MP-50, Actinide Resin, UTEVA Resin, and Termoxid-39) have limitations, including poor radiolytic, chemical and physical stabilities. Therefore, developing alternative materials to overcome those shortcomings is a priority.

This study evaluated sulfonated carbon materials for use in inverse 225Ac/213Bi radionuclide generators. The synthesis protocol was optimized with regard to the pyrolysis temperature and sulfonation conditions. The materials were characterized with regard to the pore size distribution, the nature of the functional groups and the zeta potential. The separation of Bi3+, La3+ (as surrogate for 225Ac) and Ac3+ using the sulfonated carbon materials were examined by batch experiments, as a function of different parameters (e.g. pH, salt concentration, solid-to-liquid ratio, and contact time). The sulfonated carbon materials exhibited a high selective uptake of Bi3+ in the presence of high salt concentrations at low pH. Inversely, the sorption capacity for La3+ and Ac3+ onto the sulfonated carbon materials decreased with increasing salt concentrations and decreasing pH. Batch desorption results showed that a high percentage of Bi3+ can be eluted from sulfonated carbon materials by HCl, NaI, or NaCl solutions. More importantly, the sulfonated carbon materials showed high levels of resistance against radiolysis, fast sorption kinetics, good durability, and recyclability. The evaluation of the different materials enabled a better understanding of the sorption mechanisms of Bi3+ and Ac3+ onto these sulfonated carbon materials.

Based on the separation performance, the most suitable sorbent was examined using column chromatography. The 213Bi yield from the inverse generator reached 94% in 1 mL of 1 M HCl with an 225Ac impurity of less than 0.04% of the eluted 213Bi activity. Experiments also revealed that a guard column with AG MP-50 reduced the impurity of 225Ac without affecting the 213Bi yield. These findings indicate that the sulfonated carbon materials are promising adsorbents in inverse 225Ac/213Bi radionuclide generators for the production of high-purity 213Bi for medical applications.

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