Radium-228 separation and thorium-229 production

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Actinium-225 ($^{225}\text{Ac}$) is becoming more in demand now that it has proven to be successful in alpha radioimmunotherapy, specifically for leukemia. $^{225}\text{Ac}$ is the daughter product of thorium-229 ($^{229}\text{Th}$); it is extracted from thorium supplies at Oak Ridge National Laboratory (ORNL), but due to the limited supply of thorium, the needed quantities of $^{225}\text{Ac}$ cannot be produced. The leukemia treatments are still in trial phase, but in order for them to become widely used, the $^{225}\text{Ac}$ must become readily available. Currently, radium-228 ($^{228}\text{Ra}$) targets are being considered as a production route for $^{229}\text{Th}$. When a $^{228}\text{Ra}$ target is placed in a high flux of neutrons, it is speculated that $^{229}\text{Th}$ will be produced. The $^{228}\text{Ra}$ recovered during this project will be used to produce research targets to determine if neutron irradiation of $^{228}\text{Ra}$ is an effective method for producing $^{229}\text{Th}$.

At ORNL, there are several hundred quality-analysis samples in storage from $^{225}\text{Ac}$ production during 1997-2007 which contain $^{228}\text{Ra}$. $^{228}\text{Ra}$ is the first alpha-decay daughter of $^{232}\text{Th}$, which is found in a large portion of the $^{229}\text{Th}$ stock currently used for $^{225}\text{Ac}$ production. Every 60 days, the Ac/Ra is separated from the $^{228}\text{Th}$ stock and then further separated using resin columns to strip the Ra from the Ac. Since $^{225}\text{Ra}$ decays to $^{225}\text{Ac}$ with half-life of 14.8 days, a bi-weekly run of the Ra pool separated from the Ac product is also processed to provide smaller batches of $^{225}\text{Ac}$. The quality analysis samples of the Ra pool taken during processing are typically 5 µL from 1 mL and often contain $^{228}\text{Ra}$; this is why we are examining these samples.

Gamma ray analysis is used to examine the composition of the samples from $^{225}\text{Ac}$ batches, which have been allowed to decay for at least 5 years. A one-year period provides ample time for the $^{226}\text{Ra}$ to decay away given its half-life of 14.8 days. The samples are combined using cascade rinsing with 8M HNO$_3$ and then cleaned using resin columns. These resin columns consist of MP1 200-400 mesh column, which separates $^{226}\text{Ac}$ from $^{229}\text{Th}$, and an MP50 100-200 mesh column, which separates $^{226}\text{Ra}$ from $^{228}\text{Ac}$. The key gamma rays for $^{226}\text{Ac}$, a tracer for $^{228}\text{Ra}$, are 338 keV, 911 keV, and 968 keV. Following the assumption that $^{228}\text{Ac}$ is in equilibrium with $^{228}\text{Ra}$, the activity is calculated with these key gamma energies. The total material recovered, 31.4 ng, is now ready for target production for $^{229}\text{Th}$ research.