Polypropylene Pipe and Beads

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Polypropylene is the recommended material for ultrapure water systems if one can not or does not need to go the expense of using PVDF. (PVDF also gives off extremely toxic fumes if there is a fire hot enough to decompose it).

Three samples of piping were obtained from suppliers and NAA and radon emanation measurements were done. The primary purpose for NAA is to determine if there are any elements which are present in an anomalously large concentration and to get concentration of U and Th (at the top of the chain). Radon emanation measures the radium (lower in the chain).

In addition, several samples of the beads used to make the pipe were obtained from the source manufacturer.

The results of NAA and radon emanation are summarized in the table below.

	Th (ppt)	U (ppt)	222Rn emanation
3" ID white pipe	G 216 +- 11	**	1.5+-0.4 Rn m-2h-1
FABCO 1.5" white	G 140 +- 16 CRL <178	**	1.0+-0.3
2" ID grey Chemline	G ** CRL **		17+-1
PVDF (Italy)	CRL 620 +- 15	76	<1.1
G. Fisher	CRL **		

G= Guelph CRL=Chalk River **= too high interference

The NAA numbers for the U are not conclusive because of the high interference associated with other activation products. They do, however, indicate that there is lots of Zn in the Fabco 1.5" and grey Chemline and there is antimony in the Fabco pipe. (B. Knox has found an informative paper on NAA in various plastics by E. Haas et al, J. Radioanal. Nucl. Chem 168, 403 (1993). It has a table showing U and Th in the 3 ppb range and several other trace elements Na, Fe, Cu, etc.) The metals and other "foreign" elements could come from removed residues of the polymerisation catalyst, wear in the processing machinery and additives (see below). The Nalgene catalogue quotes 21 elements in PP totalling 519 parts per million.

We can convert the radon emanation number into a rough "equivalent"

U level. Assume the diffusion length for radon is about 0.5 mm (which is typical of plastics).

Then for one square meter of 0.5 mm thick piping, the weight is (0.05)*(10^4)(0.91 gm/cm2) = 379 grams of polypropylene. For an emanation rate of 1 Rn per square meter per hour, the amount of uranium in the 1 square meter is

1 Rn/hr x 4.5 x 10^9 x365 x 24 x 238 /(ln2 x 6.02 10^23) =

2.2 x 10^{-8} grams uranium.

Hence the concentration of uranium is

2.2 10^-8 / 379 grams = 58 x 10^{-12} = 58 ppt !

The diffusion of radon depends exponentially on the diffusion length so the estimate of 58 ppt is probably uncertain to a factor of 5 to 10. 226Ra (the radon parent) may also be in disequilibrium with the top of the chain. The NAA results above do not contradict the radon emanation result.

The table below summarizes the CRL NAA results on the beads and the radon emanation rates.

	Th (ppt)	U (ppt)	Rn emanation
Himont 956	1800	<130	0.6+-0.2 m-2h-1
PVDF (Quebec)	<100	<210	<0.3
Himont 258	++	++	prelim <0.4

++ = Counting in progress (lots of sodium)

The high number on Th for the Himont 956 is an indication that we have to exercise caution with respect to the thorium 220Rn daughter and the resulting 11 hour Pb that gets into the water.

The clean batch of Himont 258 will also be measured for thoron (220Rn) emanation at Guelph.

Comment

Polypropylene additives can be grouped into the following classes: fillers, plasticizers, lubricants, anti-aging additives, flame-retarders, colorants, blowing agents (to make cellular plastic and to increase the dielectric strengh), cross-linking agents, anti-static additives and UV degradable additives (refer to the book "Plastic Materials" by J. Brydson). Anti-aging additives are absolutely necessary to prevent adverse changes in the polypropylene with time.

For our piping we want a polypropylene that does not contain

fillers, lubricants, flame-retarders, colorants (pigments), blowing agents, anti-static additives and UV degradable additives. We want to avoid heavy metals and low molecular weight for the anti-aging additive. The polypropylene should be able to go down to 0 degree C without losing its mechanical properties. This means a copolymer is required.

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