Reduction of Radioactivity in ^{232}Th via Induced Cluster Decay?

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A novel and proprietary process – Co-Created and Co-Owned by TED and ZDN – has been privately demonstrated to rapidly reduce radioactivity. Instrumented replication – of earlier exploratory thermal reaction study – resulted in an ~51% (±2.5%) reduction of in ^{232}Th. Accompanying this was finding added Mg with both non-terrestrial ratios of: (1) ^{25}Mg to ^{24}Mg of 1.03:1 (vs. terrestrial ~1:7.5, $p = 0.0002$); and (2)) ^{26}Mg to ^{25}Mg of 0:1 (vs. terrestrial ~1:1, $p = 0.0001$). Profoundly unanticipated under the experimental thermal conditions (by orders of magnitude), these findings appear consistent with a cluster-decay/fission of ^{232}Th by emission of $^{24\text{-}25}$Ne and $^{206\text{-}207}$Hg particles (via herein outlined pathways). Supporting this was: ~1:1 balance between the ~51% loss in ^{232}Th mass and the cluster-fission consistent ^{24}Mg & ^{25}Mg masses (via respectively ^{206}Hg and ^{207}Hg). This instrumented replication consequently is strongly suggestive of cluster-fission – with a rapid 51% reduction of ^{232}Th (≤19 Days). We recommend independent research assessing the validity of this apparent relatively low-temperature cluster-fission of ^{232}Th.

INTRODUCTION

An instrumented-replication was conducted toward understanding the nature of previously observed rapid (Minutes) and profound (>20X) reductions in apparent radioactive emissions of post thermally-treated ^{232}Th (~14 Billion-Year Half-Life). Previous ^{232}Th studies had revealed a pattern of an initial substantial reduction within an hour post a modest (3660K) thermal process (YS &TED). This was then followed by shallow continuing declines toward an effectively background value during the following weeks. Of particular note, these ^{232}Th series studies had been undertaken given its remarkable long half-life vs those of a variety of other radioactive radionuclides that earlier had evidenced similar "radiation reductions" (TED & ZDN). Our purpose here was to initiate formal investigations of possible radiation-reduction mechanisms following thermal treatment of ^{232}Th.

BACKGROUND

Standard nuclear decay processes (esp. ^{232}Th) initially appeared profoundly inconsistent with our previous and current results. However, "*cluster decay*"— heavy nuclei decay via an intermediate process between alpha decay and spontaneous fission – appeared to offer a not implausible theoretical mechanism (Sandulescu, Poenaru & Greiner, 1980). In this regard, Sandulescu et al.'s speculated process was initially confirmed by the observation of heavy-ion 30-MeV, carbon-14 emission from radium-223 (Rose & Jones, 1984). More pertinently, regarding ^{232}Th, Poenaru, et al. (1989) calculated a possible ^{232}Th → ^{26N}Ne + ^{206}Hg cluster fission model[3] and subsequently Bonettii, et al. (1995) first reported observation of a spontaneous cluster decay of ^{232}Th. Subsequently, du Toit, Wyngaardt and Perez (2014) delineated explorations of the

cluster emission of Ne isotopes from the nuclei ^{232}Th and ^{234}U. Of note, however, du Toit et al. were unable to distinguish between the isotopes ^{24}Ne and ^{26}Ne. In this regard, as will be seen shortly, we delineate pathways for both of these (P-1 and P-3) as well as a novel ^{25}Ne decay avenue (P-2) which we have found hold particular promise for our findings. We note – before delineation of perspective cluster decay routes – a recent review that outlines some of the above history as well as provides salient understandings of ongoing research (Jain et al., 2023).

CLUSTER DECAY ROUTES

The following outlines three plausible ^{232}Th cluster decay pathways (P-1 to P-3) – with transitional half-lives – that are consistent with previous research. These, it should be noted, are not exhaustive; indeed, there are other plausible cluster decay pathways, e.g., ^{232}Th → ^{22}O + ^{210}Pb (e.g., Santhosh, Priyanka & Unnikrishnan, 2014). As also reflected by Santhosh et al., two of these – (P-1) and P-3) – have been particular objects of study, but not the intermediate pathway to ^{25}Mg. (P-2). This latter ^{25}Mg pathway – as that for ^{24}Mg (P-1) – will become especially relevant later with regard to our later presented spectrographic results.

P-1: $^{232}_{90}\mathrm{Th} \rightarrow {}^{26}_{10}\mathrm{Ne} + {}^{206}_{80}\mathrm{Hg}$

$^{26}_{10}\mathrm{Ne} \xrightarrow{\beta^-,\ 197\ \mathrm{ms}} {}^{26}_{11}\mathrm{Na} \xrightarrow{\beta^-,\ 1.077\ \mathrm{sec}} {}^{26}_{12}\mathrm{Mg}$ stable

$^{206}_{80}\mathrm{Hg} \xrightarrow{\beta^-,\ 8.15\ \mathrm{min}} {}^{206}_{81}\mathrm{Tl} \xrightarrow{\beta^-,\ 4.2\ \mathrm{min}} {}^{206}_{82}\mathrm{Pb}$ stable

P-2: $^{232}_{90}\mathrm{Th} \rightarrow {}^{25}_{10}\mathrm{Ne} + {}^{207}_{80}\mathrm{Hg}$

$^{25}_{10}\mathrm{Ne} \xrightarrow{\beta^-,\ 602\ \mathrm{ms}} {}^{25}_{11}\mathrm{Na} \xrightarrow{\beta^-,\ 59.1\ \mathrm{ms}} {}^{25}_{11}\mathrm{Mg}$ stable

$^{207}_{80}\mathrm{Hg} \xrightarrow{\beta^-,\ 2.9\ \mathrm{min}} {}^{207}_{81}\mathrm{Tl} \xrightarrow{\beta^-,\ 4.77\ \mathrm{min}} {}^{207}_{82}\mathrm{Pb}$ (stable)

P-3: $^{232}_{90}\mathrm{Th} \rightarrow {}^{24}_{10}\mathrm{Ne} + {}^{208}_{80}\mathrm{Hg}$

$^{24}_{10}\mathrm{Ne} \xrightarrow{\beta^-,\ 3.38\ \mathrm{min}} {}^{24}_{11}\mathrm{Na} \xrightarrow{\beta^-,\ 14.959\ \mathrm{h}} {}^{24}_{12}\mathrm{Mg}$ (stable)

$^{208}_{80}\mathrm{Hg} \xrightarrow{\beta^-,\ 42.5\ \mathrm{min}} {}^{208}_{81}\mathrm{Tl} \xrightarrow{\beta^-,\ 3.05\ \mathrm{min}} {}^{208}_{82}\mathrm{Pb}$ (essentially stable)

METHOD

Thorium dioxide (10g) and an amount of this proprietary pyro-flux mixture – including a Pb component – were placed in the reaction chamber with air-filter and ignited. The resulting pyro-metallurgical process temperature exceeded 3,390°C (6134°F), the melting point of thorium oxide. Beta and gamma radiation were assessed before ignition, and both 30 minutes and 19 days after reaction initiation (*Ranger EXP Meter, E.I. International, Inc, undated)*. Mass spectrometric analyses were subsequently performed at the University of Washington using their *Nu Instruments: Inductively-Coupled-Plasma Mass Spectrometer* (Nelson, 2020*)*. A variety of other non-listed instrumentation was also employed, but their results proved essentially unrelated to interpretations of the radiation and spectrometric findings.

RESULTS AND DISCUSSION

Radiation and spectrographic results are sequentially delineated and discussed in the body of this section. Implications for future research are delineated in the concluding section.

RADIATION

Table 1 summarizes the Beta and Gamma radiation levels over the course of the experiment. Examining this table, a broad – statistically significant pattern – is evident across the four assessments ($F(3,3) = 52.26$, $p<.005$).[1] Specifically, on Day 1 (pretreatment), Source Material Beta and Gamma levels were respectively: 1) ~500- and 444-fold over Background; 2) these ratios had fallen ~20 and ~4 fold within 30 minutes post-treatment on the same day, and 3) respective Beta (CPM) and Gamma levels (µR/hr) had returned to essentially Background by Day 19 ($t(3) = 0.71$, NS for Ln-transformed data).

Table 1 Radiation Assessments Across Experimental Periods

TYPE	BACKGROUND	SOURCE MATERIAL (^{232}Th)	30 MINUTES	19 DAYS
BETA	~30 CPM	~15000 CPM	~600 CPM	~25 CPM
GAMMA	~9 µR/hr	~4000 µR/hr	~33 µR/hr	~7 µR/hr

SPECTROGRAPHIC RESULTS

Tables 2 and 3 respectively outline salient spectrographic results and typical terrestrial proportions of Mg and $^{235\&238}$U isotopes.[2] Examining Table 2, one may first note that substantial portions of initial ^{232}Th (~half) are still present in the residual "white metallic disk" (D01) and a "black powder (S01) post reaction products – with a ~51% (±2.5%) reduction weighted by relative sample masses). This result ordinarily would have suggested – in contrast to the above reported observations -- that beta and gamma radiation levels might have been near half those of the source material pre-treatment at Day 19 (vs. effectively

[1] ANOVA was here performed on Ln-transformed values using the mean score interaction as error (Q-Q Plot – though limited in power – supported uses of Ln-transformation and use of the interaction term as "error." Later analyses employed "essentially orthogonal" ***t***-comparisons of observed vs. terrestrially expected proportions. Bittner (2022) recently overviewed the robustness of ANOVA (and relatedly t-tests as $F(1, dF) = t^2(dF)$).

[2] We chose – though observed ^{235}U/^{235}U ratio is significantly different from ordinarily terrestrial -- to not highlight this as anomalous ratios occasionally occur in trace samples (e.g., Sakuragi, Meason, & Kuroda, 1983).

background). However, a consultant's report of a previous parallel Pb associated anomalies, strongly suggested this was largely due to a combination of surface coating and interior shielding by Pb (introduced with flux material).[3]

Further examining Table 2, it is noteworthy that substantial levels of Mg are in the residual "white metallic disk" (D01) and a "black powder (S01) post reaction products. This is remarkably intriguing as Mg was essentially *not-present* prior to the pyro-treatment (i.e., *not in ^{232}Th sample, pyro, and/or other materials*). Equally intriguing, one also may note – in contrast with terrestrial isotope proportions (Table 2) – both: 1) somewhat more than equal relative proportions ^{25}Mg to ^{24}Mg in both the "white metallic disk" (D01) and 2) a "black powder (S01) residual products (1.02:1 and 1.03:1) and 2) no reported detection of ^{26}Mg in either D01 or S01. These latter results altogether profoundly contrast against the terrestrial range of; 77%-79% ^{24}Mg vs. 10%-11% ^{25}Mg ($t(1) = -3599.29$, $\boldsymbol{p} < .0002$); and 10-11% ^{25}Mg vs. 11% ^{26}Mg ($t(1) = 6586.79$, $\boldsymbol{p} < .0001$). .

Table 2. Mass Spectrometric Results (ppm)

SAMPLE	^{232}Th (ppm)	^{24}Mg (ppm)	^{25}Mg (ppm)	^{26}Mg (ppm)	^{235}U (ppm)	^{238}U (ppm)
D01	5829	1574	1619	ND	1.4	1.4
S01	6498	4718	4855	ND	1.8	1.7

Table 3. Terrestrial Isotope Relative Natural Abundances (%)

NATURAL ABUNDANCE	^{232}Th (%)	^{24}Mg (%)	^{25}Mg (%)	^{26}Mg (%)	^{235}U (%)	^{238}U (%)
	100%	77%-79%	10%-11%	11%	0.72%	99.3%

Beyond the remarkable contrast between typical natural terrestrial and the unexpectedly observed Mg isotopes, was the intriguing ratio of Mg to ^{232}Th in the samples. Specifically, the ratios of total found $^{24+25}$Mg to residual ^{232}Th (ppm) was (1) ~1.02 both within and across D01 and S01, and 2) this is remarkably near the ratio of 1.04 that might be anticipated with a 51% conversion of ^{232}Th to $^{24+25}$Mg. This – and the profound mismatch between observed and natural $^{24-25}$Mg isotopes -- would appear to point toward near equal frequency of cluster decay routes P-2 and P-3 (albeit P-2 apparently slightly favored over P-3).

CONCLUSION

Results of our replication are essentially consistent with a novel process for reducing ^{232}Th – via cluster-decay emission of $^{24-26}$Ne and $^{206-208}$Hg – to non-radioactive isotopically-stable elements (esp. ^{24}Mg and ^{25}Mg). Reflecting – in addition to an ~ 51% reduction in ^{232}Th mass – spectrographic analysis revealed 1) an ~1:1 ratio between the ~1/2 residual ^{232}Th and posited total ^{24}Mg+^{24}Mg (via. $^{206-208}$Hg), and 2) a near theoretically anticipated ratio of ^{25}Mg to ^{24}Mg of 1.03:1 (vs. terrestrial ~0.13:1). This proprietary process consequently may have unexpectedly achieved ~51% reduction of ^{232}Th in 19 days vs. the nominal ^{232}Th half-life of 14 billion years – a finding that strongly begs for near-term independent replication.

[3]Pb flux shielding – itself -- may have considerable utility in other contexts (e.g., nuclear waste management).

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