NPRE 481
Practical 4: Write an Abstract II

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Pyroprocessing is a material process where specimen are subjected to temperatures over 800 °C. Current pyroprocessing typically uses Al_2O^3 as a crucible. However, Al_2O^3 crucibles are not reusable – Al_2O^3 crucibles are only single use vessels. Single use vessels are not only wasteful, but, when processing radioactive materials, generate unnecessary quantities of radioactive waste when the radioisotopes interact with the crucible. Therefore, this study determined the reusability of crucibles composed of four different materials: Al_2O^3, BeO, AlN, and SiC. The objective was to find a more reusable alternative to the single-use Al_2O^3 crucible to reduce the amount and radiotoxicity of radioactive waste. Each crucible underwent the same electrode deposition run using Cd as the cathode and LiCl-KCl-UCl_3-$RECl_3$ as the electrolyte – the deposition run was continued until the crucible was determined unusable. The deposition run was postceded by a distillation process. Before and after each electrode position run, the salt compositions were identified by inductively coupled plasma atomic emission spectroscopy. Following distillation, the metal residues were also analyzed via inductively coupled plasma atomic emission spectroscopy. Results indicate cathode potential is significantly influenced by the concentration and composition of the salt. The Al_2O_3 crucible lasted a single heating process as the metal depositions reacted with the crucible. The AlN crucible was recycled until the seventh electrode position tests and surface cracks appeared after three tests. The SiC crucible was found to be externally stable and was recycled four times. However, metal deposits reacted with the SiC crucible at the distillation temperature – namely, a U-Si reaction is possible as shown by the HSC chemistry v6.0 software. The best performing crucible was the BeO crucible, which was recycled 13 times with cracks forming on the outer and inner surface after the fifth test. The BeO crucible also has a the low reaction rate with other non-Gd metals. However, Gd is very rare naturally, in fuel fabrication, and the salts used for this process – the Be-Gd reaction is of minimal concern. Removal of the Cd ingot after cooling was not possible in the BeO crucible. With further design optimization and/or surface treatment to counteract the Cd removal, the BeO crucible was the best alternative to the single use Al_2O_3. BeO crucibles should be considered for their reusability in pyroprocessing and low reaction rates. BeO crucible usage would also serve to reduce nuclear waste generation due to reusability.