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Advanced Fuels Campaign

ADVANCED LWR FUELS

LWR Fuels

- **[LANL]** The crystal structure of uranium monosilicide (USi) was investigated using neutron diffraction on the HIPPO beamline at LANSCE. The inorganic crystal structure database (ICSD) lists three entries for this compound, all with different space groups (Zachariasen, 1949: Pbnm, Badaeva & Dashevskaya, 1972: Pnma, le Bihan et al, 1996: I4/mmm). Knowledge of the crystal structures of the phases in the U-Si system is of great importance to investigations of the phase diagram, identifying possible contamination phases during processing etc. All previous studies were performed with X-rays, making this study the first utilizing neutrons. For X-rays, the diffraction signal is heavily biased towards the heavier uranium atom, while for neutrons the contribution of the Si atoms to the diffraction signal is similar, allowing to study the crystallography of the Si atoms in more detail. The data collected at LANSCE is consistent with the crystal structure published by le Bihan et al. For the first time, high temperature data was collected, allowing study of how the crystal structure evolves with temperature. Powder neutron diffraction data analysis is on-going using the Rietveld full pattern analysis method. The samples were synthesized at LANL by J.T. White, S.C. Vogel (LANL) collected the neutron diffraction data and is collaborating with T. Wilson (U South Carolina) on the data analysis. (S. Vogel)
- **[LANL]** Work conducted within the Advanced Fuels Campaign was presented at the 2019 NuMat Conference by a number of researchers at LANL. Dr. Nicholas Wozniak presented a talk titled "Thermophysical properties, microstructure, and oxidation behavior of UN-UO2 composites," which highlighted the improved thermal conductivity of UO2 with UN additions while also incrementally improving the oxidation performance relative to the reference UN case in autoclave conditions. Two posters were also presented at the conference that showed recent fundamental mechanical property measurements on high uranium density fuels as well as quantitative determination of hydride degradation mechanisms in U3Si2. These presentations showcase achievements that have been accomplished within the AFC to the broader national and international community. (J. White)
- **[LANL]** A paper titled, "Defect evolution in burnable absorber candidate material: Uranium diboride, UB2," was published in the Journal of Nuclear Materials. This was a collaborative effort (LANL, UNSW, WEC, and Bangor University) to study the stability, diffusivity and clustering behavior of defects in uranium diboride in light of its potential application as a burnable absorber in nuclear fuel. One of the findings was that deviations in stoichiometry are not readily accommodated and as such stoichiometry control is important during fabrication to avoid lower melting point phases or phases with reduced mechanical properties. (E. Kardoulaki)
- **[ORNL]** The first-generation microfluidics based sol-gel system to produce surrogate microspheres, e.g. cerium oxide, with tighter tolerances and more flexibility in sizes has been installed. Preliminary runs to produce sol-gel broth droplets of Ce and Zr nitrate solutions have been performed. Results are shown in Figure 1 below. This work is underway to explore possible paths to reducing the minimum particle size that can be produced from a sol-gel route (J. McMurray)

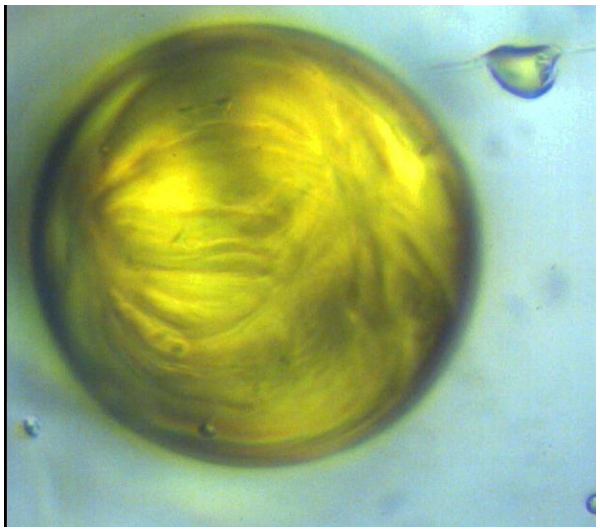


Figure 1. A ~200 μm droplet consisting of a Ce nitrate based sol-gel broth.

LWR Core Materials

- **[ORNL]** SiC/SiC composite fuel cladding failure due to microcracking during normal operating conditions remains one of the critical feasibility issues for its application in LWRs. Hermeticity evaluation of SiC-based tubes following high and low heat flux neutron irradiation are being carried out by using the permeation testing station at ORNL. Seventeen neutron-irradiated specimens have been tested, including 4 CVD SiC tubes, 5 GA SiC/SiC tubes, 3 coated GA SiC/SiC tubes, 2 CEA SiC/SiC tubes, and 3 KAERI SiC/SiC tubes. The results are summarized in Figure 2. It is apparent that all tested neutron-irradiated CVD SiC tubes under high and low heat flux remain hermetic and one bare and two coated SiC/SiC composite tubes following low heat flux neutron irradiation still have gas tightness. In contrast, all tested SiC/SiC composite tubes following high heat flux neutron irradiation are not hermetic as well as two SiC/SiC composite tubes following low heat flux neutron irradiation. Generally, neutron irradiation under high heat flux results in greater helium leak rate. Helium leak rate of coated samples following high heat flux neutron irradiation is relatively lower than that of the same sample without coating. It is noted that measured helium leak rate is a function of applied helium pressure difference across the sample and starts to reach saturation when pressure is greater than 100 torr. (X.Hu, Y.Katoh)

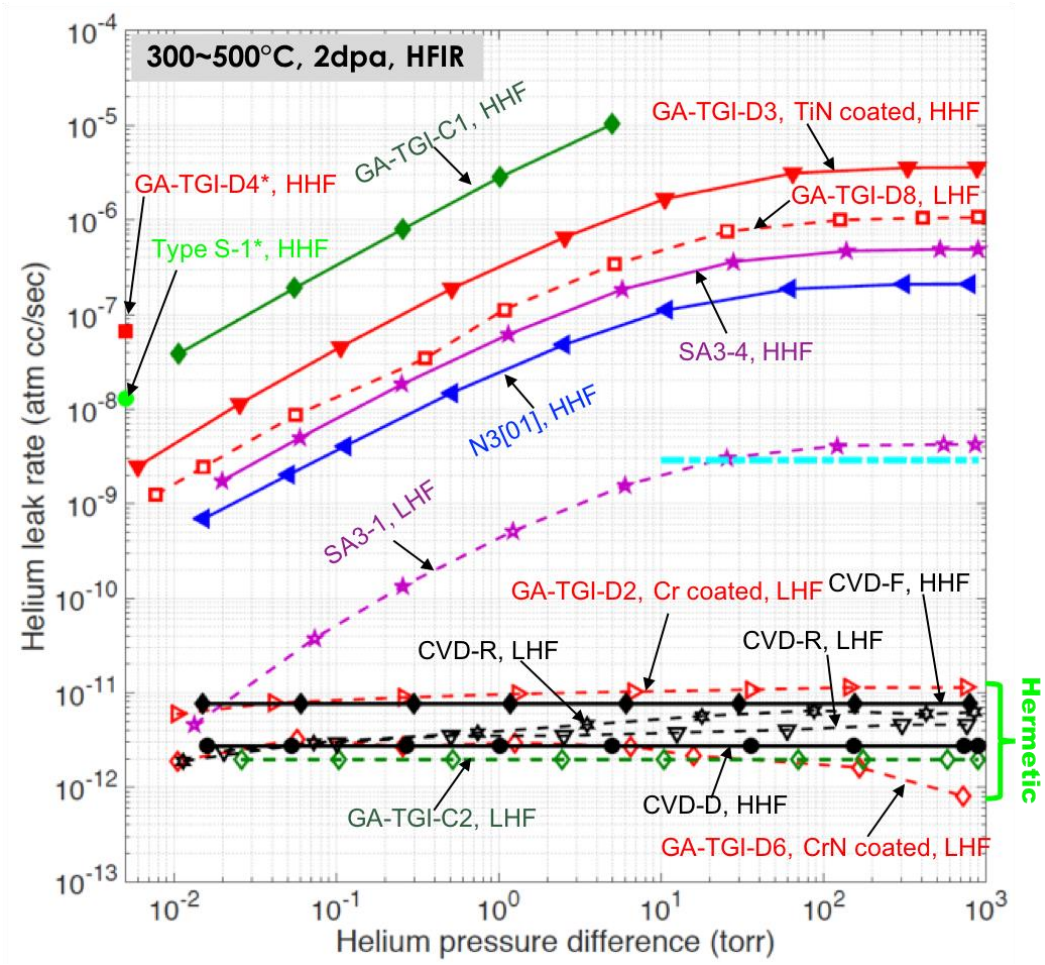
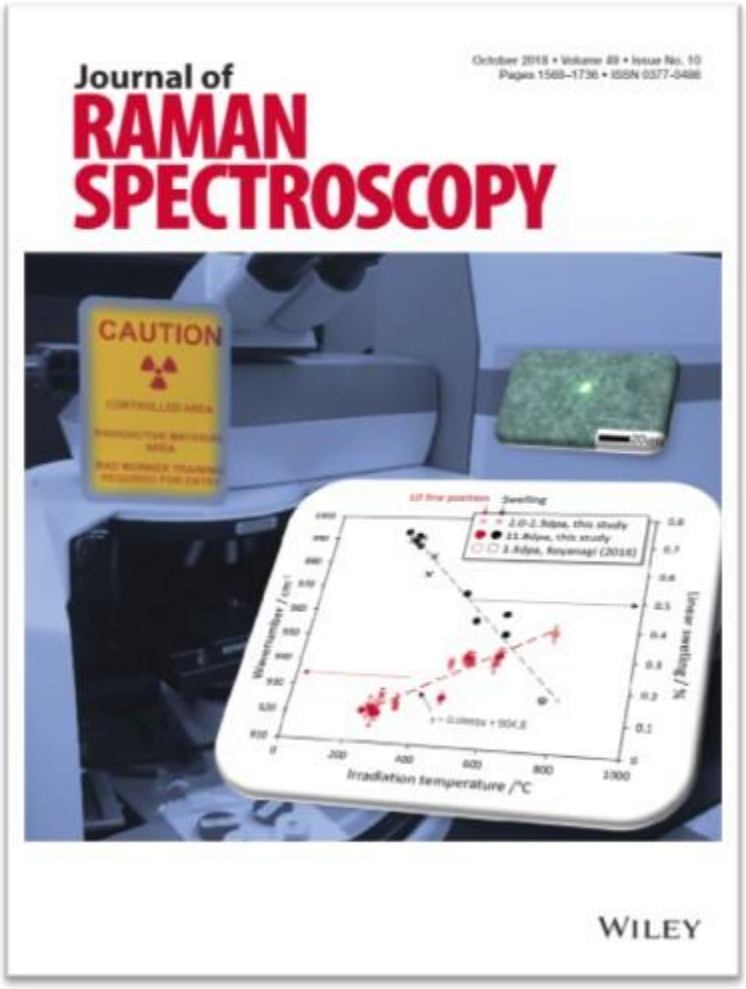


Figure 2. Helium leak rates of various SiC/SiC composite tubes following high and low heat flux neutron irradiation as a function of applied helium pressure. (* Large helium leak rate when exposed to atmosphere and high-pressure testing was not attempted. HHF: High Heat Flux; LHF: Low Heat Flux.)

- **[ORNL]** Part of the study on PIE of SiC/SiC composite cladding has been published in the Journal of Raman Spectroscopy. This study established correlation among Raman peak position, swelling, and irradiation temperature. The findings illustrate how Raman spectroscopy is a useful tool for nondestructively assessing irradiated SiC materials including SiC cladding. This article has been selected as a cover of the journal (see the image below). (Y. Katoh)



Published paper:
Takaaki Koyanagi, Yutai Katoh, Michael J. Lance, Raman spectroscopy of neutron irradiated silicon carbide: Correlation among Raman spectra, swelling, and irradiation temperature, *Journal of Raman Spectroscopy*, 2018, 49:1686–1692.

Submitted journal paper:
Takaaki Koyanagi, Kurt Terrani, Torill Karlsen, Vendi Andersson, David Sprouster, Lynne Ecker, Yutai Katoh, In-pile tensile creep of chemical vapor deposited silicon carbide at 300°C, *Journal of Nuclear Materials*

- **[ORNL]** Based on the successful fabrication of the ODS "CrAZY" Fe-10Cr-6Al-0.3Zr + 0.3Y2O3 thin tube, 500μm thick and 1.68m long, ORNL is developing processing routes to scale up tube production and optimize the CrAZY tube microstructure. 100lbs of Fe-12Cr-6Al-0.3Zr powder was purchased from ATI Powder Metals and 40lbs of this powder was shipped to Zoz GmbH in Germany for powder ball milling. Zoz started to ball mill the powder using a Simoloyer CM20 to increase the powder batch to ~3kg compared to ~1kg for the CM08 previously use at ORNL. The powder will then be shipped to ORNL for extrusion of 5 master ODS CrAZY rods that will be pilgered by a Japanese industrial partner for thin tube fabrication. (S. Dryepondt)
- **[ORNL]** A paper titled "Post Irradiation Examination of Nanoprecipitate Stability and alpha' Precipitation in an Oxide Dispersion Strengthened Fe-12Cr-5Al Alloy," was accepted for publication

by Scripta Materialia, and Caleb Massey successfully defended his PhD thesis titled "Multiscale Investigations of Nanoprecipitate Nucleation, Growth, and Coarsening in ODS FeCrAl Alloys: Optimizing Sink Strength for Nuclear Applications" at the University of Tennessee on October 30, 2018. (S. Dryepondt, C.Massey)

- **[LANL]** Deuterium diffusion testing was completed on two FeCrAl alloys (Fe 15Cr 4.5 Al and Fe 13.5Cr 5 Al). Pressure was varied up to 300 torr and temperature ranged from 300-600C. Similar results were obtained for both alloys and was documented in a report to meet a level 3 milestone. Future testing will also be performed with tritium. (J. Wermer)

LWR Irradiation Testing & PIE Techniques

- **[INL]** Irradiation of ATF-2 during ATR cycle 164B (84 effective full power days through October) and scoping design improvements continued. (G. Hoggard)
- **[INL]** Measurements of the atmosphere in the capsule of several ATF-1 capsules that contained FeCrAl rodlets was performed. This confirmed that no fission gas was present in the capsule atmosphere, and the measured volume corresponded to the free volume of the capsule only. This shows that these rodlets remained hermetic during irradiation. (J. Harp)
- **[INL]** Image analysis of ATF-1 concepts was presented at the NuMat2018 conference in Seattle. (J. Harp)
- **[ORNL]** Eight rabbit capsules containing a variety of oxide dispersion-strengthened (ODS) ferritic alloy tube samples (Figure 3) were successfully delivered to the High Flux Isotope Reactor (HFIR) for insertion during cycle 483 (November−December 2018). FeCrAl alloy samples will be irradiated at 350°C (light water reactor applications) to doses ranging from 2−40 dpa. FeCr alloy samples will be irradiated at 550°C (sodium fast reactor applications) to similar doses ranging from 2−40 dpa. The tubes will be evaluated post-irradiation to determine irradiation effects on microstructure and mechanical properties. (C. Petrie, A. Le Coq, S. Dryepondt, D. Hoelzer, S. Maloy)

Figure 3. OFRAC01 rabbit capsule, parts and ODS tube specimens prior to assembly. A total of eight capsules have been delivered to HFIR for irradiation in FY19.

LWR Fuel Safety Testing

- **[INL]** Project kick-off meetings were held for the doped pellet cracking, Zr-hydriding, and microstructure characterization projects. Detailed schedule planning was developed. (L. Emerson)
- **[INL]** A data package was finalized supporting concurrent in-pile testing of instruments through SETH experiments in TREAT. An optical pyrometer assembly was fabricated for concurrent testing with possibility of TREAT fuel cladding measurement. The MPFD was prepared for insertion into TREAT prior to the SETH C experiment. The second pyrometer was received for duel measurement in the SETH B-1 experiment. The procurement schedule and request for Halden LVDTs were prepared. (K. Bowman)
- **[INL]** Extensive data analysis was performed to reconcile some confounding data output from the first two MARCH SETH transients. A third transient was performed to confirm the conclusions reached via the data analysis. The confirmation was successful, and the completion of the MARCH SETH transient series is now underway. (D. Dempsey)
- **[INL]** Sensitivity analysis commenced, as well as plan development for the Aqua-Separate Effects Test Holder (SETH) experiment. Creation of a Serpent model was initiated for the NASA SIRIUS experiment. (T. Pavey)

LWR Computational Analysis & Fuel Modeling

- **[ORNL]** Recent work on modeling ATF cladding concepts had focused on the development of more accurate failure criteria for FeCrAl cladding. Recent burst tests show much higher rupture stresses than the previously-developed ultimate tensile strength failure model would predict. Because the plasticity model used in BISON is derived from older UTS data, it limits the maximum stress that can be achieved in the cladding, a new plasticity model will need to be developed to continue using a stress-based failure criterion.

  Alternatively, strain/strain-rate based criteria are being investigated because they may offer an improved prediction for cladding failure where the UTS is not reached. This work consists of implementing a plastic strain/strain-rate limit into the current plasticity model to be used in conjunction with the stress-based failure model. This is similar to current models used for Zircaloy cladding. Work on improving the FeCrAl cladding failure model is expected to continue by recalibrating the current plasticity model to this new fit, and by implementing measured strain data from previous burst experiments into the failure criteria. Modeling work supported by the AFC was also presented at the TOPFUEL 2018 and NUMAT 2018 conferences earlier in October. (B.Wirth)
- **[ORNL]** A manuscript on the deformation analysis of SiC-SiC channel box was accepted by the *Journal of Nuclear Materials* [G. Singh, J. Gorton, D. Schappel, N. R. Brown, Y. Katoh, B. D. Wirth and K. A. Terrani, Deformation Analysis of SiC-SiC Channel Box for BWR Applications, *Journal of Nuclear Materials*]. In this work, the effect of non-uniform dimensional changes caused by spatially varying neutron flux and temperatures on the deformation behavior of the channel box over the course of one year was evaluated. These analyses were performed using the fuel performance modeling code BISON and the commercial finite element analysis code Abaqus, based on fast flux and temperature boundary conditions that were calculated using the neutronics and thermal-hydraulics codes Serpent and CTF, respectively. The dependence of dimensions and thermophysical properties on fast flux and temperature were incorporated into the material models. These initial results indicate significant bowing of the channel box which may lead to severe channel box – control blade interference. The channel box bowing behavior is time dependent and driven by the temperature dependence of the SiC irradiation-induced swelling and the neutron flux/fluence gradients. Additional analyses, with top of the channel box constrained against displacement in vertical direction, and to different degrees in horizontal directions, showed the development of high stresses which may lead to

mechanical damage in the channel box during operation. We are currently in the midst of performing additional analysis for varying BWR operating conditions. (B. Wirth)

Industry FOA

- **[INL]** Characterization and reporting was completed for batch 1a and 1b fuel pellets Fuel pellet visual inspections were completed, as well as fuel pellet dimensional inspections and surface finish inspections. Assembly of the as-built data package was completed for submission to Westinghouse for review. (S. Martinson)
- **[ORNL]** Tensile testing of 33 SS-J type FeCrAl tensile specimens was completed at ORNL's IMET facility. Tensile tests included both welded and non-welded FeCrAl specimens with various compositions and microstructures irradiated near 7.5 dpa at 236, 282, & 460°C. Preliminary test results show embrittlement of welds (based on no total elongation) at these irradiation conditions while non-welded parent specimens exhibited various degrees of hardening and embrittlement based on irradiation temperature and composition. (K. Field/D. Zhang)

ADVANCED REACTOR FUELS

AR Fuels

- **[INL]** Work has progressed on welding development for the new FAST test design. Under this development, welds test end plugs have been fabricated and successfully welded, showing the feasibility of the pulsed GTAW method of welding. As a continuation of this work a conceptual design has been initiated on glovebox applicable weld fixturing which will increase the welding throughput as well as improve consistency from weld to weld. (R. Fielding)
- **[INL]** The Fuel Additive portion of the work package pulled a publication effort and some experimental work forward as an opportunity made itself available. (J. Giglio)

AR Core Materials

- **[LANL]** As the CRADA with Terrapower for high dose material testing in BOR-60 nears its end, initial discussions are underway for extending the CRADA. (S. Maloy)
- **[PNNL]** Further work took place on barrier hardening coefficient estimates in support of milestone "M3FT-19PN020302025: Report on and Perform Neutron Irradiated Material Microstructure Analysis and Barrier Hardening Coefficient Determination (FY17)." Contributions such as precipitates, line dislocations, dislocation loops, grain size, and solid solution strengthening are all being considered for four different alloys. The available information assembled thus far continue to support barrier hardening coefficients of ~0.1 and ~0.4 for alpha-prime and G-phase precipitates, respectively and a strength of ~0.3 for YTiO precipitates. Solid solution strengthening contributions for oxygen and nitrogen as well as contributions due to line dislocations and dislocation loops are still being refined. (M. Toloczko)
- **[PNNL]** The milestone report titled, "Mechanical properties of HT-9 steels irradiated in FFTF to 9–42 dpa (M3FT-19PN020302035)," was completed and submitted. This post-irradiation evaluation was a carryover activity from the last fiscal year. To obtain additional tensile property data for the core materials database, eighteen tensile specimens irradiated in SFR-relevant conditions in FFTF were selected from the HT-9 steel specimen library of the past FFTF-MOTA irradiation program and were tension-tested also at SFR operation temperatures. This report is to present the result of the uniaxial tensile testing for the set of eighteen FFTF irradiated HT-9 steel specimens. The effect of different irradiation temperatures was significant in the strength and ductility of HT-9 steels, while no

significant difference was found for the two irradiated HT-9 steel heats (81963 and 92239) in the same irradiation conditions. (T.S. Byun)

- **[PNNL]** As part of the program to advance the technology associated with fabricating tubing from difficult-to-fabricate materials, the PNNL rolling mill has been modified so that it can perform pilgering of tubes. This will establish a unique R&D capability within the DOE complex. The rolling mill with pilger dies installed and ready for startup testing is shown in Figure 4 below. The initial startup pilgering run is complete and the run underway is shown in Figure 5 below. Desired modifications were identified during the startup run and the engineering necessary to implement these is complete. PNNL has not yet received its FY-19 funding and this is limiting the implementation of these modifications and progress on this project. After startup testing with stainless steel, MA956 and 14YWT will be pilgered. (R. Omberg)

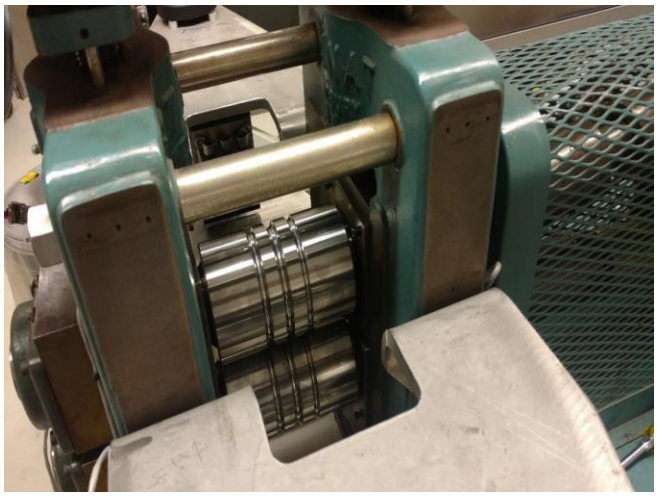


Figure 4. Pilger mill with roller dies installed ready for startup testing.

Figure 5. Initial startup pilgering run.

- **[PNNL]** An invited talk was presented by S. Maloy at NuMAT 2018 in Seattle, Washington on Process Development of Ferritic Steels for High Dose Reactor Applications. The talk summarized recent research on ferritic/martensitic steel and ferritic ODS steel development. (S. Maloy)
- **[ORNL]** Five cans were designed and fabricated from 4140 steel for upcoming extrusion of ball milled powder of OFRAC for producing five master rods. The OFRAC powder is currently being ball milled using the high kinetic energy CM08 Simoloyer. A total of 10 ball mill runs are planned for producing 10 kg of OFRAC power. The significance of producing the five master rods is that they will be used for fabricating thin wall tubing under the guidance of NFD (Nippon Nuclear Fuel Development). The goal is to produce tubing with an outer diameter of 6 mm and wall thickness of 0.5 mm. (D. Hoelzer)

AR Irradiation Testing & PIE Techniques

- **[INL]** FAST Conceptual Design Review was completed just prior to start of FY2019. Preliminary Design and Fabrication Development efforts are well underway. (C. Murdock)
- **[INL]** The current status of transmutation PIE efforts including work on the FUTURIX-FTA irradiations, AFC-1 irradiations, and EBR-II minor actinide irradiations was presented at the 15th Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation in Manchester UK. This talk highlighted US leadership in this area where very little work is being done outside of the US internationally. (J. Harp)
- **[INL]** The current status of PIE on the AFC concepts including low smear density – sodium free metallic alloy fuels were presented at the NuMat 2018 conference in Seattle Washington. An additional talk at NuMat focused on the current PIE being performed on historically irradiated fuel from EBR-II including minor actinide bearing fuel and various U-Pu-Zr irradiated pins. (J. Harp)
- **[INL]** Chemical analysis of an EBR-II irradiated U-19Pu-10Zr+minor actinide bearing fuel pin was initiated in the INL MFC Analytical Laboratory. (J. Harp)
- **[INL]** Dialog with the hot-cell and engineering have been initiated, and conceptual design work on the furnace testing rig have begun. (J. Harp)
- **[ANL]** In order to assess the impact of low enriched uranium (LEU) on the SFR core performance based on once-through and continuous recycling fuel cycle modes, a series of sensitivity study with various fuel mixtures was conducted, which include LEU (~ 20%) fuel only, Pu fuel only, and 5%LEU and Pu mixture in once-through and recycle SFRs. In all cases, depleted uranium was used as make-up fuel. For comparison purpose, both weapon-grade and reactor-grade plutonium was considered in this study. Based on the S-PRISM core, fuel and core design parameters were iteratively adjusted to achieve a target discharge burnup (~10%) and conversion ratio (break-even). The preliminary results indicate that the addition of 5% LEU to SFR can save about 3.5% content of plutonium regardless of once-through or recycling fuel cycles. Additional analysis is underway to assess detailed physics and safety parameters. (T. Kim)

AR Fuel Safety Testing

- **[INL]** Project kick-off meetings were held to define project scope, objectives, and responsibilities. Conceptual design of MARCH heat sink module (THOR) was initiated. Modeling of old TREAT sodium loops was commenced. (L. Emerson)
- **[INL]** A kick-off meeting with project objectives, scope, and milestones was held with project team. An outline has been created for the international joint project transient test plan. (L. Emerson)

AR Computational Analysis & Fuel Modeling

- **[INL]** Recognizing difficulty fabricating 1/16" diameter pellets for the 1/3 scale MOX irradiation, BISON calculations were performed to investigate temperature distribution in 1/16" diameter spheres instead of pellets. Results show that prototypic temperature distribution can be achieved. Small spheres are easier to fabricate than small pellets by using the sol-gel and similar methods. Figure 6 shows temperature distribution in a 1/3 scale MOX rodlet filled with single-stacked 1/16" spheres. (P. Medvedev)

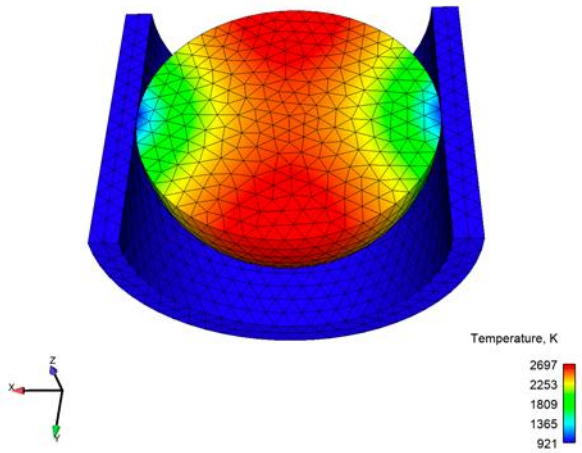


Figure 6. Temperature distribution in a 1/3 scale MOX rodlet filled with single-stacked 1/16" spheres.

CAPABILITY DEVELOPMENT

CX Fuels

- **[INL]** Installation of the TCM at IMCL is being coordinated with the Thermal Properties Cell team. The TCM is scheduled to be transported to the IMCL on Dec 10 with installation and system testing to follow. Final testing of the TCM and preparations for transport are ongoing. The feed through for the sample heater has been integrated into the control cable and an initial system check performed. (S. Martinson)

TREAT Testing Infrastructure

- [**INL]** A technical meeting was held at Halden with Halden and INL technical staff resulting in defined joint work scope, agreed upon by INL and Halden technical leadership, paving the way to efficient and effective transfer of Halden technology needed at INL. The Statement of Work was written and approved, and a contract requisition has been completed, (T. Pavey)

For more information on Fuels contact Steven Hayes (208) 526-7255.

Material Recovery and Waste Forms Development

PROCESS CHEMISTRY AND INTEGRATION

- **[ONRL]** A manuscript titled, "Efficient Separation of Light Lanthanides(III) by Ligands with Tunable Rigidity," has been submitted to the Wiley publisher. A poster titled, "Strategic Study on Lanthanide Separation Through Effective Ligand Design," was presented at 20th Symposium on Separation Science & Technology for Energy Applications conference on October 22 held in Gatlinburg, TN. Computational work has been initiated for the DTTA-PzM ligand – a new aminopolycarboxylate substrate, which was synthesized at ORNL and its performance studied by researchers at INL (collaborative effort). We are in the process of acquiring an additional amount of Am-241and Eu-152/154 radio tracers to finalize the extraction studies involving rigid phenanthroline-based ligand. (S. Jansone-Popova)
- **[ANL]** ALSEP waste has been placed into five drums that await survey by waste management, which have been scheduled for November. (W. Ebert)
- **[ORNL]** The evaluation of larger cation exchanged Cs-LTA membranes was continued. Experiments were performed varying the run time from 4 to 48 hours while maintaining all other conditions with some variation in feed concentration. The HTO/H2O separation performance of Cs-LTA zeolite membranes are summarized in Table 1. The calculated average HTO permeance and the average HTO/H2O separation factor of the Cs-LTA membranes were 359±54 GPU and 1.78±0.38, respectively. To verify the reproducibility of the membrane performance, the separation measurements were conducted for 48 hours with another sample (Cs-LTA (2)). The second membrane showed the HTO permeance of 272 GPU and the HTO/H2O separation factor of 1.36. Overall, the results are consistent and reproducible within the limits of experimental and analytical errors in measurement. An interesting observation is that although the feed concentration was varied by a factor of 2, the separation factor was not substantially impacted by the tritiated water concentration suggesting that the membrane-based separation can potentially work well at low tritiated water concentrations anticipated in nuclear waste treatment. When compared with the K-LTA membrane, the separation factor of HTO/H2O with Cs-LTA membrane is substantially higher. However, the permeance of the Cs-LTA membrane is substantially lower than that of K-LTA membrane. The draft of the Milestone report was submitted for review and approvals on October 31, 2018. (B. Jubin)

Table 1: Permeance and separation factor of tritiated water results Cs-LTA on CoorsTek alumina disk support

Expt.	Membrane	Time (hours)	Radioactivity (mCi/mL)			Permeance (GPU)		Separation factor (α)
			Feed	Retentate	Permeate	HTO	H_2O	
1	**K-LTA**	24	1.054	1.080	0.9729	6120	5533	1.08
2	**Cs-LTA (1)**	4	0.7567	0.7027	0.4054	409	638	1.87
3	**Cs-LTA (1)**	24	0.5405	0.5135	0.2567	302	531	2.11
4	**Cs-LTA (1)**	48	0.5135	0.5135	0.3784	366	415	1.36
5	**Cs-LTA (2)**	48	0.5135	0.5135	0.3784	272	308	1.36

WASTE FORM DEVELOPMENT AND PERFORMANCE

Electrochemical Waste Forms

- **[ANL]** The coordinated test plan for producing and testing an iron phosphate waste form for dehalogenated EChem waste salt is being implemented. ANL is consulting with colleagues at PNNL and INL as the material (or materials) is made and will commence testing when products are provided in early 2019. A journal paper summarizing the results of tests with prototype materials is being drafted. (W. Ebert)
- **[PNNL]** The Memorandum of Understanding (MOU) for joint work between PNNL, Washington State University (WSU), and Australian Nuclear Science and Technology Organization (ANSTO) was approved by DOE headquarters in October. It was then signed by PNNL and WSU and is currently at ANSTO for signatures. This work will involve collaborative efforts to assess ceramic waste form production and optimization for electrochemical salt wastes. (B. Riley)

Ceramic Waste Forms

- **[LANL]** Advanced Waste Forms (Ceramics), FT-19LA03010501, Ming Tang attended Nuclear Materials 2018 conference which was held October 15-18, 2018, at Seattle, WA and gave a presentation titled "Radiation-induced Volume Swelling and Microcracking in Glass Ceramic and Crystalline Ceramic Nuclear Waste Forms."
- Hollandite phase as a promising crystalline host for Cs, is observed in several multiphase ceramic waste forms. To study the radiation tolerance of hollandite phases, in situ dual beam irradiation with 1 MeV Kr and 12 keV He ion irradiations were performed on single phase hollandite samples with various chemical compositions at room temperature in the Intermediate Voltage Electron Microscopy (IVEM)-Tandem Facility at Argonne National Laboratory (ANL). The IVEM-Tandem Facility is a partner facility of the Nuclear Science User Facilities (NSUF) supported by the U.S. Department of Energy-Office of Nuclear Energy (DOE-NE) for in situ TEM studies of materials under controlled ion irradiation and sample conditions. Detail results will be presented in the future report. (M. Tang)

Glass Ceramics Waste Forms

- **[ANL]** Five glasses provided by SRNL are being prepared for modified PCTs that will be conducted to quantify the effect of the solution pH on the glass dissolution rates and the triggering of Stage 3 dissolution. The glasses have been used in previous studies at SRNL and are well-characterized, and are referred to as EA, Purex, HM, Batch 1, and Blend 1. Tests may also be conducted with the international simple glass (ISG). The concentrations of key glass constituents in the different glasses are provided in Table 2 and span a fairly wide range; the low and high values are highlighted in blue and pink, respectively. (W. Ebert)

Table 2. Compositions of glasses, in oxide mass%

Oxide	EA	Purex	HM	Blend	Batch	ISG
Al_2O_3	3.7	2.99	7.15	4.16	4.88	5.90
B_2O_3	11.3	10.33	7.03	8.05	7.78	17.6
BaO	—	0.20	0.11	0.18	0.15	—
CaO	1.12	1.09	1.01	1.03	1.22	4.57
CdO	—	—	—	—	—	—
Cr_2O_3	—	0.15	0.19	0.13	0.11	—
Cs_2O	—	0.06	0.06	0.08	0.06	—
Fe_2O_3	7.38	13.25	7.78	10.91	12.84	—

Oxide	EA	Purex	HM	Blend	Batch	ISG
K_2O	0.06	3.41	2.21	3.68	3.33	—
La_2O_3	—	—	—	—	—	—
Li_2O	4.26	3.22	4.62	4.44	4.43	—
MgO	1.72	1.41	1.41	1.49	1.42	—
MnO	1.34	2.07	2.15	2.08	2.11	—
MoO_3	—	0.08	0.22	0.15	0.08	—
Na_2O	16.8	12.62	8.56	9.13	9.00	12.4
Nd_2O_3	16.8	0.06	0.55	0.22	0.15	—
NiO	0.57	1.19	0.41	0.89	0.75	—
P_2O_5	—	—	—	—	—	—
RuO_2	—	0.01	0.04	0.03	0.02	—
SO_3	—	—	—	—	—	—
SiO_2	48.7	46.5	55.8	51.9	50.2	56.3
TiO_2	0.70	0.68	0.56	0.89	0.68	—
ZrO_2	0.46	0.05	0.33	0.14	0.10	3.20

- **[SRNL]** The crucible induction melter (CIM) was started-up and the operability confirmed. However, the drain tube on the CIM had a large melt-induced crack along its length. The drain tube has been shortened and will be tested with glass-ceramic feed material. If further deterioration in the Pt/Rh occurs, the glass-ceramic melter test (M4FT-19SR0301050410) will be significantly delayed and put on-hold while an assessment of the CIM and system is made. (P. Smith, J. Amoroso)

Iodine Waste Forms

- **[ANL]** Six specimens of HIPed AgI-bearing mordenite provided by ORNL were received for testing. The same materials are being evaluated at PNNL using different test methods. Shown in Figure 7, material at the bottom ends of small HIP cans remaining after samples for PNNL tests were cut will be used in tests at ANL. The materials were prepared at different temperatures (525-900 °C) and pressures (100-175 MPa) and for different processing times (3-12 h) that resulted in different appearances. The AgI contents of the different materials are not known. At ANL, these materials will be used to relate electrochemical measurements to immersion test responses. The samples will probably be embedded in epoxy and only a portion of the surface will be exposed during the test; the edge of the steel HIP can will be masked. (W. Ebert)

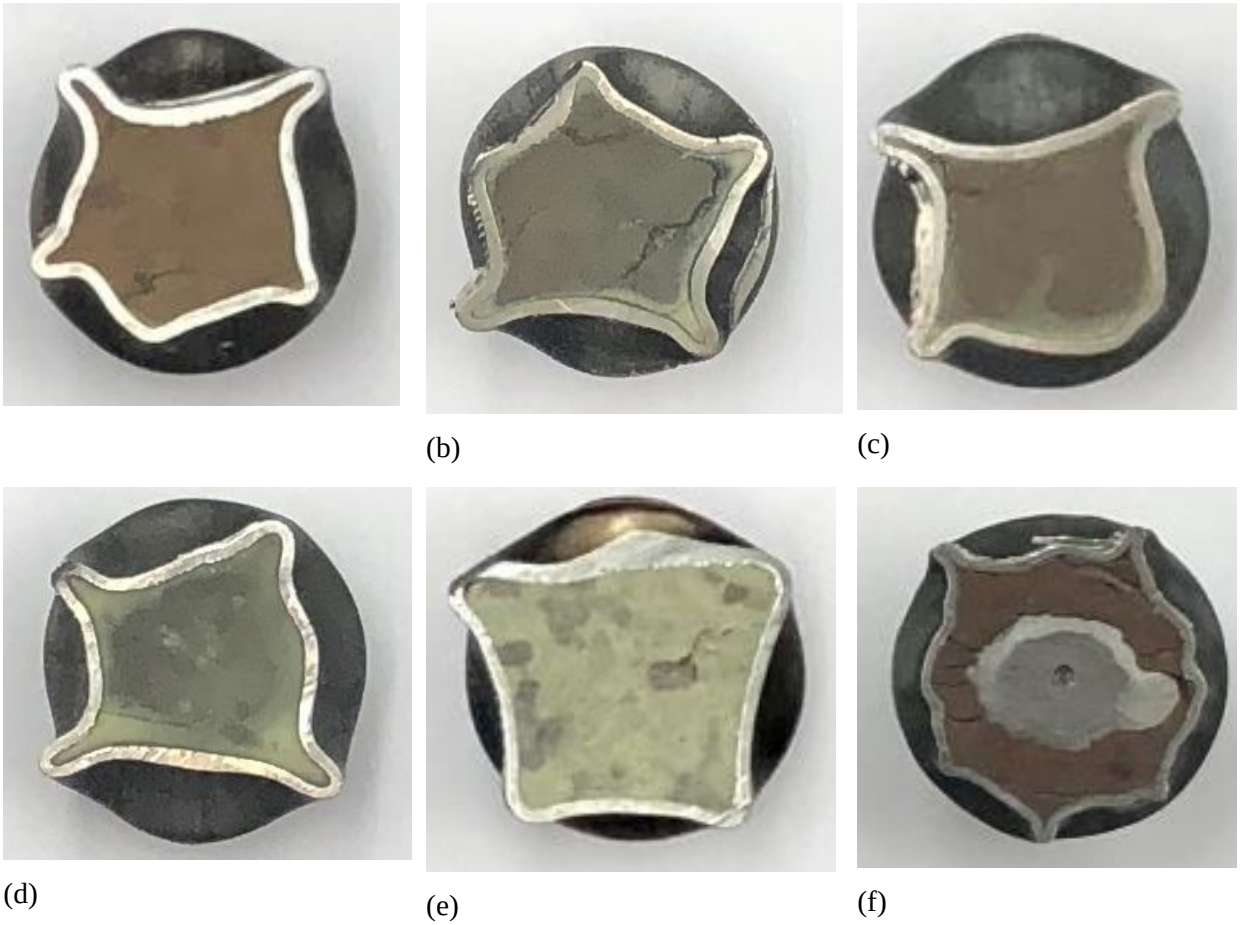


Figure 7. Photographs of as-received HIPed spec specimens (a) HIP17-2, (b) HIP17-6, (c) HIP17-8, (d) HIP17-17, (e) HIP17-18, (f) HIP17-22. The diameter of the bottom of the HIP can is about 0.75 inches (1.9 cm).

DOMESTIC ELECTROCHEMICAL PROCESSING

- **[ANL]** Preparation of an engineering-scale system for demonstrating U/TRU codeposition on a solid cathode is underway to allow continuation of the parametric electrochemical engineering study supporting that demonstration. Products generated in previous experiments are being examined to assess the effect of the cathode system geometry on reduction efficiency. The study of Zr behavior during the oxide reduction process is ongoing. A new apparatus is being assembled to make electrochemical measurements during dissolution of Zircaloy-2 in LiCl-Li2O salts. This apparatus will be used to apply methods developed for studying aqueous corrosion of steel-based waste forms to corrosion in salt. (W. Ebert)

SIGMA TEAM FOR OFF-GAS

- **[INL]** A long-term deep-bed adsorption test continues for capturing organic iodide species in simulated vessel off-gas (VOG) from aqueous used fuel reprocessing. This test was started in August 2018, and has reached about 1,800 hours by the end of October. The simulated VOG is air with a target 1 ppm concentration of iodobutane (C4H9I) as a surrogate for a range of possible organic iodides that could be present in VOG. This iodobutane concentration represents the high range of expected organic iodide concentrations in VOG. This test is planned to continue until the MTZ progresses into the bed so that the front end of the sorbent bed approaches its practical saturation

concentration and maximum silver utilization, and so that the depth of the MTZ can be determined. Initial results of this test were reported in the Level 3 milestone report titled, "Initial Results of Iodine Capture from Iodobutane in Vessel Off-gas," (NTRD-MRWFD-2018-000189, September 2018).

Figures 2 and 3 show how the (presumably) chemisorbed iodine concentrations and Ag utilizations have increased for over run time different bed depths. These measurements were made by collecting and analyzing small samples of sorbent from different bed segments. The total cumulative bed depth is about 7.5 inches. The iodine concentrations and silver utilizations have increased in the first ~1.5 in. each time that the sorbent has been sampled up to hour 1,546. No adsorbed iodine has yet been detected beyond about 2 inches deep in the bed.

This is thus far consistent with mass transfer theory for fixed sorbent beds. The practical saturation concentration of iodine in the sorbent is approached when (a) the iodine concentration in at least the first 1 or 2 bed segments does not significantly increase in repeated sorbent samples, and (b) the iodine concentration in bed segments 2 or 3 approach the concentration in segment 1. (J. Law)

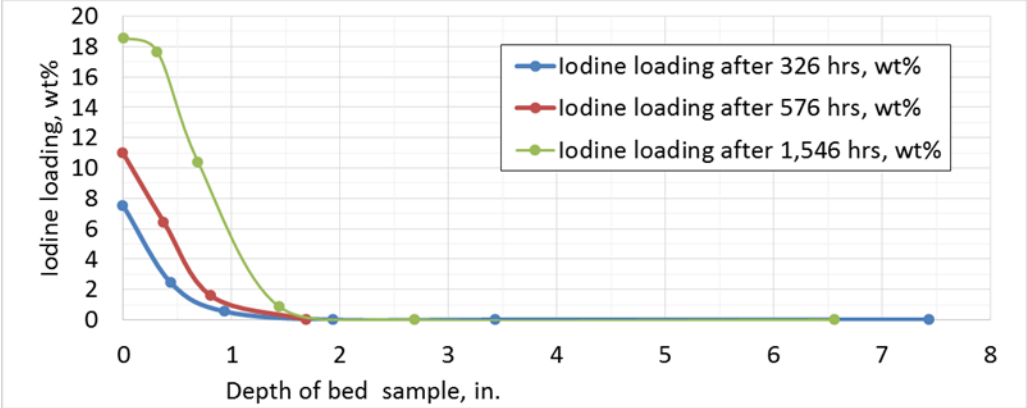


Figure 8. Iodine loading on Ag Aerogel sorbent during simulated VOG testing with a target 1 ppm iodobutane concentration in the inlet simulated VOG.

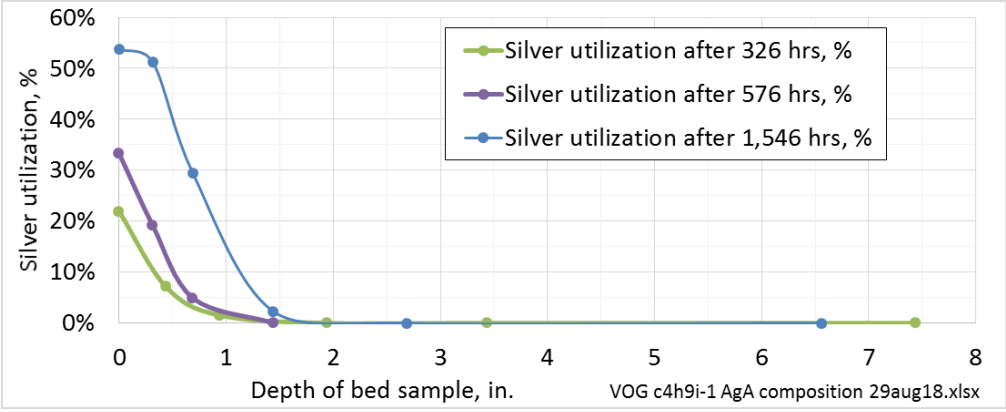


Figure 9. Silver utilization in Ag Aerogel sorbent during simulated VOG testing with a target 1 ppm iodobutane concentration in the inlet simulated VOG.

- **[ORNL]** Preliminary design concepts for the off-gas capture system for advanced tritium pretreatment are under consideration for the test system and an outline of the proposed tests has been developed. (B. Jubin)

- **[ORNL]** The report that will fulfill the carryover milestone, "Quantify the potential physisorption on silver-based sorbents that was potentially observed in FY 17 VOG testing," has been drafted. One aspect of the FY18 VOG testing focused on addressing a hypothesis that a significant portion of iodine remained physisorbed in some VOG tests and that when the sample was removed using a vacuum system this phyisorbed iodine was removed from the sorbent media which in turn resulted in the incomplete mass balance closure. The key conclusion is that the use of a vacuum extraction method to remove the iodine loaded sorbent material from the test apparatus does not impact the observed loading of the material. (B. Jubin)
- **[ORNL]** A report summarizing production of four large-format HIPed I–AgZ samples has been completed but has not completed the document approval process. These samples are 1.5 in. diameter and 2 in. length and contain 49 g of I–AgZ. Two samples were prepared at an iodine loading of 64 mg I/g I-AgZ, and two samples were prepared at an iodine loading of 135 mg I/g I–AgZ. These two sets of duplicate samples will be made available upon request in support of iodine waste form durability method development efforts. (B. Jubin)
- **[ORNL]** In FY18 the effects of NO and NO2 on methyl iodide and iodine adsorption onto AgZ were studied using a statistically designed test matrix. Efforts in FY19 will complete this work to determine the effects of NO and NO2 on I2 and CH3I adsorption onto silver-functionalized aerogel. The first tests conducted using aerogel as the CH3I sorbent did not show any CH3I loading onto the sorbent; troubleshooting is ongoing. (B. Jubin)
- **[PNNL]** One fundamental issue impeding the large-scale employment of metal-organic frameworks (MOFs) in commercial and industrial applications is the mechanical stability of the engineered particles. Thus, the shaping of MOFs on a macroscopic level (i.e. converting a fine microcrystalline powder into a shaped body while preserving the intrinsic properties of the MOF) is very important. Strategies to overcome this problem involve the incorporation of various binders and the use of various processes to produce MOF bodies with different shapes including pressing, extrusion, and granulation to produce pellets, granules, and spheres. As part of improving the mechanical stability of room temperature MOF (CaSDB MOF), several polymers were identified and for the production of engineered particles for evaluating mechanical stability.

  Among many polymers tested, we chose poly(methyl methacrylate) or PMMA because it is economical, structurally flexible, transparent, UV tolerant, as well as chemical and heat resistant. Fabrication of the MOF pellets was achieved as follows. First, a known amount of PMMA (~10% by mass) and the CaSDB MOF powder were sonicated in dichloromethane to solubilize the polymer and disperse the MOF powder. The solvent was evaporated to produce shaped bodies of MOF. Simple mechanical stability of the particles were tested by placing a 1 kg weight on the particles for a known amount of time. The particle size before and after were measured to assess any deformation due to the weight. Figure 10 shows the engineered particles of CaSDB MOF with PMMA improved mechanical stability. Experiments with shaker table and nanoindentation experiments in comparison with best carbon and zeolites are in progress. (P. Thallapally)

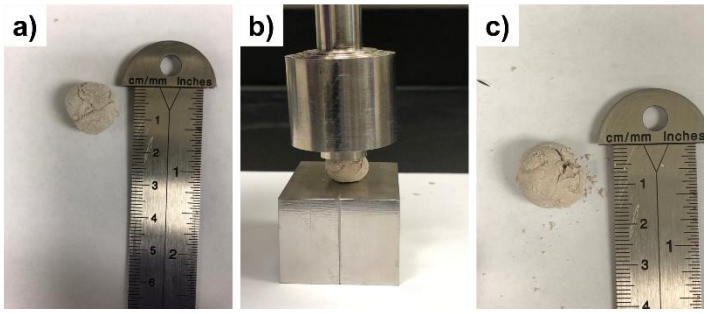


Figure 10. Photographic images representing the weight bearing capacity of CaSDB MOF, a) CaSDB MOF size before weight b) particle with 1 kg weight, c) CaSDB MOF after weight. The engineered particle still retains its shape and size.

FLOWSHEET DEMONSTRATIONS

- **[INL]** Meetings and walkthroughs have been conducted with Safeguards and Security experts to determine the required upgrades needed for building CPP-653 to make it secure for classified unirradiated fuel. With the upgrade requirements known, work orders are being submitted for those changes.

  Modifications to the Material Recovery Pilot Plant (MRPP) are required for contamination control when unirradiated fuel will be used. Design is ongoing for vessel modifications, glovebag design, and approaches to completing required tasks with input from Radcon Engineering and technicians. Mockups of some of the activities have been completed to aid in the design. CPP-651 Fuel storage requirements have been identified and action items are being addressed. This will allow for the shipment and storage of the fuel samples to be initiated. Fire and Emergency management personnel have now been toured through the CPP-653 facility and the MRPP. These tours will aid the response to an emergency within CPP-653 should one occur. (M. Warner)

- **[ORNL]** Further cold tests were made on the new glass down-flow purification reactor and it was determined that a modification is needed to be made to reduce back-pressure from the gas effluent. The modification is in progress and is expected to be finished in early November. A poster titled, "Progress in Recovery and Purification of Zirconium from Used Nuclear Fuel Cladding – a Major Element of Waste Management," was presented at the 20th Symposium on Separations Science and Technology. (R. Jubin)

- **[INL]** Analysis of alternatives to recommend the best facility to house the hybrid demonstration process was initiated. Three facilities were identified – the Fluorinel Dissolution Process (FDP hot cell in CPP-666, the unfinished Fuel Processing Facility (CPP-691), and the New Waste Calcining Facility (CPP-659) – all located at INTEC. Additionally, INL provided support for the DOE 90-Day study evaluating alternatives for production of high assay low enriched uranium (HALEU). (M. Patterson)

- **[ORNL]** A presentation was made at the 20th Symposium on Separations Science and Technology, titled, "Spent Nuclear Fuel Management – Identifying and Overcoming the Barriers to Commercial Reprocessing and Recycling in the USA," just prior to the PNNL presentation on "Simulant Testing of a Co-Decontamination (CoDCon) Flowsheet for Product with a Controlled Uranium -to-Plutonium Ratio." (R. Jubin)

- **[PNNL]** The paper, "Simulant Testing of a Co-Decontamination (CoDCon) Flowsheet for a Product with a Controlled Uranium-to-Plutonium Ratio," was presented by Gregg Lumetta at the 20th Symposium on Separation Science and Technology for Energy Applications in Gatlinburg, Tennessee, October 24, 2018. This paper discussed the multiple testing of the co-decontamination

(CoDCon) tri-butyl phosphate (TBP) based solvent extraction flowsheet that is being performed to determine the uncertainties associated with maintaining a target U/Pu ratio in the Pu-containing product. The first two flowsheet tests used simple dissolved fuel simulants containing only U and Pu, but increasingly more complex simulants are being used in subsequent test, with the ultimate goal of performing tests with irradiated fuel. The solvent extraction system is monitored in real-time using optical spectroscopy techniques, which allows for adjustment of the flowsheet conditions to accurately maintain the U/Pu ratio. Results from the first three CoDCon flowsheet tests were presented in this paper. (G. Lumetta)

For more information on Material Recovery and Waste Forms Development contact Terry Todd (208) 526-3365

MPACT Campaign

MANAGEMENT AND INTEGRATION

NTD & Technical Support

- **[LANL]** MPACT Federal Program Manager, NTD, and CAM held the FY18 Annual MPACT Meeting via VTC on October 10, 2018 and a Milestone 2020 VTC on October 24, 2018. MPACT Federal Program Manager and NTD held a program coordination call with DOE/NNSA R&D on October 25, 2018.

ADVANCED FUEL CYCLE SCOPING

Advanced Process Modeling and Simulation (Process Tests)

- **[PNNL]** Worked to identify source material for LANL's Microcalorimetry detection system, which will be used to support the 2020 Milestone. PNNL has a varied inventory of unique radioactive materials that would positively impact the analysis of the Microcalorimetry team. These can be loaned and/or committed to LANL but will need some degree of preparation in order to be shipped to LANL as per their receiving requirements. Samples of note include North Anna sister rods, ATM-109 spent fuel, and dissolved HEU samples. PNNL also has multiple samples of Weapons Grade Plutonium (with processing pedigreed) and a purified Pu-242 sample.

MSR Safeguards (Modeling)

- **[SNL]** The two-fluid MSR and safeguards model has been updated based on data input from ORNL. The safeguards portion of the model is being developed.

Advanced Fuel Cycle Scoping – Review Panel

- **[ANL]** Participated in MPACT working group teleconference describing path forward for campaign during FY19.
- **[BNL]** Participated in the project planning conference call on October 10, 2018.
- **[INL]** Performed review of technical literature on MSR reactors. Communication with Andrew Worrall on future ORNL meeting.
- **[LANL]** Prepared for the next Advanced Fuel Cycle Scoping Review Panel telecon and provided input for the Advanced Fuel Cycle Scoping VTC.

SAFEGUARDS AND SECURITY BY DESIGN – ECHEM

Microfluidic Sampler

- **[ANL]** A custom two-chamber insulated enclosure was designed to facilitate high-temperature testing of the sampling loop droplet generator. A separate chamber surrounding the sample ejection orifice will allow access at temperature for sample collection and minor repairs, while a removable lid on the main chamber will enable quick access for modifications and repairs after system cooling.
  Initial experiments to test the microfluidic sampler using water were run. Tested various designs of the droplet generator with the orifice in slightly different positions relative to the incoming nitrogen pulse from the solenoid valve. Various housing and impeller designs for the low-flow salt pump were iteratively fabricated and tested, leveraging our rapid prototyping/3D printing capabilities. Design improvements included reducing tolerances for improved efficiency and leak reduction. Finalized

designs for the droplet generator, flow cell, and preliminary designs for the pump were sent to local direct metal laser sintering (DMLS) vendors for quotes on fabrication.

Actinide Sensor

- **[INL]** The uranium experiments in FY19 will be performed in a different facility than previous years. The radiological glovebox used in the past is being removed to be upgraded. This year's uranium experiments will be performed in the Fuel Cycle Glovebox (FCG) located in the Fuel Cycle Facility (FCF). A furnace has been located, access to be facility has been granted and qualification for working in the new glovebox is in progress.

Bubbler for Measuring Density and Depth of Molten Salt

- **[INL]** Collaborated with the Hot Fuel Examination Facility (HFEF) engineers and operators to clean the bubbler in the hot cell. The operators were able to clean it using water, but a layer of corrosion product remained. New gas lines were purchased and assembled for the bubbler. Effort was put towards getting the height gauge ready for use in cell, including developing a drip free tip and understanding the electronics and routing them out of cell. Presented at the International Pyroprocessing Research Conference (IPRC) in Ibaraki, Japan.

OR Voltammetry

- **[INL]** Prepared and presented a poster at the International Pyroprocessing Research Conference (IPRC) in Ibaraki, Japan.

ER Voltammetry

- **[ANL]** Progress is being made toward the automation of the voltammetry analysis to provide near real-time output of data from the sensor. Preliminary design explorations are also being performed to assess the viability of installation of the multielectrode array voltammetry sensor in the IRT electrorefiner at INL. A presentation of the voltammetry technology was made at the International Pyroprocessing Research Conference in Tokai Japan.

MODELING ADVANCED INTEGRATION AND MILESTONE 2020:

Advanced Integration (Methods)

- **[LANL]** Finished simulating the HDND at confirmatory locations. Began analyzing data for Voltammetry.

Advanced Integration (Security Facility Models)

- **[SNL]** The baseline physical plant model is continuing to be developed. The building model has been complete, and current work is developing the site layout.

EXPLORATORY RESEARCH / FIELD TESTS

Microcalorimetry

- **[LANL]** Began an initial measurement campaign on LANL Pu items to evaluate the ability of the instrument and data acquisition to handle large data sets (> 100 million counts). This has been very successful so far, with this number of counts now routinely collected in an overnight measurement. The main challenge is in processing this data into an energy-calibrated spectrum, which is currently done after the measurement. In collaboration with the University of Colorado, developing completely

automated software to generate processed but un-calibrated spectra for each individual pixel. Began developing a robust algorithm to automatically combine the individual-pixel spectra into a single output suitable for isotopic analysis codes. Began collecting information on items to measure in the end-user assessment from Argonne, Idaho, and Pacific Northwest National Laboratories.

High Does Neutron Detector

- **[LANL]** Continued collaboration with PDT and INL on design details of the miniature HDND. PDT will fabricate a 3D model for LANL and INL testing to assess mechanical and remote handling feasibility.

For more information on MPACT contact Mike Browne at (505) 665-5056.

Systems Analysis and Integration (SA&I) Campaign

CAMPAIGN MANAGEMENT

- **[ANL, BNL, INL, LLNL, ORNL, PNNL, SNL]** Campaign Lab leads/Work Package Managers revised the Work Packages (WPs) for FY 2019 to incorporate information on the carry-over funds, and the WPs were approved by campaign management.
- **[ANL]** Attended the 15th Information Exchange Meeting on Partitioning and Transmutation of Actinides and Fission Products (15IEMPT), Manchester, UK, September 30-Oct 3, 2018, and presented the lessons learned from the E&S study; T. A. Taiwo et al., "Lessons Learned from Recent Nuclear Fuel Cycle Scenarios Studies".

EQUILIBRIUM SYSTEM PERFORMANCE (ESP)

Performance of Fuel Cycle Systems

- **[ANL]** Attended the 15th Information Exchange Meeting on Partitioning and Transmutation of Actinides and Fission Products (15IEMPT), Manchester, UK, September 30-Oct 3, 2018, and presented a paper entitled, "Once-through Sustainable Sodium cooled Fast Reactor".
- **[ORNL]** An initial review of previous analysis and results for related nuclear energy systems has been completed. It is planned that existing HWR data and inputs can be used and hence shorten the time required to complete the work.

Economic Analysis Capabilities and Assessments

- **[ANL]** Attended the Pacific Basin Nuclear Conference, Sep. 30 - Oct. 3, 2018, San Francisco and presented the following paper and participated in a panel discussion on sustainable fuel cycles which was moderated by Dr. Monica Regalbuto (INL).
  - F. Ganda, et al., "Development of a cost estimation algorithm for advanced nuclear reactor concepts".
- **[ANL]** Attended the OECD/NEA Working Party on Nuclear Energy Economics (WPNE) on October 24-25, 2018 at the NEA headquarters in Paris, France, as the new U.S. representative. During this meeting, a report on "Cost of Electricity Generation" and the current activities of NEA in the area of nuclear economics were discussed.
- **[ANL]** The activity on the cost of Public versus Private construction costs was initiated with the collection of data on the SNS and APS. Useful data was identified on the SNS, but the effort was so far unsuccessful for the APS. Additionally, the involvement of BNL, INL and PNNL was initiated with the preliminary assignment of tasks that should be commensurate to the available funding by each of these laboratories, respectively on collection of additional data, on literature searches, and on the methodology checking.
- **[BNL]** Initial NSLS II construction and cost data has been provided to ANL.
- **[ANL]** Reviewed O&M cost and O&M cost reduction strategies available through the Nuclear Energy Institute, past work on O&M estimates, and other sources. Working toward an improved O&M understanding as the first step in order to identify cost reduction strategies.
- **[ANL]** The work on the expansion and improvement of the ACCERT cost algorithm for FY19 was initiated. The initial task is to focus on the models for the 3 following accounts: (1) Air, water, steam service systems; (2) Waste treatment system; (3) Coolant treatment and recycle. Those accounts are

quite complex, involving each tens of subcomponents. In addition, held a conference call with Bob Varrin of Dominion Engineering (DE) and discussed the ACCERT capability.

- **[INL]** Provided review and comments for upcoming report "Economic Analysis of Alternative Transition Pathways to Improve Economic Considerations in Fuel Cycle Transition".

Daily Market Studies of Advanced Nuclear Energy Systems

- **[ANL]** Attended the 6th international conference on Nuclear and Renewable Energy Resources (NURER 2018), Sept. 30 – Oct 4 2018, Jeju, Korea and presented a paper entitled "Economic Impact of Flexible Nuclear Operation Estimated with EDGAR Optimization Code," by N. Stauff, et al.
- **[ANL, BNL, INL, PNNL, ORNL]** Held a conference call on October 29, 2018 to explain the work scope of "the Daily Market Studies of Advanced Nuclear Energy Systems."
- **[ANL]** Updated EDGAR code to display the total electricity cost breakdown, which provides insight into which penalties are associated with the scenario investigated.
- **[SNL]** We continued to make improvements to our internal processes for data entry and on updating the Catalog Requirements Document.

Enhancements to the Cost Basis Report (CBR) Tool

- **[ANL]** Work on the improvements of the Cost Basis Report was initiated, with the primary focus on "capitalizing" on the work initiated in FY18 and in previous years, and of expanding into new areas that should be prioritized, as discussed at the Campaign meeting in September 2018 with the management and with the federal manager.
- **[INL]** Coordinated with F. Ganda, K. Williams and E. Hoffman on planned updates to the CBR in the current fiscal year. Working closely with K. Williams, Hansen has updated Module D1. In October we gathered the information required for the update then began marking up the D1 module where changes need to be made. Given the identified changes and information to include in the update, will begin working on the sub-module D1-1.

Analysis of NES to Augment Information in Fuel Cycle Catalog

- **[ORNL]** A videoconference meeting was held to demonstrate the existing capabilities within OR-SAGE, where the tool had been previously applied for DOE-NE activities, and to discuss the details of the scope of work for FY19. The meeting was attended by Federal Managers and all of the lab leads from across the Campaign.
- **[ANL, BNL, INL, ORNL]** Two fuel cycle concepts, the three-stage Indian fuel cycle (EG38) and a Chinese fuel cycle (EG31) were selected for analysis and development of Fuel Cycle Data Packages. The work scope and schedules were assigned to the contributing labs.
- **[ORNL]** A presentation and demo video about OR-SAGE was prepared for the above meeting, and the meeting was attended by the OR-SAGE lead developers. In preparation for the meeting and for the FY19 workscope a brief review was made of NRC guidelines related to fuel cycle facility siting.

Maintain/Update Campaign Analysis Tools

- **[INL, BNL]** The Transmutation Data Library package has been uploaded to the Campaign SharePoint site by INL. The package also includes all files needed to re-generate the MySQL database. The re-generation process has been independently verified by BNL.

Campaign Special Sessions at International Topical Conference

- **[ANL, INL]** Had a conference call with the technical program chair, J. Law (INL), of GLOBAL 2019, and it was agreed that the S&AI campaign would host a panel session and support the Track 1 of the conference: Fuel cycle Strategies and Approaches.

DEVELOPMENT, DEPLOYMENT AND IMPLEMENTATION ISSUES (DDII)

Transition Analysis Studies

- **[ANL]** Submitted abstract for ICAPP 2019 on the combined topics of 1) fast spectrum MSR core and fuel cycle design and 2) resulting fuel cycle transition performance compared to SFRs.
- **[ANL]** Reviewed journal papers on advancements in fuel cycle modeling and modeling transition scenarios using Cyclus to potentially help with ORNL's assessment of Cyclus.

Regional and Global Impacts

- **[PNNL]** Planning for FY19 work on investigating the long-term scale, timing and value of nuclear energy within the context of a comprehensive U.S. and global energy system.

Implications of Deploying Multiple Advanced Nuclear Energy Systems

- **[ANL]** Began laying out plans for what is in and out of scope for this project. Reviewed the Compendium Report and other information. Identified a preliminary approach. Will put together a summary and begin interactions with other participants in November.

Adaptation of OR-SAGE for NES Analysis

- **[DOE-NE, ANL, BNL, INL, LLNL, ORNL]** Held a webinar for demonstration of the nuclear plant siting analysis code, OR-SAGE, on Oct. 31, 2018.

For more information on Systems Analysis and Integration contact Temitope Taiwo (630) 252-1387.

Joint Fuel Cycle Study Activities

- Electrorefining process experiments for two batches of interim LWR fuel were completed in the Integrated Recycling Test (IRT) equipment in HFEF.
- Distillation of the universal basket and uranium products from electrorefining process experiments were completed.
- A joint Electrochemical Recycling and Safeguards and Security working group meeting was held in Daejeon, Korea, the week of October 29.
- Remote equipment qualification for LiCl Crystallizer was initiated.

For more information on Joint Fuel Cycle Studies Activities contact Ken Marsden (208) 533-7864.

AFCI-HQ Program Support

UNIVERSITY PROGRAMS

Site: University Research Alliance at West Texas A&M University in Canyon TX, and the following universities: University of Michigan, University of Tennessee, University of California at Berkeley, Texas A&M University, Vanderbilt University, University of Idaho, Oregon State University, Kansas State University, Northwestern University, University of Nevada at Las Vegas, Clemson University, Rensselaer Polytechnic Institute, Purdue University, Georgetown University, Virginia Commonwealth University, Florida International University, and other universities.

Universities engaged in Nuclear Technology research via URA programs since 2001:

Boise State University
Boston College
Clemson University
Colorado School of Mines
Georgia Institute of Technology
Georgetown University
Idaho State University
Florida International University
Florida State University
Kansas State University
Massachusetts Institute of Technology
Missouri University of Science and Technology
North Carolina State University
Northern Illinois University
Northwestern University
Ohio State University
Oregon State University
Pennsylvania State University
Purdue University
Rensselaer Polytechnic Institute
Rutgers University
Texas A&M University
University of Arkansas
University of California at Berkeley
University of California at Santa Barbara
University of Chicago
University of Cincinnati
University of Florida
University of Idaho
University of Illinois at Urbana-Champaign
University of Michigan
University of Missouri
University of Nevada at Las Vegas
University of New Mexico
University of North Texas
University of Notre Dame
University of Ohio
University of South Carolina
University of Tennessee at Knoxville
University of Texas at Austin
University of Virginia
University of Wisconsin
Vanderbilt University
Virginia Commonwealth University
Washington State University

INNOVATIONS IN NUCLEAR TECHNOLOGY R&D AWARDS

Summary Report

- University Research Alliance provided information to the 2018 Innovations Awards winners who are presenting their award-winning papers at the Innovations in Nuclear Technology R&D Awards technical session, to be held Wednesday November 14 at the American Nuclear Society Winter Meeting in Orlando FL, and worked with the ANS to set up the session. Dr. Daniel Vega, Acting Director of the Office of Materials and Chemical Technologies in the Office of Nuclear Energy at the Department of Energy, will chair the session.
- University Research Alliance received desktop awards for the 2018 award winning students, which will be presented at the ANS meeting to those attending, and mailed to the remaining winners.

- University Research Alliance continued to update the Innovations Awards announcement distribution list in anticipation of the 2019 Innovations Awards.

- ***For more information on the University Research Alliance contact Cathy Dixon (806) 651-3401.***