ATLANTIC: Accident ToLerANT fuels In recycle

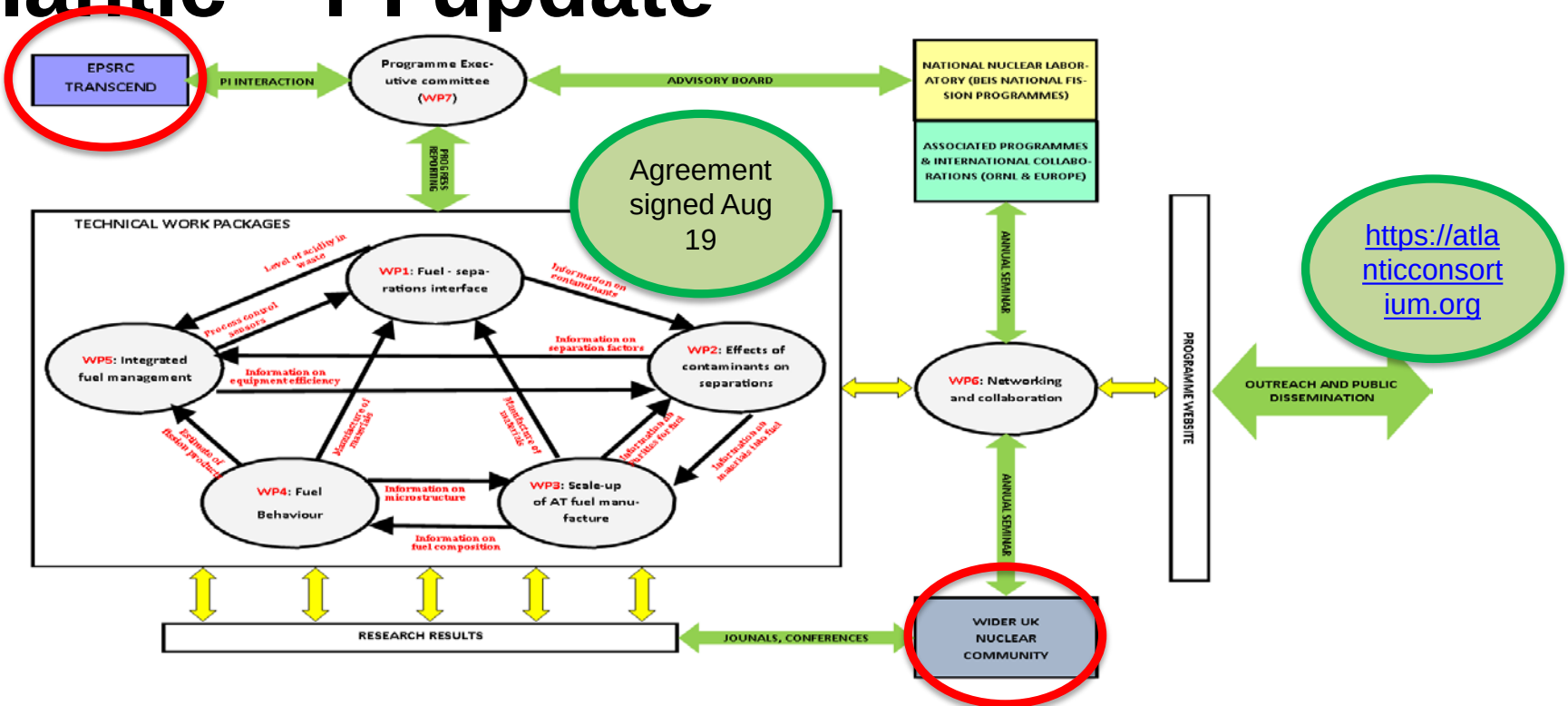
PI – Prof. Bruce Hanson

Nuclear Academics Discussion Meeting

8th to 9th September 2020

Cambridge

Atlantic – PI update



Atlantic – project status

ATLANTIC

	University	PDRA/PhD	Researcher	Start date
WP1 Fuel-Separations interface				
WP 1.1 The effect of scale up of dissolution kinetics	Leeds	PhD	Julio Vazquez Chavez	
WP 1.2 Voloxidation as a pre treatment for accident tolerant fuels	Leeds	PDRA	Sarah Pepper	
WP 1.3 Corrosion and Dissolution of Accident Tolerant Fuels under Conditions Relevant to Head End	Lancaster	PDRA		Jan-19
WP 1.4 Molecular Simulation of the Corrosion of Accident Tolerant Fuels: A Modelling Study	Lancaster	PhD	Nicola Zagni	9/17/2018
WP2 Effects of Contaminants on Separations				
WP 2.1 Design and Synthesis of soluble and immobilized ligands for speciation studies	Reading	PDRA		Jul-19
WP 2.2 Determining the speciation and the effect of contaminants on elemental separations (Ln/Ac) using the BTPhen family of ligands	Manchester	PDRA	Kathryn George	Apr-19
WP 2.3 Development of new tools to analyse speciation	Oxford	PDRA		Oct-19
WP3 Investigation and Optimisation of Accident Tolerant Fuel Materials				
WP 3.1 Radiation Effects in Novel Accident Tolerant Fuels	Liverpool	PDRA	Glyn Cobourne	May-20
WP 3.2 Accident Tolerant Nuclear Fuels – Options and Designs	Liverpool	PhD		
WP 3.3 The Manufacture, Characterisation, and Testing of U3Si2 Fuel Pellets	Manchester	PDRA	Robert Worth	Feb-19
WP 3.4 Synthesis and characterisation of uranium nitrides	Sheffield	PDRA	Shikuan Sun	
WP4 Fuel Behaviour: non-stocihiometry and the fuel-water interface				
WP 4.1 Understanding non-stoichiometry, inhomogeneity and durability in U-Si and U-N systems and its effect on fuel properties	Cambridge			
WP 4.2 Ab initio random structure searching to improve fabrication routes for U3Si2 and UN fuels	Cambridge			
WP 4.3 The ATF-water interface; the corrosion of U3Si2 and UN in radiolytic conditions	Bristol	PhD	Lottie Harding	Oct-17
WP 4.4 Improving the corrosion resistance of accident tolerant fission fuels	Bristol	PDRA	Eleanor Bright	Jan-20
WP 4.5 Atomic scale modelling of UN fuel	Imperial	PDRA	Conor Galvin	Jun-20
WP5 Integrated Management of Accident Tolerant Fuels				
WP 5.1 Recycling potential of ATF in integrated separation technologies	UCL	PDRA	Dimitrios Tsaoulidis	Jan-19
WP 5.2 'Development, characterization and utilisation of integrated enhanced electrochemical sensing and monitoring	Edinburgh	PDRA	Ilka Schmueser	Dec-18

Atlantic – technical highlights

•WP1 – **Julio Vasquez-Chavez (UoL)** is investigating voloxidation of fuels as a pretreatment for reprocessing; using air and steam on Zr. At >900^{o}C the cladding forms a brittle oxide.

•WP2 - **Steve Faulkner (Oxford)** is measuring speciation by deconvolution. Developing methods to separate signals using time-, wavelength-, and temperature dependent luminescence spectroscopy.

•WP3 - **Rob Harrison (UoM)** working on Ce_3Si_2 oxidation as U_3Si_2 surrogate. TGA, XRD, HRTEM, STEM-EDS and EFTEM have confirmed the formation of CeO_2, SiO_2 and Si up to 750^{o}C in air.

•WP4 - **Eleanor Lawrence Bright (UoB)** is characterising corrosion and oxidation of UN surfaces using TEM, XRR, XPS. UN surface passivates at room temperature (U_2N_3 interlayer forms).

•WP5 - **Ilka Schmueser (UoE)** is developing electrochemical sensors for process control.
Use electrochemistry to generate a signal that tells you something about a target chemical.

Synthesis of uranium nitride

Synthesis by reaction with ammonia gas

- An ammonolysis reaction furnace has been designed, tested and operated successfully – Fig 1.
- Ammonolysis of UF_4 proved partially successful, yielding phase assemblage of UN_2 and UO_2, which may be of interest as a mixed nitride-oxide accident tolerant fuel
- Exploring alternate route starting from NH_4UF_8 precursor – synthesised in good yield from mechanochemical reaction between UF_4 and NH_4HF_2. Reaction kinetics of NH_4UF_8 formation appear faster than reported - under investigation.

Synthesis by low temperature with $NaNH_2$ molten salt

- Method used to synthesise transition metal nitrides from oxides by reaction in $NaNH_2$ molten salt at ca. 240°C for 24 h.
- To develop capability, investigated mechanism of reaction between Fe_3O_4 and $NaNH_2$; reaction is not selective yielding Fe_3N_{1+x}, FeN, and metastable $FeO_{1-x}N_x$.
- Reaction between uranium oxides and $NaNH_2$ investigated; failed to form nitride phase, but reaction of UO_{2+x} with $NaNH_2$ effects a low temperature reduction to stoichiometric UO_2
- Product colour change suggests different surface chemistry, possibly surface nitridation, XPS planned at Royce Institute.

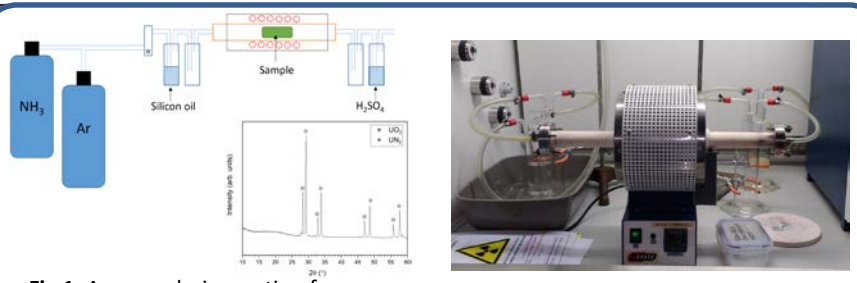


Fig 1: Ammonolysis reaction furnace

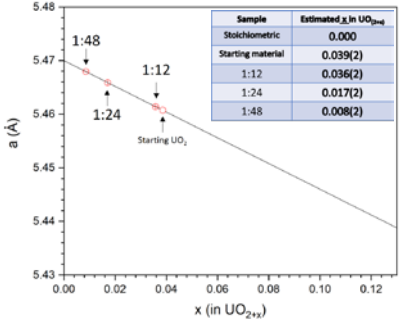


Fig 2: Products of reaction from UO_2 and $NaNH_2$, in 1:n mole ratio at 240°C, 24h. Oxygen determination by internal standard XRD and unit cell parameter calibration

Recent publications from ATLANTIC and PACIFIC:

- A. Mason *et al.*, molten salt synthesis of Ce doped zirconolite for the immobilisation of pyroprocessing wastes and separated plutonium, Ceramics International, *in press*.
- S. Sun *et al.*, On the existence of the compound "$Ce_3NbO_{7+\delta}$" prepared under air atmosphere, Journal of Rare Earths, *in press*.

Atlantic

part of a wider community of research on recycle

1st annual meeting at IWM had representatives from many related programmes