Masahiko Nakase Lab.

Science x Engineering x Digital
Innovative Nuclear Energy System

Laboratory for Zero-Carbon Energy

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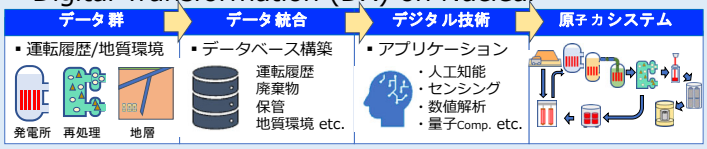
- **Establish the innovative nuclear energy system**
- **Integration & optimization of nuclear fuel cycle**
- **Fukushima Reconstruction & revitalization**
- **Chemistry of actinides & medical RIs**

To achieve a zero-carbon society by 2050, the utilization of nuclear energy is important. Nuclear power is not only used for electricity generation but also has potential in various fields, such as carbon-free hydrogen production and medical use. We aim to solve the difficult problems in nuclear energy by **an integrated approach: Science × Engineering × Digital technologies**. Finally, we aim to realize a better society by constructing a new nuclear energy system.

Innovative Nuclear Energy System

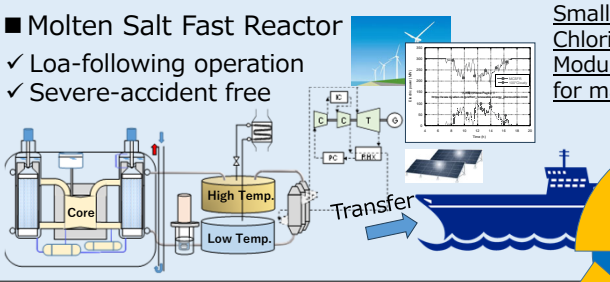
■ Digital Transformation (DX) on Nuclear



■ Molten Salt Fast Reactor

✓ Loa-following operation

✓ Severe-accident free

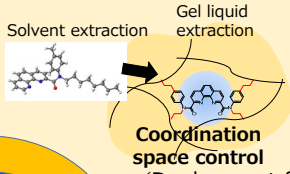


Small Molten Chloride Fast Modular Reactor for maritime

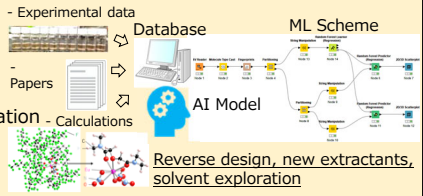
Separation Science

■ Actinide Science

- Valence control/extraction separation
- Solution & Complex Chemistry
- Organic synthesis, characterization



■ Chemoinformatics



Reverse design, new extractants, solvent exploration

Efficient material exploration by ML approach
(1) Experimental design; application of human-in-the-loop
(2) Estimation of actinide separation behavior from simulated elements
(3) Optimization of chemical process design (life cycle)

✓Deployment from chemical reactions in test tubes to engineering processes

✓Dry reprocessing, electrochemical separation (planned)

Nuclear

Integration of Nuclear Fuel Cycle

■ Nuclear Material Balance Code 4.0

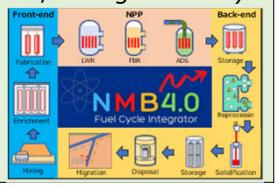
- Development and published free of charge with JAEA

No.1 No. of Users (Over 120 users/30 organization)

✓ Quantitative study of future scenarios for nuclear energy utilization

✓ Nuclear energy utilization policy and R&D strategy planning

✓ Introduction effects and strategies for introducing innovative nuclear reactors



Fukushima Reconstruction & Revitalization

■ Fuel Debris/Waste Management

Integral approach of solidification, disposal & safety assessment

Hybrid Solidification

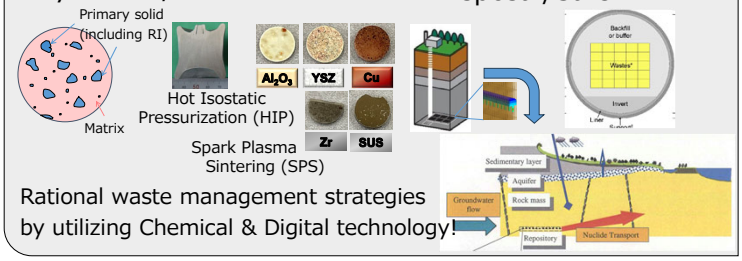
- Adaptable to a wide variety of wastes by a single concept
- Matrix characteristics allow for safety assessment
- Waste: ALPS precipitation, slurry, silver adsorbents, etc.

- Chemical analysis
- First Principle Calculations
- Radiation Effects
- Leachability
- Long-term stability

Composite solidification (Artificial rock、SYNROCK)

- Fuel debris, more robust solidified than vitrified glasses, natural analog

■ Synthesis/Characterization ■ Disposal/Safe

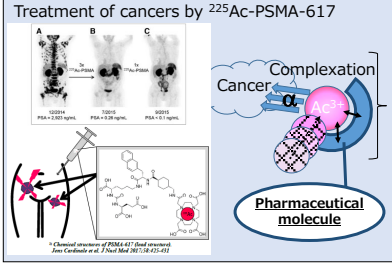


Rational waste management strategies by utilizing Chemical & Digital technology!

Medical

■ Targeted α radiation therapy

Treatment of cancers by ^{225}Ac-PSMA-617



✓ Molecular structure exploration & optimization for more selective and stronger complexation with Ac^{3+}, Ra^{2+}

✓ Rapid Ac/Ra purification ⇒ Gel-liquid chromatography

✓ Machine learning approach

- Relation of Ac^{3+} with simulants, La^{3+}, Eu^{3+} and Am^{3+} ; similar chemical properties