Accident Tolerant Fuels for a more sustainable future

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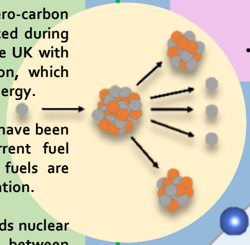
INTRODUCTION

Nuclear power plays a significant role in a zero-carbon future. With no direct carbon emissions produced during operation, nuclear energy currently provides the UK with around 20% of its energy using nuclear fission, which involves the splitting of nuclei and a release of energy.



Since the 1960s, Accident Tolerant Fuels (ATFs) have been in development as an improvement to current fuel technologies to support reactor safety. Such fuels are simulated to predict their behaviour during operation.

It's vital to explore the public perceptions towards nuclear power in order to foster relationships between stakeholders to ensure a more sustainable future.

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FUKUSHIMA

- A loss-of-coolant accident (LOCA) occurred at the Fukushima nuclear power plant in 2011 after a tsunami destroyed the coolant pumps
- The fuel, uranium dioxide (UO_2), melted as heat couldn't be transferred quickly enough. A meltdown occurred, and radioactive elements were released into the surroundings
- Fukushima, along with Chernobyl, have both made significant impacts on nuclear history and the public's views towards nuclear power
- As a response to LOCAs, the industry began to focus on ATFs

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ATFs

- Increase the coping time for reactors to bring the reactor under control during an accident
- Possess high melting points, high thermal conductivities, high specific heat capacities, and low thermal expansions
- Would replace the fuel in existing reactors

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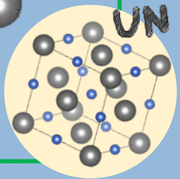
EXPLORING URANIUM NITRIDE

- One example of an ATF is uranium nitride (UN)
- UN has a higher melting point and a higher thermal conductivity than UO_2, and has a high uranium density — economically advantageous!
- UN has unfavourable reactions with hot water, along with a complicated manufacturing process
- Molecular dynamics evolves a system of atoms over time using Newton's 2nd law of motion: $F = ma$. Using atomistic simulation techniques like molecular dynamics can determine the thermophysical properties of fuels
- From simulations, a phase transition pressure has been found[1]. Further to this, N atoms require less energy to diffuse through the UN lattice when N vacancies are present



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THE FUTURE OF NUCLEAR ENERGY

- With escalating environmental change in the age of the Anthropocene amidst increasing energy demands, alternative energy sources are needed
- Very little fuel is needed for nuclear fission, compared to the amount of fossil fuels needed to produce the same amount of energy (~130 g of uranium produces the same amount of energy as 1.83×10^6 kg of coal — this is the weight of one hamster vs. 290 elephants, respectively)

- Nuclear waste is a major issue; its burial raises many questions regarding the future. What's the best way to handle the waste? How do we warn future generations of radioactive waste burial sites?
- Waste isn't the only issue — anti-nuclear campaigners have cited environmental loss and the cost of nuclear power as concerns
- Analysing nuclear discourses can bring together nuclear power stakeholders to improve the energy landscape of the future

[1]: V. Tseplyaev, S. Starikov, The atomistic simulation of pressure-induced phase transition in uranium mononitride, Journal of Nuclear Materials 480 (2016) 7 – 14.

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