Accident Tolerant Fuel

By Michelle Leslie

This March marks five years since Fukushima. On March 11, 2011, a 9.0 magnitude earthquake opened up the sea floor and within an hour, a wall of water almost 50 ft (15 m) high would drown the coast of Japan.What was described as a once in a thousand year event, left a trail of destruction in its wake, including a nuclear accident the world will never forget.The power of that catastrophic event would melt three cores of the Fukushima Daiichi nuclear power plant. Images of a hydrogen explosion producing billowing clouds of smoke garnered the attention of international media. Fukushima was also an alarm bell to industry. More had to be done to protect the safety of people and the environment. Enter an award winning team of researchers at the Massachusetts Institute of Technology (MIT). In 2015, they were awarded three million dollars for their collaborative effort on the development of accident-tolerant fuels.

This fuel development program run by the U.S. Department of Energy (DOE) is a direct response to what happened at Fukushima. Inside a nuclear reactor, uranium produces energy by a process called fission. This process of splitting atoms creates an enormous amount of heat. In order to keep a reactor stable and operating safely, a constant flow of water keeps the reactor cool.

In the absence of water, the uranium fuel continues to heat up and eventually the casing that surrounds the uranium cracks, allowing oxidation to occur.

Oxidation is a chemical reaction that occurs when metal interacts with water which produces hydrogen gas. When hydrogen gas is introduced to oxygen an explosion can occur, potentially releasing a large amount of radiation into the surrounding environment. Accident tolerant fuels (ATF) are fuels that are capable of withstanding very high heat. This means that in an accident situation where there is a loss of coolant, they can slow down or prevent the production of hydrogen gas.

In today's nuclear reactors, uranium is coated in zirconium which has a melting point of just over 1800°C (3272 °F).

Some of the options being explored include ceramic coverings and advanced metals such as silicon carbide, which can withstand temperatures up to 2700°C (4892°F).

When the earthquake and subsequent tsunami rolled onshore and the coolant system at the Daiichi power plant was knocked out it, is estimated that temperatures inside the reactor core rose to 2800°C (5072°F).

Had ATFs been around in 2011, the explosion may never have happened. Being more resilient to higher heat, it would have taken the fuel casings much longer to crack, thereby buying plant operators more time to spring into action.

With nuclear power generating 15 percent of the world's power, developing safer and more reliable options is critical. Today, 55 countries are involved in the efforts. The U.S. DOE's program, which is integrating the work done by labs, industries and universities (including the work being done at MIT), is expected to be commercially available to be deployed in light-water reactors by 2020.