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The World At War:

Chemical Reactions That Changed the World

How Chemistry Unlocked the Power of Uranium-235

Imagine holding a bright yellow rock in your hand that contains enough energy to power a city, change the course of a war or save lives. Hidden within certain rocks deep beneath the Earth's surface is Uranium-235, one of the most significant substances ever discovered. Although Uranium-235 is famous for the nuclear reactions that power reactors and atomic bombs, few people realise that chemical reactions made its use possible. This essay explores how chemistry unlocked the power of Uranium-235 and how this remarkable isotope changed the balance of world power, energy production, medicine and the future of human civilisation.

History of Uranium-235

In 1789, a German scientist, Martin Heinrich Klaproth (Maar, 2023), discovered a new element while studying the mineral ore pitchblende. He named it Uranium after the recently discovered planet Uranus (Maar, 2023). More than a century later in 1896, a French scientist, Henri Becquerel, discovered that Uranium emitted invisible radiation naturally (Romano *et al*., 2021)._Then, in 1935, Canadian-born physicist Arthur Jeffrey Dempster used a mass spectrometer to identify Uranium-235, revealing that natural uranium contains different isotopes (meaning it could have different numbers of neutrons in its nucleus) and paving the way for future nuclear research (Encyclopaedia Britannica, 2025). This explained the radioactivity of uranium, that is, it has an unstable nucleus - the balance of protons and neutrons inside the atom is not stable. Over time, it naturally releases energy and particles to reach a more stable state. A breakthrough followed in 1938 when German chemists Otto Hahn and Fritz Strassmann discovered that bombarding uranium with neutrons produced barium, a much lighter element. This unexpected result provided the first evidence that the uranium atom could be split into smaller nuclei, releasing enormous amounts of energy in the process (American Physical Society, 2007). In 1939 Austrian physicist Lise Meitner and her nephew Otto Frisch explained this process, naming it nuclear fission (Meitner and Frisch, 1939).

The Role of Chemical Reactions in Uranium-235 Enrichment

Recognising the tremendous power of nuclear fission, from 1942 during World War II, the United States of America, the United Kingdom and Canada collaborated on the Manhattan Project for research and development to produce nuclear bombs. Their work revealed that natural uranium consists of 99.3% by mass of Uranium-238, which is heavy and stable, and only 0.7% by mass of Uranium-235 (World Nuclear Association, 2025).

This is when a chain of chemical reactions, devised by chemist Harold Urey, a key member of the Manhattan Project, unlocked the nuclear reactions that ultimately changed the world.

Firstly, uranium ore was mined, crushed and mixed with acids or bases to dissolve and separate uranium from rock and other minerals by a series of chemical reaction. Secondly, the uranium solution was purified by chemical reactions with ammonia or hydrogen peroxide that resulted in a precipitate, which is a concentrated uranium compound known as yellowcake. Finally, in a series of three chemical reactions, yellowcake was converted into uranium hexafluoride, which becomes a gas upon gentle heating, as shown in Figure 1 (Dill, 2021), allowing Uranium-235 and Uranium-238 to be separated in centrifuges (IAEA, 2024; World Nuclear Association, 2025).

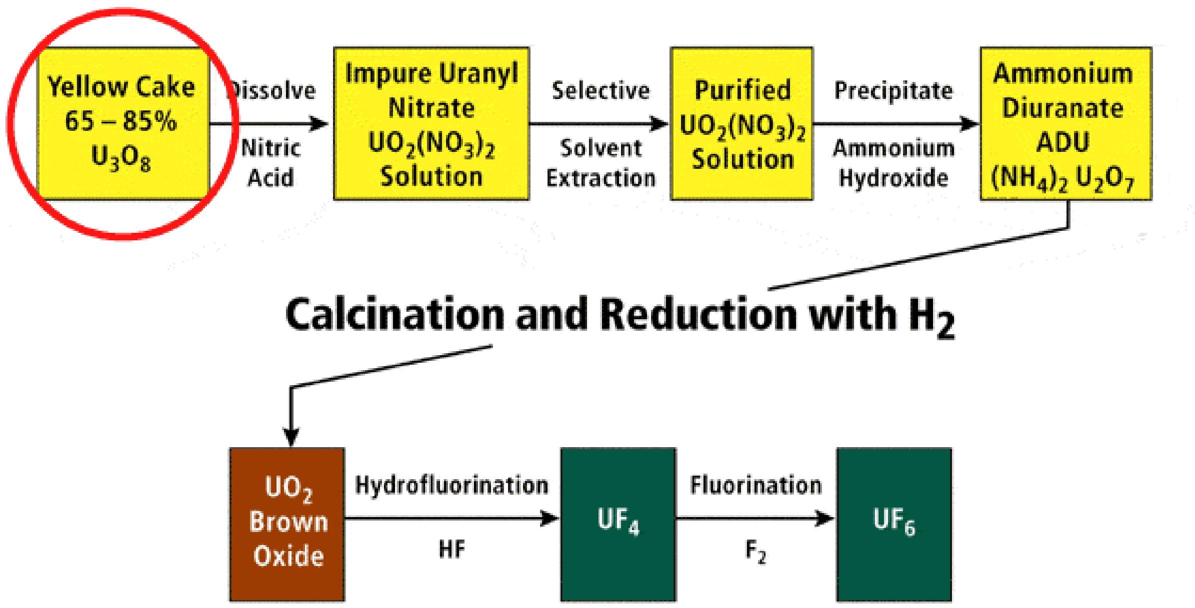

Figure 1: Diagram of a uranium conversion process using wet UO_2 production via Ammonium Diuranate (ADU) precipitation.

The concentrated Uranium-235 was then cooled and oxidised into solid fuel cells to be installed in a bomb. These processes turned an ordinary mineral buried underground into a fuel capable of producing enormous amounts of energy. The chemical processes involved are shown in Figure 2:

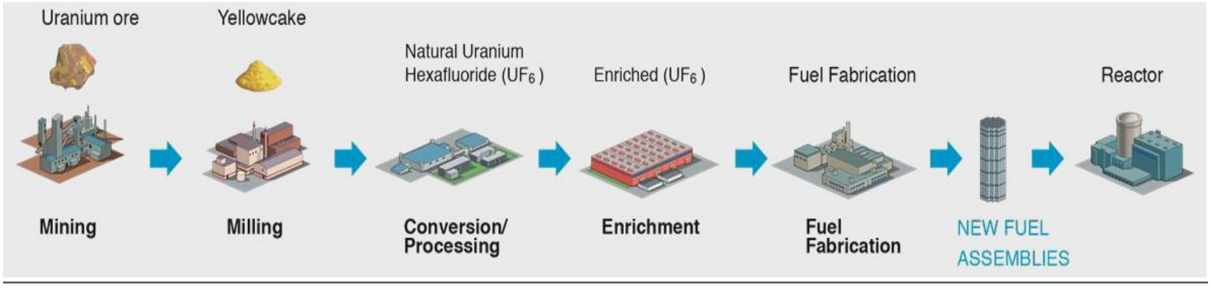

Figure 2: The nuclear fuel cycle (ENEC, 2024), demonstrating the stages from uranium extraction to electricity generation in a nuclear reactor.

How the World Was Changed

On 6 August 1945, the United States dropped "Little Boy", a Uranium-235 atomic bomb, on the Japanese city of Hiroshima, becoming the first nuclear weapon ever used in warfare (U.S. Department of Energy, 1999). The massive energy release from the explosion destroyed over seventy percent of the city and killed over one hundred thousand people. A second hydrogen bomb devastated Nagasaki and shortly after, Japan surrendered, bringing an end to World War II. Recognising the political power that nuclear energy could bring, nations scrambled to install their own facilities. Russia, an ally of the United States in the War, was privy to the chemical processes for uranium enrichment and built their own bomb factories, leading to decades of hostility between the two countries, known as the “Cold War”. In 1968, the Nuclear Non-Proliferation Treaty (NPT) was signed (United Nations, 1968), allowing the USA, Russia, China, UK, and France to continue as nuclear weapon states, in exchange for other nations being allowed to use nuclear enrichment for peaceful technology.. Other countries such as India, Pakistan, Israel and North Korea defied the treaty and built their own enrichment facilities. The USA and the International Atomic Energy Agency monitor nuclear activity in Iran, whom it considers a threat to its Middle Eastern allies. Clearly the chemical reactions that led to uranium enrichment and the contentious NPT treaty changed the world by putting geopolitical power firmly in the hands of five countries and their allies.

On the positive side, one of the greatest benefits of Uranium-235 is its ability to generate large amounts of electricity. As the world's population grows and countries search for cleaner energy sources, nuclear power offers an important solution. Remarkably, just 3.2 kilograms of Uranium-235 can produce enough electricity to power a large city for a day (World Nuclear Association, 2025). To generate the same amount of electricity, a coal-fired power station would need about 10,000 tonnes of coal, roughly the difference between the weight of two cats and four hundred truckloads of coal. Unlike coal-fired power stations, nuclear power stations produce virtually no greenhouse gases while generating electricity (World Nuclear Association, 2025). Although nuclear energy must be managed carefully because of safety and waste concerns, many countries see it as an important way to provide reliable electricity while reducing carbon emissions and helping to combat climate change.

Although Uranium-235 is best known for nuclear power and atomic weapons, it also plays an important role in saving lives. Nuclear reactors fuelled by Uranium-235 produce radioactive isotopes that are used in medicine around the world (IAEA, 2024). These isotopes help doctors diagnose diseases, treat cancer and sterilise medical equipment. For example, Technetium-99 is used in millions of medical scans each year (IAEA, 2024) to create detailed images of organs, bones and the heart, helping doctors detect illnesses early. Another isotope, Cobalt-60, is used in radiation therapy to destroy cancer cells and shrink tumours. Radioactive isotopes are also used to sterilise syringes, surgical instruments and medical supplies, ensuring they are safe for patients. It is remarkable that the same scientific discoveries that led to nuclear weapons and power stations have also provided tools that improve health and save countless lives. This demonstrates that the power unlocked by Uranium-235 can be used not only for energy and industry, but also for the benefit of humanity.

Impact on Future Human Civilisation

The influence of Uranium-235 extends beyond Earth. Nuclear science developed from Uranium-235 research has helped power deep-space missions and may one day support human settlements on the Moon and Mars (NASA, 2024). Scientists have also designed nuclear rockets that use the energy released by Uranium-235 to heat hydrogen gas and produce powerful thrust. Because nuclear fuel contains far more energy than chemical fuels, it could make future journeys through the Solar System faster and more efficient (World Nuclear Association, 2025). As humanity looks towards exploring other planets, the power unlocked by Uranium-235 may help carry us further into space than ever before.

Conclusion

The story of Uranium-235 is often told through nuclear explosions, power stations and space exploration, but none of these achievements would have been possible without chemistry. A series of chemical reactions transformed uranium from an ordinary mineral hidden in rock into a concentrated fuel capable of releasing enormous amounts of energy. Among these reactions, the conversion of uranium into uranium hexafluoride (UF_6) was the critical breakthrough that made uranium enrichment possible. This single chemical process unlocked the nuclear reactions that changed warfare, reshaped global politics, generated low-carbon electricity, advanced modern medicine and may one day help humans explore other planets. The journey of Uranium-235 demonstrates how chemistry can transform not only substances, but also the course of human history.

[1,348 words]

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