SCIENTISTS DEVELOP A TECHNIQUE FOR OBSERVING RADIATION DAMAGE DURING FEMTOSECONDS – SCIENCEDAILY

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Scientists at Nanyang University of Technology, Singapore (NTU Singapore) have developed a technique for observing how radiation damages molecules in a time frame of just one quadrillion seconds – or femtoseconds.

The technique involves dissolving organic molecules in water to simulate the state of molecules contained in biological tissue. This allows the research team to notice radiation damage in biological tissue and molecules with greater precision and clarity than ever before.

Nuclear or "ionizing" radiation can damage our bodies by altering DNA and other biological molecules because it disintegrates the chemical bonds that hold the molecules together.

Using their new technique, scientists have observed vibrations from collisions of ionizing radiation particles with an organic molecule, which eventually caused the collapse after a strong stretching, bending, and twisting motion. These vibrations occurred only when the molecules dissolved in water, which is a significant improvement in previous studies.

Associate Professor Zhi-Heng Loh, an assistant professor at NTU's Department of Physical and Mathematical Sciences who led the research, said, "This is the first time anyone has noticed ionization molecular dynamics in aqueous solutions at the femtosecond time scale. In previous studies. scientists could only observe ionization products after the molecule had already broken down. "

Although radiation hazards have been widely recognized since the 1930s, when Marie Curie died from anemia caused by prolonged exposure to radioactivity, the exact processes by which ionizing radiation changes molecules is not yet fully understood.

The study used methods from femtochemistry to record how atoms and molecules behave at ultra-short timescales, such as creating or breaking chemical bonds that take several quadrillions of a second or femtoseconds.

Femtochemistry uses lasers that emit extremely short pulses of light, and each pulse creates a recording of a chemical reaction. These can then be joined together like a video frame to watch ultra-fast chemical processes from start to finish.

Discovering how radiation changes molecules

Assoc. Prof Loh and his team sought to understand how ionizing radiation affects biological molecules. As a starting point, they focused their attention on the phenoxide ion, a relatively simple organic molecule containing many of the same types of chemical bonds found in the proteins that make up living tissue.

High resolution spectroscopy has previously been used to study phenoxide in its gaseous form, and researchers have observed a relatively simple behavior: when attacked by ionizing radiation, each phenoxide molecule vibrates at a single frequency, such as a bell ringing in a single clear tone. However, this method could not be used to study organic molecules dissolved in water, which is similar to the state of molecules found in biological tissue.

Using a pulse laser machine, the NTU team was able to record how radiation damages phenoxide molecules dissolved in water. The team identified multiple vibrational frequencies, different from the one frequency observed in gaseous phenoxide. They found that when radiation causes molecules to eject an electron, the molecule vibrates in a very complex pattern, more like the sound of a cymbal or gong than a ringing bell.

"In the future, we will build on this to explore how radiation affects larger and more complex molecules, such as proteins and nucleic acids, which are the building blocks of life," said Assistant Professor Prof Loh.

"Our research team specializes in femtochemistry, and once we became interested in the topic, it turned out to be relatively simple to adapt our femtochemistry methods to the vibrational motion of ionized molecules dissolved in water. To our surprise, no one has ever addressed this. special problem, ”he added.

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