NTU scientists create a new method for studying radiation damage to molecules

This new method involves observations being made over time-frames of one quadrillionth of a second.

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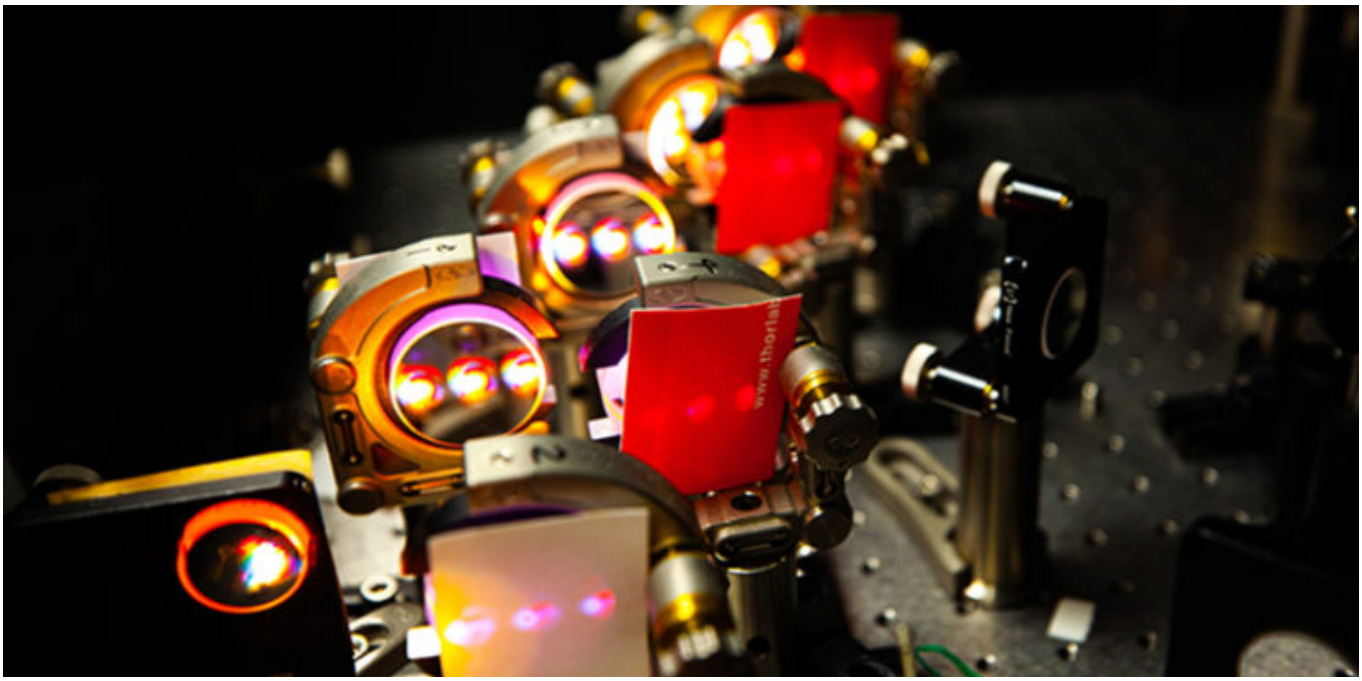

Scientists from the Nanyang Technological University (NTU) have created a method for studying how radiation destroys molecules over time-frames of one quadrillionth of a second (femtosecond).

The method uses the dissolving of organic molecules in water to re-create the state in which molecules are found in biological tissue. This allows the research team to observe how radiation damage happens in biological tissue with more precision and accuracy.

Some of the damage caused by radiation includes nuclear or "ionising" radiation, whereby DNA and other biological molecules are altered due to the disintegration of the chemical bonds holding molecules together.

When applying their newly created method, observations were made on the vibrations generated by collisions of ionising radiation particles with an organic molecule. These collisions resulted in the breaking apart of the molecule, after going through violent stretching, bending, and twisting motions.

Vibrations were observed only when the molecule was dissolved in water.

Associate Professor Zhi-Heng Loh, an Assistant Chair at NTU's School of Physical & Mathematical Sciences and research lead said, "This is the first time anyone has observed ionisation-induced molecular dynamics in aqueous solutions on femtosecond time scales. In previous studies, scientists were only able to observe the products of ionisation after the molecule had already been broken apart."

The detrimental effects of radiation have long been observed since the 1930s, a period during which Marie Curie died from anaemia as a result of long-term exposure to radioactivity.

This was caused by the same processes whereby ionising radiation alters molecules.

The developed technique uses methods from femtochemistry to observe how atoms and molecules behave at ultra-short periods. Observations of molecule behaviours include the formation or breaking of chemical bonds at femtoseconds.

How the technique was created

Assoc Prof Loh and his research team focused on understanding how ionising radiation affects biological molecules.

They first focused on the phenoxide ion, a simple organic molecule that contains various of the same types of chemical bonds which are found in the proteins that make up living tissue.

Based on a previous study involving the use of high-resolution spectroscopy to study phenoxide in its gaseous form, observations of a phenoxide molecule vibrating at a single frequency when struck by ionising radiation were made.

The setback with this study method was that it could not be used to observe organic molecules dissolved in water, which is akin to how molecules exist in biological tissue.

The research team used a pulsed-laser apparatus to record how radiation damages phenoxide molecules dissolved in water. multiple vibrational frequencies were detected which stood out from the single frequency observed in gaseous phenoxide.

It was found that the molecule vibrates in a highly complex pattern when the radiation causes the molecules to eject an electron.

Assoc Prof said that there are plans to “investigate how radiation affects larger and more complicated molecules”. This includes protein and nucleic molecules.

“Our research group specialises in femtochemistry, and once we got interested in the topic, it turned out to be relatively simple to adapt our femtochemistry methods to studying the vibrational motion of ionised molecules dissolved in water. To our surprise, no one had ever tackled this particular problem before,” he said.