New horizons in radiotherapy?

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Targeted radiation therapy that is less harmful to healthy cells could see the light of day thanks to a team of French researchers from the Laboratoire de Chimie Physique - Matière et Rayonnement (CNRS/UPMC) working in collaboration with German and American scientists. Until now, radiotherapy treatments employed to combat cancer used a wide energy range when irradiating biological tissues. By studying at a fundamental level the behavior of molecules subjected to radiation with a carefully chosen energy, the researchers paved the way for tomorrow's radiotherapy treatments, which would not affect as much surrounding tissue and whose total radiation dose would be considerably reduced.

This work, which sheds new light on the behavior of matter at the atomic scale and which could have important benefits in medicine, is published on 22 December 2013 on the website of the journal *Nature*.

The radiotherapy currently used in nearly half of cancer treatments irradiates biological tissue using a radiation with a wide energy spectrum in order to destroy the cancerous cells. The work of the international team headed by two CNRS researchers from the Laboratoire de Chimie Physique - Matière et Rayonnement (CNRS/UPMC) should make it possible to improve the precision and quality of treatment by more finely targeting the range of energy used. Their fundamental research originally aimed to study the behavior at the atomic scale of matter subjected to radiation, here an X-ray type of radiation, whose energy is selected with extreme precision. When an atom absorbs X-rays of a given energy, a process known as "interatomic Coulombic decay" takes place, leading to the emission of electrons by one of the atoms within a molecule. In their experiment, the researchers demonstrated that it is possible to produce a large amount of low energy electrons in the immediate environment of this target atom, giving rise to a phenomenon of resonance. In what way can these results be interesting for radiotherapy? In a living environment, these low energy electrons are capable of causing the breakage of a double strand of neighboring DNA. However, living cells, including cancerous cells, are usually capable of repairing the damage caused to a single strand of DNA, but not to the double strand. Using this process, it is therefore possible to envisage targeting cancerous cells to destroy them.

Since the irradiation of biological tissue in radiotherapy takes place over a wide energy range, the advantage of using a finely chosen radiation so as to bring about a resonant emission of the electrons is twofold: X-rays penetrate deeply into the tissues but only specific atoms within chosen molecules, administered beforehand so as to target the cancerous cells, are thus excited and the healthy tissues further away are not affected by the irradiation. In addition, the resonant excitation is ten times more efficient than the non-resonant excitation produced by less specific irradiation. The overall radiation dose may thus be considerably reduced.

These results have for the moment been obtained on small molecules made up of less than five atoms.

The researchers now plan to test this process of producing electrons on more complex molecules containing several hundred or even several thousand atoms, such as the molecules that make up living cells. In the long term, the aim is to produce such electrons, toxic for DNA, within cancerous cells. To do so, the researchers are envisaging irradiating tissues with X-rays having the appropriate energy, after using a target atom to tag the cancerous cells.

More information: "Resonant Auger decay driving intermolecular Coulombic decay in molecular dimers," F. Trinter, M.S. Schöffler, H.-K. Kim, F. Sturm, K. Cole, N. Neumann, A. Vredenborg, J. Williams, I. Bocharova, R. Guillemin, M. Simon, A. Belkacem, A.L. Landers, Th. Weber, H. Schmidt-Böcking, R. Dörner and T. Jahnke. *Nature* 2014. [DOI: 10.1038/Nature12927](https://dx.doi.org/10.1038/Nature12927)

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