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Biosciences using synchrotron infrared microspectroscopy

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Infrared spectroscopy and microscopy may look an exotic analytical tool in biology. It's rather known for identification of molecular vibrational motion in chemistry , physics, geology, space science…. But, the technique has clearly showed its potential when a synchrotron source was thought to be used instead of a traditional thermal source (also called lab-source).

Vibrational spectroscopy identifies the resonant vibrational motion of molecular groups, as each of them has a single, or multiple resonant frequency, called also absorption bands, characteristic of their identity.in addition, the resolution is such that any perturbed environment (for example ordered / disordered beta sheets) can be identify at sub-micron level. Infrared spectroscopy use the IR photons emitted by a thermal source, in the energy domain 2-200 microns (which are long wavelength compared to the most known X-ray photons). Originally, an active field of research has been developed around the changes of motion of the main component of an human cell or tissue (protein, lipids, DNA, RNA etc.), in order to identify any evolution or disease. When the synchrotron radiation was identified as a bright source that can be coupled with such an instrument, one has realized that the brilliance advantage of such a source makes possible to probe tissues and cells at sub-cellular resolution. This has held a big promise in detecting any change in the nucleus of individual cells, with a fast data recording at high lateral resolution, with very good spectral quality(S/N) . There exist several biological and biomedical applications which emphasize on the promising future of synchrotron infrared micro-spectroscopy in these scientific disciplines. This will be the main objective of this talk. In particular, I will details the following examples:

• Urinary stone disease, constitutes a major health problem and is affecting an increasing number of people. Calcium oxalate, calcium phosphate, uric acid, ammonium hydrogen urate and magnesium ammonium phosphate are the main components of stones. Very small crystals in the kidney biopsy sample, of 2,8-dihydroxyadenine (2,8-DHA) were identified , and this has direct relevant therapeutic implications. Doctors from Hospital for a rapid screening of kidney sections actually routinely use IR synchrotron microscopy. This results in a direct implication in the patient therapy and recovery.

• The potential changes occurring in hematopoietic cells expressing BCR-ABl and BCR-ABL carrying T3151 mutation, conferring resistance to most tyrosine kinase inhibitors currently used has been evaluated using IR micro-spectroscopy. The use of the synchrotron is fully justified due to the small dimension of human leukemia cells .

• Stem cells research is a very important research topic nowadays. Several studies have shown that IR microscopy can determine the differentiation state of the stem cells. But more importantly, we have been able to show that synchrotron IR microscopy can assess unambiguously the reprogrammation of stem cells, which is more difficult otherwise.

• Liver steatosis is a severe disease that can lead to hepatosteatosis, cirrhosis and cancer. The precise determination of the steatosis content during the liver transplant is crucial with recommendation to select livers exhibiting no more than 20% steatosis. This drastic recommendation contrasts with the incapacity of usual histological methods to rigorously provide an objective and non-biased assessment of steatosis. Synchrotron infrared microspectroscopy has helped determining the presence of micro vesicle with lipids content that can be directly related to the lipidomic HPLC tests. The database established with the synchrotron source is actually used to condition an IR thermal source based microscope, to be set up in hospital for direct diagnostic during liver transplant.

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