Department of Molecular and Translational Medicine

PhD Program in Molecular Genetics, Biotechnologies and Experimental Medicine

“Raman Spectroscopy in Biological and Medical Research - Trends and Perspectives”

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Raman spectroscopy is considered as a promising tool for detection of subtle chemical alterations in various cells due to low signal from water, non-destructive approach, good spatial resolution, photostability, and the possibility of obtaining full chemical information at once. However, spontaneous scattering is rather weak and requires long time for spectra acquisition. The alternative is Stimulated Raman Spectroscopy (SRS) or Coherent Anti-stokes Raman Spectroscopy (CARS) using non-linear effects to enhance intensity of scattered light. Raman microscopy can be successfully used for living systems to analyse below the micron scale, at the level of single organelles and molecules (metabolites), but sometimes it lacks sensitivity or specificity or speed.

The use of molecular probes in Raman imaging is a relatively new technique in subcellular research, however, very fast and dynamically developing. Compared to the label-free method, it allows for a more sensitive and selective visualization of organelles within a single cell. Directly visualizing biological structures and activities at the cellular and subcellular levels remains by far one of the most intuitive and powerful ways to study biological problems. For hyperspectral detection and imaging of living cells, it is very desirable to use probes with strong and unique Raman vibrations in the biological silent region (1800 – 2800 cm-1). Here it is shown a biorthogonal chemical imaging of cells to track biochemical changes associated with mitochondrial function at the cellular level in an in vitro model. Both commercially available and newly synthesized highly sensitive Raman probes for selective imaging of mitochondria in live cells is presented.

Hence, the main goal of this study is to overcome methodological and technical limits of Raman imaging in detecting small organelles and specific molecules within cells by harnessing physics, chemistry, medicine, pharmacology, biology, engineering, and data analysis, to use these advanced technologies in life sciences. The combination of specificity and sensitivity of the Raman probes with information obtained from spontaneous Raman spectroscopy and SRS/CARS on living cells gives diagnostic potential to these methods. They can support classic approaches in tracking cellular processes, studying chemoresistance, and characterizing drug-cell interactions.

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