Raman and SERS Analysis of Biomolecules and Cells

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Raman and surface enhanced Raman scattering (SERS) are techniques that can be used to provide a rich amount of information on a number of different biological systems. This presentation will cover two examples where we have made use of SERS and Raman to understand more about the biological nature of two key biomedical systems relating to cardiovascular disease and cancer.

In the first example, a study is presented on the use of functionalised nanoparticles to understand the expression of adhesion molecules commonly found in cardiovascular disease and in particular due to atherosclerosis. The aim was to understand how SERS could be used with three differently antibody functionalised silver nanoparticles that would react with ICAM-1, VCAM-1 and p-selectin using a Raman tag on each nanoparticle. The reason for this is that these three biomarkers have been shown to be over expressed on the surface of endothelial cells as atherosclerosis progresses and can be viewed as a marker of atherosclerosis at a molecular level.[1] Ultimately, four nanotags were produced, three for the biomarkers and one with an IgG control. We were then able to study individual coronory artery cells and examine the expression of the biomarkers before moving onto tissue sections which contained a lesion and a non-lesion site. This set of data showed that the ICAM-1 was over expressed at the lesion site but also found in the non-lesion site. VCAM-1 was only found at the site of the lesion and p-selectin was again found in both the lesion and non-lesion sites. We were able to achieve semi-quantitation by using the control IgG nanoparticle which allowed an indication of the amounts of the biomarkers being expressed relative to each other. We were then able to advance from the tissue sections and move to an *in vivo* model where data will be presented on the outcome of *in vivo* experiments looking for the expression of these adhesion molecules in a mouse model.

In the second study, data will be presented on the use of Raman spectroscopy to understand more about the effect of small molecule drugs on cancer cells relative to non-cancer cells and in particular on the lipid synthesis. To achieve this we have used 2D mapping in the high wavenumber region and ratiometric analysis used to understand the effect of small molecule drugs on the increase or decrease on lipid synthesis on prostate cancer cells. (Figure 1) The results have shown some interesting selectivity for a particular small molecule relative to a normal cell in that this small molecule has a preference for a cancer cell and appears to up regulate the lipids. This was a very simple approach to understanding the effect of small molecule drugs and the data presented will show how Raman spectroscopy and ratiometric analysis can be used to provide an accurate analysis on the effects of small molecule drugs on cancer

cells and whether further indepth testing of the efficacy of these drugs as anti-cancer agents should be pursued.

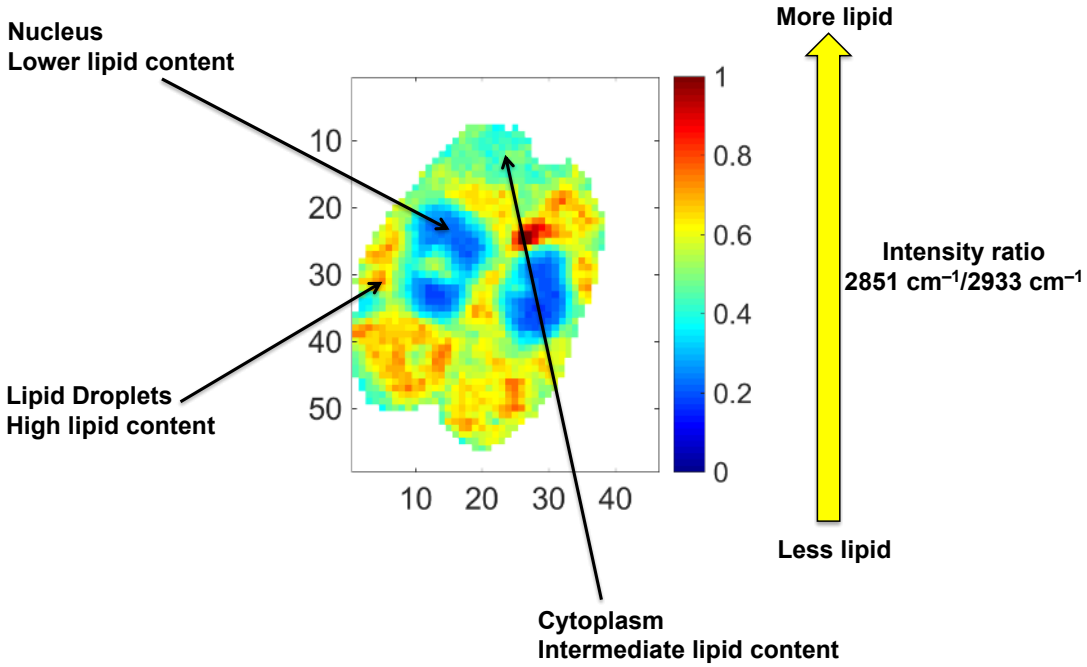

Figure 1 – Raman mapping of two cells using high wavenumber mapping and 532 nm excitation. The ratio of intensity of the bands at 2851:2933 cm^{-1} was used to plot a false colour heat map showing regions of high lipid and áreas of low lipid e.g. the nucleus.

REFERENCE

[1] MacRitchie, N., G. Grassia, J. Noonan, P. Garside, D. Graham and P. Maffia *Heart*, **2018**;104:460-467.