SERS-active 3D printed scaffolds; combining hybrid materials to better understand the tumour environment

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Hybrid materials offer many advances in biomedicine thanks to their flexibility in physicochemical attributes such as geometry, scale, permeability, and responsive behaviour to externally applied stimuli. Specifically, the combination of inorganic nanoparticles and organic matrixes allows one to design biocompatible scaffolds in which mammalian cell growth (including aspects such as division, migration, differentiation) can be controlled and studied in real time.

With the aim of better understanding the tumour environment, we have designed a 3D printed scaffold which supports long term cell growth in 3D (Figure 1). The scaffolds are printed with a large (1cm^2) footprint yet retaining micro-scale resolution. Within the porous walls are embedded plasmonic gold nanoparticles (AuNPs), thereby simultaneously providing surface enhanced Raman spectroscopy (SERS) mapping and sensing components to allow high resolution imaging and detection of soluble components, respectively[1]. Additionally, we are investigating the ability to combine heterogenous 3D printed materials to produce complex 3D cell models to explore aspects such as drug delivery and metastatic cell migration from the tumour environment.

A key feature of our work involves SERS imaging and the technical aspects thereof. SERS offers important advantages over other commonly used microscopy techniques as it allows us to follow cell migration and division in a non-disruptive manner, avoiding the commonly encountered photobleaching and phototoxicity that otherwise occurs with fluorescence microscopy. Furthermore, imaging depths are increased thanks to the use of NIR excitation sources. Such bio-3D printed models provide an important stepping-stone or even alternative to in vivo studies. We foresee these models as systems in which factors such as local pH[2], temperature, degree of cellular migration, and metabolite production can all be studied in a controlled environment.

References

[1] García-Astrain, C., Lenzi, E., Jimenez de Aberasturi, D., Henriksen-Lacey, M., Binelli, MR., Liz-Marzán, LM. Advanced Functional Materials 30 (2020) 2005407
[2] Zhang, Y., Jimenez de Aberasturi, D., Henriksen-Lacey, M., Langer, J., Liz-Marzán, LM. ACS Sensors, 5 (2020) 3194-3206

Figures

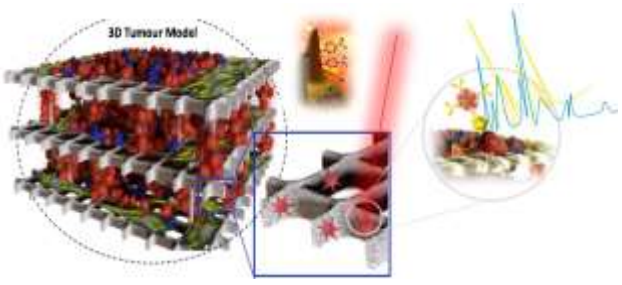

Figure 1: Model of a biocompatible 3D printed scaffold with SERS activity and supporting cell growth