PROJECT INVESTIGATORS:
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Using limpet-derived metal enzymes in sustainable bio-manufacturing

"Limpet tooth has the greatest tensile strength of any known biomaterial. A biomimetic material based on limpet tooth could offer a sustainable and biodegradable alternative to plastics, with a net-zero carbon footprint."

PROJECT AIMS: Limpet tooth-derived material could offer a strong yet biodegradable alternative to plastics. Limpet tooth is generated by the limpet radula organ, the transcriptome of which encodes a plethora of proteins that bind, transport, reduce and oxidise iron.

Our aim is to move away from the use of limpets as the source of cells and towards a fully sustainable cell-free model. We have previously used limpet cell conditioned media to mineralise chitin scaffolds with iron oxide crystals to improve the mechanical properties of the scaffolds.

In the current work, we aim to determine the exact nature of the secreted factors in limpet cell conditioned media that engender scaffold mineralisation. We will analyse the secretome of limpet cell conditioned media using high-performance liquid chromatography with subsequent proteomic and metabolomic analysis.

OUTCOMES & NEXT STEPS:
A grant of £127,839 has been awarded by the Defence and Security Accelerator (DASA) to further develop the limpet tooth material for a project on 'Synthetic biology to develop enhanced body armour based on limpet tooth'. The project is in partnership with the US company Materic, which will help scale-up production of electrospun chitin scaffolds for mineralisation.

RESULTS: We identified and characterised novel factors that have a key functional role in the iron oxide mineralisation process present in limpet tooth that we can now use to enhance our procedures for the mineralisation of chitin to make new material.

Isolated limpet cells were maintained at pH 7.8 and temperature of 14°C, similar to seawater. We tested new methods for the isolation of mineralising fractions from cell cultures. These fractions were then characterised according to chemical composition and macro-structure. This included demonstrating the presence of and ability to evoke iron oxide crystals in key fractions.

Incubation of electropsun chitin scaffolds with the identified factors resulted in the formation of iron oxide deposits. Limpet teeth contain iron oxide in the form of goethite and our methods contrast with the synthetic generation of goethite that typically requires a pH of 11-12 and temperature above 60°C.

This study has resulted in a better understanding of the mineralisation process and more refined procedure for the generation of synthetic limpet tooth material. This will inform our approaches as we move forward towards scaling up processes.

Change in technology readiness level: 2 to 3

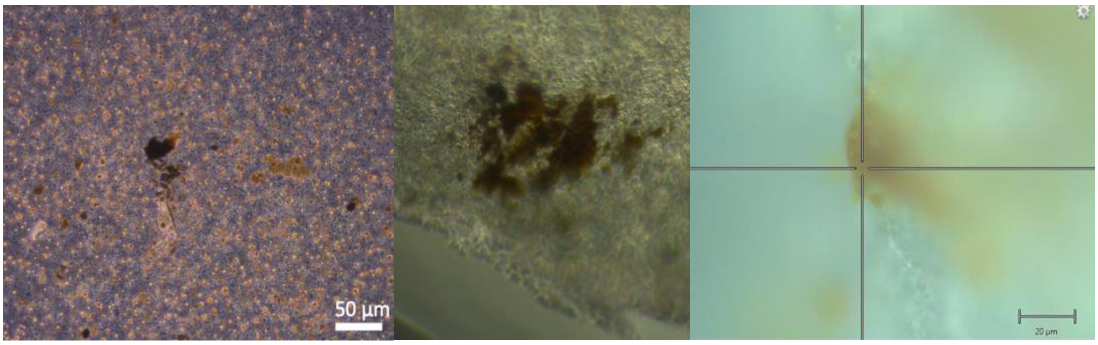

Image showing (left) limpet cells in culture; iron deposits formed in chitin incubated with cell secretome isolates (middle and right).