Template-assisted Electrohydrodynamic Atomisation (TAEA) Patterning of Bioactive Materials on Curved Metallic Substrates

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Introduction
Coating the surface of metallic load bearing joint prostheses with bioactive materials can significantly enhance direct biological fixation, resulting in shorter recovery times and fewer revision surgeries for patients. Template-assisted electrohydrodynamic atomisation (TAEA) patterning has the potential to provide an improved coating method to the industry-standard method of vacuum plasma spraying. This is due to reduced processing temperatures (~20°C), greater controllability, a wide variety of predetermined topographical geometries that improve cell movement and biological response, as well as its simple set up and lower energy requirements. Further developing TAEA to use a greater range of coating materials and substrate geometries will improve the functionality and commercial viability of this process, whilst improving the quality, longevity and functionality of coated orthopaedic implants.

Aim
The aim is to develop our patented and published TAEA process into a patterning technique (see Fig. 1) for bioactive materials on curved substrates for clinical use, in particular for orthopaedic implants.

Objectives
(i) To carry out TAEA patterning with biomaterials (ceramics such as hydroxyapatite and biopolymers) on curved titanium substrates.
(ii) To investigate how the microstructure of the resultant coatings can be controlled by systematically varying the substrate curvature, coating material concentration and TAEA process parameters mainly the electric field and flow rate of coating materials.
(iii) To characterise the deposited pattern microstructure, mechanical properties and bioactivity.

The program of work to adapt the TAEA process for curved substrates can be divided into five key stages:

1. A conveyor mechanism will be designed and built to hold, move and/or rotate the curved substrate during spraying for even deposition.
2. Coating materials, templates, liquid carriers and substrates will be prepared and fully characterised.
3. TAEA will be carried out and the effect of key process parameters will be investigated.
4. The effect of each parameter on the patterns will be studied using advanced microscopy and nanoindentation.
5. Bioactivity will be investigated with osteoblast cell cultures and time-lapse microscopy.

Brian Mercer Award
The Royal Society’s Brian Mercer Feasibility Award has enabled the Biomaterials Group from the Department of Mechanical Engineering and the Institute of Biomedical Engineering at UCL to further develop their TAEA research towards commercialisation. This process could ultimately provide an improved industrial method of manufacturing coated orthopaedic implants and other clinical inserts.