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PhD Abstract – Antimicrobial Surface Coatings via Cold Spray and 3D Printing Technologies
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Surface contamination and subsequent microbial transmission is a persistent problem in healthcare facilities, contributing to the global pervasion of nosocomial infections and the aggressive prevalence of resistant strains. Touch-contact surfaces, as effective intermediaries for pathogenic transmission, are priority targets for solution development.

Polymer metallisation of ABS, PEEK and PC polymers with antimicrobially active copper, silver and zinc metals, via multi-step and multi-material additive manufacturing, for antimicrobial surface coating production, was investigated. Cold spray and polymer 3D printing technologies were, for the first time, integrated for the application of self-sanitising surface coatings. Theoretical modelling, in conjunction with a targeted particle depth-of-penetration model and adapted Taguchi optimisation method, aided cold spray parameter selection. Successful coatings were achieved using a novel independent parameter effects and variation decision framework and a tailored experimental optimisation procedure. Antimicrobial efficacy was evaluated using two, independent, *in vitro* assays: a diffusion assay and an adapted time-kill assay simulating touch-contact pathogenic exposure. Preliminary prototype trials were also conducted, which included a 3D printed smartphone cover.

Enhanced antimicrobial efficacy under both wet and dry contact conditions was observed. In a touch-contact environment, cold spray coatings were found to be five times more biocidal than their respective base metals. A 50% w/w copper-zinc coating on a 3D printed ABS substrate exhibited synergistic bacteriostatic activity: found to be 43% more effective than the combined average activity of copper and zinc coatings against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. Additional test pathogens included *Enterococcus faecalis* and *Candida albicans*. A combination of factors is believed to be responsible for this activity, including the known mechanisms of action of oligodynamic metals, enhanced diffusion of ions and surface topography supporting direct microbial contact, made possible by the novel coating process employed. Antimicrobial activity was not significantly impaired by resistant pathogens: gentamicin-methicillin-resistant *S. aureus*, azlocillin-carbenicillin-resistant *P. aeruginosa* and a fluconazole-resistant *C. albicans*. Against these resistant pathogens - under dry, touch-contact conditions - the cold spray coatings achieved complete microbial elimination within 12 min for a copper coating on 3D printed ABS and within 5 min for a copper coating with a 5 wt% silver additive on a copper metal substrate. In response to the global need for alternative solutions to infection control and prevention, these effective antimicrobial surface coatings are proposed.