Innovate UK

Results of competition: The management and use of Biofilms

Competition code: 1506_FS_EMTECH_I_BF

Total available funding for this competition was £1.5 million from Innovate UK & BBSRC

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: WH Partnership Ltd **Partner names:** Newcastle University, University of South Wales	Online Microbial Fuel Cell Biofilm BOD Sensor	£89,811	£69,852
Project description - provided by applicants			
Monitoring of organic pollution in wastewater is a difficult challenge for the water treatment industry. Due to infrequent sampling there is a high possibility that pollution could be discharged into the environment undetected and lead to further problems downstream. Bioelectrochemical sensing systems are an emerging technology which uses biofilms grown upon electrodes to convert organic pollution into electricity. Based on the amount of electricity generated, the amount of organic pollution can be determined. This approach can therefore be used to provide continuous online monitoring of wastewaters in virtually real-time in comparison with existing measurements requiring 5 days. The project will deliver a prototype sensor based on Bioelectrochemical Systems , capable of being retrofitted to existing wastewater treatment plant infrastructure, in order to rapidly measure Biochemical Oxygen Demand (organic pollution) and toxicity.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Parkside Flexibles (Europe) Ltd **Partner names:** Sci-Tech Adhesives Ltd., Banham Poultry Ltd., Institute of Food Research Norwich, Bangor University	Anti Campylobacter -BIofilm Technology (AC-BIT)	£99,822	£79,252

Project description - provided by applicants

To prevent transmission in the human food chain this feasibility project will target control of biofilms formed by microbial pathogens in the meat supply chain. The work will be tested Campylobacter and Salmonella, two of the most common foodborne pathogens in the United Kingdom. A particular focus will be given to the possible inhibition and removal of such biofilms using natural products. The research will build on multi-disciplinary expertise in pathogen biofilm, meat supply chain processing, and natural product chemistry.
This will underpin future research on the design of anti-biofilm products for the meat packaging or cleaning product industry, which will be used in subsequent projects for usage in cleaning products formulation for the food industry, or in meat packaging (MAP trays, soaker pads or sealing foils).

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Neem Biotech Ltd **Partner names:** Membranology Ltd., Jellagen Pty Ltd.	Development of an active wound dressing built with electrospun jellyfish collagen and capable of delivering natural antimicrobial agents	£98,322	£68,825

Project description - provided by applicants

Biofilms are present in chronic wounds and are known to contribute to continued infection and inflammation with antibiotic resistance of biofilms complicating the problem. Current wound healing treatments are associated with antibiotic resistance and often use mammalian (bovine) collagen treatments, which risks contamination from disease causing agents such as prions (Bovine Spongiform Encephalopathy) and interspecies viruses. In the present Feasibility Study, by embedding jellyfish collagen with novel plant derived antimicrobials, it will be possible to produce a prototype product capable of delivering antimicrobial agents directly to the wound and reduce the need for antibiotics.

By combating biofilms in chronic wounds, the consortium will reduce the burden on the NHS and drastically improve the quality of life of chronic wound sufferers. The wound healing product output of this project will address the current problems with wound chronicity that contribute to this growing problem in the UK.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Unilever **Partner names:** University of York	Real time visualisation & modelling of biofilm inhibition by lactam	£99,845	£74,869

Project description - provided by applicants

Microbial control actives drive hygiene performance or preservation in FMCG formulations, packaging, and processing. Today's petrochemical options are receiving safety, regulatory and NGO pressure and have been shown to be ineffective on established biofilms on inert or biological surfaces. Current cleaning products contain anti-microbial actives that improve surface hygiene and freshness by killing planktonic microbes. There is increased industrial interest in commercialising anti-biofilm technologies that push the boundaries in health and hygiene. Furanone derived lactam analogues jam quorum sensing. To-date it is not fully understood which stage(s) of the process they impact on. This project aims to visualise in real-time phenotypic changes to non-planktonic bacteria induced by a soluble lactam analogue and in tandem model the very earliest stages of non-planktonic cell-surface association to lasting impact on mature biofilm structure and functionality. Monitoring flow dynamics will shed light on cellular attraction and active diffusivity and help us identify the limiting factor(s) in biofilm growth inhibition and design novel or complementary anti-biofilm technologies.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Unilever **Partner names:** University of Leeds	The use of lactams to inhibit biofilm growth in durable non-wovens	£100,000	£75,000
Project description - provided by applicants			
Within the nonwovens sector personal and household care, hygiene, medical and filtration products are constantly challenged by microbial contamination. In durable nonwovens the hygiene problem is addressed mostly through anti-microbials such as silver and quaternary ammonium compounds. However these present environmental and toxicological risks, are of limited efficacy on biofilms, and also present a risk of increasing microbial resistance. Recently the screening of a library of over 600 furanone-derived lactams has revealed variants that disrupt quorum sensing during biofilm growth and development. This feasibility project will explore the application of these as anti-biofilm coatings on nonwoven textiles. Using different application techniques during manufacture, analogues will be covalently and non-covalently bound within the matrices, or at the surface, of polyolefin and cellulosic materials. The efficacy and durability of the antifouling coating on nonwoven products will be explored and the possibility of a biotechnology platform that covers a range of applications across durable nonwoven market segments will be assessed.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Adtec Europe Ltd. **Partner names:** Royal Hampshire Hospital, Salford Royal NHS Foundation Trust	Efficacy of non-thermal gas plasma on sub-clinical wound infection (biofilm) in patients with diabetic ulcers	£100,000	£75,000

Project description - provided by applicants

There is a need for support in the management of biofilms, although there is a growing interest in infection management, there is limited comparative information regarding wound care products and their efficacy on established biofilms. We believe non-thermal gas plasma (NTGP) has the potential to not only enable the healing of chronic wounds that are stalled by sub-clinical wound infection (biofilm) but accelerate healing time. The intention of this investigation is to generate data that can be used as a guide by clinicians in the management of chronic wound infections. We believe this study has the potential to provide a significant advancement in optimising chronic wound management and could be extended to other potential applications such as treating biofouling in distribution pipes found in the food and water industries.
Lead Industrial partner is Adtec Europe Ltd, with support from Mr Keith Cutting, Dr Paul Chadwick Consultant Podiatrist, Ms Samantha Haycocks Advanced Podiatrist at Salford Royal NHS Foundation Trust, Ms Rosie Legg Podiatrist and clinical/academic partner Dr Matthew Dryden at the Royal Hampshire Hospital.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Procter & Gamble Technical Centres Ltd. **Partner names:** University of Birmingham	New materials for managing biofilms (NEMAB)	£99,281	£64,640

Project description - provided by applicants

The presence of biofilms in manufacturing can act as a source of product contamination, resulting in persistent quality issues, equipment failure (microbially induced corrosion) and an ongoing cost to manufacturing companies through ensuring their absence and removal. Ultimately, this results in a cost to the environment, through waste disposal, energy costs and water usage, and in the worst cases can impact on consumer health.

This project looks to evaluate new materials which can be used in manufacturing to minimise the presence of biofilms and improve the cleanability of manufacturing processes. If the project is successful, we would look to improve the environmental footprint of manufacturing, while improving the efficiency of delivering quality products to the UK's consumers.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Processs Instruments **Partner names:** Warwick University	Biofilm Activity Analyser for Healthcare Applications	£99,545	£74,561

Project description - provided by applicants

Biofilm formation associated with water storage units in the healthcare industry is a serious issue in e.g. dental healthcare and renal dialysis, due to potential bacterial infections. Biofilm build-up in the non-disposable plastic pipes connecting dental water systems and dialysis catheters, in particular, are a cause for increasing concern amongst healthcare professionals. Current monitoring techniques required as part of dental and dialysis guidelines do not provide continuous assessment of biofilm activity. Instead, monitoring is based on lab techniques, or dip-stick kits, which can take many days to complete. We aim to investigate the feasibility of new innovative technology based around biocompatible diamond electrochemical sensors, which can be miniaturised and placed directly in the appropriate tubing. The sensor will provide real-time, continuous feedback on biofilm growth, thus immediately informing on "unsafe" biofilm levels and recommending biocide treatment procedures. As the diamond sensor is chemically resistant long-term placement is possible. This feasibility study will be carried out between the SME Process Instruments and the University of Warwick.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: 5D Health Protection Group Ltd. **Partner names:** University of Liverpool	Wound Triggered Synergistic Antibiofilm Frameworks	£98,600	£72,064
Project description - provided by applicants			
This project is a collaboration between the 5D Health Protection Group Ltd and the University of Liverpool Clinical Engineering Department. The research and development collaboration will enable the development of the next generation antibiofilm technologies that can be applied to medical platforms for enhancing clinical outcome. One important area for use of this technology would be woundcare considering now that chronic wounds have been shown to now contain biofilms. Many complex biofilms found in non-healing and infected chronic wounds are recalcitrant to presently used antimicrobial interventions. Furthermore these interventions are often overused and have no enhanced clinical benefit. In addition the project will involve the development of a framework that involves the intelligent triggered release of synergistic agents for maximum impact and reduced hospital costs. Presently such technology does not exist in the market so this innovation will create the first world leading prototypes and advanced technologies that presently do not deliver to the expectations required for biofilm management in non-healing and infected chronic wounds.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Unilever **Partner names:** Manchester Metropolitan University	Rational modification of lactams for improved efficacy in home care applications	£99,774	£74,805
Project description - provided by applicants			
Beyond removal of dirt, home and personal care formulations such as laundry detergents, kitchen and bathroom cleaners aim to deliver health and hygiene benefits in line with Unilever's Sustainable Living Plan. These benefits are currently delivered by chemical antimicrobials which have a limited efficacy on established biofilms. The screening of a library of over 600 furanone-derived lactams has revealed variants that disrupt quorum sensing and biofilm growth in model environments. This feasibility project aims to enhance the bioavailability and efficacy of lactams in home care applications via rational modification of existing principal analogues. Possible routes of derivatisation will range from introduction of charged groups for solubility, enhancing the 'active site' functionality, and grafting complex polymeric lactam-containing materials for targeted delivery to surfaces and biofilms. A focused library of around 10 novel analogues will be constructed, synthesised, and their anti-biofilm efficacy will be explored against real biofilms on a range of home and industrial surfaces. The platform opportunity of improved lactams in home care will be assessed.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: The PJH Partnership Ltd. **Partner names:** n/a	Investigating the use of SCO2 to impregnate medical materials for the prevention of microbial biofilms	£60,935	£42,654
Project description - provided by applicants			
The PJH Partnership Ltd have developed supercritical technology that when used with an anti-bacterial dopant, may prevent the formation of biofilms on medical device materials. Through a series of experiments and industry engagement, PJH will undertake a 10-month programme of work to validate process efficiencies and performance, in terms of the depth and volume of deposition, effective dispersion, dopant characterisation, and material evaluation and economic assessments. This approach draws upon the impregnable performance of supercritical CO2 and patented technology and test methodologies. Test materials will include industry approved implant devices, from which ongoing medical trials are scheduled to confirm anti-bacterial effects for biofilm prevention. Assessment across plastic and metal materials will determine the scope of use, with wider applications in the healthcare industry. Following this 10-month study, medical trials will be undertaken prior to commercialisation, envisaged 2018.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: International Paints Ltd (AkzoNobel) **Partner names:** University of Southampton	Measuring predictors of drag penalty of ship-fouling biofilms	£99,388	£73,685
Project description - provided by applicants			
Biofilm fouling on ships leads to costly drag penalties, and the marine coatings industry seeks to develop technologies that will eliminate or reduce "slime". This project explores the feasibility of using marine fouling biofilm mechanical and physical properties as predictors of associated drag, and thus more sophisticated metrics of coating performance than the current standard. Biofouling and coatings experts at International Paint Ltd. and biofilm mechanics experts at the University of Southampton will partner to develop and validate innovative methods and apparatuses for measurement of (i) biofilm drag and (ii) mechanical/physical properties of intact, immersed biofilms on marine coatings. With these methods, the teams will compile the first dataset of biofilm drag penalties with respect to the mechanical/physical properties of these compliant materials. The test methods and broader knowledge of biofilm properties and drag will directly benefit coatings research and development, product performance modelling, and fundamental materials science.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Bioquell Ltd. Partner names: n/a	Evaluating the efficacy of H2O2 vapour against biofilms formed by multi-drug resistant organisms (MDROs	£51,337	£30,802
Project description - provided by applicants			
The project aims to evaluate the efficacy of Bioquell's 35% hydrogen peroxide vapour (HPV) technology against single and multi-species biofilms, produced by multi-drug resistant organisms (MDROs) associated with hospital acquired infection. Recent evidence shows that biofilms can survive in excess of 12 months on surfaces within hospital rooms, even after terminal cleaning with bleach. It is believed that these biofilms act as reservoirs for infection, with the potential to contaminate patients who come into contact with them. Bioquell is working in conjunction with University of Southampton.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: MOFgen Ltd. **Partner names:** n/a	Biofilm management in wound healing using Metal Organic Frameworks (MOFs)	£99,300	£69,510
Project description - provided by applicants			
This project aims to explore the feasibility of using a new class of chemical compound called Metal Organic Frameworks (MOFs) to deliver antimicrobial metal ions and nitric oxide (NO) gas for the wound management market. The purpose is to prevent biofilms forming in wounds and to increase healing rates (NO is both antimicrobial and a wound healing promoter).			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Clear Water Revival Ltd. **Partner names:** University of the West of England (UWE)	Management and use of beneficial bacterial biofilms to control aquatic pathogens, for reliable chemical-free sanitisation of swimming pools.	£99,821	£80,422

Project description - provided by applicants

The swimming pool filtration market (worth £3.2bn) currently lacks chemical-free alternatives despite customers' demands of healthier, easier and cheaper solutions to pool water treatment. This project helps to fully realise the mass market potential for natural bio-filter based water treatment technology, through innovative and robust scientific research and development into aquatic pathogen behaviour and control using bio-films. Project Objectives: Determine how our biofilms reduce levels of waterborne pathogens; ascertain whether bio-films housed within a bio-filter allow re-introduction of pathogens in water; develop optimal habitats & management of biofilms to maximise pathogen removal; & quantify pathogen survival rates on full-scale filtration models. The invaluable knowledge gained during the project will enable a set of optimised operational parameters (e.g.: optimal pH/ flow rates) and substrate properties (e.g. pore size, depth), which maximise the efficiency, repeatability and reliability of biofilm performance (w.r.t. pathogen control) for real-world conditions.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: BioFilm Solutions Ltd. **Partner names:** n/a	A feasibility study to determine the effectiveness of a novel polymer coating in reducing biofilm formation within beer dispense systems.	£85,285	£56,699
Project description - provided by applicants			
Biofilm Solutions is a micro company created to exploit a novel method of reducing biofilm formation within beer dispense systems. We have been granted exclusive licensing rights to explore the potential applications and benefits of this innovative technology. A recent study with our research partner demonstrated a significant reduction in the build-up of biofilm on the inner surface of a beer dispense line using our product. The aim of this project is to assess whether this innovative technology can effectively control biofilm formation in beer lines in a dynamic, simulated pub environment. Keeping beer lines clear of biofilms wastes over 500M litres of water and 70M pints in the UK alone. Our product could significantly reduce the frequency of line cleaning resulting in less wastage of beer, water and a reduction in chemical cleaner usage. It would also improve the maintenance of beer quality. A successful outcome would prove commercial viability and demonstrate major benefits for the manufacturer, the proprietor, the consumer and the environment.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Medtrade Products Ltd. **Partner names:** n/a	Biofilm Combatting Technology for Wound Care Application	£135,767	£81,460
Project description - provided by applicants			
This project is focused on Wound Care where 60% of chronic non-healing wounds possess microorganisms in a biofilm form causing a significant social and economic impact. It has a negative effect on patient quality of life resulting in a large impact on the health care system in terms of cost and resource. This novel technology destroys biofilm formation. The objective is to completely challenge the biofilm combatting technology using complex biofilm models that mimic chronic wound scenarios and to determine it's optimum capability.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: NCIMB Ltd. **Partner names:** Probiotics International	Neutralising the harmful effects of dental biofilms by bacterial replacement therapy	£99,705	£66,813
Project description - provided by applicants			
Dental caries is a widespread oral disease that is costly for health services to treat, and causes pain and loss of teeth to those affected. It is caused by production of acid by oral bacteria in biofilms on the teeth and gums commonly known as dental plaque. Brushing teeth can reduce this problem, but many people do not do so regularly or thoroughly. This project will investigate the application of bacterial replacement therapy in the form of a lozenge containing a suitable probiotic strain to help develop an anti-caries environment within the dental plaque biofilm. The project will combine the strengths of two UK SMEs, a world-class culture collection centre and a leading probiotics manufacturer. The project will investigate strains held within the NCIMB culture collection for their potential to create novel biofilms to combat dental caries.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Anacail Ltd. **Partner names:** n/a	Biofilm management in food processing environments	£97,898	£68,529
Project description - provided by applicants			
Ozone is one of the most powerful biocidal agents known to science: bacteria, spores, viruses and biofilms are all susceptible to destruction by ozone. Anacail are currently developing the technology for the food packaging industry through the treatment of sealed packs. The technology has potential application in a linked area: reservoirs of contaminated liquid (drains) in food processing plants. Parallel work in assessing ozone on a number of pathogens and has shown the potential for ozone to treat biofilms. With Innovate UK support Anacail will develop and evaluate in real factory environments, a prototype for destruction or growth inhibition of Listeria in food factory drain wells thus reducing infection spread and cross-contamination.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Varicon Aqua Solutions Ltd. Partner names: Plymouth Marine Laboratory, Durham University	Development of a Novel Membrane Photobioreactor, for cultivation of *Haematococcus pluvialis* as a Biofilm	£107,846	£69,892
Project description - provided by applicants			
Microalgae have the potential to produce an array of compounds in a manner more sustainable than the conventional petrochemical industry. This project aims to explore a novel and innovative method to produce algal biomass and bio-products at lower costs than conventional production systems. Namely we aim to investigate the commercial opportunity of using a proprietary membrane photobioreactor (MBR) to produce the high value pigment astaxanthin from a biofilm of the microalgal strain *Haematococcus pluvialis*.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: Gama Healthcare Ltd. **Partner names:** University of Huddersfield	Investigation of efflux pump biocide and antibacterial resistance mitigation in organisms within biofilms	£99,242	£69,557
Project description - provided by applicants			
Products derived from this project will enhance patient safety and aim to reduce the incidence of small surgical site infections and catheter related infections. Dealing with biofilm-protected organisms is seen as an important step in improving clinical outcomes in a number of medical cases. Novel formulations proposed in this project potentially offer a significant step in this respect.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Lead name: NCIMB Ltd. **Partner names:** n/a	Alternative methods for the control of biofilm formation in oilfield systems.	£85,176	£59,623
Project description - provided by applicants			
Microbial biofilms can cause significant economic and environmental issues in oilfield systems from reduction in flow rates, souring of crude oil and contribution to corrosion of concrete and metal surfaces. Current methods for the control of biofilms in these situations include the use of chemical biocides which are expensive and can lead to environmental contamination. This project will evaluate the application of bacteriophage as a natural alternative for biofilm control in oilfield systems. Although phage technology is not novel in itself its application it has not been used actively in industrial situations. This project will evaluate the application of phage technology for biocontrol for assets in the UK North Sea continental shelf.			

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