Book of Abstracts

Bioinspired Materials 2018 conference

The Bioinspired Materials conference is organized for the third time by a team of researchers from Manchester Metropolitan University. The 2016 edition was a symposium with a number of local attendees and this expanded to an international event in 2017 and 2018. New in the 2018 edition is that all registered participants will have the opportunity to publish an extended abstract in the MDPI journal Biomimetics. These abstracts will undergo peer review and deadline for submission is in December.

Participants are invited to submit full papers and reviews
in areas related to the conference themes
to be considered for publication in a Special Issue of *Biomimetics*

Selected Papers from "Bioinspired Materials 2018"

Guest Editors: **Marloes Peeters, Araida Hidalgo-Bastida, Patricia Linton**

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We have a line-up of exciting speakers and aim together the scientific community in the field of biomimetic sensors, materials chemistry, 3D-printing and tissue engineering.

We look forward to welcome you to Manchester.

For the organization of this event, we would like thank our sponsors including:

List of participants

List participants	Affiliation	Contribution
Dr Patricia Linton	Manchester Metropolitan University	LOC
Dr Marloes Peeters	Manchester Metropolitan University	LOC
Dr Araida Hidalgo-Bastida	Manchester Metropolitan University	LOC
Prof Alberto Saiani	University of Manchester	Keynote
Jane Wood	Manchester Metropolitan University	Keynote
Prof Patrick Wagner	KU Leuven	Keynote
Aqib Asghar	Manchester Metropolitan University	P6
Dr Thomas Allen	Manchester Metropolitan University	O12
Kai Betlem	Manchester Metropolitan University	P1
Marta Calvo Catoira	Università del Piemonte Orientale	P2
Dr Robert Crapnell	Manchester Metropolitan University	P3
Dr Tim Gabriel	Manchester Metropolitan University	P24
Dr Gary Dougill	Manchester Metropolitan University	n/a
Dr Alexander Hudson	Manchester Metropolitan University	P3
George Hurst	Manchester Metropolitan University	P4
Oliver Jamieson	Manchester Metropolitan University	n/a
Amanpreet Kaur	Guru Nanak Dev University	P5
Rana Khayat	Manchester Metropolitan University	P25
Dr Mark McLaughlin	Manchester Metropolitan University	n/a
Dr Francesco Mecozzi	Manchester Metropolitan University	n/a
Dr Louise Melling	Manchester Metropolitan University	n/a
Claire Mur'Tala	Manchester Metropolitan University	P27
Dr Mamum Rashid	Manchester Metropolitan University	n/a
Dean Roberts	Manchester Metropolitan University	P6
Pankaj Singla	Guru Nanak Dev University	P7
Faifan Tantakitti	Chiang Mai University	P8
Dr Silvia Tedesco	Manchester Metropolitan University	P4
Dr Qiuyu Wang	Manchester Metropolitan University	P23
Hadil Elbardisy	Damanhour University	P9
Nicholas Aldred	Newcastle University	P10
Anca Florea	Antwerp University	P11
Gethin Allen	Swansea University	O11
Craig Allan	Swansea University	O11
Dr Mona Ali Ahmed	The American University in Cairo	P12
Dr Alison Edwards	Medway School of Pharmacy	O9
Benjamin Filby	University of Hull	O8
Katie Costello	University of Surrey	P19
Dr Priyanka Gupta	University of Surrey	O4
Suzan el Akaad	Ghent University	P13
Dr Stuart Hannah	University of Strathclyde	n/a
Dr Geertje van Keulen	Swansea University	O11
Dr Mehran Khorshid	KU Leuven	P14
Cosimo Ligorio	University of Manchester	P15
Dr Patricia Losada-Perez	Universite Libre de Bruxelles	P22
Joseph Lowdon	Maastricht University	O3
Karl Norris	University of Lancaster	O5
Dr Pijush Kumar Paul	Gono Bishwabidyalay (Bangladesh)	O2

Prof Vesselin Paunov	University of Hull	O10
Ramisha Reman	University of Bradford	P16
Nabelah Khan	University of Bradford	P17
Dr Sachin el Shah	University of Hull	P18
Stella Totti	University of Surrey	O7, P20
Anna-Maria Tryba	University of Lancaster	O6
Heitor Valarini	Universidade de São Paulo	P26
Derrick Yongabi	KU Leuven	P21
Prof Mun’de Vestergaard	Kagoshima University (Japan)	O1

Preliminary programme

Bioinspired Materials 2018 programme
09:00 – 09:45 Registration with coffee / visits exhibitors
09:45 – 09:50 Welcome to the conference
Session 1 – Biomimetic sensor platforms
09:50 – 10:25 Keynote lecture Prof. Patrick Wagner (KU Leuven)
10:24 – 10:45 O1: Prof. Mun'de Vestergaard (Kagoshima University)
10:45: 11:05 O2: Dr. Pijush Paul Kumar (Gono Bishwabidyalay University)
11:05- 11:20 O3: Mr Joseph Lowdon (Maastricht University)
11:20 – 11:35 O4: Dr. Priyanka Gupta (University of Surrey)
11:35 – 11:45 O5: Karl Norris (Lancaster University)
11:45 – 11:50 O6: Anna-Maria Tryba (Lancaster University)
Chair: Dr. Marloes Peeters
11: 50 – 12:30 – Lunch
12:30-13:05 – Poster session 1
Session 2 – Hydrogels
13:05 – 13:45 Prof. Alberto Saiani (University of Manchester)
13:45 – 14:00 O7: Miss Stella Totti (University of Surrey)
14:00 – 14:15 O8: Benjamn Filby (University of Hull)
14:15 – 14:35 O9: Dr. Alison Edwards (Medway School of Pharmacy)
Chair: Dr. Araida Hidalgo-Bastida
14:35 – 15:15 Coffee break and poster session 2
Session 3: Biofabrics and bioengineering
15:15 – 15:45 Jane Wood (Manchester Metropolitan University)
15:45 – 16:05 O10: Prof. Vesselin Paunov (University of Hull)
16:05 – 16:25 O11: Gethin Allen (Swansea University)
16:25 – 16:45 O12: Dr. Tom Allen (Manchester Metropolitan University)
16:45 – Closing ceremony and announcement poster prizes

Keynote speaker 1 – Prof. Patrick Wagner

KU Leuven

Prof Wagner, from the Laboratory of Soft Matter and Biophysics, has a research group that focuses on biosensors. He has a particular focus on thermal detection and the use of synthetic recognition elements. He is a full professor with over 300 published papers.

Abstract - Biosensing with biomimetic receptors: MIPs and SIPs

In this presentation, I will give an overview on recent trends in the synthesis and application of man-made biomimetic receptors, especially molecularly-imprinted polymers (MIPs) and surface-imprinted polymers (SIPs). Such polymer-based bio-receptors can be prepared by low-cost protocols and, in comparison to their natural counterparts such as immunoglobulins, they can operate under non-physiological conditions regarding temperature, ionic strength and pH value of the analyte. Moreover, MIPs and SIPs can be regenerated for repetitive use and their target-binding affinity comes close to the affinity constants of biological receptors.

To start with MIPs, I will first explain the concepts of bulk- and suspension polymerization under presence of template molecules, resulting in MIP-microparticles that are characterized with respect to affinity and selectivity by batch-rebinding experiments using UV-Vis spectroscopy. Specific examples include MIPs for nicotine, histamine and serotonin and their integration with a variety of bio-analytical detection principles such as impedance spectroscopy, quartz-crystal microbalances and thermal detection based on the heat-transfer method HTM [1, 2]. These concepts are still feasible when analyzing "real-life samples" such as urine, saliva, intestinal fluids, plasma and whole blood by using differential sensing in order to correct for non-specific adsorption of competitor molecules in these complex matrices. As an outlook to a medical application, I will briefly address the development of a catheter-based, intestinal sensor for the diagnosis of the irritable bowel syndrome IBS.

In contrast to these molecularly-imprinted receptors for small-molecule detection, surface imprinting of polymer layers (SIPs) is the method of choice when it comes to the detection of larger biological targets such as proteins, viruses, cells and bacteria. The reason for this surface-based strategy is the facile extraction of template particles and easy access of target particles to the receptor sites; both steps would be hindered when the receptor site is surrounded by a dense polymer network as in case of MIPs. After a few examples of protein imprinting (imprinted as a whole or by epitope imprinting), I will move to eukaryotic cells such as macrophages and human cancer cells [3]: Strategies to enhance the selectivity between similar cell types play an important role together with the enrichment of target cells captured on the sensor-chip surface under presence of an excess of competitor cells. These concepts are also beneficial in the context of bacterial detection in samples of water, food, and drinks. Examples include detection techniques for E. coli and S. aureus, while the concept is generic and applicable to a wide variety of other bacterial contaminations and maybe also to infections in humans [4]. To conclude the presentation, I will introduce recent experimental developments, aiming at multiparametric MIP- and SIP-based bio-detection with respect to multiple targets in an array-type sensing format.

References

[1] M. Peeters et al., Analytical and Bioanalytical Chemistry 405 (20), 6453 – 6460 (2013).
[2] M. Peeters et al., Analytical Chemistry 85 (3), 1475 – 1483 (2013).
[3] K. Eersels et al., ACS Applied Materials and Interfaces 5 (15), 7258 – 7267 (2013).
[4] E. Steen Redeker et al., ACS Infectious Diseases 3 (5), 388 – 397 (2017).

Keynote speaker 2 – Prof. Alberto Saiani

University of Manchester

Prof Alberto Saiani was awarded an European PhD in 1997 by the Université Louis Pasteur, (Strasbourg, France). Following his PhD he was awarded a Fellowship by the Japanese Society for Promotion of Science (JSPS), which allowed him to spend one year as postdoctoral research fellow at Osaka University (Japan). In 1998 he was recruited as postdoctoral research associate at Imperial College in the Chemical Engineering department where he staid two years. In September 2000 he was appointed to a lectureship at the Université Blaise Pascal (Clermont-Ferrand, France) and in September 2002 he was appointed to a lectureship in Molecular Materials in the School of Materials, The University of Manchester. In 2013 he was awarded an EPSRC Fellowship and founded a company dedicated to the commercialisation of the peptide hydrogel technology developed in his group.

Keynote speaker 3 – Jane Wood
Manchester Metropolitan University

Jane Wood is a senior lecturer in textile technology within the department of Apparel. She studied Textile Chemistry at the University of Leeds and moved to Manchester Met after 15 years in industry. She is currently working on biofabrics and implementation of electronics into clothing. She was one of the poster prize winners of Bioinspired Materials 2016 and will showcase her bioinspired clothing at the event.

Session 1: Biomimetic sensor platforms

O1 - Bio-inspired Membrane Systems: Applications to elucidate biomolecular interactions

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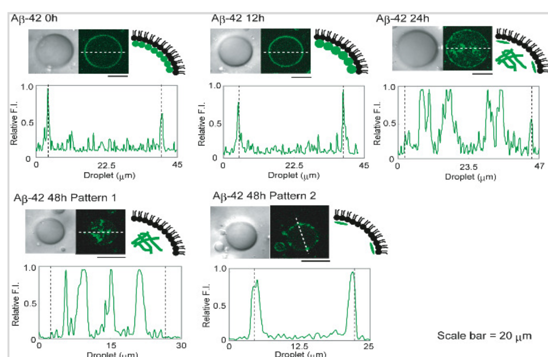
Development and application of *bio-based* and *bio-inspired* technologies to (i) screen for, identify and quantify molecules of interest; (ii) profile and characterize molecular activities/events; and (iii) help elucidate pathophysiological mechanisms is major field _with applications in various fields including biomedical, environmental, energy, food and agriculture. Most of our work has looked at bioenseor development nad application. In this talk, we aim to introduce development and exploitation of biomimicking membrane techology. Specifically, we will highlight the fundamental chemical principles intrinsic in biological and biophysical interactions and their exploitation in development of biomimicry membrane technology.

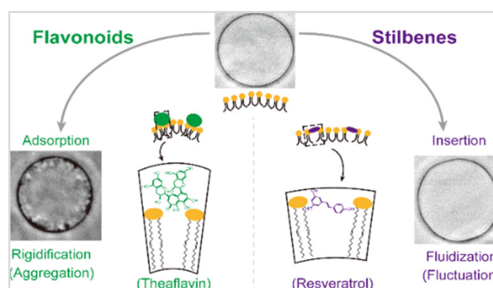
Biomimicry membranes are cell-sized, lipid vesicles that mimic the biological cell. Since the relative compositions of lipid mixtures used influence molecular self-organization and vesicle properties, preparation for tailored application is possible. Thus, biomimetic membranes enable a researcher to manipulate a 'biological' micro-vesicle under a controlled environment. We will discuss concrete examples of the application of this technology to

(i) advance the understanding of Alzheimer's amyloid beta mechanisms towards neurotoxicity in Alzheimer's disease. Our studies show that the mechanisms involved may include re-organization of membrane lipids, and changes in membrane fluidity. Localization of the peptide (monomeric through to fibril species) within the membrane systems was imaged (**Fig. Top left**); and

(ii) semi-characterize the bioactivity of naturally-occuring compounds (polyphenols) in foods (functional biomolecules) using this technology. Our work shows structure-depend induction of membrane dynamics by the polyphenols, shading light into the importance of side chains, the types, and location.

(ii) understand membrane structure re-organization in induced by lipid oxidation (**Fig. Bottom left**). This is of particular interest because many diseases have been reported to be caused or advanced quickly by oxidative stress.





We will conclude by discussing the challenges in design, development, and application of this technology. We will also look briefly at how these biological molecules, in particular the self-assembly nature could further inspire development and utilization other molecules.

References

- Phan, H.T.T., et al. Biophys. Reports *In press*
- Phan, H.T.T., et al. FEBS Lett., 588, 3483, 2014
- Phan, H.T.T., et al. Biochim. Biophys. Acta, Biomembr., 1838, 2670, 2014
- Phan, H.T.T., et al. Biochim. Biophys. Acta, Biomembr. , 1828, 2487, 2013
- Vestergaard, M.C., et al. Edited by T. Farooqui and A. Farooqui., Wiley-Blackwell, John Wiley & Sons Inc., Oxford, United Kingdom, 163, 2013
- Vestergaard, M.C., et al. Biochim. Biophys. Acta, Biomembranes, 1828, 1314-1321, 2013.
- Morita, M. et al. Soft Matter, 8, 2816, 2012.
- Vestergaard, M.C., et al. Biochim. Biophys. Acta, Biomembranes, 1808, 2245, 2011

O2 - Biomimetic molecularly imprinted polymer nanoparticles for oral protein delivery

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Polymeric nanoparticles have gained interest for protein drug delivery due to their high surface area to volume ratio which results in the improvement of transmucosal transport. Furthermore, they offer controlled-release properties for encapsulated drugs and they are capable of protecting the encapsulated proteins from chemical degradation. Molecularly imprinted polymers nanoparticles (MIPs) are capable of serving as potential carrier for protein therapeutics owing to its custom-made particles, robustness, ease of preparation and surface modification, high drug loading capacities and good biocompatibility. In this study, MIPs were synthesized using single and mixed functional monomers employing methacrylic acid (MAA), *N*-hydroxyethyl acrylamide (HEAA) and polycaprolactone triol (PCL-T) in the presence of insulin as template via aqueous precipitation polymerization technique. Dynamic laser light scattering (DLS) measurements revealed the size of the MIPs is around 200 nm which was confirmed by transmission electron microscopy (TEM) observations and atomic force microscopy (AFM). AFM was able to show the imprints of the template were that of the protein insulin. The MIPs exhibited a much higher affinity towards the insulin. There was a significantly higher partition behavior at a pH of 7.4 in a sustained–release manner, compared to pH of 1.2. The MIPs produced significant reduction in initial blood glucose level in Wistar rats compared to the control group up to 24 h. The intestinal absorption of insulin after oral administration was confirmed by the immunofluorescence and immunohistochemistry study. The fluorescent intensity of rhodamine labeled insulin for MIPs was significantly greater ($P<0.0001$) than that of control polymer. Moreover, ultrastructural examination of intestinal segments by electron microscope displayed the uptake of insulin loaded MIPs nanoparticles via transcellular pathway by enterocytes. The results suggest that biomimetic MIPs nanoparticles could be an effective carrier for oral insulin delivery.

O3 - Surface Grafting Molecularly Imprinted Polymers onto Aluminium Surfaces

Joseph Lowdon[1], Kasper Eersels[1*], Renato Rogosic[1], Benjamin Heidt[1], Hanne Diliën[1], Erik Steen Redeker[1], Marloes Peeters[2], Bart van Grinsven[1], Thomas J. Cleij[1]

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2. Manchester Metropolitan University, Faculty of Science and Engineering, School of Science and the Environment, Division of Chemistry and Environmental Science, Chester Street, Manchester M1 5GD, United Kingdom.

Introduction:

Over the past few years, the combination of MIPs and the Heat Transfer Method (HTM)[1] has proven to be a powerful tool in the analysis of small molecules and bacteria.[2] However, the current method of MIP deposition relies up pressing the MIP powder into a PVC layer, which is hard to reproduce, and leads to limited sensitivity. Other methods also include combining the MIP powder with a graphene-based ink to directly print the MIPs onto a substrate, which also leads to a decreased in sensitivity.[1,3] This work looks at the concept of directly grafting a MIP onto the surface of an aluminium chip, removing the need for current deposition methods.

Method:

Aluminium chips were hydroxylated and reacted with a silicon based linking molecule, allowing a azo based initiator to be bound to the aluminium surface. Polymerisation was then conducted into the presence of the initiator functionalised aluminium, monomer, crosslinker and a template molecule, facilitating the growth of a MIP directly on the aluminium surface. The template was then extracted, and the affinity of the MIP towards the template molecule evaluated using the HTM.

Results and Discussion:

Experiments were conducted at physiologically relevant concentrations, with varying MIP compositions and silicon linker molecules. Experimental data shows a clear difference between NIP and MIP, allowing for easy differentiation even at low nanomolar concentrations, meaning biologically applicable samples can be measured. This was compared to the original method of deposition and was found to be more sensitive, showing a higher percentage increase in thermal resistance at low concentrations (Fig. 1). This opens up the possibility to test whole blood samples to a higher degree of precision, which has previously been demonstrated with the HTM.[4]

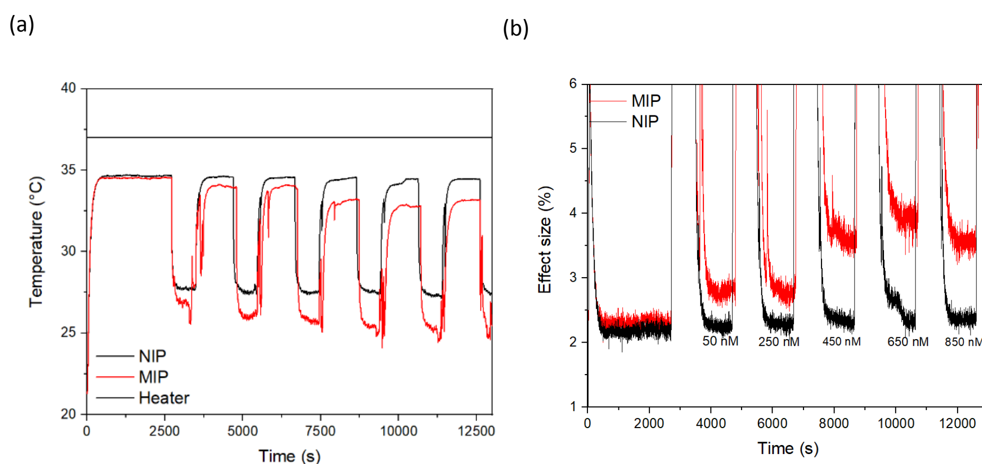

Figure 1. The thermal increase when varying concentrations of 2-MXP is added to both the MIP and NIP layer (a), and the percentage increase in thermal resistance for both MIP and NIP (b).

References:

[1] Casadio, S.; et al. Chem. Eng. J. 2017, 315, 459-468.
[2] Canfarotta, F.; et al. Nanoscale 2018, 10, 2081-2089.
[3] Lowdon J. W.; et al. Analyst. 2018, 143, 2002-2007
[4] Vandenryt, T.; van Grinsven, B.; et al. Sensors 2017, 17, 2701.

O4 - **A novel scaffold based biomimetic advanced multi-culture system for pancreatic ductal adenocarcinoma *in vitro* mimicry – a prelude to vascularisation**

***Priyanka Gupta*[1], *Paola Campagnolo*[2], *Andrew Nisbet*[3,4], *Roger Webb*[5], *Giuseppe Schettino*[6] *and Eirini G. Velliou*[1]**

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Introduction: Over the past years, 3D tumour model systems have garnered attention due to their ability to mimic *in vivo* tumour niches much more realistically in comparison to the typically used 2D suspension cultures. Scaffold based 3D cellular models are of special interest and importance due to their ability to provide structural integrity, ability to provide cell- cell and cell- EMC interaction as well as the option of co culturing multiple cell types. In addition, scaffolds are also tuneable in terms of size, pore diameter and porosity, offering robust control of the tumour biomechanical environment[1]. Our lab has previously reported that poly urethane (PU) based scaffolds can be used as a robust 3D structure to develop a pancreatic cancer tumour model using a single cell type[2]. However, the tumour microenvironment consists of a variety of cell types, including pancreatic stellate cells and endothelial cells which all contribute to the tumour formation, metastasis, response and resistance to treatment. The aim of our work is to develop, for the first time, a multiple culture robust 3D pancreatic tumour model on PU scaffolds using pancreatic cancer, pancreatic stellate and endothelial cells (HUVEC).

Methods: PU scaffolds were prepared using Thermal Induced Phase Separation (TIPS) method. Surface modification of the scaffolds enabled coating with fibronectin for enhancement of ECM mimicry. Cells were seeded on to the scaffolds at a seeding density of 0.5×10^6 cells/ scaffold for the mono culture and 0.25×10^6 cells/scaffold, per cell type for the multi-culture systems. Long term culture (4 weeks) was carried out within the scaffolds. Various *in situ* assays including cell viability, live-dead analysis, SEM etc were carried out at specific time points throughout the culture period.

Results: Preliminary data show that HUVECs are able to attach and proliferate on both coated and uncoated PU scaffolds over 4 weeks' time period. Cell viability analysis also highlighted that HUVECs preferred fibronectin coated scaffolds in comparison to uncoated ones, similar to the pancreatic cancer cells. We also show the feasibility of co culturing long term pancreatic cancer cells and HUVECs on both uncoated and coated PU scaffolds. Our findings show the great potential of our PU scaffolds to support *in vitro* mimicry of the pancreatic tumour microenvironment, serving as a platform for personalised treatment screening.

Reference:

1. Totti, S. et al. Designing a bio-inspired biomimetic in vitro system for the optimization of ex vivo studies of pancreatic cancer. *Drug discovery today* **22**, 690-701 (2017).
2. Totti, S., Allenby, M.C., Dos Santos, S.B., Mantalaris, A. & Velliou, E.G. A 3D bioinspired highly porous polymeric scaffolding system for in vitro simulation of pancreatic ductal adenocarcinoma. *RSC Advances* **8**, 20928-20940 (2018).

O5 - DOLOMITE AND CALCITE ENHANCEMENT OF WHEY PROTEIN ISOLATE HYDROGELS FOR THE REGENERATION OF BONE TISSUE.

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In previous work, we have characterised hydrogels made of whey protein isolate (WPI), an inexpensive by-product from the dairy industry. This initial work showed that WPI hydrogels can promote the expression of fibroblast collagen, facilitate stem cell differentiation and allowed the adherence, proliferation and calcium deposition of bone-forming cells. Although WPI hydrogels have showed promising results for the regeneration of bone tissue, we wished to enhance their properties by including a calcium mineral phase. Thermodynamically, calcite is the most stable polymorph of calcium carbonate (CaCO3) and has been successfully used to promote bone regeneration previously. Dolomite ($CaMg(CO_3)_2$) is a form of magnesium calcite used in the building industry and is available in large amounts in Poland. As a component of calcium phosphate, magnesium has been shown to promote the proliferation of bone-forming cells. We hypothesised that Mg incorporation into CaCO3 would also positively influence cell behaviour, and that addition of dolomite and calcite to hydrogels, (highly hydrated three-dimensional polymer networks) would improve cell proliferation. Addition of preformed inorganic particles to hydrogels is a common mineralization strategy. In this study, the characteristics and cytocompatibility of dolomite and calcite WPI hydrogel composites were assessed. Micro-CT imaging showed good cross-sectional distribution of calcite/dolomite particles. SEM analysis highlighted that the surface of both hydrogel composites are much rougher than WPI standalone hydrogels, which is known to promote cell adhesion. MG63 cells adhered to calcite/dolomite WPI hydrogels and were able to proliferate similarly to control WPI hydrogels.

O6 - Composites of gellan gum hydrogel incubated in whey protein isolate solution with addition of polyphenols/ silver nanoparticles obtained by using red tea.

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Introduction: Gellan gum (GG) is an anionic polysaccharide widely used in the food and pharmaceutical industries (1)., It has been recently used as a hydrogel biomaterial for cartilage regeneration (2).
Whey Protein Isolate (WPI) is obtained by the removal of sufficient nonprotein constituents from whey so that the finished dry product contains not less than 90% protein. WPI is produced by physical separation techniques such as precipitation, membrane filtration and/or ion exchange.
Due to the unique properties of silver nanoparticles nad pure poluphenols there is growing interest in their applications. Current trends in nanotechnology are focused on developing a new technique to synthesize nanoparticles using biological methods associated with the use of plant extracts, fungi, bacteria (3).These methods are a promising alternative to conventional approaches which can minimize the use of hazardous substances. The silver nanoparticles synthesis using red tea infusion as a reducing and stabilizing agent and their characteristics have been done, added to GG hydrogels and incubated in (WPI) in different concentration.

Preparation of hydrogels: Briefly, 16 ml aqueous 0.875% w/v GG solution at 90°C was mixed with 3.6 ml aqueous 0.169% w/v CaCl2 at 90°C, resulting in a GG–CaCl2 solution. After cooling to 50°C, 0.4 ml 5, 15 or 25 mg/ml polyphenols solution was added Immediately after polyphenols and silver nanoparticles addition, 20 ml GG solution was cast in glass Petri dishes of diameter 10 cm at room temperature and left for 20 min to ensure complete gelation. Hydrogel discs 7 mm in diameter and 5 mm in thickness were cut, using a hole punch.
Preparation of silver nanoparticles :10 g of dry tea leaves were extracted in 100 ml of water at 80°C. The mixture was covered with a watch glass and allowed to infuse for 30 min. The synthesis of silver nanoparticles was achieved using classical chemical reduction of silver ions. For this purpose, different volumes of tea infusion were added to 50 ml of 250 ppm AgNO3 aqueous solution ranging between 2–10 ml, depending on experiment. Formation of nanoparticles was periodically monitored using recording UV–Vis spectra.

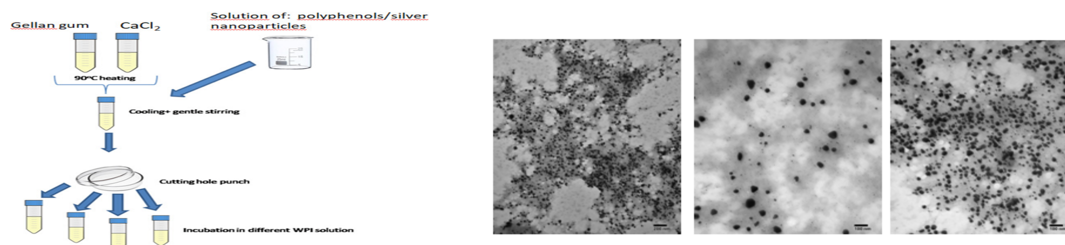

Fig.1 Scheme of obtaining GG-WPI hydrogels with polyphenols or silver nanparticles obtained by using red tea. Figure 2: Silver nanoparticles

Thanks to taking photos using the TEM microscope, it was possible to observe the generated particles. In the pictures we can see how much they were able to obtain and that they are spherical and do not succumb to agglomeration

Conclusions and plans for future
Based on the conducted tests, it can be concluded that silver nanoparticles have been obtained by chemical reduction. The obtained nanoparticles well as polyphenols are characterized by antibacterial properties, therefore the developed hydrogels with their addition will undergo cell and bacteriological tests. In addition, mechanical tests of hydrogels are provided.

References: 1. „Occurence, production and applications of gellan, curent state and perpectives" AM.Fialho, LM Moreira, AT. Granja,Appl.Microbiol Biotechnol 79: 889–900.
2. „In vitro engineered cartilage using synovium-derived mesenchymal stem cells with injectable gellan hydrogels" Fan J, Gong Y, Ren L et al. 2010; . Acta Biomater 6: 1178–1185.
3. "Silver nanoparticles for medical applications produced with the use of stabilizing-reducing compounds derived from natural resources" K.Pluta, A.M Tryba, D. Malina, Adv. Nat. Sci.: Nanosci. Nanotechnol, 8,1-7 (2017).

Session 2 O7 - A novel 3D polymeric tool for accurate screening of the performance of immunodiagnostic polymeric microneedles

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INTRODUCTION: Melanoma is the most lethal skin cancer, having a rapid increase of occurrence over the past 30 years1.To date, the most effective treatment for melanoma is the early diagnosis, which is followed by surgical resection. Therefore, in order to improve these disappointing statistical figures, it is essential to develop efficient diagnostic tools for rapid detection of the disease's specific markers. Minimally invasive microneedles (MNs) are promising candidates, as they enable rapid and pain-free protein biomarker detection *in situ*. However, validating the developed microneedle (MN) systems remains a bottleneck. To date, the most commonly used systems for *in vitro* microneedle validation are either homogeneous solutions that contain the target antigen to be detected by the MNs or excised animal skin. Animal skin strikes many similarities with the human skin, however the animal skin properties, such as stiffness, elasticity, porosity, which vary between different patients cannot be easily tuned/ tailored 2. Furthermore, antigen solutions can be informative for a preliminary evaluation of the MN arrays, but they are not representative models of *in vivo* skin structure and biomarker concentration. Biomaterial based 3D structures can simulate important skin tissue features, such as stiffness, elasticity, porosity, structure, extracellular matrix presence that can vary between different patients, different skin types and with ageing. Moreover, they can provide a realistic structural environment for the penetration and action of MN. Therefore, these biomaterial based 3D structures have great potential as screening tools for MN evaluation.

The aim of this work was to validate the S100 expression, a marker that is upregulated in melanoma, on a microporous polymer based 3D melanoma model. S100 expression in the model was confirmed using a novel immunodiagnostic microneedle device.

METHODS: 3D polymer (PU) based microporous scaffolds (5x5x2.5mm3) were developed using the Thermally Induced Phase Separation (TIPS) method, as described previously3. The porosity was 80% and the pore size 100-120 µm. Thereafter, the metastatic melanoma cell line A-375 was injected and cultured in those scaffolds for 5 weeks. Evaluation of cell distribution within the PU matrix was conducted with Scanning Electron Microscopy (SEM). Viable (live) cells were visualised *in situ* with confocal laser scanning microscopy (CLSM) of several sections of each scaffold. Furthermore, the detection of the S100 marker was carried out with PLA microneedles both on the 3D scaffold and for the cell culture supernatants. The PLA microneedle device was produced, surface modified and coated with the S100 antibody as previously described, followed by the detection of the antigen via immunoassay analysis on the microneedle surface4.

RESULTS: The MN device was able to detect the S100 secretion from the melanoma cells in the scaffold after 35 days of a viable culture, producing a clear and visible detection signal similar to the one detected for the positive control samples. However, S100 gradients were not detected in the cell culture supernatants, suggesting that this versatile scaffolding tool can be an advantageous low cost animal free tool to be use as a surrogate for the *in vitro* evaluations of the MNs.

REFERENCES: 1American Cancer Society, 2018. 2K. Moronkeji and R. Akhtar, in Mechanical Properties of Aging Soft Tissues, eds. B. Derby and R. Akhtar, Springer International Publishing, Cham, 2015, pp. 237-263. 3S. Totti, M. Allenby, S. B. d. Santos, A. Mantalaris and E. Velliou, *RSC adv*, 2018, **8,** 20928-40 4K. W. Ng, W. M. Lau and A. C. Williams, Drug Deliv Transl Res, 2015, **5**, 387-396.

O8 - High throughput fabrication of cell spheroids by templating water-in-water Pickering emulsions

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Tissue engineering requires large amounts of cell spheroids [1-3]. Tissue spheroids have been actively used as 3D tumour models [4], tissue reconstruction and organ bioprinting [2]. Spheroids of adherent cells can be formed using different processes for cell clustering where they adhere to each other rather than to a substrate. The current processes of cell spheroid production involve spinner culture, NASA rotary culture and non-adhesive surfaces [5], the hanging-drop culture [6] and 3D culturing in microwells [7]. Although many techniques for tissue spheroids preparation have been reported, none of them are currently able to rapidly produce significant amounts of spheroids. Here we describe a simple and generic technique for high throughput generation of tissue spheroids based on encapsulation of dispersed adherent cells in a water-in-water Pickering emulsion stabilised by protein particles [8]. The emulsion is formed from a cell suspension in an aqueous solution of dextran (DEX), which is dispersed in an aqueous solution of polyethylene oxide (PEO) containing protein particles. The cells are trapped in the DEX drops of a stable DEX/PEO emulsion which they prefer compared with the continuous PEO phase. Further addition of more concentrated PEO phase leads to osmotically driven shrinking of the DEX drops and compresses the adherent cells into tissue spheroids which are isolated by breaking the emulsion by dilution with a culture media. We demonstrate the method by using HEK293 fibroblasts and show that the cells preserve their viability in the spheroid generation process. We also successfully prepared model membranes by growing HEK 293 cell spheroids in alginate films until they overlap and produce a tissue. This work will give researchers cheap and scalable technique for rapid preparation of similarly sized spheroids of adherent cells for bio-inks for 3D organ bioprinting applications and potentially for tumour models.

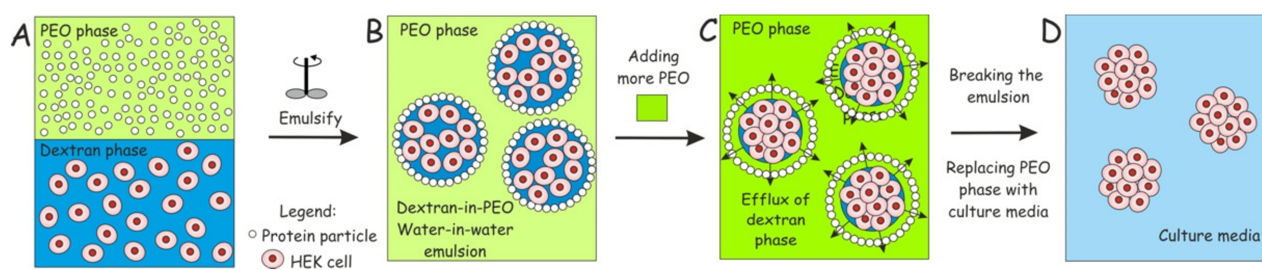

Figure 1. Schematics for our method for preparation of cell spheroids by templating DEX-in-PEO water-in-water Pickering emulsions.

[1] T. Sato, R.G. Vries, H.J. Snippert , M. Van de Wetering , N. Barker, D.E. Stange , J.H. Van Es , A. Abo, P. Kujala , P.J. Peters , H. Clevers, *Nature*, 2009, **459**, 262.
[2] A.A.K. Das, R.F. Fakhrullin, V.N. Paunov, in Cell Surface Engineering: Fabrication of Functional Nanoshells, The Royal Society of Chemistry, 2014, pp. 162-184.
[3] V. Mironov, R. P. Visconti, V. Kasyanov, G. Forgacs, C. J. Drake and R. R. Markwald, *Biomaterials*, 2009, **30**, 2164.
[4] J. Friedrich, R. Ebner and L. A. Kunz-Schughart, *Internat. J. Rad. Biol.*, 2007, **83**, 849.
[5]Y. Morimoto and S. Takeuchi, *Biomater. Sci.*, 2013, 1, 257.
[6] Y. C. Tung, A. Y. Hsiao, S. G. Allen, Y. S. Torisawa, M. Ho and S. Takayama, *Analyst*, 2011, **136**, 473.
[7] M. Kato-Negishi, Y. Tsuda, H. Onoe and S. Takeuchi, *Biomaterials*, 2010, **31**, 8939.
[8] A.A.K. Das, B.W. Filby, D.A. Geddes, D. Legrand, V.N. Paunov, *Materials Horizons*, 2017, **4**, 1196.

O9-Our hydrogel journey so far: discoveries and challenges

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Low molecular weight hydrogelators (LMWHGs) can form viscoelastic solid-like materials by formation of a three-dimensional fibrous network derived from the non-covalent self-assembly of the gelator molecules in water (and other biologically relevant media).[1] Our research focuses on (i) the design, synthesis and characterization of novel LMWHGs and their corresponding functional biomaterials and (ii) evaluation of potential applications, e.g. cell culture.[2]
Our journey began with the design of several monosaccharide amphiphiles in the hope of making successful hydrogelators. Out first two aromatic carbohydrate amphiphiles were GalNHFmoc and GlcNHFmoc.[3] We then progressed to explore alternative, more biocompatible, aromatic motifs which were food/drug-based as well as inclusion of phenylalanine. In parallel, we also explored other aromatic moieties to allow gelation of the diphenylalanine motif (FF). Throughout this time our strategy was simple: the minimum number of synthetic steps (e.g. by use of chemoselectivity) and the use of biocompatible building blocks with potential for added value, e.g. biorecognition.
We have met a number of challenges on the way. The most persistent of these has been purification of the amphiphilic molecules. Some of these issues were overcome by simple changes of reagents, e.g. replacement of DIPEA by $NaHCO_3$ for amide bond couplings. A further significant challenge, as organic chemists, was materials characterisation. After much optimisation, we now use a range of techniques (IR, fluorescence, TEM/SEM, XRD, rheology, NMR, etc.) to characterise our materials. In addition, we have developed a range of experiments using circular dichroism (both synchrotron and conventional instrumentation) which has enabled us to not only characterise the gel macroscopically, but to also undertake multi-site sampling within the gel, allowing evaluation of a number of parameters including homogeneity within a given gel sample.[4]
We have now identified and characterised eleven hydrogelators and their hydrogels and have started to explore potential applications. Initial cell culture work has included 2D culture of glioblastoma cancer cells for evaluation of cytotoxicity and proliferation capacity. Further cell types will be evaluated with both pure and multi-component hydrogels. Other applications have involved the use of the hydrogels to stabilise silica-based nanoparticles in solution during storage and no toxic effects of the hydrogels as a storage medium were seen in *ex ovo* experiments.[5]

References
1. Du X, Zhou J *et al. ACS Appl. Mater. Interfaces* **2016**, *8*, 22005.
2. Liu J, Sun Z *et al. Nature Materials* **2016**, *15*, 13.
3. Birchall LS, Roy S *et al. Chemical Science* **2018**, *2*, 1349.
4. Sitsanidis E, Piras C *et al. Chirality* **2018**, *30*, 708.
5. Giovannini G, Kunc F *et al. RSC Advances* **2017**, *7*, 19924.

Session 3 Biofabrics and Bioengineering

O10 - Enhanced antimicrobial effect of berberine and chlorhexidine in nanogel carriers with cationic surface functionality

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We report a strong enhancement in the antimicrobial action of berberine and chlorhexidine encapsulated into polyacrylic acid-based nanogels followed by further surface functionalisation [1]. Due to the highly developed surface area, the nanogel carrier amplifies the contact of berberine and chlorhexidine with microbial cells and increases its antimicrobial efficiency. We show that such cationic nanogel carriers of berberine can adhere directly to the cell membranes and maintain a very high concentration of berberine directly on the cell surface. We developed a novel surface functionalized nanocarrier for berberine by using polyacrylic acid based-nanogel particles (Carbopol Aqua SF1) coated with a cationic polyelectrolyte (PDAC) which shows a strong boost of the berberine antimicrobial action. We demonstrated that the antimicrobial action of the PDAC coated nanogel loaded with berberine and chlorhexidine on *E. coli*, yeast, and *C. reinhardtii* is much higher than that of the equivalent solution of both free berberine and free chlorhexidine due to the electrostatic adhesion between the positively charged nanogel particles and the cell membranes. Our results also showed a marked increase in their antimicrobial action at shorter incubation times compared to the non-coated nanogel particles loaded with the same antimicrobial agent under identical conditions. We attribute this boost in the antimicrobial effect of these cationic nanocarriers to their accumulation on the cell membranes which sustains a high concentration of released berberine or chlorhexidine causing cell death within much shorter incubation times. This study can provide a blueprint for boosting the action of other cationic antimicrobial agents by encapsulating them into nanogel carriers functionalised with a cationic surface layer. This nanotechnology-based approach could lead to the development of more effective wound dressings, disinfecting agents, antimicrobial surfaces, and antiseptic and antialgal/antibiofouling formulations.

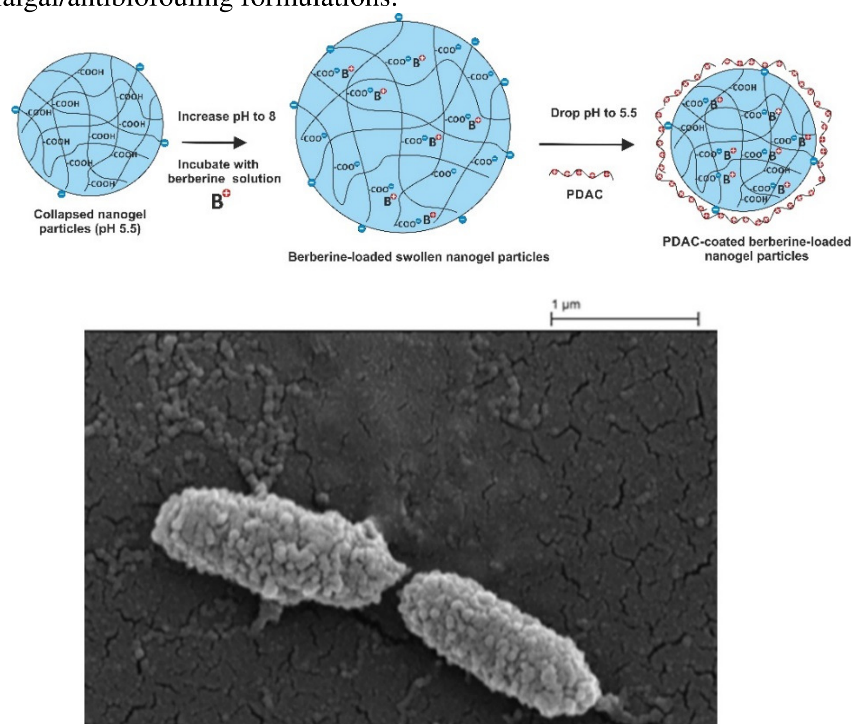

Figure 1. TOP: Fabrication of cationic surface functionalised nanogel particles loaded with berberine and their antibacterial effect; BOTTOM: *E.coli* cells after incubation with berberine-loaded carbomer nanogel surface functionalised with PDAC.

Acknowledgements. M.A. is grateful to the Higher Education Ministry of Iraq for financial support from his PhD studentship.

[1] M.J. Al-Awady, G.M. Greenway, V.N. Paunov, *J. Mater. Chem. B*, 2017, **5**, 7885-7897.

Gethin Allen

O11 - Development of synthetic biology inspired protein based compounds as novel corrosion resistant metal coatings and transparent adhesives

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Supported by Defence and Security Accelerator (DASA), Defence Science and Technology Laboratory (Dstl) project grants CDE100367 and ACC101824.

The initial project investigated the potential of natural and engineered amyloid proteins from Streptomyces sp. as novel corrosion protection coatings for steel and magnesium alloys. A synthetic promoter system was developed to drive the expression and secretion of various functional amyloid proteins which are typically very difficult to express and purify. The native chaplin protein was used to coat different substrates such as HDG, Galfan, Magizinc steels and AZ31 magnesium alloy with one or more applications, creating layers of tens to hundreds of nm thickness. Coated HDG and AZ31 alloys were more resistant to corrosion in a 3.5% NaCl solution, as measured using SVET to determine mass loss and hydrogen evolution due to corrosion. Multiple applications of the protein increased the resistance. Various additions and modifications have been investigated to improve the properties of the coatings, including genetic modification of the gene sequence to incorporate protein binding domains and chemical modification. Chaplin protein with a covalently bound chemical corrosion inhibitor retained the ability to form amyloid fibrils and coat materials.

Amyloid proteins were also found to have potentially useful adhesive properties and we are investigating their application in optically transparent adhesives. Adhesives currently used to bond laminated or layered transparent materials are prone to degradation in optical clarity due to water ingress and eventual delamination. We have investigated the bonding potential and transparency of natural and engineered amyloid proteins, both alone and in the presence of partner biopolymers and bulking materials, as a novel synbio-adhesive to bond glass and polycarbonate. These adhesives have the added advantage that they are light-weight, thinner, and potentially have a lower environmental impact than the conventional adhesives.

This project has provided proof-of-concept for the use of synthetic biology inspired amyloid protein based compounds as both adhesives and corrosion resistant metal coatings.

O12 - Bioinspired auxetic materials for sports equipment

Tom Allen
Manchester Metropolitan University

Auxetic materials have a negative Poisson's ratio (NPR), meaning they expand laterally when stretched and contract laterally when compressed [1]. NPR can enhance other properties such as energy absorption and indentation resistance, while offering synclastic curvature (doming rather than saddling). Auxetic materials occur in nature and include cat skin, cow teats and nacre from sea shells.

The first man-made auxetic material was made from open cell foam, produced using a thermomechanical process, that is now well-established. The first step in the process involves compressing the foam in a metal mould to around a third of its volume to produce a re-entrant cell structure. The foam is then heated in an oven close to its 'softening temperature', following which it is cooled within the mould to set the re-entrant structure in place. Under tension, the buckled cell walls of the re-entrant structure straighten, causing expansion of the foam and an NPR. As well as foam, manmade auxetic materials can be made from composites, fibres and textiles, as well as additively manufactured (3D Printed), with specific geometries designed to expand or contract as required.

The enhanced properties of auxetic materials make them prime candidates for improving sports equipment, particularly for protection against impact. There are some commercial sports products with auxetic features, including running shoe uppers and midsoles, and helmet liners, with NPR often achieved by moulding material to create a specific structure. This presentation gives an overview of research investigating the application of auxetic materials to sports safety equipment and apparel, including those made from foams and 3D Printing. It will showcase experimental and modelling approaches involved with designing and testing auxetic materials. Results include enhanced indentation resistance and reduced peak impact force for auxetic materials, compared to their conventional counterparts.

[1] Duncan, O and Shepherd, T and Moroney, C and Foster, L and Venkatraman, P and Winwood, K and Allen, TB and Alderson, A (2018) Review of Auxetic Materials for Sports Applications: Expanding Options in Comfort and Protection. *Applied Sciences*, 8 (6). ISSN 2076-3417

Poster session

P1 - *A Novel Approach to Evaluate Microorganism Viability and Microbial Growth Using the Highly Versatile Heat-Transfer Method (HTM)*

K. Betlem , M. Zubko , D. Sawtell , B. van Grinsven, T.J. Cleij, P. Kelly , M. Peeters

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Keywords: Heat Transfer Method (HTM), yeast, Saccharomyces cerevisiae, DNA

The Heat Transfer Method (HTM) is a novel, versatile and low-cost thermal technique that has already shown its use in the analysis of (biological) targets ranging from small molecules, to DNA, to whole cells and bacteria. The surface can be functionalized with specific receptors (DNA, polymers) for measurements and is the central element through which the heat flux will pass. The internal temperature of the heat sink, T_1, is measured by a thermocouple and steered via a controller, which is connected to a power resistor. The front side of the chip is exposed to the liquid, where T_2 is measured at the solid–liquid interface. To extract the heat-transfer resistance R_{th} (°C/W) quantitatively, the ratio of the temperature difference $\Delta T = T_1 - T_2$ and the input power P according to $R_{th} = \Delta T/P$, is analysed. Changes at the interface will reflect in a difference in the overall thermal resistance[1]. Here, we report a novel application for the HTM with the *real-time* viability study of microbes, using yeast (*Saccharomyces cerevisiae)* as a model organism. To accompany this study, the existing flow cell was redesigned, preventing the build-up of gasses produced in the metabolic cycle yeasts, leading to an increase of the R_{th} signal corresponding with the increasing concentration of cells in the flow chamber. Therefore, it was possible to discriminate between a wild type strain (DLY640) and a temperature sensitive mutation (*cdc13-1*) based on the growth kinetics. At temperatures higher than 30 °C the mutant strain stops growing[2]. This corresponds to a decrease in temperature of the optimal growth rate of the cells compared to wild type yeast cells.

The influence of factors inhibiting the replication process of yeast cells can be followed *in real- time* using this technique. Here, the signal increase in the thermal resistance under normal growth conditions seized when changing to a growth medium depleted of nutrients, the introduction of a toxic component (Cu_2SO_4) or application of a thermal shock treatment. Upon restoring the normal conditions, only the nutrient depleted condition remained viable, in all other situations the yeast cells where permanently eliminated. These results were confirmed by classical plating experiments of yeasts that were exposed to the same conditions as during the HTM measurement.

Having the advantages of simplicity, signal processing and portability, the setup can be used on site without requiring a lab environment. The described methodology is versatile and can be adapted to study different antimicrobial properties, such as the response to antibiotics on a wide range of different microbes.

1. B. van Grinsven, K. Eersels, M. Peeters, P. Losada-Pérez, T. Vandenryt, T. Cleij and P. Wagner, ACS Applied Materials & Interfaces, 2014, 6, 13309-13318.
2. K. Betlem, S. Hoksbergen, N. Mansouri, M. Down, P. Losada-Pérez, K. Eersels, B. van Grinsven, T. Cleij, P. Kelly, D. Sawtell, M. Zubko, C. Banks and M. Peeters, Physics in Medicine, 2018, DOI: 10.1016/jp.hmed/2018.05.001.

P2 – POLYLYSINE ENRICHED DECELLULARIZED MATRICES: A PROMISING APPROACH FOR VASCULAR SURGERY

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Introduction

Cardiovascular diseases are a leading cause of death worldwide[1]. Current clinical approaches show poor efficiency in the replacement of small-caliber arteries (<6 mm). The use of autologous saphenous vein or mammary artery is currently the gold standard. Alternatively, the use of synthetic grafts is possible, despite it leads to implant failure for small-caliber systems[2].
Due to the different compliance between the native vessel and the synthetic graft, the mechanical behavior of the vessel wall is a major cause of inefficient substitution[3]. In addition, the difference in mechanical properties could generate different blood flow with respect to physiological values, promoting the formation of thrombi or aneurysms.
The use of decellularized scaffolds has shown good prospects in various applications for regenerative medicine[4]. Through the decellularization process, the cellular elements are completely removed, retaining the native extracellular matrix (ECM). The scaffold obtained is an excellent substrate for cell adhesion, growth and proliferation. However, it may weak the structure of the vessel. The purpose of this work is to obtain a scaffold chemically enriched with polylysine. This acts as a cross-linker making the scaffold more resistant from the mechanical point of view, without altering biocompatibility and hemocompatibility properties.

Experimental Methods

The matrices were obtained by decellularization and enrichment with polylysine (sueGraft®) of porcine arteries (femoral and carotid). In order to verify the effectiveness of the decellularization process, DAPI, hematoxylin/eosin staining, and quantification of residual DNA were performed. The efficiency of the enrichment procedure was also verified, through XPS and TOF-SIMS analysis. After culture of endothelial cells on the enriched matrix, biocompatibility of the material was verified. In order to measure elasticity, burst pressure and degradation in working condition, mechanical tests were performed. Finally, several parameters related to hemocompatibility of the scaffold were evaluated.

Results

DAPI and hematoxylin/eosin staining confirmed the effectiveness of the decellularization method. The quantification of the DNA test showed that the amount of residual DNA was significantly reduced compared to untreated control. Values obtained resulted much lower than the threshold values reported in literature.
Cells grown on polylysine-enriched matrices showed excellent biocompatibility
The analysis of the Young moduli showed that stiffness value of the enriched matrix is not significantly different to native vessel. Burst pressure test showed strengthening of the polylysine-enriched matrix, which can withstand higher pressures compared to native vessel. Matrix degradation test showed that the polylysine-enriched vessel has almost no weight loss, which indicates an absent degradation.
Concerning hemocompatibility, the evaluated parameters suggest that polylysine-enriched matrices increase clotting time.

Discussion

The matrices obtained by decellularization of blood vessels and enriched with polylysine show an excellent biocompatibility, promising mechanical properties and improved hemocompatibility properties for the intended use as vascular substitutes. Based on these results, matrices enriched with polylysine are a promising approach for vascular substitution.

References

1. Mozaffarian D, et al, Circulation. 131(4):e29-322, 2015.
2. Rathore A, et al., Nanomed Nanobiotechnol. 4(3):257-272, 2012.
3. Pashneh-Tala S et al. Tissue Eng Part B Rev. ePub, 2015.
4. Chiu JJ et al. EPhysiol Rev. 91(1):327-387, 2011.

P3- Smart Thermometers: Screening for Biomarkers Using Thermal Detection Methods

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2. MIP Diagnostics

Molecularly Imprinted Polymers (MIPs) are synthetic antibody mimics; similar to antibodies, they have high affinity for a chosen template molecule but their advantages include low-cost, superior chemical and thermal stability, and a straightforward production process. In this contribution, we will focus on strategies to develop sensors from MIPs which include i) dipcoating of nanoMIPs onto thermocouples, and ii) screen-printing of polymers to develop bulk modified MIP-Screen Printed Electrodes (MIP-SPEs).
Thermocouples were dipcoated with nanoMIPs designed for various targets, ranging from a small molecule (vancomycin) to a larger macromolecule (Epithelial Growth Factor Receptor, a known biomarker). These thermocouples were subsequently inserted into a flow cell that was coupled to a home-made thermal device, which allows precise control over the temperature in the flow cell and its surroundings. The binding of biomolecules to the MIP layer increased the thermal resistance at the interface of the functionalised tip, which led to lower temperatures being recorded by the thermocouple[1]. Blank thermocouples, without the presence of the polymer recognition layer, did not show any fluctuation in the temperature signal, demonstrating the high specificity of this method. The noise on the signal was minimal and for all targets, limits of detection in the low nanomolar regime were determined.
Secondly, we have developed a functionalization procedure for screen-printing ink by direct mixing with MIP particles. It was possible to mix up to 30% of the particles in an ink, with SEM analysis demonstrating the presence of the MIP powder on the surface. Using the neurotransmitter noradrenaline as a model compound, we have demonstrated that we can print functionalized SPEs on a range of substrates such as polyvinylchloride, paper, tracing paper and polyester. Tracing paper absorbs a large amount of water and can deform as a result, meaning it was not possible to measure buffered solutions. However, the results with paper as the substrate were promising and showed it preformed comparably to polyester, providing a more sustainable alternative.

The two presented sensor platforms are easy to use, low-cost, and have potential for mass production. This adds value to the commercialization of this sensor platform, and brings it a step closer to incorporation into current technologies. We foresee applications in the food industry and clinical medicine, where there is a great need for rapid and low-cost detection of certain biomarkers. It is a highly versatile platform as changes are only required to the MIP layer for different desired targets. A range of thermocouples can also be employed to transform these sensors into an array format.

[1] F. Canfarotta, J. Czulak, K. Betlem, A. Sachdeva, K. Eersels, B. van Grinsven, T.J. Cleij, **M. Peeters,** *Nanoscale,* 2018, **10,** 2081-2089.
[2] S. Casadio, J.W. Lowdon, K. Betlem, J.T. Ueta, C.W. Foster, T.J. Cleij, B. van Grinsven, O.B. Sutcliffe, C.E. Banks, **M. Peeters,** *Chem. Eng. J.* 2017, **315,** 359-368.

P4 – George Hurst

Investigation of Solid Residues from Biomass Catalysis

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Introduction: A growing interest of researchers is the development of lignocellulosic biorefineries that utilise materials as diverse as wood and straw for the production of essential chemicals. Catalytic methods are especially promising due their high selectivity for high value chemicals such as levulinic acid and lactic acid, which can be used as fuels or for plastics respectively. Mineral acids such as sulphuric acid have been found to produce satisfactory yields of levulinic acid but also produce significant amounts of insoluble solid residue. The solid residue is composed of inert parts of the biomass but also contains by-products of the catalysis. Both the minimisation and valorisation of the waste solid residue is essential to producing commercial quantities of "biochemicals". It is therefore imperative to first quantify and characterise the solid residues.

Methods: Biomass samples were ball milled to and analysed for structural sugars using acid NREL method 510. The reactions were conducted using an Anton-Parr Monowave 300 microwave reactor with 2M H_2SO_4 with solids concertation between 1-7.5wt%. The reaction time varied between 15-120mins with reaction temperatures between 160-200°C. The heating time was 2 minutes and the reaction vessel was cooled using compressed air to 55C. The solution was then filtered with lab filter paper and the filtrate was then analysed for organic acids using HPLC. The solid residue and filter paper were washed with deionised water before being dried and weighed.

Results: The initial results show that the solid residue cannot be avoided with poplar wood and sulphuric acid. The solid residue yields varied between approximately 30-50% with an approximate inverse relationship between levulinic acid yield and residue yield. It was also noticed that biomass concentration had only a small effect on the levulinic acid yield and the solids yield.

Keywords: Biomass, catalysis, solid residues

References:

[1] Sluiter, A. et al. *Determination of Structural Carbohydrates and Lignin in Biomass*. NREL, Colorado, USA, 2008

P5 – Title: Heat-Transfer Method (HTM) for the real-time detection of bacteria from wastewater samples and prevent bacterial contamination using drugs and other alternatives

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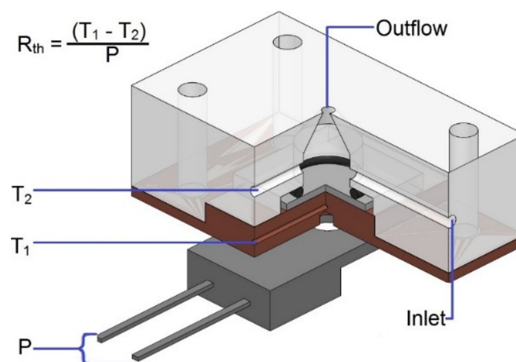
Keywords: Bacteria, Heat-Transfer Method, Antibiotics, UV treatment,

In previous work, the Heat-Transfer Method (HTM) was used to study the viability of yeast cells (*Saccharomyces cerevisiae*), proving the ease in sample handling, the straightforward data interpretation, and cost effectiveness of thermal sensing. In this work, we will explore the use of the Heat-Transfer Method (HTM) for the real-time detection of bacteria from wastewater samples. The complexity of the samples is shown by characterizing up to six different bacterial species in samples, all exhibiting different growth characteristics, and they were divided into gram positive and negative species. The thermal responses of gold electrodes upon exposure to strongly diluted samples of bacteria was monitored, and showed an increase in thermal resistance at the solid-liquid interface with increasing concentrations of the bacteria. Specially designed flow cells were synthesized using 3D printing to facilitate longitudinal experiments. Lastly, the HTM will be used to study the effect of different bactericidal components such as antibiotics, disinfectants and UV treatment, which will determine how we can optimize wastewater treatment and prevent bacterial contamination. With this new application of the HTM, we have shown the real-time growth of bacteria and determined aspects (temperature, nutrients, pH) that influence the growth. The method can easily be adapted for further study of other microorganisms and in particular to study the response of bacteria to selected antibiotics. Currently, we are determining and optimizing conditions facilitating the removal of bacteria from wastewater samples.



Reference:

1. K. Betlem, S. Hoksbergen, N. Mansouri, M. Down, P. Losada-Pérez, K. Eersels, B. van Grinsven, T.J. Cleij, P. Kelly, D. Sawtell, M. Zubko, C. Banks, M. Peeters,∗,2018. Real-time analysis of microbial growth by means of the Heat-Transfer Method (HTM) using Saccharomyces cerevisiae as model organism, Physics in Medicine, 6, 1–8.

P6: Dean Roberts, Aqib Asghar, Kai Betlem, Marloes Peeters
Manchester Metropolitan University

Introduction

With the increased focus on mental health issues in recent years, it logically follows that pharmaceutical companies have seen an increase in demand for anti-depressants. Fluoxetine (brand name Prozac), acts as a Selective Serotonin (5-hydroxytryptamine; 5-HT) Reuptake Inhibitor, acting as an antagonist for the 5-HT receptors. This increased demand for anti-depressants such as fluoxetine has seen detectable amounts of the drug finding its way into natural water sources as a result of the high percentage of prescription drugs disposed into water systems, posing environment issues. Recent studies show concentrations to be approximately 0.02 µg/L in surface water[1]. In aquatic life these substances result in drowsiness, increasing the ease of predation on these species and altering the food chain and causing bio-accumulation of other species. As solutions of drug molecules have been shown to 'quench' fluorescence, and molecularly imprinted polymers have been shown to be highly selective towards a desired template, it was hypothesised that should a fluorescent polymer be synthesised with a specific template, an optical antibiotic detection method could be produced as a proof of concept for optical fluoxetine detection further down the road.

Experimental

The fluorescent polymer was synthesised using a synthesised anthracene derivative monomer, AIBN initiator and EGDMA crosslinker and a clomipramine template was initially selected. The fluorescence of the synthesised polymer was evaluated using fluorescence microscopy. A small mass of sample was placed between 2 slides alongside methanol as a solvent. The fluorescence was then analysed at 4 different wavelengths of light. A 1 mM solution of the template antibiotic was added to the slides, and the fluorescence re-evaluated using the same wavelengths as used previously.

Results and Discussion

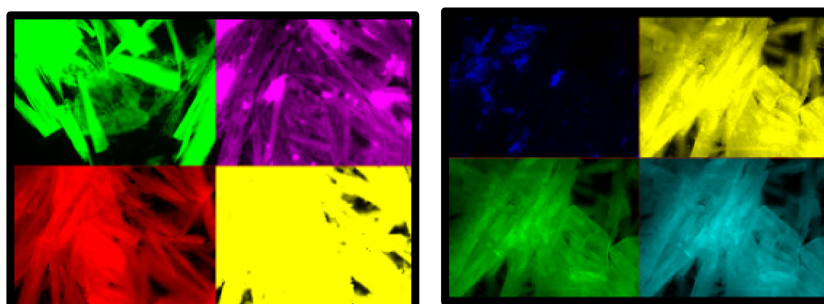


Figure 1: Comparison of fluorescence microscopy images before (left) & after (right) the addition of Clomipramine 1 mM solution. Each quadrant represents a different wavelength of light.

Comparison between the monomer and polymer using fluorescence microscopy showed a clear change in the intensity of fluorescence. This can also be seen in Figure 1, as the more intense spots of fluorescence, particularly in the top right left panel before the addition of antibiotic. The addition of the 1 mM clomipramine solution shows a decrease in the intensity of fluorescence at all wavelengths tested and this is particularly evident when comparing the top left panels (Figure 1). The drawback to these images is they are not representative of the same section of the polymer. A more suitable method would be to create a time-lapse which covers the same section before, during and after addition of antibiotic solution. Optimisation of the ratio of fluorescent monomer units against non-fluorescent units is expected to improve the detection system.

Conclusions

We have developed a polymer based detection system that is able to show an optical difference in response to the presence of a predetermined anti-biotic solution.

References

J. Corcoran, M. J. Winter, C. R. Tyler, Crit. Rev. Toxicol., 2010, 40, 287-304

Acknowledgements

-The Royal Society of Chemistry, for an analytical trust bursary for D.Roberts

P7 - **Temperature Induced Solubilization of Hydrophobic Active Pharmaceutical ingredient Lamoterigine in Different Pluronics- A Detailed Solubilization, SANS, DLS, HTM, *in vitro* Release and Microscopy Study.**

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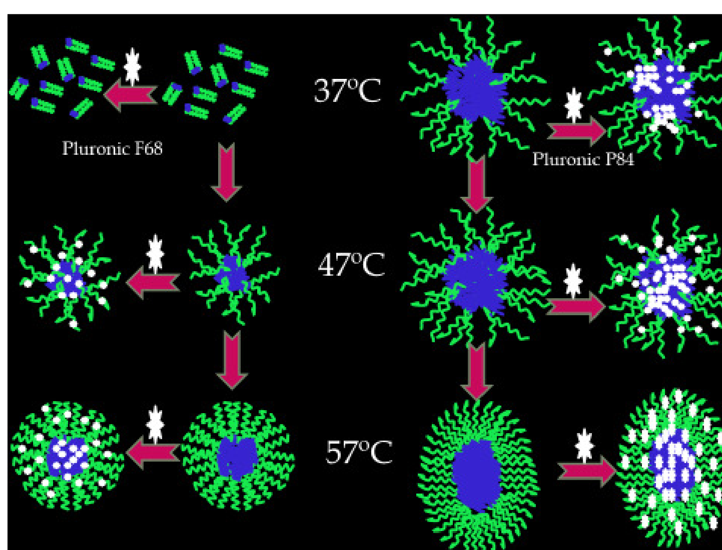
Abstract-

Pluronic (Tri–block copolymers) play an important role in pharmaceutical performance to increase the solubility and bioavailability of hydrophobic drugs. These micelles often lack stability, exhibit unsatisfactory drug loading capacity, or have broad size distribution this work aims to solve this issue by studying the solubilization of hydrophobic drugs in different pluronic micelles at variable temperature. Herein, a series of five pluronic micelles viz. P84, P85, F127, F108 and F68 have been select for study solubilization of hydrophobic drug Lamotrigine (LAM) at different temperatures i.e. 37℃, 47 ℃ and 57℃ using Uv-Visible spectroscopy. We have observed that solubilization of LAM increased with increase in the temperature. The morphological and structural changes taking place in pluronics by increasing the temperature was determined using small angle neutron scattering (SANS) measurements, Scanning electron microscopy (SEM), heat transfer methods (HTM), and dynamic light scattering (DLS). From SANS measurements we observed that at 57℃, in case of P84 micelles there is remarkable increase in the aggregation number and resulting in the conversion of the spherical micelles in to prolate ellipsoidal micelles. This is first report in which we explained the structural changes that occur in the thermoresponsive micellar media with the help of HTM methods. A significant difference between hydrodynamic diameter (*Dh)* of loaded and unloaded micelles assure that LAM was solubilized in pluronic micelles. The SANS results revealed that aggregation number decreases in the presence of LAM, causing the number density of micelles to increase. *In vitro* drug release study of five different pluronic formulations show sustained release behaviour. The present results demonstrate that by changing the temperature we can modulate the Structure (morphology), drug loading capacity as well as release behaviour from the pluronic micelles.



P8 – **Optimization of cell culture methods for a production of monoclonal antibody specific to Hemoglobin F**

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Abstract

Monoclonal antibody (mAb) specific Hemoglobin F has a potential to be used in a production and commercialization of an immunological test for diagnosis of beta thalassemia and sickle cell disease. The antibody is currently being produced *in vitro* from a mouse hybridoma in a batch, static culture, a method which is known to have low efficiency and requires intensive labour. This project aims to improve the yield and the cost-effectiveness of the antibody production by investigating the cell behavior and response to variable cell culture conditions, namely cell inoculation density, materials of the culture substrates, and the frequency of media exchange. The cell growth, cell viability, glucose consumption, lactic acid production, and mAb yield are measured and compared. Furthermore, a feasibility study using hollow fiber bioreactor to culture cell in a high density and continuous mode is performed and includes optimization of operative parameters such as flow rates of media and cell solution, and a level of glucose present in the feed media.

Keywords: monoclonal antibody production; hybridoma; mammalian cell culturing; hollow fiber bioreactor

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P9 **"Bioinspired Materials Conference 2018"**

Forensic Electrochemistry: The Electroanalytical Sensing of Mephedrone Metabolites

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Abstract

Introduction: The pervasiveness of the production and abuse of new psychoactive substances (NPS), termed "legal highs", has sparkled the recruitment of a rapid, on-the-spot, sensitive analytical protocol for their sensing and quantitation. Mephedrone (4-MMC) has been one of the popular legal high deliberates among drug abusers and imposes serious public health problems. A considerable number of analytical reports have been published for mephedrone quantitation, however, the quantification of its metabolites has not until now been largely overlooked, with the few reports present laboratory based and unsuitable for cost/time effective on-site inspection by the non-specialist. In this work, we report for the first time the electrochemical sensing of two 4-MMC metabolites, namely nor-mephedrone (4-methylcathinone, 4-MC) and dihydro-mephedrone (4-methyl ephedrine, 4-MMC-R), utilising screen-printed graphite electrodes (SPEs) as electroanalytical sensing platforms. SPEs are favoured since they can be mass-produced, providing a cost effective, reliable and reproducible electroanalytical sensors that can be employed without initial pre-treatment steps.

Methods: Cyclic voltammetric measurements were performed for 4-MC and 4-MMC-R in phosphate buffer solution (PBS) pH 7.0 and 3.0, respectively, as well as in spiked human urine samples using SPEs.

Results and discussion: The proposed protocol was validated according to the International Conference on Harmonization (ICH) guidelines, in model buffer solutions as well as in spiked human urine. The accessible linear ranges were found to correspond to 40 – 300 µg mL^{-1} (RSD% = 0.47 – 1.58%, *N*=3) for 4-MC in PBS pH 7.0 and spiked human urine, while the analytical linear range was more sensitive in the case of 4-MMC-R as follows, 15 – 300 µg mL^{-1} (RSD% = 0.12– 0.23%, *N* = 3, in PBS pH 3.0) and 25 – 300 µg mL^{-1} (RSD% = 0.93 – 1.89%, *N* = 3, in human urine). The potential interference of adulterant metabolites commonly found in NPS street samples was also explored (at both pH 7.0 and 3.0). The limits of detection (LOD, 3σ) were calculated and found to correspond to *ca*. 7.11 and 4.39 µg mL^{-1} for 4-MC and 4-MMC-R, respectively, in PBS and *ca*. 8.86 and 6.22 µg mL^{-1} for 4-MC and 4-MMC-R, respectively, in spiked human urine samples. The electrochemical approach reported herein provides a novel laboratory tool for the identification and quantification of synthetic cathinone metabolites and has potential for the basis of a portable analytical sensor for their fast, cheap, reliable and accessible determination in the field.

P10 - Nicholas Aldred

ENBA: The European Network Of Bioadheson Expertise

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Composed of partners from 39 countries and funded under COST Action 15216 (2016-2020), ENBA aims to draw together elements from diverse fields of science and engineering, throughout Europe and beyond, that either require or target biological adhesion processes. Stakeholders range from academics of various disciplines to dental technicians, surgeons, production engineers in hi-tech manufacturing and developers of non-stick or antifouling coatings, through to those involved in the production of wood products or advanced construction materials. The ultimate goal is delivery of advanced engineering solutions to specific high-value problems, inspired by adhesion processes in nature. ENBA is delivering this through the development of fundamental knowledge, facilitated by networking activities including workshops, conferences and Short-Term Scientific Missions. By coordinating the basic research activities on-going in international laboratories, developing collaborations and leveraging national funding mechanisms, the Action is fostering greater interdisciplinarity, awareness and knowledge-sharing among network members from the physical, social and life sciences. ENBA is an open network, and welcomes applications for membership from interested parties via the Action website (www.ENBA4.eu).

P11 – Anca Florea

A molecularly imprinted polymer sensor for selective detection of cocaine in street samples

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Introduction

Electrochemical sensors have gained increasing interest for the detection of illicit drugs, due to their rapidity, sensitivity, low cost and portability. The integration of molecular imprinted polymers (MIP) with electrochemical transducers represents a promising approach for sensitive and selective detection of illicit drugs in complex matrices. Among the preparation methods for MIP, electropolymerization is a simple and convenient route, allowing to easily control film thickness and obtain thin, adherent films in one-step, directly on the surface of the transducer.

Methods

An amperometric sensor based on MIP for direct detection of cocaine in street samples was developed. Monomers with high recognition ability for cocaine were selected by computational modelling and deposited directly on the surface of graphene-modified electrodes via electropolymerization by cyclic voltammetry. Prior to MIP electrodeposition metallic nanoparticles (Pd) were electrodeposited onto graphene electrodes to improve the sensor's performance.

Results and discussion

Firstly, taking into consideration the binding scores of computational modelling, poly(*p*-aminobenzoic acid) and poly(*o*-phenylenediamine) layers were employed in voltammetry studies and compared in terms of binding affinity and electrochemical response towards cocaine; *p*-aminobenzoic acid showed better conductivity and higher sensitivity for cocaine and was thus further selected as monomer for MIP synthesis. The cyclic voltammograms for both MIP and non-imprinted polymer (NIP) show the growth of the polymeric film onto the electrodes. The extraction and rebinding steps were optimized by square wave voltammetry (SWV). The integration of nanomaterials in MIP (graphene, metallic nanoparticles) increase the performance of the sensor, having the benefit of enhancing the number of accessible complementary cavities, the catalytic activity of the surface and the fast equilibration with the analyte. The MIP sensor showed satisfactory sensitivity for cocaine detection with good reproducibility (detection limit 50 µM, RSD 0.71%, n=3) and was able to selectively detect cocaine in real street samples.

P12 – 3D Spongy Graphene Modified Screen-Printed Sensors for the Voltammetric Determination of Narcotic Drug Codeine

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Abstract: A novel adenine-functionalized spongy graphene (FSG) composite, fabricated *via* a facile and green synthetic method has been explored as a potential electrocatalyst toward the electroanalytical sensing of codeine phosphate (COD). The synthesized composite is characterized using Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, X-ray powder diffraction, UV−vis absorption spectroscopy, scanning electron microscopy, high resolution transmission electron microscopy (HRTEM), and thermogravimetric analysis. The FSG was electrically wired *via* modification upon screen-printed (macro electrode) sensors, which behave as a hybrid electrode material for the sensitive and selective codeine phosphate (COD) determination in the presence of paracetamol (PAR) and caffeine (CAF). The FSG modified sensor showed an excellent electrocatalytic response towards the sensing of COD with a wide linear response range of $2.0 \times 10^{-8} – 2.0 \times 10^{-4}$ M with a detection limit (LOD) of 5.8×10^{-9} M, indicating its potential for the sensing of COD in clinical samples and pharmaceutical formulations.

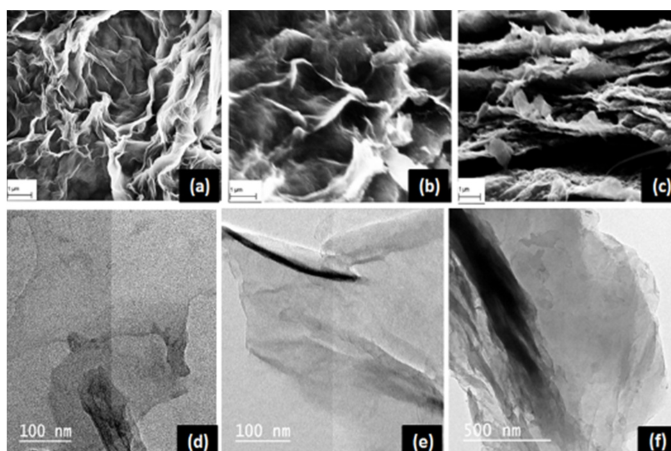
Introduction : Herein, a simple method is utilized to fabricate spongy functionalized graphene (FSG) through freeze-drying graphene oxide solution to inhibit graphene sheets from restacking, resulting in interconnected, and permeable 3D arranged crimped sheets. Such 3D arranged structure gives rise to a better contact at the electrode/electrolyte interface and quickens the charge exchange kinetics. This was trailed by functionalization of the spongy graphene oxide with adenine. The interaction between the host materials can be evidenced from the involved functional groups, resulting in several changes of the structure of graphene that are expanding the interlayer spacing or layer scrolling. After annealing, functionalized spongy graphene architecture (FSG) was obtained, which helps to avoid the stacking between graphene interlayers and reduce the likelihood of forming graphite. It is worth mentioning that FSG has not previously been explored towards the electrochemical detection/sensing of COD. The use of FSG-modified screen-printed electrodes (SPEs) improves the electrochemical response, compared to unmodified graphite SPEs, by decreasing the electrochemical oxidation potential of COD.

Method

Screen-printed electrodes (SPEs) form the basis of the FSG sensor and allow the electrically wiring of the FSG. The SPEs were fabricated as reported previously. FSG/SPE modified electrodes were prepared by drop-casting 5.0 µL of an aqueous solution containing 0.2 mg mL^{-1} FSG onto SPE with a micropipette. After 30 minutes, the ethanol evaporated (at ambient temperature) and the modified electrodes were ready for use.

Results and discussion

The developed sensor exhibits low limits of detection (5.80×10^{-9} M) and quantification (1.93×10^{-8} M) with a wide linear range (2.00×10^{-8} to 2.00×10^{-4} M) introducing a promising alternative for the quantitative determination of PAR, COD and CAF in their mixtures as commonly found in pharmaceutical formulations.



P13 – Molecularly Imprinted Polymers for the Capacitive Detection of Amphetamine-Type Stimulants

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Introduction

Illicit drug use includes the non-medical use of a variety of drugs that are prohibited by international law. Their usage is a global public health concern as it has been estimated that 230 million people worldwide (approximately 5% of the world's population) abused illicit drugs at least once in their life. Some of these drugs are naturally occurring while others such as amphetamine and amphetamine type stimulants (ATS) can be synthesized in laboratories. Detection of chemical markers related to the illegal synthesis of these drugs of abuse in sewage water is an approach to monitor the imperilment of the environment by chemical production waste. Therefore, this work, presents a capacitive biosensor for the detection of 4 methyl- 5 phenylpyrimidine (4M5PP) as an ATS-marker using molecularly imprinted polymers (MIP) as recognition elements. At first the best monomers were selected using molecular modeling, and different polymerization techniques were tested for the synthesis process. In the final step, the method was validated using contaminated environmental water samples.

Methods

Pyrimidine was chosen as the template molecule to make group specific MIPs towards different ATS-markers, including 4M5PP. A computational approach was used to aid in the particles' design. For this Spartan '16 software (Wavefunction, California, USA) was employed to estimate the interaction between the template and the functional monomer by calculating the binding energies between different monomers, cross linkers and template. A combination of two monomers (methacrylic acid and 2-vinylpyridine) was selected to enhance the interaction between the monomers and the template. Emulsion polymerization was then chosen for the synthesis, and the obtained particles were immobilized on a gold electrode surface through electropolymerization via matrix entrapment by using 0.1M tyramine. Finally, the measurements were done using a continuous flow system with a capacitive sensor (Capsenze, Lund, Sweden) resembling a continuous waterflow.

Results and Discussion:

The synthesized particles for 4M5PP showed high selectivity and significant sensitivity towards the target compound. The limit of detection was 500 µM with a linear range of 500 µM – 3 mM. The sensor was tested in environmental water samples, and it showed the same results as in purified water (Sartorius, Goettingen, Germany). Cross-reactivity experiments were performed with four structural similar compounds: benzylmethylketone (BMK), amphetamine, N-formylamphetamine (N-FA) and nicotine. Their concentrations were in the same order as 4M5PP to obtain a relevant comparison. The percentages of cross reactivity were 38%, 28% and 46% for both amphetamine and N-FA, nicotine and BMK, respectively. The impact of different additives on the capacitive signal (detergents, shampoos, pharmaceuticals, and sweeteners) was tested. Pharmaceuticals and sweeteners showed a decrease in the capacitance drop. The major impact resulted from the detergents and shampoo, with 0.1% detergent and 0.1% shampoo giving false positive results.

Acknowledgment:

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P14 - Strong heat blocking effect of self-assembled nanostructures – The case of thiol monolayers

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Thiol self-assembled monolayers (SAMs) are molecular assemblies of organic constituents formed spontaneously by the adsorption process of molecules in liquid or vapour phase on metal or metal-oxide surfaces. Over the last decades, SAMs have become popular due to their utility in various applications. In biosensing platforms, SAMs are often used as linkers to tether receptors to biochip surfaces [1]. To get a full understanding of SAM-properties, it is important to study also their formation kinetics and thermal-transport properties. The latter has not yet been addressed. However, it is already known that DNA and adsorbed cells at solid-liquid interfaces show a heat-blocking effect, which is utilized in the HTM (heat transfer method) biosensing technique [2].

In this work the HTM was employed to study the formation kinetics of thiol SAMs on gold surfaces using ethanol as a solvent. Two thiols: 1-dodecanethiol and 11-mercaptoundecanoic acid (11-MUA) differing only in their specific head groups were studied. The results indicate that the presence of a SAM on the gold surface leads to a surprisingly strong increase in the interfacial heat-transfer resistance R_{th}, given the fact that thiol molecules are only 1.5 nm in length. Furthermore, there is a concentration-dependent jump in R_{th} for concentrations higher than 0.5 mM. The thermal resistance displays a two-step evolution for concentrations below 0.5 mM: Initially, the thermal resistance decreases in comparison to a blank gold substrate. In a second phase, R_{th} increases gradually, eventually reaching a stable plateau value. This behavior can be attributed to a transition from a lying-down to a standing-up conformation of the thiols. Complementarily, the layer formation was monitored with the quartz crystal microbalance, Fourier-transform infrared spectroscopy, and atomic force microscopy.

The results demonstrate that a nanometer thin ‘thiol carpet’ causes an unexpectedly strong heat-blocking effect at gold/ethanol interfaces. Furthermore, the absolute increase in the thermal-boundary resistance depends on the used head group. This observation points to an interface effect, which can possibly be explained by the mismatch between the phonon frequencies of gold and the vibration frequencies of ethanol and thiol molecules in the THz regime.

Acknowledgements
Financial support by the Research Foundation Flanders FWO (project G.0B62.13N) is gratefully acknowledged.

References

[1] C. Vericat, *et al. Chem. Soc. Rev.* **39**, 1805 – 1834 (2010).

[2] B. van Grinsven, *et al. ACS Applied Materials & Interfaces* **6** (16), 13309 – 13318 (2014).

P15 – Peptide/graphene oxide hydrogel nanocomposites for intervertebral disc repair

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INTRODUCTION: Low back pain associated with intervertebral disc degeneration (IVDD) has been classified as a major contributor of global disability, affecting 84% of population and costing the healthcare over £12 billion/year in UK only[1]. Current treatments for IVD degeneration rely on disc replacements, which are highly invasive and poorly efficient in the long-term. Novel minimally invasive cell-based therapies allow delivery of cells or cell-seeded biomaterials at the injury site to repopulate damaged tissue and promote repair/regeneration. Among injectable biomaterials, self-assembling peptide hydrogels (SAPHs) represent potential candidates as 3D cell carriers, since they can mimic the native tissue supporting cell viability and differentiation[2,3]. Moreover, the advent of graphene-related materials as nanofillers has made the fabrication of graphene-hydrogel nanocomposites appealing[4], in which filler properties can be further exploited to direct the cellular fate[5]. Here, we incorporated graphene oxide (GO) within a SAPH to develop a novel biocompatible peptide-GO nanocomposite as a potential cell carrier for IVD repair applications.

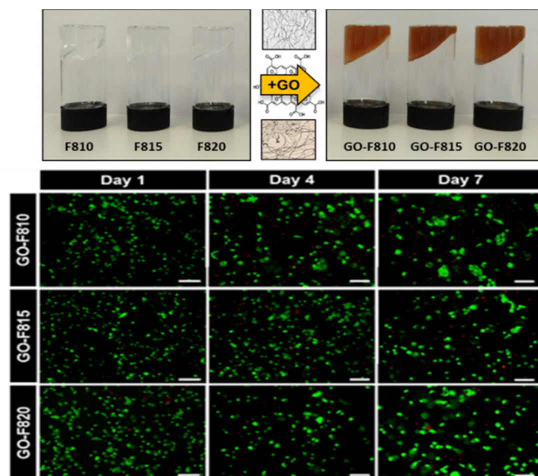

Figure 2. **Peptide and hybrid gels (top). Cell viability in the GO-containing hydrogels (below). For Live/Dead assay green= alive, red= dead cells. Scale bar=100um.**

METHODS: Peptide hydrogels were prepared by dissolving 10, 15 and 20 mg/ml of FEFKFEFK peptide powder in HPLC water and further titrated with 0.5M NaOH to a final pH of ~4. Peptide solutions were mixed with an aqueous solution of GO (mean size: 4.79 ± 2.13µm) to form peptide-GO hybrid hydrogels with GO final concentration of 0.5 mg/ml. Hydrogel microstructure was observed with FTIR, atomic force and transmission electron microscopy (AFM and TEM), while mechanical performance was assessed via oscillatory rheometry. Bovine nucleus pulposus cells (BNPCs) were then encapsulated in formed hydrogels and cultured in 3D for 7 days. Cell viability and metabolic activity were monitored 1, 4 and 7 days after encapsulation using Live/Dead and AlamarBlue assay.

RESULTS: GO flakes were homogenously dispersed in F8 samples, showing different levels of interactions with the peptide-based nanofibrillar network. Under specific peptide/GO ratios, the incorporation of GO enhanced the mechanical properties of peptide hydrogels, achieving average storage moduli (G'~10.5-12.8 kPa) comparable with human NP tissue (G'~10 kPa). Moreover, hybrid hydrogel resulted in biocompatible scaffolds, preserving characteristic NP rounded morphology, with high viability and constant metabolic activity over the period of observation, compared with GO-free systems that showed scaffold degradation and reduced metabolism.

DISCUSSION & CONCLUSIONS: These preliminary results showed that GO can be added to SAPHs to create mechanically-reinforced scaffolds, which resulted biocompatible for the 3D culture of NP cells. Hence, this study offers the rationale for a future use of peptide/GO hybrid hydrogels as scaffolds for NP cells, which results particularly appealing for novel cell-based approaches in NP tissue engineering.

REFERENCES: [1]S. Richardson. (2013) *The Intervertebral Disc*, pp.177-200. [2]A. Mujeeb (2013) *Acta Biom.* **9**(1), pp.4609-4617. [3]L. Castillo Diaz (2016) *J Tissue Eng*, **7**:1-15 [4]Wychowaniec *Biomacromolecules* (2018), **19**, 2731–2741 [5]L. Kenry *et al.* (2018) *Biomaterials*, **155**: pp.236-250.

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P16 – The Impact of Surface Energy Characteristics on Cell Viability of Modified Polyether-ether-ketone and Polyether-ether-ketone/Glass for Tissue Engineering

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Abstract

Aims and Objectives: The aim of this study was to examine the effect surface energy characteristics have on cell viability of Polyether-ether-ketone (PEEK), grooved surface topography PEEK, glass fibre reinforced PEEK (PEEK_GL) and grooved surface topography PEEK_GL for tissue engineering using various techniques such as Scanning Electron Microscopy (SEM) and goniometer. Also to evaluate the cell viability of PEEK, PEEK patterned, PEEK_GL and PEEK_GL patterned for tissue engineering to observe whether patterned topography and composite materials can effect the cell viability of MG-63 osteosarcoma cells using MTT cell viability assay.

Materials and methods: This study observes how microinjection moulded PEEK, PEEK Patterned, PEEK_GL and PEEL_GL Patterned surface topography impact the surface energy characteristics of PEEK and PEEK 30wt% glass composite, and how the surface energy influences cellular viability. An AST goniometer was used with depositions of 2μl of water, glycerol and cell culture media, and images were captured after 5 seconds. This was repeated three times and images obtained were examined using image J and an average angle measurement and standard deviation were recorded. Surface energy was calculated using Fawkes Theory from contact angle measurements obtained from AST Goniometer followed by cells were routinely cultured and cell viability analysed using MTT cell viability assay.

Results and Discussion: The patterned PEEK substrates were examined under the SEM to observe consistent grooved surface topography. Fawkes surface energy theory was utilised to observe PEEK_GL (37.94mN/m ± 8.66) to have the highest surface energy followed by PEEK patterned (35.95mN/m ±14.16), PEEK (30.75mN/m ± 4.59) and PEEK_GL patterned (24.75mN/m ± 10.75). The MTT cell viability assay for MG-63 Osteosarcoma cells observed a significant correlation between the surface energy and cellular adhesion between PEEK_GL (68% ± 10.59) and PEEK_GL patterned (76.39% ± 3.24). PEEK patterned (98% ± 3.55) displayed the utmost cell viability percentage and PEEK (12% ± 0.32) the lowest cell viability percentage.

Conclusion: It can be concluded that surface energy is influenced by the grooved patterned topography and glass composite. A significant correlation between surface energy and cell viability of MG-63 cells amid PEEK_GL and PEEK_GL patterned can be identified. Further investigation is required to identify alternative mechanical characteristics to enhance cell viability of PEEK, PEEK Patterned, PEEK_GL and PEEK_GL patterned.

P17 – Degradation and Weight Loss of Electrospun Tubular Scaffold for Vascular Tissue Engineering

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Introduction

Electrospinning has recently emerged as a leading technique for generating biometric scaffolds fabricated of synthetic and natural polymers for tissue engineering applications. Electrospinning allows the integration of various biomaterials to be effectively tailored to create constructs that provide the essential characteristics. Fabricating vascular grafts aims to regenerate and mimic the extracellular matrix structure abundant in the walls of the inherent vessels. Prior to implantation, the investigation of scaffold characteristics such as degradation and solid surface tension are vital in ensuring appropriate and effective function.

Methods

Polycaprolactone (PCL) and Poly (lactic co-glycolic acid) (PLGA) 85:15 are biopolymers that were selected for this investigation due to their outstanding properties such as biocompatibility, degradability and cost effectiveness. Furthermore, previous literature has also highlighted the benefits of each synthetic polymer [1-2]. For this project, a total of six scaffolds were fabricated of which three were of PCL 15% (W/V) and three PLGA 10% (W/V). Spin time varied with periods of 30, 60 and 90 minutes. Once fabricated, the scaffolds were cut and weighted prior to the initiation of the 12-week experiment. The degradability was assessed via scaffold weight-loss and the change in fibre diameter. Scaffold topography was evaluated using scanning electron microscopy (SEM) which, highlighted the morphology, structure and physical characteristics including fibre diameter occurring over the 12-week period. Furthermore, the wettability of the scaffold was determined using various solutions alongside scaffold handling were examined. Additionally, this experiment also looked at scaffold behaviour under controlled conditions thus, the fabricated constructs were exposed to a controlled temperature of 37°C for a duration of four weeks. Again, six scaffolds were removed weekly to be assessed under the SEM to assess the degradation.

Results & Discussion

Overall both PCL and PLGA scaffolds displayed exceptional fibre structure and excellent degradability over the course of the experiment. The fibre diameter gradually increased thus, exemplifying gradual degradation. The percentage weight-loss of the scaffold increased and so, indicated the degradability of the scaffold. Although, both PCL and PLGA degraded, the results represented significant degradation in PLGA compared to PCL. As expected, this was also significant in the scaffolds observed under controlled conditions.

Conclusion

The conclusions drawn from this project are that both PCL and PLGA coupled with the correct testing provide great promise for future endeavours within vascular tissue engineering. However, for future work we are aiming to fabricate more complex architecture including coaxial electrospinning to provide a better scaffold for vascular tissue engineering.

References

1. Deshpande, P., et al. (2013) "Simplifying corneal surface regeneration using a biodegradable synthetic membrane and limbal tissue explants" *Biomaterials*, 34(21):5088-106.
2. Mahjour, S.B, et al. (2016) Improved cell infiltration of electrospun nanofiber mats for layered tissue constructs. J Biomed Mater Res Part A, 104(6):1479-88.

P18 – Synthesis of Nano Composite Materials from Plant Virus

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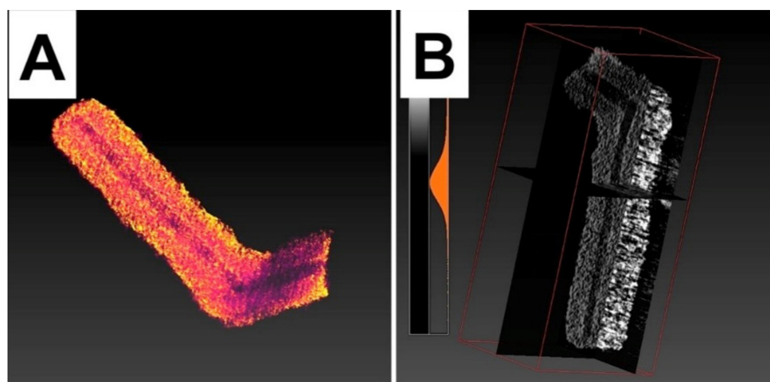
While synthesis of metallic nanoparticles and nanorods are well established, hollow and porous nanotubes produced by bio-template are as yet rare. Biotechnology can be exploited in preparation of novel structures such as Cowpea mosaic virus (CPMV)[1] and tubular structures such as Trp-RNA attenuation protein (TRAP)[2] and Tobamovirus (TMV) and ToMV).[3,4] These can act as templates for materials such as metals and metal oxides nano structure.

The external and internal surfaces of plant virus consisting addressable active hydroxyl, carboxyl and amine functional groups. These functionalities are utilized for *in situ* nucleation of inorganic materials.

Nanoparticles consisting of iron oxides have been generated on wild type TMV using wet chemistry.[5] Dialyzed virions in aqueous suspension was mixed with aqueous Fe(II) and Fe(III) salts under controlled pH conditions generating coating with a ≈ 50 nm thick ion oxide layer. High-resolution 3D-TEM tomography images **A** and **B** of synthesized iron oxide nanotubes after removal of virus contained a central hollow channel running along their lengths and showed the metallic porous wall of tube. We are now investigating these structures with a view to their possible utilization in nano-electronics and as electrode materials for lithium-ion batteries.



P19 - Evaluating pathogen-natural microflora communication in viscoelastic biomaterial-based 3D food models

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Introduction: Bacterial communication and growth location is of increasing interest when investigating the growth and/or inactivation of pathogenic bacteria in/on structured food systems. Natural microflora present in food products may be detrimental to pathogen growth due to competition, communication, and/or the production of metabolic products such as acids or natural antimicrobials (e.g. nisin from lactic acid bacteria). Bacterial location and colony size, both in monoculture and in co-culture with natural microflora, can have a significant impact on the environmental stress response within a colony, i.e., self-induced acid stress, starvation stress, oxidative stress, presence of natural antimicrobials etc. Thus, different interactions are possible for systems of varying microstructure.
Most available studies on the interactions between natural microflora (e.g. lactic acid bacteria) and food-related pathogens (including *Listeria*) are conducted in liquid broth systems, although many food products are solid or solid(like) e.g. soft cheeses, meats. Cells in/on a solid system grow as colonies or as biofilms and experience a significantly different environment to a liquid system, with diffusional limitations (oxygen, nutrients) and accumulation of (acidic) metabolic products around the colony causing a self-induced (acid) stress that may affect the microbial environmental response and communication. Real food products may be used for these studies, however they are informative only for the specific food product under study, with significant batch-to-batch variability in microstructure and rheological characteristics. Furthermore, the food system must also be treated before use to remove background microflora, which often affects the food system microstructure.
Therefore, to achieve a fundamental understanding of pathogen/natural microflora communication and growth location in solid/solid(like) food systems, it is necessary to develop a reproducible food model system which can mimic as accurately as possible the microstructure of a wide range of solid/solid(like) food products.
Materials and Methods: Monophasic viscoelastic food model systems were prepared using 3%, 5%, or 7% w/v Xanthan gum (XG), or 10% w/v Whey protein (WPI), and a biphasic system was created using 5% XG and 10% WPI in 1:1 ratio. Systems were rheologically characterised at 10ºC, 30ºC and 37ºC. Additionally, confocal laser scanning microscopy techniques (CLSM) were used to visualise the growth location and colony/biofilm formation of *L. innocua*, *L. lactis* NZ9700 (nisin-producer) and *L. lactis* NZ9800 (non-nisin producer) in monoculture and also *L. innocua* in co-culture with each *L. lactis* strain.
Results and Discussion: A range of reproducible, viscoelastic solid(like) food model systems of varied structural complexity have been developed and characterised. The use of CLSM techniques showed differences in microbial spatial organisation. More specifically, in monoculture all bacterial strains demonstrate preferential growth on the protein phase of the biphasic viscoelastic system up to early stationary phase, but then spread into larger colonies across both phases. By contrast in co-culture, no phase selectivity is observed for all systems, and cell clusters increase in size from early to late stationary phase. *This is the first reported observation of such changing preferential growth in a biphasic, co-culture system.*
Our findings give a systematic quantitative insight on the impact of co-culture with nisin-producing *L. lactis* on the growth of *Listeria*, in food model systems of varying structural complexity. They highlight the importance of accounting for bacterial stress adaptation, communication and growth location in solid(like) systems with natural microflora when designing novel decontamination processes.

P20 - **Evaluation of chemotherapy and radiotherapy screening in an *in vitro* polymer based pancreatic cancer model**

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Introduction: Pancreatic cancer is an aggressive disease with an extremely low survival rate1. This is partly due to the tumour heterogeneity and the high resistance of the disease to the current treatment options (chemotherapy and radiotherapy) that follow the surgical resection. This resistance is partly attributed to the dense extracellular matrix (ECM) presence (fibrosis) that surrounds the tumour area, which combined with the low vascularity acts like a shield for the tumour and inhibits cell death2. Recent progress in tissue engineering and the development of three-dimensional (3D) culture systems has enabled a more realistic recapitulation of a 3D tissue/ tumour, including the niches and structure of the tumour microenvironment (TME) as well as the ECM composition, consequently increasing the accuracy of *in vitro* models for this malignancy3. In this work, we modified our previously developed 3D polymer based pancreatic cancer model to mimic various features of the extracellular matrix composition of pancreatic tumours and we performed chemotherapy and radiotherapy screening on our modified polymeric scaffolds.

Methods: Polyurethane based highly porous scaffolds were generated as previously described4. Thereafter, scaffold surface modification took place with different ECM proteins, i.e. additionally to fibronectin with laminin, collagen-I and RGD (Arg-Gly-Asp). PANC-1 pancreatic cancer cells were seeded in scaffolds with various ECM coatings and the cell culture was monitored for at least 46 days. *In situ* sectioning, fluorescent staining and imaging with CLSM enabled the cellular and environmental gradient spatial determination and the *de novo* ECM production within the 3D models. For the treatment experiments, on day 29 of culture, scaffolds were treated for 48 h with a range of 10-100 μM of the chemotherapeutic drug gemcitabine (which is commonly used for pancreatic cancer treatment) and/or with clinically relevant X-ray doses (0-8 Gy). Post treatment cell viability was monitored for 17 days. More specifically, MTS viability assay as well was performed and live/dead staining and confocal laser scanning microscopy (CLSM) images of multiple scaffold sections were generated and compared. Additionally, cellular apoptosis was evaluated *in situ* measuring the caspase 3/7 activity.

Results: The pancreatic cancer cells retained high viability in the 3D polymeric models until the culture end point for all the different protein coatings, with the fibronectin coated model exhibiting the highest cell growth and *de novo* collagen production by the cells. Additionally, no starvation gradients (LC3 negative), but only hypoxic gradients (HIF-1a positive), the level of which affected the treatment efficacy, were detected in both ECM coated and uncoated models. Long term post treatment monitoring indicated the chemotherapy and irradiation reduced cell viability and increased caspase 3/7 activity at levels similar to the ones reported in *in vivo* studies, pointing the great potential of our biomaterials based model for screening of pancreatic cancer.

References: **1**R. L. Siegel, K. D. Miller and A. Jemal, *CA Cancer J Clin*, 2018, **68**, 7-30. **2**C. J. Whatcott, R. G. Posner, D. D. Von Hoff and H. Han, in *Pancreatic Cancer and Tumor Microenvironment*, eds. P. J. Grippo and H. G. Munshi, Trivandrum (India), 2012; **3**S. Totti, S. I. Vernardis, L. Meira, P. A. Perez-Mancera, E. Costello, W. Greenhalf, D. Palmer, J. Neoptolemos, A. Mantalaris and E. G. Velliou, *Drug Discov Today*, 2017, **22**, 690-701. 4S. Totti, M. Allenby, S. B. d. Santos, A. Mantalaris and E. Velliou, *RSC adv*, 2018, **8,** 20928-40.

P21 - **Cellular recognition mechanisms of surface imprinted polymers**

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Recognition layers for cellular identification are crucial for many cell-based biosensors. For such applications, biological recognition elements such as antibodies have become the gold standard due to their exceptional specificity, selectivity and affinity towards their targets. However, the use of bio-recognition elements is limited by key factors, including high production cost, limited shelf life and narrow physico-chemical range of operation. Therefore, there is a need for alternative receptors that do not suffer from these disadvantages. Many studies have shown that biomimetic receptors synthesized by cell imprinting on polymer layers are effective for specific and selective recognition of cells [1, 2]. Despite the potential applications of these receptors, their underlying cellular recognition mechanisms remain unexplored. Hereby, we explored the factors influencing the recognition of cells by their corresponding surface-imprinted polymers (SIPs). We hypothesized that geometric compatibility, lipids, proteins, and hydrogen bonds play a major role in the recognition mechanisms of cells by SIPs.
Baker's yeast cells (*Saccharomyces cerevisiae) were used as model cells to create SIPs, and the surfaces* were characterized by atomic force microscope (AFM), scanning electron microscope (SEM) and water contact angle (CA) measurements. Fourier transform infrared spectroscopy (FTIR) and x-ray photoelectron spectroscopy (XPS) were used for functional group identification. Furthermore, the effect of membrane proteins was assessed by monitoring the binding of cells to a SIP layer treated with pepsin, while the effect of membrane lipids was studied by monitoring the adhesion of cells on a lipid-vesicle-imprinted polyurethane layer.

Analysis of SEM, AFM and CA measurements showed that cell imprinting creates hydrophobic cavities geometrically identical to the template cells. In these cavities, target cells preferentially bind. In addition, FTIR and XPS analysis of the SIP surfaces revealed the presence of phospholipids remnants, with no indication of proteins. Accordingly, HTM measurements showed that a phospholipid-coated layer enhances cell binding.

The results suggest that SIPs recognize cells due to geometric compatibility and phospholipids left behind during imprinting. There is no evidence of transferred proteins in the SIP cavities. Moreover, the effectiveness of pepsin-treated SIP layers in binding cells further indicates that cell recognition by SIPs is probably independent of proteins imbedded in the SIP cavities. However, this does not roll out the surface proteins, and other physico-chemical properties of the incoming target cell on the selective binding of the cells to their corresponding SIPs.

References

[1] Hayden, O *et al. Angew. Chem. Int.* 2006, 45(16): 2626–2629
[2] Eersels, K. *et. al. Langmuir* 2015, 31, 2043–2050.

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P22 – Detection of model anesthetics interacting with solid-supported lipid membranes

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Solid-supported lipid membranes are popular models that connect biological and artificial materials used in bio-technological applications. Controlling the lipid organization and the related functions of these model systems entails understanding and characterizing their phase behavior. Quartz crystal microbalance with dissipation (QCM-D) is an acoustic-based surface-sensitive technique which is widely used in bio-interfacial science of solid-supported lipid membranes. Its sensitivity to mass and energy dissipation changes at the solid-lipid layer-liquid interface allows the detection of phase transformations of solid-supported membrane geometries.[1] QCM-D has recently emerged and is steadily growing as a versatile technique to detect and characterize the phase behavior of different solid-supported lipid membrane geometries (see Fig. 1).[2] A useful application of QCM-D phase transition studies is the screening of model anesthetics, such as ethanol, making the phase transition approach a straightforward method for biosensing purposes.[3]

In this work, we use quartz crystal microbalance with dissipation monitoring (QCM-D) to examine the phase behavior of DPPC supported vesicle layers exposed to increasing concentrations of alcohols bearing different alkyl chain length. On the one hand, we apply a Voigt-based viscoelastic model to obtain the shear viscosity temperature profiles. On the other hand, we used a recently developed strategy to analyze phase transitions by calculating the temperature derivative of the directly measured frequency and dissipation shift responses. [4,5] A lowering of the main phase transition temperature T_m and decrease in cooperativity occur upon addition of all alcohols. The extent of the T_m shift increases with increasing alcohol concentration and alkyl chain length. This can be explained by the tendency of longer alcohols to partition in the hydrophobic lipid bilayer compared to shorter chain alcohols, thus weakening the van der Waals interactions between lipid hydrophobic chains.

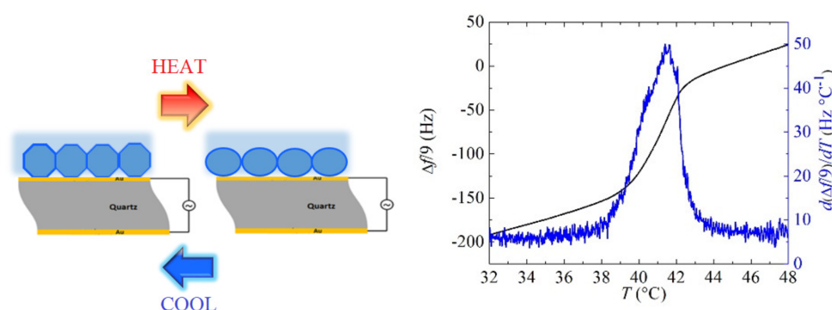

Fig. 1. (left panel) Schematic of the supported lipid vesicle layer changes upon the main phase transition of DPPC. (right panel) Frequency shift and its temperature derivative response at the main phase transition.

References
[1] M. C. Dixon, *J. Biomol. Tech.* 19, 151 (2008).
[2] S. Neupane, Y. De Smet, F. U. Renner, P. Losada Pérez, Front. Mater. 5, 46 (2018).
[3] A. Peschel, A. Langhoff, E. Uhl, A. Dathathreyan, S. Haindl, D. Johannsmann, I. Reviakine, J. Chem. Phys. 145, 204904 (2016).
[4] P. Losada-Pérez, M. Khorshid, P.Wagner, J. Phys. Chem. B 119, 4985 (2015).
[5] P. Losada Pérez, M. Khorshid, F.U. Renner, Plos One 11, pp. e0163518 (2016).

P23 – Qiuji Wang

Abstract X. **New synthetic compounds possess activities against leukaemic cell growth *in vitro***

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Leukaemia is a type of cancer that starts in blood-forming tissue. It occurs with an unregulated cell proliferation of immature leukocytes. Current treatment, chemotherapy and bone marrow transplant cannot completely cure leukaemia and have various life-threatening side effects. Research for treatments in leukaemia is rapidly developing.

In this study, the effects of two synthetic compounds, termed C36 and C39, on the growth, survival, and metabolism of Jurkat cells were investigated using cell proliferation assay, cell cycle analysis by flow cytometry, caspase activity assay and cell energy phenotype test.

Results show that the treatment of Jurkat cells with C36 and C39 led to a reduction of Jurkat cell growth and cell cycle arrest in the G1 phase. These compounds also increased caspase 3 activity. The mitochondrial respiration in compound-treated cells also decreased.

These findings suggest that synthesized compounds C36 and C39 have the potential to serve as anti-cancer drugs for treating leukaemia.

P24 – Tim Gabriel

Electrodeposited nanostructured materials for energy related applications

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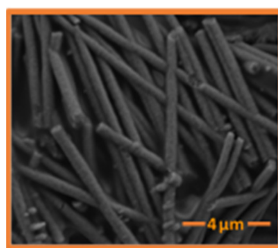
The fabrication of nanostructured materials is of significant importance due to its application in devices including lithium-ion batteries, supercapacitors, photovoltaics and fuel cells[1]. Nanostructuring can enhance the physical characteristics of a material by offering higher surface areas, enhanced kinetics or reduced degradation. In the case of MoS_2, the development of high surface areas with extensive curvatures (wires, rods, tubes or inverse-opals) can create more catalytically active edge sites improving the performance towards the hydrogen evolution reaction[2]. With V_2O_5, these advanced physical properties are demonstrated by shorter diffusion paths, rapid charge and discharge rates and higher Li-ion capacities for electrodes[3].

Electrodeposition, via hard (membrane, colloidal) and soft (surfactant-based) templating strategies, offers a low-cost, tuneable, facile route to the formation of novel 3D nanomaterials with enhanced physical characteristics in a variety of mesoporous nanowires, nanorods and nanotubes[4].

Mo_xS_y and V_xO_y nanorods, nanowires and nanotubes with a diameter of 400 nm have been electrochemically grown within the pores of polycarbonate (PC) membranes, illustrated by scanning electron microscopy studies (figure 1). The identity of the various vanadium oxide nanomaterials was confirmed, after subsequent annealing in air, by EDX and wide angle XRD. Characterisation of the internal mesoporous structuring within the nanowires was evidenced by low angle XRD and TEM, showing pore diameters of between 5 to 10 nm.

Figure 1: Mesoporous vanadium oxide nanowires electrodeposited using a gold backed PC membrane with a 0.4 µm pore diameter.



1.Aricò, A. S.; Bruce, P.; Scrosati, B.; Tarascon, J.-M.; van Schalkwijk, W., Nanostructured materials for advanced energy conversion and storage devices. *Nature Materials* **2005,** *4*, 366.

2.Li, F.; Zhao, X. L.; Mahmood, J.; Okyay, M. S.; Jung, S. M.; Ahmad, I.; Kim, S. J.; Han, G. F.; Park, N.; Baek, J. B., Macroporous Inverse Opal-like MoXC with Incorporated Mo Vacancies for Significantly Enhanced Hydrogen Evolution. *ACS NANO* **2017,** *11* (7), 7527-7533.

3.Armstrong, M. J.; Burke, D. M.; Gabriel, T.; O'Regan, C.; O'Dwyer, C.; Petkov, N.; Holmes, J. D., Carbon nanocage supported synthesis of V2O5 nanorods and V2O5/TiO2 nanocomposites for Li-ion batteries. *Journal of Materials Chemistry A* **2013,** *1* (40), 12568-12578.

4.Lai, M.; Riley, D. J., Templated electrosynthesis of nanomaterials and porous structures. *Journal of Colloid and Interface Science* **2008,** *323* (2), 203-212.

P25 – Rana Khayat

Anatomical adaptations in the Common Pipistrelle (*Pipistrellus pipistrellus*) wing reduce the likelihood of tearing and increases healing: a novel biomaterial?

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Bat wings consist of a unique arrangement of biomaterials, which promote healing and reduce the likelihood of tearing. However, thousands of bats are taken in to care with wing tear injuries annually, although many of these tears can heal relatively quickly. This study focuses on the three largest sections of the wing: *chiropatagium I, chiropatagium II* and *plagiopatagium*, and characterises the fibres, material properties and healing capabilities of the wings in the Common Pipistrelle. It also provides the first characterisation of bat wing tears. Results show that each section of the wing has a good supply to promote healing; however, the lowest blood vessel density was found in the *plagiopatagium* section, meaning that this section is likely to have the slowest rate of healing. Each section of the wing contained a net of collagen and elastin fibres, that limits tearing in all orientations, meaning that most tears are just small holes. All wing sections had similar material properties, although the *plagiopatagium* section contained the most elastin, which might also increase healing times as the elastin holds open the tears; indeed, the *plagiopatagium* wing section took the longest time to heal. However, it also contained the most tears despite the anatomy being similar between each of wing sections. Therefore, we suggest that the plagiopatagium is being targeted by predator attacks, such as a cat.