IOP PGS Printing for the Future

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Programme

10:30 AM - 11:00 AM	**Registration and Arrival Refreshments**
11:00 AM - 12:30 PM	**Welcome and Presentations Session 1** Harrie Fuller Yitian Zhang Yu Jiang Ffyon Moody Joseph Kilbride Abigail Trujillo Vazquez
12:30 PM - 1:00 PM	**Invited Speaker 1** Professor J Rafael Castrejón-Pita
1:00 PM - 2:00 PM	**Lunch and Posters** Nizzy James plus other poster presentations
2:00 PM - 2:30 PM	**Invited Speaker 2** Josie Harries
2:30 PM - 3:45 PM	**Presentations Session 2** Thomas Fone Min Fu Erica Watchorn Jing Shi Dan Davie
3:45 PM - 4:00 PM	**Afternoon break**
4:00 PM - 5:00 PM	**Presentations Session 3** Alex Jenkins Louis Masters Gagan Kumar Sharma Miguel Quetzeri-Santiago
5:00 PM - 5:10 PM	**Presentations and Closing Remarks**

Invited Speakers

Inkjet Printing and Droplet Dynamics

Castrejon-Pita J.R. [1]
[1] *University College London, United kingdom*

Invited Speaker 1, June 1, 2023, 12:30 - 13:00

In this talk, Prof Castrejón-Pita will explore some basic concepts of inkjet printing and provide examples of current research projects aiming to expand our understanding of droplet dynamics and expand inkjet compatibility to highly viscous liquids, biofluids and other complex fluids.

Over the last few years, inkjet printing has evolved from a desktop application to a modern industrial manufacturing method that is used on ceramics, electronics, fabrics, food, labels, plastics, biomaterials and 3D printing methods. Inkjet applications expand every day due to the technology's intrinsic advantages; it is efficient, wasteless and digital. In fact, inkjet aims to expand beyond the printing of ink, to the printing of electronics, glues, varnishes, paints, metals, and cells. For that to occur, the sector needs to overcome a series of obstacles. In this talk, Rafael will describe some of the recent and current fundamental studies being carried out to achieve this aim.

Development of new products; challenges and opportunities

Dr Josie Harries[1]
[1]*Domino Printing, United kingdom*

Invited Speaker 2, June 1, 2023, 14:00 - 14:30

The release of new and innovative products into the market is crucial for the continued growth of companies. However, the development and commercialisation of new products can be costly and time consuming with many factors needing to be taken into consideration to achieve commercial success.

During this presentation we will discuss the approaches that can be taken during the development cycle to ideate, design and release new products, and will share examples of how utilising these practices can lead to success in the marketplace.

Contributed Speakers

Based Electroluminescent Devices

Mr. Min Fu[1], Mr. Kevin Critchley[1], Mr. Stephen Evans[1]
[1] *University of Leeds, Leeds, United Kingdom*

Presentations Session 2, June 1, 2023, 14:30 - 15:45

Quantum dots (QDs) refer to semiconductor nanocrystals in that electrons and holes are confined in three dimensions. They are deemed ideal light emitters because the electronic and optical properties can be tuned by their size and morphology. InP QDs are an excellent candidate for replacing heavy metal-based QDs in the next-generation of display devices due to their small bulk band gap (1.35 eV), large excitonic Bohr radius (10.0 nm), high photoluminescence quantum yield, narrow emission, broad color tunability, and less toxicity. The structure of QDs-based light emitting diodes (QLED) includes a substrate, anode, hole injection layer, hole transport layer, emissive layer, electron transport layer, and cathode. Apart from the commonly used spin coating method, inkjet printing is a promising technology to achieve high-resolution QLED with merits of using less material and patterning without using a mask.[1] However, the coffee ring effect (CRE) causes a non-uniform pattern during the evaporation of droplets because of different drying rates at the center and edge of the droplet.[2] Adding another solvent to form a binary system[3] or a surfactant[4] are popular ways to mitigate the CRE. Introducing a binary mixture can create a Marangoni flow which can be used to balance the capillary flow to achieve a flat uniform film. Here, we applied cyclohexylbenzene and decane as the solvents of InP QDs ink and studied the influence of different volume ratios of decane and various substrate temperatures on the CRE. The uniform pattern was successfully obtained, therefore, inkjet-printed QLED was assembled and compared the electrical performance with the spin-coated device.

[1] P. Yang et al. Adv. Opt. Mater. 2020, 8, 1901429.
[2] R. D. Deegan et al. Nature 1997, 389, 827.
[3] A. A. Pahlavan et al. Phys. Rev. Lett. 2021, 127, 024501.
[4] H. Roh et al. Adv. Opt. Mater. 2021, 9, 2002129.

The Path to Defect-Free Hybrid Manufacturing of Advanced Ceramics

Mr Louis Masters[1], Dan Davie[1], Prof. Robert Kay[1]
[1] *University Of Leeds, Leeds, United Kingdom*

Presentations Session 3, June 1, 2023, 16:00 - 17:00

Hybrid manufacturing combines two or more distinct manufacturing processes, leveraging the advantages of each process whilst mitigating their limitations. Combining material extrusion with subtractive processes allows for the geometrical complexity of freeform fabrication with the surface finish and precision characteristic of conventional manufacturing; we use this approach to enable the production of functional parts from advanced ceramic materials. Defects such as voids and pores inherent to extrusion processes are difficult to predict and detrimental to part integrity. In alignment with data-driven manufacturing processes promoted by Industry 4.0, this report proposes to address this through automated in-situ monitoring. Images and scans of each additive layer are captured by a machine mounted camera and laser scanner. We compare the respective layer data with the digital model, evaluating the geometrical accuracy of a part. Analysis of typical extrusion defects such as raster gap voids and pores in sub 100µm detail are enabled alongside surface roughness measurements which monitor tool wear. We generate a layer-by-layer database of defects in a part, alleviating the need for post-production testing, and allowing for the optimisation of printing parameters in-situ via closed-loop communication between the machine and measurement systems. This process feedback also enables the removal of defective layers which can then be reprinted, reducing the number of parts that get wasted. This work demonstrates in-situ monitoring and defect correction for hybrid manufacturing, proving the viability of this technology for the creation of defect-free advanced ceramic components for high performance applications.

Suppression of Crystallisation in Saline Drop Evaporation on Pinning-Free Surfaces

Mr Alex Jenkins[1], Dr Gary Wells, Dr Rodrigo Ledesma-Aguilar, Dr Daniel Orejon, Dr Steven Armstrong, Professor Glen McHale
[1] *University of Edinburgh, Edinburgh, United Kingdom*

Presentations Session 3, June 1, 2023, 16:00 - 17:00

For sessile droplets of pure liquid on a surface, evaporation depends on surface wettability, the surrounding environment, contact angle hysteresis (CAH) and surface roughness. For non-pure liquids the evaporation characteristics are further complicated by the constituents and impurities within the droplet. For saline solutions, this complication takes the form of a modified partial vapour pressure/water activity caused by the rising salt concentration as the aqueous solvent evaporates. It is generally thought that droplets on surfaces will crystallise when the saturation concentration is reached i.e. 26.3% for NaCl in water. This crystallisation is initiated by contact with the surface and is thus due to surface roughness and heterogeneities. Recently smooth, low contact angle hysteresis surfaces have been created by molecular grafting of polymer chains. In this work we hypothesise that by using these very smooth surfaces on which to evaporate saline droplets, we can suppress the crystallisation caused by the surface interactions and thus achieve constant volume droplets above the saturation concentration. In our experiments we used several different surfaces to examine the possibility of crystallisation suppression. We show that on polymer grafted surfaces, i.e. Slippery Omniphobic Covalently Attached Liquid-like (SOCAL) and Polyethylene Glycol surfaces, we can achieve stable droplets as low as 55% at 25 °C relative humidity with high reproducibility using NaCl in water solutions. We also show that it is possible to achieve stable droplets above the saturation concentration on other surfaces, including superhydrophobic surfaces. We present an analytical model, based on water activity, which accurately describes the final stable volume as a function of the initial salt concentration. These findings are important in for heat and mass transfer in relatively low humidity environments.

Evaporation dynamics of multiple sessile droplets

Joseph Kilbride[1], Fouzia Ouali[1], David Fairhurst[1]
[1]*Nottingham Trent University, Nottingham, United Kingdom*

Welcome and Presentations Session 1, June 1, 2023, 11:00 - 12:30

Ink-Jet printers dispense droplets on surfaces which evaporate leaving circular ink stains. Selective deposition of these droplets allows for the formation of detailed images. However, these images are limited in resolution by the size of the circular footprint the droplet forms on the substrate, governed by its wettability. To improve this resolution, one could manipulate [1] the internal flow inside the droplet controlling the ink deposition's shape and density. One method of controlling this flow is utilising the vapour interactions between adjacent droplets in close proximity. In order to do this, we first need to understand how multiple droplets evaporate in groups.
The interactions through the vapour phase are governed by diffusion, there have been several recent theoretical and numerical models which describe the resultant reduced evaporation rates of multiple droplets on surfaces [2,3]. However, the experimental work required to validate these models has fallen behind due to difficulties dispensing and determining the transient volumes of droplets arranged in arbitrary 2D patterns [4]. We take extensive experimental data from various sessile droplet arrays of varying shape, density and length scale. We have developed a Pattern Distortion [5] technique which relates a droplets lens like magnification of a pattern placed beneath it, to its geometry. We can use this to extract transient volumes as well as lifetimes. This data is quantitatively compared to the different theoretical models [2,3], evaluating their performance as we vary each of these quantities, extending our previous work [4,5,6]. We are able to demonstrate the limitations of the current diffusive theories and guide future improvements.

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Jetting and droplet formation of particle-loading fluids for industrial applications

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Presentations Session 2, June 1, 2023, 14:30 - 15:45

Inkjet printing is an attractive method for patterning and fabricating objects across many areas of industry. There is a growing interest in the printing of functional inks, which tend to have a complex rheology and/or high particle-loading. Examples include inks containing glass frit, which can be printed directly onto glass, and conductive inks used to print circuits. The printing performance is often limited by the rheological parameters of the inks. Understanding of the role of complex rheology in the jetting of loaded inks is needed to facilitate the wider application of inkjet printing of particle-loading fluids.

In this study, we characterise the complex rheology and the jetting of model dispersion inks (containing 10, 15 and 20 vol.% TiO_2 nanoparticles) and compare them with those of model inks without particles. The jetting of the model fluids was conducted with a commercial inkjet printhead (nozzle diameter 34 μm) and visualized with stroboscopic imaging and/or high-speed imaging. For low particle concentrations, the jetting behaviors of loaded inks are generally similar to those of unloaded inks, provided their Ohnesorge number and Weber number, although particle loading tends to make the jetting process more unstable. At 20 vol.%, the particle concentration prevented reliable jetting. The extensional rheological behavior measured from the filament stretch and break-up test was found to be the most reliable indicator of the jettability of an ink. The jetting maps of the unfilled and filled fluids were produced and compared.

Two-dimensional MXene decorated MoS2 nanohybrid films for high-performance Wearable Supercapacitors

Mr. Gagan Kumar Sharma[1,2], Dr. Bhaskar Dudem[1], Professor Davinder Kaur[2], Professor S. Ravi P. Silva[1]
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Presentations Session 3, June 1, 2023, 16:00 - 17:00

With the major developments in portable and wearable electronics, there is increasing demand to evolve flexible energy storage systems. From this viewpoint, supercapacitors are attaining significant interest and are considered a candidate based on their high-power density, excellent rate capability, rapid charge-discharge, and longer cyclic lifespan. In particular, the scientific community has focused on nanocomposite thin films based on flexible supercapacitors to facilitate eco-friendly alternative for green energy harvesting. Herein, we adopt a nanohybrid film grown over a flexible carbon cloth substrate, exhibiting outstanding electrochemical performance through a synergistic effect between constituent layers. Two-dimensional (2D) nanomaterials such as Molybdenum disulfide (MoS2) and MXene (Ti3C2Tx) have been shown to exhibit promising electrode properties and provided a new avenue of research in fabricating wearable supercapacitors. MoS2, as a transition metal dichalcogenide (TMD), with its typical 2D layered nanostructure facilitates intercalation/de-intercalation of electrolytic ions (Li+/Na+) between the large interlayer spacing without volume expansion. The hexagonal 2H phase of MoS2 is semiconducting but has a large ion-accessible surface area and remarkable intrinsic capacitance. However, the MoS2 suffers from lower electronic conductivity, short cycling stability, and nanolayer restacking, which largely limits its usage in practical charge storage technologies. To overcome these challenges, hybridizing with another 2D material Ti3C2Tx MXene, provides enhanced conductivity, better specific capacitance, and structural stability to the flexible electrodes. Ti3C2Tx is a representative member of the transition metal carbides and/or nitrides family for energy storage applications. Therefore, we propose a new approach of incorporating MXene into the molybdenum disulfide, which increases the interlayer separation of MoS2 and hence increases the effective surface area, capacitive response, and charge-discharge stability of hybrid electrodes. In our experiments, the various structural and electrochemical characterization is systematically performed and compared for pristine and composite forms. To probe the practical energy storage capacity, the as-synthesized MoS2-Ti3C2Tx composite electrode is investigated with an aqueous 1M Li2SO4 electrolyte in the conventional three-electrode system. The mechanical robustness and pliability of the supercapacitor cell are verified through the flexibility test. The device working model with a practical demonstration is designed for real-world application.

Life in full colour: Recreating photographs of Madame Yevonde

Ms Harrie Fuller[1], Ms Elizabete Kozlovska[1]
[1] *University of the West of England , Bristol, United Kingdom*

Welcome and Presentations Session 1, June 1, 2023, 11:00 - 12:30

'If we are going to have colour photographs, for heaven's sake let's have a riot of colour, none of your wishy-washy hand-tinted effects' (National Portrait Gallery, no date).

Yevonde Cumbers (1893-1975), who worked under the professional name Madame Yvonde, was a portrait photographer unafraid of controversy. She had a passion for the suffragette movement, which drove her towards financial independence and creative expression. In her famous series 'The Goddesses' she used the Vivex tri-colour camera to portray high society women from a different, more playful perspective. When colour photography was first invented, the photography community was prejudiced against it, perceiving it as not a serious medium of expression (Hacking, 2015). Yevonde disproved this by being the first photographer in England to have an exhibition consisting entirely of colour portraits it was hosted at the Albany Gallery in London to a positive reception (Smith, 2002). This helped colour photography gain acceptance in pre-war society.

The process Madame Yevonde used to create these vivid colours was the Vivex colour process. Vivex was the first professional colour printing service in the United Kingdom. However, it only existed for a decade, from 1928 until 1939. It was invented by D.A. Spencer (Science and Media Museum, 2020), and Madame Yevonde worked with him to push this process along with colour photography beyond its existing limits.
We were provided with the 3 original RGB negatives of the image 'Andromeda' by the National Portrait Gallery (Figure 1). The aim was to recreate the original appearance of the Vivex image, using a modern photomechanical process. Re-creating these images today comes with a myriad of difficulties. Firstly, as an industrial process, Vivex did not publish its process, as these were highly competitive commercial secrets. Another issue was Yevonde's liberal approach to colour meant she did not use the Vivex colour calibration cards. This means that every image has a unique colouring. The final issue was due to the complicated registration technique. Vivex built up the image using three layers of gelatine-coated cellophane, one for each subtractive colour negative (Coppin, Spencer, 1948). The literature states that the image was registered by stretching the cellophane locally. However, this vague description poses more questions than answers.

Using a mix of digital and analogue processes, we explored different possibilities of re-creating this image. The printing methods used were relief, planographic and Woodburytype. In this talk, we discuss our methods and results, as well as future possibilities of photomechanical printmaking.

References:

- Coppin F.W., Spencer D.A, Basic Features of the Vivex Process (1948), The Photographic Journal, (88), pp. 78 – 84
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- Smith, Lindsay, 'There is a Garden in her Face': Madame Yevonde's Photographic Colour (2002), Women: a cultural review, 13:2, pp. 121-139
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- A Short History of Colour Photography, (Science and Media Museum, 7th July 2020), accessed 9th May 2023

Barrier Technologies for Food Packaging

Ffyon Moody[1], Professor Davide Deganello[1], Dr Christopher Phillips[1], Mr Craig Hardwick[2]
[1]Swansea University, Swansea, United Kingdom, [2]Klockner Pentaplast, Pontefract, United Kingdom

Welcome and Presentations Session 1, June 1, 2023, 11:00 - 12:30

The food packaging industry is under pressure to increase the recyclability of plastic packaging. While the majority of food packaging trays, can be made from a mono-material such as PET, the flexible films for protein products are currently multilayer polymer laminate structures which are difficult and costly to recycle. Different plastics and adhesives are laminated together to reduce the permeability to gases and vapours, maintain a high seal strength and hold together the various layers. Such combinations of materials are impractical to separate so the whole film is often rejected upon recycling. Mono-PET is currently widely recyclable, however it is permeable to Oxygen. The key challenge of this work is to improve the barrier properties of mono-PET films by addressing the gas permeability of PET. An overview of current barrier technologies will be presented, discussing their current field of application & development, their potential application in food packaging: potential advantages and limitations. The overview will also cover testing methodologies and technical challenges in their use. The goal will be to develop a novel barrier coating for PET to achieve good barrier properties, recyclable through current infrastructure whilst being scalable for mass production and ensuring there is minimal impact to manufacturing line speed.

Exploring the Potential of 2.5D Printing for Recreating the Appearance of Ancient Artwork from Mexico

Abigail Trujillo Vazquez, Dr Susanne Klein, Dr Karina Rodriguez Echavarria
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Welcome and Presentations Session 1, June 1, 2023, 11:00 - 12:30

For pre-colonial cultures of Mexico, colours were a part of language. The symbolic meanings of colours were used by artists to represent their culture, history and overall knowledge in various forms of artwork from jewellery and pottery to painting applied on buildings. During the last century, a considerable amount of pre-Hispanic wall painting and stucco relief suffered irreversible damage due to environmental exposure and human action. In some cases, records of imagery and colours taken by 19th and 20th century explorers, when the ancient artworks were discovered, are the only way to gain insights on the original condition of an artwork.
This work explores the making of 2.5D prints with the aim of recreating the appearance of polychromic stucco reliefs from the Maya region, based on early 20th century records, such as watercolours and hand-tinted photographs. Here a 2.5D print is a print with surface elevation, which has chromatic and dimensional attributes. The methods used include photomechanical and digital processes, suitable to add spatial and visual complexity to flat surfaces. To investigate how adding relief and surface texture influences the reproduction of colour prints were produced via digital elevated printing, as well as intaglio, planographic and relief printmaking techniques. The relation of surface structure, glossiness and colour of digital prints was studied for digitally produced elevated prints. The research aims to develop innovative ways to represent an artwork and to contribute to enable wider audiences to get closer to the experience of seeing a lost piece of art.

Understanding metallic splashes for optimizing soldering and printing

Miguel Quetzeri-Santiago[1], Ms. Karen Meza-Alarcón[5], Prof. Antonio del Rio Portilla[2], Prof. Miguel Angel Neri Flores[3], Dr. Rafael Castrejón-Pita[4]

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Presentations Session 3, June 1, 2023, 16:00 - 17:00

In this talk, we'll dive deep into the behaviour and spreading dynamics of molten metallic alloy droplets, and share our latest findings on how to control splashing during soldering and printing.

Using five solders, including three rare earths and a commercial alloy, we assess their splashing behaviour under different material and impacting conditions. By melting down the metallic solders in a heated chamber and then dripping them onto a smooth copper flat substrate as spherical droplets, we capture high-speed imaging and use image analysis to measure the impact speed, droplet size, and dynamic contact angle.

Our results reveal that the impact behaviour of the molten metal droplets can be well-parameterized by the splashing ratio and the dynamic contact angle - which encompass the impact and liquid properties. These findings provide the industry with a valuable criterion for selecting the maximum soldering injection speed or droplet size to prevent splashing during soldering or the jetting of molten metals.

Robocasting Feedstock Design for Functional Ceramic Applications

Mr Dan Davie[1], Professor Robert Kay[1]
[1] *University Of Leeds, United Kingdom*

Presentations Session 2, June 1, 2023, 14:30 - 15:45

Advanced Ceramics (ACs) are a category of engineered materials, generally with high strength, hardness, and thermal resistance. They can also exhibit functional properties such as superconductivity, optical transparency, or piezoelectric activity, which require controlled microstructure with close to maximum theoretical density. This poses a significant challenge for ceramic Additive Manufacturing (AM) techniques, which frequently suffer from high residual and/or fabrication porosity. Robocasting (RC), a Material Extrusion AM method, shows promise to produce high density components due to the high ceramic content in RC feedstock materials. However, the interdependent relationships between powder characteristics, paste formulations, printability, and density are poorly understood, limiting the uptake of RC for novel, functional materials. This work draws on a body of existing research to explain the physiochemical mechanisms involved in preparing paste materials for Robocasting using colloidal processing techniques. The influence of powder characteristics on paste design is discussed, using Alumina as a reference ceramic. A rudimentary paste material was designed using a cellulose binder and a cationic dispersant with ceramic volume fraction ~45%. Rheological behaviours including the viscoelasticity and pseudoplasticity of the paste were characterised, the results were compared to the Herschel Buckley model and Feilden's figure of merit, key indicators of a materials printability. This unified methodology can be applied to any powdered ceramic to tailor the rheology and maximise the solid fraction of feedstocks for RC. Streamlining this preparation process will enable rapid uptake of novel ceramics for next-generation products with extraordinary material properties.

3D printing and analysis for biomaterial scaffolds

Mr Yitian Zhang[1], Prof Davide Deganello[1], Dr Zhidao Xia[1]
[1]*Swansea University, Crymlyn Burrows, United Kingdom*

Welcome and Presentations Session 1, June 1, 2023, 11:00 - 12:30

3D printing has emerged as a promising technology for the fabrication of biomaterial scaffolds in the field of bone regeneration. Many different materials of implanted scaffolds have been discovered and used in the past few years with successful outcomes, including calcium phosphate[1][2], polylactic acid[3], and titanium[4]. The integration of 3D printing technology and image analysis has the potential to enhance the field of bone grafting through personalized graft designs that minimize risks associated with traditional methods. The study reviews the use of open-source software for microCT [5] and MRI image analysis to guide graft printing and treatment. An ongoing project employing these technologies is briefly discussed, showcasing the potential to improve the visualization and quantification of changes. The potential impacts of these advancements in the field of bone repair and regeneration are highlighted.

Reference

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Impact of Binder Composition on the Performance of Activated Carbon Supercapacitor Electrode

Thomas Fone[1], D Jones[1], D Deganello[1], C.O. Philips[1]
[1]*Swansea University, United Kingdom*

Presentations Session 2, June 1, 2023, 14:30 - 15:45

This work presents the application of Ethyl Cellulose and Diacetone Alcohol in ink formulation for activated carbon supercapacitor electrodes, chosen for their lower minimal environmental footprint. The impact of reduced binder composition on electrode performance will be examined. This presentation will cover the full experimental process: electrode synthesis, material characterization, and electrochemical testing, alongside a comprehensive discussion of the results.

A TIME-DEPENDENT RHEOLOGY-BASED ANALYSIS TO UNDERSTAND FILAMENT MORPHOLOGY IN EXTRUSION-BASED 3D PRINTING OF CEMENTITIOUS MATERIALS

Mr Yu Jiang[1], Prof Abir Al-Tabbaa[1], Prof Ronan Daly[1]
[1] *Department of Engineering, University of Cambridge, Cambridge, United Kingdom*

Welcome and Presentations Session 1, June 1, 2023, 11:00 - 12:30

Cementitious materials exhibit time-dependent rheological properties. This behaviour is especially important in 3D printing which has gained momentum in recent years (Bos, Menna et al. 2022). The rheological changes over time drive subsequent changes in the dimensions of extruded filaments, which can't currently be compensated with software-based corrections. This filament thinning leads to an increase in porosity of the final printed product, which is one of the main defects in 3D printing of cementitious materials.

In this study, the time-dependent rheological properties of cementitious materials for 3D printing are characterised and correlated with extrusion behaviour. Here we explore the correlation between increasing extrusion pressure and the evolution of rheology, from analysis of various rheological tests, and how the change in filament morphology is dependent on the development of Bingham-Papanastasiou parameters, i.e. dynamic yield stress, plastic viscosity, and flow behaviour index (m), obtained from flow curve tests. Numerical studies were conducted to reveal the effects of time-dependent rheology on filament morphology, which will be compared against experimental results.

We demonstrate how the morphology of extrudate depends on rheology changes over time in a ram extrusion system. For industrial applications, where screw pumps are widely adopted, the effects on volumetric flow rate can further induce noticeable filament thinning. By taking into consideration the pattern in which filament dimensions are changing, engineers can design printed structures in a way to reduce porosity and improve mechanical strength.

This study deepens the understanding of the evolution of filament morphology in 3D printing and its dependence on time-dependent rheological properties to facilitate accurate and repeatable printing.

Citations:
Bos, F. P., et al. (2022). "The realities of additively manufactured concrete structures in practice." Cement and Concrete Research 156: 106746.

Integrating spiropyran mechanophores to indicate the ‘health’ of biomedical materials during manufacture

Erica Watchorn[1]
[1] *University of Cambridge, United Kingdom*

Presentations Session 2, June 1, 2023, 14:30 - 15:45

Hydrogels are the functional material of choice when it comes to tissue engineering constructs due to their biological compatibility and mechanical properties. Hydrogels are becoming increasingly popular, and research focuses more on adopting 3D printing as a fabrication method. Although bioprinting of hydrogels has been proven to be feasible, the mechanical forces experienced during the printing processes can be destructive and can lead to damaged structures within the material.

Here, we present a new strategy to integrate force-sensitive species known as ‘mechanophores’ within hydrogel systems and examine their activation in industrially relevant flows. The mechanical shear stresses generated during 3D printing processes can transfer energy to the chemical bonds, and drive mechanophores to undergo controlled chemical transformations. These chemical transformations provide real-times stress distribution of the matrix which can be directly observed through a visual response. The strain experienced can be controlled by a number of factors including the hydrogels properties such as its viscosity and composition, as well as the selected printing parameters, such as the inlet pressure, flow rate and nozzle dimensions. The overall aim of the project is to examine the scale of the forces during manufacturing processes and investigate how this affects the material in order to scale-up the production of these hydrogels for the intended application.

Keywords: Hydrogels, Additive Manufacturing, Mechanochemistry

Poster Presentation

Inkjet printing of gold ultrathin gold nanostructures incorporated Ployvynyl alcohol mutlilayers for testing the ezymatic/catalytic activity.

Mrs. Nizzy James[1], Prof Stephen Evans[1], Dr Kevin Critchley[1]
[1] *University Of Leeds, Leeds, United Kingdom*

Lunch and Poster Session, June 1, 2023, 13:00 - 14:00

Natural enzymes act by accelerating the rate of chemical reactions for specific reactions and substrates. However, their high sensitivity to the external environment, low stability, higher costs of production and purification hinders wider applications in area of biosensing, food industry and pharmaceutical processes. Artificial enzymes are emerged as a better alternative to tackle these drawbacks of natural enzymes. Catalytically active nanomaterials, referred as nanozymes, is a class of artificial enzymes that shows properties unique to the natural enzymes. Nanozymes have many advantages that includes, the controlled synthesis, tuneability and long-term stability over natural enzymes[1]. Over past years, gold nanoparticles (AuNP) have proven to be a great candidate for replacing the nano enzymes. It has been reported that as the size of AuNP is reduced, the catalytic efficiency increased manyfold[2].

Recently Ye et al. reported the synthesis of freestanding, atomically thin gold nanosheets (AuNS) for the first time [3]. The developed lower dimensional structures like AuNS ad Au Nanotapes (AuNT) showed exceptional catalytic activity which was tested by using these as catalyst in the reduction of 4-nitrophenol by sodium borohydride. As a step towards developing reusable biocatalysts, these Au nanostructures were incorporated into the PVA hydrogel network. A recent study in the group revealed that the catalytic activity can be tuned and found to have increased with the increase in aspect ratio of the AuNS/AuNTs incorporated PVA hydrogel.

Inkjet printing of AuNS/AuNT incorporated PVA suspensions is an efficient method to make hydrogel with higher aspect ratios compared to using moulds or other methods such as electrospinning. The proposed plan is to print a AuNS/AuNT PVA hydrogel mesh for the effective diffusion of the reagents into the hydrogel matrix and thereby reacting with the AuNS/AuNP catalyst incorporate in the hydrogel network. However, the inkjet printing of PVA suspensions is a less explored and a very few publications are there till date [4][5]. The solvents used, the molecular weight of PVA, Degree of hydrolysis and weight percent of PVA in the suspensions play very crucial role in the inkjectability of PVA suspensions. Additional challenges like polymerisation inside the cartridge, nozzle clogging, gel formation after printing also needs to be addressed.

References

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