Electrodeposition of a Bi/Mg alloy to form high performance Mg electrodes for rechargeable Mg batteries

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Abstract

The growing demand for electrochemical energy storage has motivated interest in post-lithium battery technologies. Rechargeable magnesium batteries (RMB) are attractive due to magnesium's high volumetric capacity and abundance. The active materials of these batteries, which are highly reactive metals, react with material in high energy batteries, creating a solid electrolyte interphase (SEI). These usually protect the metals from further reactions while being conductive to their ions. Unfortunately, commercialisation of RMBs has been hindered due to problems with rechargeability owing to magnesium blocking SEIs.

One solution to this problem is the use of inorganic salts to form more magnesium conductive SEIs, especially due to the lower reactivity of the metals of those salts compared to magnesium. Here, we introduce an electrochemical pretreatment in which magnesium and an additive metal are co-deposited by slowly cycling electrodes dipped in solutions of their salts to form an interphase. Bismuth salts have been studied extensively and reported as magnesium-based SEI forming agents. With that in mind, bismuth triflate, a bismuth salt, is used as a model example to demonstrate the effectiveness of this approach.

The treated electrodes exhibit higher efficiency with the magnesium ions requiring lower energy to be deposited. Spectroscopic analysis indicates that the formation of an alloy-based interphase has occurred. Importantly, this pretreatment eliminates the activation period typically associated with inorganic salt additives.

[1] M. Yoshio, R. J. Brodd and A. Kozawa, *Lithium-ion batteries: Science and technologies*, Springer New York, 2009.

[2] D. Atkins, E. Ayerbe, A. Benayad, F. G. Capone, E. Capria, I. E. Castelli, I. Cekic-Laskovic, R. Ciria, L. Dudy, K. Edström, M. R. Johnson, H. Li, J. M. G. Lastra, M. L. De Souza, V. Meunier, M. Morcrette, H. Reichert, P. Simon, J. P. Rueff, J. Sottmann, W. Wenzel and A. Grimaud, *Adv Energy Mater*, 2022, 12.

[3] K. Habib, L. Hamelin and H. Wenzel, *J Clean Prod*, 2016, **133**, 850–858.

[4] R. Mohtadi, O. Tutusaus, T. S. Arthur, Z. Zhao-Karger and M. Fichtner, *Joule*, 2021, 5, 581–617.

[5] Z. Lu, A. Schechter, M. Moshkovich and D. Aurbach, *On the electrochemical behavior of magnesium electrodes in polar aprotic electrolyte solutions*, 1999, vol. 466.

[6] R. A. DiLeo, Q. Zhang, A. C. Marschilok, K. J. Takeuchi and E. S. Takeuchi, *ECS Electrochem Lett*, 2015, **4**, A10.

[7] Z. Meng**,** Z. Li, L. Wang, T. Diemant, D. Bosubabu, Y. Tang, R. Berthelot, Z. Zhao-Karger, M. Fichtner, *ACS Appl. Mater. Interfaces* 2021, **13**, 31, 37044–37051

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Transdermal Delivery of Adalimumab for the Treatment of Crohns Disease

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Introduction: More than 500,000 people in the UK are living with Crohns or Colitis [1]. One of the treatments for Crohns is adalimumab (Humira), a monoclonal anti TNFα antibody, that has to be administered by the patient every 7-14 days via subcutaneous injection. However, it is estimated that up to 30% of people suffer with needle-phobia with some saying they would avoid injections to treat a severe medical condition [2]. If Crohns disease is left untreated it can lead to complications such as strictures, fistulas, and abscesses. It also increases the risk of other conditions such as colon cancer [3]. Our aim is to utilise permeation enhancers to develop a transdermal alternative so we can enhance patient compliance.

Methods: Adalimumab is a large (148kDa) hydrophilic molecule, meaning that it is unlikely to pass through the skin without the addition of permeation enhancers. For this we selected cationic molecules with multiple amine groups e.g. polyarginines. Initially we used characterisation methods (DLS, Zeta potential, and FTIR) to ensure that the addition of the permeation enhancers does not impact the structure and function of the adalimumab. This was followed by cytotoxicity studies on epithelial and fibroblast cells to ensure the required concentrations would not irritate the skin. Monolayer and TEER studies were then performed to assess whether the permeation enhancers utilised a transcellular or paracellular route. Finally, franz cells were used to assess drug permeation through full thickness pig skin. In the future, we are planning to formulate the drug into a suitable administration method and run in vivo studies to confirm efficacy.

Results: Characterisation studies were performed which showed minor aggregation following the addition of the peptides to the drug; however, the majority of the sample remained unchanged, and these aggregates could be eliminated via filtration. Cytotoxicity studies were then conducted to ensure that prolonged exposure would not irritate the skin. Our results showed no statistically significant toxicity at efficacious concentrations after 24 hours. This suggests they would be suitable for this application. We also performed monolayer and TEER studies. This data suggested that the permeation enhancers successfully passed through the biological membrane but that the longer chain polyarginines utilised a transcellular route while the shorter polyarginines utilised a paracellular route. Following the TEER studies, we performed franz cell studies using full thickness pig skin as an ex-vivo model (samples quantified using ELISA). This confirmed that with the addition of our permeation enhancers, approximately 10% of the adalimumab (44.7µg out of 500 µg) was able to pass through the skin barrier. Whereas, without the permeation enhancer, no adalimumab was detected in the receptor fluid showing no full thickness skin permeation.

[1] Veral M A, et al. PLoS One. 2025: e0329317 - DOI: 10.1371/journal.pone.0329317

[2] Alsbrooks K, et al. PLoS One. 2022: e0276814 - DOI: 10.1371/journal.pone.0276814

[3] Yoon S, et al. Int J Gastrointest Interv. 2023: 29-36 - DOI: 10.18528/ijgii220003

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Quantum Computing to Study Electronic Structure

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We have all heard the term 'Quantum', but how is it linked to chemistry or even biology? It all comes down to the behaviour of the electron, as this determines many chemical processes, and perhaps even biological processes. Quantum computing offers a way to study these systems on their own level, quantumly, as Feynman first proposed in 1982[1]. By using quantum computing to aid existing chemistry calculations, a better understanding of the electronic structure can have applications in drug discovery and material design. In biology, understanding these quantum systems can help us replicate them. For example, the energy transfer in photosynthesis is highly efficient and may have a quantum explanation[2], and investigating this could lead to the replication of this process for solar energy.

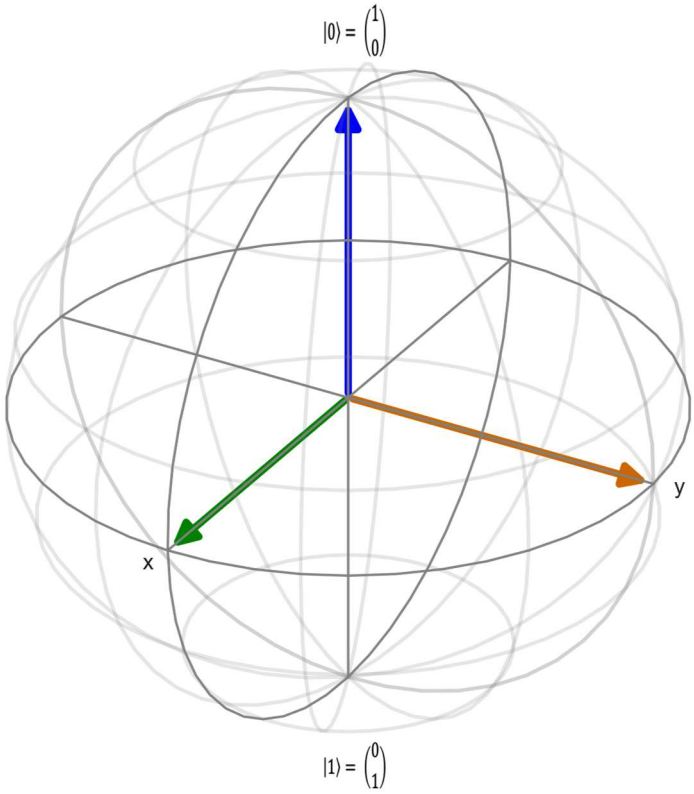

Figure 1 - A Bloch sphere which represents all the values a qubit can take. Qubits are what make up a quantum computer.

1. Feynman et al., Int. J. Theor. Phys., 1982, 467, 10.1007/BF02650179
2. P. Ball, Phys. World, 2018, 31, 44.

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Development of anti-scarring peptides to prevent corneal blindness and other scar related disabilities and diseases

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Introduction: Corneal scarring is a major cause of permanent vision loss worldwide, notably affecting populations in developing countries, where ocular trauma, infection, and limited access to surgical care are prevalent (1). Vision loss is driven by disordered collagen deposition during wound healing (2). Decorin regulates collagen fibrillogenesis, but its therapeutic use is limited by size, stability, and manufacturing challenges (3). This study investigates a decorin-inspired synthetic peptide, CW1, as a simplified anti-scarring strategy for ocular applications.

Method: Binding assays were conducted to confirm the specificity of CW1 for collagen and to identify critical binding regions. Atomic force microscopy was used to visualise CW1-induced changes in collagen fibril organisation. Cytocompatibility was evaluated in fibroblast, corneal and retinal cultures. To enhance delivery, CW1 was encapsulated in PLGA nanoparticles, and characterised via scanning electron microscopy and single-molecule fluorescence microscopy for structural integrity and successful loading.

Results: Binding studies confirmed the specific interaction between CW1 and collagen, with critical areas identified in the central region. Atomic force microscopy revealed that CW1 altered collagen fibril organisation, producing a more aligned and less entangled matrix compared with untreated collagen. Cytocompatibility tests demonstrated no evidence of cytotoxicity. CW1 was successfully encapsulated in PLGA nanoparticles, retaining structural integrity and peptide loading.

These findings demonstrate that a decorin-inspired peptide can bind collagen and modulate matrix organisation without cytotoxicity. Encapsulation into PLGA nanoparticles supports its potential for topical ocular delivery.

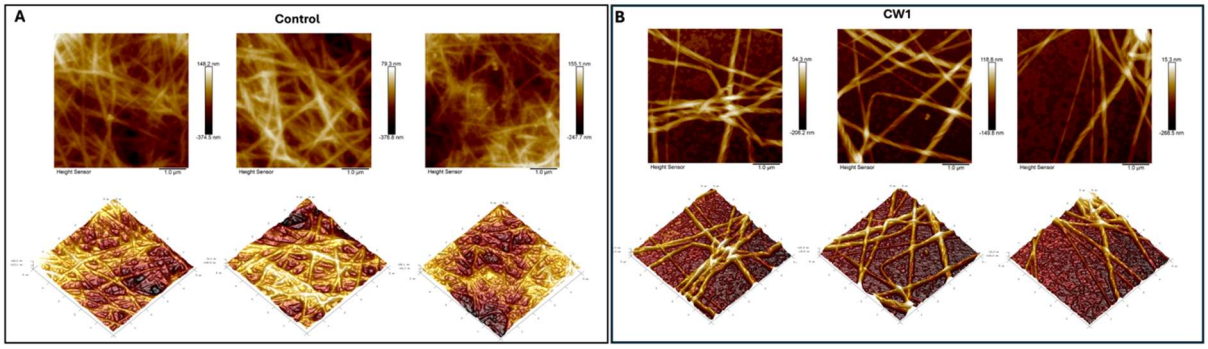

Figure 1: Atomic force microscopy (AFM) imaging of collagen gels formed in the presence or absence of CW1. (A) AFM imaging of control collagen gels without CW1. (B) AFM imaging of collagen gels formed in the presence of CW1. For all conditions, representative 2D height sensor images (top row) and 3D reconstructions (bottom row) are shown. All scans were acquired using tapping mode over a 5 µm × 5 µm area. Height scales are indicated besides each image.

Acknowledgements: This work was supported by the EPSRC, grant EP/S023054/1.

References: (1) Jeng et al, *Ophthalmology*, **2021**, 649, DOI: 10.1016/j.ophtha.2020.06.042. (2) Syed et al, *Int J Mol Sci*, **2023**, 13438, DOI: 10.3390/ijms241713438. (3) Zhang et al, *J Biol Chem*, **2009**, 8888-97, DOI: 10.1074/jbc.M806590200

Next Generation Bio-instructive Polymers for Chronic Wound Treatment

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About 10 million people suffer from Osteo Arthritis (OA) in the UK, that's 1 in 6 people and there are just over half of those suffering of knee OA. In OA and rheumatoid arthritis (chronic conditions that are onset by age, environmental factors and or genetics) there are problems with tissue inflammation, joint and eventual bone degradation in fingers, wrists and knees are key issues to tackle. In the clinic there is no cure and only lines of treatment to manage pain exist such as through the use of NSAIDS, corticosteroid as wound healing is a complex process, especially when dealing with chronic wounds. Ultimately surgical procedures are required for joint replacement and can cost as much as £18,000. This research looks at finding a surgery free option that aims to stop if not slow inflammation and onset of degradation cascades, namely in the knee joint, to prevent the wounds from becoming chronic. Carrying on from work at the University of Nottingham in generating bio-instructive polymers that have anti-inflammatory and wound healing properties,[1,2] this work aims to incorporating these polymers with alginates[3] and hyaluronates to create a biocompatible injectable drug carrier.

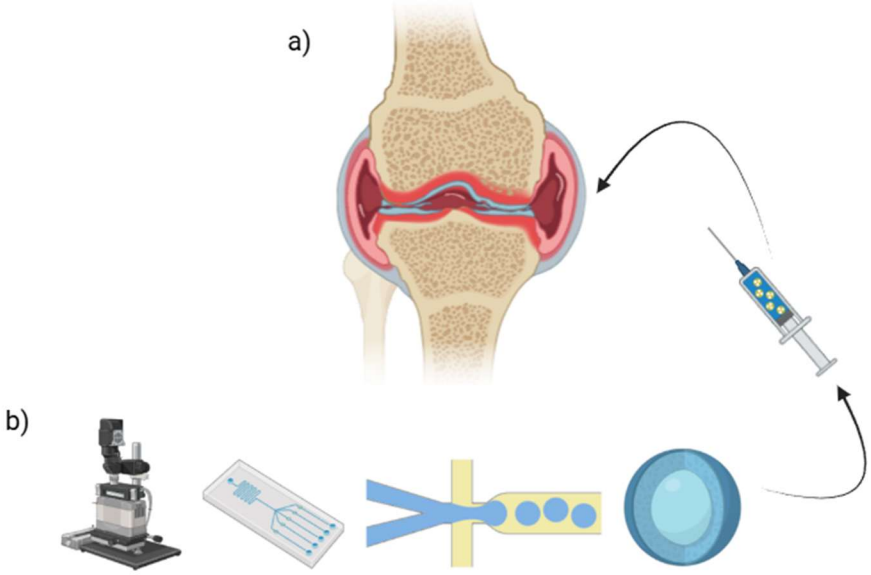

Figure 2 a) A depiction of the a knee suffering from OA and b) The proposed solution of an injection to the synovial joint through a bio-instructive substance generated through microfluidics

1. A. Latif et al, Advanced Materials, 2022, 36(43):2208364 10.1002/adma.202208364
2. V. Cuzzucoli Crucitti et al, ACS Applied Materials and Interfaces, 2021, 13(36), 43290-43300 https://doi.org/10.1021/acsami.1c08662
3. A. Vegas et al, Nature Biotechnology, 2016, 34, 345-360 https://doi.org/10.1038/nbt.3462

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Designer Superplasticizers via the utilisation of CO_2

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Using CO_2 mineralisation strategies in construction materials remains a promising (although challenging) prospect for carbon footprint reduction in the concrete industry. Optimising CO_2 uptake whilst also improving its fresh and hardened state properties is important in cement science. Cement production accounts for 8% of all global CO_2 emissions[1], yet significant CO_2 is reabsorbed in setting cement. We envisaged the development of new CO_2 derived poly-carbonate cement additives to maximise CO_2 uptake while simultaneously improving its pouring characteristics and set strength. Herein, we describe a novel class of superplasticizers (Figure 1) synthesised via carbonation-driven functionalisation of polymer precursors and assess their performance in Portland-cement.

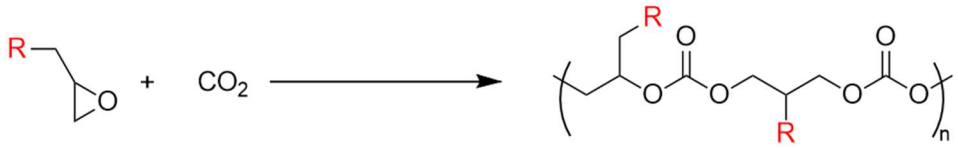

Figure 1. Reaction of CO_2 and a functionalised glycidol to form a polycarbonate[2]

Our reaction involves the carbonation of an epoxide containing anionic functional groups (R in Figure 1) which interact with the positively charged cement surface resulting in significant water reduction and improved handling characteristics. Our superplasticizers are analysed via FTIR, NMR, ReactIR and GPC and their behaviour under cementitious hydrolysis conditions studied.

Our aim is to deliver polymer additives that are able to act like a traditional superplasticizer while also improving CO_2 mineralisation. This is achieved through chemical hydrolysis of carbonate groups from the polymer hydrolysis during the setting period. These will become directly involved in mineral carbonation in the setting concrete/cement. This allows a dual-function admixture maximising cement performance and the integration of carbon dioxide within the binder matrix.

In conclusion, our new CO_2 derived superplasticizers could offer a route to integrate captured carbon into concrete chemistry while preserving admixture performance. By delivering CO_2 directly to reactive sites, these polymers promote controlled mineralisation, improve material stability and durability, and enable sequestration within the binder.

1. Ige, O.E. et al, *Clean Technologies*, **2025**, 7, https://doi.org/10.3390/cleantechnol7040085
2. Motokucho, S. et al, *Journal of Polymer Science Part a-Polymer Chemistry,* **2004,** 2506-2511, https://doi.org/10.1002/pola.20081

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Plastic Pollution versus Protein Protagonists: can enzymes be the solution to the plastic pollution crisis?

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The global demand for plastic continues to rise, polyethylene (PE) is projected to become two of the most widely produced plastics by 2050[1]. In turn, the accumulation of plastic waste presents a significant environmental challenge. Current disposal routes such as landfill, incineration, and recycling carry significant environmental and social costs, highlighting the need for alternative solutions one of which is biological degradation, which is the focus of my research.

PE is commonly described as recalcitrant and resistant to degradation[2]. Despite this, recent studies have shown that microbial consortia can grow using polyethylene as a food source, suggesting certain bacteria possess the machinery required to degrade, internalise and mineralise this highly persistent plastic[2,3]. My PhD will explore the enzymes evolved by PE-degrading bacteria, revealing how they recognise, modify, and ultimately dismantle polyethylene. By piecing together this enzymatic puzzle, my research aims to expose a biological pathway that could transform polyethylene waste from an environmental burden into a resource, opening new routes for sustainable plastic recycling.

1 M. Dokl, A. Copot, D. Krajnc, Y. V. Fan, A. Vujanović, K. B. Aviso, R. R. Tan, Z. Kravanja and L. Čuček, Sustainable Production and Consumption, 2024, 51, 498–518.

2 Z. Cai, M. Li, Z. Zhu, X. Wang, Y. Huang, T. Li, H. Gong and M. Yan, Microorganisms, 2023, 11, 1661.

3 J.-M. Restrepo-Flórez, A. Bassi and M. R. Thompson, International Biodeterioration & Biodegradation, 2014, 88, 83–90.