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Scientific Keynote

Enhancing 3D bioprinting functionalities using ion-releasing bioactive glass nanoparticle-containing bioinks

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3D bioprinting offers a promising approach to fabricate customized scaffolds for tissue engineering and in vitro models [1]. One approach being investigated to improve bioinks for 3D bioprinting is the use of composite bioinks which incorporate ion releasing bioreactive (nano)particles. In this context, research at the FAU Institute of Biomaterials in Erlangen has focused on hydrogels based on alginate dialdehyde-gelatin (ADA-GEL) incorporating ion-releasing bioactive glass (BG) nanoparticles which can be designed to improve printability, mechanical properties, degradation behaviour and biological performance of the 3D bioprinted constructs.

In this presentation we will describe the synthesis of ADA via oxidation of alginate [2], and the fabrication of mesoporous BG nanoparticles (MBGNs) via evaporation-induced self-assembly [3] and microemulsion-assisted [4] sol-gel methods. It will be shown that differences in particle size, surface area, and porosity of MBGNs influence the extent of ion release and the gelation of the inks. Different biologically active ions investigated are Cu, Zn, Mg, B, Li, and Ce. Ibn some cases, released ions acted as in situ crosslinking agents, leading to tunable gelation behavior and a defined processing window. With optimized printing parameters, the composite inks produced continuous filaments and three-dimensional structures with shape fidelity.

Bioprinting studies were conducted using NIH/3T3 fibroblasts and C2C12 myoblasts [5] in order to establish the functionalities provided by the incorporated ion releasing MBGNs. Local ion release in the hydrogel can lead to significant effects on cellular response indicating potential advantages of utilizing biologically active ions as signaling agents instead of organic molecules or growth factors. For example, incorporating 0.1% w/v MBGNs in cell-laden constructs led to enhanced metabolic activity, highlighting the beneficial role of ion-releasing particles. This work demonstrated that ADA-GEL based composite hydrogels with ion-releasing particles provide reliable printability, tunable properties, and improved cellular responses, supporting their potential as an ionic medicine strategy for bioprinting applications.

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[1] S. Heid, A.R. Boccaccini, Acta Biomater. 113 (2020) 1–22.
[2] B. Sarker et al., J. Mater. Chem. B 2 (2014) 1470–1482.
[3] K. Zheng, et al., Journal of the American Ceramic Society 98 (2015) 30–38.
[4] K. Zheng, A.R. Boccaccini, Adv. Colloid Interface Sci. 249 (2017) 363–373.
[5] H. H. Lu, et al., Biomaterials Advances 172 (2025) 214233.

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Aldo R. Boccaccini is Professor of Materials Science (Biomaterials) and Head of the Institute of Biomaterials at University of Erlangen-Nuremberg, Germany. He is a visiting professor at Imperial College London, UK, and RWTH Aachen University (Germany). He has an Engineering degree from Instituto Balseiro, Argentina (1987) and a Doctorate in Engineering (Dr.-Ing.) from RWTH Aachen University, Germany (1994).

The research activities of Prof. Boccaccini are in the field of ceramics, glasses and composites for biomedical, functional and/or structural applications with focus on bioactive materials, scaffolds for tissue engineering, nanomaterials for drug delivery, biofabrication and antibacterial coatings. He has been a visiting professor at different universities around the world and has given more than 150 presentations at international conferences (as keynote, invited and plenary speaker). Boccaccini has published more than 1100 scientific papers and 25 book chapters. He has co-edited 8 books. His work has been cited more than 88,000 times (h-index = 134) according to Scopus®, and more than 115,000 times (h-index = 154) according to Google Scholar®. Boccaccini was included in the "Highly Cited Researchers" lists in 2014 and 2018 (Clarivate Analytics). He is also listed as one of the most cited researchers in the world according to the latest editions of the Stanford List of Highly Cited Researchers published in 2023, 2024 and 2025, where he ranks as one of the most cited (top 50) researchers worldwide in the field "Materials". He is also consistently ranked among the top scholars internationally in various categories by ScholarGPS (Global ranking: #30 in Biomaterials, highest ranked researcher based in Germany).

Boccaccini was the Editor-in-Chief of the journal Materials Letters for 14 years (2010-2023) and currently holds the position of Emeritus Editor-in-Chief. In June 2024, he was appointed Editor of the journal Progress in Materials Science (Elsevier). He serves also as Editor of the journal Bioactive Materials.

Boccaccini is a Fellow of four major materials science/technology societies, namely Institute of Materials, Minerals and Mining (UK), American Ceramic Society, European Ceramic Society and Society of Glass Technology. Boccaccini served as the president of the Federation of European Materials Societies (FEMS) for the regular two year period (2024-25), having been a member of the Board of FEMS since 2016.

He has received multiple awards and honors, including the Materials Prize of the German Materials Society (2015). Boccaccini is also an elected member of the World Academy of Ceramics, the National Academy of Engineering and Applied Sciences of Germany (acatech) and fellow of the European Academy of Sciences (EurAsc). In 2022, he was conferred the degree of Honorary Doctor of Philosophy at Åbo Akademi University, Turku, Finland, and in 2025, he received the three Honorary Doctorates; from Riga Technical University (Latvia), Alexander Dubček University of Trenčín, (Slovakia) and International University of Catalonia Barcelona (Spain). He was member of the Council of the European Society for Biomaterials (ESB) for 8 years (2015-2023), serving as ESB vice-president in the period 2020-2023. Since 2022 he has been a member of the Board of the Bioceramics Network of the European Ceramic Society (ECerS).

In 2023, he was elected Fellow of Biomaterials Science and Engineering (FBSE) by the International Union of Societies for Biomaterials Science and in 2024 he was inducted to the prestigious College of Fellows of the American Institute for Medical and Biological Engineering (AIMBE). This recognition, which represents the top two percent of engineers in medical and biological fields, acknowledges Boccaccini's significant contributions to bioactive materials design for regenerative medicine, drug delivery, and 3D bioprinting. In 2025 the European Society for Biomaterials (ESB) honored Prof. Boccaccini's achievements with the prestigious George Winter Award. He also received in 2025 the Larry L. Hench Lifetime Achievement Award of the American Ceramic Society.