Editorial

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This present, first issue of the fourth volume is dedicated to the memory of Dr Kajal Mallick, the first Editor-in-Chief of our journal, who unexpectedly passed away over Christmas 2013 (Dr Mallick's obituary was published in the March 2014 issue of *Bioinspired, Biomimetic and Nanobiomaterials*).¹

Dr Mallick was an internationally renowned material scientist with a strong focus on biological and medicinal sciences. As a material scientist, he was always open to other scientific disciplines and innovative technology routes as such the bioinspired approach. He strongly developed the new field of bioinspired materials, especially for biomedical applications. Most recently, he headed the Tissue Engineering and Ceramic Processing research group (TiECeP), which includes a large number of undergraduate and graduate students, as well as doctoral candidates from the natural and engineering sciences. His research and teaching was focused on the synthesis, structure, processing and characterisation of materials including ceramics, glass and glass–ceramics, polymers, metals and biomedical materials. His other areas of significant research impact included functional, engineering and electroceramics for mobile and telecommunication applications as well as superconductors. He published nearly 100 refereed papers in leading peer-reviewed high-impact international journals, as well as a number of contributed/invited conference papers.

The Dr Kajal Mallick memorial issue honours his life's work in his various fields of research. It includes part of his own work and contributions from his friends and partners in sciences. Major contributions come from the area of biomedical science, and novel scaffold fabrication and bone regenerative medicine. This issue further encompasses innovative ceramic manufacturing techniques and bioinspired materials such as optical structures and theoretical consideration on the toucan beak.

The first paper by Winnet and Mallick² and accompanied work derives from the renowned Warwick Manufacturing Group and reflects the research of Dr Kajal Mallick. The topic of this paper is the fabrication of porous 3D bioscaffolds by adaptive foam reticulation. Highly interconnected and porous hydroxyapatite (HA) scaffolds with controllable macroporosity and microporosity were produced using the adaptive foam reticulation technique, combining foam reticulation and freeze-casting methodologies. The developed process yielded an optimised macropore structure from the polymeric template. Designed micropores are introduced into the struts using the porogen approach. The cell culture and

assay test distinctly showed that the scaffolds are not cytotoxic and can be used as bone grafts.

The next paper by Gu *et al.*³ deals with the evaluation of the dynamic nanomechanical behaviour of healthy compared with disordered (osteogenesis imperfecta (OI)) human cortical bone. The assessment of the viscoelastic properties of bone is of profound interest, because the time-dependent mechanical properties relate to the fracture risk of bone under dynamic loading. The authors studied the nanomechanical behaviour of the intact, demineralised and OI human cortical bone specimens by dynamic nanoindentation. Their results suggest that the viscoelasticity of bone is primarily attributable to the mineral component. This study is a valuable to the literature for the understanding of the viscoelastic response of bone material diseased bone.

The advances in techniques and technologies for bone implants are presented by Munro and McGrath.⁴ In order to cope with the current developments in society and medicine, efficient materials that can increase and actively repair the function of damaged or diseased bone are essential. Their review provides an overview into the current state-of-the-art materials. Emphasis is laid on new metals and metal alloys that are potentially more biocompatible, porous metal foams that mimic the structure of a spongy bone, and advanced composites that incorporate the properties of multiple materials within one implant. This review also provides insight into additive manufacturing techniques that allow for a tailored design of the properties and the production of custom-made implants.

Due to its similarity to bone, HA is widely investigated and used in bone replacement applications. The paper by Cox *et al.*⁵ also comes from the Warwick Manufacturing Group (including the work of Dr Kajal Mallick) and compares the synthesis of nanosized HA, which was produced by aqueous precipitation, solvothermal synthesis and two self-propagating combustion techniques. The authors could prove that the physico-chemical variations during processing could significantly influence key properties such as solubility, bioactivity, potentiality and biocompatibility. Their profound research work provides distinct evidence that the selection of the synthesis method and conditions to produce HA is critical for providing a specific physico-chemical property.

One of the greatest challenges in orthopaedic surgery is the repair of large skeletal defects. A major problem is the mismatch of mechanical properties of bone and the implant, and the tailor-made

fabrication of such implants. The work of Meredith and Mallick⁶ shows a feasible approach for the fabrication of high-strength scaffolds for bone regeneration. This research area also represents one of the core activities of Dr Kajal Mallick. Their research reports on a practical solution to the above challenge by applying a continuously working extrusion process using clay-like HA pastes. The manufactured samples exhibited high strength and supported the proliferation of osteosarcoma cell lines.

A topic related to bioinspired manufacturing is presented by Nithyanandan *et al.*⁷ Their work refers to the bioinspired electrohydrodynamic ceramic patterning of curved metallic substrates. Their developed novel method of template-assisted electrohydrodynamic atomisation has been applied to pattern curved metallic surfaces for the first time. They produced parallel lines of titania with diameters in range of tenths of microns on convex and concave titanium substrates. It was shown that their method is highly controllable and compatible on a wide range of substrate geometries. This is an important milestone since applying the method on more complex surfaces would enable the patterning of bioactive compounds for various shapes and geometries.

An interesting approach for the fabrication of bioinspired optical structures, which might be of importance for industrial applications, is given by Parker and Townley.⁸ Biological structures often exhibit functional characteristics, which rely on their specific architecture. However, generating the complexity of biological structure with artificial methods is limited. Using biology (i.e. bioengineering methods) would be an elegant way to produce complex structures. The authors present the very first attempt to culture the wing scales of a butterfly and encountered many obstacles and challenges. These are expected to be improved in future studies, but the authors anticipate that cell cultures would probably not be a viable technique to provide the butterfly optical structures for industry in the near future, although the experiments revealed important results of scale development.

Coming back to the topic of biomedical materials, the work of Naseri *et al.*⁹ presents the fabrication and characterisation of zein-based bioactive glass scaffolds. Plant proteins exhibit certain advantages for biomaterial processing due to their ease of availability and good biodegradability. In their study, the authors report on the composite foams based on zein and 45S5 bioactive glass particles by salt leaching. The protein–bioglass scaffolds show an enhanced bioactivity with considerably improved mechanical properties. These composites are a new bioactive material with potential applications in bone tissue engineering.

The paper by Yucesoy *et al.*¹⁰ relates to the emerging interest in developing bio-functionalisation routes. The work introduces a new platform that could serve as a bioengineering platform for assembling diverse enzymes onto material surfaces for laboratory-on-a-chip-based sensing and energy-harvesting systems. The

authors investigated the direct bioelectrocatalysis at the interfaces by a genetically engineered dehydrogenase. A fusion protein that genetically conjugates gold-binding peptide to formate dehydrogenase was engineered and the expressed proteins were tested for both enzyme activity and self-directed gold-surface functionalisation ability. The findings distinctly show that the self-immobilisation of the engineered enzyme onto different gold electrodes was successful and the catalytic activity was retained. The presented engineered peptide-mediated, self-integrated electrode systems can be extended to develop a wide range of biosensing and energy-harvesting platforms using different combinations of materials and biomolecules.

A predictive model relating to physical properties during bone ageing would be an interesting tool for tissue engineering applications. The paper by Khovanova *et al.*¹¹ also involves the work of Dr Kajal Mallick. This study investigates the correlation of age in male and female specimens with the physico-mechanical properties of trabecular bone, including compressive strength, bone volume fraction, structural model index, trabecular thickness factor, level of inter-connectivity and pore morphology. The analysis involved the generation of an artificial neural network based on a distinct set of 35 samples available. It was shown that the age strongly correlates with the physical properties of the bone affected by severe osteoarthritis. The compression strength was found to be the most important factor for predicting bone ageing. Within certain limitations of the input data set, the developed model provides a consistent tool for tissue engineering applications.

The final paper by Fairbairn¹² deals with the deduction of material properties from simulation results. The author selected a toucan (*Ramphastos toco*) beak, an extraordinary strong structure in nature. He reduced the beak structure to basic functional elements and determined the material properties and geometric ratios between three key elements of the beak. From the results it was deduced how this natural structure achieves its strong, lightweight form. The analysis of the results gives direction to improve material's application using these ratios for an increased composite beam performance through design.

The decease of Dr Kajal Mallick still fills us with the deepest grief. This issue is dedicated to the honour and memory of him. His science and achievements will be unforgettable to all of us. He followed his way of science and journal management very energetically and with great commitment. We sincerely hope that we can further develop this field of materials science along his lines. He will not be forgotten.

REFERENCES

1. Zollfrank, C. Obituary: Kajal Mallick. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 3 (1), 1.
2. Winnett, J.; Mallick, K. K. Porous 3D bioscaffolds by adaptive foam reticulation. *Bioinspired, Biomimetic*

- and Nanobiomaterials* **2015**, 4 (1), 3–13, <http://dx.doi.org/10.1680/bbn.13.00026>.
3. Gu, C.; Katti, D. R.; Katti, K. S. Dynamic nanomechanical behaviour of healthy and OI human cortical bone. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 14–24, <http://dx.doi.org/10.1680/bbn.14.00018>.
 4. Munro, N. H.; McGrath, K. M. Advances in techniques and technologies for bone implants. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 25–35, <http://dx.doi.org/10.1680/bbn.14.00015>.
 5. Cox, S. C.; Walton, R. I.; Mallick, K. K. Comparison of techniques for the synthesis of hydroxyapatite. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 36–46, <http://dx.doi.org/10.1680/bbn.14.00010>.
 6. Meredith, J.; Mallick, K. K. High-strength scaffolds for bone regeneration. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 47–57, <http://dx.doi.org/10.1680/bbn.14.00019>.
 7. Nithyanandan, A.; Mahalingam, S.; Huang, J., *et al.* Bioinspired electrohydrodynamic ceramic patterning of curved metallic substrates. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 58–66, <http://dx.doi.org/10.1680/bbn.14.00020>.
 8. Parker, A. R.; Townley, H. E. Making photonic structures via cell culture: *Morpho* butterfly scales. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 67–71, <http://dx.doi.org/10.1680/bbn.14.00026>.
 9. Naseri, S.; Hum, J.; Lepry, W. C., *et al.* Fabrication and characterization of zein–bioactive glass scaffolds. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 72–77, <http://dx.doi.org/10.1680/bbn.14.00025>.
 10. Yucesoy, D. T.; Karaca, B. T.; Cetinel, S., *et al.* Direct bioelectrocatalysis at the interfaces by genetically engineered dehydrogenase. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 78–88, <http://dx.doi.org/10.1680/bbn.14.00022>.
 11. Khovanova, N. A.; Shaikhina, T.; Mallick, K. K. Neural networks for analysis of trabecular bone in osteoarthritis. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 89–99, <http://dx.doi.org/10.1680/bbn.14.00006>.
 12. Fairbairn, J. Toucan beak composite structure ratio analysis and simulation. *Bioinspired, Biomimetic and Nanobiomaterials* **2015**, 4 (1), 100–107, <http://dx.doi.org/10.1680/bbn.14.00031>.