# Biomaterials for human healthcare*

MEETING REPORT

The global biomaterials market is estimated to be US$ 88.4 billion by 2017 (ref. 1). A rise in musculoskeletal disorders further enlarges the scope of biomaterials in healthcare, which imposes a burden of more than US$ 250 billion every year on the society. It is interesting to note that North America has the largest share of the biomaterials market in the world. However, the Indian market is slowly emerging.

In the light of emerging trends, a three-day international conference on design of Biomaterials (BIND 12) was organized in Bangalore to (i) identify problems associated with the design and fabrication of biomaterials; (ii) review the progress being made in this important area in India vis-à-vis the rest of the world; (iii) discuss the development of novel techniques integrating nanotechnology, stem cell or regenerative medicine and tissue engineering and (iv) to serve as a platform for young researchers to present their findings before the biomaterials community.

BIOMAT-12, a workshop that preceded the conference, was inaugurated by K. B. R. Varma (Indian Institute of Science (IISc), Bangalore). The main objective of the workshop was to educate and train the next generation of Indian biomaterials researchers. The workshop was designed to cover basic concepts such as structure, properties, processing and characterization of biomaterials, and the evaluation of blood, cell and bacterial compatibility of materials, to advanced topics such as tissue scaffolds, drug delivery and imaging. Lectures were supplemented with demonstrations and laboratory visits. Overall, the workshop served as a platform to disseminate information to future stakeholders on the subject by echelons through a series of classroom lectures and laboratory training sessions.

Some of the talks that followed during the sessions are as follows. Bikramjit Basu (IISc) highlighted the fundamental concepts and importance of understanding the cell–material interaction in biomaterials science and engineering. H. K. Varma (Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvanathapuram) focused on hydroxyapatite (HA)-based biocomposites used as bone substitutes, development of synthetic bone scaffolds and some clinical studies using ceramics scaffolding with growth factors. N. Ravishankar (IISc) provided a brief introduction to scanning and transmission electron microscopes, the operation, the imaging modes and detectors and the importance of the correct interpretation of the data obtained from these techniques. Annie John (Sree Chitra Tirunal Institute for Medical Sciences and Technology) covered the preclinical evaluation for skeletal tissue engineering towards orthopedic applications, explaining basic developmental biology of bone and cartilage, remodelling mechanisms and aspects of selecting optimal design of scaffolds. Ajoy Ray (Bengal Engineering and Science University, Howrah) presented a hybrid approach for early detection of malignancy. Aniruddh Jagannath (M.S. Ramaiah Hospital, Bangalore) discussed the use of biomaterials for neural tissue engineering applications.

Kaushik Chatterjee (IISc) spoke on the need for blood-compatible materials, the principles of blood–material interactions and blood compatibility of devices. A video lecture by Phil Salmon (Bruker Micro CT, Belgium) on the fundamentals and applications of micro-CT to biomaterials described the basic concepts of micro-computed tomography and its advantages over other conventional techniques. A few case studies were also presented on how micro-CT was being used to characterize the samples to determine porosity, the interconnectivity of pores and other parameters that are important for biomaterials.

A laboratory visit to the cell culture and bacterial culture facilities developed by Bikramjit Basu at IISc was arranged, which was followed by Jyotirmoy Chatterjee's (IIT Kharagpur) presentation on the importance of multi-modal imaging in regenerative medicine research. T. S. Sampath Kumar (IIT-Madras) delved into engineering hard tissues using fibrous composites and nanocarriers. An industrial visit to DUCOM Instruments Pvt Ltd, Bangalore exposed the attendees to live demonstration and principles of the tribometer, used to obtain tribological properties of biomaterials.

The design and development of biomaterials require integration of concepts and expertise of two widely different disciplines, i.e. materials science and engineering with biological sciences. In order to ensure the continuous growth of this emerging field, numerous initiatives have been taken at IISc. Also, several academic courses are being taught at undergraduate and graduate levels in topmost universities, including the IITs.

During the inaugural session of the conference M. S. Valiathan, the mind behind India's first artificial heart valve, emphasized on the need for developing biomedical devices and stressed that the events like BIOMAT 12 workshop and BIND 12 conference would act as a catalyst to stimulate young minds towards creating affordable healthcare in India. P. Balaram (IISc) while addressing the gathering stated the growing need for interdisciplinary research, education and introduction of recent interdisciplinary programmes at the interface of engineering and biological sciences.

The biomaterials market is broadly segmented into two categories: type and application. Metals, ceramics, polymers and natural biomaterials find a wide range of applications in healthcare – orthopedic, cardiovascular, ophthalmic and dental applications as well as wound healing and drug delivery systems. A series of lectures segmented in technical sessions covered various topics from basic concepts of materials science, salient properties of biomaterials, concept of biocompatibility, structure and properties of biological cells, bacteria and tissues, cell fate and cell–material interaction and *in vitro* biocompatibility testing. Different aspects of research related to the development of orthopedic biomaterials, cell–material interactions, novel biopolymers, nanobiomaterials and tissue engineering were discussed by 33 invited speakers and was attended by close to 200 delegates from USA, Belgium, Germany, United Kingdom, France, Portugal, Nepal and various Indian institutes.

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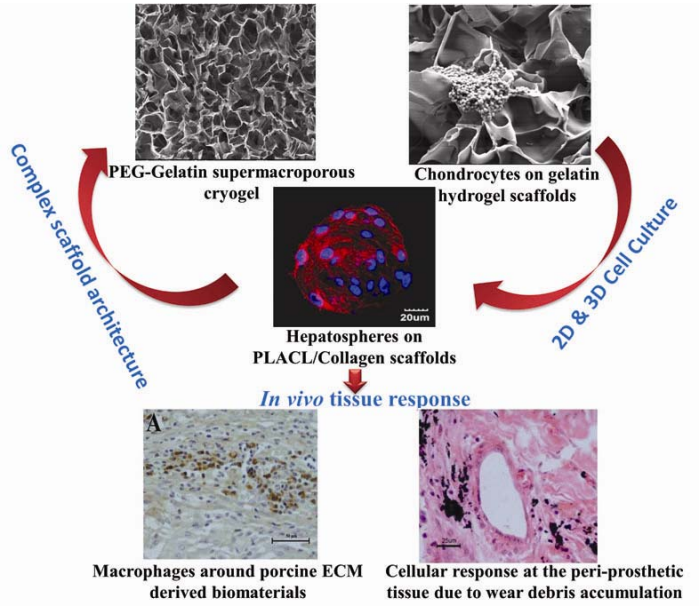


Core theme of BIND'12 Conference – An overview

In his plenary talk, Myron Spector (Harvard Medical School, Boston, USA), bestowed with C. P. Sharma Award (2013) for his outstanding contributions in the field of regenerative medicine, focused on injectable biopolymer gels for neural and musculoskeletal regeneration and on designing novel biopolymers as favourable micro-environments for tissue formation. Besides invited talks, the meeting hosted a poster presentation contest in which about 75 posters were displayed under three different categories: (i) nanotechnology in biomaterials, (ii) cell and tissue engineering, and (iii) orthopaedic biomaterials. Additionally, an editors' meet brought together editors of leading international journals on biomaterials, who addressed concerns of participants on publication of articles and improving the quality of the manuscripts. Parallel to the conference proceedings, opportunities for synergistic interactions as well as various funding avenues were discussed to promote international collaboration in the field of biomaterials with the US delegates.

Although tissue engineering strategies for a wide variety of tissues of the human body are being explored, regeneration of osteochondral tissues has seen the most progress. The ability to engineer bone tissues promises to offer better alternatives to the current clinical strategies involving the use of allografts and autografts. In recognition of the large volume of work in bone tissue engineering, a session was organized on this topic. The first talk in the series was dedicated to late Debabrata Basu, a pioneer in bioceramics for orthopedic and dental applications at the Central Glass and Ceramic Research Institute, Kolkata. Indranil Manna (IIT Kanpur) recalled the contributions of Basu, who dedicated his career to developing novel, low-cost and India-centric solutions for Indian patients. Amit Bandyopadhyay and Susmita Bose (Washington State University, USA) discussed laser processing of load-bearing bone implants and wet chemical synthesis of calcium phosphate ceramics for drug delivery respectively. The speakers stressed on the need to use advanced manufacturing and processing techniques for the fabrication of biomedical devices.

The advent of nanotechnology has made a significant impact on many areas of our lives, in particular the area of electronics with faster and smaller devices flooding the consumer market every day. Nanotechnology promises to revolutionize healthcare through innovations in imaging, drug delivery and 3D tissue scaffolds. A session on nanobiomaterials addressed challenges in making nanobiometrials, their applications and toxicity, which is a prime concern.

Orthopedics, one of the foremost branches of medicine, where the use of biomaterials has resulted in significant clinical success has several issues related to prosthesis such as plates, screws and joints primarily made of metallic alloys that are widely used. There is a growing need to improve the performance of these medical devices. Narendra B. Dahotre and Rajarshi Banerjee (University of North Texas, USA) discussed various surface engineering strategies to achieve appropriate surface morphology and chemistry. It is being increasingly realized by the biomaterials community that conventional manufacturing and materials processing techniques are inadequate to meet the specialized needs of biomedical application of materials. Thus, novel techniques are required to synthesize, process and characterize biomaterials. Osseointegration is determined by desired pore size distribution and pore interconnectivity. An entire session was organized on innovative fabrication and characterization of tissue-engineered scaffolds.

Plenary lectures were also delivered by Guy Daculsi (University of Nantes, France), Jonathan Knowles (University College, London) and David F. Williams (editor-in-chief, *Biomaterials*; Wake-Forest Institute of Regenerative Medicine, USA). Daculsi shared his recent work on biphase calcium phosphate ceramics for bone regeneration. Knowles spoke about using phosphate-based bioglasses for hard and soft tissue regeneration. Williams, in his keynote lecture presented a brief outline of a unified theory of biocompatibilty which is developed to explain the biocompatibility phenomena across all the fields where biomaterials are interfaced with tissues.

The challenges of working with stem cells and their interactions with biomaterials were taken into account. Given their pluripotency and self-renewal capacity, stem cells are likely to be the major cellular sources for different regenerative medical therapies. Shyamala Mani (IISc) presented her study on directing differentiation of embryonic stem cells to specific neuronal subtype that is critical for modelling disease pathology *in vitro*. Kaushik Chatterjee presented his recent work to demonstrate how biophysical cues from scaffolds can be used to direct stem cells for bone tissue engineering.

1. A report by Markets And Markets titled 'Biomaterials market and applications – Global forecasts to 2017'.

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