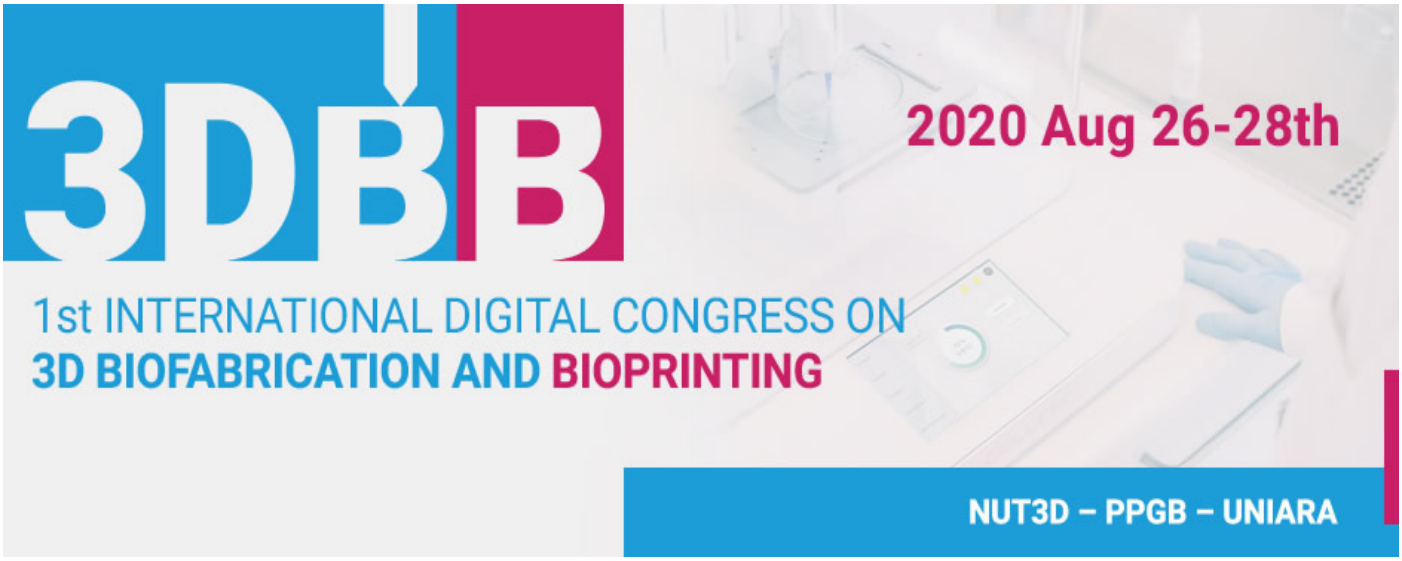


The 1st International Digital Congress on 3D Biofabrication and Bioprinting (3DBB) is an event organized by the Postgraduate Program in Biotechnology (PPGB) at the University of Araraquara – Uniara, São Paulo State, Brazil, which took place online and free of charge during three days, from the 26th to the 28th of August 2020.

Due to the COVID–19 pandemic, 3DBB was performed digitally.

The theme of the congress was Biofabrication / 3D Bioprinting, in general, with openness to all topics related to regenerative medicine and tissue engineering in an automated way.

The congress was aimed at graduate and undergraduate students, academics (professors and researchers), as well as the industry, both for Brazilian and foreign participants.

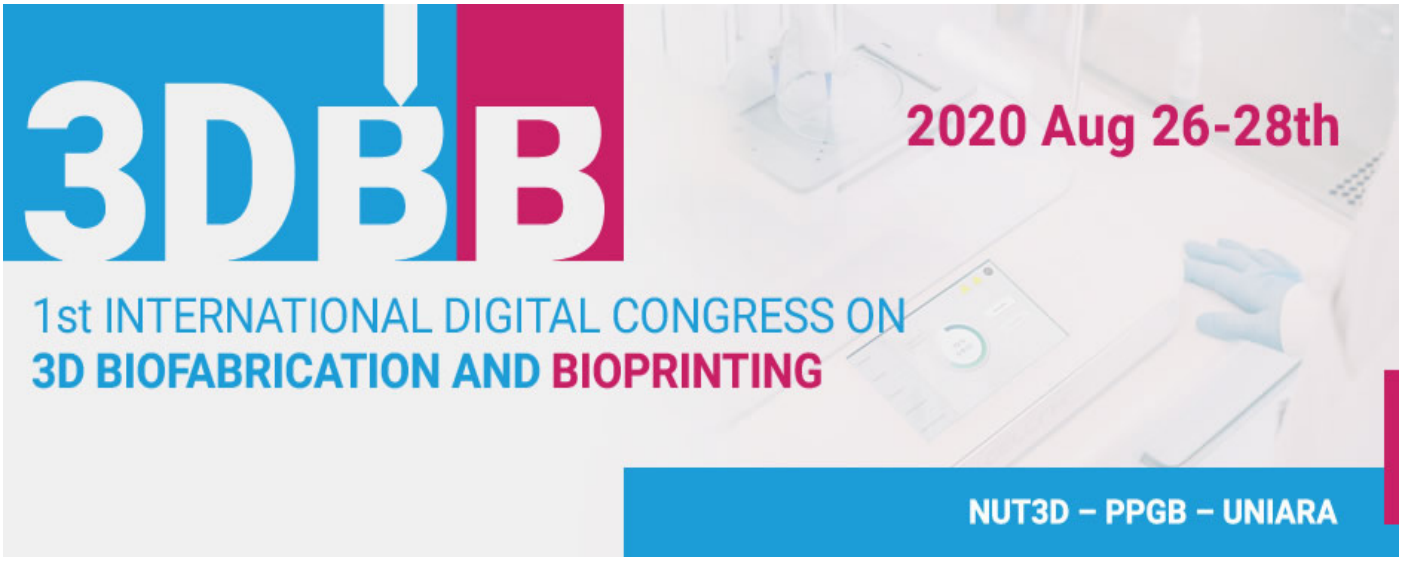
The event organized by the University of Araraquara (Uniara) with support from the Renato Archer Information Technology Center (CTI), offered participants with lectures by world renowned scientists from the biofabrication of institutions such as CTI Renato Archer, the University of Campinas (Unicamp), Federal University of Rio de Janeiro (UFRJ), Federal University of Rio Grande do Sul (UFRGS), Brazilian Brazilian Agricultural Research Corporation (Embrapa), as well as Wake Forest Medical School (USA), University of Manchester (UK), University of Maastricht (The Netherlands), University Technological University (Austria), Simón Bolívar University (Venezuela).

The 3DBB was divided into 7 thematic areas: Biofabrication and Bioprinting; Devices and Processes; Information Technology; Biomaterials; Cell cultures; Clinical and Industrial Applications; and Other Topics.

Two mini–courses were held ("3D Design for Bioprinting" and "InVesalius: Open Software for Reconstruction of Medical Images", a panel of debates among Brazilian entrepreneurs in the bioprinting area, as well as the submission and presentation of more than 70 works – the abstracts of which are presented in this edition of IJAMB – in addition to a special digital panel with videos dedicated to solution developers with 3D printing to combat the COVID–19 pandemic.

I hope you enjoy the abstracts and I hope to review everybody in the next edition of 3DBB!

Rodrigo A. Rezende, PhD
Creator and President of 3DBB.



Evaluation of prototype printing of national 3D bioprinter for tissue engineering

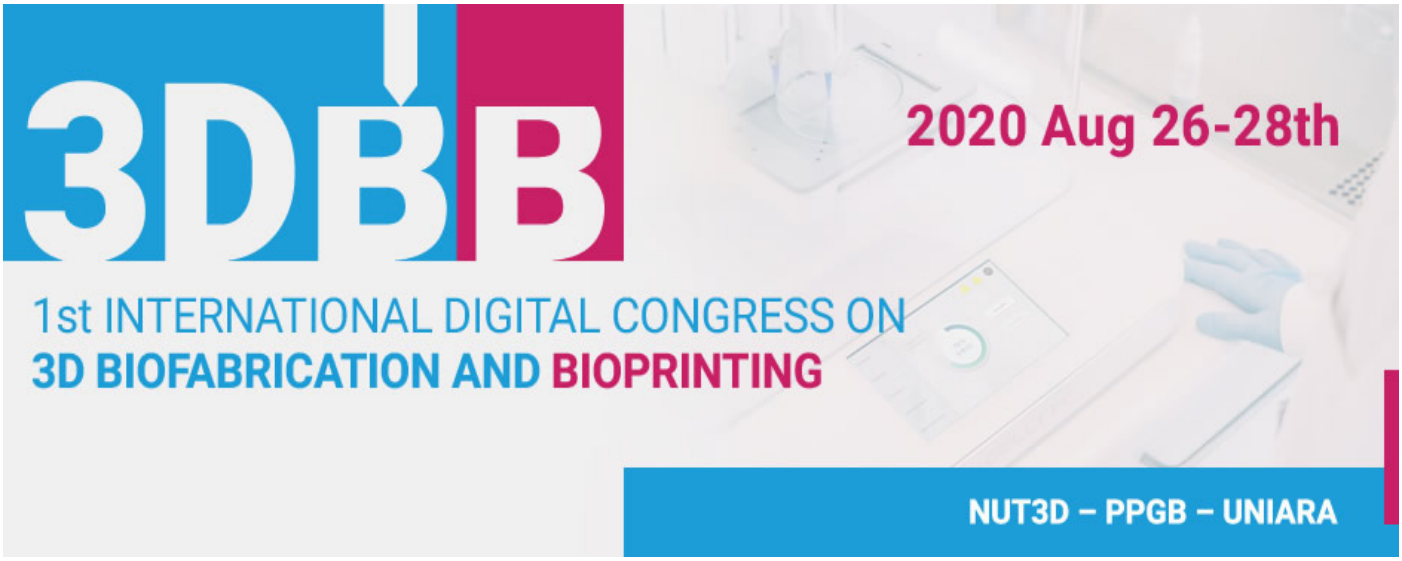
Vanessa Manchim Favaro; Vagner Rogério dos Santos*; Denys Emilio Campion Nicolosi***

(Biofabrication and bioprinting (in general)

Abstract: The applications of three dimensional (3D) bioprinting in tissue engineering and regenerative medicine have attracted the attention of many researchers. The 3D bioprinting process can be classified in three phases, pre–processing, processing and post–processing. Pre–processing involves the conception or capture of a bioimage and its representation using a CAD software. In the processing phase, the tissue or organ is printed. Finally, in the post–processing phase, it is necessary to check the maturation and monitor the tissue or organ. As the 3D bioprinting area is relatively new, many devices, software and methods are adapted and not are duly created for bioprinting, so the development of these tools are the current challenge of the area. The aim of the work is the standardization of the national 3D bioprinter Cbot prototype printing for tissue engineering. We used the Hadron Max® 3D printer (Wietech) and the Nivea Crème as product. The standardization variables utilized were: Nivea Crème viscosity; needle diameter (4 gauges); head speed; speed that the piston goes down; accuracy of bioprinting. The standardization phases were: creation of a 3D model in STL format using FreeCAD 0.18 software; open in the printer control software (Repetier Host); monitoring of the 3D printing; registration of the final product. The initial results of the prototype show that the viscosity of the Nivea Crème was above 300,000 cp with a torque of 99% and temperature of 24.7°C. In conclusion, the product is too viscous for the viscometer utilized. Therefore, other tests are necessary to continue our protocol.

Keywords: Bioprinting; Bioprinter; Viscosity; Prototype; Tissue Engineering.

* Universidade Federal de São Paulo (Unifesp), Brazil.
** Instituto Dante Pazzanese, São Paulo, Brazil.



In Vitro study of polymers used for the confection of occlusive devices

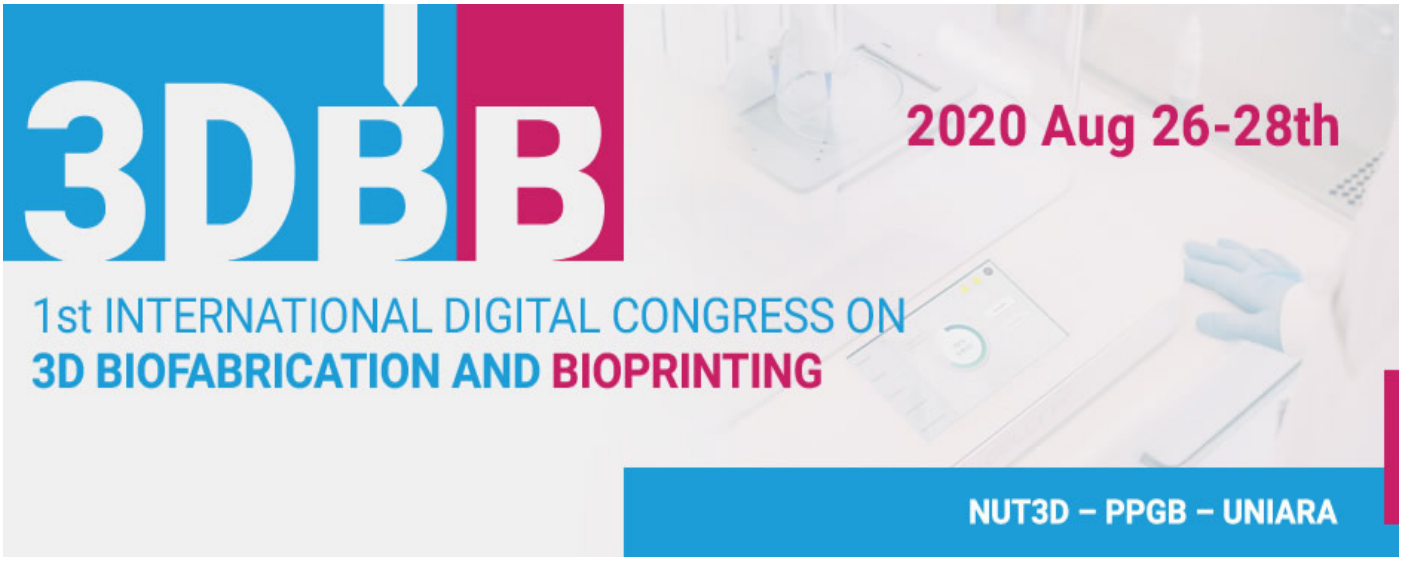
Ana Clara Hecker de Carvalho; Laura Hecker de Carvalho**, Dayanne Diniz e Souza Morais**, Renata Coelho Soares*, Nadja Maria Oliveira*; Maria Jacinta Arêa Leão Lopes Araújo Arruda* ; Ana Isabella Arruda Meira Ribeiro**

(Biomaterials)

Abstract: Occlusal devices are widely used in dentistry and can be made from different resins (Polymethylmethacrylate [PMMA] or Polyethylene Teraftalto [PET]) by techniques that include thermopolymerization, additive manufacture by photopolymerization and thermoforming, each one with theirs advantages and disadvantages. In view of the advances resulting from the use of 3D printing in health, it has been suggested to make occlusal splints using this technology for patients with temporomandibular disorders (TMD) instead of thermoformed or conventional thermopolymerized plates. This study aimed to analyze and compare the characteristics of flat splints obtained from the colorless acrylic base photopolymer used in 3D Printing (Group I), PET thermoformed plates (Group II) and conventional thermopolymerized acrylic resins (Group III).
The characterization of the samples occurred through their thermal stability (TGA), glass transition temperature (Tg), water sorption and UV–visible spectroscopy. The results of thermogravimetry, which are associated with the thermal stability of the samples, indicated that the degradation of the samples it occurred in a different way (a single stage for the thermopolymerized and in two stages for the others) and that the sample from the GIII group was the most stable, starting to lose mass at approximately 360 °C. The order of thermal stability found was GIII> GI> GII. Water absorption data confirmed these results with samples from the GIII group (thermally cured PMMA) absorbing less moisture than the others. These behaviors were attributed to an incomplete polymerization of the samples of the GI group in the photopolymerization process. Despite the fact that the UV–visible absorption tests were performed on solid samples with adaptations in the display of the samples in the sample holder, structural differences were found between PMMA resins polymerized by different methods (GI and GIII) and PET (GII). The wave lengths at which the transitions were observed decreased in the order: GI> GIII> GII. In general, displacements for longer wave lengths occur when there is more extensive conjugation. Apparently, the conjugation order was GIII> GI> GII. Thus, it can be concluded that Group III, represented by conventional thermopolymerized acrylic resins, proved to be more stable than the other groups in the proposed tests, being more suitable for the manufacture of occlusal devices.

Keywords: 3D Printing; Three–Dimensional; Temporomandibular Joint Dysfunction Syndrome; Occlusal Splints; Biocompatible Materials; Dental Materials.

* Universidade Estadual da Paraiba (UEPB), Campina Grande, PB, Brasil.
** Universidade Federal de Campina Grande (UFCG), Campina Grande, PB, Brasil.



3D cultures based on agarose micro–molds for the spheroid formation of medullary thymic epithelial cells

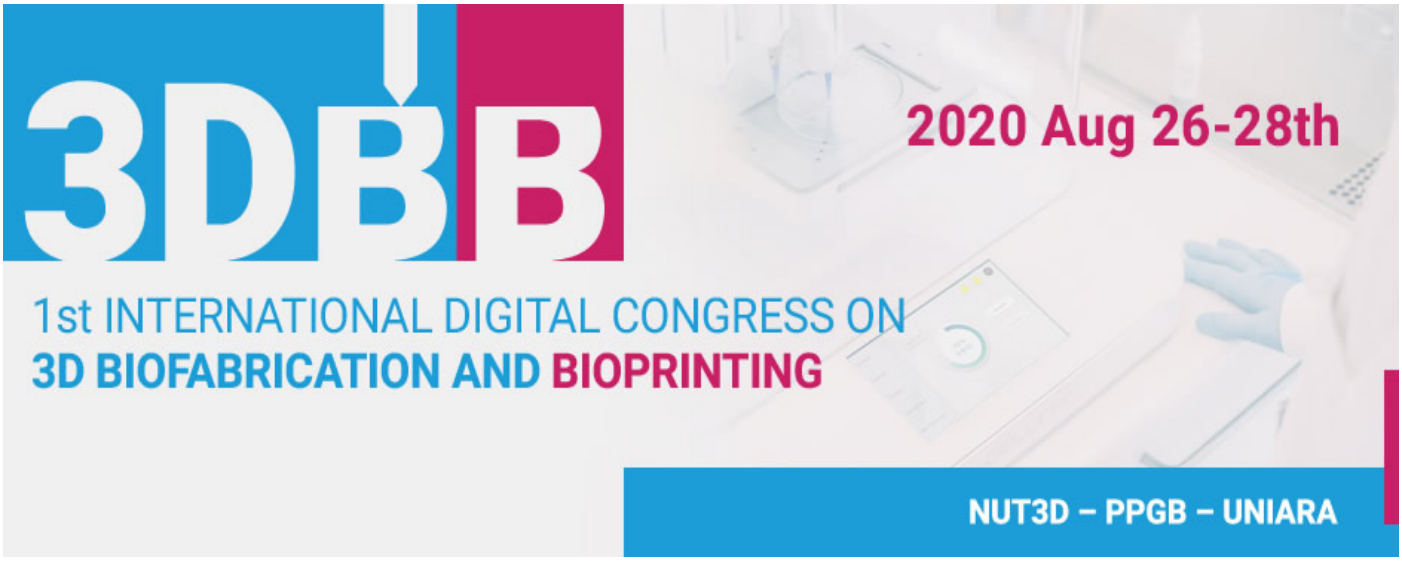
Ana Carolina Monteleone Cassiano; Janaína De A. Dernowsek**; Dimitrius L. Pitol***; João Paulo M. Issa***; Eduardo Antonio Donadi*; Geraldo Aleixo Passos****

(Cell cultures)

Abstract: The thymus is a primary lymphoid organ whose function is the generation of mature T cells and the induction of central tolerance. The thymic microenvironment is formed by thymocytes, medullary epithelial thymic cells (mTECs), and cortical epithelial thymic cells (cTECs). The mTECs are responsible for presenting the peripheral autoantigens (PTAs) to the thymocytes, leading to the elimination of those that recognize them. The–refore, cell aggregation and adhesion correspond to essentially biological processes in the structure and function of the thymus. The Scaffolds are biocompatible biomaterials in which cells adhere and/or interact with each other and with the extracellular matrix to produce living tissues like the original. The structure of the scaffold provides mechanical support for cell development, transport of nutrients, growth factors, and others. To increase the efficiency of T cell development, we establish and characterize a model for the formation of spheroids and promote the aggregation of TECs. We use an agarose mold with non–adherent micro–wells, making the mTEC cells, once seeded in these compartments aggregate with each other. It was possible to show the spheroid formation sequence from mTEC cells, from their deposition in the agarose microwells (0 h) until their complete structuring, after 24 h of culture. To better characterize the model, we constructed a growth and cell viability curve, comparing 2D (monolayer) and 3D (spheroid) cultures. The 2D cell curve grows exponentially faster and the viability in the early stages of both is similar, but 2D maintains the highest viability for longer. To verify the formation of the necrotic centers, we performed the LIVE/DEAD assay and observed that the red cells (dead) increase over time in the center of the spheroids, reaching almost 40% in the time of 48h. The analysis of high–resolution microscopy allowed us to observe with cuts of 1um the internal structure of these spheroids and how they aggregate over time. We perform scanning electron microscopy to study the external cell surface in detail, which proved to be strongly compacted with a well–defined contour. These results provide us with a better understanding of the 3D mTEC–mTEC interaction. The formation of spheroids with mTEC cells is a useful model to study the aggregation and adhesion between these cells, which is a fundamental role in intra–thymic communication, the process of whose is crucial for the structuring of the thymus in vivo.

Keywords: 3D cell cuture; Spheroid; Thymus; Mtec; Agarose Micro–Molds.

* Faculdade de Medicina de Ribeirão Preto FMRP–USP.
** National Institute of Science and Technology in Regenerative Medicine – INCT Regenera.
*** Faculdade de Odontologia de Ribeirão Preto– FORP/USP.



Kinetic study of plla synthesis in conditions applicable to medicine

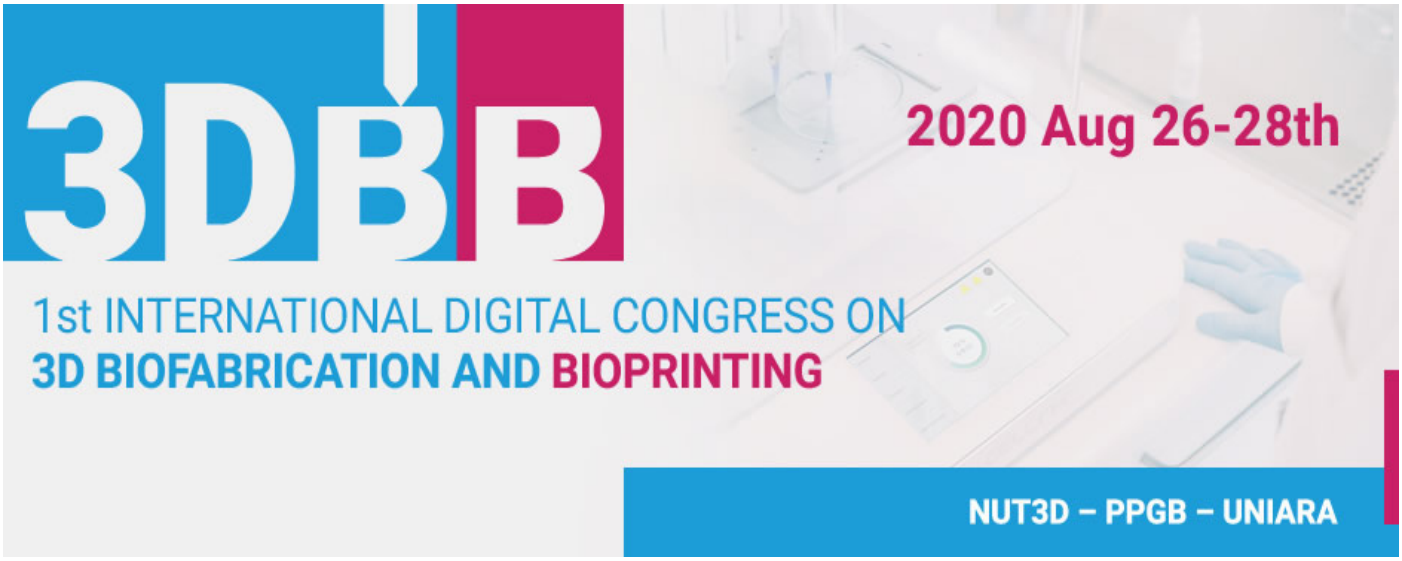
Samuel Diógenes Azevedo de Souza; André Luiz Jardini*; Maria Ingrid Rocha Barbosa Schiavon*; Rubens Maciel Filho*; Viktor Oswaldo Cárdenas Concha*; Maria Regina Wolf Maciel**

(Biomaterials)

Abstract: Poly (L–lactic acid) (PLLA) is a synthetic and hydrolytically unstable aliphatic polyester, a fact that is of increasing interest in medical applications, from sutures to vascular and urological stents, and devices for orthopedic applications (such as pins), for degrading and eroding over time. The conventional routes for the polymerization of PLLA involve direct polycondensation (generating, at first, a low molar mass polymer) and the opening of the cyclic L–lactide ring (forming a polymer with the greater molar mass concerning polycondensation), however, L–lactide is a product of high added value, which is an obstacle in the process of obtaining. Since the molar mass can directly influence the degradation period and the future erosion of PLLA, gel permeation chromatography (GPC) becomes an effective ally in the characterization of the molar mass of the polymer, either by the numerical molar mass (Mn) (for short chains), the average weight molar mass (Mw) (for medium chains), or the molecular molar mass (Mz) (applied to long chains). Thus, once we obtain the molar mass of samples collected during the reaction of the polymer synthesis, we can analyze conditions related to the kinetics of its formation, therefore, in this work, we evaluated the reaction kinetics in obtaining the PLLA. During the polymerization process, four sample collections were carried out over 18 hours and later characterized by gel permeation chromatography, giving the average weight molar mass necessary to present the consumption of L–lactic acid over time, and linear regression with the best fit by the integral method.

Keywords: Poly Lactic Acid; Degradable Polymer; Biomaterial; Integral Method; Gel Permeation Chromatography.

* INCT–BIOFABRIS / Faculdade de Engenharia Química – Unicamp, Campinas, SP, Brasil.



Surgical optimization using 3D print model for orbital fracture repair: a case report

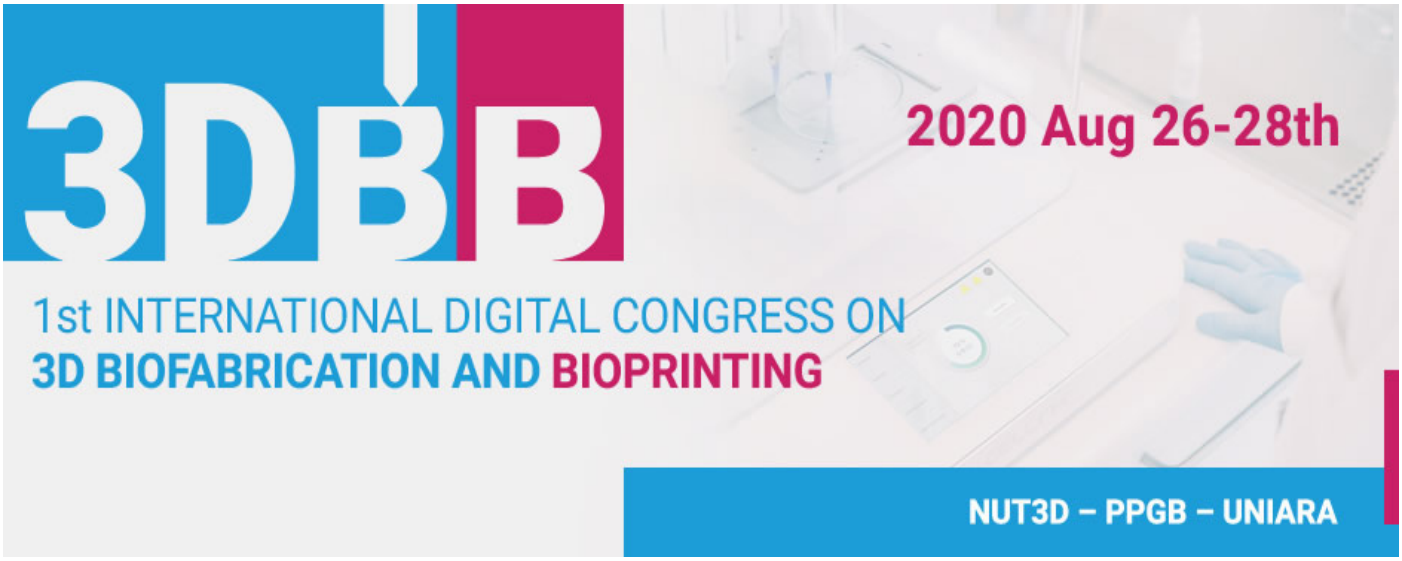
José Cleveilton dos Santos; Luís Fernando O. Gorla*; Luiz Henrique S. Torres*; Mário Franscisco. R. Gabrielli**; Valfrido A. Pereira–Filho**; Marisa Aparecida C. Gabrielli***

(Applications)

Abstract: The orbital floor fractures are among the most common injuries in oral and maxillofacial traumatology, present in approximately 40% of facial fractures. The management of these fractures is difficult and inadequate reconstruction may lead to severe complications such as diplopia, enophthalmos, decrease of visual acuity, and limitation of eye movement. Three–dimensional printing (3DP) technologies can help surgeons in many ways and have become more accessible in the past few years. The aim of this paper is to present a case of orbital fracture where surgical optimization was obtained using a 3DP model. M A O, a female patient, 52y, victim of physical abuse was examined at Hospital Santa Casa de Araraquara by the Oral and Maxillofacial Surgery team from the São Paulo State University (UNESP). She was diagnosed as presenting a severe left orbital floor fracture extending to the medial orbital wall. Clinically, she presented soft tissue injury at the left supraorbital region, restriction of the left eye movement in infra and supraversion, subconjunctival hemorrhage, left periorbital swelling and binocular diplopia in the upper gaze. We used the computerized tomography DICOM file in the open source software InVesalius to create a Standard Triangle Language (STL) file, then printed the STL in a Digital Light Processing (DLP) printer MoonRay®. Two 3DP models were made: a) one model of the fractured orbit to evaluate the extension of the fracture and to cut the titanium mesh in the correct size and b) another model, of the mirrowed right orbit, to pre–bend the titanium mesh before the surgical procedure. Surgical access was obtained via subciliary approach, the mesh was positioned and fixed with two screws in the inferior orbital rim and correct eye position was recovered. Extrinsic eye movement restriction and diplopia resolved. The patient has been symptom free since then. In conclusion using the 3DP model improved the accuracy of fit of the reconstructive titanium mesh, decreased operative time and anesthesia duration, as it has been described in the literature.

Keywords: Printing; Three–dimensional; Orbital fractures; Diplopia.

* DDS, PhD Student, Department of Diagnostic and Surgery, São Paulo State University (Unesp), School of Dentistry, Araraquara.
** DDS, MsC, PhD, Assistant Professor of the Department of Diagnostic and Surgery, São Paulo State University (Unesp), School of Dentistry, Araraquara.



Production of PLLA / curcumin bioactive membranes for wound healing

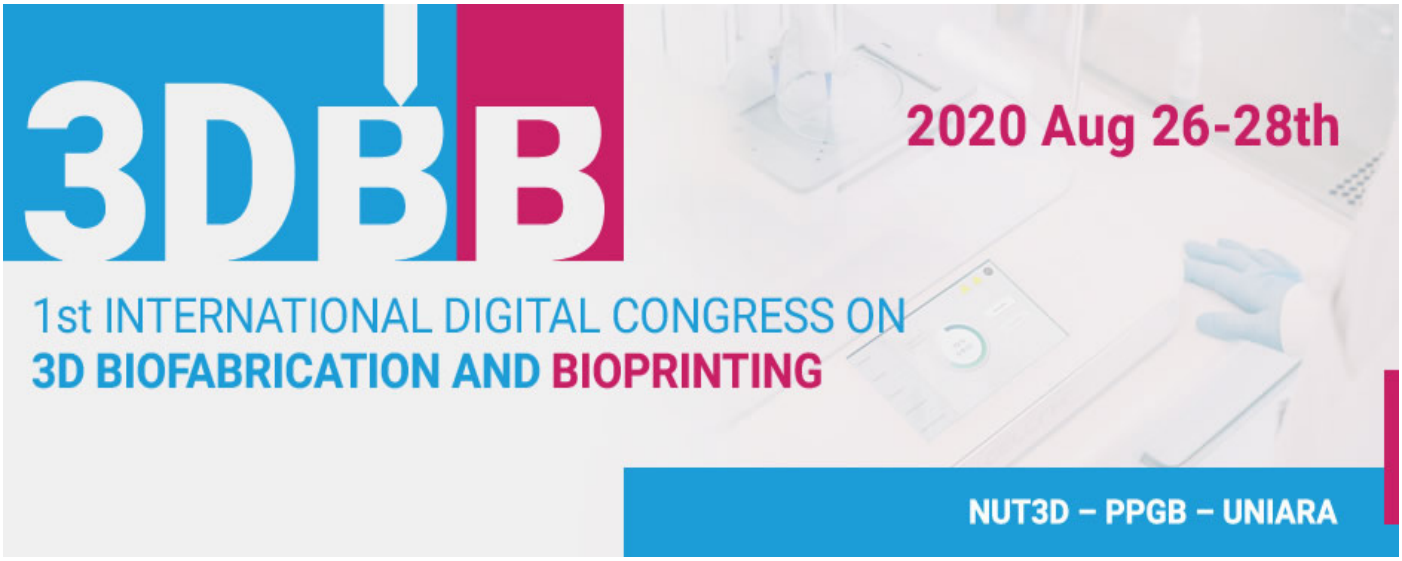
Karla barbosa; Isabella C. P. Rodrigues*; Mateus F. Oliveira*; Letícia Tamborlin***; Augusto D. Luchessi*; Éder S. N. Lopes**; Laís Pellizzer Gabriel**

(Biomaterials)

Abstract: A wound can be described as a rupture in the integrity of the skin and its healing occurs through the activation of inter and intracellular pathways, a major problem of a fissure in the continuity of the skin is the risk of bacterial infection and its complications. Tissue engineering (ET) is a multidisciplinary research field that studies the production of biological substitutes that mimic the extracellular matrix of tissues for cell adhesion and proliferation. It can assist in restoring the integrity of damaged tissues. In the present study, the processing and evaluation of polymeric membranes based on poly (lactic acid) (PLLA) and curcumin was carried out, with potential for applications in wound healing and fighting infection processes. PLLA is a biocompatible polymer and with significant importance for the pharmaceutical and biomedical areas. Curcumin is a natural compound and has antibacterial and antioxidant potential, in addition to therapeutic action on inflammations and diseases such as diabetes and cancer. Rotary jet spinning is a prominent technique in the processing of polymeric membranes due to the high rate of fiber production, thus allowing the production of these membranes on a larger scale and at a lower cost. The membranes PLLA and PLLA / curcumin were processed in the concentrations of PLLA at 8% (m / v) and curcumin at 4% (m / m), with a rotation speed of 18,000 rpm and at room temperature and were also characterized. The membrane morphology was verified using Scanning Electron Microscopy (SEM) and fibers with diameters smaller than 10 µm were identified. Using the Fourier Transform Infrared Spectroscopy (FTIR) technique, the chemical bands characteristic of the polymer and curcumin, and the absence of the organic solvent, were identified. The performance of the thermogravimetric analysis allowed the thermal characterization, which determined the thermal stability of the membranes up to 280 °C. Hydrophobic characteristics were identified in the membranes with the contact angle technique. Cell viability was assessed using the MTT technique, which confirmed the biocompatibility of PLLA and PLLA / Curcumin membranes. The antimicrobial activity test confirmed the antimicrobial action of curcumin. With the drug release test, he verified the dispersion of curcumin in its application medium. Finally, it was found that the processed membranes are bioactive and suitable for applications in wound healing.

Keywords: Curcumin; Rotary Jet Spinning; PLLA; Wound Healing; Membranes.

* Faculdade de Ciências Aplicadas, Universidade Estadual de Campinas (Unicamp).
** Faculdade de Engenharia Mecânica, Universidade Estadual de Campinas (Unicamp).
*** Instituto de Biociências, Universidade Estadual Paulista (Unesp).



Manufacture of high quality 3D scaffolds by extrusion based bioprinting technique

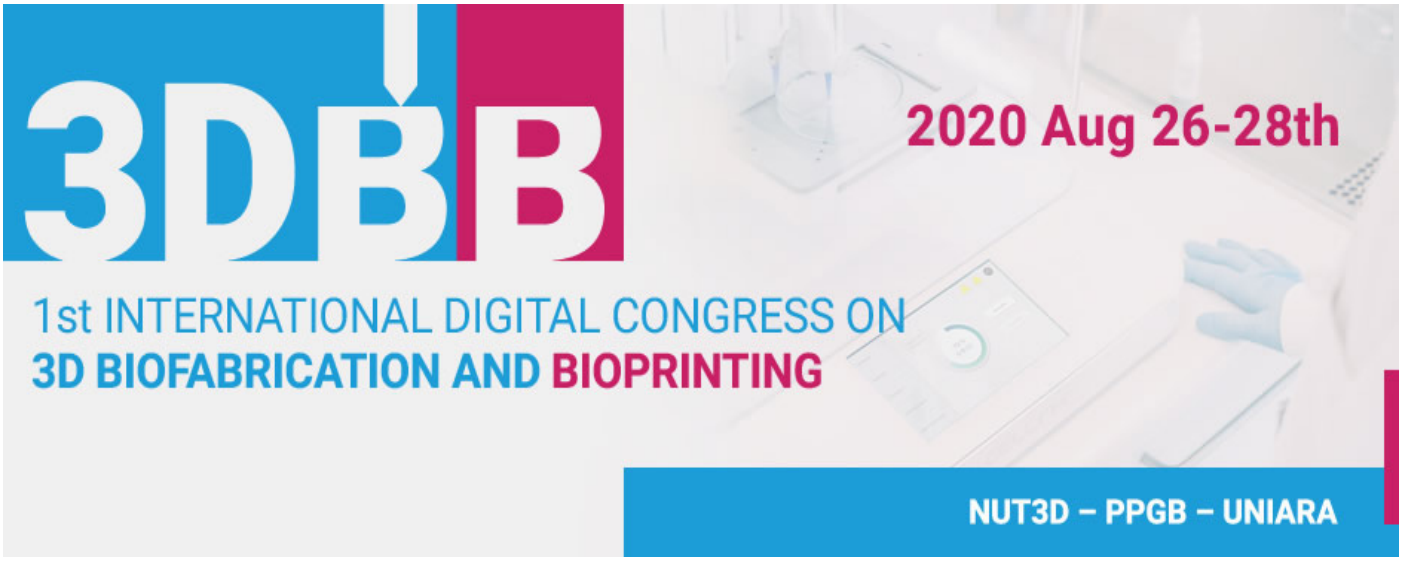
Verónica Passamai; Sergio Katz*; Vera Alvarez**; Guillermo R. Castro**

Biofabrication and bioprinting (in general)

Abstract: In recent years, extrusion based bio–printing (EBB) techniques have been used to produce scaffolds with controlled micro–architecture and geometry for biomedical applications, including research in drug delivery, tissue engineering and wound healing, among others. EBB is one of the most studied methods of additive manufacturing due to several advantages, such as precise deposition, cost–effectiveness, simplicity, process speed, materials availability, homogeneous distribution of bioactive components, versatility, and predictability. However, it requires specific knowledge to adapt biomaterials and equipment to the application needs. In the present work, general characteristics of EBB and biopolymer inks requirements are reviewed, printability concepts are summarized so as an approach to its analysis. An experimental application was carried out using a 3D bio–printer fabricated on NBM–CINDEFI Laboratory (La Plata, Buenos Aires, Argentina). Three pectin–based inks, two of them with celluloses addition, were formulated to obtain well defined 3D scaffolds. To evaluate the ink behavior, extrudability, printability and thermogravimetric analyses were carried out. As a result, high quality 3D printed scaffolds were obtained with different geometries. Cellulose addition, as an excipient, modifies and enhances mechanical and physical properties of biopolymer inks. Rheological measurements, and biophysical analysis of the biopolymer inks will allow to standardize the synthesis procedures, combined also with cytotoxicity assays to ensure its 3D bioprinting applications for different biomedical applications.

Keywords: Scaffolds; Biopolymer Inks; Printability; Extrudability; Bioprinting.

* Laboratorio de Nanobiomateriales (NBM), CINDEFI–CONICET–Universidad Nac. de La Plata, Argentina.
** Grupo de Materiales Compuestos (CoMP), INTEMA–CONICET– Universidad Nac. de Mar del Plata, Argentina.



Perspective on current scenario of bioinks for osteochondral repair based on 3D bioprinting

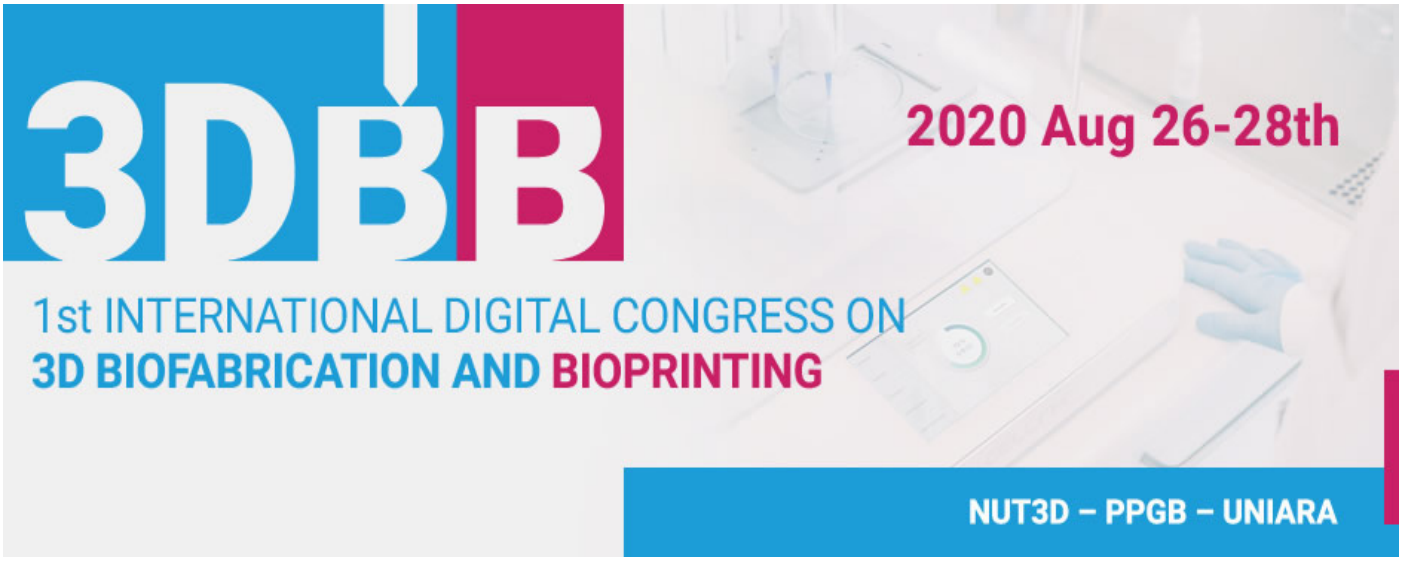
Juliana Daguano; Ana Pereira**; Fabiana Cunha Giora**; Karina Santos*; Andrea Rodas*; Jorge Vicente Lopes da Silva***

Biofabrication and bioprinting (in general)

Abstract: Bioprinting has become a promising area for application in transplants and recovery of injuries, mainly for the skin and osteochondral tissue, because it allows the growth of human tissue independently. Characterized by the destruction of articular cartilage, the osteochondral lesion treatment has not yet been effectively addressed. Existing repair techniques often do not offer complete healing to the patient and are, therefore, inefficient, depending on the stage of the disease. Methodology: This study aims to present an overview and the state of the art of bioinks, relating information on 3D bioprinting by extrusion and repair of osteochondral tissue, as an alternative treatment. Academic research and the market for bioink and bioprinters were compared to prove the feasibility. Initially, scrutiny was carried out, bringing together approximately 230 publications and 16 companies, using search tools such as Scopus, Google Patents, and LinkedIn. The search results in data representative of the set of most favorable requirements for bioprinting of osteochondral tissue, such as rheology of the material, biochemistry and mechanics of the artificial extracellular matrix, and cell viability and differentiation. Results: From that, 23 articles were selected, among which alginate stood out as the main component of bioink (52%), and could be associated with hydrogels, such as gellan gum, GelMa (methacrylate gelatin), and cellulose. As a mineral component, Laponite appeared in most research (13%). Furthermore, the Pluronic F127 polymer has been one of the leading choices as a sacrificial component of bioinks (12.5%), and therefore its typical rheological behavior highlights its use during the printing process. As for 18 patents filed in the past six years, the USA owns 39% of intellectual property, following by China with 28%. The patents show that the innovations are concentrated in the formulation of bioinks, and new methods of 3D bioprinting. The USA also leads the bioprinting market with 37.5% of the registered companies at Linkedin, followed by Brazil and Canada, both with 12.5% focused on this segment. CEIIInk (USA) is the most outstanding company in the sector, with a portfolio based on materials presented by the academic area. Conclusion: Thus, it appears that the market and the academy are in line, focusing on the improvement of bioink formulations and 3D bioprinting methods, to create products that can biomimicry the tissue microenvironment.

Keywords: 3D bioprinting; Bioink; Osteochondral Tissue; Market; Bioprinting Review.

* Universidade Federal do ABC – UFABC, Brasil
*** DITPS – Divisão de Tecnologias para Produção e Saúde – Centro de Tecnologia da Informação Renato Archer, Campinas, SP, Brasil



Decellularized spinal cord matrix bioink production for 3D bioprinting

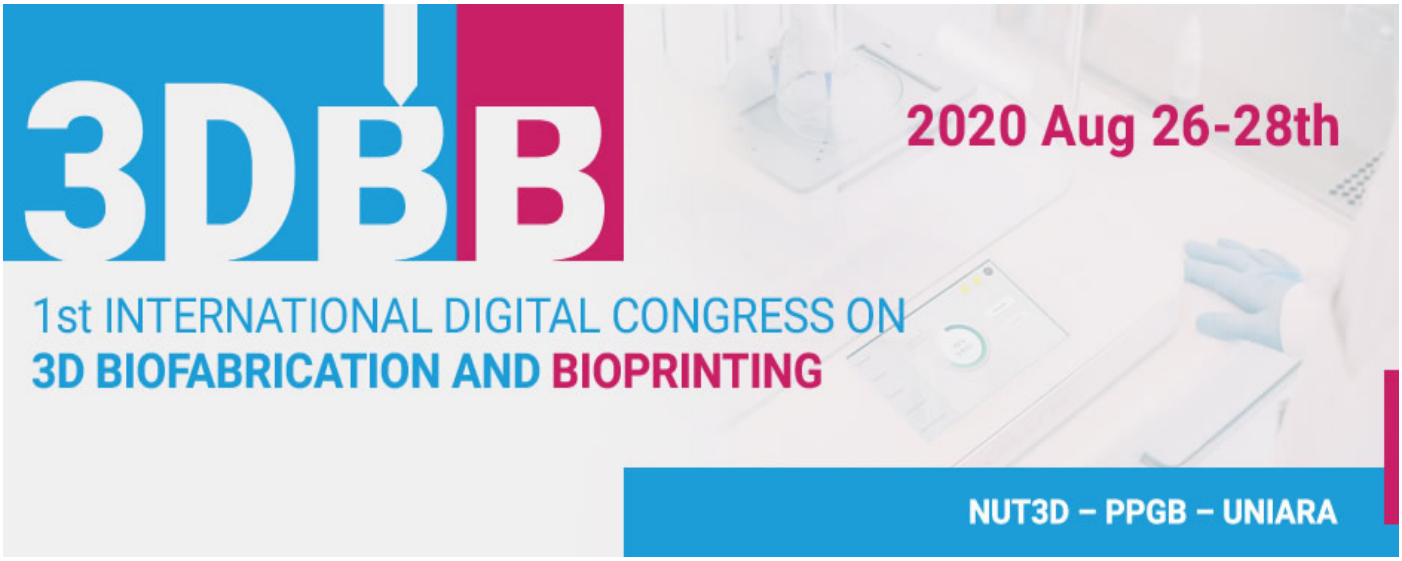
Marcelo Garrido dos Santos; João Pedro Prestes**; Cristian Teixeira***; Luiz Sommer***; Fernanda Stapenhorst França***; Laura–Elena Sperling****; Patricia Helena Lucas Pranke*****

Biofabrication and bioprinting (in general)

Abstract: Spinal cord injury (SCI) is a highly debilitating neurological syndrome that compromises the lives of patients, causing permanent loss of motor functions and sensibility, and for which there is no efficient therapy. Bioprinting is an innovative approach in regenerative medicine and the use of a bioink containing extracellular components may lead to improved functional recovery. The aim of this study has been to produce a bioink using lyophilized rat Decellularized Spinal Cord Tissue (DSCT). Methodology: The spinal cord of the animals was collected, cut in 1 cm length segments and submitted to a 9 hours decellularization process using consecutive immersions in 1% sodium dodecyl sulfate (SDS), 1% Triton X–100 and PBS. Following this, the genomic DNA content was measured. Histological sections of the samples were stained with DAPI or with hematoxylin and eosin and the collagen content was quantified by spectrophotometry. In order to assess the cytocompatibility of the DSCT, PC12 cells were cultivated on top of the decellularized tissue and cytotoxicity was analyzed using MTT assay. The DSCT was lyophilized to produce the bioink and 1.5% DSCT was mixed with 4% alginate, 3% gelatin and PC12 cells. The bioink was bioprinted in a disc with a density of 1.5X106 cells per mL. The cytocompatibility of the construct was analyzed by MTT and Live/Dead assay. Results: The DNA quantification indicated that the DSCT presented 224.41 ng DNA/mg of tissue, while the control spinal cord tissue presented 12737.13 ng of DNA/mg of tissue and the histological analysis revealed only a few cells at the end of the process. The DSCT presented a decrease of 17.65% collagen content when compared to the native spinal cord. The MTT assay indicated that the DSCT did not alter the cell viability. The bioink was bioprinted and it produced a 3D structure representing a disc of 0.3 mm height and 10 mm diameter with a total volume of 50 µL. The MTT test indicated that the bioprinted material presented a tendency towards higher cell viability and adherence in comparison with the control after 3 and 7 days. The DAPI staining indicated cell presence in multiple layers of the bioprinted material. Conclusion: It was possible to produce a bioink with the combination of alginate, gelatin, the PC12 cells and DSCT, which were able to maintain cell viability and support cell growth on a 3D structure. Therefore, this bioink may be an easily–available cell carrier for SCI treatment.

Keywords: Spinal cord injury; Decellularization; 3D bioprinting; Bioink.

* Universidade Federal de Clências da Saúde Porto Alegre (UFCSPA).
** Universidade Vale do Rio dos Sinos (Unisinos).
*** Universidade Federal do Rio Grande do Sul (UFRGS).
**** Instituto de Pesquisa com Células–Tronco (IPCT).



Poly (ε–caprolactone): development of a rotary jet spinning system and synthesis of porous membranes

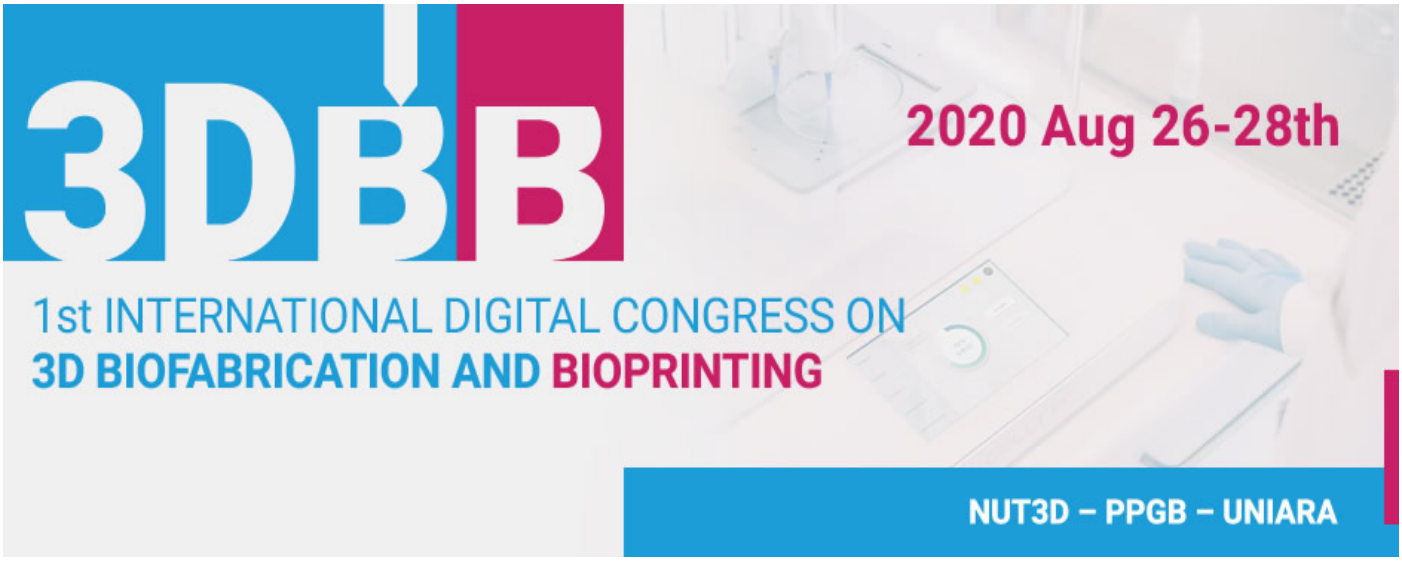
Elcio Malcher Dias Junior; Tainara Lima*; Debora Silva*; Viktor Cardenas**; Luis Adriano Nascimento*; Carlos Emmerson Costa*; Marcele Fonseca Passos**

(Biomaterials)

Abstract: Biodegradable polymers have attracted the attention of many researchers in recent years. Among the most well–known biodegradable polymeric materials, poly (ε–caprolactone) (PCL) stands out due to its excellent biodegradability and mechanical properties, which amplify its applications in tissue engineering. Then, the objective of this work was to develop an innovative rotary jet spinning system to obtain porous PCL membranes, with potential applications as wound dressings. The system of rotary jet spinning was developed according to three components: collector, responsible for capturing the fibers formed; reservoir, the container used for the deposition of the polymeric solution and its subsequent ejection through the holes/capillaries of the wall, according to the centrifugal force and engine, with different rotation speeds. The PCL solutions were prepared at different concentrations: 15%, 17.5% and 20% w/v, using dichloromethane as a solvent. The solutions were obtained at atmospheric pressure and speeds between 3.200 and 20.000 rpm to observe the fibers´ organization and plasticity. Then, the samples were dried at 45 ° C for 48 hours to remove the residual solvent. The surface morphology was analyzed using the scanning electron microscopy (SEM) technique. The results demonstrated the technical viability of the rotary jet spinning system, producing elastic and organized fibers. The concentration of 15% w/v with a rotation speed of 3.200 rpm enabled more visually elastic fibers, with an average diameter of 7.71 µm. At this same concentration, at speeds close to 20.000 rpm, fibers were obtained with diameters between 8.33 µm and 22.55 µm. Lower speeds, close to 5.000 rpm, formed fibers with a greater thickness, between 7.22 µm and 32.95 µm, in the concentration of 17.5% w/v. The concentration of 20% w/v led to fibers´ formation with diameters between 4.02 µm and 11.54 µm. It was also observed the homogeneous presence of micro and macropores in all samples, demonstrating the rotary jet spinning system´s technical viability for obtaining porous membranes with potential use in skin dressings.

Keywords: Poly (ε–caprolactone); Biodegradable polymers; Rotary jet spinning.

* Universidade Federal do Pará (UFPA).
** Universidade Federal de São Paulo (Unifesp).



Three–dimensional technologies applied to the development of a customized upper limb prosthesis

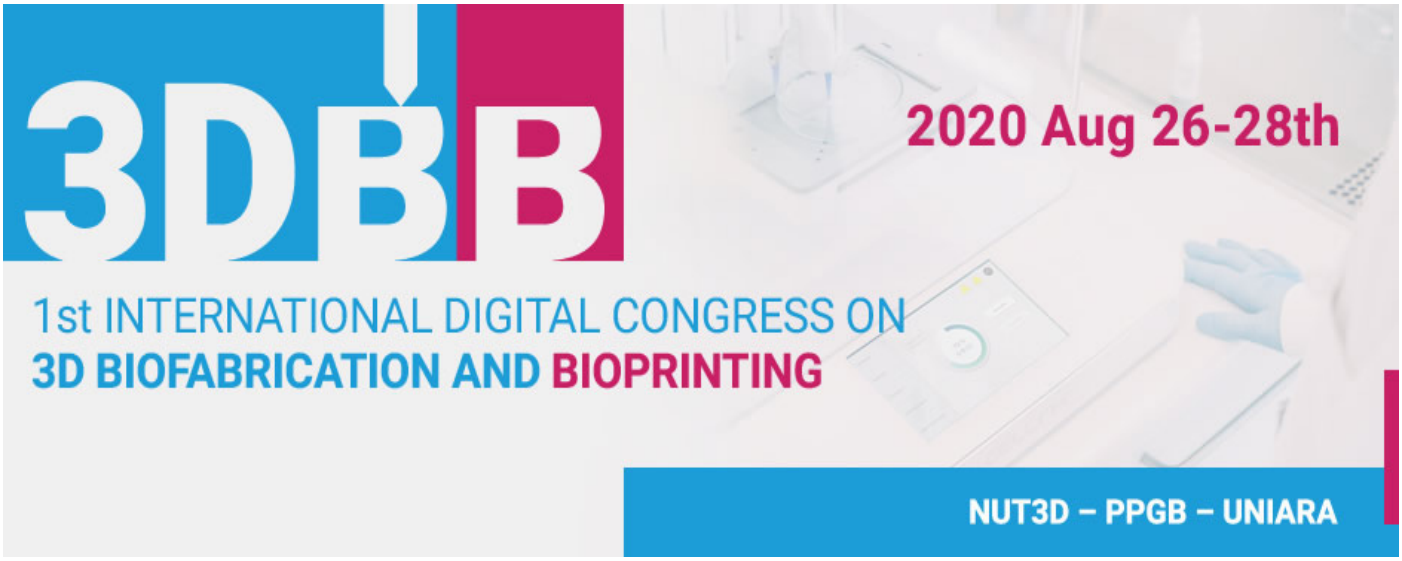
Carlos Alberto M. Dos Santos Filho, Ketinlly Yasmyne N. Martins**; Rodolfo R. Castelo Branco**; Isabella D. Gallardo**; Anna Kellssya L. Filgueira**; Lucas Vinícius A. Sales***

(Devices and processes)

Abstract: The process of acquiring three–dimensional images from 3D scanning associated with the manipulation of software that enables the development of devices compatible with reality, in the current scenario of using the Additive Manufacturing – AM, enabling considerable advances in the production of medical devices. In this perspective, with regard to customization and production efficiency, three–dimensional technologies have created a new scenario for the development of prostheses. This study aims to describe the use of three–dimensional technologies in the development of a customized upper limb prosthesis. Methodology This is a study developed at the Laboratory of Three–dimensional Technologies, allocated at the Center for Strategic Technologies in Health at the State University of Paraíba, with appreciation by the research ethics committee under number CAAEE 10308819.5.0000.5187. The research included a male patient, 34 years old, with transradial amputation of the left upper limb. A 3D scanner was used to capture three–dimensional images of the patient´s stump, which were manipulated in the Autodesk Meshmixer software, generating a geometric mesh .STL. After that, the prosthesis was designed, including the socket, forearm and hand, together with the assembly mechanism and dynamic movement simulations of digital operation, in the Autodesk Inventor software. Finally, the prosthesis was made using the AM in the FDM process, using PLA material. Results: The entire production process was carried out in 200 hours, minimizing several stages of the traditional manufacturing process, requiring only a single contact with the patient in the analysis of the digital dimensioning of the stump. The prototyped real model did not show dimensional variations when compared to the digitized model, resulting in an acceptable anatomical geometric conformity. Conclusions: The association of three–dimensional scanning with the management of modeling software and additive manufacturing proved to be effective for the production of customized upper limb prosthesis, highlighting the optimization in the production process, when compared to the traditional process, both for the development team and for the individual. Presenting itself as a light and low cost customized device, thus enabling a possible change of design and adaptation of the patient to new fabrications of prosthesis interfaces.

Keywords: Imaging Three–Dimensional; Manufactures Materials; Printing, Three–dimensional; Prosthesis; Three–Dimensional Technologies.

* Universidade Federal de Campina Grande – UFCG, Campina Grande, PB, Brasil.
** NUTES – Universidade Estadual da Paraíba – UEPB, Campina Grande, PB, Brasil.



Semi–interpenetrating network of PHEMA–PCL, interspersed with anti–inflammatory properties, for use as a skin wound dressing

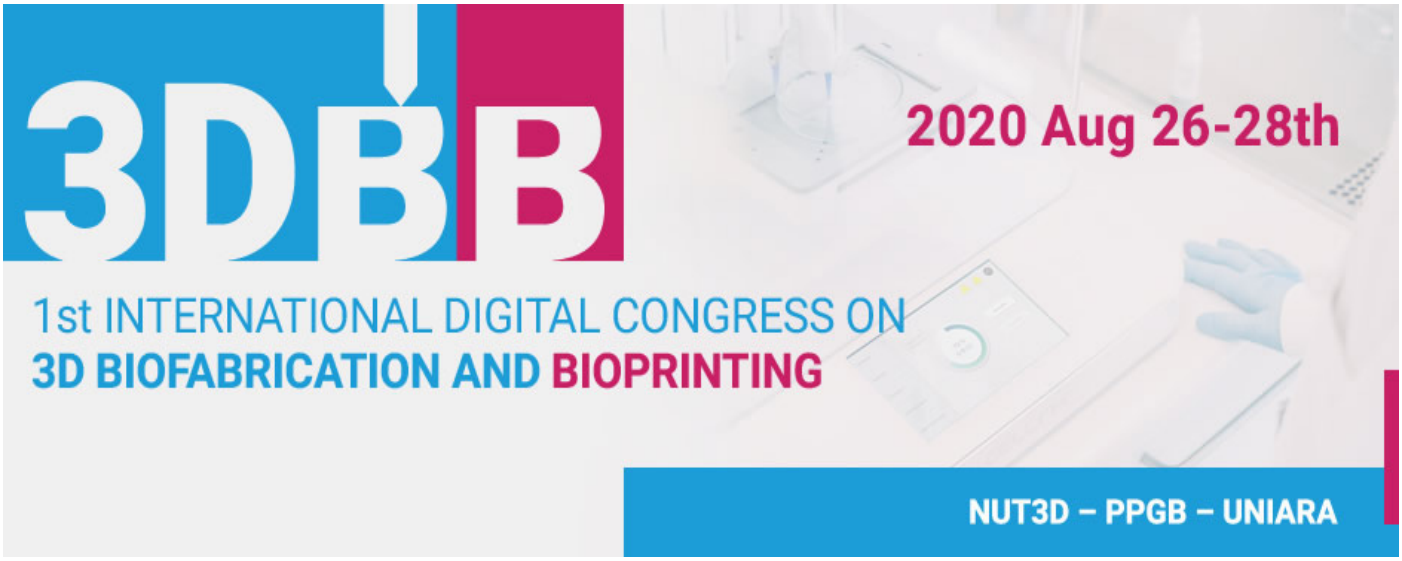
Tainara de Paula de Lima Lima; Yan Gabriel Lima*; Elcio Malcher Dias Junior*; Débora Silva*; Luís Adriano Nascimento*; Carlos Emmerson Costa*; Carmen Gilda Dias*; Viktor Conchas**; Marcele Fonseca Passos**

(Biomaterials)

Abstract: The human body has "tools" that support its functioning and maintain the body´s homeostasis, and one of them is the skin. It acts as the biological system´s primary barrier, preventing external bodies from threatening its integrity. However, this "heroic" act of the skin causes damage to itself (skin wounds, for example), which requires extra care, through the wound dressing's performance. Therefore, biomaterials such as polycaprolactone (PCL) and poly (2–hydroxy–ethyl methacrylate) (PHEMA), can be used to develop dressings with optimized properties, aiming the efficiency in the healing process. Thus, this work´s objective was to synthesize and characterize semi–interpenetrating networks (semi–IPNs) of PHEMA–PCL, interspersed with bioactive compounds, derived from vegetable oils from the Amazon region, for use as a skin wound dressing. The polymeric synthesis was realized through the rotary jet spinning process to obtain the PCL´s membranes, followed by the interpenetration process between the hydrogel (PHEMA) and the synthesized PCL´s membranes. The bioactive compound, with the anti–inflammatory property, was intercalated, in concentrations of 0.64% w / w and 1.27% w / w, in relation to the PCL mass (20 g). The obtained materials were characterized by the contact angle test, fluid absorption assays, and scanning electron microscopy (SEM). The contact angle assays emphasized that the material had hydrophilic characteristics but also a variation of PHEMA on the samples´ surface. The fluid absorption test, in saline sulfate buffer solution (PBS), showed that the semi–IPN network has swelled, with values ranging from 90.9 to 160.5%. The morphological analyzes showed dispersed fibers, with diameters between 6 to 31.31 µm, and certain porosity, which makes it an essential characteristic for cell proliferation. Therefore, analyzing the results can conclude the potential that the material presents as a skin dressing. Even though, it is still necessary to optimize the PHEMA distribution on the surface of the PCL membranes and evaluate in vivo and in vitro features, to verify the anti–inflammatory action of the bioactive compound.

Keywords: Biomaterials; Wound dressing; Semi–IPN´s network; PHEMA–PCL; Polymers.

* Universidade Federal do Pará – UFPA, Belém, PA, Brasil.
** Universidade Federal de São Paulo – Unifesp, Diadema, SP, Brasil.



Development of bioactive composites scaffolds for bone tissue–engineering

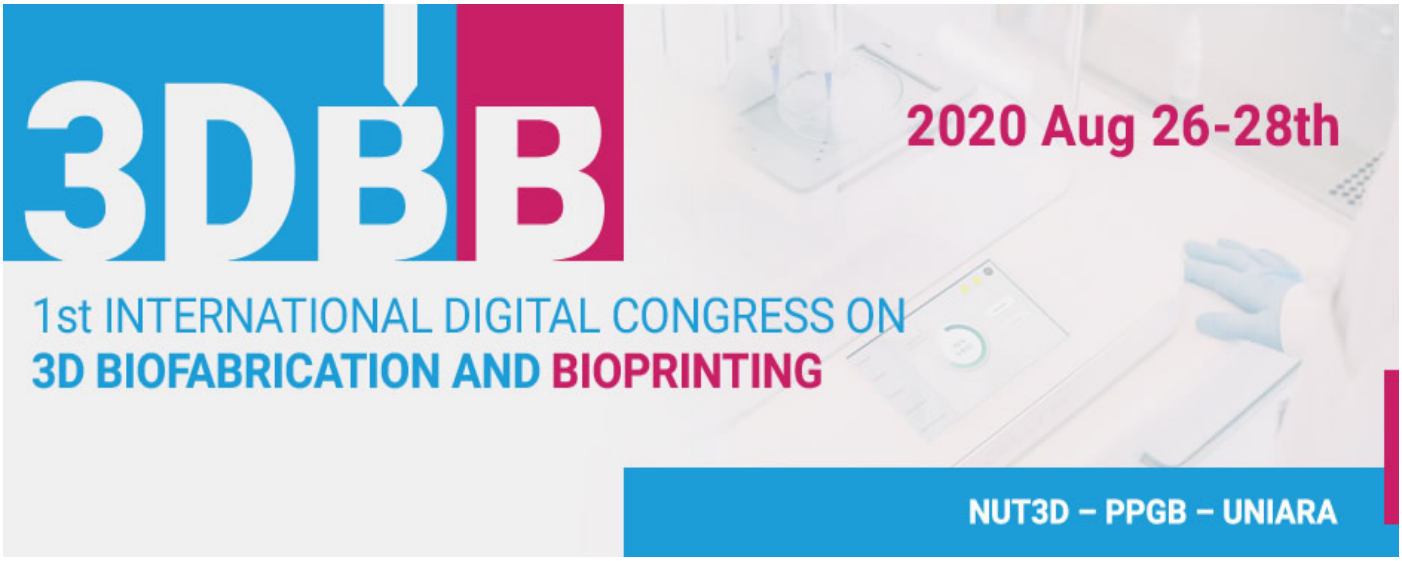
Nida Iqbal ; Saman Iqbal***

(Biomaterials)

Abstract: Tissue engineering is an interdisciplinary field that involves the combination of biomaterials, cells, and engineering methods for the purpose of tissue regeneration. The aim of this field is to lead the organs or tissues to regenerate with the help of biocompatible and biodegradable scaffold that acts as a template for the cells to grow. Scaffolds are the main component in tissue engineering as they are used to provide support and ideal microenvironment for the incorporation of the cells and bioactive molecules in order to repair and remodel damaged tissues or organs. To help the organs regenerate better, the scaffold needs to imitate the natural extracellular matrix (ECM) behavior of that particular organs which are fibrous structure at nanoscale. The typical properties of scaffolds are porous, biocompatible and biodegradable. There are several methods to fabricate thre–e–dimensional (3D) scaffolds which are electrospinning, phase separation, freeze dry, self–assembly, 3–D printing etc. Among all these techniques, electrospinning has attracted more attention due to its simple equipment setup, low cost, able to process various kind of polymers and synthesize long aligned continuous nanofibers. The aim of this study was to fabricate and characterize Poly (lactic acid) (PLA)–Zeolite composite nanofibers using electrospinning technique. Electrospinning was performed with an applied voltage of 12kV at 1 mL/h for 5 hours. Prepared composite scaffolds were chemically characterized using Fourier Transform Infrared spectroscopy (FTIR) and Energy Dispersive X–ray (EDX). The results indicated that the addition of zeolite resulted in the presence of silica and aluminum along with carbon and oxygen elements in the EDX spectrum and the appearance of absorption peak in the spectra of PLA–Zeolite composite fibers. The surface morphology was analyzed with Scanning Electron Microscopy (SEM) and Water Contact Angle (WCA). The results showed that relative smooth and round nanofibers were obtained and the hydrophobicity of the nanofibers decrease with the increasing of zeolite percentage. Bioactivity of the composite nanofibers was evaluated using simulated body fluid (SBF) solution and it can be confirmed through the formation of apatite precipitation on the surface of the nanofibers.

Keywords: Biomaterials; Bioactivity; Tissue Engineering; Scaffold; Electrospinning.

* Bio–Medical Engineering Centre University of Engineering and Technology (UET), Lahore, New Campus, University of Engineering and Technology (UET), Lahore New Campus.
** Department of Physics, University of Engineering and Technology, Lahore, Pakistan.



Rheological behavior of carboxymethylcellulose (CMC) and laponite nanocomposite inks

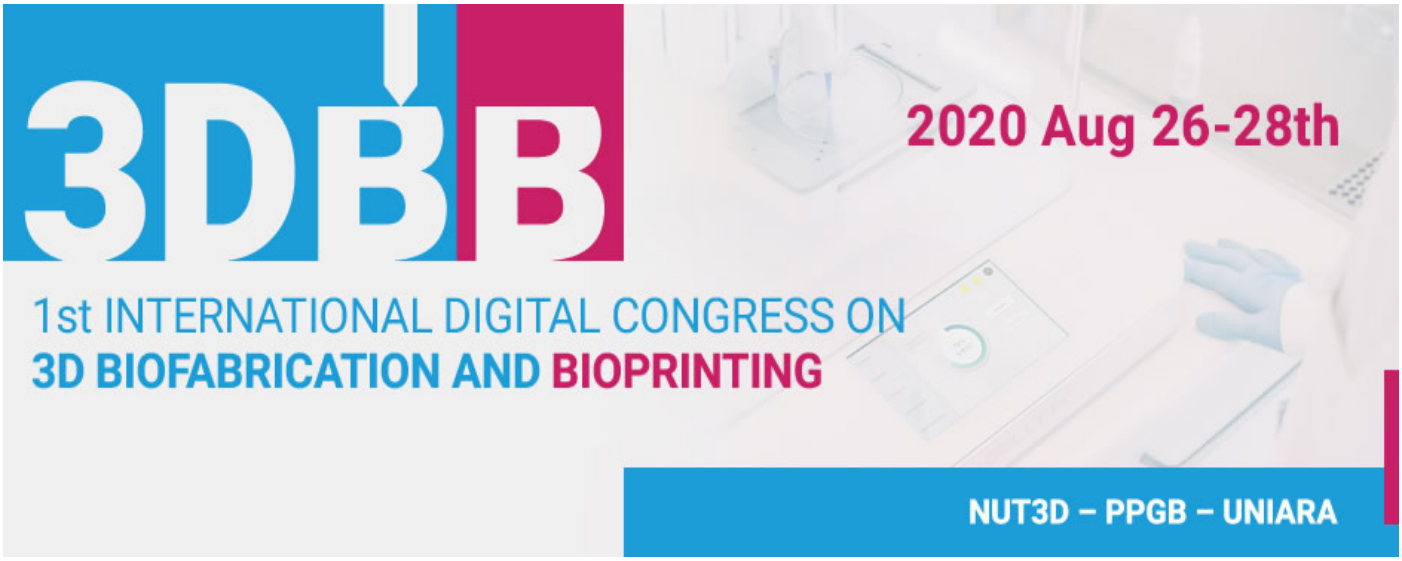
Ingri Julieth Mancilla Corzo; Jéssica Heline Fonseca*; Marcos Akira D´Ávila**

Biofabrication and bioprinting (in general)

Abstract: Hydrogels are materials with the ability to absorb large amounts of water, resulting in systems with unique characteristics and are widely applied in the biomedical area [1]. Among these applications, the fabrication of scaffolds by Additive Manufacturing (AM) for tissue engineering is appealing and challenging, mainly due to their rheological behavior [2]. Then, rheological properties and colloidal interactions are fundamental to define printability since they have strong influence in the shape fidelity and porous formation of printed structures. A new system of colloidal ink composed of Carboxymethylcellulose (CMC) and nanosilicate of Laponite was developed in this work. Different concentrations of CMC, Laponite, and CMC–Laponite (CMC–Lap) mixtures were studied. Rheological characterizations were carried out in a Modular Compact Rheometer (Anton Paar MCR–102, Austria) at 25 °C, with a cone–plate geometry (50 mm diameter and 1 mm the gap). Shear thinning was observed for all CMC solutions (0.25 to 4 wt.%) and the Cross viscosity model was used to fit the experimental data. On CMC–Lap mixtures, physical gels were observed even in low CMC and Laponite concentrations. The gel obtained was transparent and uniform. The addition of Laponite reinforced the polymer network by increasing its viscosity, storage (G´) and loss (G´´) moduli of the inks. The Ostwald–de Waele model described well the viscosity behavior of the mixtures. CMC–Lap gels showed shear–thinning behavior and self–recovery characteristics due to their rapid rearrangement of the internal phase after being subjected to shear stress. Moreover, time sweep tests revealed that CMC–Lap solutions suffer aging due to increases in storage modulus. Electrostatic interactions and hydrogen bonds are the two possible types of interactions that occur between the CMC chains and Laponite nanoparticles. FTIR spectra revealed a weak hydrogen bonding between the silanol (Si–O) groups of Laponite and hydroxyl (–OH) of CMC. Hydrogels of CMC–Laponite crosslinked with CaCl2 presented low cytotoxicity for fibroblasts, indicating that this system has potential for applications in AM processes for tissue engineering. References. [1] I. M. El–sherbiny and M. H. Yacoub, “Review article Hydrogel scaffolds for tissue engineering : Progress and challenges,” 2013. [2] J. Malda et al., “25th Anniversary Article : Engineering Hydrogels for Biofabrication,” pp. 5011–5028, 2013.

Keywords: Additive manufacturing (AM); Nanocomposite hydrogels; CMC; Laponite; Ink.

* Department of Manufacturing and Materials Engineering, School of Mechanical Engineering, University of Campinas (Unicamp), Campinas, SP, Brazil.



3D printing cellulose–based nanocomposite ink

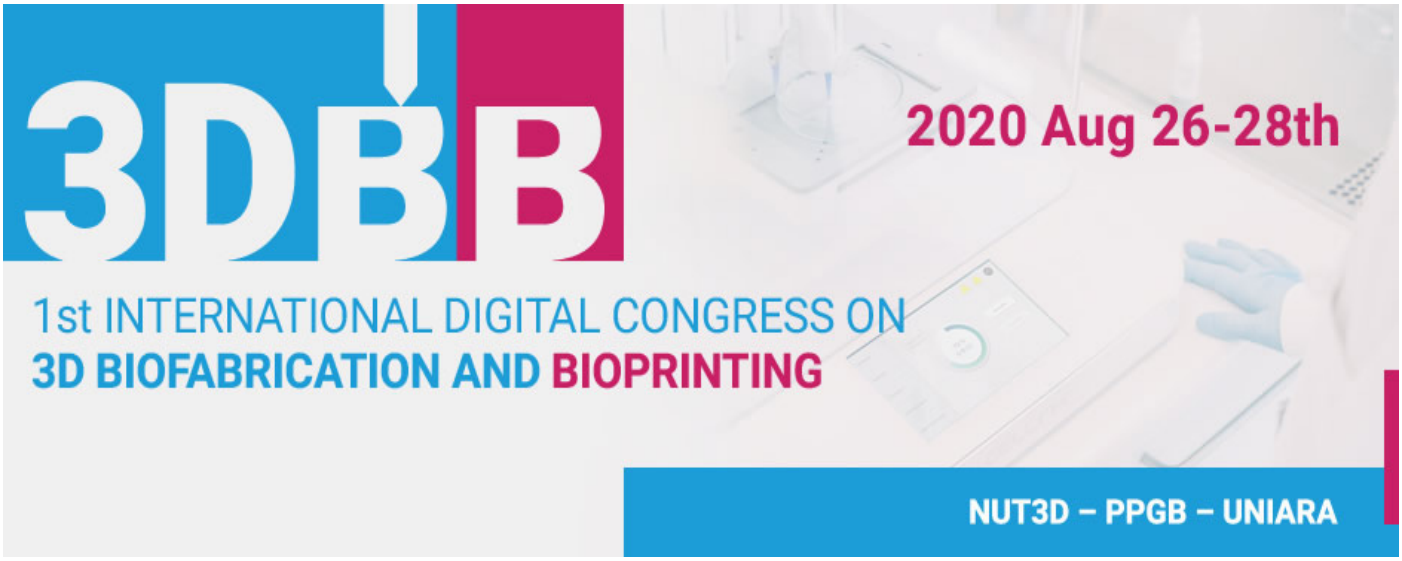
Jéssica Heline Lopes Da Fonseca; Ingri Julieth Mancilla*; Marcos Akira D´Ávila**

Biofabrication and bioprinting (in general)

Abstract: In the last years, the development of cellulose–based inks for 3D printing has received significant interest due to numerous cellulose and their derivatives properties. Carboxymethyl cellulose (CMC) is an anionic water–soluble cellulose derivative widely used as superabsorbent hydrogels. Another cellulose derivative is cellulose nanocrystal (CNC), a rod–like nanoparticle that can be applied for the mechanical strengthening of hydro–gels and also presents potential use in several applications in the biomedical field. Based on this, we have proposed to investigate if CMC and CNC mixtures result in cellulose–based nanocomposite gels suitable for extrusion printing. Interactions between CNC and CMC resulted in physical gels, where both rheological properties and the effects of extrusion printing parameters were studied. A Modular Compact Rheometer (Anton Paar MCR–102, Austria) with a plate–plate geometry (50 mm diameter and 1 mm the gap) at 25 °C was used to perform rheological measurements. Extrusion printing was performed on the customized 3DCloner Lab printer using a 22G nozzle tip of 25 mm in length, and a diameter of 0.70 mm (Injex, Brazil). Gels presented shear–thinning, solid–like viscoelastic behavior, viscosity recovery, and continuous filaments were obtained during printing. Tests with different print and extrusion speeds evidenced the influence of both on the geometry obtained. Therefore, among the studied parameters, we used the extrusion speed of 45 mm/s, and a print speed of 15 mm/s to obtain geometries with better shape fidelity. After printing, the geometries were submerged on citric acid (CA) aqueous solution at 2.0 wt.% for 5 minutes to obtain a crosslinked structure. Cylindrical scaffolds with 12 mm diameter and 4 mm height were lyophilized and dipped in phosphate buffer saline (PBS, pH 7.4) at 37 °C for two days to measure the swelling ratio. After two days, the swelling degree of 726.1 ± 25.5% was measured. Moreover, low cytotoxicity to CMC/CNC crosslinked hydrogels as confirmed through MTT assay of fibroblasts.

Keywords: Nanocomposite Gels; Extrusion Printing; CMC; CNC; ink

* Department of Manufacturing and Materials Engineering, School of Mechanical Engineering, University of Campinas (Unicamp), Campinas, SP, Brazil.



Using additive manufacturing technology to assist the production of im-mobilization orthosis

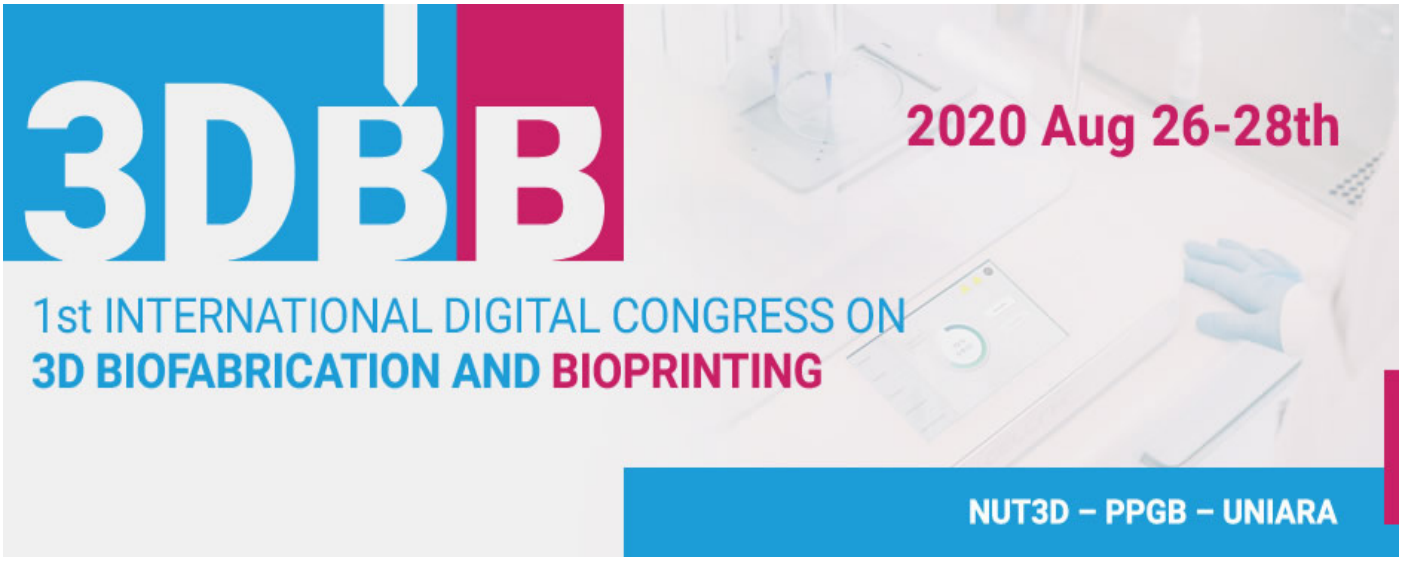
Marlem Oliveira Moreira; Renata De Souza Coelho Soares**

Biofabrication and bioprinting (in general)

Abstract: CAD (Computer Aided Design) technology provides materials and methods for molding and creating objects via three-dimensional printing, as well as it allows greater customization. In terms of health, it makes orthosis better adapted to the patient´s anatomical shape when compared to most used accessories and thermoplastics for limb immobilization. Since scientific and technological developments influence medical decision-making, this study focuses on using software packages to mold a three-dimensionally printing device for use in rehabilitation processes, as an alternative treatment for patients with bone fractures/contusions. Methodology: This is an experimental, descriptive, and exploratory study which uses two different types of software (Makehuman® and Rhinoceros®) as tools for creating a humanoid model based on anthropometric data obtained from medical professionals, and for virtually creating a device via CAD system. This research is based on the development of an experimental device for the rehabilitation of lower limb deformity, created by researchers from the Post-Graduate Program in Health Science and Technology at Universidade Estadual da Paraíba. Orthopedic trauma physicians and physiotherapists have assisted on gathering functional and non-functional requirements. Results: For research objectives, the Makehuman® software had a satisfactory performance in creating a humanoid model, and the Rhinoceros® software provided the tools for creating and adjusting the device. The honeycomb pattern model offered a better skin-brace interface for recovering bone fracture/contusion, allowing better visualization of the injured area, and intervening in the treatment of wounds in the region; it prevents the formation of pressure ulcers, providing enough space for proper electrodes placement and other equipment use, occasioning greater agility in rehabilitation. Conclusion: Proper orthosis adjustment/adaptation, as well as its low weight, proved to be the main advantages for AM (Additive Manufacturing) technologies in fractures or contusions of the lower limbs, improving user's quality of life through innovation in treatment protocols.

Keywords: Additive Manufacturing; 3D printing; Software; Orthosis; Rehabilitation.

* Universidade Estadual da Paraíba (UEPB).



Synthesis and characterization of PCL / andiroba oil hybrid films as wound dressing

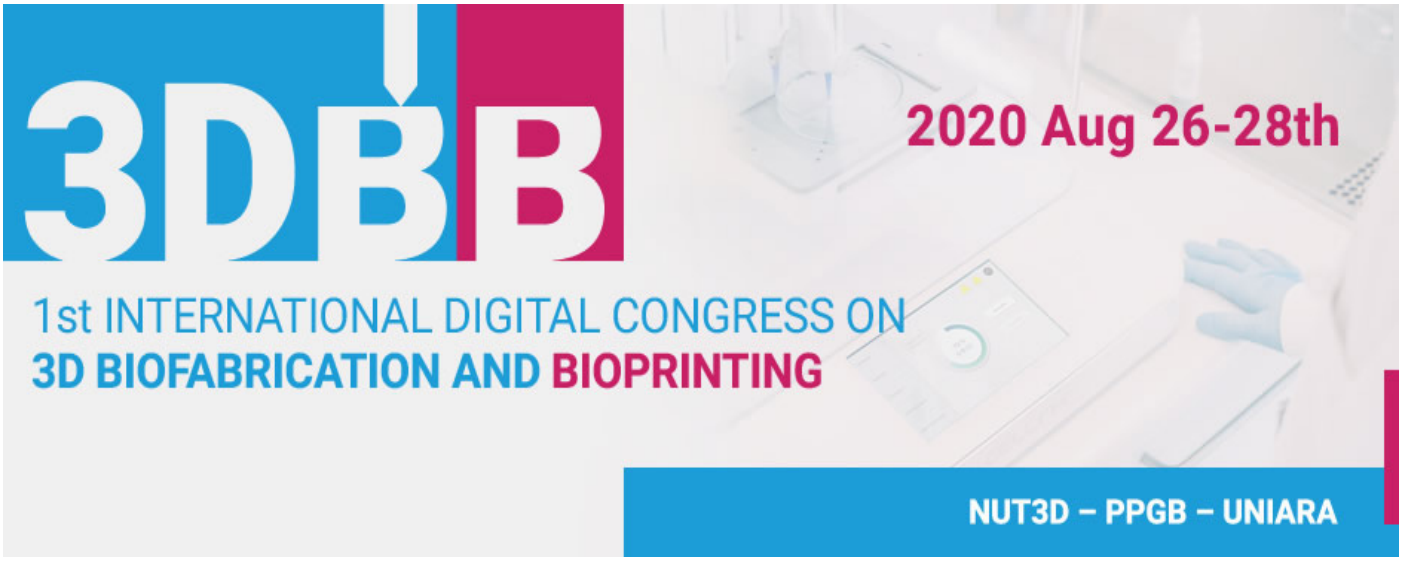
Débora Freitas Silva; Tainara de Paula Lima Lima*; Elcio Malcher Dias Junior*; Luis Adriano Santos Do Nascimento*; Carlos Emmerson Ferreira da Costa*; Marcele Fonseca Passos**

(Biomaterials)

Abstract: With the population aging and the lack of healthy practices, many citizens are affected by mechanical trauma and diseases that cause inflammations in the tissues. An alternative is to develop biomaterials able to assist in the treatment and restoration of the compromised regions. Thus, polycaprolactone (PCL) has been investigated for its biodegradable properties and versatility of application. However, hybridization studies of PCL membranes with vegetable oils, and its anti–inflammatory effects in tissues, are sparsely found in the literature. Vegetable oils, such as andiroba oil, contribute to numerous medicinal properties, participating in several stages of skin healing and acting as microbial protection in injuries. With technological potential in the health area, including natural resources of amazon basin, this project aimed to develop hybrid dressings, using the casting technique. This methodology allows us to obtain thin and low–cost membranes that assist in wound healing by releasing active principles in the polymeric matrix. Films were synthesized from a 5% w / v solution using acetone as a solvent, with different oil concentrations. The solution was prepared under constant magnetic stirring and heating to 40°C for 4h hours. The oil was added to the PCL solution and stirred for 5 minutes. Then 5 ml of each solution was deposited in molds to obtain the membranes. Drying time was four days at room temperature, followed by another four days in an oven at 40°C. Thermal analysis was performed using differential scanning calorimetry (DSC) and thermogravimetry (TGA). Contact angle measurements were also investigated. Results showed no significant macroscopic difference between control material and hybrid membranes. Despite this, the oil amorphous chain´s influence on polymer structure was verified, decreasing the degree of crystallinity. The hydrophobic character of films was influenced by oil content. But, a certain degree of films´ wettability was observed due to high porosity. Consequently, it is still possible to exchange gases or liquids on the surface of hybrid films. In general, results showed the feasibility of obtaining hybrid PCL / andiroba films with stable thermal character and curative potential.

Keywords: Polycaprolactone; Pcl; Andiroba; Amazon Oil; Wound Dressings; Biomaterials; Curative.

* Federal University of Pará (UFPA), Belém, PA, Brazil.



Developing and systematizing a process for the construction of personalized respiratory protection masks by additive manufacturing

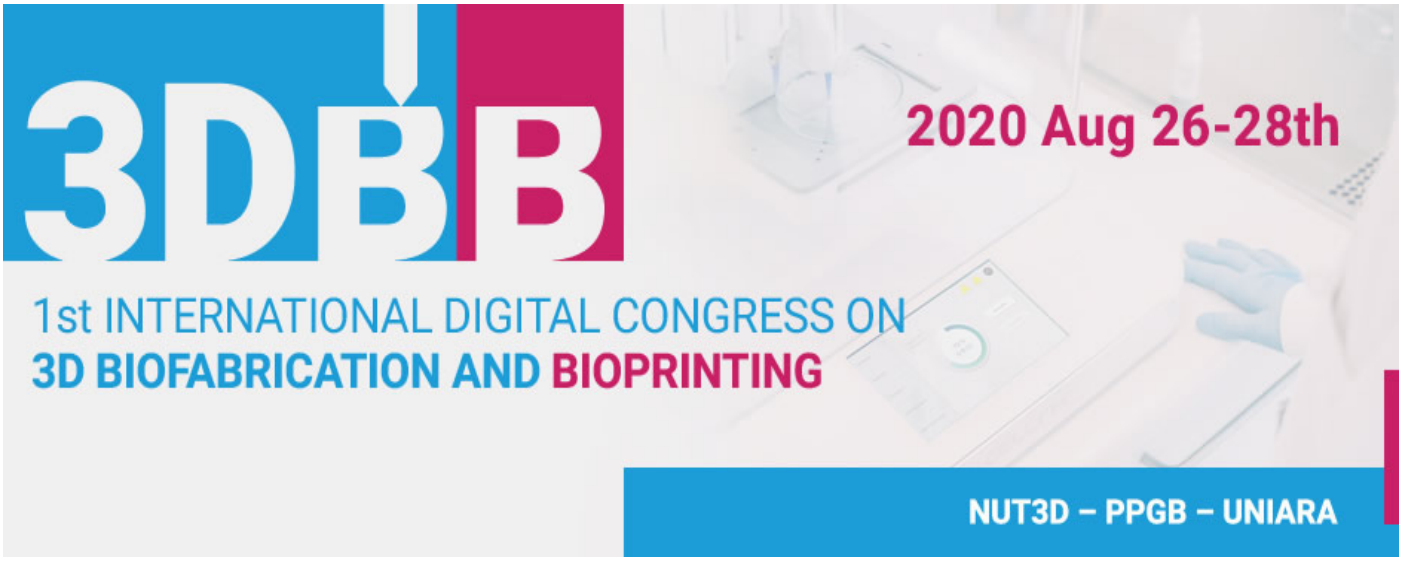
Eugenio D. A. Merino ; Diogo Pontes Costa* ; César N. Giracca*; Carmen E. M. Riascos*; Giselle Schmidt Andrés Díaz Merino**

(Devices and processes)

Abstract: The Sars–CoV–2 imposed unexpected challenges on society, such us, changes in the traditional models of productive systems and effective management of health system resources in diverse countries. In this context, a series of initiatives, in which the use of industry 4.0 technologies are important in the acceleration of the process of Personal Protective Equipment (PPE) development, specifically to health agents inserted in Covid–19 environments combat. However, some Respiratory Protection Masks tackle some issues, such as excessive pressure, skin lesions, discomfort, and incompatibility with the user's face surface. Therefore, this research aims to develop and systematize a process for the construction of personalized Respiratory Masks by additive manufacturing, which achieves the aforementioned demands. Methodology: The methodology was divided into four stages: 1. Problem identification considering the user demands; 2. selection, definition and application of procedures and materials; 3. equipment materialization; 4. user tests. As support, a 3D scanner, computer–aided design software, assisted manufacturing software and 3D printers were used. The mask was manufacturing using polymeric filament PLA (polylactic acid), broad elastic for fixation, and filters with activated carbon. Results: Applying this methodology, it is possible to produce a mask adjusted to the user's facial topology. With a satisfactory and personalized fit resulting from the virtual planning between the product and the user. The construction time was using four hours, included manufacture and assembly of the mask. Conclusion: The systematization of the production process demonstrated feasibility in manufacturing, agility in 3D printing, and precision in the shape of the user's face, verified in the materialized product when tested by the user. This helps to enable an expansion of this applicability and dissemination, which in the case of health, are pressing and necessary. As opportunities for advancing and improving this process, other devices for three–dimensional scanning and materialization can be incorporated, such as the use of polymeric resin SLA by UV curable or other materials, provided that do not harm the user's skin. Finally, the importance of developing research and applications of these technologies in human–centered projects is emphasized.

Keywords: Covid19; Additive Manufacturing; Ppe; Maks; Design.

* Federal University of Santa Catarina (UFSC), Florianópolis, SC, Brazil



Luminescent composite materials for 3D printing

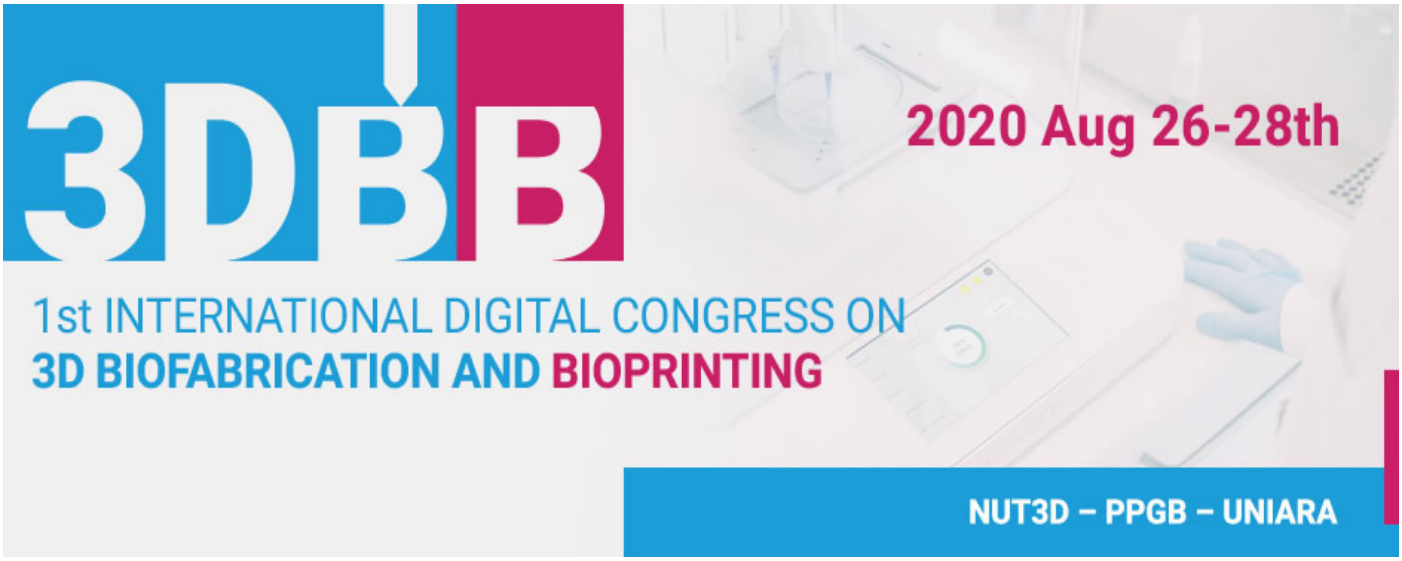
Francisco Recco Torres; Hernane Da Silva Barud**; José Maurício Almeida Caiut**

(Biomaterials)

Biopolymers have attracted great interest in tissue engineering research as they are components of living structures and have chemical and biological similarities with natural tissues. Nanofiber scaffolds developed from natural resources are interesting because of their biodegradable properties and, therefore, potentially used as temporary substrates to induce the regeneration of newly developed tissues. Gellan gum is a natural polysaccharide derived from bacteria that can be prepared in the form of a hydrogel, a versatile, functional biomaterial that can be molded into different forms of tissue. Cellulose nanocrystals, or whiskers, are crystalline domains of cellulosic fibers isolated by acid hydrolysis and are named this way due to their physical characteristics of rigidity, thickness and length. They have the potential to increase the properties of polymeric composites and serve as reinforcement for the natural fibers. It is expected that the preparation of nanocomposites based on nanocellulose dispersed in gellan gum can generate biocomposite hydrogels with tunable properties for 3D printing, allowing the manufacture of scaffolds with controllable matrix morpho–logy and porosity. Together, the structures of both biopolymers have groups that can act as a coordination environment for lanthanide ions and the properties resulting from this interaction can allow the development of new biocompatible photonic systems. The presence of the Europium (III) ion as a spectroscopic probe in the material, through the addition of a complex already reported in biocompatibility tests in cells, can allow the study of structural change at the molecular level through changes in the coordination sphere of the lanthanide ion.

Keywords: Biopolymers; Scaffolds; Gellan Gum; Cellulose Nanocrystals; Lanthanide Ions.

* Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto (FFCLRP–USP), Ribeirão Preto, SP, Brazil
** University of Araraquara (Uniara), Araraquara, SP, Brazil



Genipin extration from venezuelan caruto and preparation of chitosan 3D porous scaffold for tissue engineering

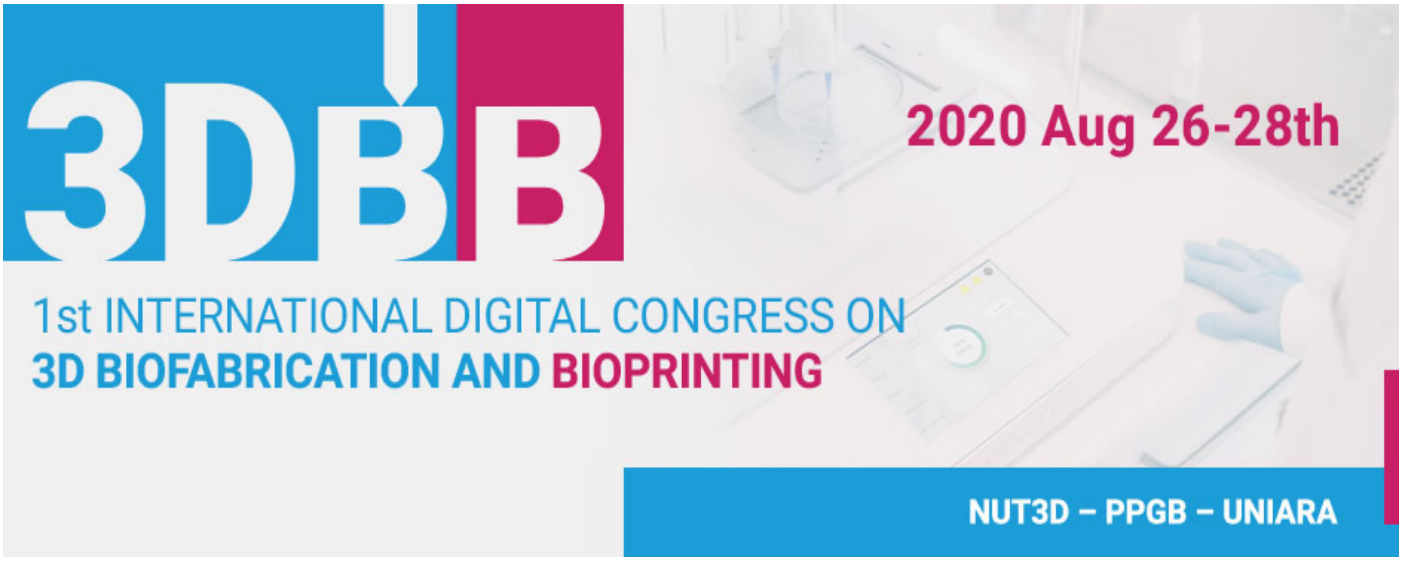
Pedro Luis Rodríguez Sequera; Marcos A. Sabino G.**

(Biomaterials)

Abstract: Genipin (GN) is a secondary metabolite found in the fruits of Genipa Americana L, its non–toxicity, its anti–inflammatory properties and the ease of reacting with primary amino groups allowing to be used as a crosslinking agent for biopolymers such as chitosan, collagen, etc. Chitosan (CH) hydrogels are currently receiving great interest from researchers due to their interesting properties: antibacterial, biocompatible, biodegradable. However, its rapid degradation and low mechanical properties make it necessary to apply stabilizing mechanisms that at the same time improve said mechanical properties. In this sense, covalently crosslinking CH is one of the possible solutions. A possible application for these cross–linked gels is the obtaining of scaffolds for nucleus pulposus; because it can improve the biomechanics of the intervertebral disc, important for transmits the load imposed on the spine (spinal tension, torsion, compression and bending). In this work, the extraction, purification and characterization of GN was carried out from the fruit of Genipa americana L (Caruto Venezolano) obtained on Venezuelan soil and to evaluate its use as a cross– linking agent to prepare CH/GN hydrogels and scaffolds. The pulp of frozen unripe fruits were grated and macerated in chloroform under constant mechanical stirring for 4 h. The chloroformic extract was filtered and the solvent was removed by distillation under reduced pressure. From the oil obtained the GN was obtained by extraction with organic solvents, the solid was purified by recrystallization, obtaining maximum yields of 4 mg GN/g of pulp. The product was characterized by FT–IR, 1HNMR and 13CNMR spectroscopy. Chitosan and CH/GN hydrogels at 0.1%, 0.5% and 1% were formed by incorpo–rating GN into a 1% solution of CH in acetic acid. After 3D porous structures were obtained by lyophilization (–48 °C, 72 h and 0.075 torr). Chemical crosslink of CH was confirmed by FTIR, the morphology of the structures was studied by SEM. Hydrogel swelling studies showed that increasing the concentration of GN decreases the capacity of CH to absorb water. Additionally hemolysis tests demonstrated that the incorporation of GN in CH gels does not affect the hemocompatibility of them. The results show how the pore size depend on the concentration of GN, generating 3D scaffold–like structures, which have potential for use in tissue engineering, and possibly as a substitute gel for the nucleus pulposus of the intervertebral disc.

Keywords: Biopolymers; Porous Scaffolds Chitosan; Genipin, S.

* Departamento de Quimica, Grupo B5IDA, Universidad Simon Bolivar, Caracas, Venezuela



Biotech–educated platelets platform creating value: ingrowth–bio hydrogel mimics crowded shape of microvascular environmental, with tissue

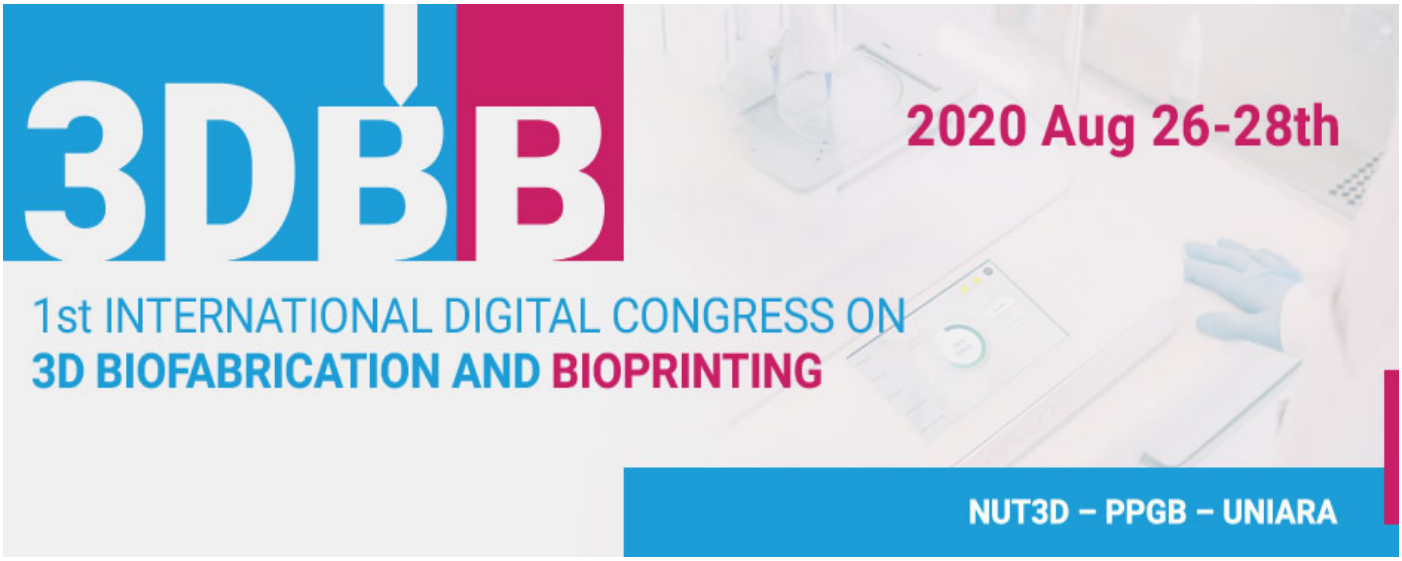
Sheila Siqueira Andrade; Alessandra V.s. Faria***

(Biomaterials)

Abstract: Biotech–educated platelets are conceptual and technological innovations that provide platelets with versatile biotechnological roles as a central scientific system with molecular and biomimetic bases to consider platelet–based solutions (hybrid materials) for therapeutic use and experimental insights into translating platelet technology to the market. While regenerative medicine is expected to ultimately improve patient safety, our knowledge of natural extracellular matrices (ECMs) has increased considerably; we have learned about platelet function and its unexpected biochemistry, especially in regenerative medicine. As a result, we developed of human platelet–based fibrinogen–, fibronectin–, and vitronectin–rich hydrogel, named InGrowth–Bio, which improves micro–vascularization in a complete 3D endothelial cell culture support or Bioscaffold. By incorporating multiple platelet–angiogenic growth factors, this hydrogel supports the proliferation of endothelial cells in 2D cultures (2D–projected images obtained by optical microscopy), and the formation of a microvascular network/structures ex vivo in 3D cultures without requiring the addition of recombinant growth factors (3D images acquired by confocal microscopy). In addition, this compound may be polymerized at body temperature through the proteolytic action of proteases secreted from target cells, offering a fully human option from a Biotech–educated platelet platform. Importantly, the InGrowth–Bio promotes blood–vessel structures formation, which is required in the context of tissue repair. InGrowth–Bio stiffness, degradability and 'stickiness' can all spur cells that form blood vessels to switch between multicellular and single–cell modes of migration. Single cells quickly invade new regions, but the multicellular mode is needed to cells collectively form a blood vessel and its maturation. Ideally, InGrowth–Bio mimics a "crowded cellular environment" led to biomimetic changes in cytoskeletal rearrangement and coordinates the migration of cells during 3D angiogenesis.

Keywords: Platelets; Biomimetics; Ingrowth–Bio; Biotechnology; growth factors

* PlateInnove Biotechnology
** University of Campinas, UNICAMP



Development And Characterization Of Membranes Based On Chitosan/ Genipin–Oil For Biomedical Applications

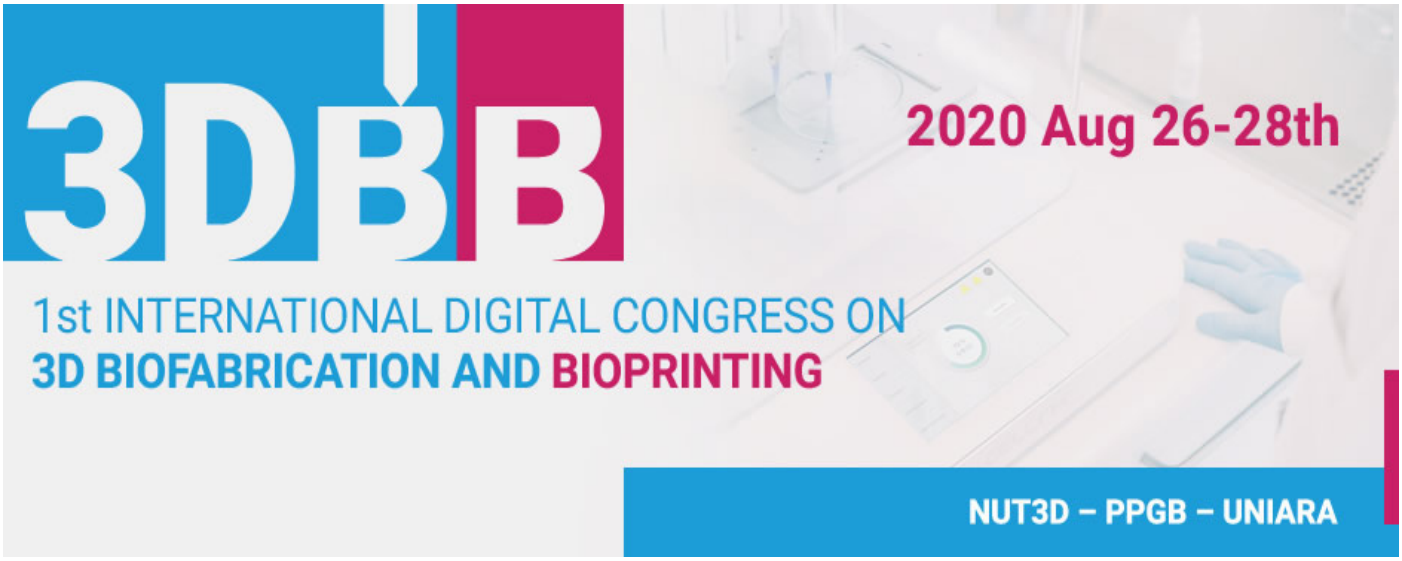
Erick De Freitas; José Ramón Domínguez**; Dinorah Herrera***; Marcos A. Sabino G.**

(Biomaterials)

Abstract: Genipin (GP) is a natural cross–linking agent that is used to cross–link chitosan (CH). From the pulp of a fruit known as Venezuelan Caruto (Genipa American L.), an oil extraction process was carried out. The extracted oil (GP–oil) was characterized and used as a reticulation agent with CH for the preparation of membranes (solvent casting) in three different formulations, contained the oil in a concentration of: 0 %, 0.05% and 0.1% w/w. The surface morphology of the membranes was evaluated by scanning electron microscopy (SEM), where an absence of superficial pores was observed. These membranes were characterized by Fourier transform infrared spectroscopy (ATR–FTIR). Accordingly, to the FTIR results, a chemical change was observed in the proportion of deacetylated units in relation to acetylated units, which determining the effect of the cross–linking process between the GP–oil and CH. Subsequently, permeability tests using Nitrogen, Argon and Air gases were performed (at 8 and 16 psi) of the membranes, which showed an impermeable character. During these permeation tests, an interesting deformation was observed in the membranes, which allowed to relate said deformation with mechanical resistance. The mechanical resistance was evaluated at high pressure rupture tests (48–56 psi), determining that the resistance to rupture increases and the elastic deformation decreases in function of % GP–oil. Swelling tests were performed to determine the water sorption of the membranes, finding a decrease in % of swelling as the GP–oil concentration increased. Using the thermal stimulation current density (TSDC) technique, the influence of oil cross–linking was determined by the mobility of the polymer chain. TSDC results indicated that in function of the GP–oil concentration increase, the mobility of the polymer chain decreased. The results by FTIR, TSDC, permeability and swelling are promising results because they show that it is not necessary to have purified GP to achieve the crosslinking of CH. The evaluation of hemocompatibility of the oil into the membranes was carried out, where it was proved that it is not cytotoxic. All these results obtained on the reticulation capacity of the GP–oil extracted from the Venezuelan Caruto, its hemocompatibility and improve mechanical resistance, open a window for its use in biomedical applications: for example in the development of 3D scaffolds for the nucleus pulposus.

Keywords: Biopolymers; Chitosan; Genipin; Membranes.

* Departamento de Quimica, Grupo B5IDA, Universidad Simon Bolivar, Caracas, Venezuela
** Departamento de Quimica, Laboratorio de Absorción Atómica, Universidad Simón Bolívar, Caracas, Venezuela
*** Departamento de Fisica, Laboratorio de Fisica del Estado Sólido, Universidad Simón Bolívar, Caracas, Venezuela



Rapid 3D prototyping biomodel as an auxiliary surgical planning method for facial tumor resection

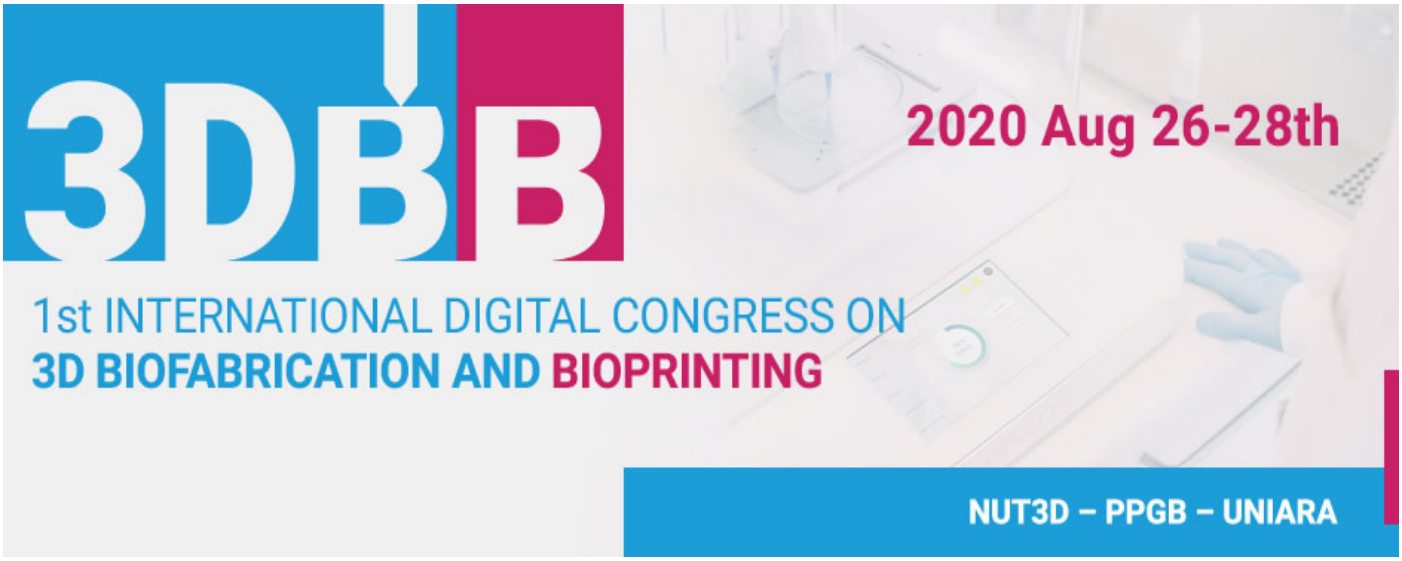
Luiz Henrique Soares Torres; Marisa Aparecida Cabrini Gabrielli*; Valfrido Antônio Pereira Filho**

Biofabrication and bioprinting (in general)

Abstract: ameloblastomas are slow growing, high recurrence and locally invasive facial tumors. Thus, an accurate surgical approach guaranteed satisfactory clinical results and less patient morbidity. The additive manufacturing technique allows to making three–dimensional models from 3D image data that a physical replica of the patient´s anatomy, assisting in planning and ensuring surgical predictability. Methodology: male patient, 32 years old, with no previous medical history, attended the ambulatory of maxillofacial surgery, with swelling on the right side, painless, with evolution of 08 months. Imaging exams showed an intraosseous trabecular lesion in the right body and mandibular angle. In histopathological analysis by incisional biopsy, the diagnosis of multicystic ameloblastoma was obtained. We opted for making a 3D model by additive manufacturing for planning tumor resection and previous modeling of osteosynthesis titanium plate. Results: the tumor resection regarding the installation of the fixation device was performed under general anesthesia. Following an 8–month follow–up, the titanium plate was fractured. A new digitally preformed and more robust device was installed. Bone grafting of autogenous origin was performed in the same session. Currently in follow–up for 01 year, he continues without recurrence or complications. Conclusions: the additive manufacturing is an effective auxiliary method in the planning of tumor resections, since it allows the visualization of the lesion margins, in addition to providing a pre–modeling of the bone fixation devices and reduction of the surgical time.

Keywords: Three–Dimensional Printing; Ameloblastoma; Neoplasms; Technology; Facial Neoplasms .

* Universidade Estadual Paulista “Júlio de Mesquita Filho”, Faculdade de Odontologia de Araraquara, UNESP/FOAr.



Development of a 3D microextrusion bio printer

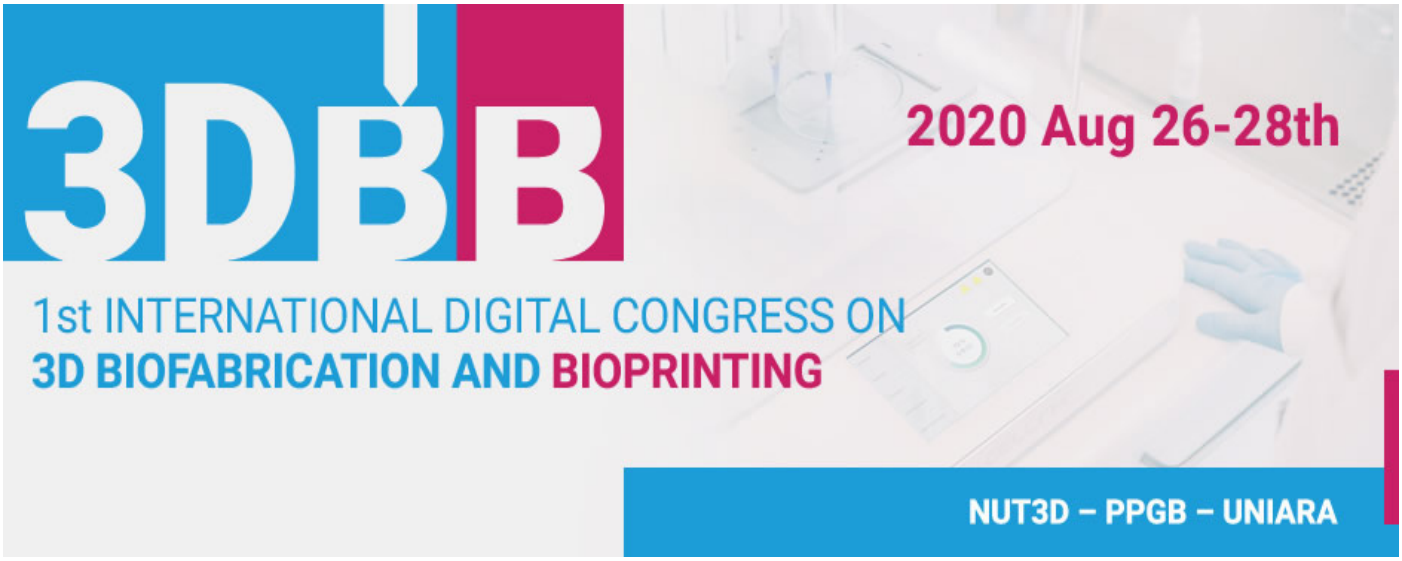
Diego Silva Batista ; Hernane Da Silva Barud***

Biofabrication and bioprinting (in general)

Abstract: Three–dimensional (3D) printing or additive manufacturing is an emerging technology that has recently been gaining significant attention in the area of medical and tissue engineering. However, commercial bioprinting platforms still have a high cost for small research facilities, especially in the academic environment. In addition, to use this technique, it is also necessary to produce hydrogels and functional bioinks that aim to match the properties, chemical, physical and biological of human tissue. In the present work, a low cost homemade 3D bioprinter was designed and built using the piston microextrusion process by adapting a commercial Fused deposition modeling (FDM) printing head of the ReprapPrusa i3 model, for bioprinting using bioinks and hydrogels. To validate the developed bioprinter, aiming at possible applications in tissue engineering, scaffolds were printed using hydrogels of different compositions. The scaffold was dimensioned in a cylinder shape, with a diameter of 10.75 mm and a thickness of 5 mm. Demonstrating its ability to manufacture 3D structures with good spatial accuracy along the X, Y and Z axes and presenting the ability to follow the projected project. The printing results demonstrate scaffolds with structural stability similar to those reported in the literature, showing that bioprinter is promising for applications in additive manufacturing and tissue engineering.

Keywords: Bioprinting; Microextrusion; Additive Manufacturing; Tissue Engineering; Homemade.

* MedTech Lab Solutions.
** University of Araraquara (Uniara), Araraquara, SP, Brazil.



Biomimetic structures development from chitosan–graft–amino acids as potential biomaterial for cell culture

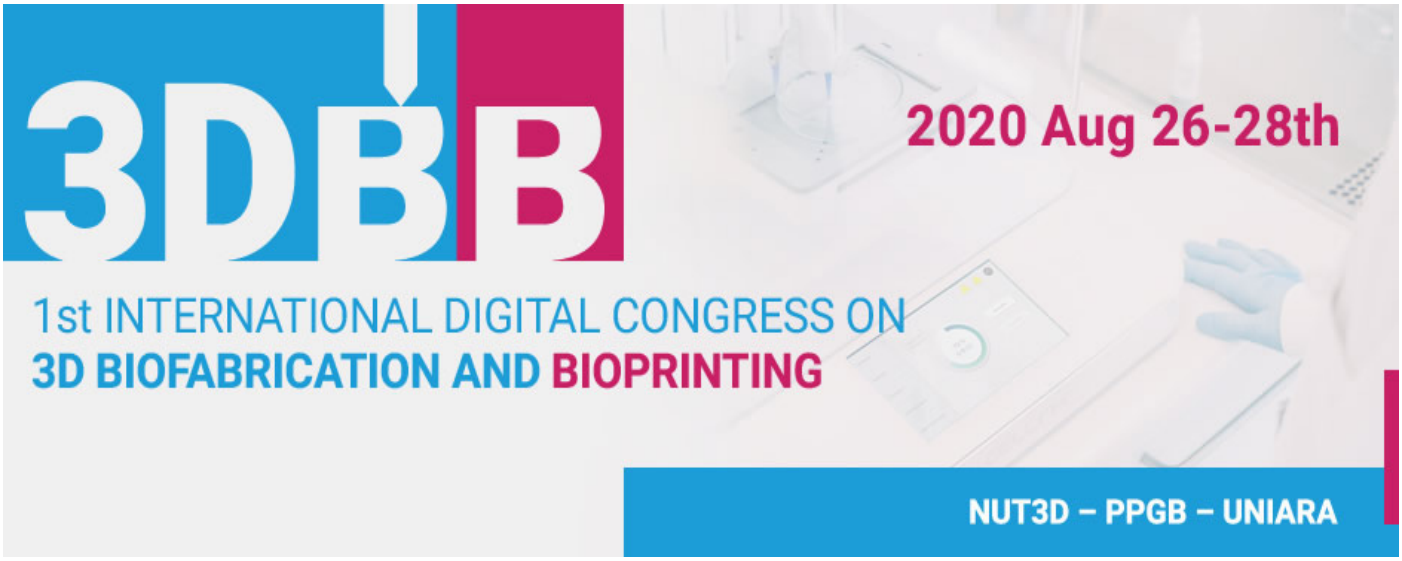
Jesús Campos; Ramón Coronado S.**; Marcos A. Sabino G.**

(Biomaterials)

Abstract: Biopolymers are important for tissue engineering and potential for artificial organs area. The polysaccharide Chitosan is one of them because contain interesting characteristics of biodegradability and biocompatibility, but has problems of application in biological systems due to its limited solubility in neutral aqueous solution. Its applicability in biotechnological and medical areas may be accomplished by chemical modification to open more possibilities to be apply in the biofabrication of 3D structures or gels for bioextrusion. In this project, chitosan (CH) was chemically modified with two amino acids (L–leucine, L–tyrosine) using carbodiimide chemistry. With the functionalized CHs (FCHs), the aim was to prepare (using electrospinning technique) biomimetic structures (scaffolds) as models for cell culture. Initially, the chemical characterization of the FCHs was performed using Fourier–transform infrared spectroscopy (FT–IR) and nuclear magnetic resonance (NMR). Follow, the solubility properties of the derivatives obtained were also studied. In the case of chitosan, this study was relevant to demonstrate that its solubility was enhanced in a physiological pH solution. Subsequently, polyblends (from solution) were prepared between the modified chitosans (FCHs) and poly (vinyl alcohol) (PVA) in proportion 25/75 FCHs/PVA. These polyblends permitted to study the experimental conditions in the electrospinning process for to obtain the scaffolds, formed by micro/nano fibers, with a morphology of interconnected pores. This morphological characterization was performed using scanning electron microscopy (SEM) and permit to observe that these structures mimic an extracellular matrix. Also, the hydrophilicity/hydrophobicity property of the FCHs and polyblends was studied using the contact angle test. Finally, biocompatibility studies were carried out in two way: using the hemocompatibility test on human erythrocytes, and in vitro viability cellular test using a hemocytometer with trypan blue. As a result, a percentage of hemolysis less than 5% point that they are not cytotoxic, and the experimental complement using cell culture in vitro shown that both biomaterials are biocompatible: but the CH graft L–leucine is better than CH graft L–tyrosine. All results were relevant to propose future potential of these biomimetic structures for cell culture, tissue engineering, bioprinting techniques, development of bioinks and other biomedical applications.

Keywords: Biomimetic structures; Biomaterial; Chitosan; Chemical Modification; Amino Acids.

* Departamento de Quimica, Grupo B5IDA, Universidad Simón Bolivar, Caracas, Venezuela
** Lester Smith Medical Research Institute, USA



Development of a polycaprolactone scaffold functionalized with nanocapsules containing heparin for use as a vascular graft

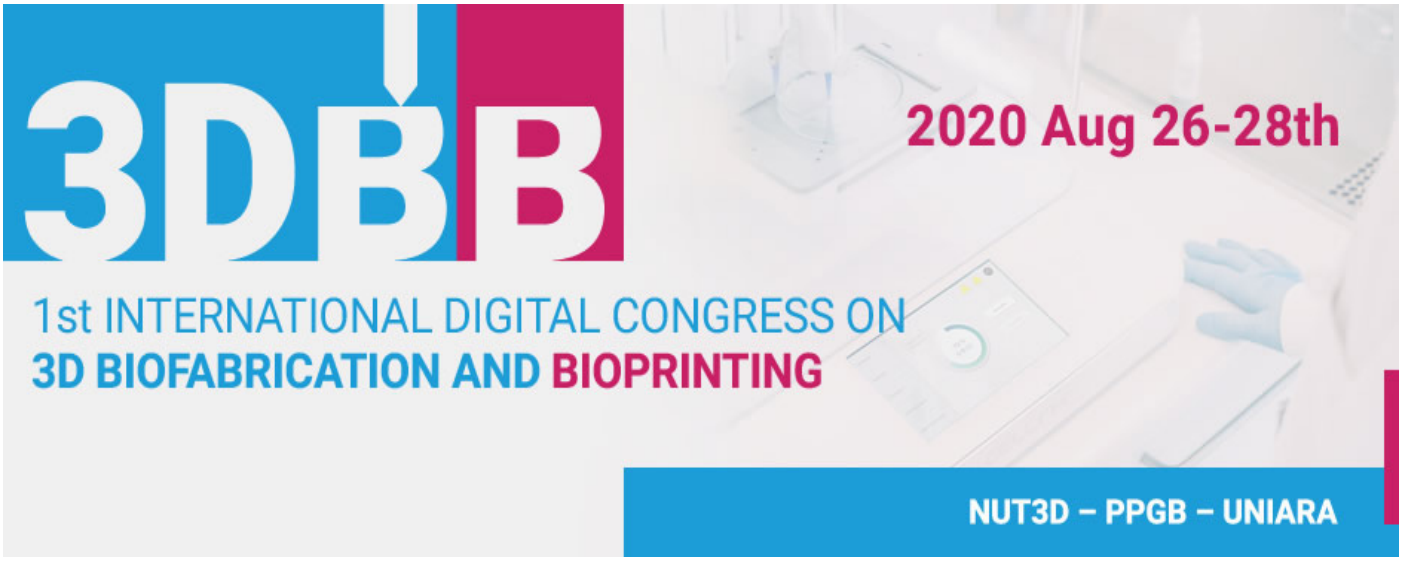
Bruna Borstmann Jardim Leal; Daikelly Iglesias Braghirolli**; Patricia Pranke****

(Biomaterials)

Abstract: Synthetic vascular grafts are widely used clinically in large diameter vessels. However, in vessels < 6 mm of diameter, they have a high failure rate due to thrombus formation. Electrospun scaffolds functionalized with biomolecules, such as heparin (Hep), can be an interesting tool for use as a vascular graft. For blood vessel regeneration, the establishment of vascular endothelium is the initial goal for the success of the grafts, which can be achieved using endothelial progenitor cells (EPCs). Aim: Develop a polycaprolactone (PCL) scaffold functionalized with nanocapsules (NC) containing Hep. Methodology: PCL scaffolds were produced by electrospinning and were functionalized with NC containing Hep by electrospraying, from an emulsion of poly(lactic–co–glycolic acid) (PLGA) and Hep. Following this, the EPCs were cultivated on the scaffolds. PCL fibers and Hep NC were characterized by morphology and diameter. For biological characterization, three groups were evaluated: PCL without NC (PCL/ControlNC), PCL with NC containing Hep (PCL/Nhep) and a culture plate treated with collagen (control group). The morphology and adhesion of cells were evaluated. The EPC morphology was analyzed by staining the nuclei and cytoskeleton with DAPI and phalloidin, respectively. For cell adhesion, following the nuclei staining with DAPI, nine random fields from each sample were analyzed under fluorescence microscopy and the number of adhered cells/ sample was estimated. Results and discussion: The PCL scaffolds presented smooth, homogeneous and randomly distributed fibers, with diameter of 0.682 ± 0.21 µm. The NC containing Hep presented round and homogeneous morphology, with diameter of 440 ± 172.4 nm. In the cell adhesion test, the control group showed 1,191 ± 412.6 cells/ sample. The scaffolds groups showed similar cell adhesion: PCL/ControlNC 697.5 ± 309.7 and PCL/Hep 692.5 ± 145.1 cells/sample. Through this test, it was observed that the presence of NC did not interfere in cell adhesion on the scaffolds. Moreover, after 7 days of cultivation, the EPCs showed elongated morphology on the scaffolds, indicating that the cells had a good adaptation on these structures even with low adhesion. Conclusion: The scaffolds favor the adhesion and adaptation of EPCs. In addition, the presence of NC did not alter these parameters. These results demonstrate that the developed scaffolds can be an interesting alternative for vascular tissue engineering.

Keywords: Tissue engineering; Regenerative Medicine; Nanocapsules; Heparin; Vascular Graft.

* Hematology and Stem Cell Laboratory, Faculty of Pharmacy, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil
** Physiology Post–graduation Program, UFRGS, Porto Alegre, RS, Brazil
*** Stem Cell Research Institute, Porto Alegre, RS, Brazil



Influence of glycerol content on the mechanical properties of thermoplastic starch films produced by tape casting

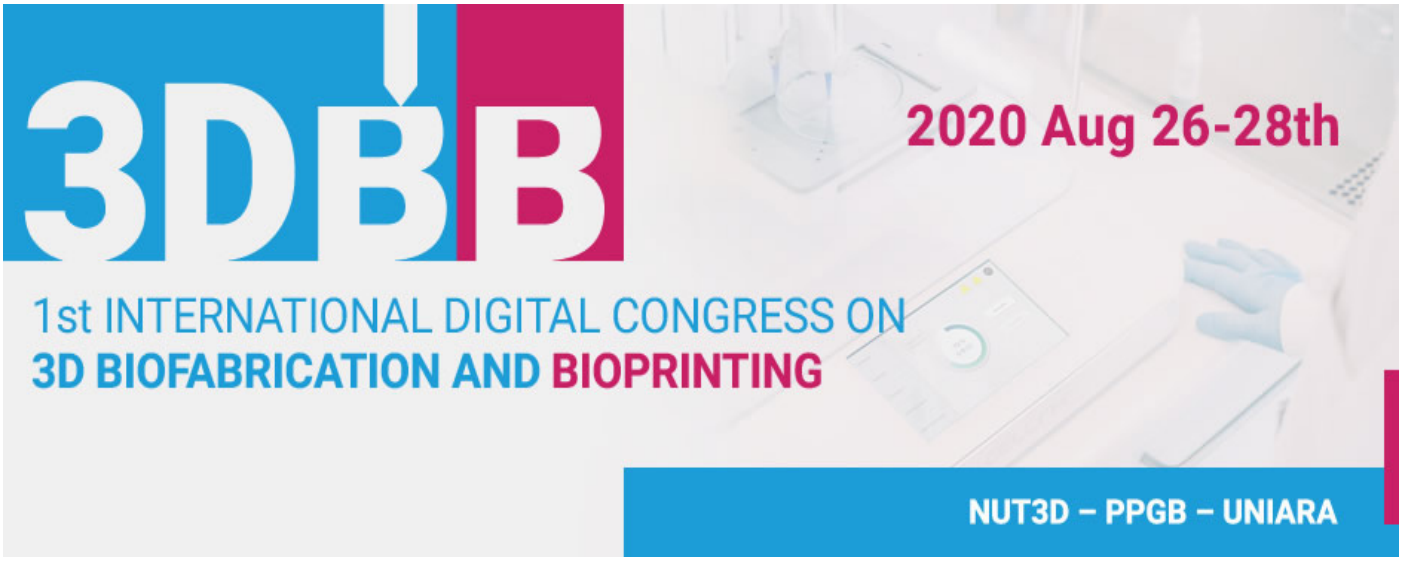
Karen De Souza Do Prado; Maria N. Castanho** ; Jane Maria Faulstich De Paiva***

(Biomaterials)

Abstract: Starch is a biomaterial extensively studied for preparing films due to its abundance, biodegradability, and low cost. Thermoplastic starch (TPS) is obtained by mixing starch with plasticizers such as glycerol and water, and TPS films are generally produced by casting. However, due to the small size of the films produced and the lack of thickness control, casting is generally unfeasible for large–scale production of TPS films. A promising alternative is the tape casting technique, traditionally used for ceramics but not yet widely explored for molding TPS films. The aim of this study was to determine the influence of composition on the mechanical properties of TPS films produced by tape casting, aiming at large scale production. Methodology: Starch/glycerol/water suspensions were prepared with 5 wt% of corn starch and four concentrations of glycerol (20, 30, 50, and 100 wt% in relation to the mass of starch). The mixtures were stirred at 80°C until gelatinization, and the films produced by tape casting with 0.15 (± 0.04) mm thickness had their mechanical properties evaluated according to ASTM D882. Results: It was observed that the increase in glycerol content resulted in decreasing trends in Young´s modulus and tensile strength, which follow power functions with a coefficient of determination greater than 0.992. The increase from 20 to 30 wt% in the glycerol content reduced Young´s modulus by 75 wt% and maximum strength by 56%, and increased the elongation of TPS films by 50%. TPS films with 5 wt% starch and 50 wt% glycerol (in relation to starch) resulted in higher Young´s modulus (19.3 MPa) and lower rupture elongation (12.1%) than values previously reported in the literature for films produced by conventional casting, which can be explained by the orientation of the polymer chains during processing. The tensile strength value (1.3 MPa) was comparable to that reported in the literature for films produced by casting. Conclusion: Therefore, the results of this work show that tape casting is a viable technique to be used in the large–scale production of TPS films for different applications, especially those that require materials with greater stiffness.

Keywords: Starch; Glycerol; Film; Tape Casting; Mechanical Properties.

* Materials Science Program, Federal University of São Carlos, PPGCM/UFSCar, Sorocaba Campus, Sorocaba, SP, Brazil.
** Production Engineering Department, Federal University of São Carlos, UFSCar/DEP–So. Sorocaba Campus, Sorocaba, SP, Brazil.



Perspectives of bioprinting in regenerative medicine

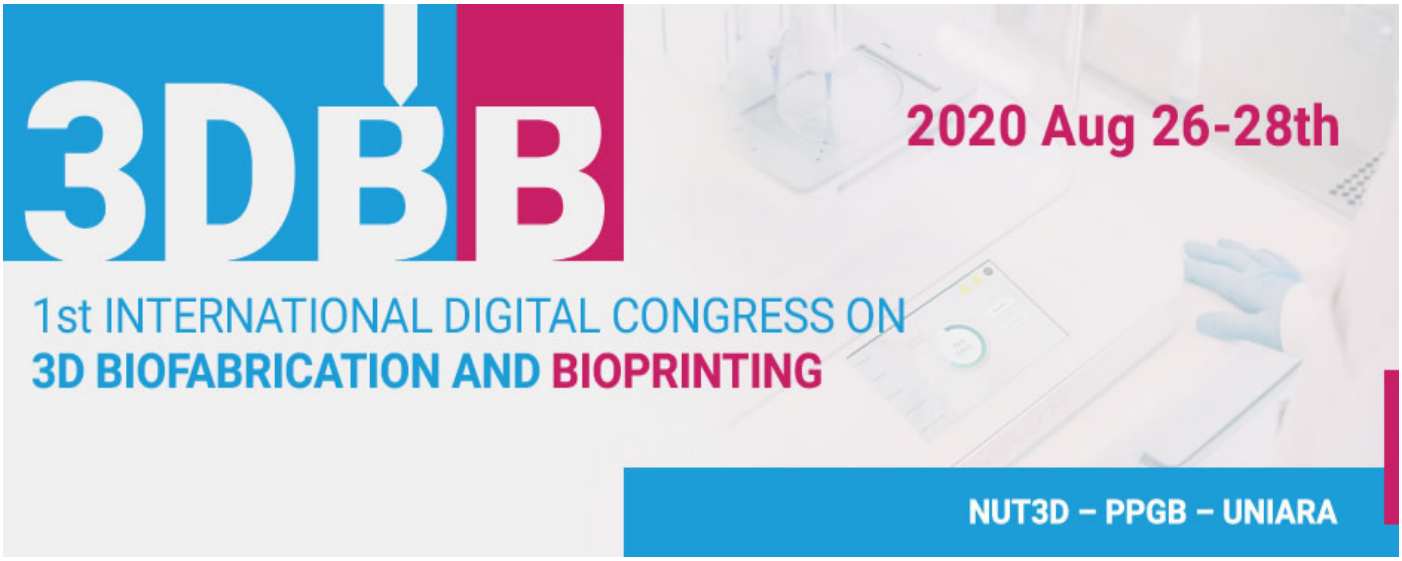
Anna Kellssya Leite Filgueira; Ketinlly Y. N. Martins*; Rodolfo R. Castelo Branco*; Isabella D. Gallardo*; Carlos A. M. Dos Santos**; Lucas V. A. Sales***

Biofabrication and bioprinting (in general)

Abstract: Regenerative medicine makes it possible to repair or replace damaged organs, tissues and cells. The future potential of this area grows in association with the development protocols of biocompatible artificial tissues and 3D bioprinting, which has provided new evolutionary strategies for the area. In this context, the present study aims to review the currently available literature and analyze the bioprinting perspectives in regenerative medicine. Methodology: It refers to an integrative literature review in order to generate a consolidated overview of the topic addressed. The elaboration of the study respected the PICO (Patient, Intervention, Comparison, Outcome) strategy based on the guiding question "What are the perspectives of bioprinting (I) in the current scenario of three–dimensional printing (P) for improving regenerative medicine (O)?". The literature survey was conducted in two electronic databases – ScienceDirect (Elsevier) and the Virtual Health Library: VHL (Bireme). The search strategy used was the association of the descriptors "Regenerative Medicine", "Bioprinting", "Three–dimensional Printing", and after of their respective correspondents in English, duly registered in DeCS (Health Sciences Descriptors), through the Boolean operator ´AND´, respecting the individuality of each electronic base. The inclusion criteria were: allowing access to the full text and respecting the thematic approach. The exclusion criterion used was to be presented in languages other than English, Portuguese and Spanish. The articles' selection was made by reading titles, reading abstracts, and finally, reading the full text. Results: The literature survey offered 209 documents. Of these, 185 articles provided only the abstract and did not participate in the research. Eight articles met the proposed exclusion criteria. Sixteen articles were analyzed regarding the thematic approach and, after reading the title and abstracts, six duplicates were found. Finally, 10 articles were reviewed. Of these, no clinical research was found. Conclusions: Advances in bioprinting have a diversity of applicability, enhancing the scenario of regenerative medicine. The lack of clinical studies of high methodological rigor, may be associated with factors that characterize the method (customization and biocompatibility) and cases absence that address the specificities of randomization, however, restricts the reliability and effectiveness of the technique.

Keywords: Tissue Engineering; Three–Dimensional; Regenerative medicine; Skin, Artificial; Bioprosthesis.

* NUTES – Universidade Estadual da Paraíba – UEPB, Campina Grande, PB, Brasil.
** Universidade Federal de Campina Grande – UFCG, Campina Grande, PB, Brasil.



A new protocol for obtaining platelet–leukocyte aggregate for use as bioink

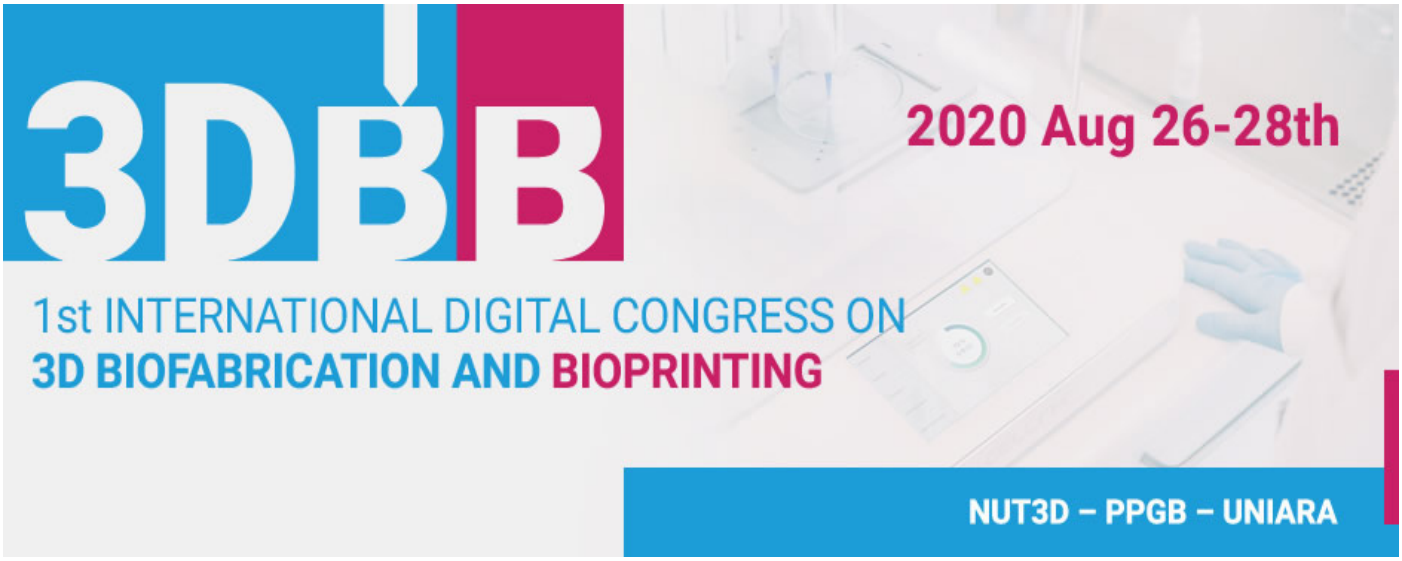
Gabriela Moraes Machado; Kalita R. Grubert*, Marcos A. do Couto*; Natasha Maurmann**; Patrícia Pranke**; Caren Serra Bavaresco**

(Biomaterials)

Abstract: The development of bioink is a challenge in tissue engineering. Platelet aggregates have been used since the 1990s and currently represent an alternative for application in 3D bioprinting as they are an autogenous material and because of the release of growth factors. Therefore, this work aims to develop and test a new protocol for obtaining platelet–leukocyte aggregate. Methodology: The blood of two patients was collected in tubes without anticoagulants, centrifuged at 300 rpm for 10 minutes, pressed and polymerized, and the biomaterial was placed in 48 well culture plates (approval protocol CAAE 20111519.9.0000.5349). Fibroblasts (MRC5 cell line) were seeded on the membranes and macroscopic, microbiological (Tryptic Soy Broth, TSB), and cellular tests [3–(4,5–dimethylthiazol–2yl)–2,5–diphenyl tetrazolium, MTT and fluorescence microscopy] were performed to assess the presence and viability of the cells. Results: The results showed that the protocol developed using low rotation generated a rigid final membrane, although with irregular edges and with the presence of red blood cells. After 6 days of incubation of the biomaterial in nutrient medium for microorganisms TSB, microbiological evaluation was made through the turbidity test, which did not demonstrate the growth of microorganisms. The biomaterial demonstrated biocompatibility with the presence of viable cells after 7 days of cultivation using the MTT test. The mean values of absorbance ± standard deviation in this test were 0.420±0.048 in the control group, where the cells were grown directly in the culture wells and 0.396±0.049 in the group where the cells were grown in the platelet–leukocyte aggregate (p= 0.205). In both the control and biomaterial groups, detection was made of viable cells stained with fluorescein diacetate and dead cells with propidium iodide. Conclusion: This protocol can be used as a bioink because its initial composition can favor bioprinting and, after polymerization, obtain favorable rigidity. Protocols for obtaining platelet–leukocyte aggregate, such as fibrin–rich plasma, use higher rotation (about 3000 rpm); the protocol for obtaining the biomaterial studied in this work showed promising results for clinical practice and also for use in surgical manipulation. However, it would be interesting to make tests comparing the release of growth factors and to make an evaluation of the membrane eluate obtained by this protocol and the protocols already described.

Keywords: Biocompatible Materials; Bioprinting; Tissue Engineering; Transplantation; Regenerative Medicine.

* Universidade Luterana do Brasil (ULBRA),Canoas.
** Federal University of Rio Grande do Sul (UFRGS)



Implantation of galantamine microparticles for reducing oxidative stress in spinal cord injury in rats

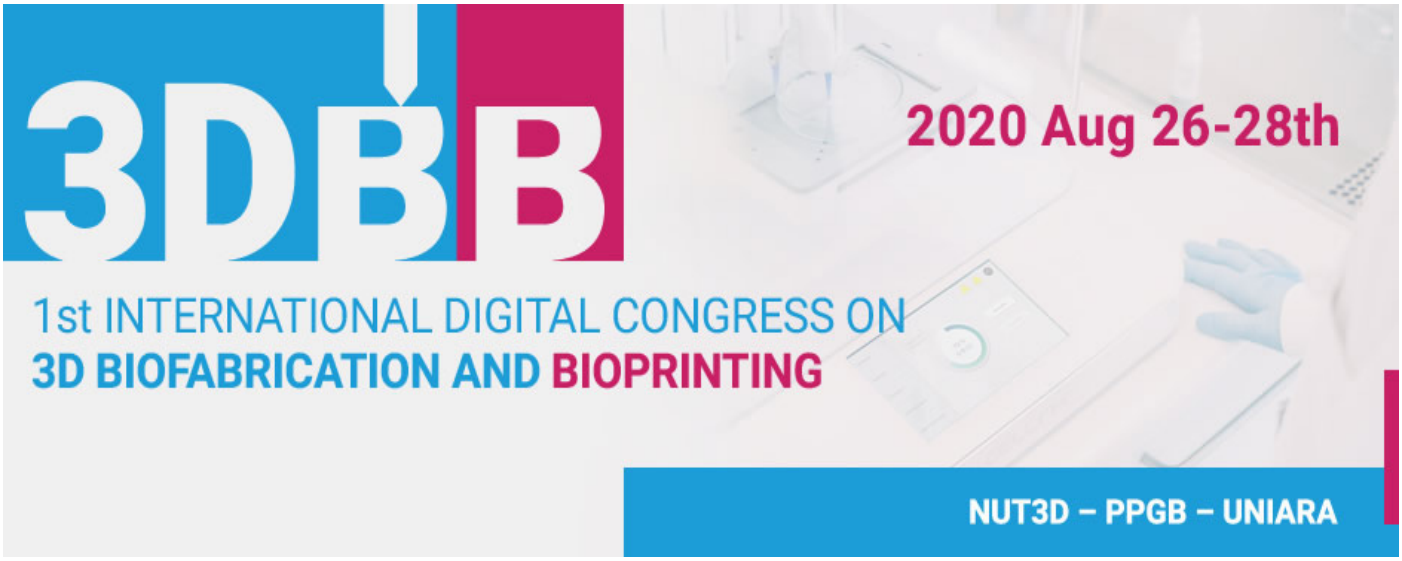
Fernanda Stapenhorst França; Cristian E. Teixeira*; Marcelo G. Dos Santos*; Gabriele G. Dido*; Cristina C. Carraro*; Laura Elena Sperling**; Adriane B. Klein*; Patricia Helena Lucas Pranke****

(Biomaterials)

Abstract: Spinal cord injury (SCI) is a serious condition that currently has no effective treatment and can lead to gross loss of body sensitivity, potentially leading to debilitating paralysis. Previous studies from our group have indicated that galantamine improves recovery after SCI. Drug release characteristics are improved with the use of biodegradable polymer carriers, which sustain the release of encapsulated drugs. Hence, the aim of this study has been to produce galantamine microparticles and to evaluate galantamine effects on oxidant parameters after SCI. Methods: The microparticles were produced by electrospraying, with 2.5% of galantamine hydrobromide in a 4% PLGA solution or 4% PLGA alone. The morphology of the particles was evaluated by scanning electron microscopy (SEM) and the diameter and zeta potential of the particles were measured by dynamic light scattering. For the SCI model, Wistar rats were submitted to a contusion injury on the thoracic spinal cord, using MASICS impactor (CEUA 35781). The animals were divided into the following groups: (1) Sham (laminectomy only), (2) only SCI, (3) SCI with intraparenchymal galantamine treatment; (4) SCI with implant of PLGA particles and (5) SCI with implant of PLGA particles containing galantamine (PG 2.5%). Three days and six weeks after the injury, the animals were euthanized and the spinal cords were collected. Reactive oxygen species (ROS) production in the spinal cord was assessed by DCF analysis, and lipid peroxidation was analyzed by measuring thiobarbituric acid reactive substances (TBARS). Results: The average particle diameter was 3,247.6 ± 1,290.7 nm for the 4% PLGA particles and 568.3±172.5 nm for the PLGA particles with 2.5% of galantamine. The zeta potential of the particles was −50.05 ± 10.3mV for the 4% PLGA particles and −23.59 ± 4.6 mV for the particles containing 2.5% of galantamine. The group treated with PG 2.5% showed significantly decreased ROS production when compared to the injury group after 3 and 42 days post injury. Furthermore, all the treatment groups presented a decreased TBARS production when compared to the injury group after 3 days, but not after 42 days. Conclusion: The present study shows that galantamine treatment, PLGA particles, and PG 2.5% were able to decrease lipid peroxidation 3 days after the injury, but only the treatment with PG 2.5% was able to reduce the oxidative stress at 3 and 42 days after spinal cord injury, decreasing ROS production.

Keywords: Spinal Cord Injury; Galantamine; Electrospraying; Antioxidant Effect.

* Universidade Federal do Rio Grande do Sul (UFRGS).
** Universidade Vale do Rio dos Sinos (Unisinos).
*** Instituto de Pesquisa com Células–Tronco (IPCT).



Study of bioink formulation and influence of bioprinting in cell viability

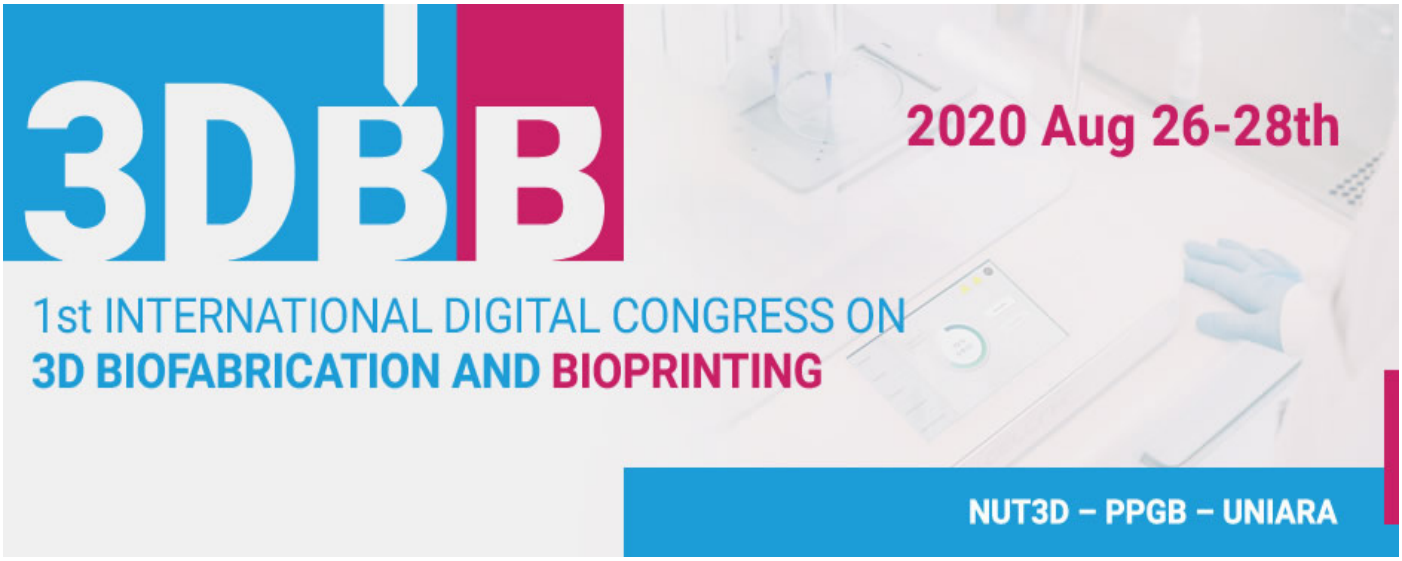
Luiza Silva de Oliveira; Natasha Maurmann*; Juliana Girón*; Maurício Felisberto*; Patricia Pranke**

(Biofabrication and bioprinting (in general)

Abstract: Bioprinting is an emerging technology with biomedical applications that allows for the production of scaffolds with cells, materials, and molecules. The aim of this research has been to study the composition of bioinks of alginate hydrogels and to compare production by manual deposition or bioprinting. Viability of keratinocytes (HaCat) and stem cells, by the 3–(4,5–dimethylthiazol–2–yl)– 2,5–diphenyltetrazolium bromide test (MTT) were tested to formulate the bioink. The solvents, water, sodium chloride (NaCl) or phosphate–buffered saline (PBS) and the concentration of alginate were compared. The bioprinter OctuplusTM (3DBS – 3D Biotechnology Solutions) was used. The results of manual deposition did not demonstrate statistical difference when the stem cells were cultivated in 2.5% of alginate with the different solvents ($p=0.55$), showing mean absorbance ± standard error of the mean (SEM) of 0.13±0.01 when PBS was used, 0.14±0.01 using water and 0.14±0.01 with NaCl, after six days. The mean absorbance ± SEM at HaCat cultivated in 3% alginate was 0.53±0.01 (control), 0.53±0.02 (NaCl), 0.58±0.04 (PBS) and 0.63±0.03 in water, showing an increasing non–statistically tendency with the use of water as a solvent ($p=0.07$). The presence of 0, 2.5 and 3% alginate in stem cell viability was evaluated and the mean absorbance was respectively 0.09±0.01, 0.14±0.01 ($p<0.01$) and 0.18±0.01 ($p<0.01$), showing that the higher concentration of alginate increases cell viability ($p=0.027$). The chosen bioink used in the comparison of manual deposition and bioprinting was composed of 3% alginate in water. The MTT results show that mean absorbance after 1 and 20–days was, 0.16±0.02 and 0.23±0,01 ($p=0.0071$), respectively when the bioprinter was used, showing cell proliferation and 0.29±0.02 and 0.19±0,00 ($p=0.0018$) when manual alginate deposition with a syringe was used, showing a decrease in cell viability. The highest cell viability obtained with manual deposition on day one ($p=0.0001$) can be related to the viability decrease caused by the higher resistance of the needle walls in the bioprinter. After twenty days, the greater viability in the bioprinted scaffolds ($p=0.0134$) can be justified by the better homogeneity and integrity of this biomaterial. Due to the fragile mechanical properties of alginate, the association of the bioprinted alginate hydrogel with 3D printed scaffolds and/or electrospun nanofibers can be a promising strategy for hard tissue regeneration.

Keywords: Alginate; Biomaterial; Stem Cells; Keratinocytes.

* Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil.



Production and testing of 3D o-rings for tissue engineering

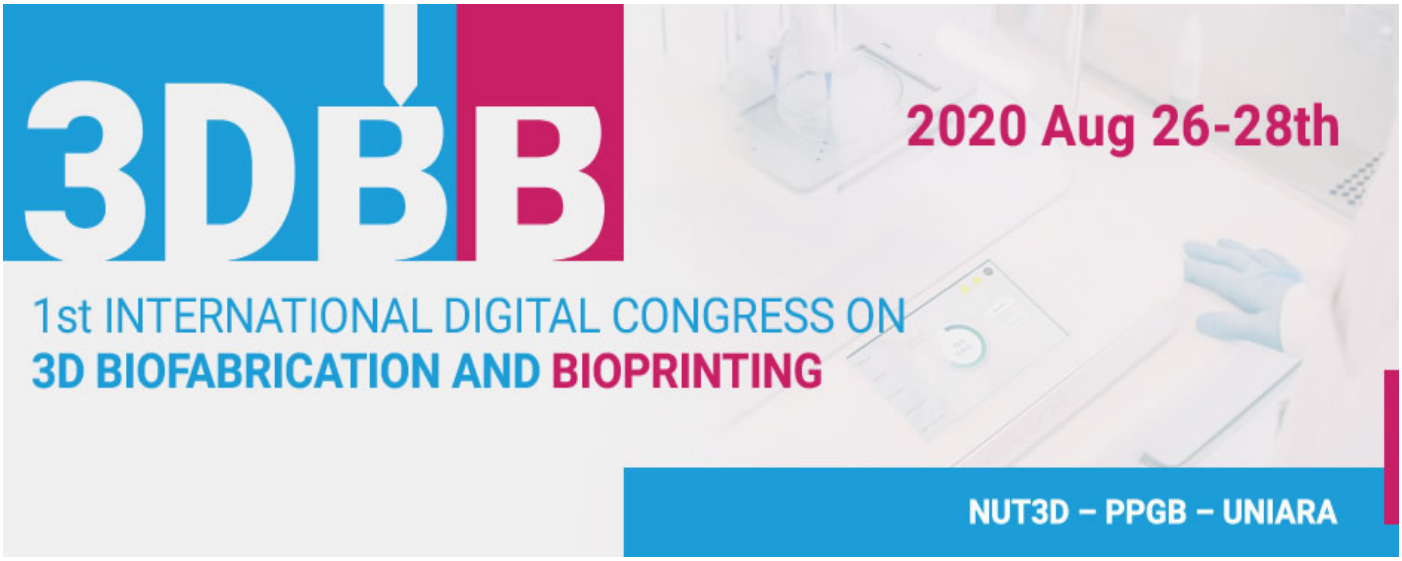
Bruna Govoni; Natasha Maurmann**; João Alvarez Peixoto*; Patricia Pranke***

(Cell cultures)

Abstract: Tissue engineering uses biomaterials as well as cells and growth factors for tissue regeneration. In order for scaffolds to remain at the bottom of the culture wells and in contact with the cells, O-rings are used. Polylactic acid (PLA), a synthetic, biocompatible polymer, can be used in additive manufacturing. The aim of this research has been to produce PLA O-rings using the three-dimensional (3D) printing technique and to test them. The O-rings were printed on the printer 3DCloner, printing volume of 150 mm x 150 mm x 150 mm, melting temperature up to 220°C, and fused filament with a diameter of 0.2 mm, generating layers in this thickness. The modeling was performed by the FreeCAD software. Each O-ring was printed with an external diameter of 15.2 mm and an internal diameter of 12 mm, height of 3 mm, and manually sanded. The materials were sterilized by autoclave or glutaraldehyde. The keratinocytes (cell line HaCat) were seeded in a density of 10,000 per well in 24-well tissue culture plates. After 6 days, the cell viability test was performed by the reduction assay 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT). As a result, the O-rings printed in additive manufacturing presented smooth and uniform surfaces. Most of the O-rings fitted into the wells of the culture plates; however, some were tight and others were loose. In the cytotoxicity test, no statistically significant difference was found between the control wells and the wells with the printed and autoclaved O-ring, indicating that the viability of the cells in the wells with this material was similar to the wells without materials ($p = 0.1469$). The values of the normalized results in relation to the mean ± standard deviation (SD) control were 100 ± 15 for the control and 88 ± 9 for the O-ring. Regarding the comparison of the sterilization method, the use of glutaraldehyde decreased cell viability in relation to the control ($p < 0.0001$), with a mean absorbance ± SD of 0.04 ± 0.01 while the autoclaved material was 0.65 ± 0.07. It can be concluded that the PLA O-ring obtained by additive manufacturing was not cytotoxic. In order for the O-rings to be more effective, the flexible PLA will be tested. Regarding the sterilization method, although glutaraldehyde is used, residues may have remained even with two washes; however, the autoclave did not cause toxicity to the cells.

Keywords: Polylactic acid; Cytotoxicity; Keratinocytes; Additive manufacturing.

* Universidade Estadual do Rio Grande do Sul (UERGS)
** Universidade Federal do Rio Grande do Sul (UFRGS)



Production of decellularized rat skin as a subtitute for skin lesions treatment

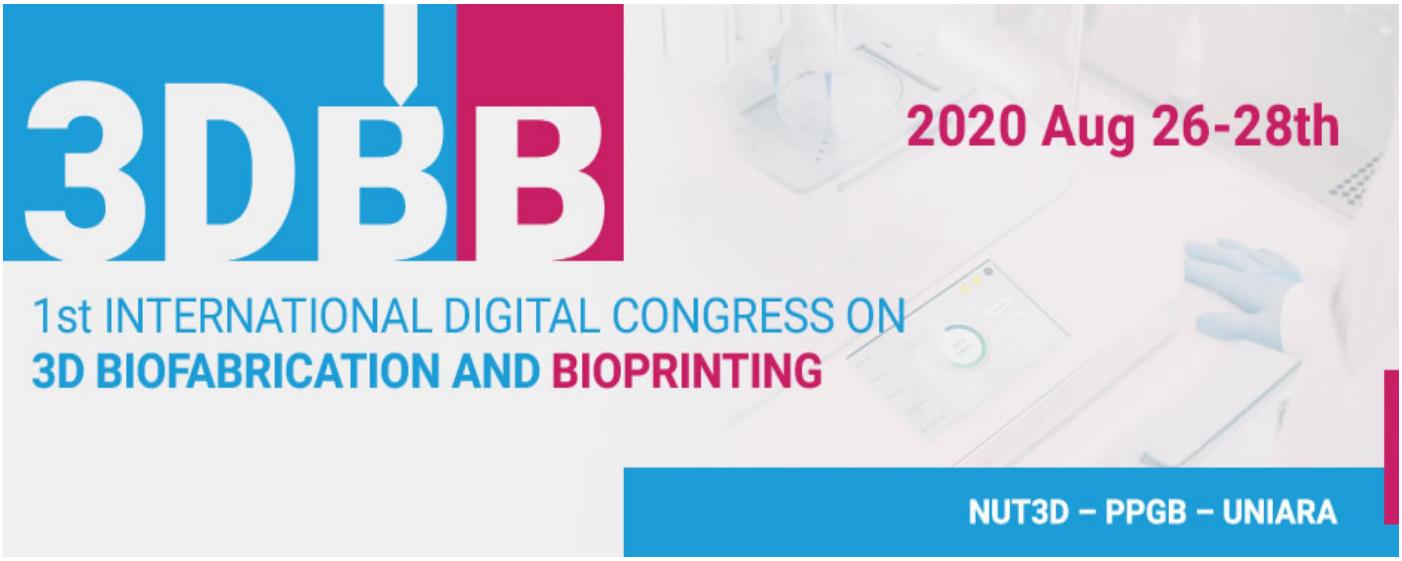
Gabriele Gulielmin Didó; Marcelo G. Dos Santos*; Fernanda S. França*; Laura–Elena Sperling**; Patricia Helena Lucas Pranke****

(Biomaterials)

Abstract: One of the main bioengineering goals is the production of biomaterials able to replace damaged tissues while promoting the natural repair process. The number of Brazilians that need a skin transplant has been constantly increasing over the last 10 years. Many dermal substitutes are available nowadays, and they are mostly acellular. Considering the high price of dermal substitutes available on the market, new alternatives must be sought to lower costs. Decellularized skin presents a great potential as a skin substitute. In this study, the aim has been to develop a protocol for decellularization of murine skin and analyze its structure to produce a dermal substitute. Materials and Methods: Discarded rat skin (CEUA 32510) was decellularized by incubation in a series of hypertonic solutions, using Triton X–100 and trypsin under continuous agitation. To establish the protocol, three different incubation times were tested during a five day, eight and a half day and twelve day period. The genomic DNA was quantified and compared to control the skin. In order to confirm the protocol efficacy, histological analyses were performed. The samples were sectioned on microtome in 5µm thickness and stained with DAPI and Masson's Trichrome. The microtomography was substituted by haematoxylin and eosin (HE) staining to realize macro and microgeometry analyses. Results: The protocol that presented better decellularization efficacy was made in 5 days. The DNA quantification analysis showed that the control skin presented a much higher DNA amount (111.8±7.02 mg gDNA/mg tissue) compared with the decellularized samples, which exhibited a low presence of DNA (3.026±1.06 mg gDNA/mg tissue). The histological sections stained with DAPI presented normal nuclear distribution of the control skin, but cell nuclei were not detected on the decellularized samples. The HE staining of the decellularized samples exhibited a conserved matrix structure, with the maintenance of the dermis extracellular matrix. The samples stained with Masson's Trichrome showed a structure consisting predominantly of collagen. Conclusion and perspectives: It was possible to establish an efficient decellularization protocol of the rat skin. This can serve as a matrix for developing a skin substitute. Future studies will be performed to test the de–cellularized tissue biocompatibility by the MTT test and cell adherence tests with ker

Keywords: Rat Skin Regeneration; Decellularization Curative.

* Universidade Federal do Rio Grande do Sul (UFRGS).
** Universidade Federal de Clências da Saúde Porto Alegre (UFCSPA).
*** Instituto de Pesquisa com Células–Tronco (IPCT).



How microfluidics and 3d printing can revolutionize pharmaceutical and medical research

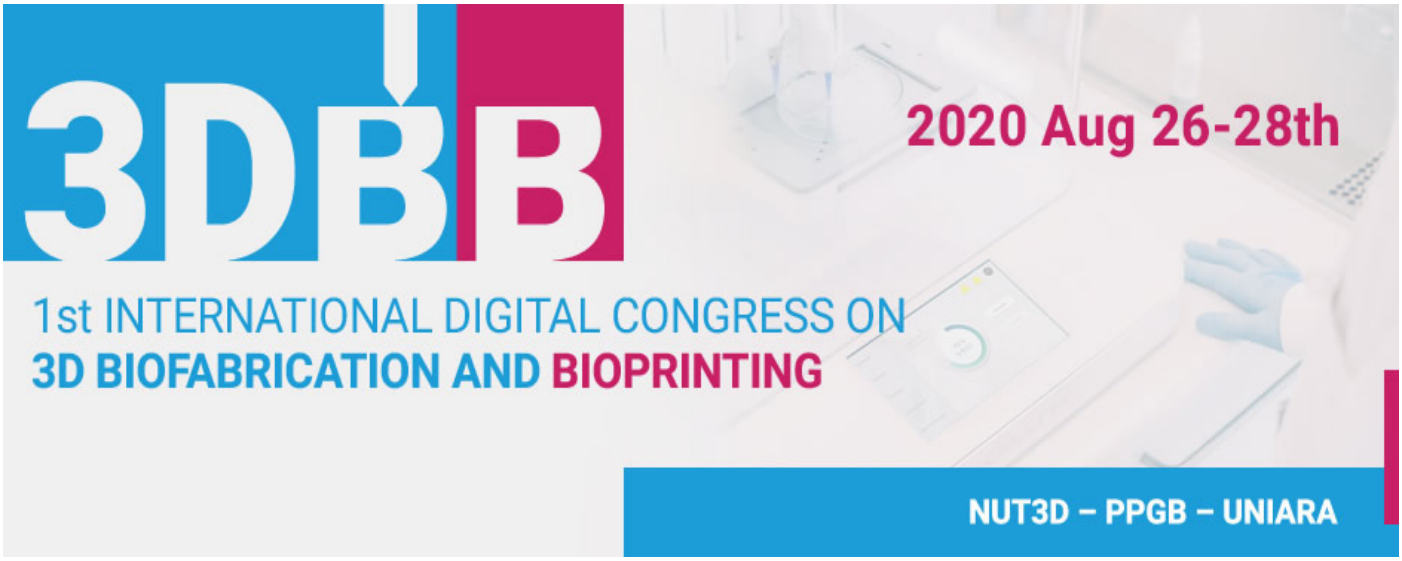
Harrson Silva Santana; Mauri S. A. Palma**; Mariana G. M. Lopes*; Giovanni A. S. Lima***; João L. Silva Jr.****; Osvaldir P. Taranto**

(Devices and processes)

Abstract: The pharmaceutical industry is one of the most important sectors in the industry, with research and development (R&D), innovation, manufacturing and marketing of medicines for human and animal health as objectives. In R&D and innovation processes, pharmacists, molecular biologists and other health professionals cooperate to obtain drugs with greater specificity and potential. The drug discovery and development process is accompanied by toxicological and clinical tests. The literature tells us that the total cost of screening drugs and developing safe and effective therapeutic assets can exceed 2 billion dollars. The development of new technologies is one of the weapons of the pharmaceutical industry to reduce costs in the development of medicines and to decrease the use of in vivo animal models. These technologies are being used in the synthesis of active pharmaceutical ingredients (API) and also in systems that mimic living tissues for toxicological and clinical tests. Among these new technologies, Microfluidics and Additive Manufacturing, also known as 3D printing, are enabling faster research and development in the pharmaceutical and medical fields, supporting new solutions for active pharmaceutical production and clinical testing without the need for in vivo animal models. In this presentation I will discuss two areas of work in our research group: API synthesis using microfluidic devices; 3D printing of microdevices combined with 3D bioprinting of solutions e.g., hydrogels, bioinks and catalysts. For the manufacture of these 3D printed microfluidic devices with solutions in their channels, we propose and build an automatic equipment consisting of a modified 3D printer with two independent systems, a module with a syringe for injection of solutions/hydrogels and a conventional head with a Fused Deposition Modeling mechanism. This automatic system allows the manufacture of microfluidic devices with channels filled with solutions in a single manufacturing step. We believe that Microfluidics and 3D Printing will expand the frontiers of pharmaceutical and medical research, as it will allow professionals from other areas to contribute to the development of the pharmaceutical industry, a fundamental sector for humanity.

Keywords: Microdevices; Medicine Drugs; Active Pharmaceutical Ingredients; Bioprinting; 3d Printing.

* School of Chemical Engineering, University of Campinas, Albert Einstein Av. 500, 13083–852 Campinas, SP, Brazil.
** Department of Biochemical and Pharmaceutical Technology, Sao Paulo University, 05508–000 Sao Paulo, Sao Paulo, Brazil.
*** Institute of Environmental, Chemical, and Pharmaceutical Sciences, Federal University of Sao Paulo, 09972–270 Diadema, Sao Paulo, Brazil
**** Federal University of ABC, CECS – Center for Engineering, Modeling and Applied Social Sciences, Alameda da Universidade, s/n., 09606–045 São Bernardo do Campo, SP, Brazil.



Production of nanoparticles with controlled release by the electrospraying method

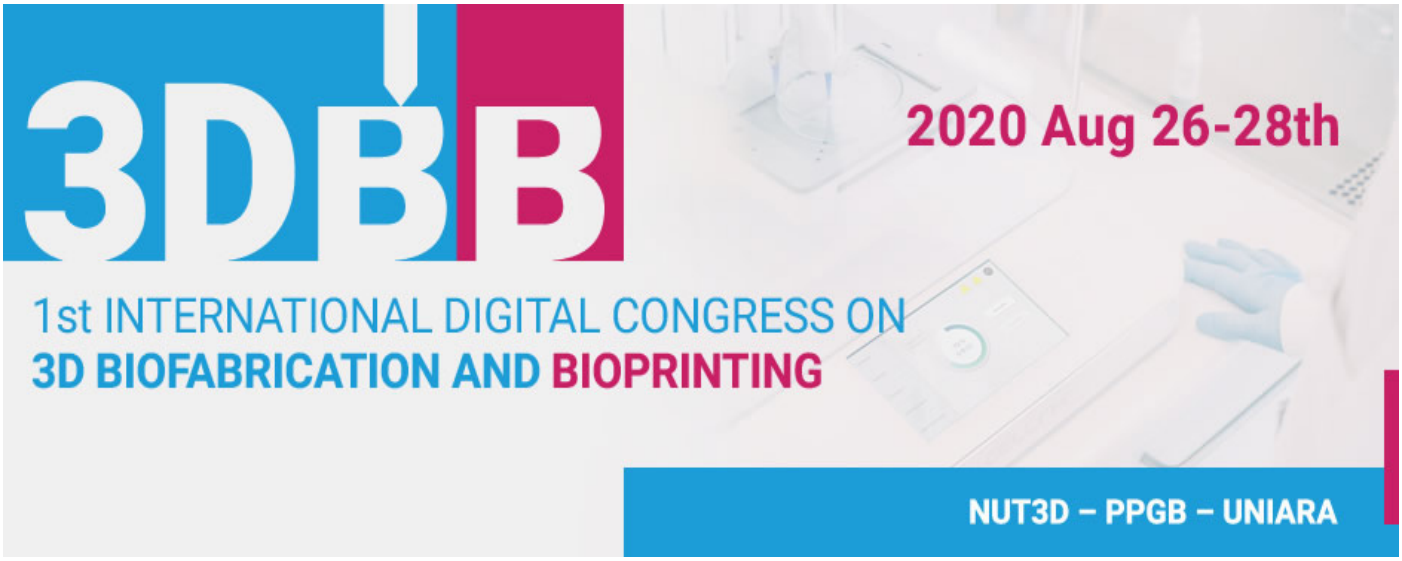
Luiz Carlos Sommer Ferreira; Laura Elena Sperling**; Patricia Helena Lucas Pranke****

(Devices and processes)

Abstract: The number of nanotechnology studies has increased substantially during the last decades and are playing a major role in the pharma–ceutical industry. Nanoparticles represent an important formulation for controlled drug release. Electrospraying technology represents a relatively simple method for producing nanoparticles. This study has aimed to establish an electrospraying protocol to produce poly (lactic acid–co–glycolic acid) (PLGA) particles with a neuroprotective compound called drug X (in the process of registering for intellectual protection), for future application of these particles in a rat model of spinal cord injury. Particles of 2 different concentrations of PLGA 50/50 (2% and 4%) and two different solvents acetonitrile (ACT) and hexafluor (HXF) were produced. Nanoparticles were produced in a device with a built–in controlled environment to helps to evaporate HXF ou ACT. To reduce the likely residual presence of solvents, after production the particles standing on the samples desiccator. Drug X was added at 1% to the PLGA 4% solution in both solvents. The particles were electrosprayed using a flow rate of 0.1 to 0.5 ml/h and voltage ranging from 23 to 29 kV. The particle morphology was analyzed by scanning electron microscopy (SEM). The particle size and zeta potential were analyzed through dynamic light scattering. Particles of PLGA alone were first tested at different concentrations and different solvents. SEM morphological analysis showed that 2% PLGA presented morphological irregularity in both ACT and HXF, whereas PLGA 4% showed greater morphological stability in both ACT and HXF. Hence, PLGA 4% was considered to be the better suited concentration for the production of microparticles. The addition of drug X to the 4% PLGA particles in ACT led to the occasional presence of fibers and irregular morphology. However, in HXF, the addition of drug X did not alter the morphology significantly. Therefore, the optimal formulation of drug X particles was 4% PLGA in HXF. The average diameter of 4% PLGA and 4% PLGA with drug X particles was 428.27 ± 77.90 nm and 842.1 ± 59.66 nm, respectively. The zeta potential was −15.33 ± 3.4 for the PLGA 4% particles and −16.27 ± 1.56 for the particles with drug X. With this study, it was possible to standardize the production of PLGA microparticles with and without drug X by electrospraying, as well as to physically characterize the particles. The optimal formulation was found to be PLGA 4% and 1% drug X in HXF.

Keywords: Electrospraying; Nanotechnology; Pharmacological Developing.

* Universidade Federal do Rio Grande do Sul (UFRGS).
** Universidade Federal de Clências da Saúde Porto Alegre (UFCSPA).
*** Instituto de Pesquisa com Células–Tronco (IPCT).



Development of a nanostructured drug for the treatment of spinal cord injury

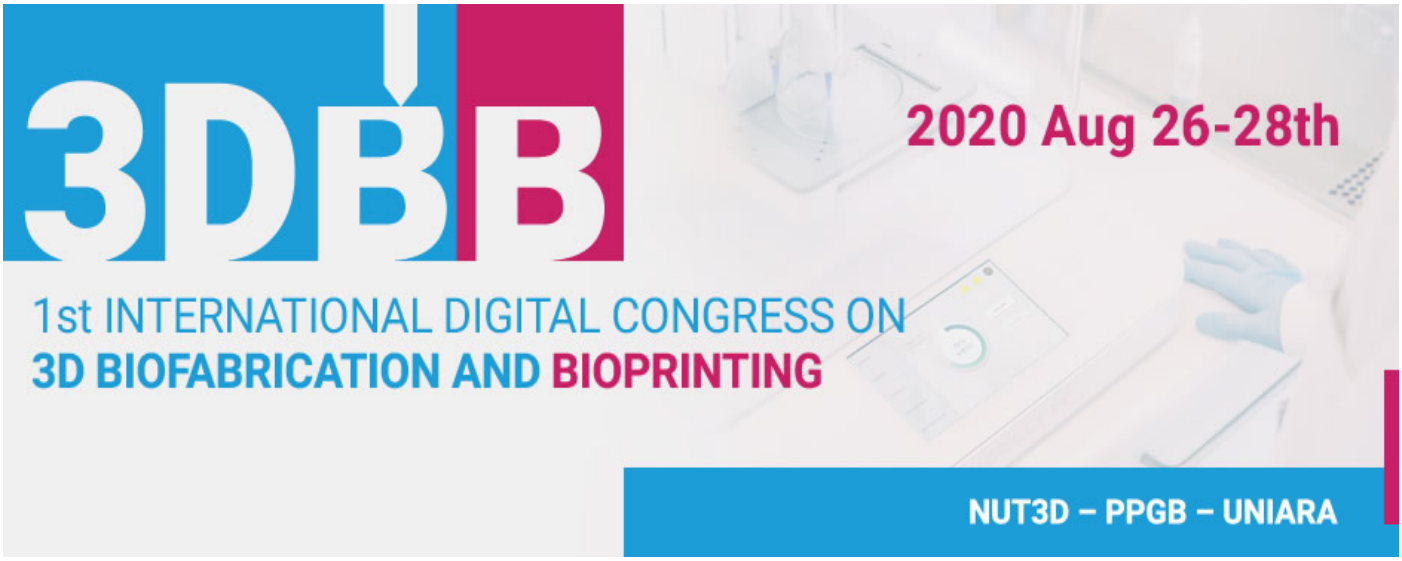
Rafaela Zimmermann; Daikelly Iglesias Braghirolli**; Patricia Pranke****

(Biomaterials)

Abstract: Spinal cord injury (SCI) is a serious condition that leads to a sudden loss of motor, autonomic and sensory function. Tissue injury associated with SCI is determined by a cascade of pathophysiological events that impair neural regeneration and restoration of motor function. Therefore, it is extremely important to develop new therapeutic strategies in this area that prevent the increase of severity of the tissue damage. Nanocapsules (NCs) are a promising drug delivery system that are being used in regenerative medicine. NCs can increase the bioavailability and concentration of the encapsuled drug in a determined target. Therefore, the use of NCs can be interesting in the treatment of spinal cord injury. In this work, a variety of systems have been developed with the aim of encapsulating a drug which has been researched (named "X") for the treatment of SCI and comparing it in terms of diameter, polydispersity index (PdI) and zeta potential. Methodology:All the NCs were prepared using the technique of interfacial polymer deposition, where the emulsions are formed by deposition of an oil phase (OP) on an aqueous phase (AP). Following this, all the NC emulsions were concentrated under reduced pressure. The polymer poly (lactic–co–glycolic acid) (PLGA) was used because it is biodegradable and biocompatible. Group I was composed of PLGA, castor oil and acetone in OP and distilled water, Triton X100 and drug X in AP. Group II was formed of PLGA, sorbitan monoesterate, TCM and acetone in OP and distilled water, polysorbate 80 and drug X in AP. Group III was formed of PLGA, copaiba oil and acetone in OP and distilled water, Triton X100 and drug X in AP. Group IV was composed of PLGA, açaí oil and acetone in OP and distilled water, Triton X100 and drug X in AP. The characterization of the NCs was conduced in ZetaSizer equipment. Results: The NCs of group I exhibited an average diameter of 138 nm, PdI of 0.450 and zeta potential of –27.7 mv. Group II presented the average values: diameter of 214 nm, PdI of 0.343 and zeta potential of –24.5 mv. The NCs of group III exhibited average values: diameter of 584 nm, PdI of 0.618 and potential zeta of –6.35 mv. Group IV presented the average values: diameter of 602 nm, PdI of 0.547 and zeta potential of –3.37 mv. Conclusions: These results reveal that the nanocapsules of groups I and II have a more suitable size and polydispersion in relation to groups III and IV, and also present values of zeta potential that reveal that the charges present on the surface of the nanocapsules prevent coalescence between them, thereby avoiding agglutination, which attests to their stability. The next phase will be the evaluation of the efficiency of encapsulation.

Keywords: Spinal Cord Injury; Nanocapsules, Poly (Lactic–Co–Glycolic Acid).

* Hematology and Stem Cell Laboratory, Faculty of Pharmacy, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil.
** Post–Graduate Program in Physiology, UFRGS.
*** Stem Cell Research Institute, Porto Alegre, RS, Brazil.



Methodology for developing assistive technology devices from medical images

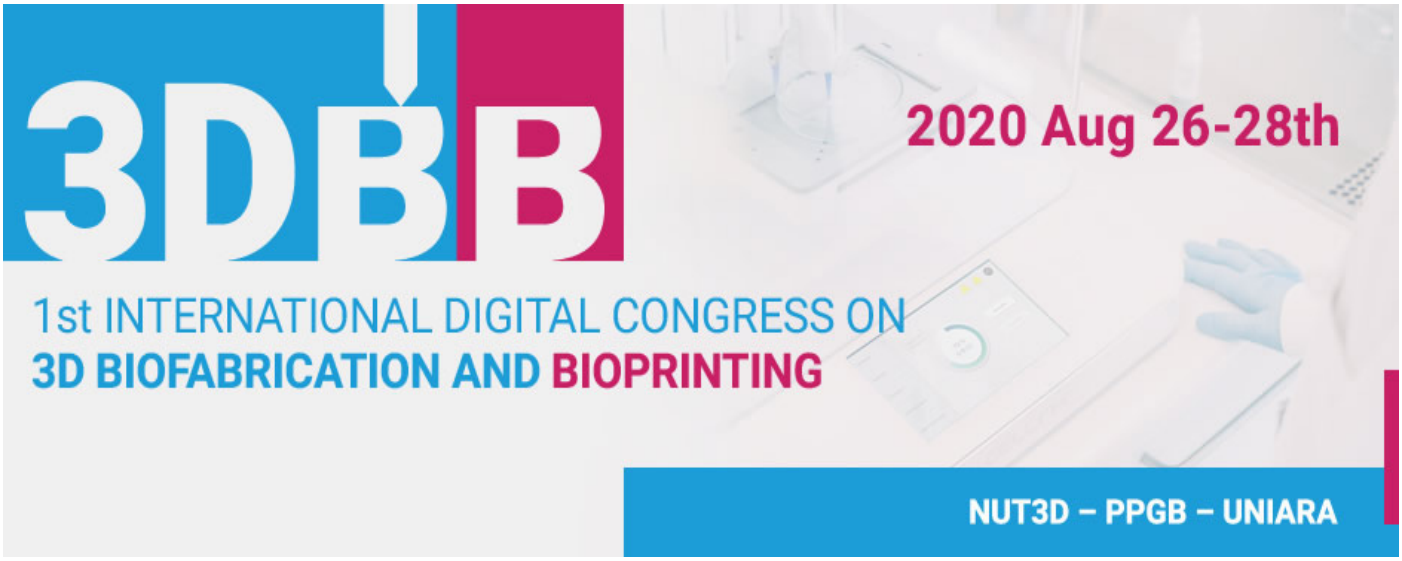
Lucas Vinícius Araújo Sales ; Ketinlly Yasmyne Nascimento Martins**; Rodolfo Ramos Castelo Branco**; Isabella D. Gallardo**; Carlos Alberto M. Dos Santos** ; Anna Kellssya L. Filgueira**; Júlia M. R. Da Costa***

(Devices and processes)

Abstract: The search for precision in the modeling of Assistive Technology (AT) devices, especially orthoses, has made technological strategies that integrate the areas of medical sciences and engineering indispensable. In this scenario, three–dimensional technologies have stood out for being able to generate a customized manufacturing process. The potential advancement in medical image acquisition equipment, mainly Computed Tomography (CT), in turn, allowed the expansion of this panorama even more, enabling, together with CAD systems (computer aided design), the development and modeling of devices manufactured based on medical exams. Therefore, this study aims to present a methodology for developing AT devices from medical images. Methodology: From medical image exams in DICOM format, preferably from CT, the treatment is performed in the InVesalius software, aiming to remove possible noise generated by artifacts during the exam, as well as analysis and choice of anatomical regions of interest. Soon after, the images are exported in STL format in mesh manipulation software, Autodesk Meshmixer, in which it is possible to perform orthosis device modeling using specific tools for mesh editing and finalization of the digital model. After that, is possible manufacturing by Additive Manufacturing and subsequent testing of the AT device on individuals. Results and Conclusion: The association of medical images with the development of AT devices using three–dimensional technologies, allows the acquisition of an equally accurate model, or even superior, to conventional processes. It is also possible to provide repeatability of this methodology, as well as offering a simplified process with open access software. This association may have advantages for the development of these devices, especially in individuals with conditions that make contact with third parties unfeasible or difficult. However, care should be taken to perform CT scans exclusively for obtaining orthoses, due to the exposure to radiation involved, and it is ideal and feasible that this methodology should be used after taking images that initially aim at the diagnosis of the patient.

Keywords: Assistive Technology; Orthoses; Additive Manufacturing; Medical Images; Computed Tomography.

* Universidade Federal de Campina Grande – UFCG, Campina Grande, PB, Brasil.
** NUTES – Universidade Estadual da Paraíba – UEPB, Campina Grande, PB, Brasil.



Digital twin model for the fabrication of porous scaffolds using masked stereolithography

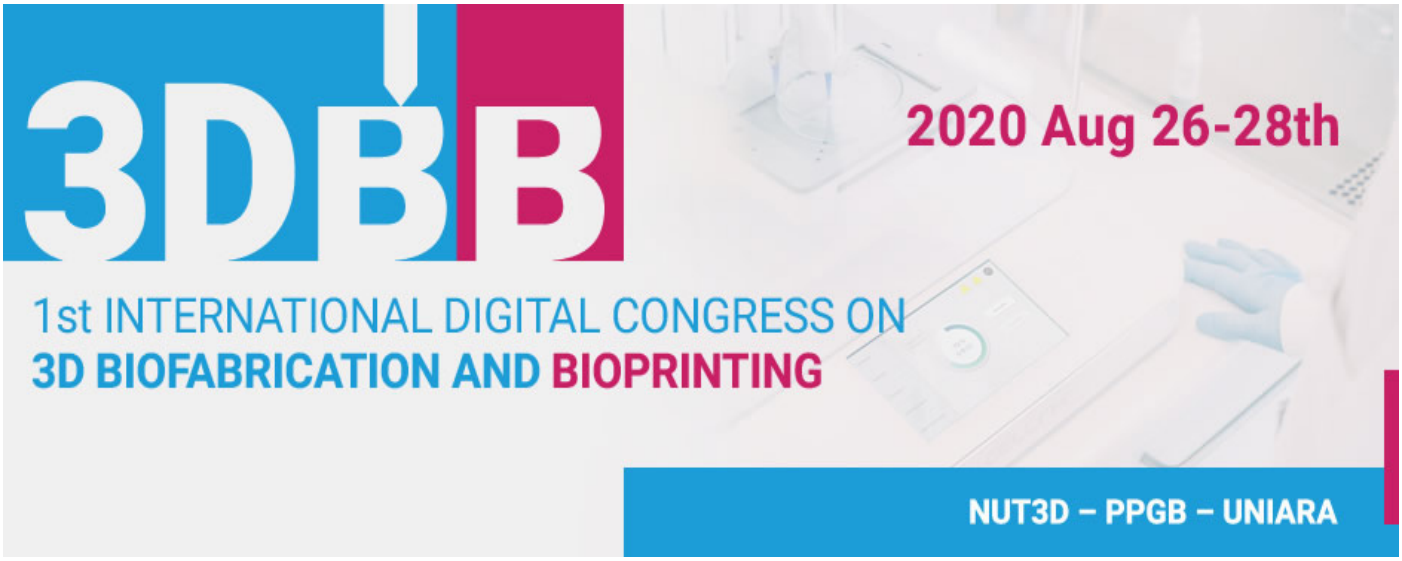
Ivannova Michelle Jumbo Jaramillo; Karolina Estefanía Serpa Andrade*; Stefany Alejandra Pusda Quiroz**

(Digital / Information Technology)

Abstract: Accurate process models is a fundamental keystone as additive manufacturing technologies are being generated and deployed. Validated models reduce the need for real–world testing of materials and processes and give bioproduct designers a predictive capability for optimizing part designs. Objective: This study evaluates a digital twin model in order to define conceptual guidelines to support the implementation of process modeling for the fabrication of porous scaffolds using masked stereolithography (M–SLA). Methods: The proposed digital twin model includes physics–based approach (fundamental M–SLA process equations), geometrical approach (triply periodic minimal surface equations) and statistical approaches (statistical process control), all of them embedded in a virtual platform in order to predict the material properties and process behavior during the manufacturing of porous structures which will be used as scaffolds in tissue engineering. Results: Preliminary results show that it is possible to optimize the design of porous structures (porosity, pore size, strut size, and orientation during fabrication) and process parameters (light intensity and pull–up velocity) to maintain the accuracy and reliability of the M–SLA process. Conclusions: A comprehensive digital twin of M–SLA process can improve porous scaffolds´ product quality, through the reduction of variation in product properties, and faster product development time. Functional implications of the proposed digital twin model regard the possibility to reduce the number of trial and error tests to obtain desired porous structures attributes and reduce the time required for scaffold qualification in tissue engineering.

Keywords: Digital Twin; Stereolithography; Digital Manufacturing; Process Modeling.

* Universidad de las Fuerzas Armadas ESPE, Ecuador



Development and evaluation of natural biomaterial made of chitosan for use as a bioink

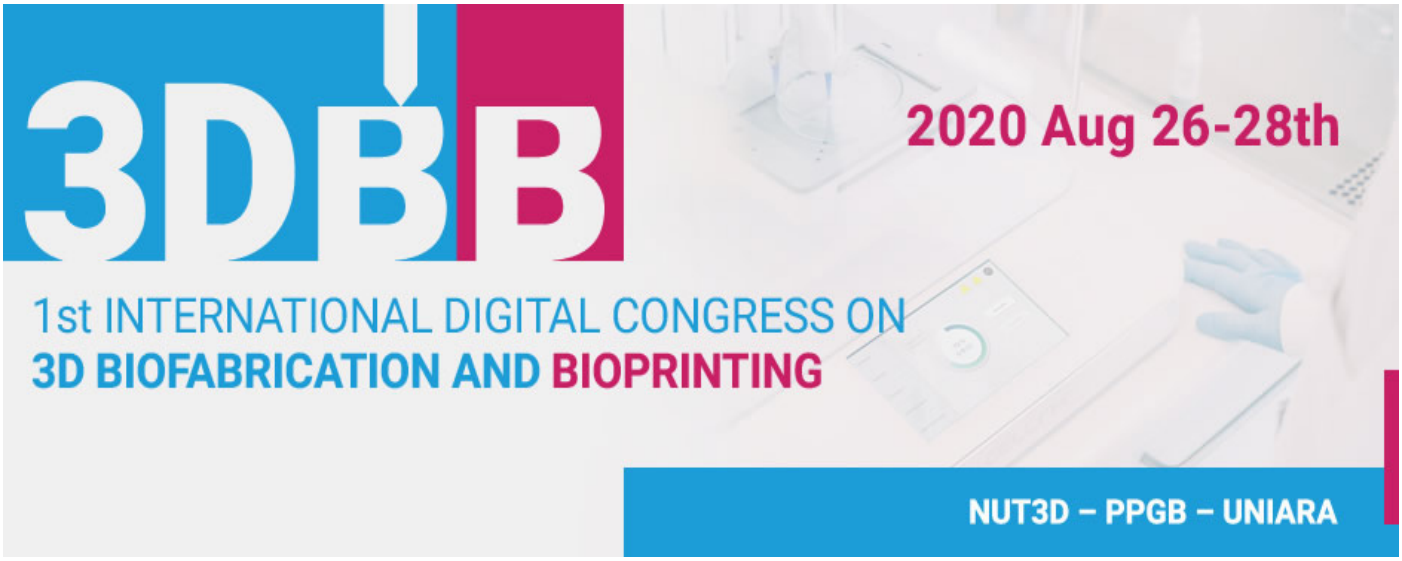
Rafaela Hartmann Kasper; Gabriela Machado*; Natasha Maurmann**; Caren Bavaresco*; Patrícia Pranke**; Luciano Pighinelli ****

(Biomaterials)

Abstract: The use of natural polymers in the production of structures used to stimulate cell development and tissue regeneration is proving to be a promising strategy in biofabrication. Chitin is an abundant polysaccharide in nature and chitosan is obtained by the process of deacetylation of chitin. Methodology: In this study, chitosan was dissolved, filtered and crowded. Following this, Buriti oil and fish scales were added to the chitosan. Chitosan and chitosan associated with the Buriti oil and Salmon fish scales were tested regarding their influence on the viability of human keratinocyte cells. The cells from the immortalized keratinocyte line (HaCaT) were seeded at a density of 5,000 cells per well, directly in 96–well tissue culture plates (TCPs). After 24 hours, the cells were treated with culture medium (control), 0.13% of chitosan; 0.13% of chitosan conjugated with salmon fish scales, or 0.30% of chitosan conjugated with Buriti oil. Cell viability was tested based on 3–(4,5–dimethylthiazol–2–yl)–2,5–diphenyltetrazolium bromide assay (MTT) after four days of cultivation. Results: The results of mitochondrial activity in relation to cell viability showed statistical significance between the cells cultivated in the well plate (control group) and chitosan tested alone. The mean and standard deviation values obtained from the results related to control of the cell viability (%) of the treated groups compared to the TCPs (used as a control group) were 100.0 ± 10.1% and the chitosan only was 87.6 ± 9.7% ($p<0.01$). In contrast, the cultivation of both types of conjugated chitosan were higher than the chitosan alone and similar to the control. The value obtained for chitosan conjugated with Buriti oil was 100.3 ± 6.8% (ns) and 95.9 ± 15.2% (ns) with the fish scales. Conclusion: It is possible to affirm that the association of chitosan with Buriti oil and Salmon scales was beneficial for the viability of the cultivated cells, being promising biomaterials for tissue regeneration. These associated biomaterials can be used as bioink in bioprinting studies as these materials presented biocompatibility.

Keywords: Biocompatible Materials; Tissue Engineering; Regenerative Medicine; Buriti oil; Fish scale.

* Universidade Luterana do Brasil.
** Universidade Federal do Rio Grande do Sul (UFRGS).
*** Biomater P&D Ind. de biomateriais LTDA.



Synthesis and characterization of polymeric hydrogel based on corn starch by click chemistry reaction (Diels Alder) for application in regenerative medicine

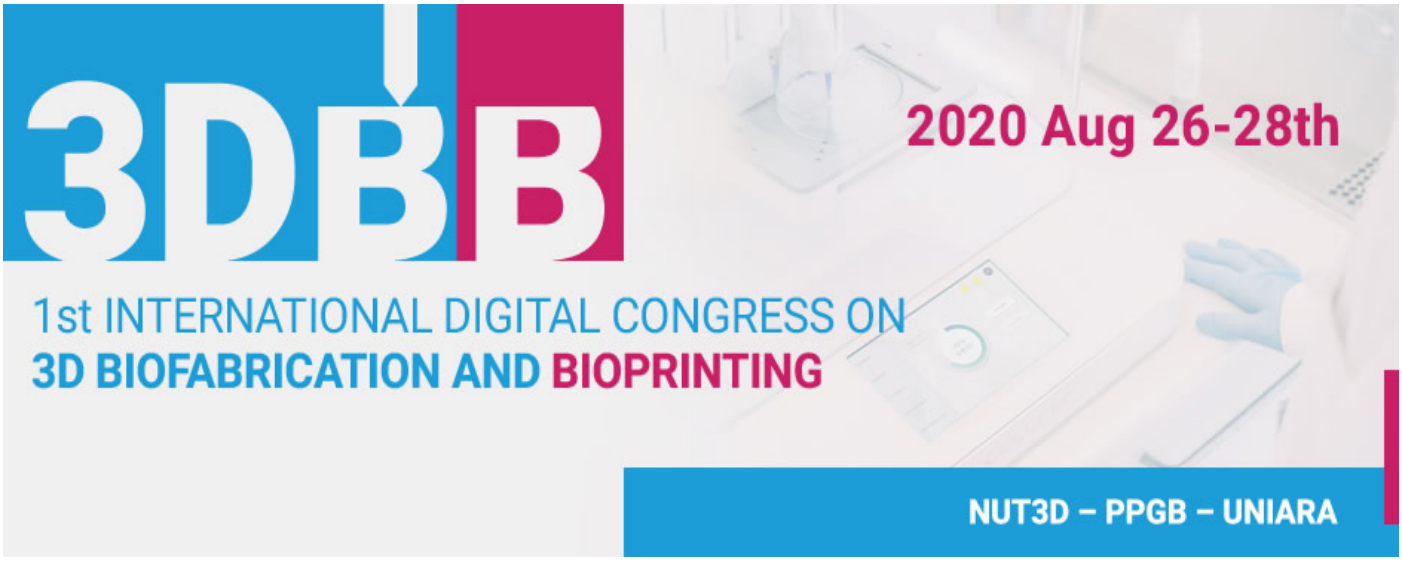
Bruna Fernandes Antunes; Alessandro Gandini**; Antônio J. F. Carvalho** Eliane Trovatti**

(Biomaterials)

Abstract: The search for new materials derived from biopolymers has received increasing attention due to its potential applicability in several sectors, including the health area. However, biopolymers still find little application in this area due to the limited mechanical properties and the rapid biodegradability under physiological conditions, which is the case of starch, for example. Starch is a polymer from a renewable natural source, of high availability, high biocompatibility and biodegradability in physiological medium and at low cost. The presence of hydroxyls in its structure allows its chemical modification, thus allowing the crosslinking of the polymeric chains. Thus, this project deals with the application of the click chemistry reaction of Diels Alder (DA) for the crosslinking of starch, in order to obtain a material with a longer biodegradation time in the physiological environment aiming at application in the health area. For this, modifications were made to the starch through gelling, oxidation, esterification and cross–linking, which were proven through Optical Microscopy (MO), Fourier Transform Infrared Electroscopy(FTIR), conducting titration and Proton Nuclear Magnetic Resonance(NMR–1H). Through the FTIR it was possible to observe that in the control starch sample, the peak 1600 cm–1 corresponding to the C=O group is in accordance with the characteristic; oxidized starch, on the other hand, shows an increase in this peak suggestive of an increase in COOH, and in the sample of esterified starch there is a decrease in it, and in addition, the peak appears in 885 cm–1 corresponding to furan rings, being suggestive of the replacement of COOH in furan. It was quantified that the substitution was 13%. Confirmed through the NMR–1H in which furan groups were visualized, in positions 7.4; 6.2 and 6.4 ppm corresponding to the H5, H4 and H3 protons of furan. In addition, the crosslinking of the material was successful after visual analysis of the increase in viscosity. Therefore, a new material with viscosity alteration properties has been synthesized and new studies can be carried out with a view to promising applications, mainly in the area of regenerative medicine.

Keywords: Modified starch; Biomaterial; Biopolymers; Tissue engineering.

* University of Araraquara (UNIARA).
** University of São Paulo (USP).



Standardization and automation of tumor spheroid production

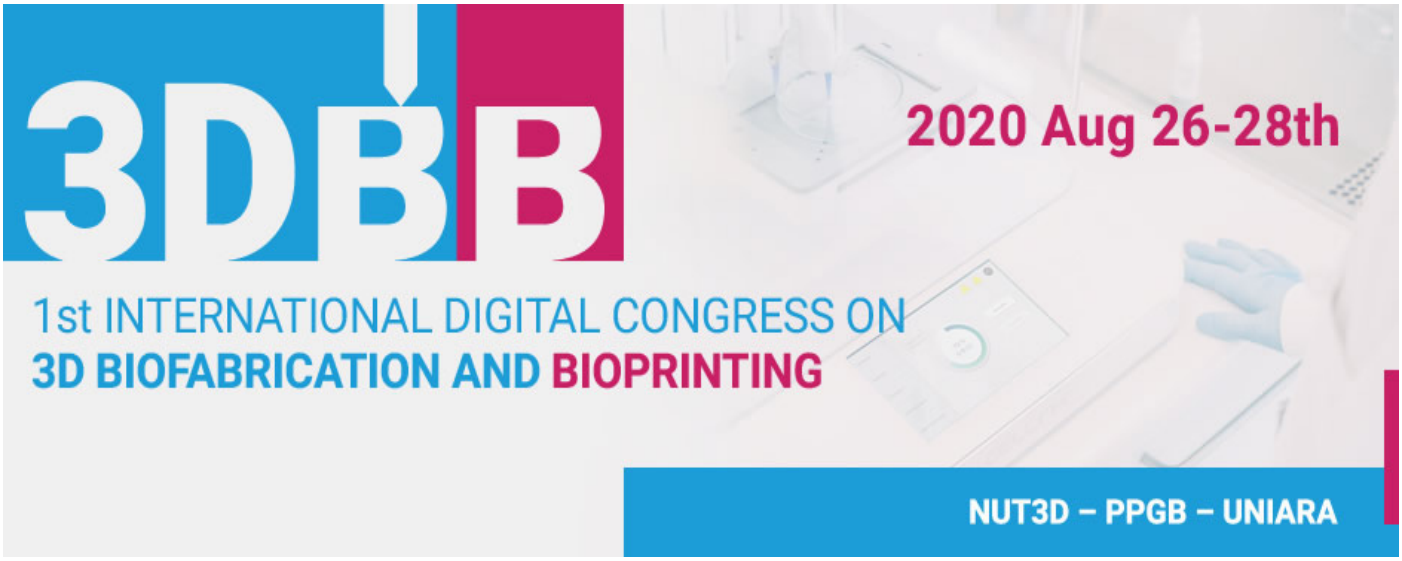
Guilherme de Almeida Miranda; Leonardo Boldrini*; Leandra Santos Baptista***

(Biofabrication and bioprinting (in general)

Abstract: Cancer is one of the most lethal diseases in the world, with high rate of morbidity and mortality in several countries. In Brazil, for example, studies show that probably more than five thousand cases will appear per year from 2020 (INCA). This increase in the number of cases may be due to the increase in life expectancy along with people´s eating habits and lifestyle. As a result, there is a need to develop new approaches that provide a better reproduction of the tumor microenvironment for carrying out studies that allow the discovery of new efficient treatments. In this context, spheroids are an excellent experimental model for the study of cancer due to their 3D organization combined with the possibility of long periods in culture and their ability to reproduce the extracellular medium with greater precision. In addition, the application of spheroids becomes an interesting strategy in this scenario, since they can be biofabricated automatically by robotization, which provides the standardization and dimension of this micro–tissue. Currently, many studies have used the production of spheroids from tumoral cell lineages for in vitro drug screening. However, these spheroids have high deformity and inefficiency in the reproducibility of their characteristics, even within the same experiment. The large–scale production of cellular spheroids in a reproducible way and with established safety standards is still something that needs advances in bioengineering and metrology. Due to this current problem, the standardization, reproduction and efficiency in the production of cellular spheroids on a large scale are of great importance for studies and their applications in cancer research. Thus, the aim of our study is to combine biological, physical and metrological parameters in a proposal for scaling and standardizing the production of multicellular tumor spheroids in an automated way. The evaluation of the mechanical properties of tumor spheroids can provide us with relevant information about the viability and structure of these spheroids, something that is still poorly explored. Besides, through quantitative and qualitative analyzes, we can evaluate the reproducibility and programming of the production method. The preliminary results obtained in this work demonstrate the potential of the automated spheroid production platform, making it possible to produce up to 3072 in a single process. It was also analyzed that different tumoral cell lineage present ideal parameters for production.Therefore, the proposed technology provides advantages of scaling, reproducibility and repeatability of the 3D culture using the micro–molded agarose hydrogel technique for the application of the manufactured spheroid as an alternative for the development of new treatments and in drug monitoring tests in cancer chemotherapy.

Keywords: Cancer; Spheroids; Production; Automation.

* Inmetro.
** UFRJ.



Development of an experimental analysis system for tissue bioprinting

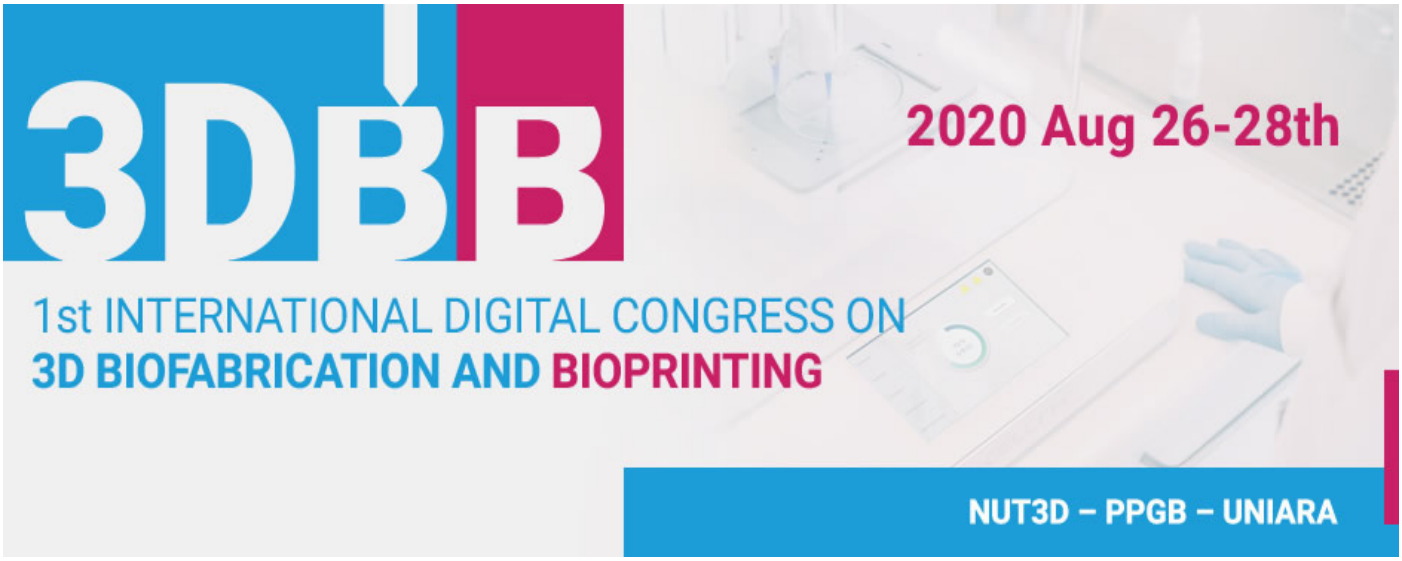
Solange Rodrigues De Oliveira; John Paul Hempel Lima**

(Biofabrication and bioprinting (in general)

Abstract: According to the Ministry of Health, in the year 2019 alone, only 33% of the family members of potential donors authorized the donation of organs, thus contributing to an increase in the demand for transplants already high in the country. Thinking about these issues and taking into account the durability and quality of transplanted organs today, medicine has been advancing in the technological field to make possible, in the near future, the production of personalized organs through a bioprinters. In this work the construction of an extruder–type bioprinter was carried out from a 3D printer model Ender from PCyes. As this is an experimental analysis, a microscope was attached to the bioprinting head in order to capture images during the entire printing process of the Bioink . The ImageJ software was also used for the analysis of these images in which it was effective in quantifying cells. The survey of effectiveness is an important step for research involving tissue production. Besides helping to eliminate possible noise at the time of manufacture, this technique can be used in the future to analyze parameters during bioprinting not observed without the aid of a microscope.The steps of the bioprinting process include a modeling that can be performed in specific software such as Autocad, Blender, Freecad (the same used in traditional 3D printing) then exported to other slicing software; this modeling can be of data images such as magnetic resonance imaging or CT scans sequentially choosing the material and type of cell grown. The bioprint by extrusion is the deposition of the Bioink that is propelled in filament form through a nozzle extruder layer by layer until forming a construct with good stabilization, at the moment of its bioprint , this material must have good rheology or good fluidity and after printed must remain stable. The filling patterns for bioprinting can be of the type, rectilinear, grid, hexagonal or concentric; respecting the characteristics of the filament such as diameter, spacing and uniformity; with an adequate topography the cells will be properly nourished, having among them communication, migration, proliferation and differentiation.

Keywords: Bioinks; Bioprinting; Tissue engineering; Organoids; Bioengineering.

* Departamento de Engenharia da Faculdade de Ciências Exatas e Tecnologia Pontifícia Universidade Católica de São Paulo (PUC–SP).



Functionalized nanotubular surfaces on TI–6AL–4V ELI alloy cellular structures made by additive manufacturing

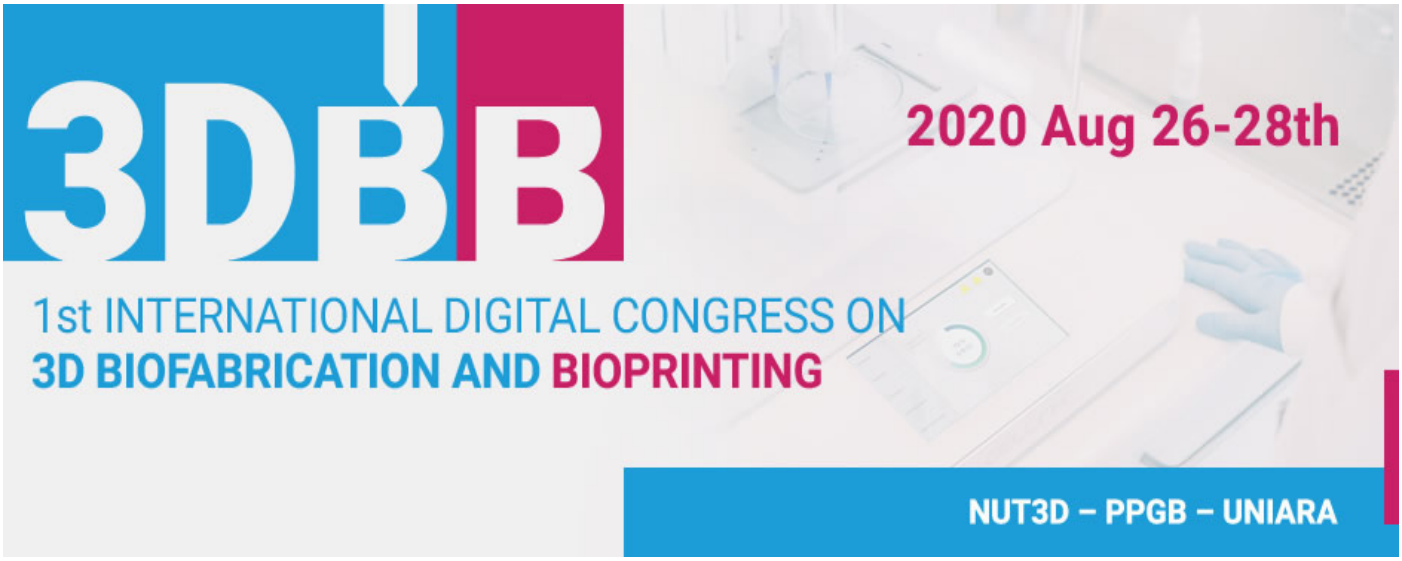
Guilherme Arthur Longhitano; André Luiz Jardini**; Rubens Maciel Filho***

(Biomaterials)

Abstract: The increase in life expectancy and the constant demand for better quality of life make the development of new materials and techniques a constant requirement. Customized implants, functionalized surfaces and biological mimetic morphologies are some current trends in medicine. In orthopedics, an implant must present biocompatibility, low stiffness and high mechanical and corrosion resistance. Additive manufacturing (AM) made it possible to produce Ti–6Al–4V ELI alloy customized implants with complex geometries, such as porous cellular structures. These structures provide better conformity of bone and implant stiffness, bypassing the bone resorption (stress shielding) process and promoting faster and longer lasting adaptation. The Ti–6Al–4V alloy may also have its surface modified by the anodizing technique. As a result, functionalizations by improving corrosion resistance, incorporation of beneficial ions and drug incorporation for in situ delivery become possible. The combination of these techniques results in reduced surgery risks, faster patient recovery, longer implant durability, better aesthetic and ergonomic results and, above all, improvement in patient´s quality of life. This work produced Ti–6Al–4V ELI alloy cellular structures by Direct Metal Laser Sintering (DMLS), a metal AM technique. The surfaces were functionalized by electrochemical anodization technique in a 1 M NH4H2PO4 and 0,3 M NH4F solution. Geometric, mechanical, and surface characterization techniques were used for analysis. Cellular structures with open porosity, which mimic bone tissue, were successfully obtained. The samples presented a 71.1% porosity with a stiffness of 2.39 ± 0.23 GPa. The surfaces presented a topography composed by nanopores and nanotubes. Fluorine ions were incorporated into the surfaces during the processes, obtaining concentrations of ~ 9.9 at%. The results suggest that the use of combined technologies for manufacturing customized and functionalized orthopedic implants can reduce infection risks and improve implants lifespan.

Keywords: Ti–6Al–4V; Additive Manufacturing; Functionalization; Nanotubes; Cellular Structures.

* Renato Archer Information Technology Center (CTI).
** School of Chemical Engineering, State University of Campinas.



Rheological evaluation of cellulose nanofibers\gelatin composite hydrogels potentially applicable to bioprinting

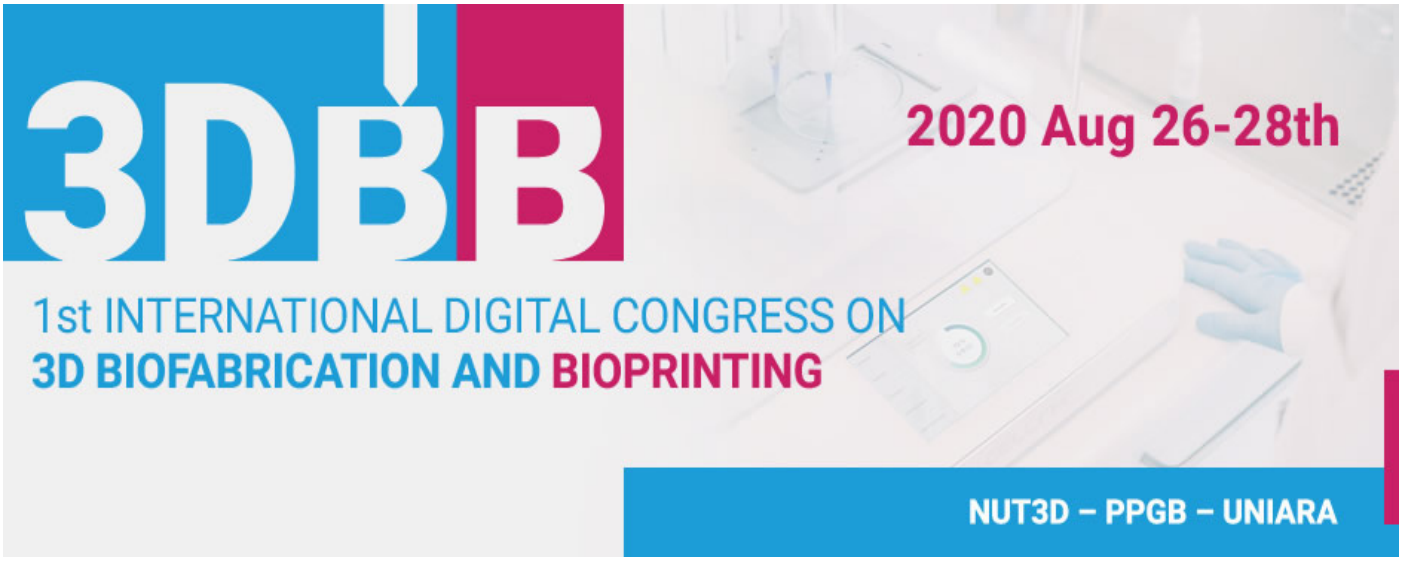
Lucas Noboru Fatori Trevizan; Hernane Da Silva Barud**

(Biomaterials)

Abstract: 3D bioprinting technology is directly related to the deposition of biomaterials, cells, biological structures and growth factors layer by layer. Studies currently carried out use hydrogels based on polymeric associations to obtain the bioinks. Hydrogels applied to bioprinting must satisfy requirements of both conventional and biological materials for optimized, functional applicability, and to reduce the rejection rates of the target organism. Generally, all of these hydrogel formulations use a viscous polymer solution for its printing. However, the properties related to this material are directly correlated with the printability, mechanics, degradation, functionalization, and must meet the biological requirements, as biocompatibility, cytocompatibility and bioactivity. One aspect of these properties is the ability to print and self–arrange three–dimensionally. Therefore, the rheology of its materials is an essential factor in determining a hydrogel applicability for bioprinting. Thus, the objective of the current work was to evaluate the rheological properties of hydrogels with different concentrations of cellulose nanofibers (PCNF) and gelatin (Gel), analyzing their viscosity property and their behavior using the rheometry. Thus, hydrogels with different concentrations in percentage of Gel/PCNF were prepared (100/0; 75/25; 50/50; 25/75; 0/100). Their rheological characterizations were performed at 25oC using a 40 mm diameter plate–plate geometry in a TA Instruments AR 1500ex Rheometer. The Ostwald–de Waele power law model was used to calculate the viscosity and the n index as a function of shear rate. In conclusion, the formulations showed that the increase of gelatin percentage affected directly the hydrogel viscosity. Furthermore, the characteristic of medium viscosity in comparison to the other formulations indicates that the formulation with 25%PCNF / 75%Gel can be considered promissory to be applied to 3D bioprinting.

Keywords: Hydrogel; Cellulose Nanofiber; Gelatin; Rheology.

* University of Araraquara (Uniara), Araraquara, SP, Brazil.



Biospeckle´s application: an analytical monitoring contribution to fungi inoculation first hours

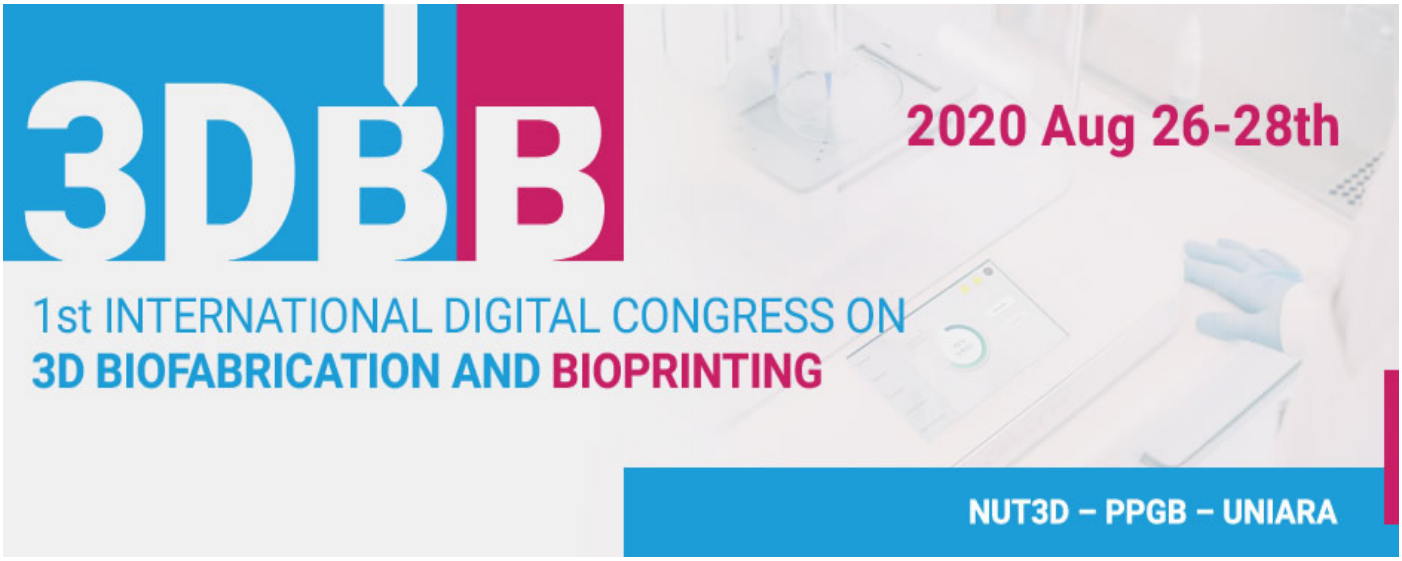
José Francisco Ferreira de Oliveira; Inacio Maria Dal Fabbro***

(Applications)

Abstract: Researches based on the application of Speckle, a technique based on the relationship of statistical interference originating at random, when the laser beam is applied to surfaces, has its appearance connected to the theory of light scattering, and this theory involves the process of interaction of light with matter. When the result of monitoring these analyzes of rough surfaces comes from one with biological activity, it is called Biospeckle. Our research proposal was to demonstrate the application of Biospeckle as a viable tool for monitoring and analyzing the possibility of biology activity in fungi on its first hours of inoculation. In order to demonstrate it, we used three indexes of biological activity analysis, namely: Moment of Inertia (IM), Differences of Absolute Values (AVD) and Speckle Space–Time (STS). By getting these indicators results, we obtained different fungi images in the first days of their incubation, evolving for the first hours, to measure the development of fungi in Petri dishes. When conducting the research, the used procedures were aiming to obtain results that could assist and help in the application of the Biospeckle in many stages of fungal incubation, but essentially on its first hours. The isolation of all filamentous fungi in their growth environment, used in this research work, was performed under aseptic conditions in the Vertical Laminar Flow Safety Chapel. It can be inferred that fungi inoculated in Petri dishes were radially developed in their early days. This process can be well observed by applying the randomly selected points distribution technique following a Gaussian distribution, which is a literature area analysis methodology, then it allows to present a new correction in the growth curve. Therefore, it is possible to follow the displacement of the nucleus of biological activity by varying the focus, applying the Gaussian distribution. All in vitro experimental research procedures were performed at the Mycology Laboratory of the Faculty of Food (FEA / UFLA) and at the Optics Laboratory (FEAGRI / UNICAMP). The fungi were provided by the library of the Collection of Culture of Microorganisms (CCDCA), located in the Laboratory of Mycology and Mycotoxins within the Department of Food Science at UFLA.. The developmental analysis showed to be quite fruitful, demonstrating that the laser Biospeckle technique revealed to be a good monitoring tool in the first hours of growth for both genus Aspergillus and Penicillium.

Keywords: Biospeckle; IM; STD; AVD; Fungos.

* Instituto Federal de São Paulo IFSP.
** Universidade Estadual de Campinas (Unicamp).



Films obtention from recovery of expanded polystyrene

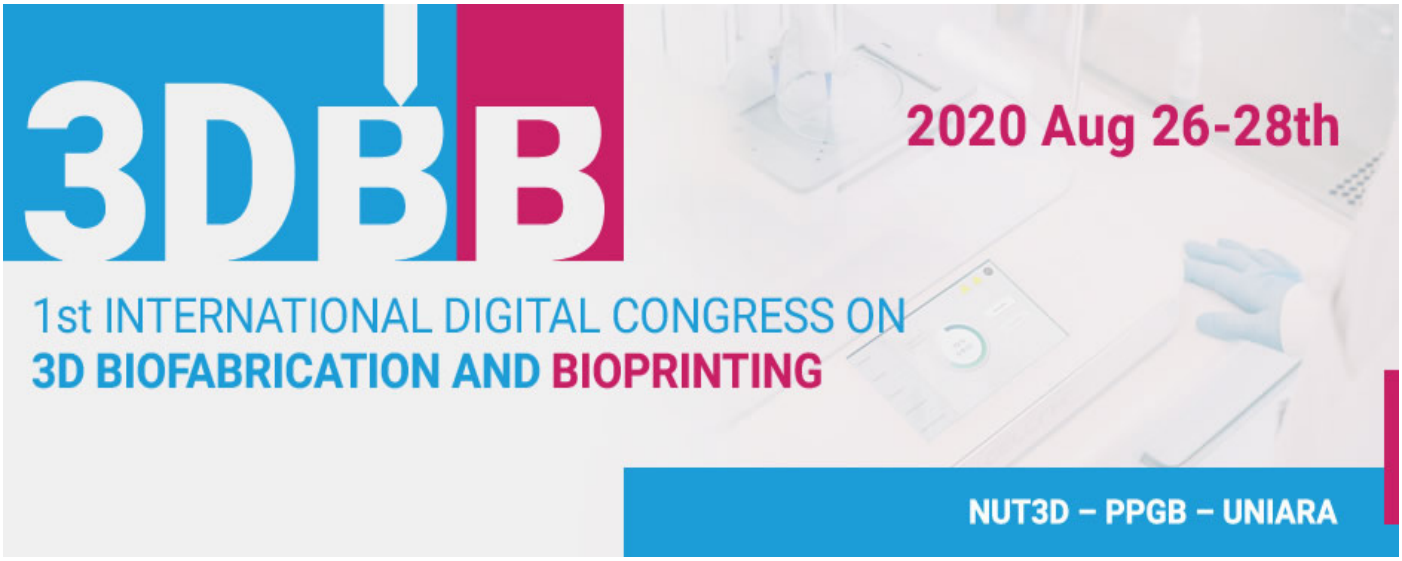
Ingrit Daniela Pardo Mendoza; Jeffrey León Pulido**

(Biomaterials)

Abstract: Expanded polystyrene (EPS) is a plastic obtained from the polymerization of styrene, and represent the fourth most used plastic along the world. EPS is used in industries such as construction, food packaging and transport of delicate materials among other applications Due to the fact that it is composed of more than 95% air. Within applications is a thermal–acoustic insulator, shock absorber and a light and durable filling material, since it is not hygroscopic, nor does it represent a substrate for microorganisms. However, have a slow degradation rate, this added to the fact that it is a single–use plastic and one of the least recycled due to its low density, it is generating significant problems for the environment since most of their waste ends up accumulating in landfills. This work presents a sustainable alternative for EPS recycling, using eucalyptus oil and limonene as natural solvents. Experimental practices were carried out where the dissolution potential was evaluated at different proportions of EPS (1:10, 1: 3, 1: 2, 3: 4, 1: 1, 1.25: 1 and 1.5: 1) in a controlled environment and the saturation point of each solvent was determined. Additionally, the influence of the temperature between 294 K and 323 K they were studied. A relation for overall composition was obtained that eucalyptus oil and limonene (1:1 and 1.5: 1 respectively) including variables such as weight and solvent properties. The result present on average both solvents can reduce the volume of waste by 96–97%. In addition, in this work was done with the obtained resins, adding ethanol in order to precipitate the polystyrene (PS), then the solvents were separated by vacuum filtration and rotary evaporator to be reincorporated in other process, the recovered PS was dried in an oven at 343 K to remove alcohol residues and obtain a polymer with high hardness if limonene is used and a polymer with characteristics of flexibility and elasticity using eucalyptus oil.

Keywords: Sustainable; dissolution y polystyrene.

* Chemical Engineering, Faculty of Engineering – EAN University, Bogotá, Colombia.



Fabrication of a biomaterial with gelatin, alginate and β–TCP for the treatment of fractures caused by osteoporosis

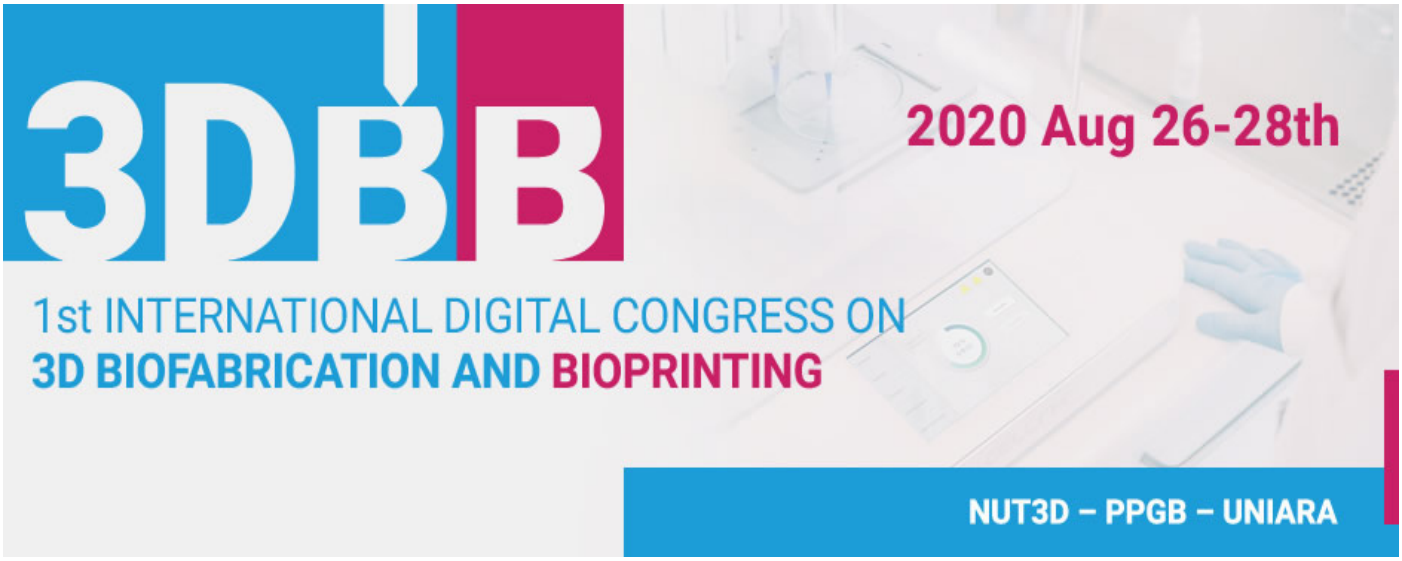
Thaís Pezza de Souza; Antonio Carlos Guastaldi*; Rodrigo Fernando Costa Marques***

(Biomaterials)

Abstract: Considering the increase of the life expectancy and the number of osteoporosis cases, the development of materials that can be used as support in bone fractures treatment decorring from this disease is necessary. With the progress in biomaterials area, there is the potential of using gelatin and alginate in their formulation, because they have good biocompatibility, low toxicity and can be used as drug delivery. It is known that β–TCP (beta tricalcium phosphate) has bioactivity and bone growth inducing properties and could compose the biomaterial formed of gelatin and alginate. Thus, the objective of this work is to obtain a biomaterial composed of gelatin, alginate and β–TCP to be used as a 3D printer ink aiming the treatment of fractures caused by osteoporosis. Methodology: β–TCP, tri–sodium citrate 2–hydrate (PA, Panreac), sodium alginate (PA, Exodo) and powdered gelatin (Synth) were dispersed in aqueous solution and then mixed in a magnetic stirring at temperature of 55°C degrees. The presence of sodium citrate ensure that agglomeration is not formed. Different concentrations were studied and the influence of each compound was evaluated by FTIR–ATR (Frontier Dual Range, PerkinElmer), DSC (2910, TA Instruments) and rheological test (rheomether AR 2000ex, TA Instruments). Results: FTIR spectra showed the bands of β–TCP (v4 PO4 – 750–500 cm–1; v3 PO4 – 1100–900 cm–1), gelatin and alginate chains (C–O carboxylic acid – 1400 cm–1; C=O carboxylic acid – 1700–1500 cm–1) and an increase of intensity after crosslinking was observed. By DSC analysis, it was observed that, when adding β–TCP and sodium citrate, the melting point temperature is shifted to lower temperatures, indicating an increase in the order of the material generated by the addition of β–TCP, that make it possible to increase the interaction between polymer chains. The rheological test showed that β–TCP increases the values of G' and G'' and that the elastic behavior is predominant, indicating that the addition of phosphate contributes to the material structure obtained, enabling an increase in the polymer chains interaction. Conclusion: The addition of β–TCP provides an increase in the mechanical properties of the material obtained and presents a viable alternative to compose the biomaterial that will be used as ink for 3D printing.

Keywords: Biomaterials; Osteoporosis; Gelatin; Alginate; β–TCP.

* Instituto de Química – UNESP Araraquara.



Development of films and filaments containing β –TCP and bacterial cellulose based on a polymeric matrix for 3D printing

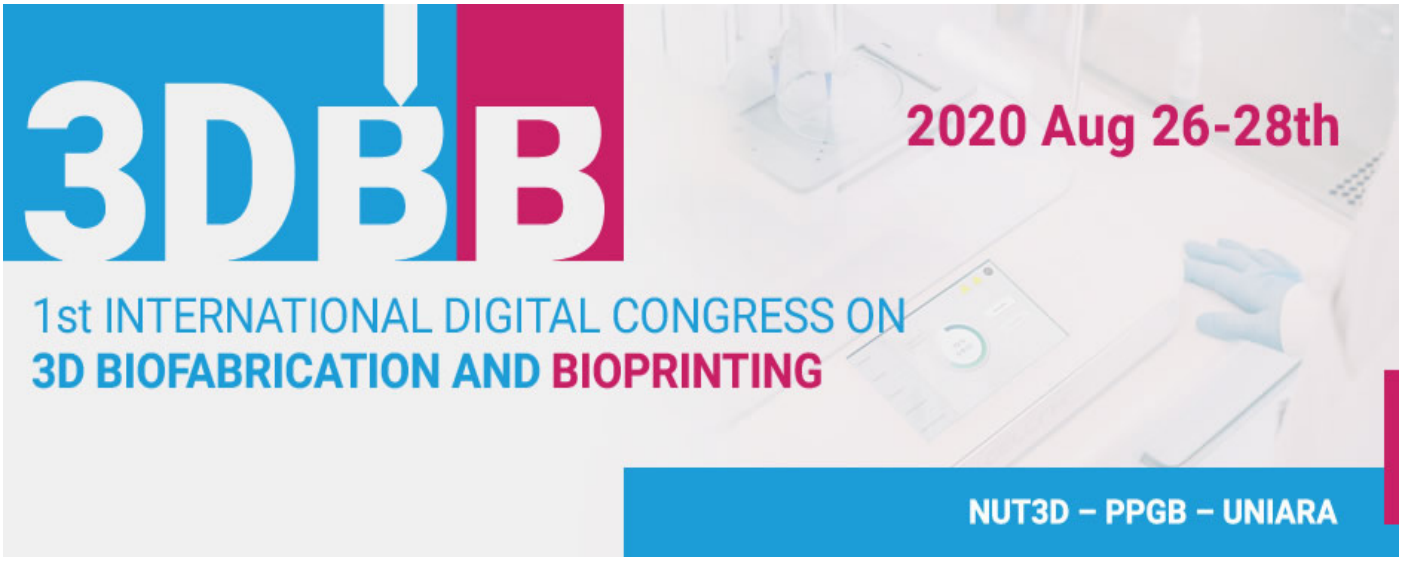
Gabriel Cardoso Pinto; Miguel Jafelicci Junior*; Antonio Carlos Guastaldi**

(Biomaterials)

Abstract: Considering the aging of the population, increase in life expectancy and quality of life, increase in accident rates, economic and technological aspects, the development of biomaterials for bone tissue regeneration is of great importance and its demand is increasing every day. However, the complex structure and properties of natural bone limit the use of synthetic materials and manufacturing techniques, currently available, which could be used as custom implants or Scaffolds for the treatment of bone defects or guided bone regeneration. This challenge can be overcome by using 3D printing technology, which is an excellent approach to overcome the limitation that supports the efficient and rapid manufacture of customized complex bone substitutes. Natural and synthetic polymers associated with calcium phosphates allow the development of important composites to be used in the manufacture of 3D Scaffolds, due to their composition, combining favorable properties of both phases. The objective of this research was to study the use of bacterial cellulose (BC) and synthesized calcium phosphates (β–TCP), in the nano and microstructure for the development of films and filaments to be used in obtaining 3D Scaffolds. To determine the best way to interact β–TCP with bacterial cellulose, it was initially proposed to obtain the film containing these two materials, with the PCL (Policaprolactone) polymer being the binding agent. Another method proposed to interact β–TCP with BC was through obtaining filaments of these materials with PLA (PolyLactic acid) as polymeric matrix in the NuLEEN laboratory extruder (UFSCar). For the films and filaments synthetized, characterizations techniques as thermogravimetry, scanning electron microscopy (SEM) and infrared confirmed the mass proportion used, the morphology and the presence of the main functional groups of β–TCP, PCL and PLA components. Due to the to the insolubility of CB, in polar and nonpolar media, there was the formation of a CB aggregate in the films synthesized, but for filaments a greater homogeneity was observed, confirming then that filaments based on PLA/β–TCP/CB are a promising alternative for an biomaterial that can be used in 3D printing for regenerative engineering.

Keywords: Calcium Phosphate; Scaffolds 3d; Regenerative Engineering; Biomaterial, Bone.

* Instituto de Química – Unesp Araraquara.



Biofabrication and the medical field: which is the scenario for 2030?

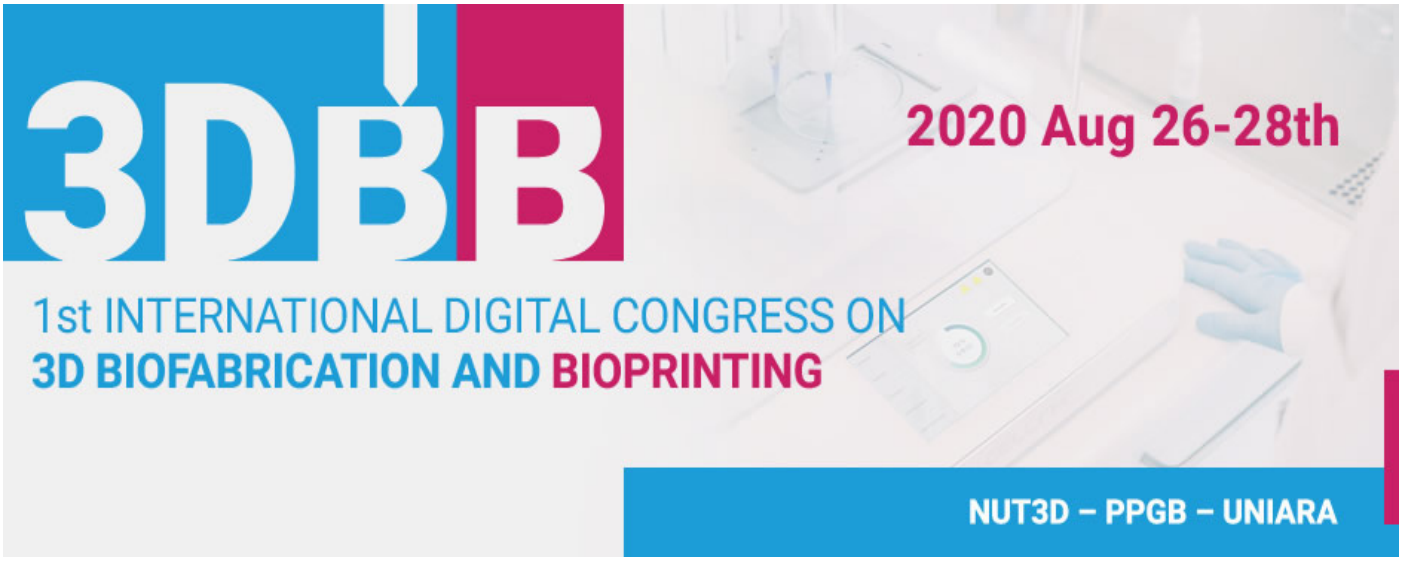
Emanuel S. Serrano; Liliana Coutinho Vitorino*; Henrique De Amorim Almeida***

(Biofabrication and bioprinting (in general)

Abstract: Nowadays, Additive Manufacturing is more and more a frequent topic of discussion , due to its effects and causes, not only at a technological level, but also in terms of economic, social and political levels and its impact has been observed on several sectors, especially in the medical field. These technologies have created a specific technological field, namely biofabrication / biomanufacturing which is capable of producing medical devices with the combination of biomaterials, drugs and growth factors with or without the inclusion cells for the production of biomedical implants for both permanent or temporary applications. These technologies have shown to be capable of meeting the requirements demanded by the medical sector. However, the significance of these technologies can't be based only on the current context, but also need to be assessed in the future context. This study intends to develop reliable future scenarios for this technology, for a very specific and important sector, namely the medical field. Concerning this prediction, academic studies dedicated to additive manufacturing and the medical field are non–existent. In this context, the Delphi method combined with the PEST analysis was applied to world experts in the field of biomanufacturing with the goal to presenting the impacts related to this technology for the horizon of 2030, concerning four different dimensions: political, economic, social and technological. The results made it possible to obtain projections for the next decade, revealing satisfactory levels of agreement among the specialists in the four dimensions that are included in this analysis, with the highest values related towards the technological dimension. This study also provides an awareness of the needs and concerns of the usage of this technology in the medical domain.

Keywords: 3D Printing; Biofabrication; Medical Applications; Delphi Method; PEST Analysis.

* Escola Superior de Tecnologia e Gestão (ESTG), Politécnico de Leiria (IPL), Leiria, Portugal.
** Centro de Investigação em Informática e Comunicações (CIIC), Politécnico de Leiria (IPL), Leiria, Portugal.



Synthesis and characterization of L–lactide for poly–L–lactic acid production aiming its application in the medical field

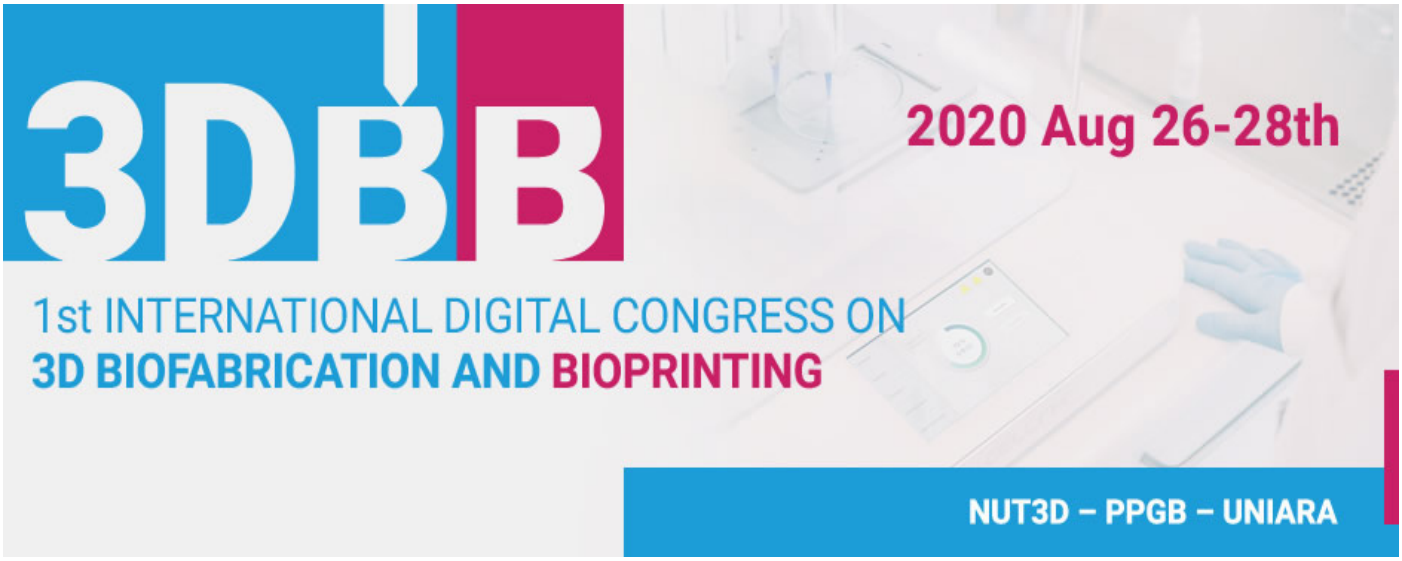
Bruna Letícia de Carvalho Cunha; Maria Ingrid Barbosa Rocha Schiavon**; Letícia Xavier*; Viktor Oswaldo Cárdenas Concha**

(Biomaterials)

Abstract: The search for polymers from natural sources increased exponentially since they have potential to replace petroleum derived polymers. Some of these biopolymers are biodegradable, which have wide application as a biomaterial in the health area. Among them, Poly Lactic Acid (PLA), stands out for being a biodegradable polyester with excellent physical and biological characteristics. The main route for high molar mass PLA has the Lactide as starting monomer, commonly produced by depolymerizing the PLA. Currently, there is a deficiency in knowledge about the lactide obtaining process and divergences about reaction parameters. In addition, the synthesis of PLA from this dimer has a high production cost, since the monomer has high added value. In this context, L–Lactide production process is fundamental for your use as a monomer for the synthesis of high molar mass PLA, which is widely used in medical applications. Therefore, this work aims to evaluate the effect of temperature, pressure and reaction time in the L–lactide synthesis process, in order to obtain a high molar mass PLA. For this, a 23 factorial design was carried out, with central point triplicate, considering a temperature variation of 170 to 200 ° C, pressure of 50 to 200 mmHg, and reaction time of 2 to 6 hours. The L–lactide produced had its thermal and spectroscopic properties characterized by techniques of Differential Scanning Calorimetry (DSC), Thermogravimetry (TGA), Fourier–transform infrared spectroscopy (FTIR) and X–ray powder diffraction (XRD). Previous results showed the formation of L–Lactide in some system points (connector between reactor and round bottom flask, round bottom flask and condenser), whose properties were compatible with L–Lactid standard sample (PURASORB® L).

Keywords: L–Lactide; Poly–L–Lactic Acid; Biopolymer; Synthesis; Characterization.

* Universidade Federal de São Paulo (Unifesp).
** Universidade Estadual de Campinas (Unicamp).



A natural extracellular matrix hydrogel derived from decellularized bovine cornea: a new biomaterial for the development of 3D models

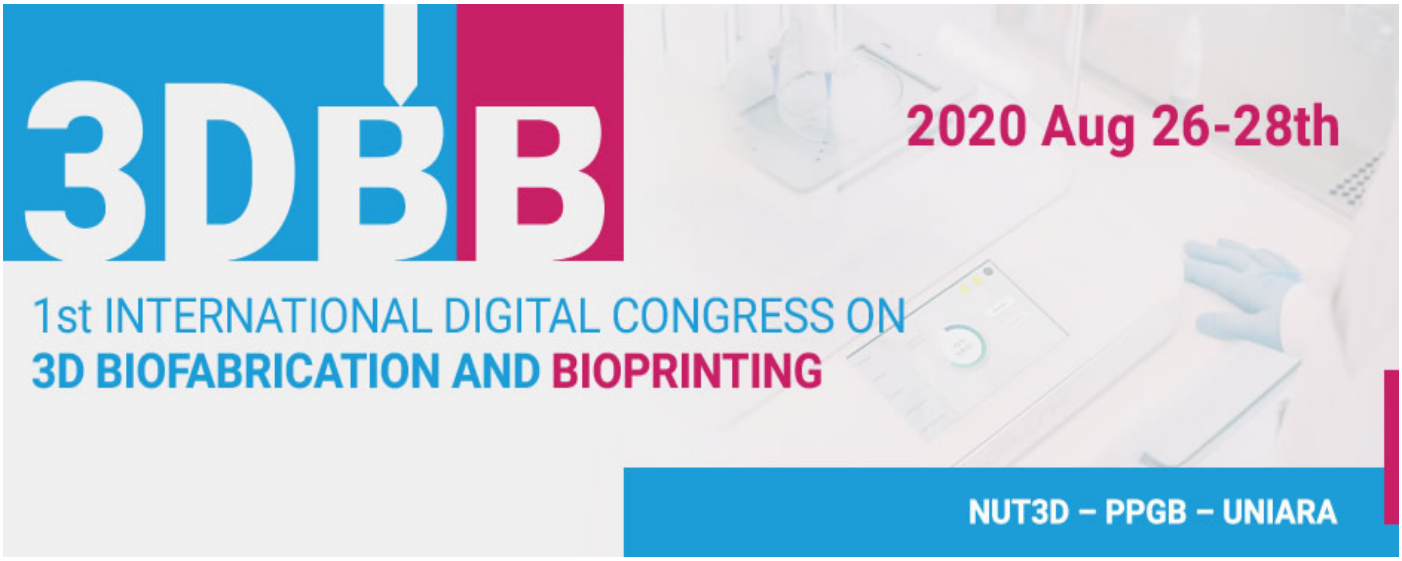
Jordana Andrade Santos; Artur Christian G. Da Silva*; Marize Campos Valadares**

(Biomaterials)

Abstract: The use of 3D cellular models to mimic biological microenvironments has been considerably increased in the last years. The development of 3D models is based on the proliferation of cells in a scaffold similar to the extracellular matrix, which generates a favorable condition for cell proliferation. Usually, the scaffolds are composed of polymers or/and matrix elements, such as collagen type 1. The marketed collagen is generally produced from rat tails, at high cost and, to improve its functionality, it is necessary to add other matrix elements and growth factors. The use of decellularized Extra–cellular Matrix (dECM) hydrogels from food industry waste can be more sustainable, representing a lower cost alternative and mimicking more closely the complexity of the extracellular matrix better than the isolated Collagen or any other material. In addition, can contribute to the reduction of animal use in research, which is alined with the 3R's principle in the context of the 21st century Toxicology. This work aims to develop a new hydrogel source for future applications in the construction of 3D tissue models.Methodology: Bovine corneas, were collected in a slaughterhouse in Goiania, Brazil. The corneas were subjected to decellularization by 0.5% Sodium dodecyl sulfate, maceration with tissue grinder, lyophilization and neutralization to obtain hydrogel. The sample was evaluated for decellularization extension by H&E staining. The structural and compositional change of dECM hydrogel components were analyzed using alcian blue stain to visualize GAGs, azan blue stain to visualize collagen, scanning electron microscopy to visualize the ultrastructure, total proteins (BCA) and Turbidimetric gelation kinetics. Hydrogel were compared with native corneas and decellularized cornea. Results: The hydrogel obtained from bovine cornea showed the concentration of total proteins was similar between different batches of samples ($p = 0.0956$).the decellularization method was effective and biochemical components (collagen and GAGs) were preserved, however in visually smaller quantities than in the native matrix. Gelation kinetics of cornea dEMC hydrogel and collagen type 1 showed that collagen reach first gelation compared to hydrogel, but all samples were cross–linked at the end of the analysis. Conclusions: The bovine cornea is a natural source of matrix components and can be applied as biomaterial in the field of different tissue engineering in future applications.

Keywords: Extracellular Matrix; Hydrogel; Tissue Engineering; Biomaterial; Cornea.

* Laboratory of Education and Research in ***In Vitro*** Toxicology, Tox In, Faculty of Pharmacy, Federal University of Goiás (UFG), Brazil.



Rheological effects of laponite clay in gellan gum gels aiming biomaterial inks for 3d bioprinting

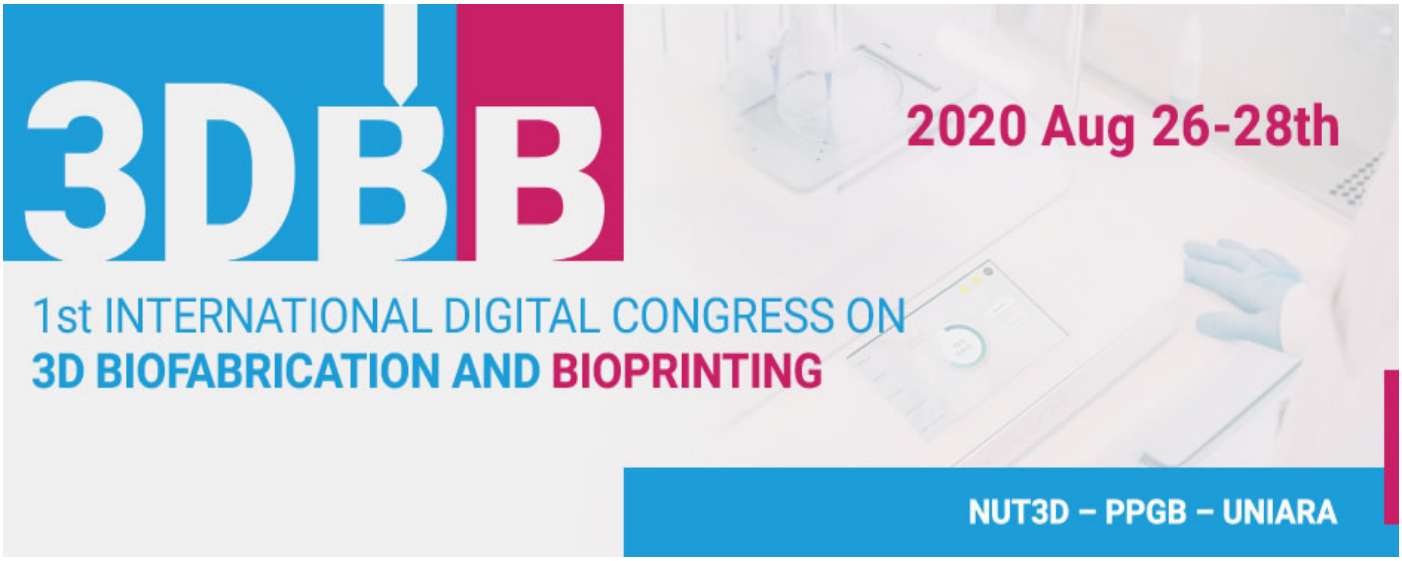
Mayté Paredes Zaldivar; Lucas Noboru F. Trevizan*; Diego Silva Batista*; Hernane Da Silva Barud**

(Biomaterials)

Abstract: The 3D bioprinting or additive manufacturing is a growing technology used in tissue engineering. It is used to deposit layer–by–layer biological inks to obtain 3D objects. These inks can be composed by biomaterials, cells and support components. The most commonly used inks are viscous polymer solutions (gels) that after printing and gelling processes became hydrogels, maintaining the 3D object structure. The gellan gum (GG) is a high molecular weight and water–soluble anionic polysaccharide produced by the bacteria Sphingomonas elodea. It is biocompatible, biodegra–dable and can form very viscous gels even at low concentrations. The laponite (Lp) is a synthetic nanosilicate clay used as a rheology modifier of water solutions. It is also non–toxic and enhances biological activities like cell adhesion and proliferation. Thus, the objective of this work was to study the rheological effects of laponite in gellan gum gels aiming to define the better gel–ink composition for 3D bioprinting. Gels with concentrations of 3% (m/V) in distilled water and different GG/Lp compositions (100/0; 90/10; 50/50) were prepared. Their rheological characterizations were performed at 25 oC using a 40 mm diameter plate–plate geometry in a TA Instruments AR 1500ex Rheometer. The Ostwald–de Waele power law model was used to calculate the viscosity and the n index as a function of shear rate. The results indicated that laponite addition affected the shear–thinning and the solid–like behaviors of GG gels. The pristine GG formed a very viscous gel, hard and slightly brittle that after laponite addition showed a significantly decrease in their viscosity. The data was successfully fitted to the Ostwald–de Waele model and all the n indexes were less than 1, indicating the pseudoplastic behavior of gels. We can conclude that effectively the laponite acts as a rheology modifier in gellan gum gels solutions and that the gel composition with 90 % of gellan gum and 10 % of laponite (90/10) showed the better viscosity characteristics. This gel composition of GG/Lp will be used as biomaterial ink in 3D extrusion bioprinting.

Keywords: Biomaterial Inks; 3d Bioprinting; Gellan Gum; Laponite; Rheology.

* University of Araraquara (Uniara), Araraquara, SP, Brazil.



Study of in-vitro degradation of poly (butylene adipate co-tereftalate) based polymers processed by FFF 3D printing

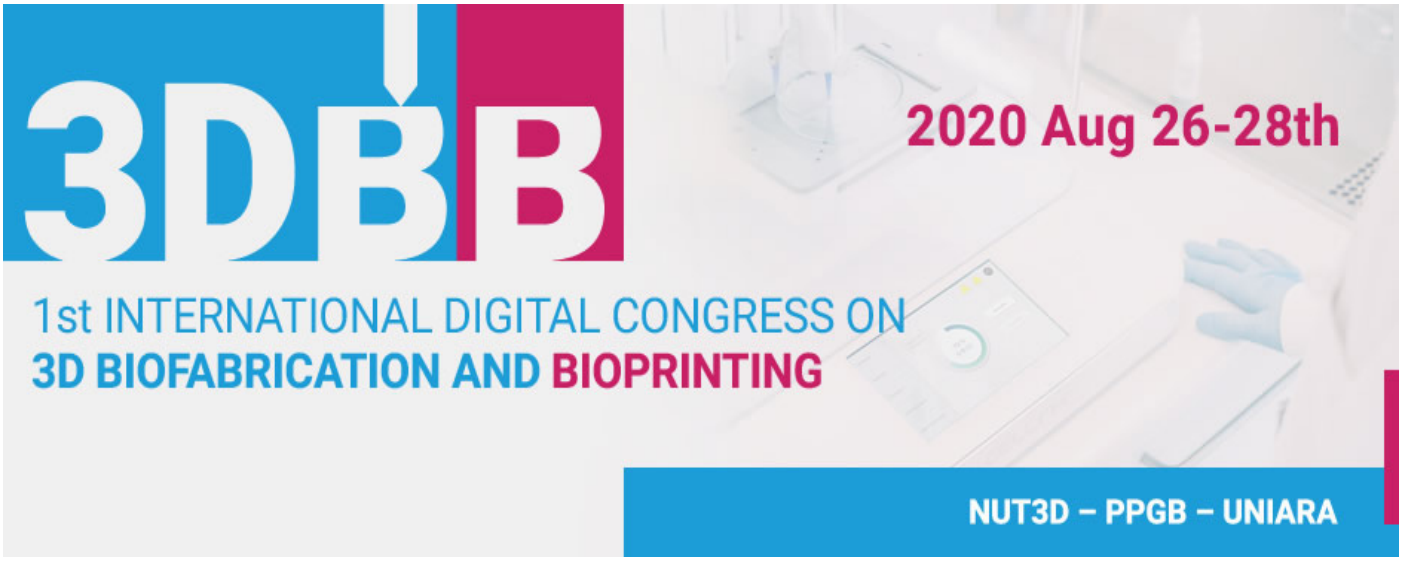
Bruno da Costa Oliveira; Luis Alberto Loureiro Dos Santos**

(Biofabrication and bioprinting (in general)

Abstract: The growing advance in the tissue engineering area makes it necessary to study and develop new materials for application as a three-dimensional support for tissue growth (scaffold). In this context, the knowledge of mechanical properties and the degradation rate of materials is of paramount importance, as they are determining factors in the application as a scaffold. In this work, the behavior of the copolymer poly (butylene adipate co-terephthalate) (PBAT) and its blend with poly (lactic acid) (PLA), in different proportions, were studied in a degradation test in PBF solution. The raw materials in the pellet form were produced and supplied by BASF, under the brand names ecoflex (neat PBAT) and ecovio (PBAT+PLA blend in different proportions). The filaments were produced by extrusion, when it were determinted the optimal parameters. The parts were processed in a FFF 3D printing equipament, variating parameters such as nozzle and bed temperature, in order to determinate the best printing profile. Variations in mechanical properties (young´s modulus/tensile strenght/elongation at break), mass loss and changes in surface morphology of printed samples were evaluated over 60 days of immersion. The printed PBAT samples showed high elongation at break and low elastic modulus compared to the blend. Parts were affected by the degradation period, with greater reductions in mechanical properties.

Keywords: Bioprinting; Biomaterials; Scaffold; Tissue Engineering.

* Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil.



Planning and execution of orthodontic traction using a printed biomodel: clinical case report

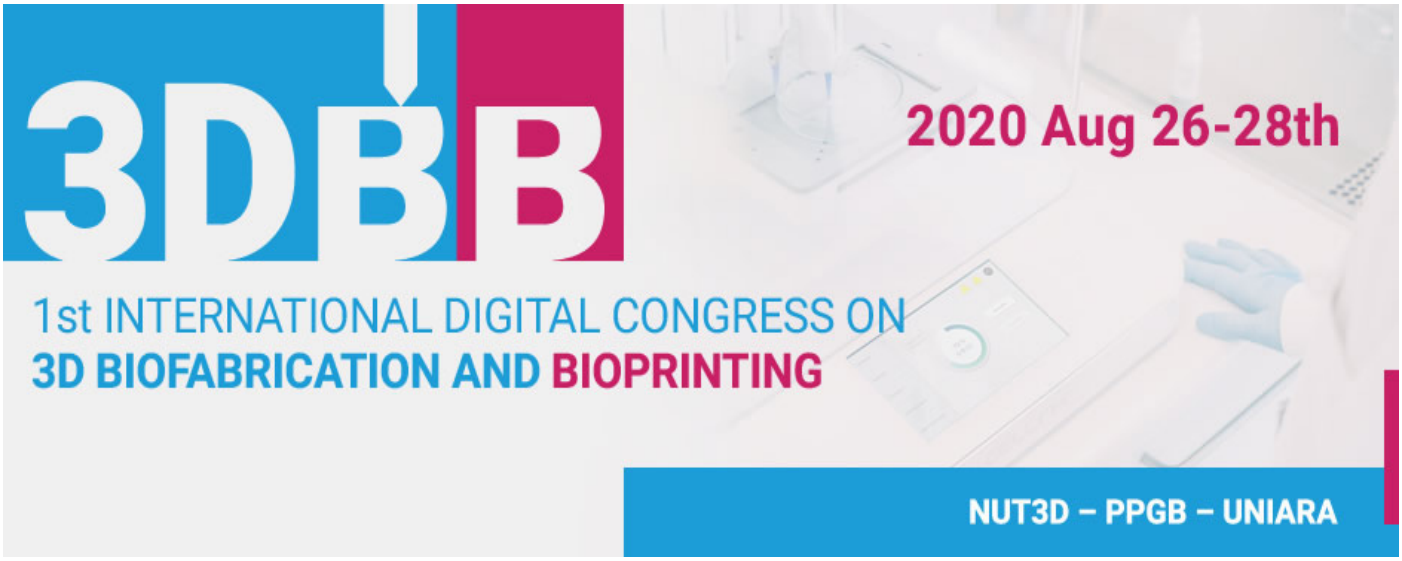
Marlos Eurípedes de Andrade Loiola; Luiz Gonzaga Gandini Junior**

(Other topics)

Abstract: Advances in digital technology have been changing the orthodontic routine. The incorporation of technologies such as three–dimensional printing assists the professional in making clinical and surgical decisions in some situations, in addition to the possibility of developing orthodontic appliances such as clear aligners that promote tooth movement. Methodology / Results: This paper presents the report of a clinical case that illustrates the applicability of this important technology in the dentist´s clinical routine. For this, a three–dimensional biomodel printed from files (DICOMs) obtained by computed tomography of an 11–year–old patient was used, with no permanent incisors in the oral cavity that bothered him. This model helped in the planning and execution of extranumerary teeth removal surgery, in addition to the correct positioning of accessories for traction of teeth retained in the jaw bone. Conclusion: The visualization of anatomical changes through three–dimensional printed models facilitates communication between the team and patients, anticipating decision making, increasing the chances of success and decreasing complications in the execution of treatment.

Keywords: Orthodontics; Imaging, Three–Dimensional ; Printing, Three–Dimensional ; Tomography ; Dentistry.

* FOAR/UNESP, Araraquara, SP, Brasil.



Biomodulatory effect of laser radiation on multicellular spheres for application in cellular therapy and bioprinting

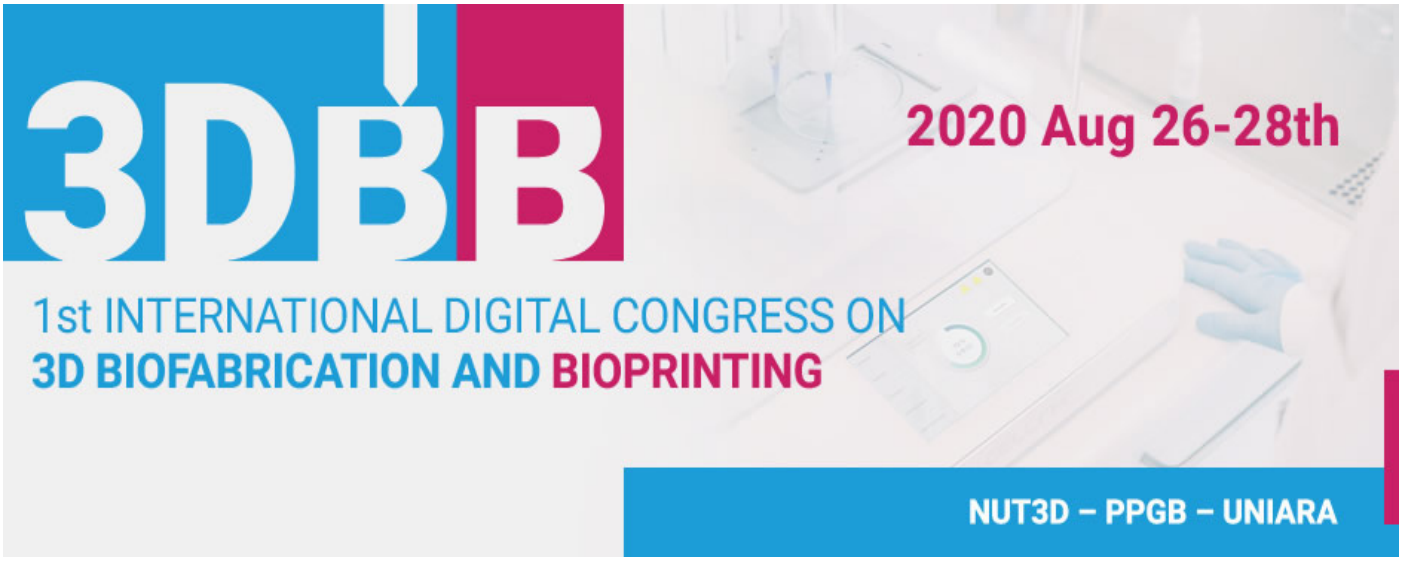
Gabriela Gomes Cardoso Gastaldi; Sandro B. Moreira* ; Rodrigo A. Rezende* ; Jorge V. L. Da Silva**; Fernanda De F. Anibal***; Cynthia A. De Castro***; Renata A. De Carvalho*; Nivaldo Antonio Parizotto* ; André Capaldo Amaral**

(Cell cultures)

Abstract: The use of mesenchymal stem cells (MSC) is a promising strategy for regenerative medicine (MR) and tissue engineering (TE) for the treatment of tissue and organ injuries. Multicellular spheroids (MS) represent an excellent alternative for cell carriers, both for cell therapy (CT) and/or bioprinting (BP) in MR and TE applications. Using biomodulating resources during the process of constitution of MS, such as low–level laser radiation (LILR), could enhance the biological response. However, research aimed at identifying the effectiveness of this proposal is scarce. Objective: The aim of this study was to analyze the biomodulating influence of LILR on MS from MSC for use in cell therapy and bioprinting. Methodology: Human subacromial bursa MSC (hSBMSC), collected in an arthroscopic procedure, were isolated, characterized and seeded in agarose molds containing microwells (3.5x105 cells/mL). The molds were irradiated, during the 5 days of constitution, with LILR at the wavelength (λ) of 685 nm, power density of 9 mW/cm² and doses of 0.5, 1.0 and 1.5 J/cm². The biomodulatory influence was determined by assessing cell viability, the potential for osteogenic differentiation and the cytokine production profile of irradiated MS compared to non–irradiated ones. Cell viability was quantified using the Rezasurina colorimetric method after the end of the irradiation protocol. To determine the differentiation potential, MS were transferred to wells in culture plates and kept under the influence of osteogenic differentiation induction medium for 14 days. At the end of this period, a histomorphometric analysis was performed to detect the bone matrix produced and stained with alizarin red. The cytokine production profile was established by the quantification of interleukins 1 beta (IL–1β), 6 (IL–6), 10 (IL–10) and tumor necrosis factor alpha (TNF–α) using an immunodetection procedure. Results: The results showed that there was no biomodulatory influence on cell viability and osteogenic differentiation and there was a dose–dependent biomodulatory influence of LILR on the production of cytokines, with a reduction in IL–6 at doses of 1.0 and 1.5 J/cm². Conclusion: It is concluded that LILR exerted a dose–dependent biomodulatory influence on cytokine production by hSBMSC grown as MS. This potential can be exploited to influence the microenvironment in TC and BP.

Keywords: Photobiomodulation; Immunomodulation; Regenerative Medicine; Cell Therapy; Bioprinting.

* University of Araraquara – UNIARA, Araraquara, SP, Brazil.
** Renato Archer Information Technology Center (CTI), Campinas, SP, Brazil.
*** Federal University of São Carlos – UFSCar, São Carlos, SP, Brazil.



Rapid 3D protoyping biomodel as an auxiliary surgical planning method for facial tumor resection

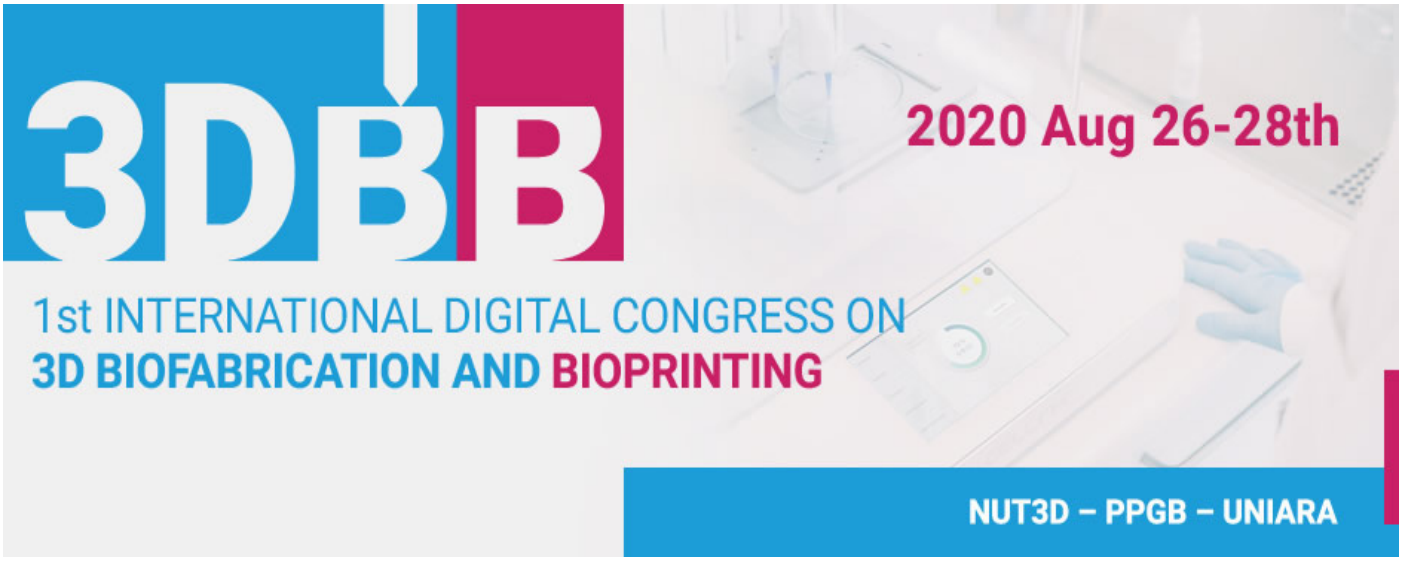
Luiz Henrique Soares Torres; L. F. O. Gorla*; Marisa Aparecida Cabrini Gabrielli*; Valfrido Antônio Pereira Filho**

(Biofabrication and bioprinting (in general)

Abstract: ameloblastomas are slow growing, high recurrence and locally invasive facial tumors. Thus, an accurate surgical approach guaranteed satisfactory clinical results and less patient morbidity. The additive manufacturing technique allows to making three–dimensional models from 3D image data that a physical replica of the patient´s anatomy, assisting in planning and ensuring surgical predictability. Methodology: male patient, 32 years old, with no previous medical history, attended the ambulatory of maxillofacial surgery, with swelling on the right side, painless, with evolution of 08 months. Imaging exams showed an intraosseous trabecular lesion in the right body and mandibular angle. In histopathological analysis by incisional biopsy, the diagnosis of multicystic ameloblastoma was obtained. We opted for making a 3D model by additive manufacturing for planning tumor resection and previous modeling of osteosynthesis titanium plate. Results: the tumor resection regarding the installation of the fixation device was performed under general anesthesia. Following an 8–month follow–up, the titanium plate was fractured. A new digitally preformed and more robust device was installed. Bone grafting of autogenous origin was performed in the same session. Currently in follow–up for 01 year, he continues without recurrence or complications. Conclusions: the additive manufacturing is an effective auxiliary method in the planning of tumor resections, since it allows the visualization of the lesion margins, in addition to providing a pre–modeling of the bone fixation devices and reduction of the surgical time.

Keywords: Three–Dimensional Printing; Ameloblastoma; Neoplasms; Technology; Facial Neoplasms.

* Universidade Estadual Paulista “Júlio de Mesquita Filho”, Faculdade de Odontologia de Araraquara, UNESP/FOAr.



Production of polymeric scaffolds by fdm from phbv polymer reinforced with ZrO2

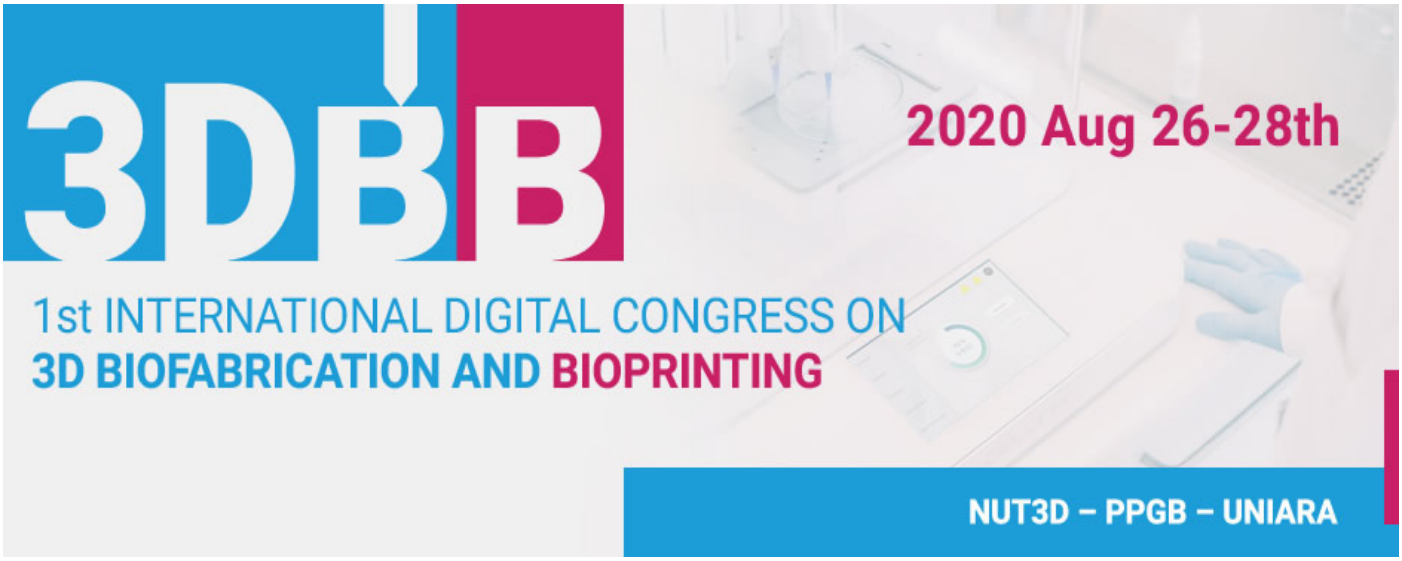
Júlia de Carvalho; Noelle Cardoso Zanini* ; Amanda Claro**; Nayara Do Amaral**; Hernane Barud**; Daniella Regina Mulinari**

(Biomaterials)

Abstract: Additive manufacturing has been one of the great technologies that emerged with the fourth industrial revolution, which reached emerging areas of rapid prototyping. The 3D printing technique, layer by layer, using FDM (Fused Deposition Modeling) has consolidated itself as cheap and accessible, using design software to personalize the printed object. Thus, regenerative medicine gained a tool to obtain small three–dimensional structures of detailed geometry with interconnected pores, the scaffolds, which act as a support for tissue regeneration. To mimic the tissues of a living organism, the scaffold material must have biocompatibility, non–toxicity, and biodegradability. A biopolymer that fits these characteristics is polyhydroxybutyrate–cohydroxyvalerate (PHBV). Hybrid organic–inorganic materials can improve the properties of pure polymers. Inorganic zirconium oxide (ZrO2), besides having good thermal, chemical, and mechanical stability, is also highlighted in regenerative medicine, for its ability to stimu–late the growth of osteoblastic cells. In this work, composite filaments reinforced with ZrO2 (1 to 10% w/w) were obtained and characterized for the manufacture of scaffolds. The ZrO2 was obtained by the Conventional Precipitation Method (CPM) and mixed with PHBV in a mini–extruder. For the filaments (PHBV and composites), the morphology was evaluated by the stereomicroscopy technique, and the microhardness by the Vickers hardness test (HV). SolidWorks was the software chosen to develop the 3D designs of cylindrical scaffolds to be printed by FDM. However, it was not possible to print the 10% ZrO2 composite due to the fragility (causing fracture) and the non–linearity of the filament length, confirmed by stereomicroscopy, which exposed changes in the sample surface: the roughness was increased by the agglomeration of the oxide in the surface, making printing impossible. As for the mechanical properties, except for the 7.5% ZrO2 composite (162 MPa), the addition of oxide in the polymeric matrix did not cause major changes in the microhardness of the composites, which obtained a range of 90 to 105 MPa, similar to pristine PHBV (105 MPa), revealing that there was possibly a weak interaction between matrix and reinforcement (due to the hybrid nature of the material). It was concluded that ZrO2 changed the filament morphology, but the mechanical properties did not show significant changes.

Keywords: PHBV; ZrO2.nH2O; Filamentos Compósitos; Manufatura Aditiva; Scaffolds.

* Universidade do Estado do Rio de Janeiro (UERJ), Faculdade de Tecnologia (FAT).
** Universidade de Araraquara (Uniara).



Valorization of palm residue as phbv reinforcement for scaffold printing by FDM

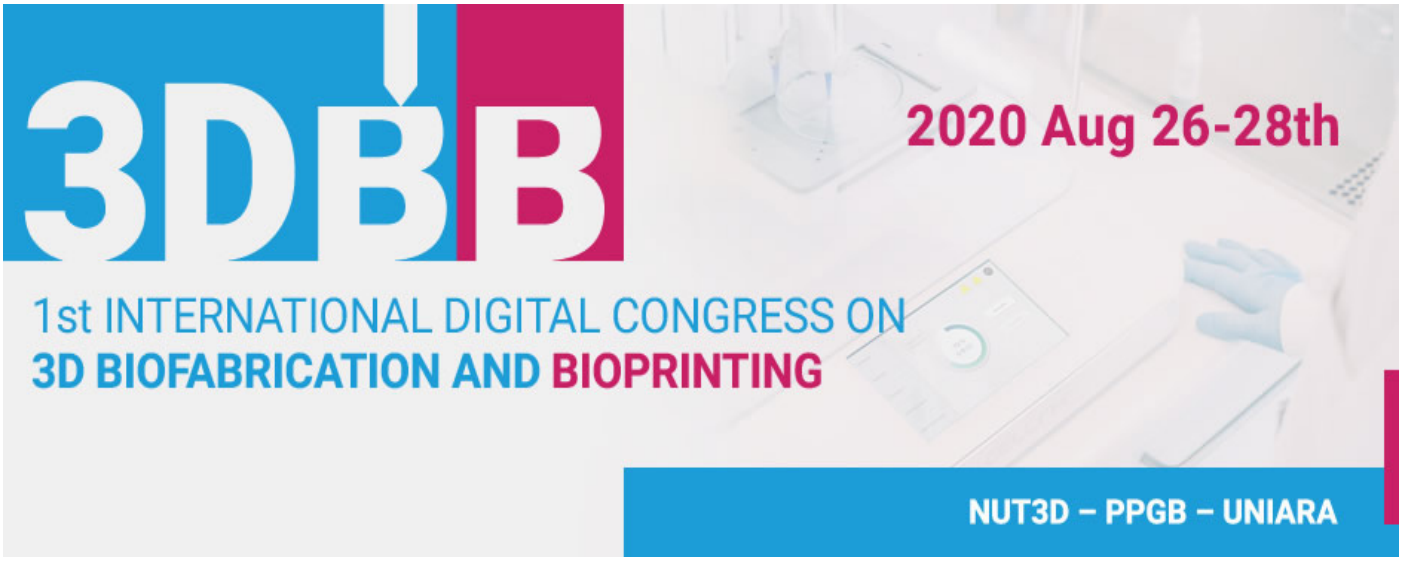
Noelle Cardoso Zanini; Emanuel Da S. Carneiro**; Lívia R. De Menezes***; Hernane Da S. Barud****; Daniella Regina Mulinari***

(Biomaterials)

Abstract: One route for the reconstruction of damaged bone tissues is the scaffolds, structures with interconnected pores of temporary support for cell growth. Surgical interventions for prostheses of conventional materials cause infections, pain, and immunological rejections. To remedy such side effects, the use of biopolymers in scaffolds stands out for their compatibility with the living organism. However, one of the disadvantages of biopolymers, such as polyhydroxybutyrate–co–hydroxyvalerate (PHBV), is the high price, discouraging their use. The incorporation of natural fibers can be stimulating to decrease the cost and at the same time improve the properties of the biopolymeric matrix. By associating the filler function with the reuse of a natural fiber considered as agro–industrial waste, the scaffold gains a green character, re–signifying a waste for a noble purpose. The production of scaffolds by Fused Deposition Modeling (FDM), is a practical additive manufacturing technique for printing complex custom 3D shapes and more financially advantageous. The FDM printer needs extruded filaments to deposit the porous structure of the scaffolds in thin layers. Thus, this work aimed to elaborate and characterize PHBV filaments reinforced with bleached fibers from the palm residue (in percentages varying from 1 to 10% w/w) for the manufacture of scaffolds by the FDM technique. Fibers from palm residue before and after bleaching (FRP and FBRP, respectively), and filaments (pure PHBV and biocomposites) were analyzed by Scanning Electron Microscopy (SEM), Infrared Spectroscopy (FTIR), Contact Angle (CA) and Cytotoxicity. SEMs of the filaments revealed a tendency for FBRP to clump at the ends during extrusion, which later corro–borated the impossibility of FDM printing of the filaments with a higher FBRP content. FTIR showed that bleaching promoted the –OH band of FBRP cellulose, facilitating fiber–matrix interaction. Biocomposite filaments revealed small decreases in the characteristic bands of PHBV, showing slight matrix–reinforcement interaction. The addition of FBRP increased the hydrophilicity of biocomposites (CA> 90°) and favored cell viability (from 95% after 7 days) classifying all filaments as biocompatible. Pristine PHBV scaffolds and 1% FBRP had cylindrical structures with interconnected pores, desirable for application in tissue engineering.

Keywords: PHBV; Bleached Fibers; Residue; Fdm; Scaffold; Tissue Engineering.

* Universidade do Estado do Rio de Janeiro (UERJ), Faculdade de Tecnologia (FAT).
** Instituto de Ciência e Tecnologia, Universidade Federal Fluminense (UFF).
*** Instituto de Macromoléculas (IMA), Universidade Federal do Rio de Janeiro (UFRJ).
**** Universidade de Araraquara (Uniara).



Mandibular reconstruction with prototyping after resection of multicystic ameloblastoma

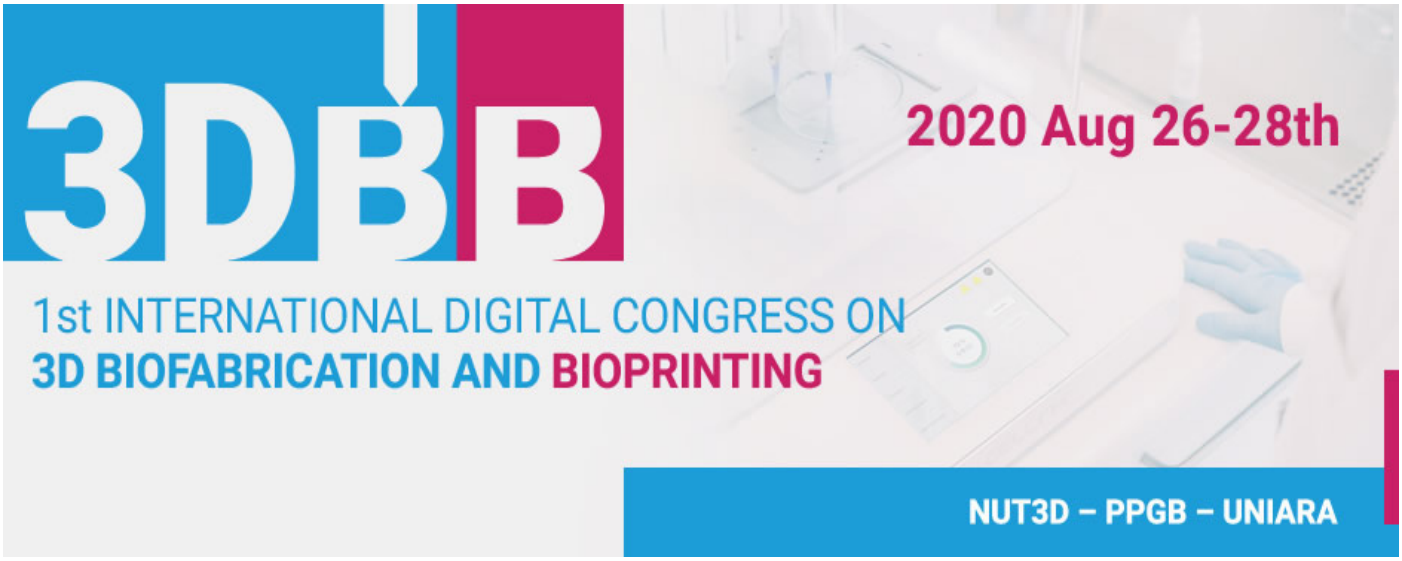
Giovanni Cunha; Valfrido A. Pereira–Filho*; Mário Francisco Real Gabrielli*; Marisa Aparecida Carbini Gabrielli**

(Biofabrication and bioprinting (in general)

Abstract: The multicystic ameloblastoma is a benign tumor relatively common of the jaw. It is clinically similar to other pathologies that affect the bones of the face. In the present report, the reconstruction of the affected mandible was performed using prototyping and the use of pre–shaped plaque. The patient was referred to the Maxillofacial Surgery service with main complaining of pain in the right retromolar region. The radiograph showed the root resorption in "knife blade" form in the second lower right molar. Moreover, there was an extensive multiloculated radiolucent area in the mandible body. The first diagnostic hypothesis was Ameloblastoma. With the computed tomography the case was planned, and the mandibular model was constructed in the 3D printing. After a second histopathological analysis, performed in the hospital, with the full lesion, the diagnosis was confirmed as multicystic ameloblastoma. In the second surgical time, reconstruction was performed with autogenous bone grafting from the anterior iliac crest. The literature reports the aggressive characteristic of the ameloblastoma, the necessity of radical treatment and reconstruction with biomaterials or grafts, such as the anterior iliac crest, which allows adequate quantity and quality of bone to restore form and function. However due to the large area that ameloblastomas and other jaw lesion can affect, the digital planning with prototyping allow a better understanding of the extent of the tumor as well as the amount, type, and location of the fixation material, which allowed predictability of the case. Reconstruction using this type of technique with 3D models could create the necessary framework to the second time surgery with bone graft, it saves surgical time and increase the possibility of correcting facial symmetry. At this moment, the patient is under follow up without tumor recurrence.

Keywords: Prototyping; Mandibular Reconstruction; Ameloblastoma.

* São Paulo State University (Unesp), School of Dentistry (FOAR), Araraquara FOAr UNESP.



Fabrication of a biomaterial with gelatin, alginate and β–TCP for the treatment of fractures caused by osteoporosis

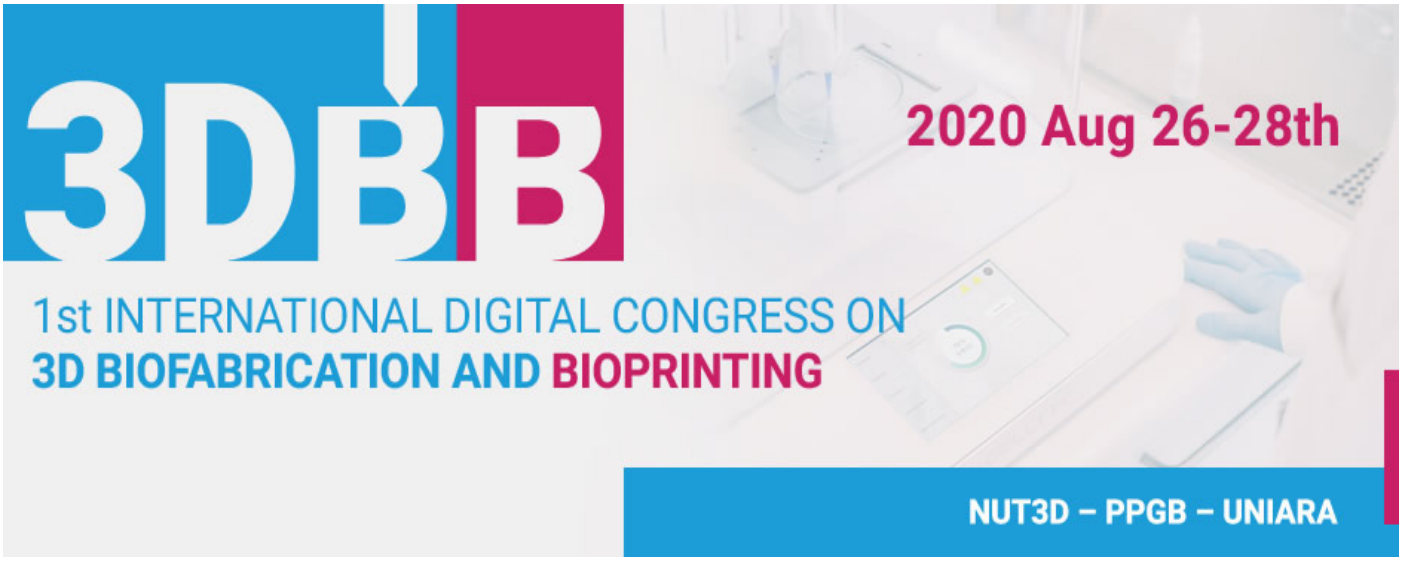
Thaís Pezza de Souza; Bruno E. Amantea*; Rodolfo D. Piazza*; Gabriel C. Pinto*; Rodrigo Fernando C. Marques*; Antonio Carlos Guastaldi**

(Biomaterials)

Abstract: Considering the increase of the life expectancy and the number of osteoporosis cases, the development of materials that can be used as support in bone fractures treatment decorring from this disease is necessary. With the progress in biomaterials area, there is the potential of using gelatin and alginate in their formulation, because they have good biocompatibility, low toxicity and can be used as drug delivery. It is known that β–TCP (beta tricalcium phosphate) has bioactivity and bone growth inducing properties and could compose the biomaterial formed of gelatin and alginate. Thus, the objective of this work is to obtain a biomaterial composed of gelatin, alginate and β–TCP to be used as a 3D printer ink aiming the treatment of fractures caused by osteoporosis. Methodology: β–TCP, tri–sodium citrate 2–hydrate (PA, Panreac), sodium alginate (PA, Exodo) and powdered gelatin (Synth) were dispersed in aqueous solution and then mixed in a magnetic stirring at temperature of 55°C degrees. The presence of sodium citrate ensure that agglomeration is not formed. Different concentrations were studied and the influence of each compound was evaluated by FTIR–ATR (Frontier Dual Range, PerkinElmer), DSC (2910, TA Instruments) and rheological test (rheomether AR 2000ex, TA Instruments). Results: FTIR spectra showed the bands of β–TCP (v4 PO4 – 750–500 cm–1; v3 PO4 – 1100–900 cm–1), gelatin and alginate chains (C–O carboxylic acid – 1400 cm–1; C=O carboxylic acid – 1700–1500 cm–1) and an increase of intensity after crosslinking was observed. By DSC analysis, it was observed that, when adding β–TCP and sodium citrate, the melting point temperature is shifted to lower temperatures, indicating an increase in the order of the material generated by the addition of β–TCP, that make it possible to increase the interaction between polymer chains. The rheological test showed that β–TCP addition increases the values of G' and G'' and, in the same time, that the elastic behavior is predominant (G'>G'') for this sample, indicating that the addition of phosphate contributes to the material structure obtained, enabling an increase in the polymer chains interaction. Conclusion: The addition of β–TCP provides an increase in the mechanical properties of the material obtained and presents a viable alternative to compose the biomaterial that will be used as ink for 3D printing.

Keywords: Biomaterials; Osteoporosis; Gelatin; Alginate; β–TCP.

* Instituto de Química – UNESP Araraquara.



Modeling and 3D printing of biomechanical prosthesis for dogs

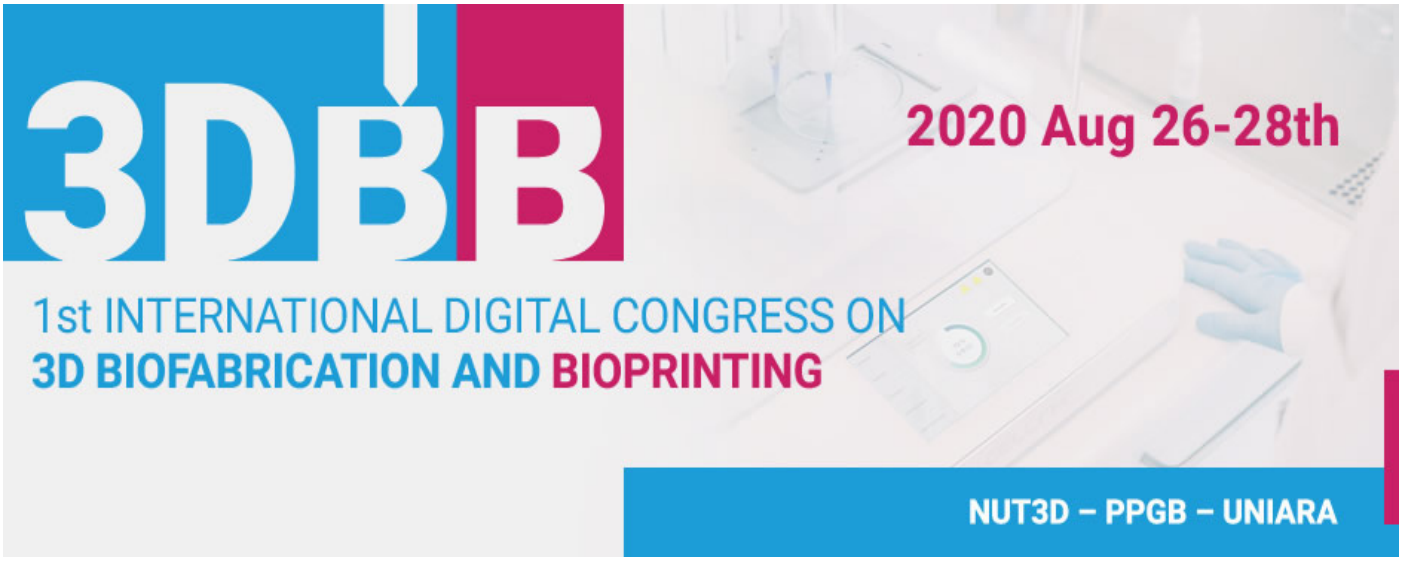
Luciana Lopes de Oliveira; Jessé Ribeiro Rocha*; Henrique José Da Silva**

(Biofabrication and bioprinting (in general)

Abstract: This work aims to model and develop, through 3D printing, a biomechanical prosthesis for a female dog. Which is justified by the lack of specialized services in the development of prostheses in Brazil. For the development of the prosthesis, characteristics such as the amputated area, sensitivity and pain tolerance were respected. It is expected that the dog´s adaptation time will be reduced. This study has the support of the Vete–rinary Hospital of UNIFRAN of a small, female, adult, SRD, canine patient, with partial amputation of the left pelvic region which was submitted and accepted by the ethics committee and authorized by the tutor. The patient was clinically evaluated general, orthopedic, muscular, biomechanical and neurological plaster bandage and plastic film were used. The plastic film was used to isolate the patient´s skin and hair in order to ensure comfort and facilitate the removal of the mold, and then the plaster bandage was applied over the plastic film. The plaster bandage was dipped in warm water and the excess was removed, so that the plaster hardening time was shortened. Then, for removal in the model, silicone rubber and catalyst were used, which were used in the following proportion, for each 100 g of silicone rubber, 02% Catalyst (by weight) was added, after the partial curing time After 4 hours, the silicone model was removed from the mold, corresponding to the region of the stump to which the prosthesis will be fitted. Photographs of the model of the amputated pelvic region were taken, where the perspectives used for were: outer (thigh), frontal (knee)), interior (thigh), posterior (hock), front and rear diagonal. Based on these perspectives, the computational modeling of the stump was performed using the Blender software. In the current stage of the work, 3D modeling of the prosthesis is being made in conformity to silhouette of the pelvic region, at the end of the prosthesis modeling it will be printed on the Ender–3 printer, using 1.75mm thick PLA filament, then the prosthesis will be fitted to the stump and the dog´s gait will be followed by a veterinarian. The process of adapting the dog to the prosthesis will be introduced gradually, respecting the patient´s limits and tolerance.

Keywords: 3D Printing; Blender; Prosthesis; Amputation; Dogs.

* Universidade de Franca – UNIFRAN.



Three-dimensional drug printing

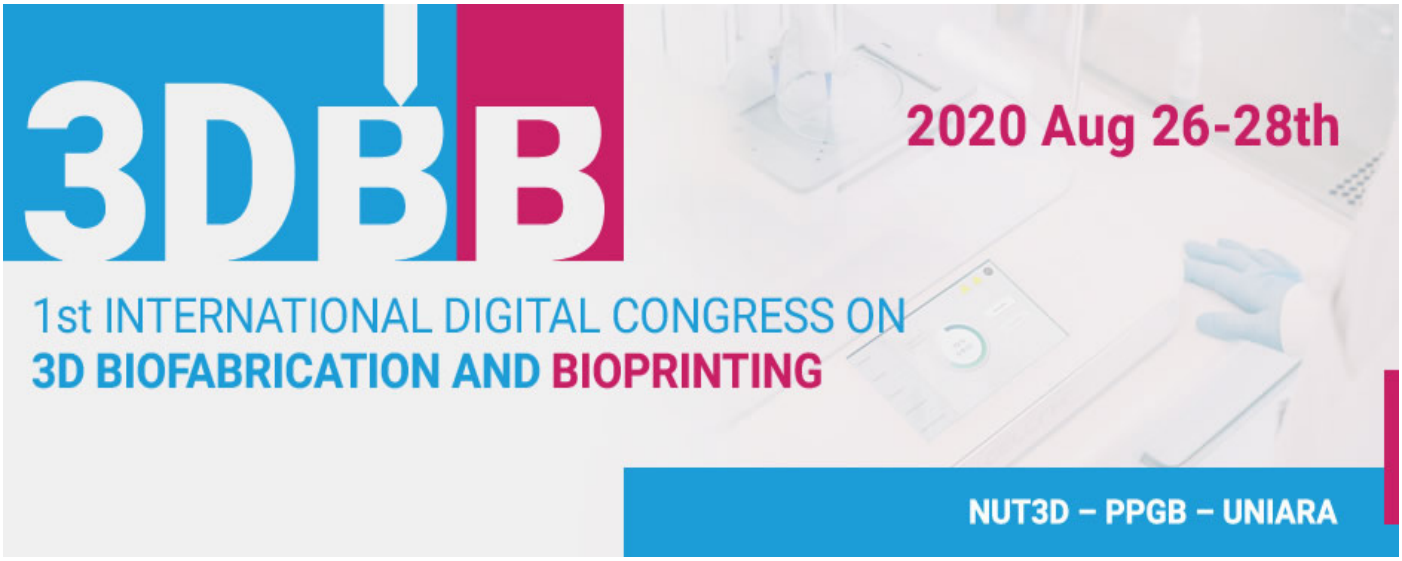
José Alberto Paris Junior; Maurício Cavicchioli**; Antonio Carlos Massabni**

(Biofabrication and bioprinting (in general)

Abstract: The pharmaceutical industry is heading for the Fourth Industrial Revolution. The growing interest in new medical devices or customized pharmaceutical and biomedical products has significantly impacted on the increase and interest in three-dimensional application. This technology is reshaping the way pharmaceuticals are designed, produced and used, allowing the development of new formulations and more complex dosages, making the production of personalized medication a reality in contrast to traditional pharmaceutical processes in terms of flexibility and customization in the manufacturing process. This pharmaceutical customization aims to maximize therapy in search of better clinical responses increasing patient safety and reducing side effects. In the Oncology area and in the researches focused on cancer treatment, this vision of more specific, individual, personalized and more efficient treatments becomes a great attraction and a necessity for the use of this new tool. The objective of this work is to develop new studies on pharmaceutical formulations based on bioactive binders and metal complexes for the controlled release of these compounds, following the procedure described by Öblom et al (1) for 3D printed isoniazid formulations in combination with pharmaceutical polimers possessing suitable properties for oral drug delivery. We hope to develop similar 3D printing tablets for selected bioactive ligands and their complexes with metals like zinc, silver, platinum and vanadium. 1. Öblom, H., Zhang, J., Pimparade, M., Speer, I., Preis, M., Repka, M., & Sandler, N. (2019). 3D-Printed Isoniazid Tablets for the Treatment and Prevention of Tuberculosis—Personalized Dosing and Drug Release. AAPS PharmSciTech, 20(2), 1–13. https://doi.org/10.1208/s12249-018-1233-7

Keywords: Binders; Metal Complexes; Pharmaceutical Formulations; Biomedical Products; Bioprinting.

* University of Araraquara (Uniara), 1217 Carlos Gomes St., Araraquara, São Paulo, Brazil.
** Department of Inorganic Chemistry, Institue of Chemistry, São Paulo State University (Unesp), 55 Proessor Francsco Degni St., 55, Araraquara, São Paulo, Brazil.



Biospeckle´s application: an analytical monitoring contribution to fungi inoculation first hours

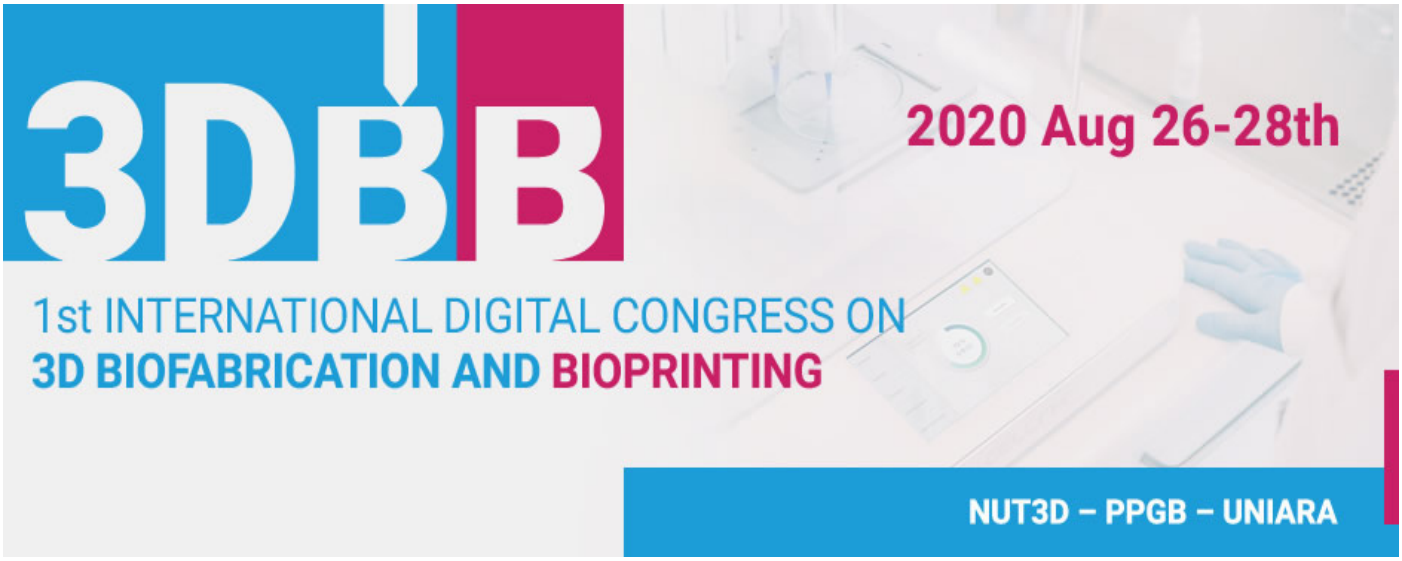
José Francisco Ferreira de Oliveira; Inacio Maria Dal Fabbro***

(Applications)

Abstract: Researches based on the application of Speckle, a technique based on the relationship of statistical interference originating at random, when the laser beam is applied to surfaces, has its appearance connected to the theory of light scattering, and this theory involves the process of interaction of light with matter. When the result of monitoring these analyzes of rough surfaces comes from one with biological activity, it is called Biospeckle. Our research proposal was to demonstrate the application of Biospeckle as a viable tool for monitoring and analyzing the possibility of biology activity in fungi on its first hours of inoculation. In order to demonstrate it, we used three indexes of biological activity analysis, namely: Moment of Inertia (IM), Differences of Absolute Values (AVD) and Speckle Space–Time (STS). By getting these indicators results, we obtained different fungi images in the first days of their incubation, evolving for the first hours, to measure the development of fungi in Petri dishes. When conducting the research, the used procedures were aiming to obtain results that could assist and help in the application of the Biospeckle in many stages of fungal incubation, but essentially on its first hours. The isolation of all filamentous fungi in their growth environment, used in this research work, was performed under aseptic conditions in the Vertical Laminar Flow Safety Chapel. It can be inferred that fungi inoculated in Petri dishes were radially developed in their early days. This process can be well observed by applying the randomly selected points distribution technique following a Gaussian distribution, which is a literature area analysis methodology, then it allows to present a new correction in the growth curve. Therefore, it is possible to follow the displacement of the nucleus of biological activity by varying the focus, applying the Gaussian distribution. All in vitro experimental research procedures were performed at the Mycology Laboratory of the Faculty of Food (FEA / UFLA. The") and at the Optics Laboratory (FEAGRI / UNICAMP). The fungi were provided by the library of the Collection of Culture of Microorganisms (CCDCA), located in the Laboratory of Mycology and Mycotoxins within the Department of Food Science at UFLA. The. The developmental analysis showed to be quite fruitful, demonstrating that the laser Biospeckle technique revealed to be a good monitoring tool in the first hours of growth for both genus.

Keywords: Biospeckle; fungos; "Moment of Inertia (IM); Differences of Absolute Values (AVD) and Speckle Space–Time (STS)".

* Instituto Federal de São Paulo IFSP.
** Universidade Estadual de Campinas (Unicamp).



Developing a new file standard for bioprinting

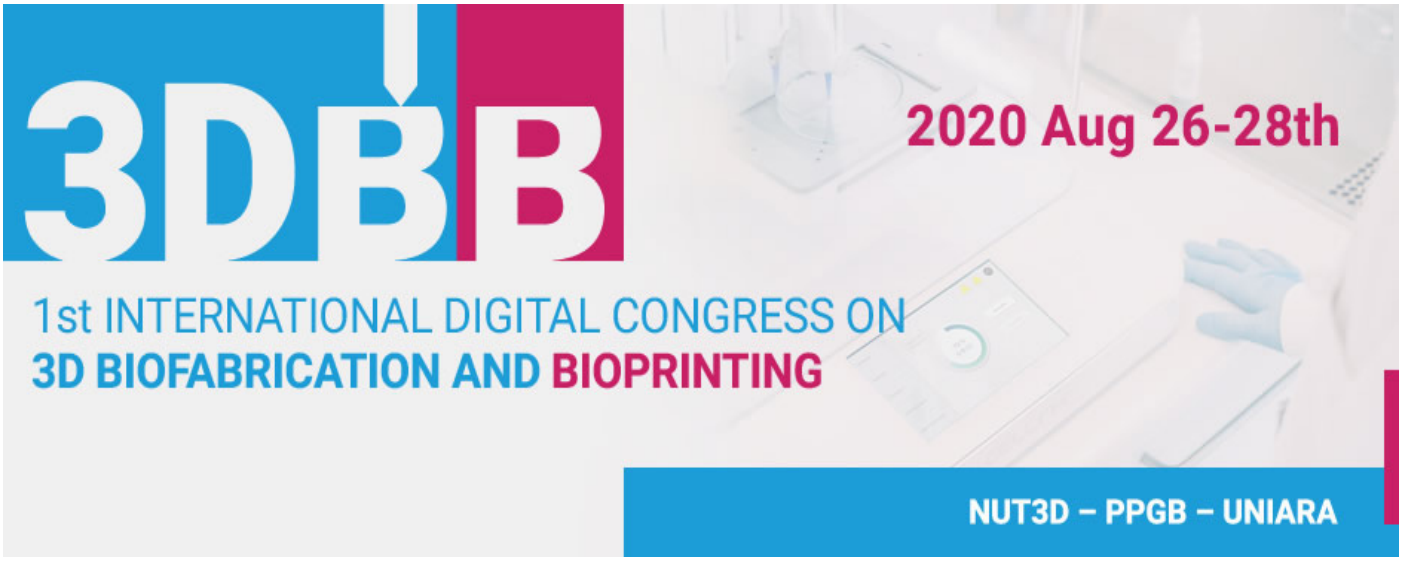
Juliano Marcello; Rodrigo Alvarenga Rezende***

Biofabrication and bioprinting (in general)

Abstract: Biofabrication is a multidisciplinary research area that has several challenges to be overcome in all areas of knowledge involved in the process so that in the future it is possible to obtain biofabricated tissues and organs. In the area of computing, much has been adapted to 3D printing systems, such as software, methods and files, making the integration and interoperability of data complex and still inefficient, requiring improvements and innovations. A classic example of the use of adapted methods is the use of design software for modeling the design of the fabric that will be biofabricated. Another example is the use of traditional ".STL" files (Stereolithography format) to transfer information related to the project to the (bio) 3D printer. However, the STL standard has a limitation in carrying other more specific information and, therefore, is a format that will not be very efficient in the process of bioprinting complex living structures. Even within the scope of Additive Manufacturing, alternatives to STL files have already emerged, as is the case with AMF (Additive Manufacturing File format) files. The creation of this pattern brought advantages in relation to the STL, making it possible to include information such as the representation of colors, textures, materials, substructures and other properties of the objects to be manufactured. As for the "non-living" objects to be printed three-dimensionally, there is a need for some properties to be incorporated into the project file for bioprinting with specific characteristics of the tissue or organ to be biofabricated. In this sense, the objective of the work is to understand which parameters will be necessary for bioprinting considering, for example, the rheological behavior of biotints, as well as equipment parameters, and to create a file format that includes this information and can be imported and interpreted by the bio-printer making it possible to build living structures that are organized, maturable and implantable. For this, it is intended, among a wide range of computational resources, to use free and open source software InVesalius dedicated to the treatment of medical images, and to create a necessary extension so that the essential properties can be inserted in the project and generate the data in the new format.

Keywords: Bioprinting; Biofabrication; Design; STL File.

* Post-Graduate Program in Biotechnology (PPGB), University of Araraquara (Uniara), Araraquara, SP, Brazil.
* Renato Archer Information Technology Center (CTI), Campinas, Sp, Brazil.



Swab development study by additive manufacturing: open access design selection and preliminary testing

João Pedro I. Varela; Alex F. De Lima*; Ygor C. M. De Lucena**; Vanderlino B. S. Júnior**; Nadja M. Da S. Oliveira***; Wanderley F. De A. Júnior**

(Devices and processes)

Abstract: Nasopharyngeal (NP) swabs are necessary to collect samples for COVID–19 testing. The aim of this research is the preliminary open source design swab study manufactured by 3D print: design and preliminary tests. For development of the first prototype in this research, it was used a methodology that consists: informational design, conceptual design, preliminary design, detailed design, manufacturing and testing. Then, two prototypes were generated, one is the open source design swab, available in a research carried out by CTC with the Virtual Hospital Valdecilla, and a device that was used in one of the tests. For manufacturing, 3D printing equipment model Anycubic Photon and 3D resin Odorless green, supplied by 3D Fila, were used. Finally, handling tests were performed (Swab bending tests at 90 and 180 degrees, head bending test, breakpoint rupture test and absorption test). This methodology was based on the tests presented in the literature to support this research. The 90° and 180° bending tests were successful, showing the tough of swab stem to bending. The head bending test showed there isn't so much deflect due to high stiffness, reaching a value at about 6.5 degrees before rupture. The breakpoint test was performed in two ways and both occurred correctly. Finally, the ab–sorption test, which the swab showed a fluid absorption at about 0.1g (50% less than a common swab, used as a control group). Thus, it was possible to carry out, in the first stage of this research, requirements, specifications, dimensions, design, simulation analysis, experimental methodologies and swab parts functions. In addition, on the second stage of research, it was carry out design selection, first swab prototype additive manufacturing and initial preliminary tests.

Keywords: COVID–19; Swab; Open Source Design; Handling Tests; Additive Manufacturing.

* Universidade Federal de Campina Grande.
** Phaser Studio 3D Print.
*** Fundação Parque Tecnológico da Paraíba.