We conducted creep experiments on CFs from and mouse tail tendon collagen fibrils and nano DMA experiments on obth CFs and electrospun PLLAs. Both experiments are facilitated through a recently developed instrument then NanoTens, for testing of nano- and microscale fibers with quick coupling and uncoupling [3].

In creep experiments we show that the transient behaviour at medium strains can be empirically described using a linear Burgers model in Kelvin-Voigt configuration. Here elastic elements exhibit moduli in the range of 0.2-10 GPa and viscous elements exhibit viscosities in the range of 102-104 MPa.s for the dashpot within the Kelvin-Voigt body and 103-106 MPa.s for the dashpot in series.

In nano DMA experiments We observe similar elastic behavior in monotonic tensile tests and elastic response in nanoDMA for CFs and PLLAs. However, the loss modulus and tangent of PLLAs is significantly higher compared to CFs. This warrants room for further optimization of PLLA material properties.

In conclusion, the the NanoTens opens the door for assessing the time-dependent properties of indivudal CFs and thus to establish a unified constitutive CF model.

1. Sensini and Cristofolini, Materials, 11(10), 2018.

2. Sensini et al., Front.Bioeng.Biotech. 2(9), 2021.

3. Nalbach et al., Rev. Sci. Instrum., 2022. Rev.Sci.Instrum. 93 2022

## Triaxial electrospun fibers for prolonged drug release

**S. Tabakoglu, D. Kołbuk, P. Sajkiewicz**

Institute of Fundamental Technological Research, Polish Academy of Sciences, Poland

Electrospun nanofibers are a challenging system for effective and targeted drug delivery in tissue engineering applications. The triaxial technique is a fairly new method under investigation. The fibers obtained by this method consist of three layers: a core and two layers surrounding the core. Triaxial electrospinning is a competitive method to solve the critical limitations in other techniques, i.e. uniaxial, and coaxial, such as lack of sustained and controlled drug release, poor solubility of drugs, problems with loading multiple drugs, and biodegradation, not adequate biocompatibility.

The first objective of the research is to optimize the manufacturing process using triaxial electrospinning to get homogenous-free beads fibers and beneficial effects on drug release.

For the development of the fibers, a combination of biodegradable synthetic and natural polymers were used: polycaprolactone (PCL) (core layer), poly(lactic-co-glycolide) (PLGA) (shell layer), and gelatin (intermediate layer). Natural polymer improves biocompatibility, while the combination of PCL and PLGA is expected to maintain preferred structural properties e.g. hydrophilicity and morphology. As a model of the drug, Rhodamin B (Rh B) was loaded for the optimization process.

Preliminary investigations including optimization of manufacturing triaxial fibers are discussed. Microscopic images demonstrated homogenous free-beads fibers were developed as a result of many trials. Furthermore, it was observed fibers are covered with an outer layer according to the expectancy. Under the shell layer, there is a middle surrounding the core layer indicating that the proposed process with parameters selected in this way allows producing of core-shell fiber structure. Preliminary *in-vitro* studies were performed with Rh B to investigate release profiles from triaxial fibers compared to coaxial fibers. The results showed triaxial fibers decreased initial burst release significantly over the coaxial fibers.

The research reported here shows triaxial fibers as promising biomaterials that can be used as novel drug delivery systems in biomedical applications.

## Synthesis and characterization of drug loaded hybrid mesoporous silica particles for biomedical applications

**A. Witecka[1], G. Rydzek[2], C. Gerardin[2]**

[1]Institute of Fundamental Technological Research, Polish Academy of Sciences, Poland; [2]Institut Charles Gerhardt, University of Montpellier, France

Mesoporous silica materials are promising candidates for drug delivery systems, due to their high specific surface area, large pore volume, ordered network and narrow pore size distribution.

Traditionally, non-ionic or ionic surfactant micelles were used as a structure directing agent of silica. However, a polyion complex (PIC) assembly, which is based on interactions between a pH stimuli-responsive double-hydrophilic block copolymer (DHBC) with a weak polyamine, benefits from functional hybrid silica mesoporous shell and a tuneable stimuli responsive copolymeric core [1]. This gives them specific functionalities, such as the ability of drug encapsulation and release in a specific pH[2].

In this study, silica particles were prepared by (i) micellization of cationic surfactant cetylpyridinium chloride (CPC), (ii) PIC assembly of neutral-ionizable poly(ethylene oxide)-block-poly(acrylic acid) copolymer (PEO-b-PAA)/CPC and silica condensation. CPC it's an oral antiseptic and it was used both as an active component of PIC assembly, due to electrostatic complexation with CPC/-PAA at pH > 4.5 and antibacterial drug which can be released from pores below pH 4.5.

FTIR and ICP confirm presence of CPC or CPC/DHBC components in obtained silica powders. DHBC has a positive impact on decreasing size of particles, improving their homogeneity and imputes mesoporosity depending on synthesis conditions: DHBC concentration, complexation between the carboxylate (AA) and amine (N) groups, ratio between the Si species/EO units. In the CPC-based system, particles are in the size range of 46-535 nm with majority ~150 nm, while in the DHBC/CPC system particles are below 50 nm. BET surface area increases from 129.4 $m^2/g$ for CPC-based silica to up to 1045 $m^2/g$ for CPC/DHBC-based silica. TEM confirms mesoporous structure for CPC/DHBC particles. Kinetics of the CPC uptake was evaluated by UV-Vis at pH of 1, 3 and 7.4 and confirms a pH stimuli-responsive release at pH 1 and 3.

[1] https://doi.org/10.1002/anie.200802431

[2] https://doi.org/10.1021/acs.langmuir.5b03221

## Development and characterization of zein-based coatings incorporating fluoride- and copper-doped bioactive glass on titanium for biomedical applications

**Z. Hadzhieva[1], K. Cholewa-Kowalska[2], T. Moskalewicz[3], I. Dlouhy[4], A. R. Boccaccini[1]**

[1]Institute of Biomaterials, Department of Materials Science and Engineering, University of Erlangen-Nuremberg, Germany; [2]Faculty of Materials Science and Ceramics, AGH University of Science and Technology, Poland; [3]Faculty of Metals Engineering and Industrial Computer Science, AGH University of Science and Technology, Poland; [4]Institute of Physics of Materials, Czech Academy of Sciences, Brno, Czech Republic

The long-term application of metallic implants is limited due to their poor osseointegration capability and proneness to bacterial infections. In order to tackle these issues, the surface of the metallic implant can be coated with bioactive and antibacterial organic-inorganic composite coatings, e.g., by using electrophoretic deposition (EPD) [1,2]. Thus, the present work aims to develop coatings based the natural polymer zein and $SiO_2$-CaO-$P_2O_5$ bioactive glass particles (BG) doped with fluoride (BG-F) and copper (BG-F-Cu) on titanium by EPD. Morphological observations demonstrated that the glass particles were homogeneously embedded in the polymeric coating matrix, while pull-off and tape tests indicated that the addition of BG particles improved the coating adhesion to the substrate. Nanoindentation measurements and scratch tests showed that zein/BG coatings possessed higher hardness and improved scratch resistance in comparison to zein/BG-F and zein/BG-F-Cu coatings. The ion substitution in the BG structure did not affect the bioactivity of the coatings as apatite formations could be detected on all composite coatings after 3 days of immersion in simulated body fluid (SBF), according to FTIR, XRD, SEM and EDX analyses. All composite coatings showed decreased wettability, higher susceptibility to collagenase degradation and lower swelling capability than pure zein coatings. Both direct and indirect cytocompatibility assays revealed significantly improved viability of osteoblast-like MG-63 cells on all composite coatings after 1 and 3 days of incubation. Moreover, the presence of ion-doped bioactive glass endowed antibacterial activity of the coatings against Gram-positive *S. aureus* and Gram-negative *E. coli* as confirmed by Alamar blue assay and SEM observations. The obtained results prove that the prepared coatings can be promising candidates to facilitate bone tissue integration and to prevent infections around orthopaedic and dental implants.

[1] Maciag et al., Materials, 14, 2021, 312.

[2] Meyer et al., Coatings, 8, 2018, 27.

## Alteration of vimentin cytoskeleton in senescent cells

**R. Khoshnevisan**

Ludwig Boltzmann Institue for Traumatology, Austria

Cellular senescence occurs in response to various triggers, including DNA damage, telomere dysfunction, oncogene activation, and organelle stress. It has been linked to tumor suppression, tissue repair, embryogenesis, and organismal aging. It is known that senescent human fibroblasts show an increase in an intermediate cytoskeletal protein, vimentin, yet the senescence-associated alteration of the function of vimentin in senescent cells is largely unexplored.

Here, we present unpublished results showing that vimentin accumulates in senescent cells and forms a highly compacted, juxtanuclear, and monopolar structure. Vimentin accumulates in close proximity to the nucleus, and our findings indicate an association between the accumulation of vimentin and the deformation of the nucleus in senescence. We demonstrate that nuclei of senescent cells showing deposition of vimentin have further increased number of DNA damage foci and display chromatin structure