Twinning to excel materials engineering for medical devices

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- **Research topics**:
- Dental and denture composite materials
- Drug delivery systems
- Scaffolds
- **Research expertise**: Processing and
- characterisation of biomaterials
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Dental composites

The use of different alumina fillers for improvement of the mechanical properties of hybrid PMMA composites

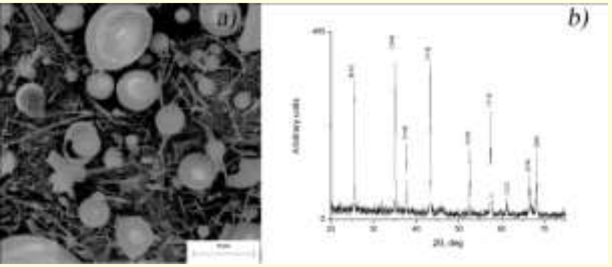

Fig. 1. FESEM micrograph of the electrospun fillers, b) XRD pattern of the bimodal alumina product calcinated at 1100 °C.

The goal of this research was to examine the feasibility of using electrospun alumina fillers as reinforcement for PMMA-based hybrid composite materials. The influence of the size and shape of electrospun alumina fillers on the mechanical properties of the hybrid composites was studied and compared with
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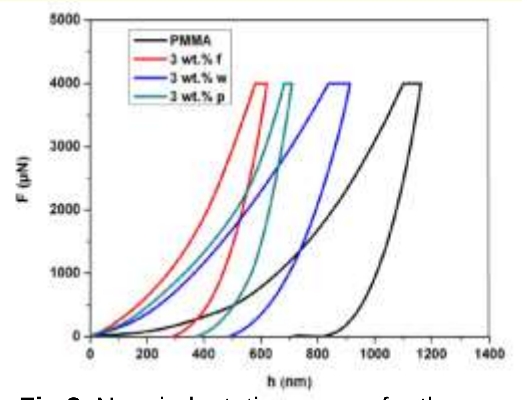


Fig.2. Nanoindentation curves for the best performing specimens obtained using electrospun alumina fillers

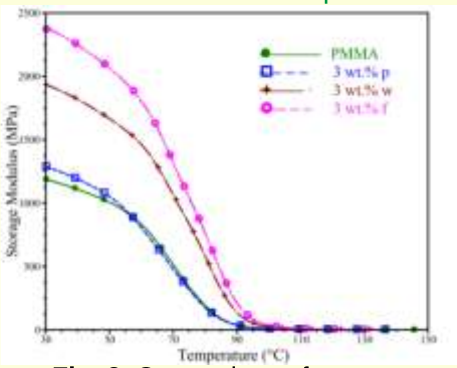
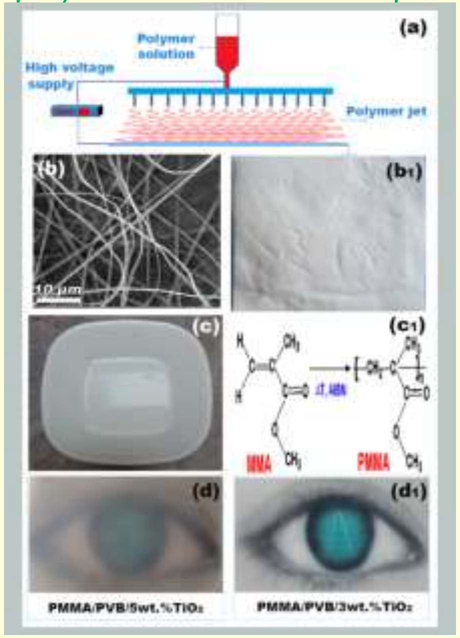


Fig. 3. Comparison of storage modulus of a PMMA matrix with alumina fillers of different shapes.

Hybrid acrylic nanocomposites with excellent transparency and hardness/toughness balance

- Composite nanofibers produced by a fast multi-needle electrospinning process
- The hybrid coating films were prepared by *in-situ* polymerization/cast technique



Scheme 1. Presentation of the preparation of transparent acrylic nanocomposites

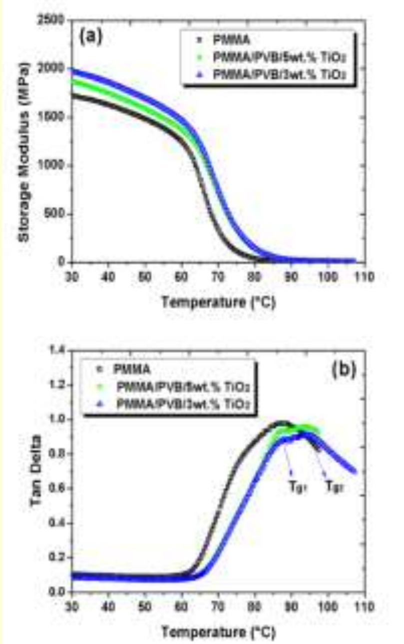


Fig. 2. Storage modulus and Tan Delta versus temperature curve for all the PMMA sample

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Drug delivery

Formulation and characeterization of nanofibers and films with carvedilol prepared by electrospinning and solution casting method

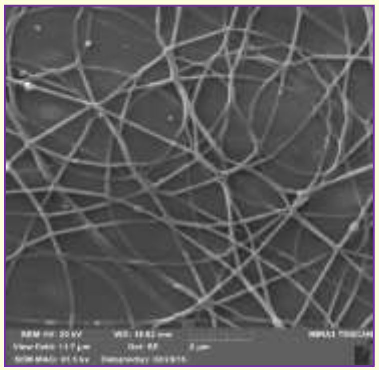

Fig. 1. FESEM of nanofibers with carvedilol

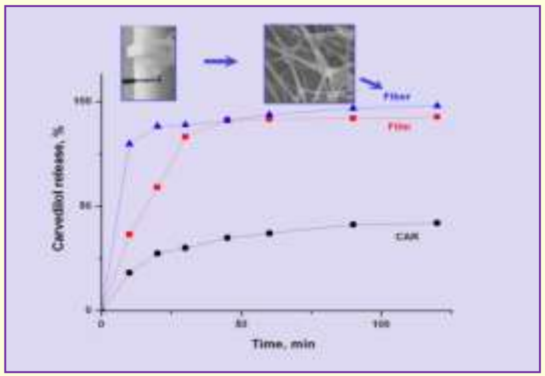

Fig. 2. Carvedilol dissolution profiles from various formulations and pure carvedilol

Table1. Predicted PK parameters for various formulations

Parameter	Fa* (%)	F** (%)	C_{max} (ng/ml)	t_{max} (h)	$AUC_{0-\infty}$ (ng h/ml)
Pure drug	66.27	19.89	16.9	1.84	142.20
IR tablet	97.92	29.38	28.67	2.4	189.53
Oral film	95.93	28.81	38.26	2	188.37
Nanofibres	99.99	30.03	38.52	2	193.82

Cefazolin-loaded polycaprolactone fibers produced via different electrospinning methods

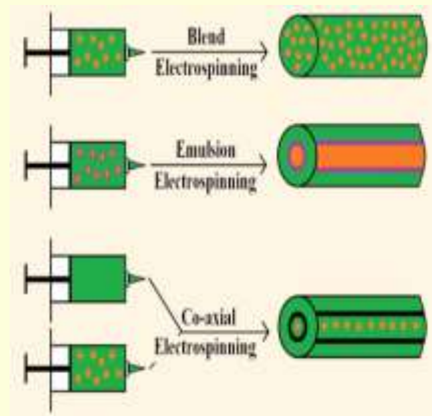

Fig.1. Schematic displays the cross-section of an individual fiber produced

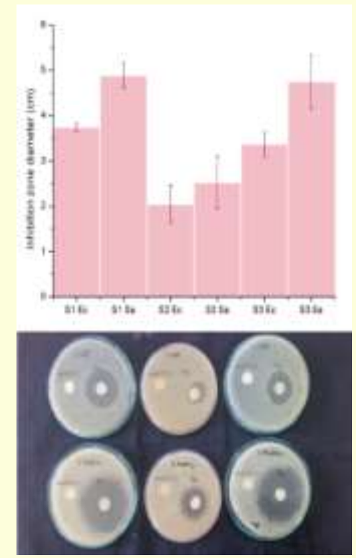

Fig.2. Inhibition zone diameter of fiber mats against *E. coli* and *S. aureus*

The produced materials are suitable for antibacterial gauzes, post-surgical treatments in order to prevent infections, as a coating for commercially available catheters, but we specifically focused on urinary catheters. Therefore, cefazolin-loaded fiber mats from S1 and S3 could be used as short-term catheters, while the obtained fiber mats from S2 could have a role as a long-term catheter.

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Drug delivery

Mucoadhesive gelatin buccal films with propranolol hydrochloride: evaluation of mechanical, mucoadhesive and biopharmaceutical properties

Due to the extensive first-pass metabolism in the liver, the drug bioavailabilty following peroral dosing is notably decreased. With buccal films that will be avoided.

Table 1. Predicted pharmacokinetic parameters following the administration of the tested buccal films and the conventional immediate-release (IR) tablets

Formulation	Dose (mg)	Cmax (ng/ml)	tmax (h)	AUC0-∞ (ng h/ml)	Fa (%)	F (%)
F1	30	66.80	2.88	612.20	99.99	99.99
F2	30	66.80	2.80	600.99	99.99	99.99
IR tablet	80	98.24	1.04	644.23	99.90	35.96

Fig. 1. Samples for dissolution test

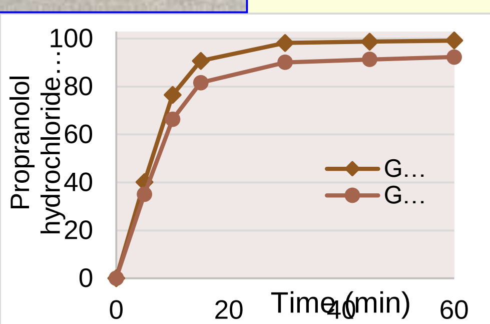

Fig. 2. In vitro release study

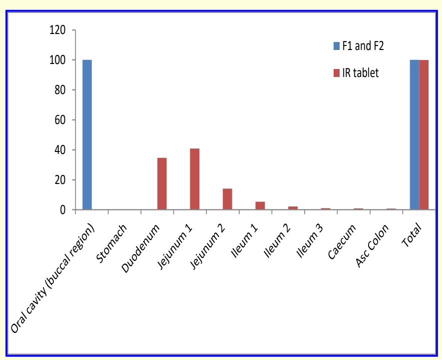

Fig.3. Predicted regional absorption profiles for the tested 30 mg propranolol formulations and 80 mg propranolol IR tablets

3D semi-solid printing of buccal films and scafolds

Fig. 1. 3D printer Ultimaker 2+, + DISCOV3RY Paste extruder

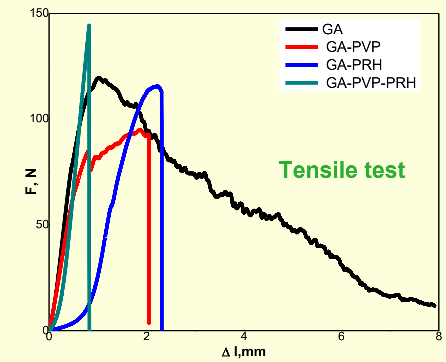

Fig. 2. Results of tensile test

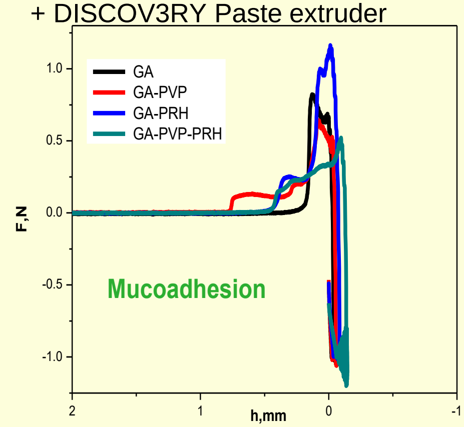

Fig. 3. Results of mucoadhesion test

Fig. 4. 3D semi solid printing

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Preparation and modeling of three-layered PCL/PLGA/PCL fibrous scaffolds for prolonged drug release

Innovation: The authors present the preparation procedure and a computational model of a three-layered fibrous scaffold for prolonged drug release. The scaffold, produced by emulsion/sequential electrospinning, consists of a poly(D,L-lactic-co-glycolic acid) (PLGA) fiber layer sandwiched between two poly(ε-caprolactone) (PCL) layers.

PCL – Poly (ε-caprolactone) 1st and 3rd layer

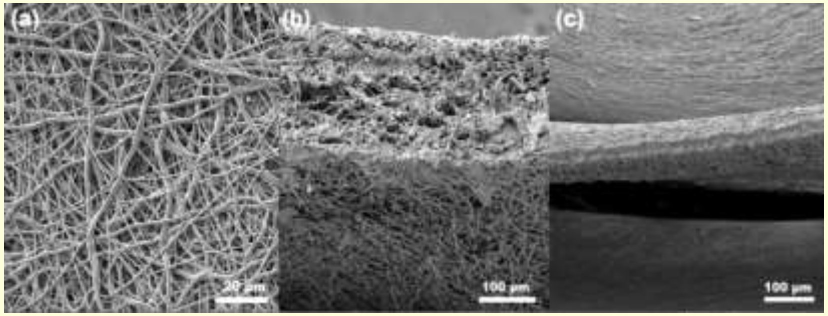

Fig. 1. FESEM images showing morphologies of the nanofiber mats of the PCL layer (a, b) and tri-layered fibrous scaffold(c)

PLGA – poly (lactic-co-glycolic) acid 2nd layer

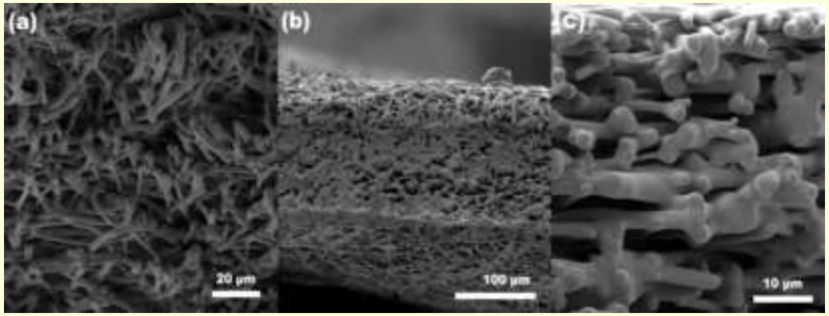

Fig. 2. FESEM images showing morphologies of the nanofiber mats of the PLGA layer (a-c)

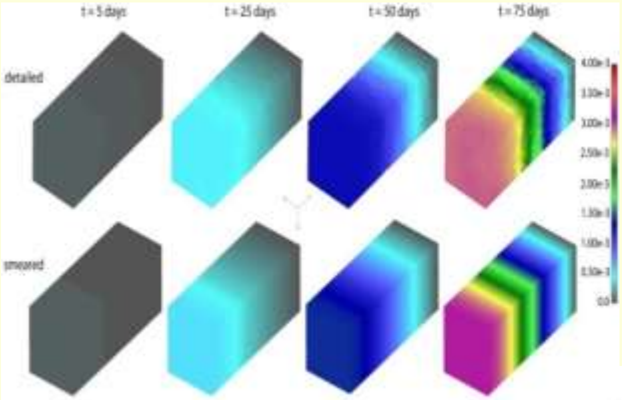

Fig. 3. Three-layered PCL/PLGA/PCL scaffold concentration field for surrounding domain of the smeared model

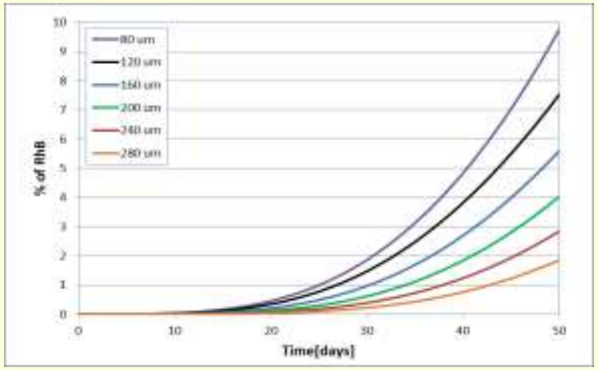

Fig. 5. Parameter-based prediction of the model: release depends on layers thickness

Fig. 4. Images of PLGA and PCL circle layers

Our unique scaffold system can be used for localized drug release and potential post-surgical cancer treatment twenty-one days after surgery.

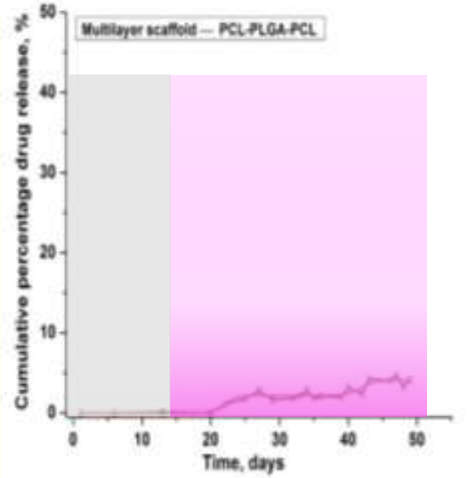

Fig. 6. Novel time-controlled scaffolds

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Facilities

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- **Processing of biomaterials:** Solvent casting/Spin coating, Hot isostatic pressing, Electrospinning, 3D printing
- 3D printer Ultimaker 2+, Nederland + DISCOV3RY Paste extruder, USA
- Noztek Pro Filament Extruder, Noztek Ltd, England Electrospinner CH-01 (Linari Engineering, Italy) that consists of a single/multi-needle system or coaxial needles fed by 2 independent pumps (R-100E, RAZEL Scientific Instruments) and high-voltage power supply (Spellman, 50 kV),
- Laurell Spin Coater 400B (Laurell Technologies, USA),
- Thermogravimetric analyzer with differential scanning calorimeter (TGA/SDT-Q600 (TA Instruments),
- Differential scanning calorimetry Q10 DSC (TA Instruments), DMA Q800 (Dynamic Mechanical Analyzer (TA Instruments),
- Hydroshot HITS-P10 Impact testing machine (Shimadzu),
- Texture Analyzer EZ Test LX (Shimadzu), TI 950 TriboIndenter, (Hysitron),
- LGG UNISPEC 2 UV/Vis Spectrophotometer, 190-1100 nm,
- CX43 Biological LED Upright Microscope (Olympus)

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Needs

Cooperation related to biocompatibility testing:

- **incorporation of advanced methods**
- **training of younger researchers**
- **complementing knowledge in basics of in vitro and *in vivo* testing**

Implementation of implants or drug delivery carriers

- **Improvement of strategic overview in the field**
- **Methods of characterization related to potential commercialization paths**

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