Nano Innovation 2017 Rome, 26-29 September
Conference & Exhibition

Rapid prototyped nano composite magnetic scaffolds for osteochondral tissue regeneration

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IPCB INSTITUTE FOR POLYMERS, COMPOSITES & BIOMATERIALS

Outlines

Additive Manufacturing

- opportunities in Tissue Repair & Regeneration

Nano-composite magnetic scaffolds

- Iron Oxide & Iron doped Hydroxyapatite (MNPs)
- PCL/MNPs PEG/MNPs nanocomposites
- Properties of superparamagnetic scaffolds

Features of superparamagnetic scaffolds used in conjunction with magnetically labeled cells

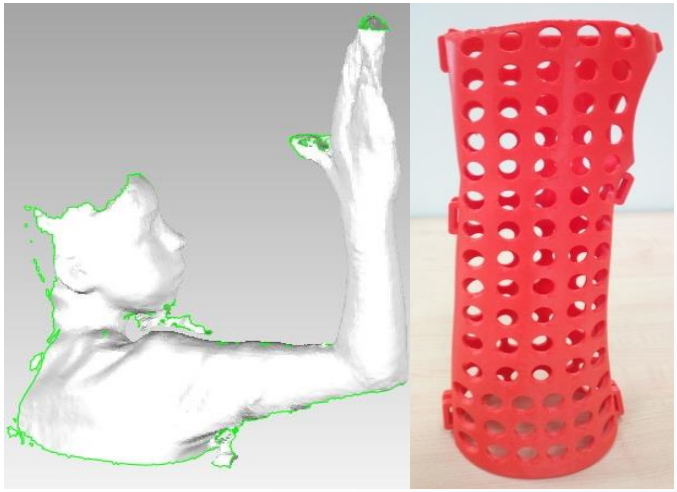
RP of nanocomposite scaffolds for osteochondral tissue regeneration

Additive Manufacturing opportunities in the MedTech industry (non-implantable devices)

Indirect Application of AM (molding)

Ink-jet

STL

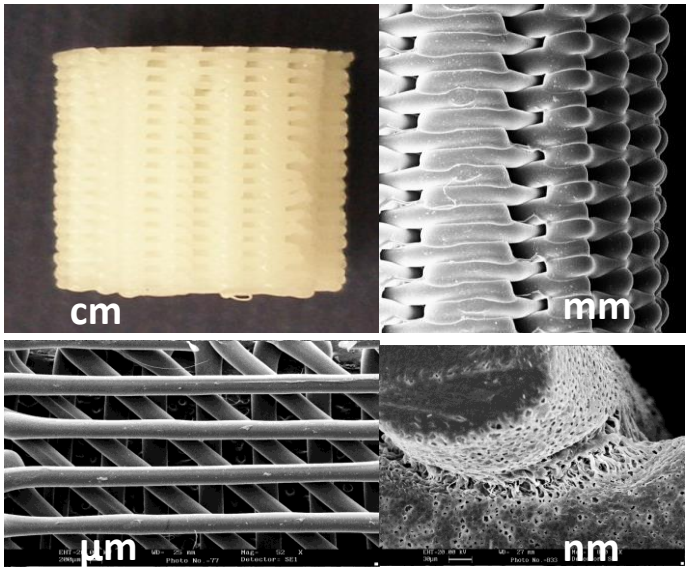


FDM

Spraybase

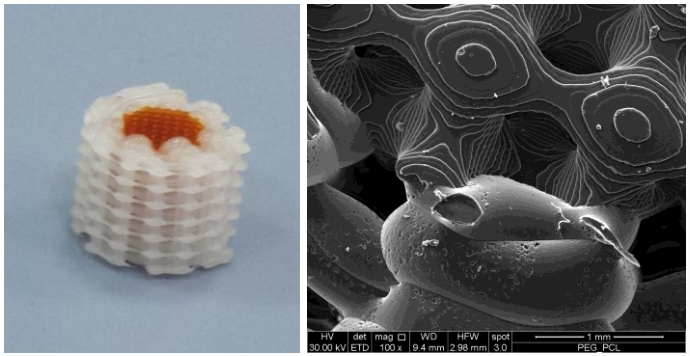
Direct Application of AM

Additive Manufacturing opportunities in the MedTech industry (implantable devices)

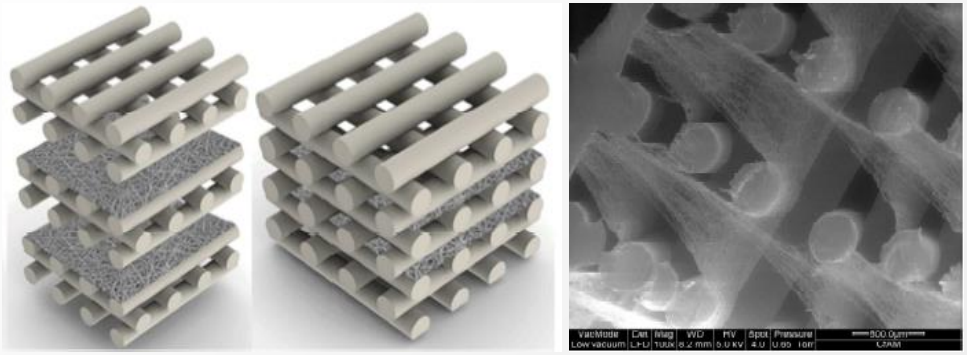


3D Bioplotting in conjunction with solvent casting/phase inversion

MSC-loaded collagen-LMW HA-4S-StarPEG sIPN

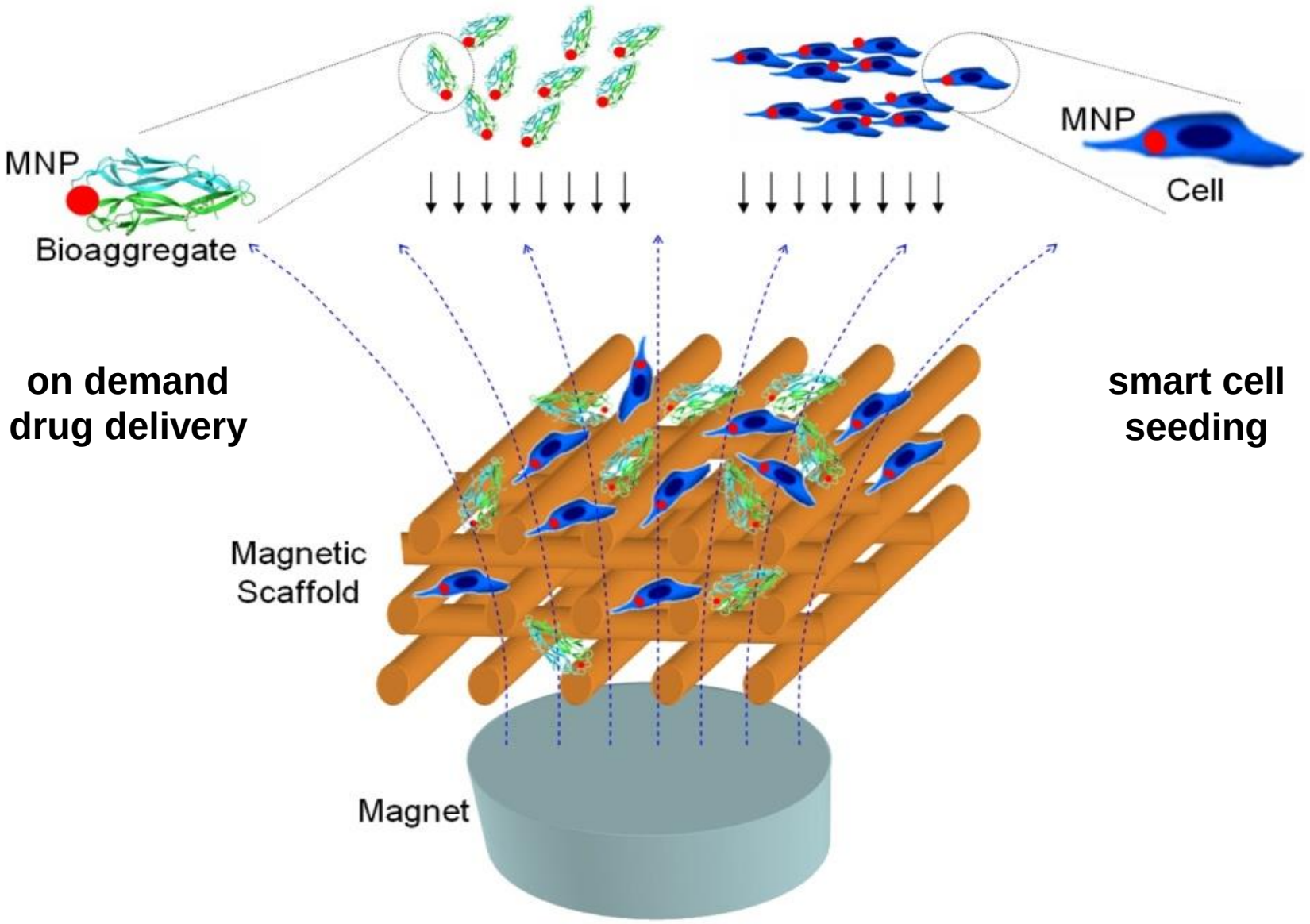


Combination of 3D Photo-Printing and 3D Fiber Deposition techniques



Combination of 3D Fiber Deposition Technique and Electrospinning

Rationale for manufacturing magnetic scaffolds



Iron Oxide & Iron Doped Hydroxyapatite MNPs

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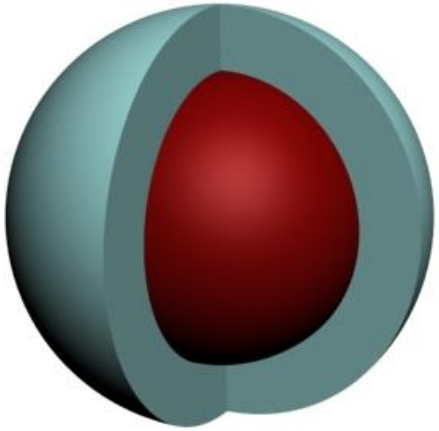
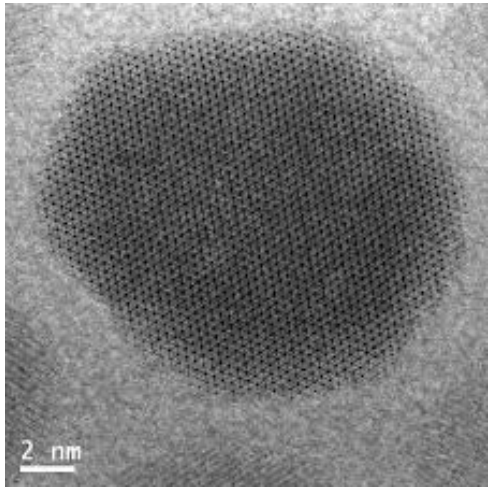
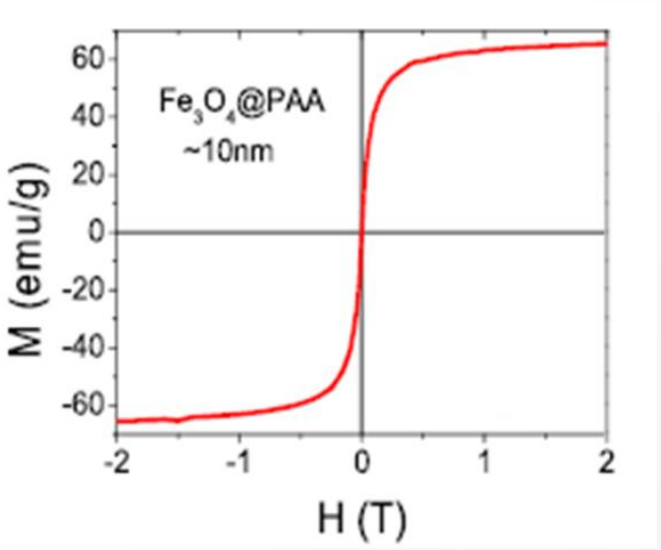
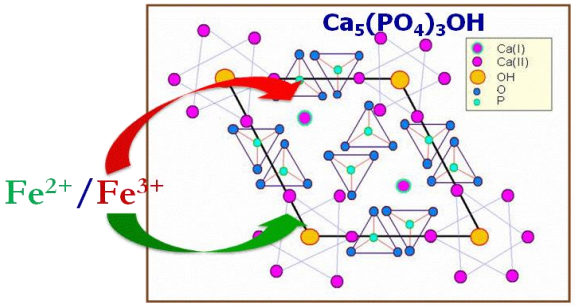
Superparamagnetic nanoparticles



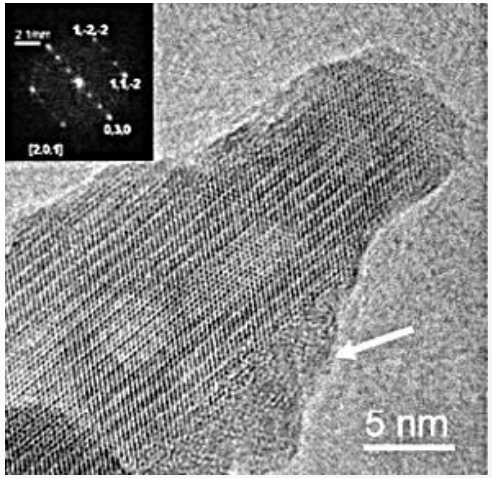
Fe_3O_4@PAA

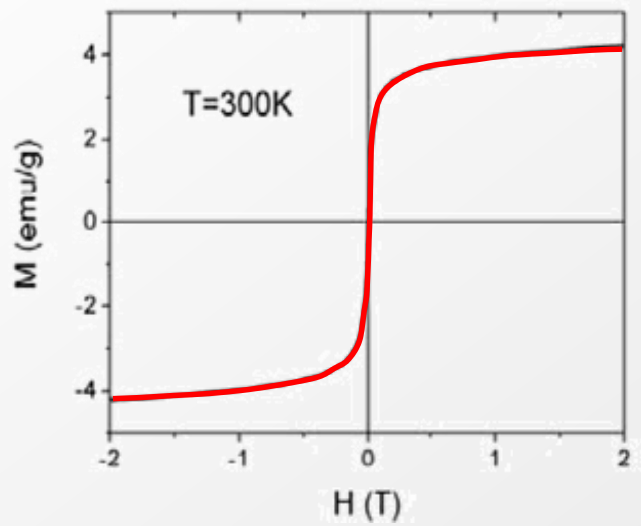






FeHA

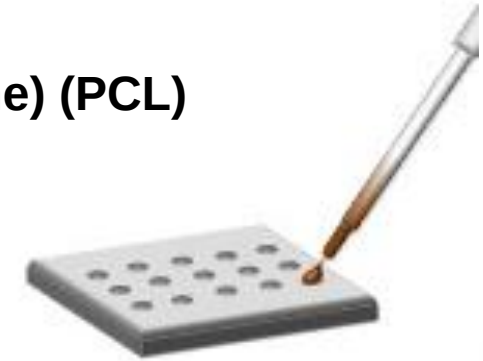


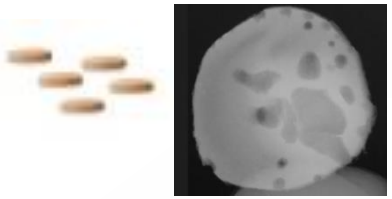


PCL/MNPs & PEG/MNPs nanocomposites

PCL/MNPs
90/10 to 50/50 w/w

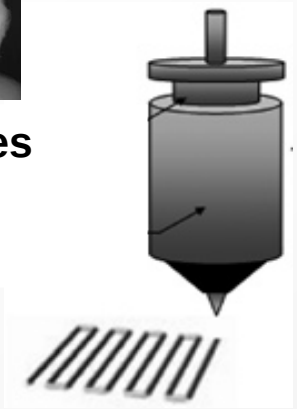
Poly(ε-caprolactone) (PCL)





2D nanocomposites
pellets

Moulding & Solvent Casting
Teflon Mould

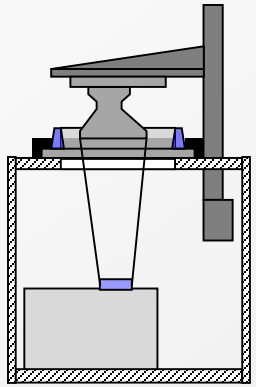


3D Fiber Deposition

Stirring & Sonication
PCL/MNPs & PEG/MNPs solutions

Poly(ethylene glycol) diacrylate (PEGDA)

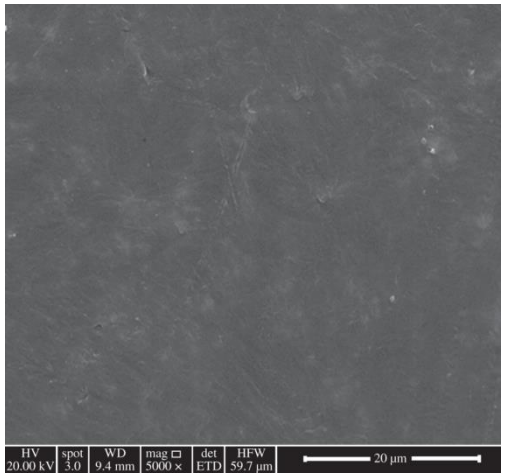
Lucirin-TPO photoinitiator

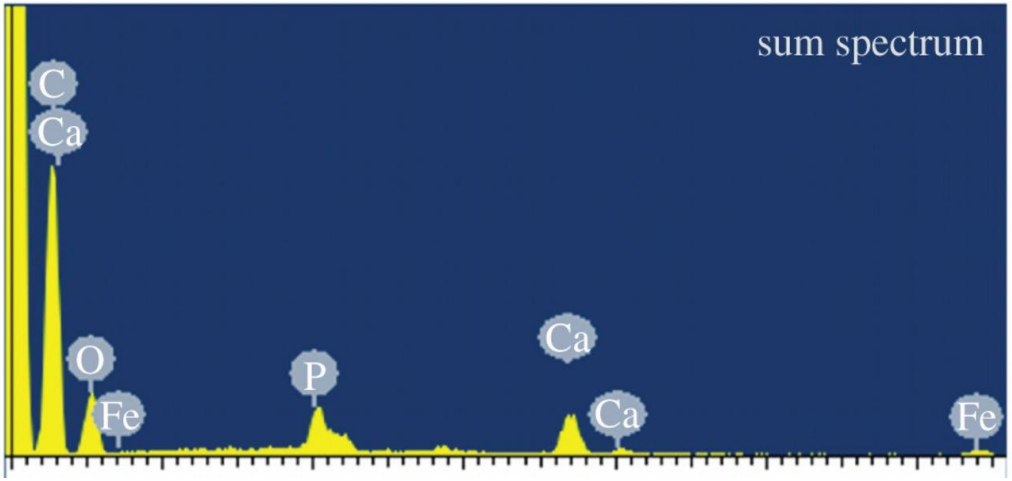


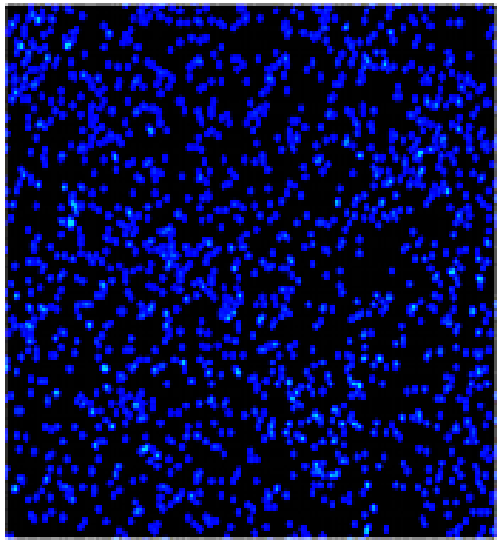
Stereolithography

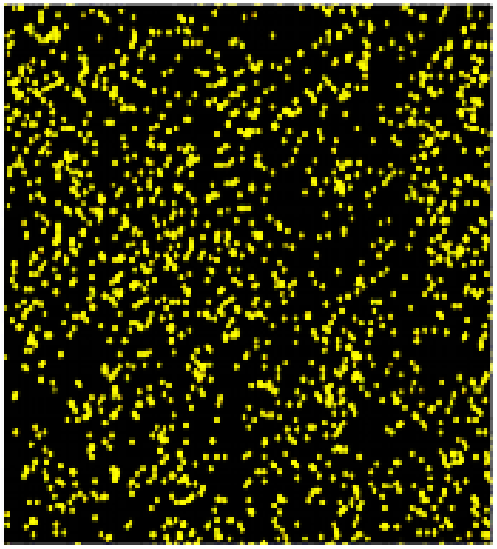
PCL/MNPs nanocomposites

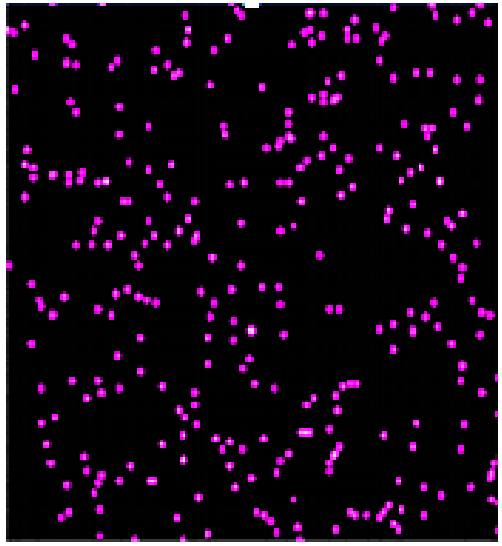
PCL/FeHa 80/20







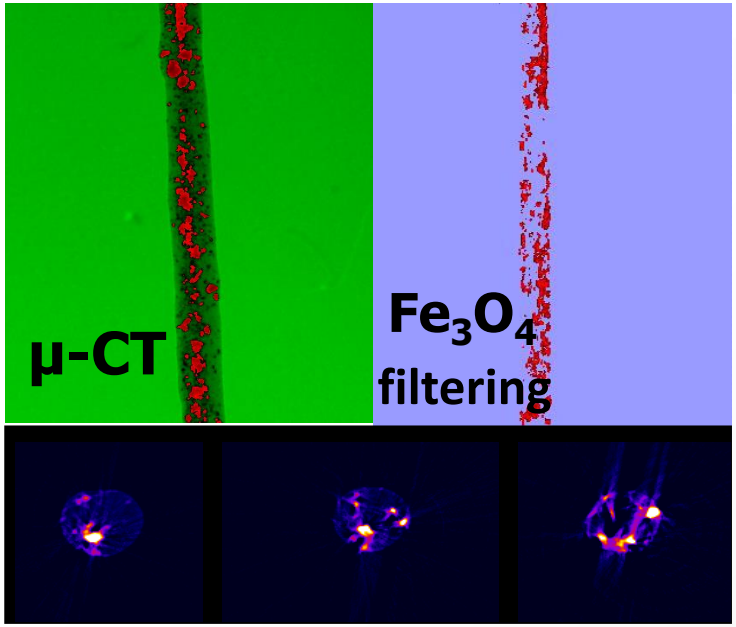


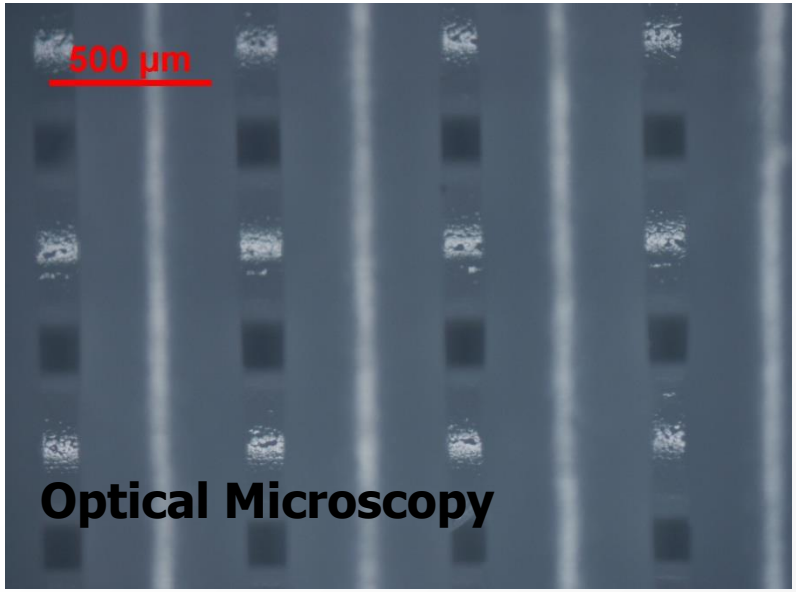


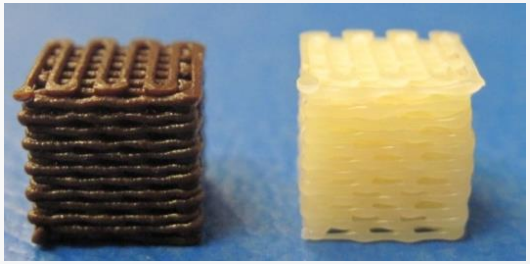
P Ca Fe

PCL/MNPs imaging

fiber

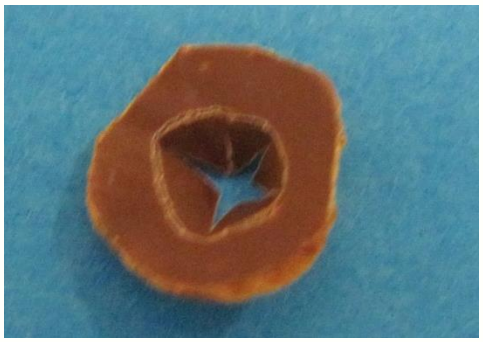






3D scaffold

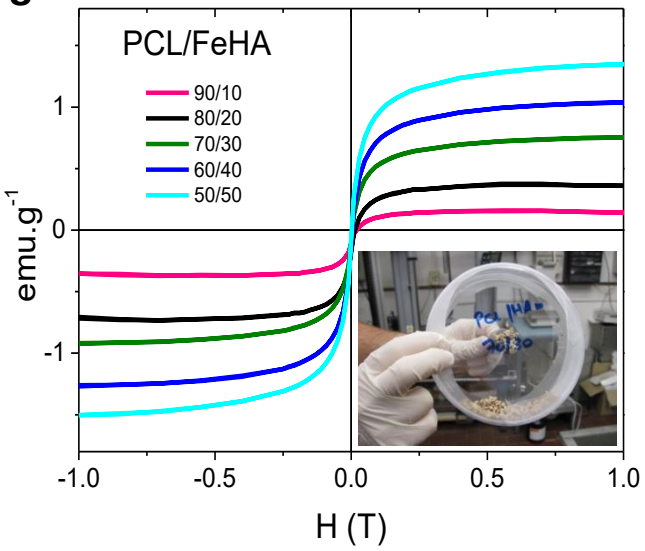
Effects of MNPs amount

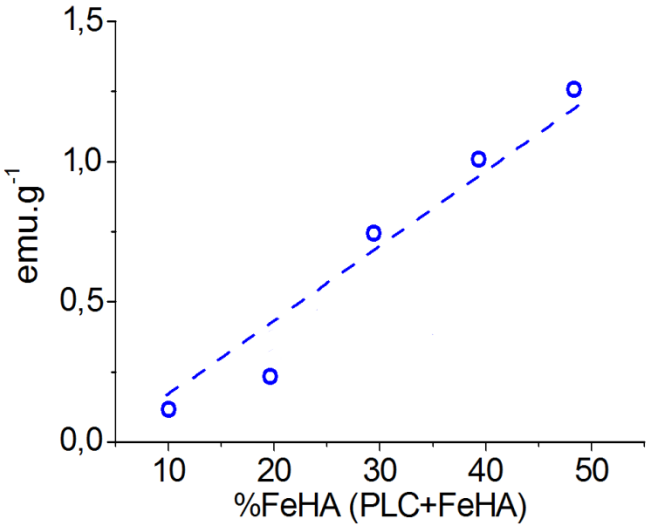


Small-Punch Test (ASTM 2183)

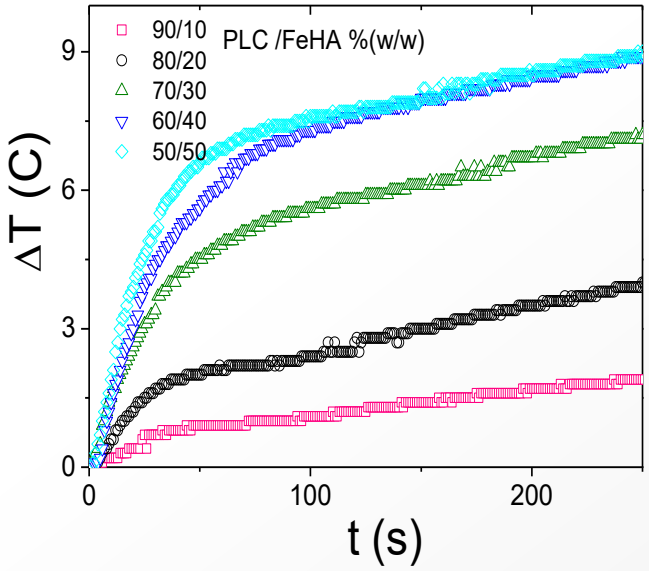
Effects of MNPs amount

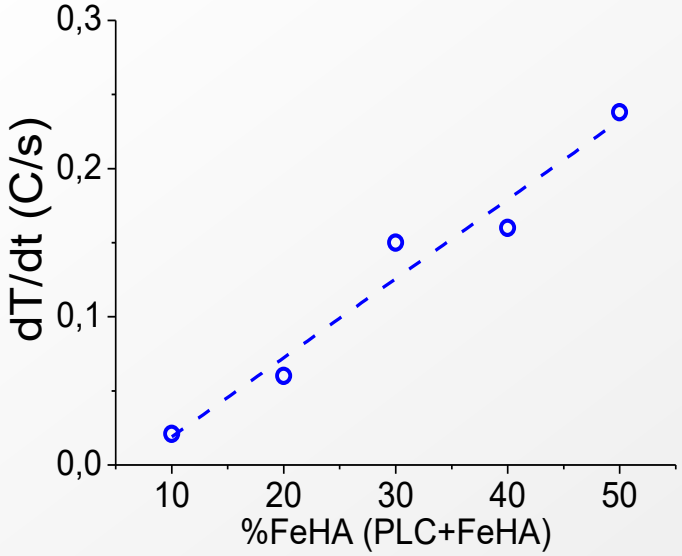
Static Magnetic Field





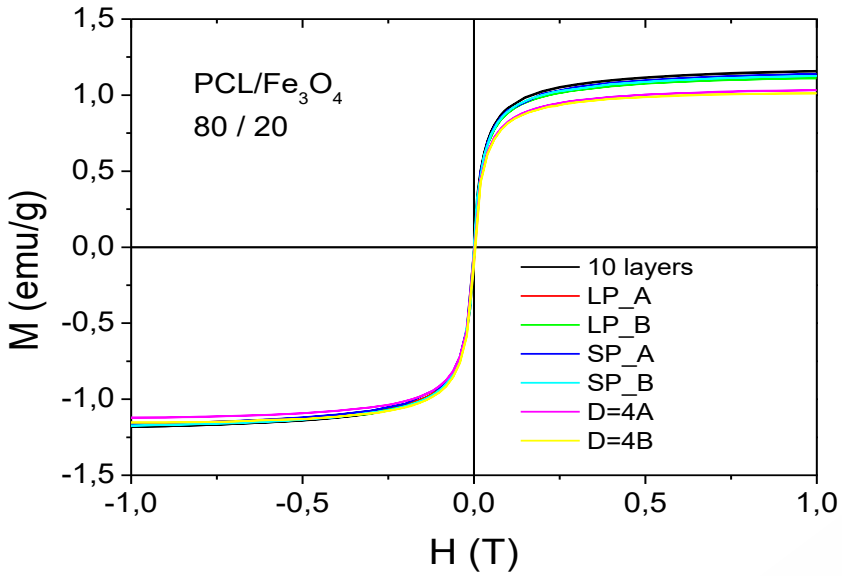
Dynamic Magnetic Field





On demand drug delivery opportunities

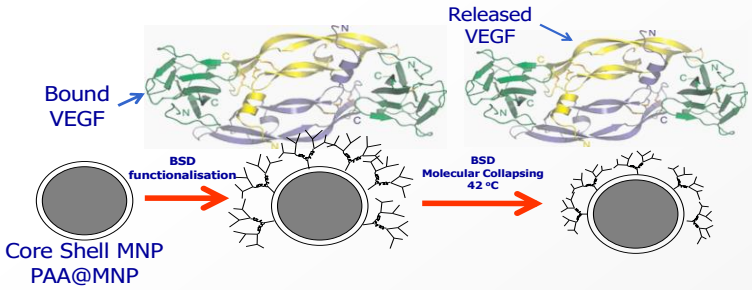
Static Magnetic Field

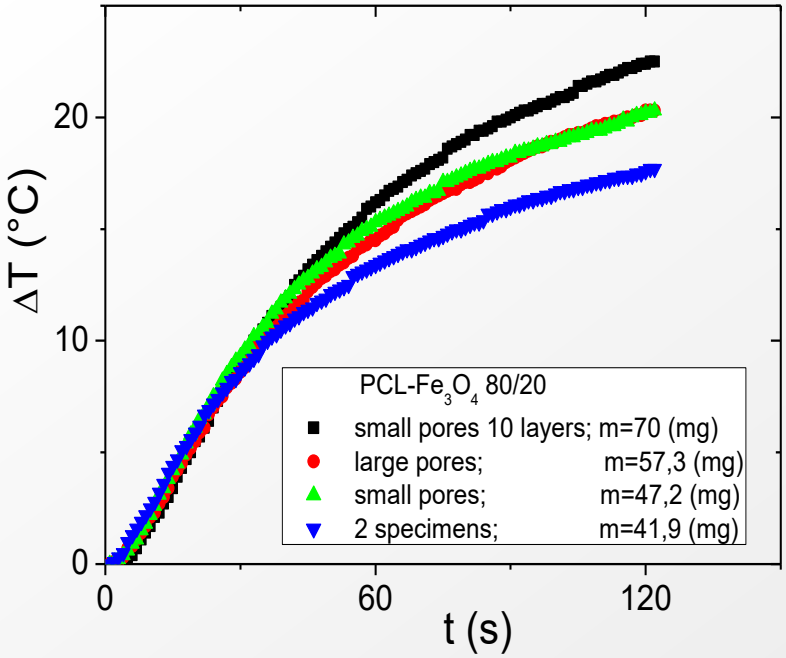


Magnetic force

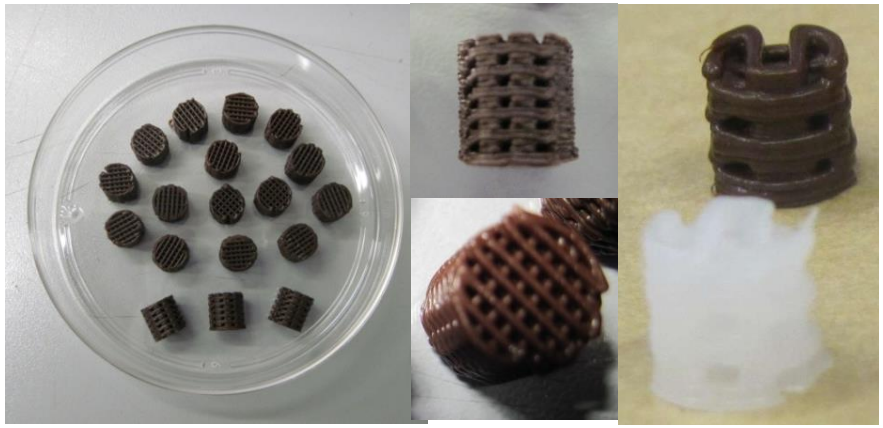
Dynamic Magnetic Field

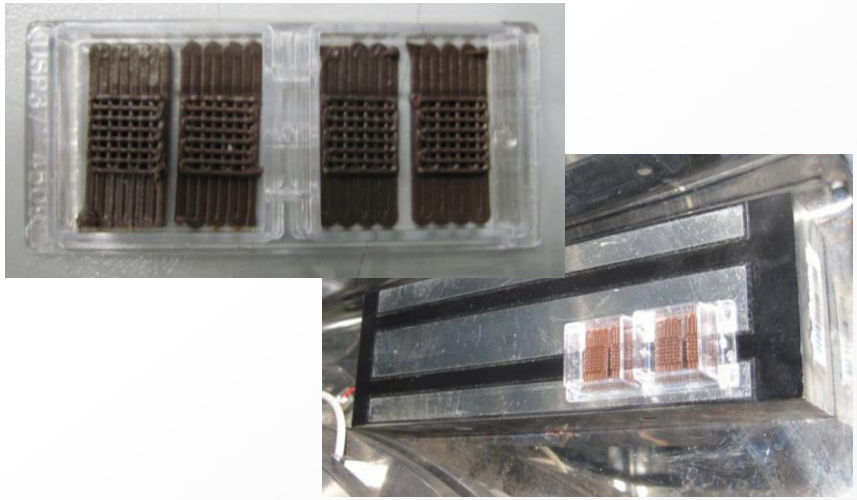
Thermoresponsive dendrimers



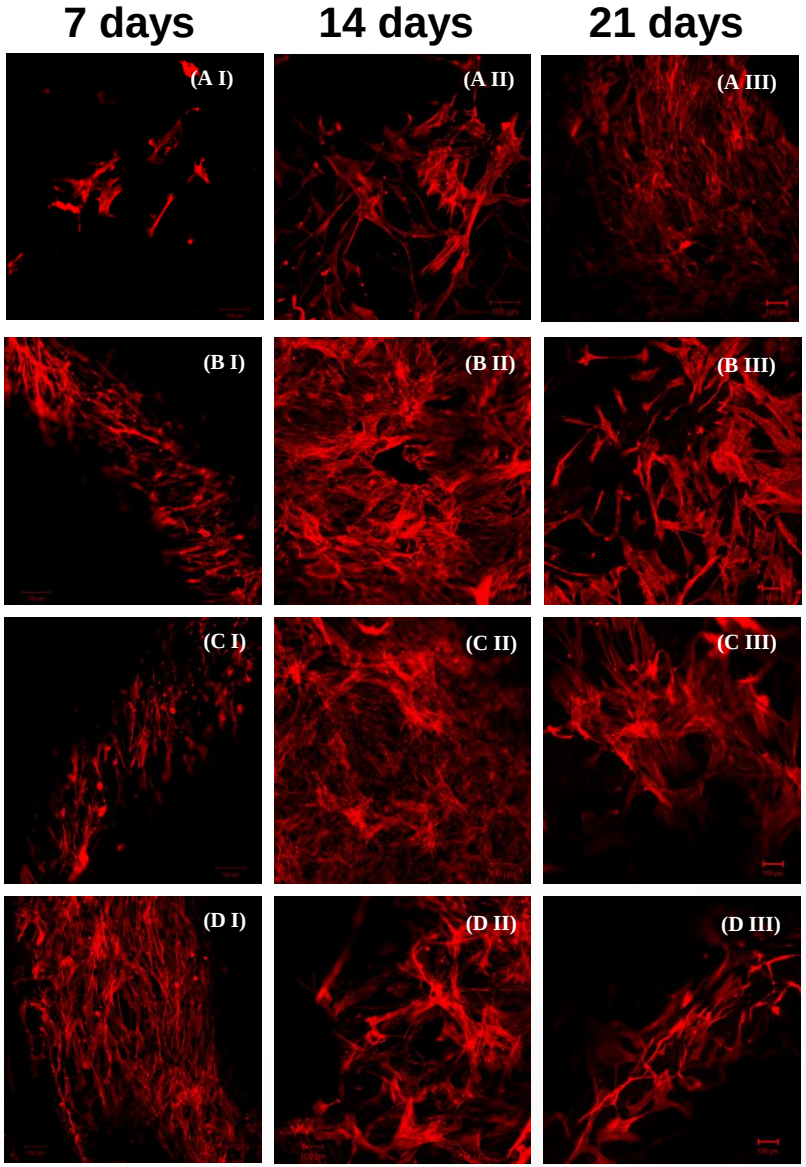


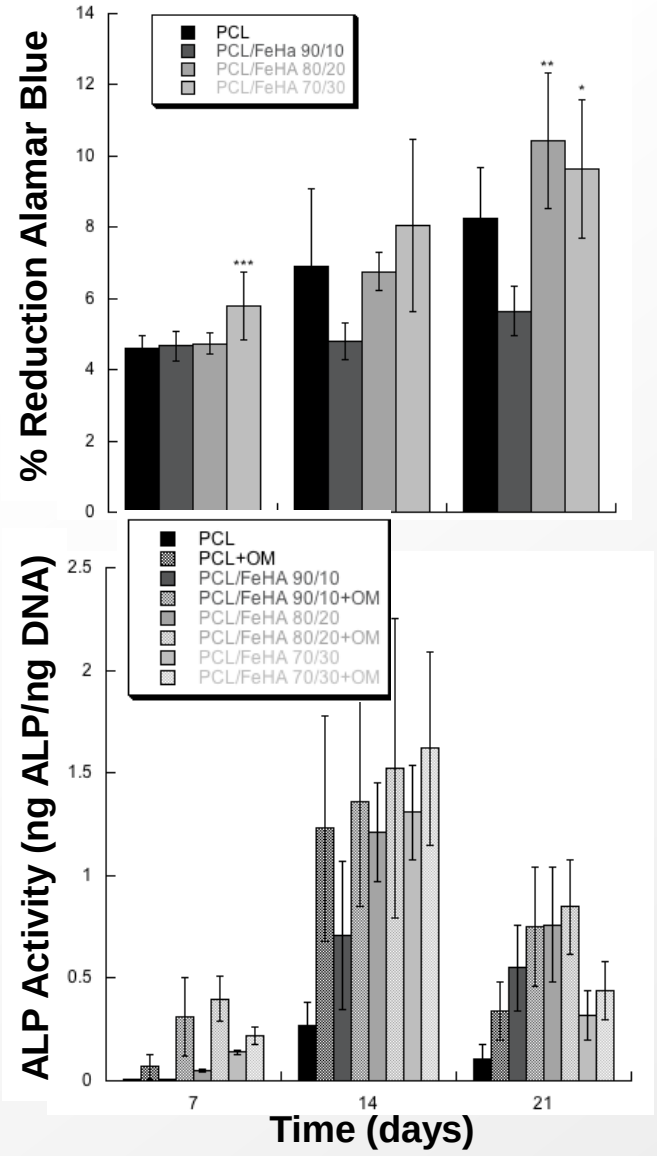
PCL/MNPs customized scaffolds for cell assay





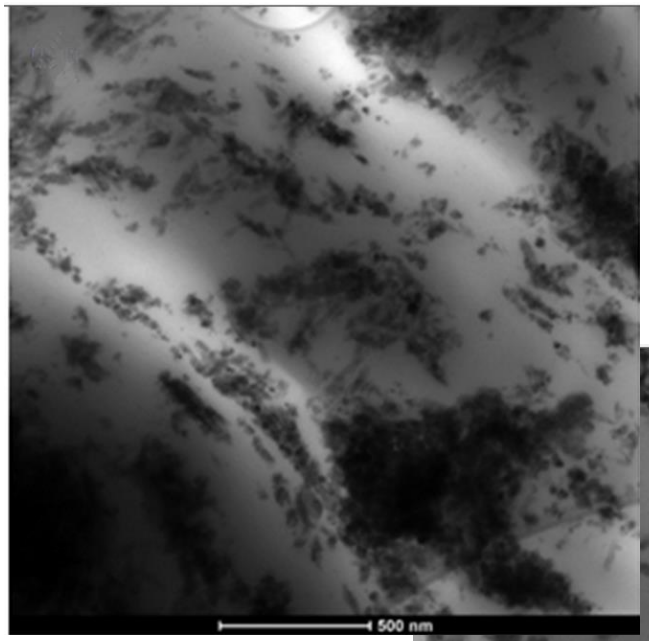
PCL/MNPs nanocomposites: in vitro assay

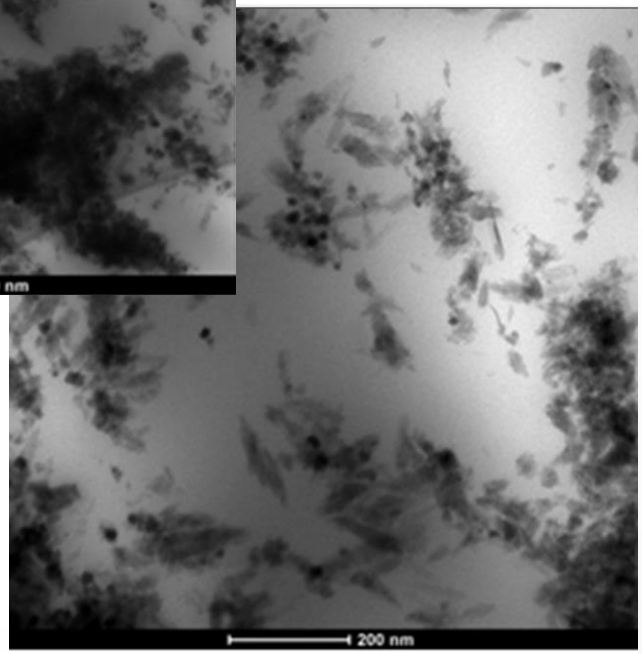




Gloria A, et al. J R Soc Interf 2013;10: 20120833.

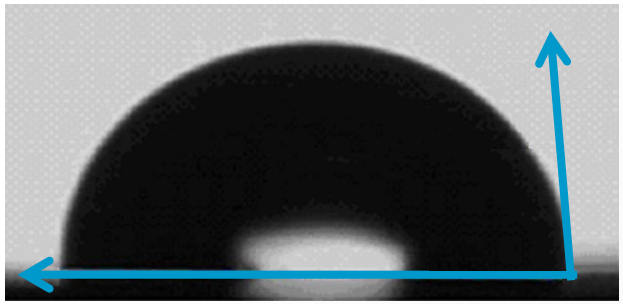
PCL/MNPs nanocomposites: contact angle

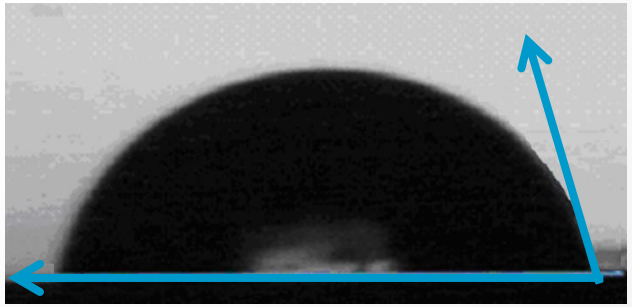




TEM Imaging

Contact Angle





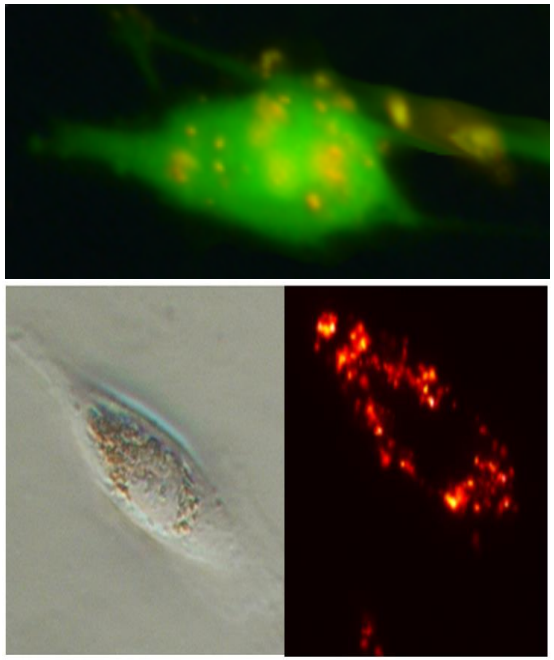
Materials	Contact Angle, θ (deg)
PCL	81.4 ± 4.4
PCL/MNPs 90/10	75.7 ± 4.6
PCL/MNPs 80/20	74.8 ± 2.6
PCL/MNPs 70/30	64.9 ± 8.2

MNPs provide a nanostructured topography & increase PCL hydrophilicity

Russo T, et al. Procedia Eng 2013

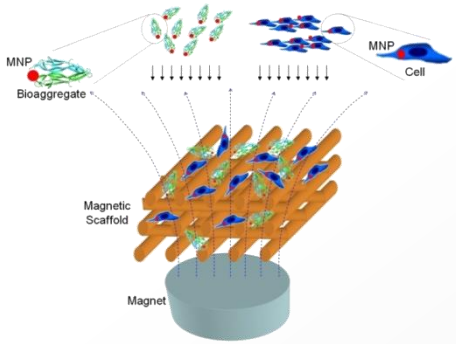
Effect of a static magnetic field

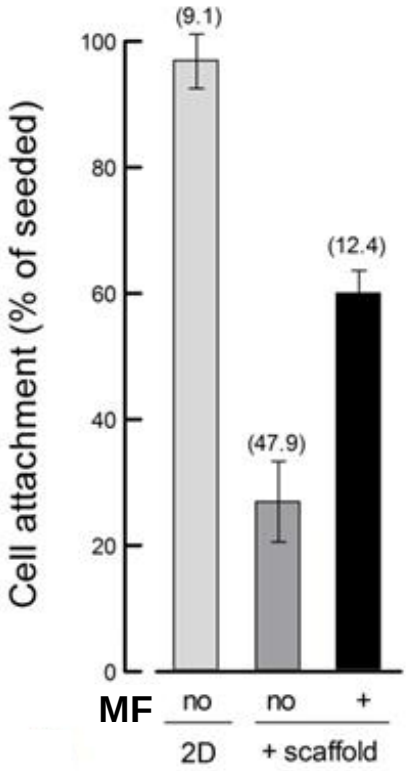
magnetic labeled hMSC

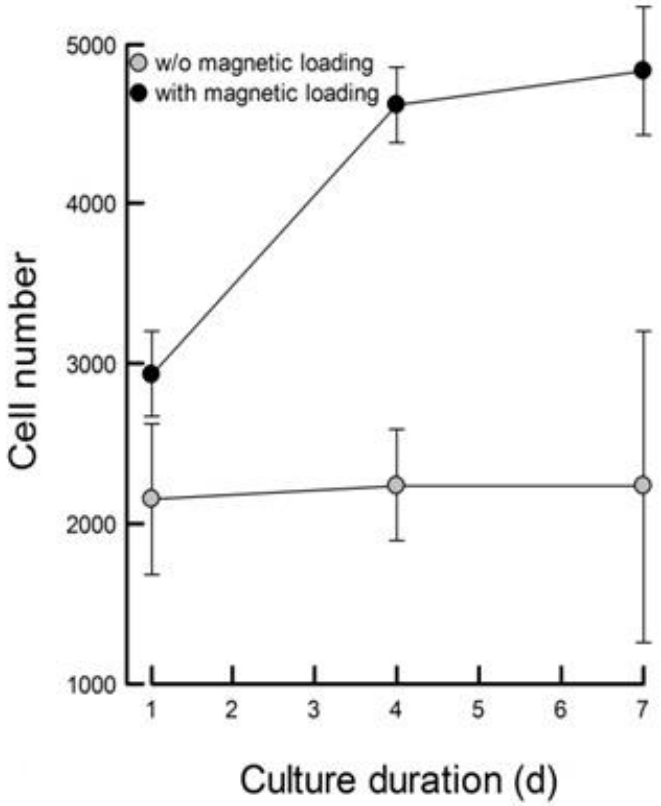


8h - MNPs accumulation on cells membrane

20h - MNPs accumulation in perinuclear space





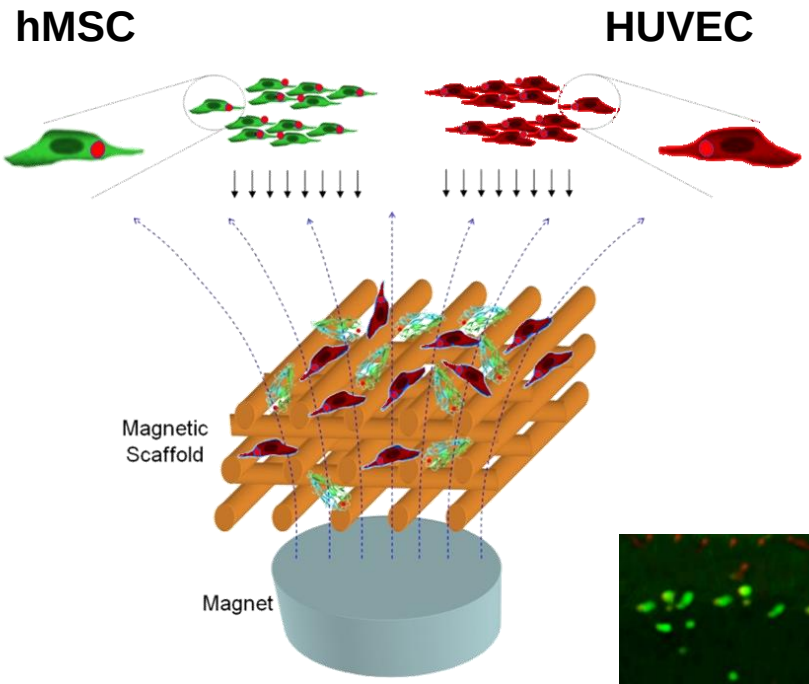


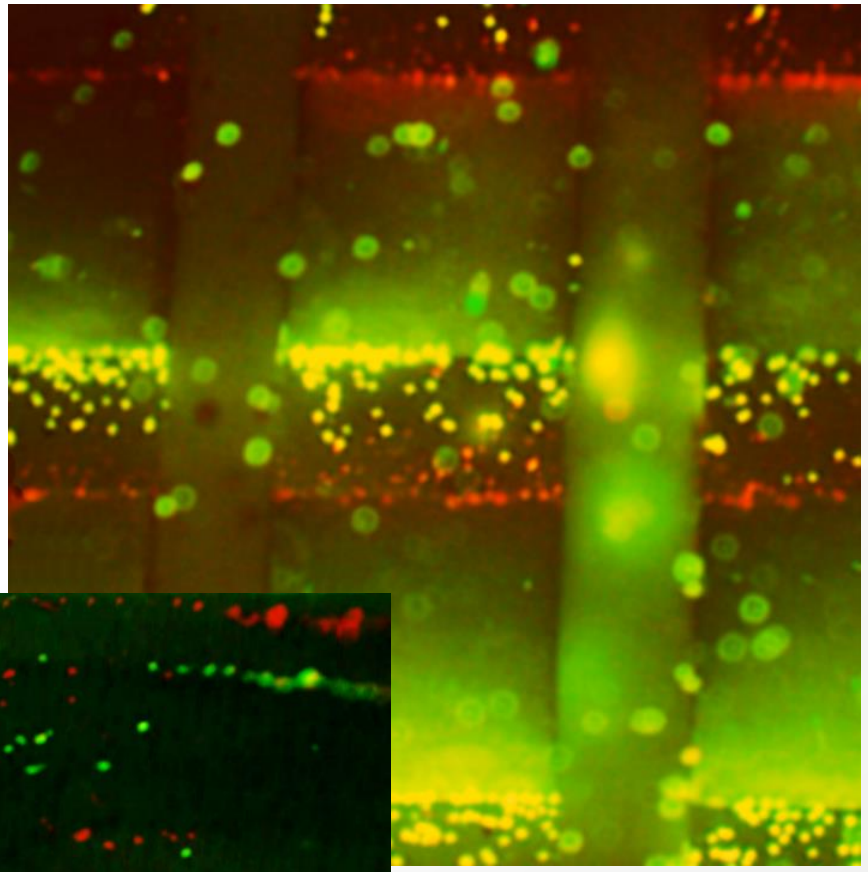
hMSC loading was 36% higher than seeding without a magnetic field.

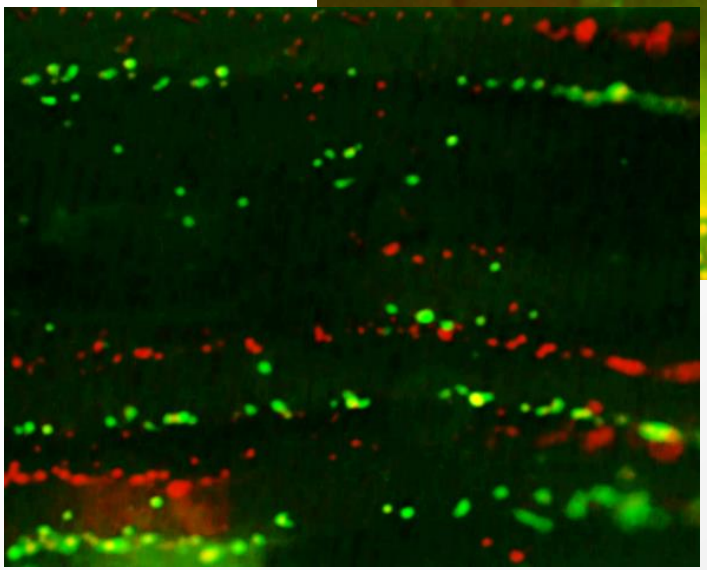
Cell growth was 2.2-fold greater than that without the application of a magnetic field.

De Santis R, et al. J. of Biomedical Nanotechnology 2015;11:1236-1246

Effect of a static magnetic field





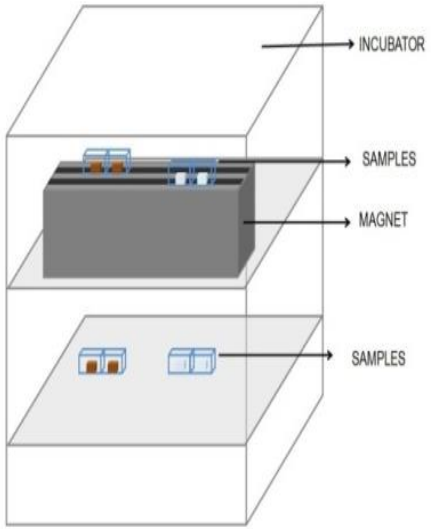


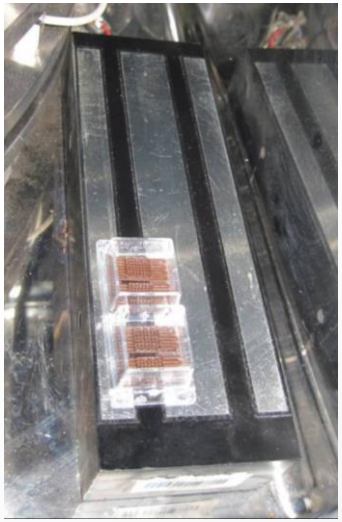
Effect of a dynamic magnetic field

Sinusoidal magnetic field
f =70Hz
A=25-30 mT

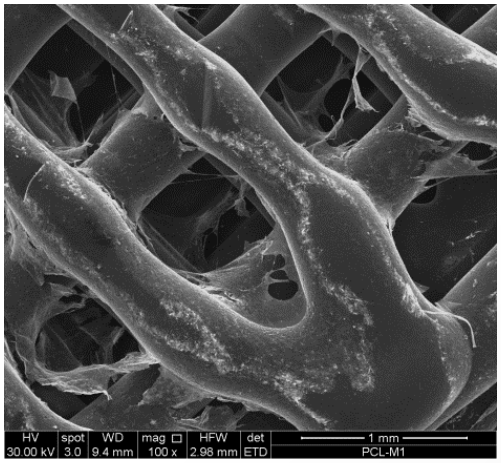
Stimulation cycle
18 min. + 54 min. relax

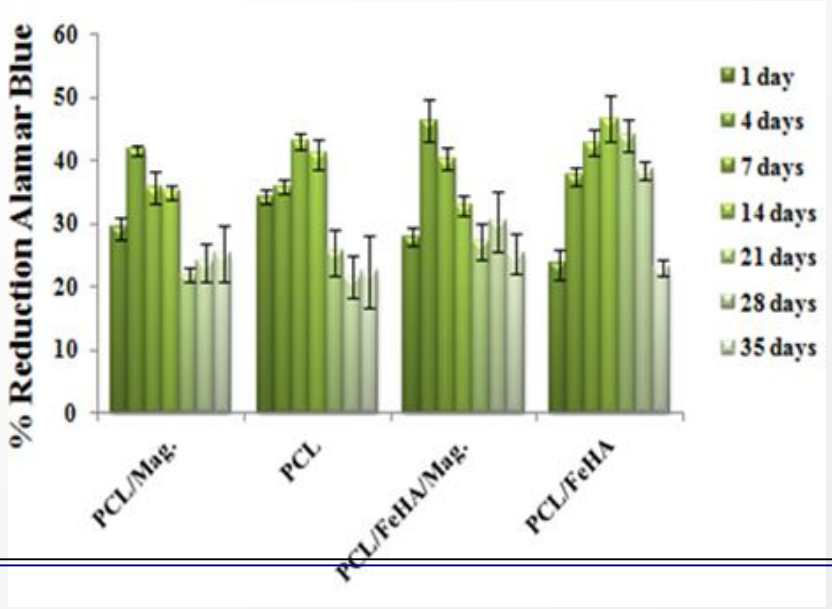
Daily stimulation
6 h/day





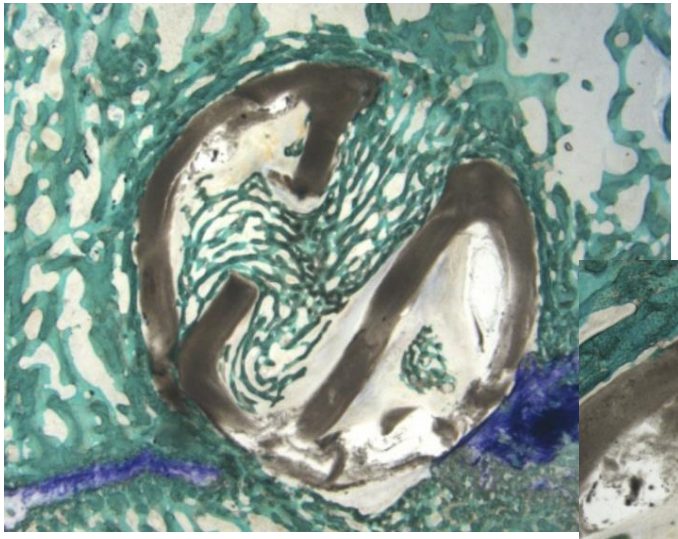
hMSC



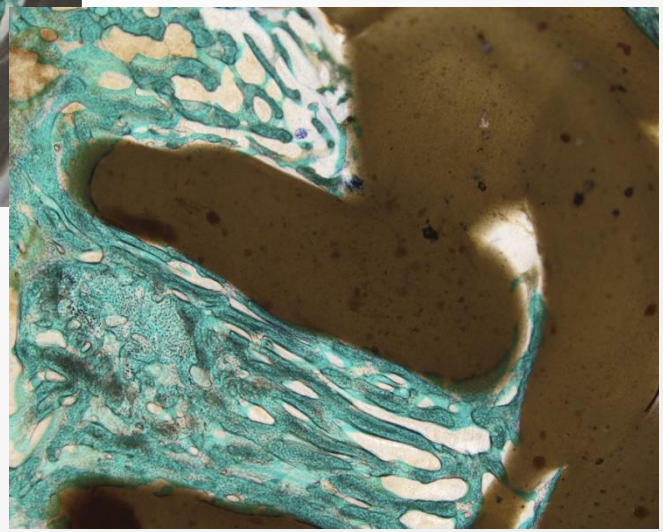


T Russo et al, Bioactive Materials 2017

PCL/MNPs scaffolds: in vivo behaviour



***In vivo* behaviour of magnetic scaffolds implanted into rabbit femur**



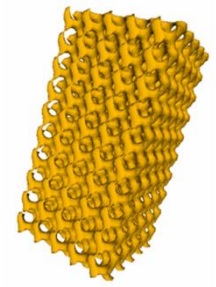
Hystological investigation at 4 weeks post-implantation showed mineralized tissue regeneration around and into the scaffold

De Santis R, et al. J. of Biomedical Nanotechnology 2015;11:1236-1246

Scaffolds for osteochondral tissue regeneration

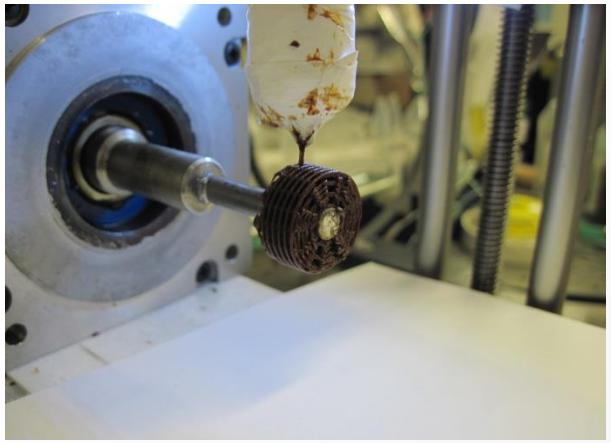
Rational for combining FDM & Stereolithography

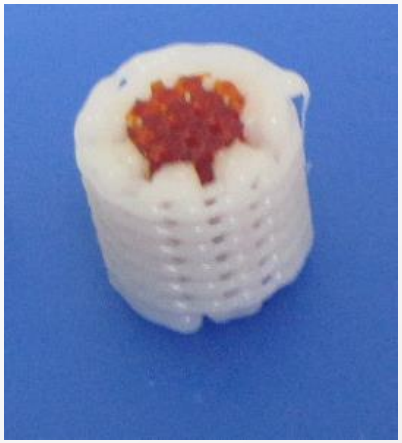
Osteochondral tissue



Stereolithography
Advantage: stratification thickness
Drawback: amount of inorganic particles

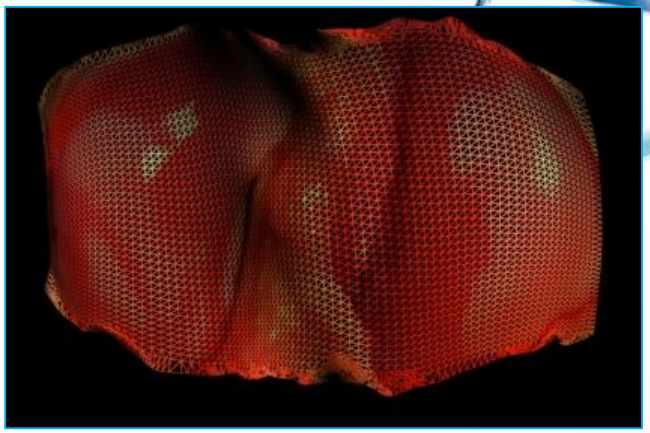
FDM
Advantage: amount of inorganic particles
Drawback: stratification thickness

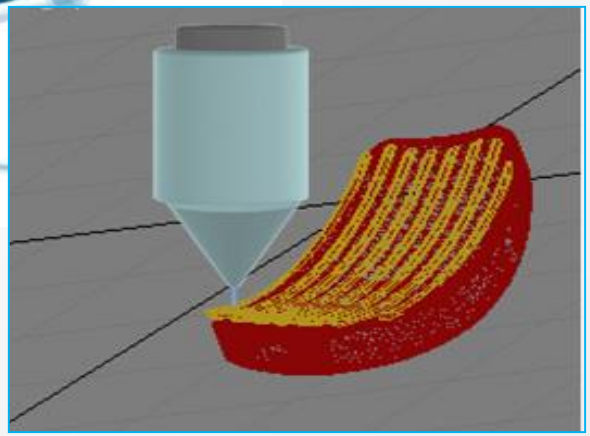




Scaffolds for osteochondral tissue regeneration

Tissue Engineering





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Thank you for the attention