Development of Drug Delivery Nanoplatforms for Orthopaedic – Associated Infections

The interest of nanotechnology in medicine grows more and more, leading to the development of a new generation of diagnostic and therapeutic approaches based on the use of nanomaterials and devices that are very small in size. In recent years the number of patients in need of such a surgery for total hip replacement rose rapidly and the reason for this is that once an articular cartilage is damaged it cannot be regenerated, as other tissues do. The most common post-surgery risk is infection which can lead to implant failure. Therefore nanotechnology is there to solve this problem. Thus, polymeric scaffolds that act as substrates for the growth, differentiation and proliferation of cells are used and they often carry a drug in order to eliminate or reduce this risk.

In this work, six nanoplatforms consisted of biodegradable polymers, which function as carriers for controlled drug release, were prepared via the Electrospinning process. More specifically, the fabrication of polymeric nano-fibrous scaffolds of polycaprolactone (PCL) took place in the first stage of this study and then PCL scaffolds loaded with drug were created. In this case vancomycin was used as drug, which contributes to the prevention and treatment of orthopedic infections. In the next stage Cellulose Acetate (CA) nanofibers and CA scaffolds in which dexamethasone drug was incorporated, were created. Dexamethasone is a drug that is not only used in both acute and chronic inflammatory diseases of the joints but also and an implant surgery.

The last stage of the present study was the fabrication of a combined scaffold consisted of PCL and CA polymers via a novel method of dual syringe Electrospinning system. First of all it was a drug-free dual system and then a drug loaded one. The same procedure, which took place for each syringe individually, was followed for the dual syringe system. More specifically, the drug delivery nanoplatform system was consisted of polymeric PCL scaffolds loaded with vancomycin drug and CA scaffolds loaded with dexamethasone drug. The characterization of these novel scaffolds took place in order to estimate their average fiber diameter, the topography and the morphology by using SEM, AFM and Optical Microscopy. Furthermore, contact angles

measurements were performed in order to determine whether the scaffolds are hydrophobic or hydrophilic.

Degradation studies of biological scaffolds were held in order to measure the changes in the weight of these polymeric structures and Drug release kinetics also took place, in order to see how the drug is being released along with time. In the final stages, cytotoxicity studies were conducted in order to examine the cell compatibility levels of all scaffolds by using a standard immortalized fibroblast L929. MTT assay, methylene blue staining and the subsequent study of the cells via SEM have proved that all the scaffolds were cytocompatible, as cell proliferation was more intense since the 3rd day.

It is concluded that the novel polymeric scaffolds consisted of both polymers and both drugs appear to be a bio-functional microenvironment that imitates the extracellular matrix and promotes cell attachment and proliferation. Thus, they are suitable for tissue regeneration and at the same time they could be a very promising approach, not only to prevent but also to treat orthopaedic implant-associated infections.