Polymeric materials: from nanoparticles to tissue implants

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Polymers are increasingly used in various medical applications from drug delivery to artificial implants in tissue engineering. Drug delivery using nanoparticles is indeed one of the most promising applications of polymers [1-2]. Our group is developing ways to produce polymeric nanoparticles for the delivery of anticancer and anti-TB drugs. Both diseases are urgent and a great danger to mankind. Below we present some of our research results.

Table 1 – Nanoparticles with anti-tuberculosis drugs

Biopolymer	Medicinal product	Loading capacity	Results of the study
Polystyrene	Capreomycin sulphate		Synthesis of polymeric nanoparticles was carried out by chain polymerisation, the average size of the obtained NPs was 173 nm.
Polyethylcyanoacrylate	Capreomycin sulphate	76,3 %	Inclusion of capreomycin sulphate in the matrix of polyethylcyanoacrylate allows to increase the drug half-life by 3 times, thus prolonging the effect of the drug. The polymeric particles had an average size of 132-550 nm.
Polylactide-co-glycolide	Isoniazid (INH)	76 %	PLGA-INH colloidal nanoparticles were developed by double emulsion, nano-deposition and emulsion methods. The average size is up to 200 nm, narrow particle size distribution.
Polylactide (PLA)	INH, Vitamin C	INH: 72 %, VitC: 83 %	PLA-INH-VitC nanoparticles were synthesised for the first time by double emulsion method. Inhibit the growth of isoniazid-resistant mycobacteria.
PLA	Streptomycin	50 %	The size of polylactic acid nanoparticles is 310 nm. The yield of NPs is 82.5 %.
Serum albumin (HSA and BSA)	INH	82 %	Nanoparticles of albumin with INH were obtained. Narrow size composition, high degree of binding. MIC - 2.5 μg/ml.
HSA	INH, Rifampicin (RIF)	INH: 27 %, RIF: 44 %	The LVs with INH and RIF were 216.7±3.7 nm in size and had a ζ-potential of -26.7±1.5.
HSA	RIF	86 %	NCs with RIF were obtained by the Taguchi method. The average size is 190.7±2.3 nm, ζ-potential is -22.7±0.3.
HSA	p-aminosalicylic acid		PASC LVs were obtained by desolvation method. Drug loading into empty albumin wafers.
BSA Polyethylene glycol (PEG)	INH	46 %	PEG fragments and amino groups of albumin. PEG-BSA-INH NPs were obtained, size 226.9±1 nm.

The final choice of a suitable polymer, particle size and production method depends firstly on the biocompatibility of the polymer, secondly on the physicochemical properties of the drug substance, and thirdly on the therapeutic goal.

Another important problem is osteoarthritis, a joint disease caused by the destruction of the soft tissues of the joint surfaces. This severe disease progresses over time. A possible solution to this problem is the use of 'soft' polymeric materials in endoprostheses, which are able to change their shape when the configuration of the bone articulation changes and, at the same time, retain the mechanical properties necessary to stiffen the joint. The elastic properties of hydrogels can be dramatically improved by creating 'double' meshes, which are two interpenetrating polymer meshes with different properties. The first mesh is usually formed by a strongly cross-linked and rigid polymer, and the second one by a weakly cross-linked and flexible polymer. In this work, we combined biocompatible and biodegradable mesh materials, which had previously been used independently, to create a high-strenght dual mesh for producing a personalised biomedical product using 3D printing technology.

References

[1] Araujo, L.; Löbenberg, R.; Kreuter, J. Influence of the Surfactant Concentration on the Body Distribution of Nanoparticles. *Journal of Drug Targeting* **1999**, 7(5), 295–302.

[2] Jin, P.; Liu, L.; Chen, X.; Cheng, L.; Zhang, W.; Zhong, G. Applications and Prospects of Different Functional Hydrogels in Meniscus Repair. *Front. Bioeng. Biotechnol.* **2022**, 10, 1082499.