THE INFLUENCE OF AgNPs AND GO PARTICLES ON THE PROPERTIES OF POLYCAPROLACTONE

Anna Kurowska[1]*, Zuzanna Ratajczyk[2], Anna Nikodem[2], Izabella Rajzer[1]

[1] Department of Mechanical Engineering Fundamentals, Division of Materials Engineering, ATH University of Bielsko-Biala, Poland
[2] Department of Mechanics, Materials and Biomedical Engineering, Wroclaw University of Science and Technology, Poland
*e-mail: akurowska@ath.bielsko.pl

[Engineering of Biomaterials 163 (2021) 97]

Introduction

According to statistical data, nasal injuries are relatively common as a result of accidents [1,2]. In order to restore the proper functioning of the nose and for aesthetic reasons, surgical reconstructive procedures are performed [3]. Currently, new materials are sought for the production of scaffolds for tissue engineering purposes, which on the one hand will temporarily replace the cartilage lost as a result of trauma, and on the other hand will support and promote the regeneration of the native tissue [4]. Polycaprolactone (PCL) is a commonly known and frequently used biodegradable polymer in tissue engineering [5]. However, this polymer is a hydrophobic material, which may significantly limit cell adhesion to the scaffold surface [6]. Moreover, PCL does not have antibacterial properties, which seem to be crucial in the reconstruction of the upper respiratory tract. The study attempts to modify the PCL polymer. Research on the influence of additives with adsorption (graphene oxide) and antibacterial (silver nanoparticles) properties on the structural and physicochemical properties of composite materials with a PCL matrix was conducted. For this purpose, micro-CT analysis, tests for hardness measurement, roughness measurement and the contact angle measurement were carried out.

Materials and Methods

Polycaprolactone (PCL) (Mn 80 kDa) in a granular form was purchased from Sigma-Aldrich, USA. Silver nanoparticles (AgNPs) in the form of a silver solution (30-35wt.% in triethylene glycol monomethyl ether with a resistivity of 11 μΩ-cm) purchased from Sigma-Aldrich, South Korea. Graphene oxide (GO) in the form of a powder (degree of oxidation: 4-10%, with an edge distribution oxygen functional groups) purchased from Sigma-Aldrich, USA.

Samples were prepared by the technique of melting the polymer. PCL granules with the additive were placed in the melting device heated to a temperature of 110°C, after melting the polymer granule, the ingredients were vigorously mixed with a baguette for 10 minutes. The plasticized polymer was then spread between two laboratory slides to obtain flat, elliptical samples. Two series of samples were obtained: PCL with the addition of AgNPs and PCL with the addition of GO in three different concentrations of modifying additives.

Mechanical properties were characterized by an instrumented hardness tester (InnovaTest Nexus®700).

The roughness measurement was carried out with a roughness tester SRT 220® to quantify the roughness variation on the micro scale. Surface wettability was evaluated by apparent water contact angle measurements. This contact angle was determined by the sessile drop method with an automatic drop shape analysis system OEG OEG®Surftens Universal. To assess the internal geometry of the scaffolds, X-ray microtomography (SkyScan 1172, Bruker, Kontich, Belgium) was performed and the following computer programs: DataViewer®, NRecon®, CTVol® were used.

Results and Discussion

Based on the hardness tests performed, a decrease in the hardness parameter for all samples with an increase in the concentration of the modifying additive was observed.

The roughness measurements showed higher values of roughness for the samples doped with AgNPs and, for each sample, the roughness decreased with an increasing concentration of the modifying additive.

Regardless of the type and concentration of the admixture, it increased the contact angle in comparison to the samples made of pure PCL, and all samples showed a contact angle of less than 90°, and therefore assumed a hydrophilic character.

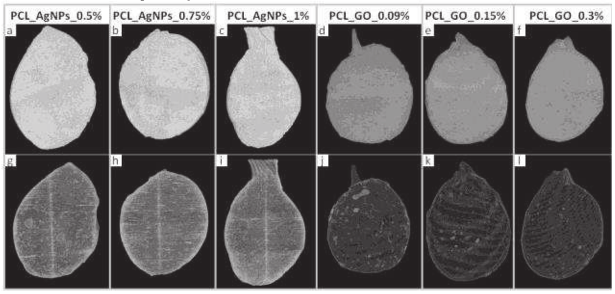

FIG. 1. Micro-CT sample images. The 3D reconstructions of the PCL matrix (a-f), the image of the samples with selected pores (g-l).

In the μCT tests, based on the photos showing selected pores, the highest porosity was found in the PCL_GO_0.09% sample, and the lowest in the PCL_AgNPs_0.75% sample (FIG. 1: g-l).

For each of the samples doped with AgNPs, on the photos showing the selected inclusions, their even distribution was observed, and the higher the concentration of the admixture in the sample, the larger and more numerous aggregates of the additive were formed.

Conclusions

In conclusion, it was shown that the PCL_AgNPs_0.5% sample showed the best physicochemical properties from the point of view of tissue engineering. This sample was characterized by the highest hardness and roughness.

The μCT tests also showed that the PCLAgNPs_0.5% sample was characterized by the most even distribution of admixture particles and the smallest number of aggregates.

Acknowledgments

This work was supported by the The National Centre for Research and Development in the frame of project: “Layered implants for nasal cartilages and bones reconstruction fabricated by 3D printing” TANGO-IV-A/0002/2019.

References

[1] C. Din-Lovinescu *et al.,* J Oral Maxillofac Surg 78(2) (2019) 254.e1-254.e8.
[2] F. Faraji, J. H. Lee *et al*., Laryngoscope Investigative Otolaryngology (2020)1–6.
[3] L. Losco, *et. al*., Medicina 56(639) (2020) 1-15.
[4] L. Lavernia, *et al*., Acta Biomater. 1(88) (2019) 42-56.
[5] N. Sultana, T.H. Khan Journal of Bionanoscience. 7(2) (2013) 169-173.
[6] I. Rajzer, E. Menaszek et al., Materials Science and Engineering C 44 (2014) 183–190.