Study of the cytotoxic properties of polyester-based copolymers for the bioresorbable triboelectric nanogenerator (TENG) development

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A promising field of application of biodegradable polymers is triboelectrics. Triboelectric nanogenerators (TENG) have great potential

- Triboelectric nanogenerators (TENG)- nanodevices for energy collection based on the triboelectric effect.
- TENGs convert the mechanical energy of vibrations into electricity, which can be used to power implantable medical devices.
- The TENGs will consist of biocompatible polymers and, after the expiration of the operating time, undergo biodegradation without requiring surgical intervention.

The aim of our work was to study the potential cytotoxicity of polyester copolymers as the basis of an implantable, bioresorbable TENG nanogenerator.

Four samples of polyester copolymers of the total composition: citrate(a)-hexanediol(b)-propane-1,2-diol(c)-glutarate(d) (CHPG) of various degrees of cross-linking (no.1-4 in order of increase of condensation) were investigated for their potential applicability for TENG.

Three cell lines of murine origin were used to study cytotoxicity: A9 fibroblast-like cells, C2C12 myoblast-like cells, J774 histiocytic sarcoma. Cell viability was estimated using a colorimetric test for the metabolic activity of cells (MTT-test).

The results of testing of each of the four polymers on each of the cell lines (A9, C2C12, J774) were grouped in the form of consecutive histograms reflecting the average optical density of the colored methyltetrazolium complex in 6 wells of polymer samples with a layout for increasing the amount of polymer (control is highlighted in color).

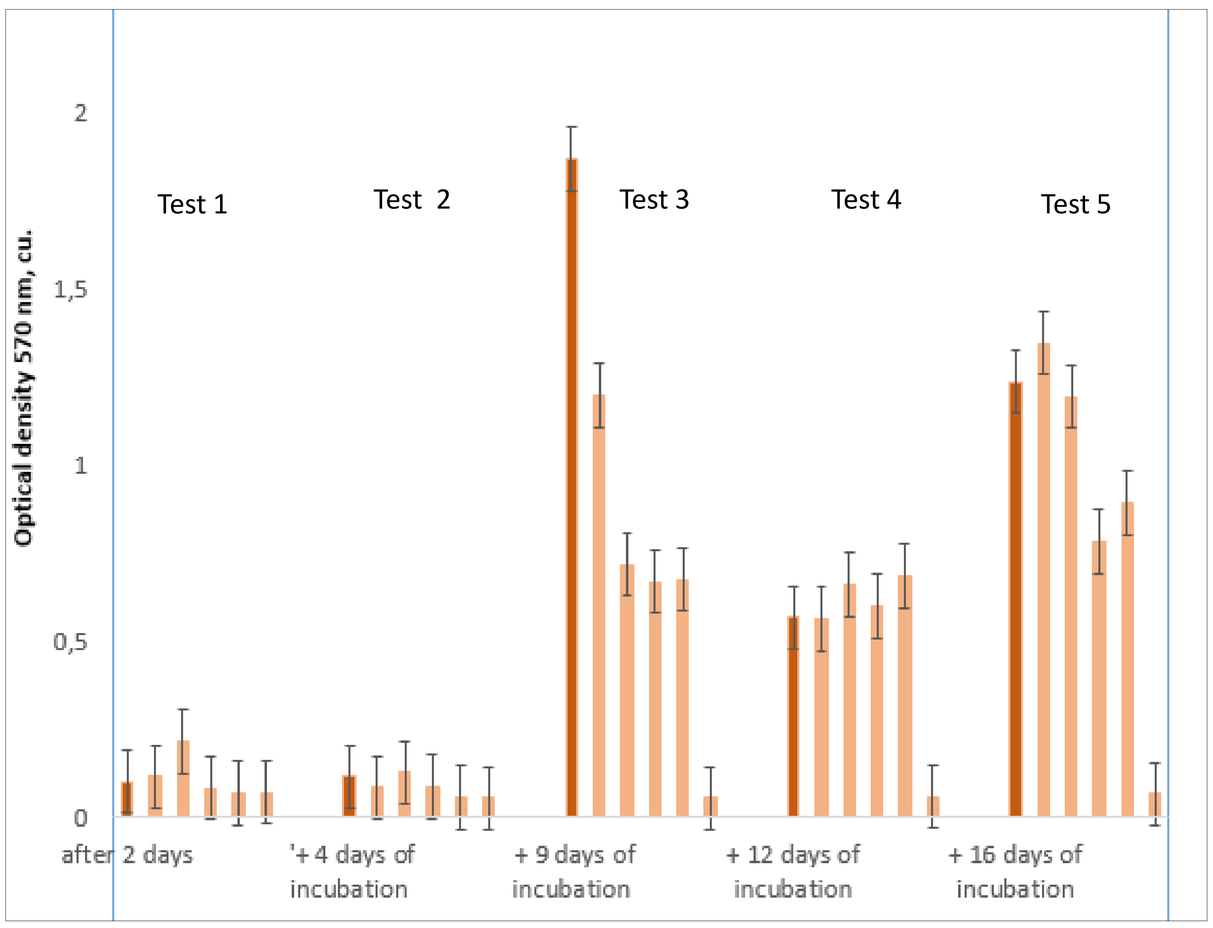

Figure 1 - Diagram of the effect of the degradation products of copolymer CHPG-1 on the viability of cells of the A9 line on the 2nd, 4th, 9th, 12th, 16th day

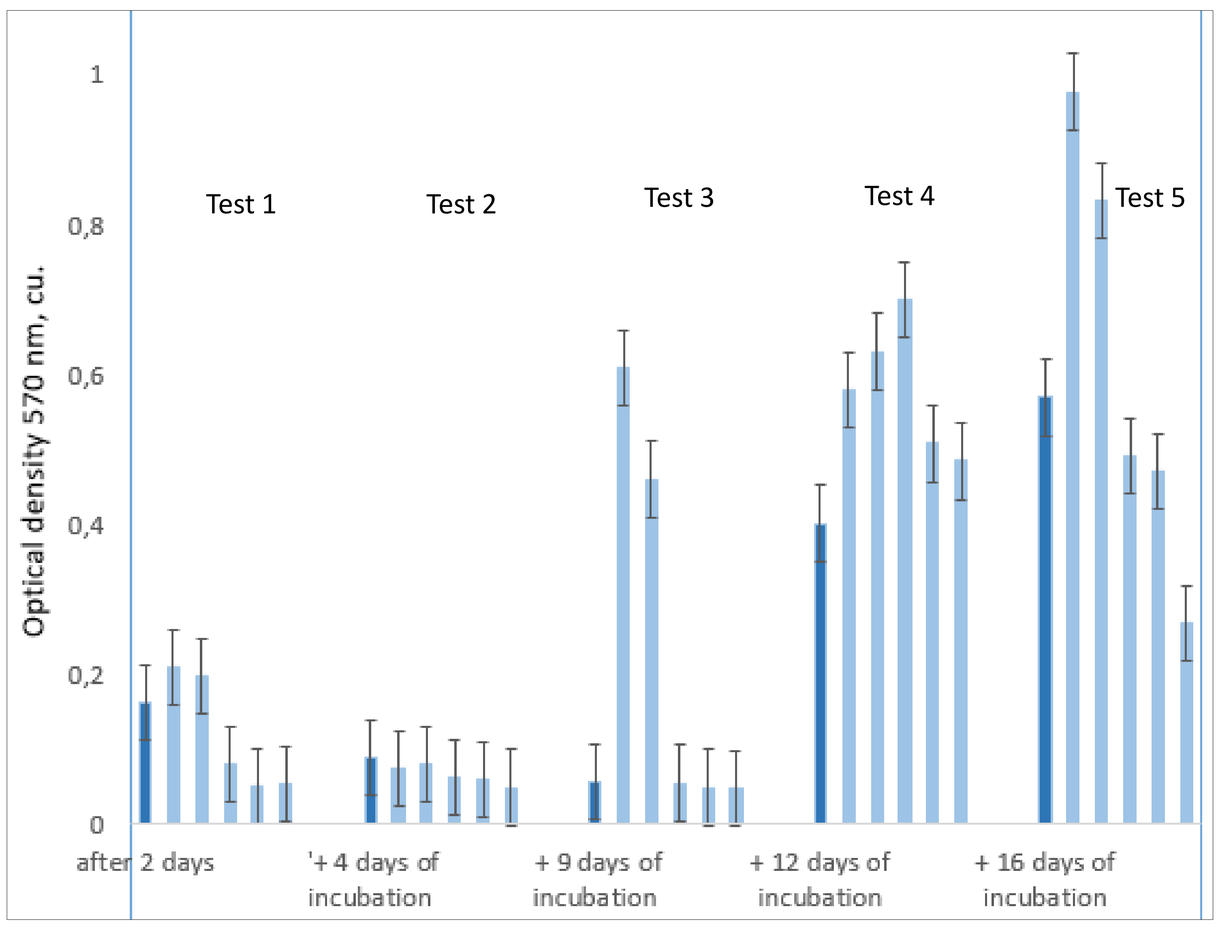

Figure 2 - Diagram of the effect of the degradation products of copolymer CHPG-1 on the viability of cells of the C2C12 line on the 2nd, 4th, 9th, 12th, 16th day

In test No. 1-2, during incubation of polymers with all types of cell cultures, signs of acidification of the pH of the medium to 4-5 units were noted. At the same time, the MTT test showed signs of cytotoxic effects. Probably, the observed signs were associated with the release of citric and glutaric acids into the medium, which are part of copolymers due to their degradation. Subsequent stabilization of the pH of the medium by adding HEPES as a buffer substance led to a decrease in the observed cytotoxic manifestations (test No. 3-5).

<u>Results: 1.</u> The cytotoxic effect was revealed to a greater extent for the copolymer CHPG-1 (Fig.1).

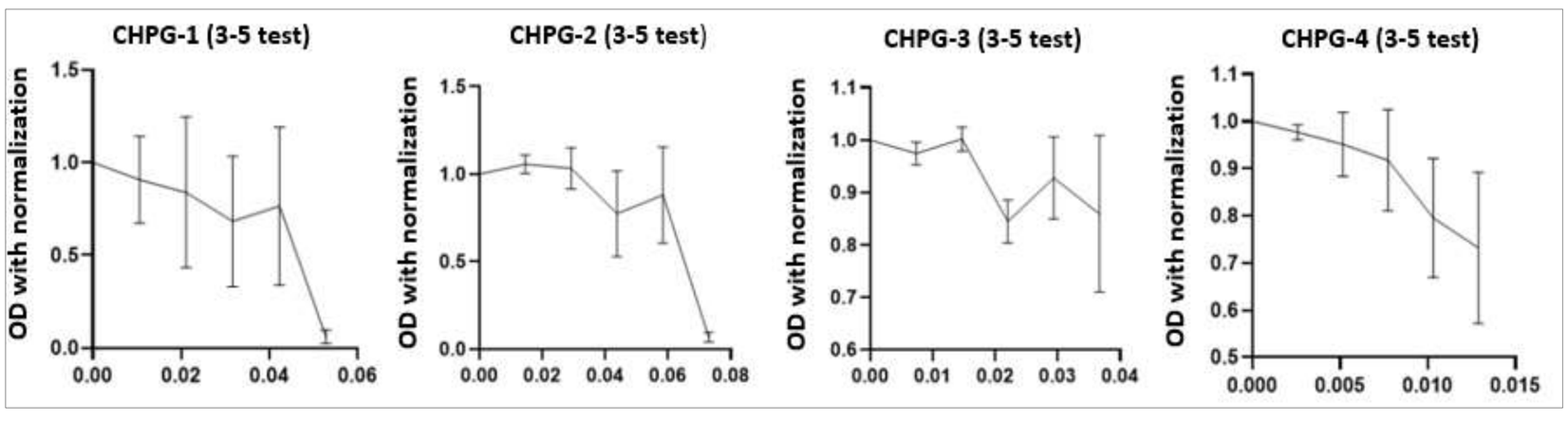

Figure 3 - Diagram of the effect of the degradation products of copolymer CHPG-1-4 on the viability of cells of the A9 line on the 2nd, 4th, 9th, 12th, 16th day

- **For copolymer CHPG-1, signs of cytotoxicity are detected on cells.**
- **Copolymer CHPG-2-3 samples do not exhibit cytotoxic effects.**
- **Copolymer CHPG-4 is not cytotoxic to cells.**

<u>Results: 2.</u> For cell lines C2C12 and O 774, copolymers CHPG-3 and CHPG-4 are the least toxic (Tab. 1).

Copolymer sample	Cell line		
	A9	C2C12	J774
CHPG-1	94% ± 5%	25% ± 5%	30% ± 5%
CHPG-2	16% ± 5%	47% ± 5%	22% ± 5%
CHPG-3	23% ± 5%	11% ± 5%	13% ± 5%
CHPG-4	18% ± 5%	15% ± 5%	0% ± 5%

Table 1 - Average percentage of dead cells compared to the control in the wells with the largest amount of polymer on the 9th, 12th, 16th day

<u>Conclusions</u>:

Cytotoxicity of the studied polymers correlates with the total amount of substance in the composition of the introduced samples and to a lesser extent correlates with the area of copolymer disks, from the surface of which low molecular weight components of copolymers and monomers are released. Cytotoxicity of degradation products increases due to acidification of the medium. There is also a correlation between the ratio of total cell mass and the mass of the sample introduced into the medium. Under conditions of 100% confluence of cultures, the manifestation of cytotoxic properties by copolymers is not confirmed, with the exception of sample CHPG-1 in the case of its complete dissolution in the medium and the cytopathological effect of sample CHPG-2 on myoblast-like cells with a high amount of sample.

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