APPLICATION OF POLYMER- AND GRAPHENE- BASED MATERIALS IN BIOMEDICAL RESEARCH

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Introduction
Regenerative medicine, combining biomaterials and stem cells constitute an innovative field in biomedical research. Mesenchymal stem cells (MSCs) represent a class of adult multipotent stem cells. They possesses the ability to differentiate into cells of mesodermal origin, including osteoblasts, chondrocytes and adipocytes. MSCs are characterized by e.g. high proliferative capacity and paracrine activity. Moreover, MSCs are easy to harvest from different sources, demonstrate low immunogenicity and may be applied in autologus and allogenic transplantations. All these features makes MSCs as one of the most promising stem cells type for regenerative medicine.
Nowadays, innovative approaches which may improve regeneration process, are a wide of interest. Growing evidence indicate, that MSCs in combination with (bio)materials constitute novel perspectives for tissue engineering and biomedical applications. Thus, natural polymers and graphene-based substrates constitute promising platforms for stem cells applications.

Materials and Methods
In this study, we develop novel concept of stem cell utilization in association with biocompatible composites. We used graphene-oxide (GO), reduced graphene-oxide (rGO) and natural polymers, such as chitosan and alginian as scaffolds for stem cell- related applications.
MSCs were isolated from human umbilical cord Wharton's jelly (hUC-MSCs) using an explant method. Cells were cultured in DMEM/F12 medium supplemented with 10% FBS in an incubator chamber at 37^0C, 5% CO_2 and 95% humidity. GO, rGO and polymer- based matrices (that were modified by graphene and hydroxyapatite) were tested as culture surfaces dedicated for hUC-MSCs. Moreover, the influence of GO and rGO-based scaffolds on chondrogenic and osteogenic differentiation capacity of hUC-MSCs was evaluated in *in vitro* condition.

Results and Discussion
Obtained results revealed that graphene- and polymer-based substrates constitute non-toxic surfaces for hUC-MSCs. We observed morphological differences of hUC-MSCs cultured on both types of tested scaffolds as compared to cells cultured on control plate (tissue culture polystyrene surface, TCPS). Moreover, the analysis indicated that decrease in proliferation capacity and metabolic activity of hUC-MSCs, cultured on modified surfaces, may be related with their high differentiation potential. Quantitative analysis of gene expression revealed these observations. Our results shown that graphene-based scaffolds may enhance hUC-MSCs differentiation toward chondrogenic and osteogenic cells *in vitro.* Thus, these data may suggest, that analyzed scaffolds exhibit a potential applicability as novel, safe and biocompatible materials for utilization in regenerative medicine.

Conclusions
Stem cells and biomaterials constitute an implication for novel grafts that may be used in tissue regeneration. Obtained results indicate positive effect of graphene- and polymer- based scaffolds on functional features of hUC-MSCs. However, further studies are required to analyze these phenomenon.

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