

1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title:

New biopolymer-based smart drug carriers

1.1. Project goals

The project aims to design the structure and synthesis of new materials based on biopolymers containing pH-, thermo- and photosensitive units and then their complete characterization and application as a starting material for the structures of smart anticancer drug carriers well as *in vitro* biological properties assessment.

1.2. Outline

The research conducted as part of the doctoral dissertation will include the synthesis of new materials capable of reacting to external factors such as pH change, temperature change or radiation of a specific wavelength. The obtained materials will be based on chemically modified biopolymers such as starch, chitosan, inulin and their mixtures with appropriate proteins to improve biocompatibility and distribution in body fluids. The obtained materials will be fully characterized in terms of their physicochemical properties and the ability to respond to the applied stimuli, and then used to obtain smart carriers of anti-cancer drugs that allow them to be selectively delivered to cancer-changed cells and released under the influence of changing factors to which it will react carrier. The scope of research will also include *in vitro* tests on typical cell lines carried out in cooperation with the Faculty of Pharmacy of the CM UMK in Bydgoszcz. Obtaining this type of materials should lead to increased safety of the use of anti-cancer drugs by limiting their side effects on healthy cells.

1.3. Work plan

- Modification of biopolymers to obtain materials sensitive to changes of pH, heat and electromagnetic radiation;
- Physicochemical characteristics of the obtained new biopolymer materials; testing the reaction of the obtained materials to changes in pH and temperature as well as electromagnetic radiation of different wavelengths (in the UV and Vis range);
- Selection of materials for obtaining potential drug carriers; synthesis of drug carriers and deposition of selected drugs on/in the carrier;
- Characterization of properties and interactions of the carrier-drug system, basic pharmacological and biological *in vitro* studies.

1.4. Literature

- Kaushik, N., Borkar, S. B., Nandanwar, S. K., Panda, P. K., Choi, E. H., & Kaushik, N. K. (2022). Nanocarrier cancer therapeutics with functional stimuli-responsive mechanisms. *Journal of Nanobiotechnology*, 20(1) doi:10.1186/s12951-022-01364-2
- Adeli, F., Abbasi, F., Babazadeh, M., & Davaran, S. (2022). Thermo/pH dual-responsive micelles based on the host-guest interaction between benzimidazole-terminated graft copolymer and β -cyclodextrin-functionalized star block copolymer for smart drug delivery. *Journal of Nanobiotechnology*, 20(1) doi:10.1186/s12951-022-01290-3
- Zhang, Y., Li, J., & Habibovic, P. (2022). Magnetically responsive nanofibrous ceramic scaffolds for on-demand motion and drug delivery. *Bioactive Materials*, 15, 372-381. doi:10.1016/j.bioactmat.2022.02.028
- Fatima, M., Sheikh, A., Hasan, N., Sahebkar, A., Riadi, Y., & Kesharwani, P. (2022). Folic acid conjugated poly(amidoamine) dendrimer as a smart nanocarriers for tracing, imaging, and treating cancers over-expressing folate receptors. *European Polymer Journal*, 170 doi:10.1016/j.eurpolymj.2022.111156
- Massaro, M., Poma, P., Cavallaro, G., García-Villén, F., Lazzara, G., Notarbartolo, M., Riela, S. (2022). Prodrug based on halloysite delivery systems to improve the antitumor ability of methotrexate in leukemia cell lines. *Colloids and Surfaces B: Biointerfaces*, 213 doi:10.1016/j.colsurfb.2022.112385
- Sabbagh, F., Muhamad, I. I., Niazmand, R., Dikshit, P. K., & Kim, B. S. (2022). Recent progress in polymeric non-invasive insulin delivery. *International Journal of Biological Macromolecules*, 203, 222-243. doi:10.1016/j.ijbiomac.2022.01.134
- Aziz, A., Sefidbakht, Y., Rezaei, S., Kouchakzadeh, H., & Uskoković, V. (2022). Doxorubicin-loaded, pH-sensitive albumin nanoparticles for lung cancer cell targeting. *Journal of Pharmaceutical Sciences*, 111(4), 1187-1196. doi:10.1016/j.xphs.2021.12.006

1.5. Required initial knowledge and skills of the PhD candidate

The candidate for the project is required to know the modification of polymeric materials, particularly biopolymers such as polysaccharides and proteins, as well as knowledge of techniques for characterizing the physicochemical properties of materials and extensive knowledge of medical chemistry at the master's level.

1.6. Expected development of the PhD candidate's knowledge and skills

During the implementation of the project, as part of the doctoral dissertation, the doctoral student will acquire knowledge in the field of design and application of modern intelligent biopolymer materials and basic biological research and determination of pharmacokinetic parameters. The skills that will be developed and acquired are advanced synthesis and modification of the surface of materials, spectroscopic characteristics of materials, application of the Surface Plasmon Resonance technique to study the interaction of materials with bioligands in real-time, planning and solving research problems, designing and carrying out research, conducting simple biological tests *in vitro* conditions, the ability to interpret and discuss the results, draw correct conclusions, present the results of own research in the form of publications and conference papers/posters, and the ability to work in an interdisciplinary team.