

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

Project title:

Intelligent polymers as materials for modern technologies

1.1. Project goals

The purpose of the work is to obtain and characterize new materials based on polymers with specific properties - sensitive to UV radiation, temperature, pH or bioactive with potential biomedical and cosmetic applications as well as for the production of protective coatings and packaging.

1.2. Outline

The chemical structure of synthetic polymers can be properly designed to provide the specific properties required in modern technologies. A unique group of polymers are contemporary designed stimulus-responsive compounds (also called "smart" or "intelligent"). Such polymers include, for example, systems capable of reproducing shape ("shape-memory materials") during the change of temperature or pH, systems generating electric current under the influence of applied force (piezoelectric materials) or photosensitive (e.g. luminescent substances). The preparation of such polymers usually begins with the design of monomers containing appropriate functional groups, which are then subjected to controlled polymerization. The second approach is to use ready-made functional polymers that can be chemically or physically modified.

In this project, macromolecular compounds with different polarity and solubility, as well as susceptible to heat, biological agents and UV radiation will be obtained.

It is planned to use biodegradable polymer matrices (synthetic polymers such as PLA, PVA or biopolymers such as cellulose and chitosan in a modified form) that will result in environmentally friendly materials. A methodology for obtaining photosensitive polymers with attached heterocyclic and aromatic moieties will be developed. Such polymers will be further modified towards planned hydrophilicity, important from the point of view of their adsorption capacity. The chemical structure, morphology and properties of the materials obtained (physicochemical, optical, photochemical, surface properties, thermal and mechanical stability, biodegradability, cytotoxicity) will be characterized using complementary instrumental methods i.e. FTIR, UV-Vis and fluorescence spectroscopy, SEM, AFM, TGA, DSC, XRD, chemical analysis, contact angle measurements and microbiological tests (in cooperation with scientists from Faculty of Biological and Veterinary Sciences, NCU). The correlation of structure and properties will allow the development of materials with unique tailored properties for special uses. Practical application of the obtained materials is expected in many fields of technology and medicine, e.g. in the packaging industry to monitor the shelf life of food products, as biosensors in medical diagnostics, in the production of implants or drug carriers with controlled release, as well as elements of optoelectronic devices. The PhD student will participate in the scientific work in the frame of Emerging Field entitled: "Polymer science and multifunctional nanomaterials". Cooperation with the Faculty of Chemistry of the University of Genova (Italy) in the field of biomaterials is also envisaged.

1.3. Work plan

1 year

The study of the thesis subject – literature review and specification of the experimental work plan, discussion of the concept of the dissertation at the doctoral seminar, learning of experimental techniques used in the realization of the project, preliminary researches, implementation of classes in accordance with the schedule of doctoral studies; passing exams;

2 year

Conducting research and writing publication, presentation of result on scientific conference, participation in compulsory classes, discussion of the results at the team's scientific seminar, preparation of the grant application; passing exams; the possibility to participate in an internship at another university (year 2nd or 3rd);

3 year

Continuation of experimental research and writing publications, presentation of result on scientific conferences, participation in compulsory classes, discussion of the results at the team's scientific seminar, passing exams, applying for an external grant, completing the results and preparing a dissertation plan;

4 year

Final supplementary research, participation in scientific seminars, doctoral examinations, writing publication, finalization of dissertation, public defense of doctoral dissertation.

1.4. Literature

- P. S. Sharma, Z. Iskierko, A. Pietrzyk-Le, F. D'Souza, W. Kutner, Bioinspired intelligent molecularly imprinted polymers for chemosensing: A mini review, *Electrochem. Commun.* 50 (2015) 81–87.
- W. Zhao, L. Liua, F. Zhangb, J. Leng, Y. Liu, Shape memory polymers and their composites in biomedical applications, *Mat. Sci. Eng. C Mater.* 97 (2019) 864–883.
- S. Kalpana, S.R. Priyadarshini, M. Maria Leena, J.A. Moses, C. Anandharamakrishnan, Intelligent packaging: Trends and applications in food systems, *Trends Food Sci. Techn.* 93 (2019) 145–157.
- D. Li, Q. He, J. Li, Smart core/shell nanocomposites: Intelligent polymers modified gold nanoparticles, *Adv. Colloid Interfac.* 149 (2009) 28–38.
- Y. Lia H. Y. Yang, T. Thambi, J.-H. Park, D. S. Lee, Charge-convertible polymers for improved tumor targeting and enhanced therapy, *Biomaterials* 217 (2019) 119299.
- Rong Hua, Anjun Qina, Ben Zhong Tang, AIE polymers: Synthesis and applications, *Prog. Polym. Sci.* 100 (2020) 101176.

1.5. Required initial knowledge and skills of the PhD candidate

Knowledge in the field of polymer chemistry (S2 studies level), fluent English, commitment to scientific work, permanent self-education, teamwork skill, the ability to interpret and describe experimental results and draw conclusions.

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

Acquiring advanced knowledge in the field of polymer chemistry; practical skills: methodology of obtaining new and safe polymer materials for modern technologies and their characterization by means of sophisticated instrumental analyses; the ability to write scientific publications and presentation of results at international conferences; ability to write scientific projects (grant applications); ability to formulate and solve scientific problems related to contemporary technology challenges; preparation for independent scientific work.