Lipid and polymer microparticles as drug delivery systems to the lungs in dry powder formulations

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Diseases of lower respiratory track such us acute and chronic infections, lung cancer, SARS-Cov-2 are one the most frequent causes of death worldwide as they can significantly compromise gas exchange in the alveoli. Such diseases are usually treated by systemic therapy, although lungs can be directly targeted through airways. Thus, by using inhalable formulations it is possible to obtain higher concentration of active pharmaceutical ingredient directly at their action site and reduce their amount distributed systemically. The two main benefits of inhalable drug delivery systems are reduced side effects thanks to lower doses administered than via typical enteral or other parenteral routes, and in the case of antibiotics – lower chance to build up antibiotic resistance. To achieve the most effective therapy fabricated powders must have: appropriate size (1 – 5 μm in diameter), uniform size distribution, required aerodynamic properties to be deposited in the bronchiole/alveoli region, sufficient drug loading and release kinetics.

In our group we are working on lipid and polymer microparticles to be used as inhalable dry powder formulations. So far we have developed novel, inhalable stimuli-sensitive drug carriers that are intended to enhance the efficacy of lung cancer therapy through guided accumulation directly at the tumour site and controlled drug delivery triggered by alternating magnetic field resulting in local increase in temperature. Such drug delivery carriers are in a form of solid lipid microparticles composed of fatty acids (lauric acid or a mixture of myristic and palmitic acid), loaded with superparamagnetic iron oxide nanoparticles and anticancer drug (paclitaxel). The microparticles fulfil sever criteria including appropriate size for inhalation (1 – 5 μm), melting temperature 42 – 45°C, high drug loading efficiency, sufficient mobility in magnetic field and enhanced *in vitro* efficacy as studied in contact with healthy and cancerous lung epithelial cells in hyperthermia conditions.

Recently we are working on polymer drug delivery systems of antibiotics and quorum sensing inhibitors for the treatment of bacterial infections in patients with chronic obstructive pulmonary disease (COPD) exacerbations. The system is based on fast degrading polyanhydride microparticles /microcapsules loaded with antibiotics (gentamycin, tobramycin, azithromycin) and quorum sensing inhibitors (curcumin, linolenic acid). The microparticles /microcapsules have appropriate size for inhalation, degrade within 7 days *in vitro* and release drug cargo, which is able to kill bacteria causing COPD. The system is cytocompatible with lung epithelial cells as shown by *in vitro* tests.

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Prof. Elżbieta Pamuła has a dual degree in Materials Science and Chemical Technology. She received her Ph.D. in Materials Science from the Faculty of Materials Science and Ceramics at AGH University of Science and Technology, Kraków, Poland. In 1998 and 2001, she was a postdoctoral fellow at UCLouvain in Belgium. In 2009, she received habilitation and became a full professor in 2014. As a visiting professor, she stayed at a number of universities: The Sydney University, Dresden Technical University, University of Oslo, University of Ghent, University of Nijmegen, University of Wageningen, University of Gothenburg, Cergy-Pontoise University. With her team, Prof. Pamuła works on resorbable polymer and composite biomaterials, scaffolds and matrices for tissue engineering and regenerative medicine, and drug delivery systems.

Currently, Prof. Pamuła serves as a Vice-Dean for Science at the Faculty of Materials Science and Ceramics, a member of the AGH Senate, and a Deputy Chair of the Biomedical Engineering Discipline Council at AGH. She is also a member of the Committee of Biocybernetics and Biomedical Engineering, as well as the Scientific Council of the Center of Polymer and Carbon Materials of the Polish Academy of Sciences.

Prof. Pamuła is a President of the Polish Society for Biomaterials (since 2016), and a member of the European Society for Biomaterials, where she has been an auditor since 2018. She was a Vice-Chair of the Organizing Committee of the 27th European Society for Biomaterials Conference in Krakow in 2015 (approx. 1000 participants) and the 4th International Conference on Biomedical Polymers and Polymeric Biomaterials (>300 participants) organized in 2018, as well as the Annual Conference of the Polish Society for Biomaterials “Biomaterials in Medicine and Veterinary Medicine” (organized since 1990, gathering annually over 100 participants from Poland and abroad).

Prof. Pamuła is a member of a number of panels evaluating research projects, e.g. ERC, EuroNanoMed, FWO Flanders, ANR France, FNRS, NCN, NCBR. She acted as a reviewer of doctoral and habilitation theses and for a professor title (> 40 reviews). Prof. Pamuła has promoted 9 doctors, 5 more doctorates are in progress. She was a supervisor of >70 master and >40 engineering theses. She conducts courses on biomaterials and composites, renewable materials, biotechnology, nanomedicine, tissue and genetic engineering, and clinical research. Since 2007, Prof. Pamuła has been a Head of Postgraduate Studies *Biomaterials - Materials for Medicine* at AGH.

She owns 8 patents and has published over 350 scientific reports, including 137 peer-reviewed articles and 14 book chapters (H-index = 30, citations = 2634, Scopus on 04.05.2023). She has given over 150 presentations at international conferences, including over 30 invited lectures. In 2020, the International Union of Societies for Biomaterials Science and Engineering awarded Prof. Pamuła the title of Fellow Biomaterials Science and Engineering (FBSE).