Macedonian Pharmaceutical Bulletin, 72 (Suppl 1) 11 - 12 (2026)
Online ISSN: 1857-8969
DOI: 10.33320/maced.pharm.bull.2026.72.03.004
Short communication

Therapy-specific drug development, novel trends for different administration routes

Rita Ambrus*

University of Szeged, Faculty of Pharmacy, 6720 Szeged, Hungary

Introduction

The objective of modern pharmaceutical technology is the research and development of stable dosage forms whose active pharmaceutical ingredients are absorbed at the appropriate site and time and exert their therapeutic effect efficiently. The application of advanced particle size reduction techniques (micro-, submicron-, and nanoscale ranges) represents a qualitative breakthrough in optimizing the performance of existing medicines and enables the formulation of novel pharmaceutical products for the treatment of various diseases. Micronization and nanonization of active pharmaceutical ingredients result in faster dissolution rates and, consequently, improved bioavailability. However, achieving the desired particle size requires specialized particle size reduction techniques, including both disintegration and integration approaches, with particular emphasis on nanotechnology. In nanoscale systems, the higher energy input and longer processing times enhance adhesive and cohesive forces, which may lead to instability of predispersions. In addition to optimizing processing parameters, the presence of suitable excipients is often necessary to stabilize the resulting products. This process is supported by the Quality by Design (QbD) concept, which incorporates both critical process parameters (CPPs) and critical quality attributes (CQAs). This modern approach also requires thorough knowledge of the Design Space. Micro- and nanoparticles with enhanced biological efficacy are suitable for administration through alternative routes, such as the pulmonary and nasal pathways, thereby bypassing hepatic first-pass metabolism associated with the gastrointestinal tract. The future of pharmaceutical development therefore points toward products manufactured using innovative technologies, offering reduced drug doses, targeted therapeutic action in selected cases, and more cost-effective production. Regarding alternative administration routes, research and development of microparticles primarily provide new opportunities in pulmonary therapy, particularly for chronic respiratory diseases where local drug action is desired. In contrast, nanosized particles have gained increasing attention for intranasal administration aimed at achieving systemic and central nervous system effects. Considering future trends, the present work contributes to the development of value-added pharmaceutical products, thereby enabling more effective treatment of numerous diseases.

In this work, the outstanding technological directions of our research carried out over the past 15 years will be presented, also from the biomedical perspective. The practical significance of our results is clearly demonstrated by the industrial and international collaborations and the pharmaceutical and university-owned patents related to the work.

*ambrus.rita@szte.hu

Materials and methods

In this work, different methods were used to decrease particle size into the micro- or the nanosize range. They can be divided into two main categories: bottom-up and top-down techniques. These two categories are not separated sharply, because the combination of the top-down and the bottom-up technique is necessary to control the particle size. Basically, we focused on the following methods: research and development of dry/wet milling; cavitation; ultrasonic-assisted nanoprecipitation and preparation of nanocarriers by nano spray drying.

We developed formulations for per os, nasal and pulmonary application. The applied model drugs were selected such as meloxicam, ibuprofen, ketoprofen, loratatiden, lamotrigine, ciporfloxacine. Different type of excipients e.g. PVA, PVP, PEG, Poloxamer, Tween, Leucine, Inhalac, Mannitol, Hyaluronic acid were used. Characterization of micrometric and physicochemical properties, structure, compatibility, stability, in vitro, ex vivo, in silico amd in vivo properties took a part of the scientific evaluations. The innovative formulations could play a significant role in modern therapies (Alshweiat et al 2020).

Results and discussion

We monitored the dry/wet grinding parameters and the factors affecting nano-precipitation, used alternative energy sources based on solvent evaporation, designed compositions and production parameters in the 1-5 µm and 100-500 nm particle size ranges. A predispersions (liquid and solid formulations of nanosuspensions) were produced with innovative technological solutions (formation of particles with a specific habit), optimized the products, and in some cases the intermediate product as final products (stabilizers, drying procedures, composition, toxicity) could be used. Furthermore, with preformulation tests, we determined the additives necessary for alternative drug intake (pulmonary, nasal) and their applicable concentrations in the case of different dosageforms. We developed a new preparation protocol for delivering nanoparticles to the lungs by developing a "nano-in-micro" inhalation product (innovative product). In silico aerodynamic model was introduced as a part of inhalation investigation protocol (Party et al 2021). A self-developed horizontal diffusion model for the examination of suspensions and powders (geometric arrangement, real-time analysis, membrane impregnation, small volume) was also used.

Conclusion

The overall aim of this work was to investigate and develop advanced, innovative particle size reduction technologies capable of modifying the physicochemical properties of model drug substances and producing predispersions suitable for pharmaceutical formulation. Furthermore, through experimental design approaches, technologies applicable to industrial practice were identified, while the development of in vitro, ex vivo, and in silico analytical methods provided knowledge supporting the development and manufacturing of modern pharmaceutical products. Such developments may create new opportunities for rapid pain relief, anti-inflammatory therapy, and the treatment of central nervous system disorders. Owing to the formulation strategy and the selected route of administration, new therapeutic indications may become available for existing pharmacologically active compounds, leading to modified treatment protocols, more advanced pharmaceutical products, and, in the long term, reduced healthcare costs.

Acknowledgement

This work was supported by the NKFI OTKA K_146148 project.

References

Alshweiat, A. et al., 2020. Nasal delivery of nanosuspension-based mucoadhesive formulation with improved bioavailability of loratadine: preparation, characterization, and in vivo evaluation. Int. J. Pharm. 579, 119166. https://doi.org/10.1016/j.ijpharm.2020.119166

Party, P. et al., 2021. Formulation and in vitro and in silico characterization of “nano-in-micro” dry powder inhalers containing meloxicam. Pharmaceutics 13, 211. https://doi.org/10.3390/pharmaceutics13020211