

Innovative ophthalmic drug delivery: vancomycin and cefuroxime eye drops based on a self-emulsifying system (SEO)

Anna Roszkowska¹; Magdalena Kaszewska²; Katarzyna Woźniczka³; Dagmara Leszczyńska⁴; Katarzyna Krzemińska⁵; Agnieszka Mosińska⁶; Gracjan Maślanka⁷; Adrian Górski⁸; Katarzyna Owczarek⁹; Vaclav Trojan¹⁰; Marzena Jamrogiewicz¹¹; Tomasz Bączek¹²; Małgorzata Sznitowska¹³

¹ Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, anna.roszkowska@gumed.edu.pl

² Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, m.kaszewska@gumed.edu.pl

³ Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, katarzyna.wozniczka@gumed.edu.pl

⁴ Department of Pharmaceutical Biochemistry, Medical University of Gdansk, Dębinki 1 Str., 80-211, Gdansk, Poland, dagmaraleszczynska@gumed.edu.pl

⁵ Department of Pharmaceutical Technology, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, katarzyna.krzeminska@gumed.edu.pl

⁶ Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, agnieszka.mosinska@gumed.edu.pl

⁷ Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, gmaslanka@gumed.edu.pl

⁸ Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, adriangorski10@gumed.edu.pl

⁹ Department of Biochemistry, Medical University of Gdansk, Dębinki 1 Str., 80-211, Gdansk, Poland, katarzyna.owczarek@gumed.edu.pl

¹⁰ Cannabis Facility, St. Anne's University Hospital Brno, Pekařská 664/53, 602 00 Brno, Czech Republic, vaclav.trojan@fnusa.cz

¹¹ Department of Physical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, marzena.jamrogiewicz@gumed.edu.pl

¹² Department of Pharmaceutical Chemistry, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, tomasz.baczek@gumed.edu.pl

¹³ Department of Pharmaceutical Technology, Medical University of Gdansk, Hallera 107 Str., 80-416 Gdansk, Poland, malgorzata.sznitowska@gumed.edu.pl

INTRODUCTION

Ophthalmic infections such as keratitis and conjunctivitis require efficient antibiotic therapy. A common challenge in the development of ophthalmic drugs is the instability of many antibiotics in aqueous solutions, which limits their formulation as ready-to-use eye drops with adequate shelf-life. Traditional alternatives, like oily formulations, often cause poor tolerance and interfere with vision. This project introduces an innovative drug delivery technology using a self-emulsifying oil (SEO) that converts into an emulsion upon contact with tear fluid, facilitating rapid dissolution of water-unstable antibiotics. Vancomycin hydrochloride (VAN) and cefuroxime sodium (CEF), selected for their clinical importance against resistant infections, were used as

a model compounds. Preclinical safety, tolerance, and efficacy were confirmed in rabbits, accompanied by pharmacokinetic and tissue distribution studies for both antibiotics in SEO to overcome aqueous instability, and allowing potential clinical applicability [1-3].

MATERIALS AND METHODS

A self-emulsifying oil (SEO) system was developed to incorporate antibiotics unstable in aqueous media, circumventing the need for extemporaneous compounding and limitations of oily eye drops. Preformulation studies involved suspension stability characterization, and compatibility with pharmaceutical packaging. Analytical evaluation included microstructural, spectroscopic, and

chromatographic methods such as HPLC-UV and LC-MS/MS for quantifying antibiotic content, impurities, and degradation products (**Figure 1**). VAN and CEF stability were assessed immediately after preparation and during storage. In vivo studies on porcine models evaluated safety, tolerance, and antibiotic pharmacokinetics, using HPLC-UV for tear concentration monitoring and LC-MS/MS for eye tissue distribution studies (**Figure 2**).



Figure 1. Instrumental analysis of CEF and VAN in tears (HPLC-UV) and eye structures (LC-MS/MS).

RESULTS

VAN and CEF suspended in the SEO system exhibited sustained stability and rapid in situ formation of an oil-in-water emulsion upon ocular administration. The delivery system maintained antimicrobial efficacy, minimized visual disturbance common to oily drops, and showed excellent tolerance in preclinical models. Pharmacokinetic data from pigs demonstrated improved ocular tissue penetration and favorable distribution relative to aqueous formulations. Analytical methods enabled reliable detection and quantification of VAN and CEF, along with their degradation pathways. Stability studies revealed optimal VAN preservation at 25°C compared to 40°C, with impurity levels within pharmacopeial limits across different stress conditions. The SEO formulations maintained clarity and analytical reproducibility after filtration, supporting quality standards.

DISCUSSION

The presented SEO platform represents the first patented ocular drug delivery system to stabilize water-labile antibiotics for ophthalmic use. This technology addresses significant formulation challenges, providing an innovative, scalable solution that supports industrial manufacturing and regulatory approval processes. Analytical advancements allowed precise impurity profiling, stability monitoring, and measurement of drug levels in ocular matrices. The sustained chemical stability, combined with the favorable pharmacokinetic profile and good ocular tolerance, highlights the clinical potential of SEO-based antibiotic suspensions. This system could replace extemporaneous compounding and circumvent shortcomings of existing oily formulations.

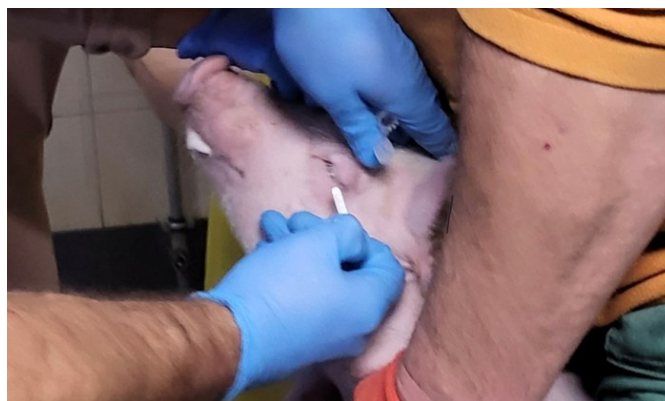


Figure 2. Collection of tears from pig's eye with the use of Schirmer strips. CEF and VAN were administered into the eyes in the SEO formulation and also in typical aqueous eye drops.

CONCLUSION

The SEO-based suspension technology offers a breakthrough in delivery and stabilization of labile ophthalmic antibiotics, with VAN and CEF eye drops as a prime examples. Preclinical data demonstrate safety, efficacy, and substantial stability improvements crucial for clinical translation. The simple composition utilizes excipients already approved for ophthalmic use and employs production processes readily adapted for industrial scale-up. This novel approach paves the way for clinical trial batch production and possible future commercialization, promising enhanced therapeutic solutions for challenging ocular infections.

ACKNOWLEDGEMENTS

The research is funded by a Medical Research Agency grant nr 2024/ABM/03/KPO/ KPOD.07.07-IW.07-0046/24-00.

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