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Nano-suspension for Ocular Drug Delivery: Advances, Challenges, and Future Perspectives – A Review

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Abstract: *Ocular drug delivery presents significant challenges due to physiological barriers such as tear drainage, limited corneal permeability, and rapid drug clearance. Conventional ophthalmic formulations, including eye drops and ointments, often suffer from poor bioavailability and require frequent administration. Nano-suspensions have emerged as a promising approach to enhance ocular drug delivery by improving solubility, prolonging retention, and enabling sustained drug release. These submicron colloidal dispersions of pure drug particles, stabilized by surfactants or polymers, offer advantages such as enhanced corneal permeability, reduced systemic absorption, and increased therapeutic efficacy. This review explores the formulation strategies, characterization techniques, and mechanisms of ocular drug absorption for nano-suspensions. Various bottom-up (precipitation, supercritical fluid methods) and top-down (media milling, high-pressure homogenization) approaches for nano-suspension preparation are discussed. Additionally, the review highlights pharmacokinetic considerations, stability challenges, sterility concerns, and regulatory hurdles associated with these formulations. Emerging trends, such as mucoadhesivenano-suspensions, hybrid nano-formulations, and personalized medicine approaches, offer exciting future prospects for enhancing ocular drug therapy. Despite current challenges, nano-suspensions have demonstrated significant potential in the treatment of glaucoma, ocular infections, inflammation, and retinal disorders. With advancements in nanotechnology and regulatory approvals, nano-suspensions could revolutionize ophthalmic drug delivery, improving patient compliance and therapeutic outcomes.*

Keywords: Nano-suspension, ocular drug delivery, bioavailability, corneal permeability, sustained release, mucoadhesion, hybrid nano-formulations, pharmacokinetics, regulatory approval, personalized medicine.

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