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Evaluation of Mucoadhesive Polymers for Nasal Delivery of Herbal Bioactives

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Abstract

A study assessed mucoadhesive polymers for intranasal herbal bioactive administration with higher residence time and mucosal permeability. Chitosan, Carbopol® 934P, and HPMC K15M were utilized to manufacture mucoadhesive nasal gels with standardized herbal bioactive fractions. Formulations were examined for pH, viscosity, spreadability, drug content, mucoadhesive strength, in-vitro release, ex-vivo penetration, and short-term stability. All formulations demonstrated a suitable pH for nasal usage and uniform drug content (97.48 ± 1.12% to 101.26 ± 0.94%). Pseudoplastic flow behavior (1820 ± 95 to 3540 ± 140 cP at 25 °C) indicates strong nasal retention from chitosan to Carbopol 934P to HPMC, but mucoadhesive strength varies. Chitosan-based formulation showed the maximum mucoadhesive force (39.4 ± 2.1 g), followed by Carbopol (32.6 ± 1.8 g) and HPMC (23.7 ± 1.5 g). In-vitro experiments revealed sustained herbal bioactive release over 8 hours, with chitosan releasing (85.9 ± 2.7%), Carbopol (74.8 ± 2.3%), and HPMC (79.6 ± 2.5%). Chitosan formulation was found to outperform HPMC-based systems in ex-vivo permeation investigations on freshly excised sheep nasal mucosa, with cumulative permeation of 68.4 ± 3.2% and apparent permeability coefficient of 3.87 ± 0.29 × 10^{-5} cm/s, 1.71-fold higher ($p < 0.05$). Fourier-transform infrared spectroscopy and differential scanning calorimetry indicated herbal bioactive molecule dispersion in polymeric matrix and no chemical incompatibility. Stability studies at 25 ± 2 °C for 30 days showed no significant pH, drug content, or release behavior changes. Due to its superior mucoadhesion, rheology, and mucosal penetration, chitosan is the best polymeric carrier for herbal bioactive nasal administration.

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Keywords: Carbopol 934P, chitosan, ex-vivo permeation, herbal bioactives, HPMC, mucoadhesive polymers, nasal drug delivery, polymeric nasal gel

INTRODUCTION

Nasal drug delivery systems represent a unique class of soft polymer-based biomedical composites designed to operate at a complex biological interface. From a materials science perspective, these systems are not merely pharmaceutical formulations but structured polymer networks engineered to control adhesion, hydration, mechanical stability, and mass transport. Although the nasal route offers rapid systemic absorption and

