IOCB 2025 Conference
The 2nd International Online Conference on Biomimetics
16–18 September 2025 | Online
MDPI

In Silico Assessment of Natural Biodegradable Polymers for Dermal Drug Delivery Systems

•Jovana Aćimović[a], Darija Obradović[a], Pavle Spasojević[b,c], Aleksandar Popović[d] , Saša Lazović[a], Tijana Milićević[a]

•[a] University of Belgrade - Environmental Physics Laboratory, Institute of Physics Belgrade, National Institute of the Republic of Serbia, Belgrade, Serbia

• [b] Innovation Center of Faculty of Technology and Metallurgy, Belgrade, Serbia

• [c]University of Kragujevac - Faculty of Technical Sciences, Čačak, Serbia

• [d]University of Belgrade - Faculty of Chemistry, Belgrade, Serbia

INTRODUCTION & Aim

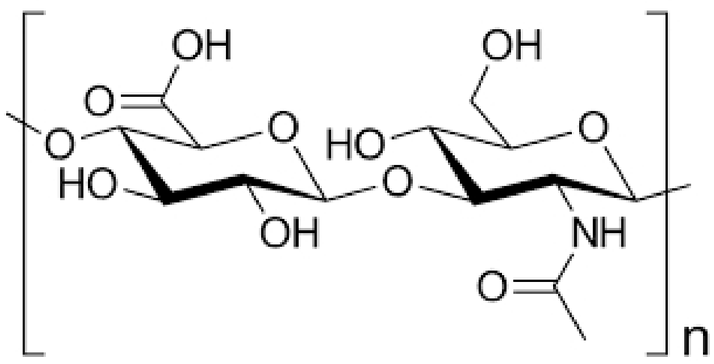
Dermal forms are promising drug delivery systems due to their many advantages and suitable applications [1]. Natural biodegradable polymers are a good fit for dermal drug delivery thanks to their biocompatibility, safety, and gel-forming ability. Polymer choice strongly affects drug release and skin permeation.

Hansen Solubility Parameters (HSPs) are in silico method used to estimate polymer drug compatibility in this research. HSPs divide interactions into three components:

- δd – dispersion forces
- δp – polar interactions
- δh – hydrogen bonding

The Relative Energy Difference (RED) shows how close a polymer is to the ideal region for dermal delivery (lower RED = closer match)

Figure 1. Structure of Hyaluronic acid



METHOD

•Polymers studied: alginate, pectin, dextran, hyaluronic acid.
•HSP analysis performed using HSPiP software.
•Reference sphere coordinates (δd = 16.5, δp = 12.0, δh = 7.7, Ro = 6.3) were taken from literature [2].

$$\delta^2 = \delta_d^2 + \delta_h^2 + \delta_p^2 \quad (1)$$

$$R_a^2 = 4(\delta_{d1} - \delta_{d2})^2 + (\delta_{p1} - \delta_{p2})^2 + (\delta_{h1} - \delta_{h2})^2 \quad (2)$$

$$RED = R_a/R_0 \quad (3)$$

- R_0 - interaction radius
- R_a - HSP distance between two molecules

The HSP forces for selected polymers were determined in the HSPiP software.

RESULTS & DISCUSSION

•Hyaluronic acid showed the lowest RED value among the tested polymers. Together with its excellent water retention, viscoelasticity, and strong interaction with the extracellular matrix, this makes it a highly promising candidate for dermal formulations.
•Alginate demonstrated favorable values close to the reference sphere. Its biodegradability, biocompatibility, and gel-forming ability make it attractive for controlled-release formulations.
•Pectin displayed relatively higher RED value.
•With its natural origin, low toxicity, and mucoadhesive properties, pectin remains a versatile excipient for drug delivery.
•Dextran, although further from the sphere, is valued for its water solubility, non-immunogenicity, and stability, which continue to make it useful in a wide range of biomedical applications.
Overall, while none of the tested polymers matched the dermal interaction sphere exactly, after hyaluronic acid the lowes RED value has alginate, then dextran and the highest Red value has pectine. The HSP results provide a guideline for further formulation strategies, blends, or chemical modifications to maximize their dermal delivery performance.

CONCLUSION

HSP analysis indicated that the studied polymers are not in the ideal range for dermal delivery. Still, they are not unsuitable, since their RED values show reasonable proximity to the target region. Thanks to their biocompatibility, biodegradability, hydrophilicity, and gel-forming ability, these polymers remain strong candidates. With further optimization and experimental validation, they could be successfully adapted for dermal drug delivery applications.

REFERENCES

1. Cvetković, D., Dankulov, M.M., Bogojević, A., Lazović, S., and Obradović, D., *Chemometr. Intell. Lab. Syst.*, **251**, no. 105168 (2024).
2. Ezati, N., Roberts, S., Zhang, Q, and H. R. Moghimi, H.R., *Iran. J. Pharm. Res.*, **19**, 572-578, (2020).