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EFFECT OF PLGA ARCHITECTURE ON THE RHEOLOGICAL BEHAVIOUR OF POLYMER SOLUTIONS IN DIFFERENT SOLVENTS

Utjecaj PLGA građe na reološka svojstva polimernih otopina u različitim otapalima

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OBJECTIVE

Establish correlations between PLGA architecture and solvent-dependent rheological behaviour, with emphasis on how molecular topology affects solution conformation, flow properties and viscoelastic response. The scientific novelty lies in evaluating molecular and rheological properties of linear and branched PLGA in pharmaceutically relevant solvents.

INTRODUCTION

- PLGA is the most widely used biodegradable polymer in long-acting injectable (LAI) formulations.
- Solution viscosity governs injectability, syringeability and processability – all critical quality attributes.
- Molecular topology (linear vs. branched) can alter chain conformation in solution independently of molar mass.
- How architecture interacts with solvent quality in concentrated PLGA solutions is still poorly described.

MATERIALS & METHODS

Polymers: Linear and branched (star-shaped) PLGA of comparable chemical composition and molar mass.

Solvents: DMSO (strong solvent) vs. ethyl lactate (moderately solvating).

Multi-detection GPC system (MALS-VISCO-RI): Determination of molar mass distribution, branching, hydrodynamic size and intrinsic viscosity [η].

Rheological characterization: Flow and oscillatory measurements on concentrated solutions (22 %) to capture the viscoelastic response (dynamic viscosity vs. shear rate).

RESULTS

Multi-detection GPC results: Linear vs. Star-shape PLGA characterization

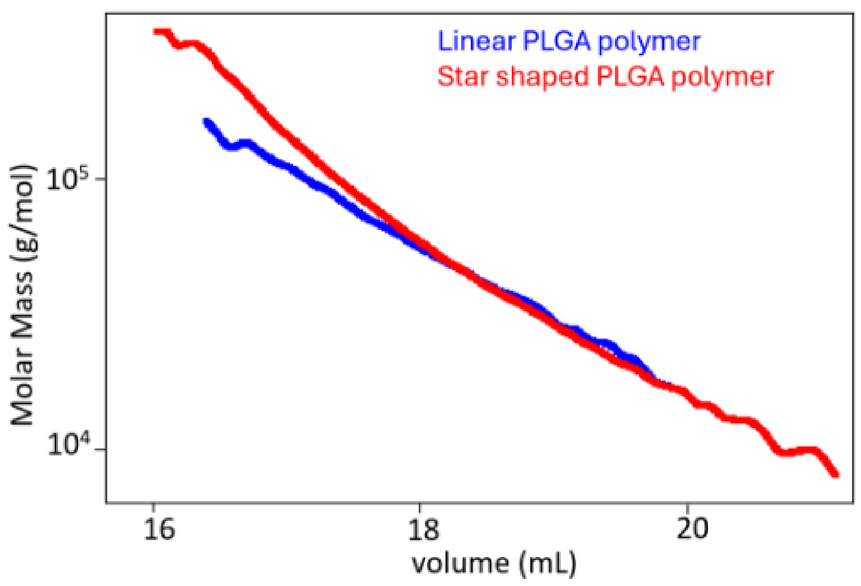

Fig. 1 – Molar mass vs. elution volume. Both grades elute over the same volume range with comparable molar mass distributions (10^4–10^5 g/mol) – well matched for a topology comparison.

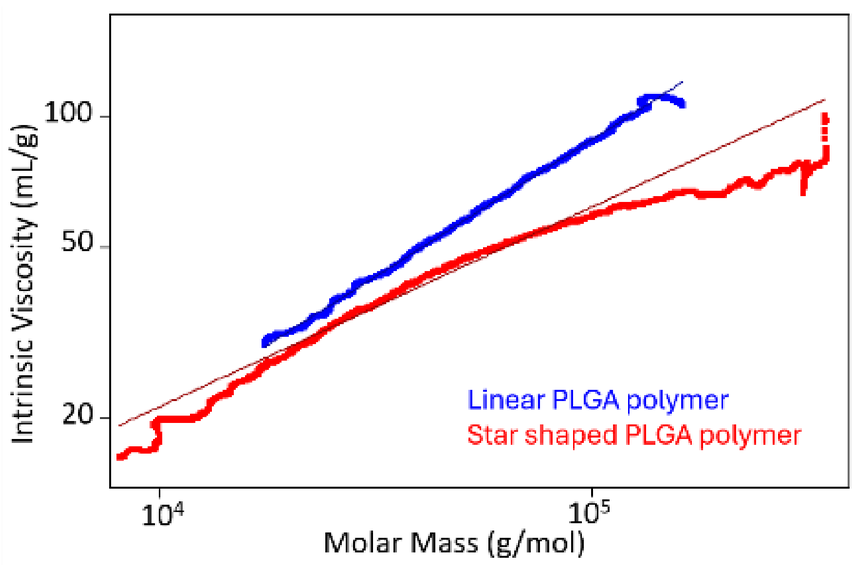

Fig. 2 – Intrinsic viscosity vs. molar mass. Across 10^4–10^5 g/mol the star-shaped PLGA shows consistently lower [η] than the linear grade at equal molar mass, and the gap widens with molar mass.

- Matched molar mass, different solution size – overlapping GPC profiles but different [η]: the contraction is architectural, not compositional.
- Branching lowers hydrodynamic volume – star PLGA occupies less space in solution at the same molar mass.
- Solvent quality sets the absolute level – both grades are about twice as viscous in ethyl lactate as in DMSO, while the architecture-driven contrast is largest in DMSO (~50% vs. 25–45%).

Rheological characterization:

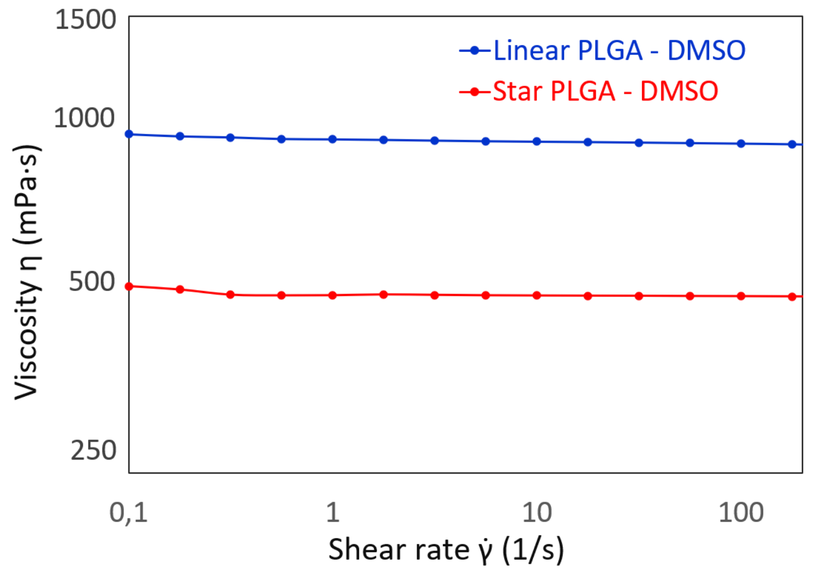

Fig. 3 – Dynamic viscosity vs. shear rate in DMSO. Both PLGA grades are Newtonian across the whole shear-rate range: the linear grade plateaus near 950 mPa·s and the star-shaped grade near 480 mPa·s – about half the viscosity at comparable molar mass.

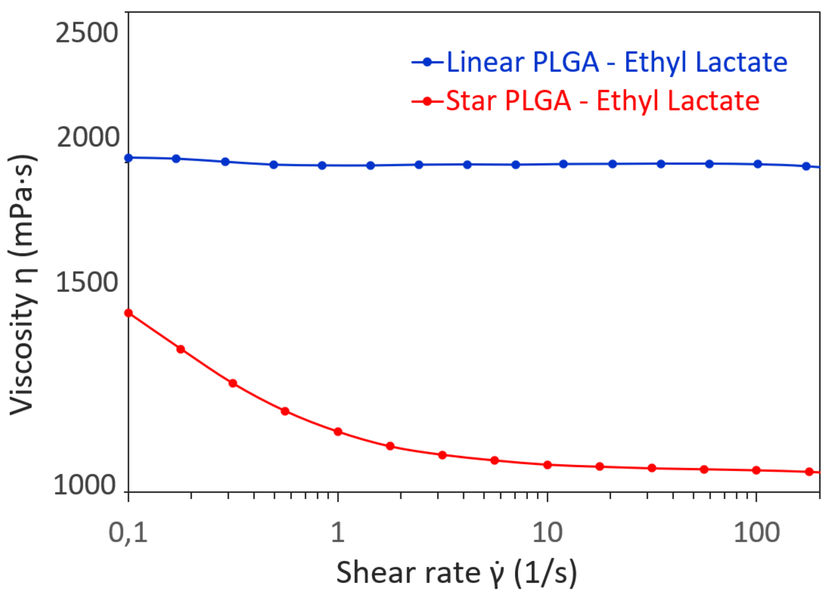

Fig. 4 – Dynamic viscosity vs. shear rate in ethyl lactate. Both grades are more viscous in ethyl lactate than in DMSO. The linear grade remains Newtonian (~1900 mPa·s), while the star-shaped grade shear-thins from ~1420 to ~1030 mPa·s.

- Polymer architecture governs viscosity: star-shaped PLGA exhibits significantly lower viscosity than linear PLGA despite comparable molar mass, reflecting its lower hydrodynamic volume.
- Ethyl lactate enhances chain interactions: both PLGA grades are approximately twice as viscous in ethyl lactate as in DMSO, demonstrating a strong solvent effect on solution rheology.
- Non-Newtonian behavior is architecture-dependent: only the star-shaped PLGA in ethyl lactate shows pronounced shear-thinning, whereas all other formulations remain essentially Newtonian.

CONCLUSIONS

Molecular topology governs solution behavior: linear and star-shaped PLGA of comparable molar mass differ markedly in intrinsic viscosity and hydrodynamic volume. Branching lowers viscosity, while solvent quality controls the absolute viscosity level and flow behavior. These two independent parameters provide complementary tools for tuning the injectability and processability of LAI formulations

KEY FINDINGS

Star-shaped PLGA showed ~50% lower viscosity than the linear grade at comparable molar mass, reflecting its more compact architecture. Ethyl lactate increased viscosity for both polymers, highlighting the influence of solvent quality on chain interactions. Shear-thinning occurred only for star-shaped PLGA in ethyl lactate – a route to higher polymer loading while preserving injectability.

REFERENCES

[1] J. Hadar et al., J. Control. Release, 320 (2020) 484–494.
[2] D. Choe et al., J. Rheol., 68 (2024) 591–601.

KEYWORDS

PLGA · branching · rheology · polymer solutions · solvent quality