# The Precise Synthesis of Ultradense Bottlebrush Polymers Unearths Unique Trends in Lyotropic Ordering

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**What was achieved?:**
Ultradense bottlebrush polymers (BBPs) with high grafting density were synthesized using novel macroinitiators. These BBPs exhibited long-range lyotropic ordering and formed hexagonal arrays, a behavior not observed in conventional BBPs. The synthesis was scalable, providing multigram quantities of these materials. The materials were characterized using light scattering techniques, revealing the impact of grafting density on macromolecular rigidity and concentration induced ordering. The study provided fundamental insights into the solution-phase behavior of BBPs, laying the foundation for biomimetic materials with advanced mechanical properties.

**Why is it important?:**
Biology creates exceptional materials from relatively ordinary molecules via precise organization across multiple length scales. This research is significant as it enables the synthesis of BBPs that mimic the assembly behavior of tropocollagen, a key biomacromolecule that underpins the multiscale structure and mechanics of tissues. Consequently, new avenues have been opened for designing synthetic materials that mimic the fibrillar structures in tissues such as cartilage and skin, features that endow them with their exceptional robustness. Specifically, the study highlighted the crucial role of structural density and entanglement in BBP assembly, providing essential insights for the design of fabrication processes of hierarchically structured biomimetic materials.

**How did BioPACIFIC MIP enable this?**
BioPACIFIC MIP enabled this study by providing access to its SAXS facility as well as the expertise of its project scientists Phillip Kohl and Youli Li. SAXS was used to characterize the solution-phase behavior of the ultradense bottlebrush polymers (BBPs) and confirm their long-range lyotropic ordering, with the project scientists' expertise aiding in the data analysis.

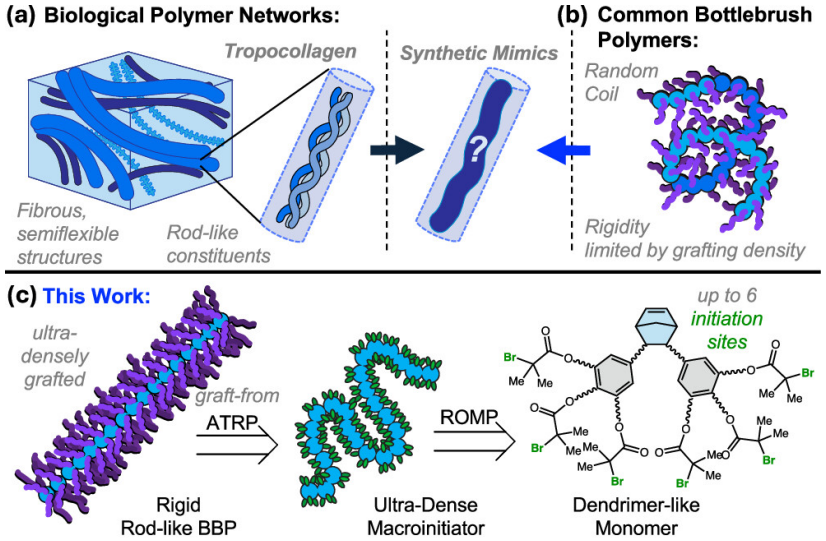


***Figure 1.*** *(a) Biomacromolecular networks are fibrous and semiflexible architectures composed of anisotropic constituents, such as tropocollagen, which demonstrates lyotropic liquid crystalline (LC) behavior that underpins its biological self-assembly. (b) Common bottlebrush polymers are characterized by random coil conformations in solution, preventing their use as LC biomacromolecule surrogates. (c) Ultradensely grafted BBP reported in this study shows unprecedented rodlike character and lyotropic ordering and are prepared via a precise bottom−up synthesis beginning with dendrimer-like monomers.*

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