Bioinspired bottlebrush polymers for lubrication, antifouling, drug delivery …and more

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Abstract

Nature has always been an endless source of inspiration for poets, painters, compositors, and even macromolecular engineers. Nature-inspired materials aim to harness, through their structure and functionalities, properties that could not be obtained through an ab-initio thinking process. Numerous bioinspired materials have already reached our everyday life such as shark skin-inspired swimsuits, the famous burr-inspired Velcro, or the water-repelling paint inspired by the lotus leaf surface nanostructure. In the biomedical field, bioinspired materials are also heavily investigated to design lifelong prosthetics, scaffolds for tissue engineering or bioadhesives for wound suture. Our contribution in this area is focused on bioinspired materials capable of controlling interfacial forces such as lubrication or adhesion. Such materials have promising applications for the treatment of dry eye syndrome or arthritis. During the past decade we have developed hyperbranched polymers called bottlebrush polymers and tuned their properties for different biomedical applications. Bottlebrushes are branched macromolecules whose architecture is similar to proteins found in our mucus or synovial joints. During the past few years, we have been investigating the behavior of bottlebrushes at the solid liquid interface[1-3] and more recently in biological media using a structure-property relationship approach. We have systematically compared monoblock versus multiblock bottlebrushes and evaluated their lubricating and antifouling properties in a wide range of media.[4, 5] Using surface sensitive techniques such as the Surface Forces Apparatus, we were able to rationalize the correlations between polymer architecture, conformation, and interfacial properties. Our more recent work aims to study the properties of these materials in living organisms, especially at the surface of cartilage, the eye and in the blood stream. Our advances in that area show that molecular brushes are excellent candidates as nanocarriers for drug delivery to the brain[6] as well as good chondroprotective agents.

References

1. Banquy, X., et al., *Bioinspired bottle-brush polymer exhibits low friction and Amontons-like behavior.* J Am Chem Soc, 2014. **136**(17): p. 6199-202.
2. Xia, Y., et al., *Biomimetic Bottlebrush Polymer Coatings for Fabrication of Ultralow Fouling Surfaces.* Angew Chem Int Ed Engl, 2019. **58**(5): p. 1308-1314.
3. Adibnia, V., et al., *Superlubricity of Zwitterionic Bottlebrush Polymers in the Presence of Multivalent Ions.* J Am Chem Soc, 2020. **142**(35): p. 14843-14847.
4. Faivre, J., et al., *Intermolecular interactions between bottlebrush polymers boost the protection of surfaces against frictional wear.* Chemistry of Materials, 2018. **30**(12): p. 4140-4149.
5. Xia, Y., et al., *Synergy between Zwitterionic Polymers and Hyaluronic Acid Enhances Antifouling Performance.* Langmuir, 2019. **35**(48): p. 15535-15542.
6. Rabanel, J.-M., et al., *Deep Tissue Penetration of Bottle-Brush Polymers via Cell Capture Evasion and Fast Diffusion.* ACS Nano, 2022. **16**(12): p. 21583-21599.

Short bio

Dr Banquy is a Full Professor of Pharmaceutical Sciences at the University of Montreal, Canada and director of the Drug Formulation Analysis research cluster. He holds the Tier2 Canada Research Chair in bioinspired materials and is currently the coordinator of an international consortium in articular nanotherapy funded by FRQS through the Euronanomed initiative. His research activities explore the behavior of soft matter at (bio)interfaces. In recent years, his group has been especially interested in the study of soft nanoparticle interactions with living matter and their implications in nanomedicine. In this area his research intents to identify which physical-chemical cues allow nanoparticles to translocate through biological barriers and to navigate in dense tissues. His group is also involved in the design of biomimetic materials for lubrication, adhesion and antifouling applications. His team has designed several lubricating polymers that are currently translated to the biomedical field and peptide based materials that could be used as strong tissue adhesives.