FY2015

Reinforcement of Resiliency of Concentrated Polymer Brushes and Its Tribological Applications - Development of Novel "Soft and Resilient Tribology (SRT)" System

Surface-coating of materials drastically improves performance

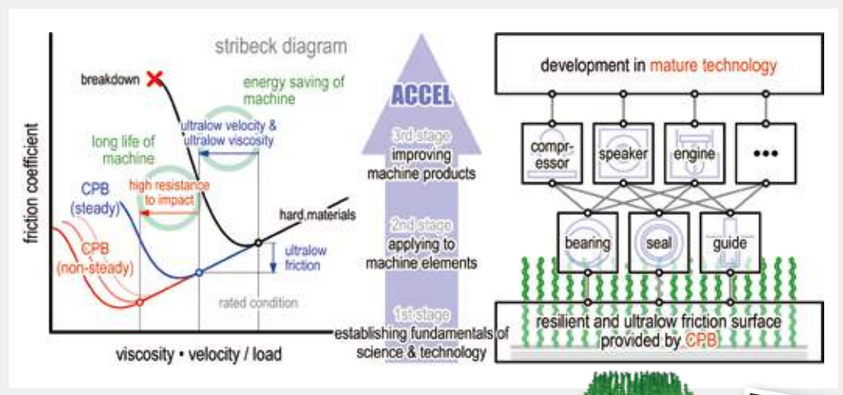
The giant molecule that is formed by the combination (polymerization) of many sets of small molecules (monomers) is called a polymer. The thin layer created by growing polymers on a material surface is a polymer brush. This will add new functions to the material surface.

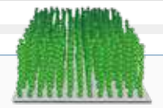
We have previously developed the *Concentrated Polymer Brush (CPB)* that provides completely new characteristics such as ultra-low friction, good lubrication, high elasticity, and excellent bio-compatibility, and further improved these characteristics by multi-layering and hierarchizing the CPBs. In addition, we have successfully and dramatically thickened the CPB layer through innovative surface formation technology and verified its superior tribological properties, including low friction, good lubrication and high wear resistance at not only the micro but also the macro levels, demonstrating the possibility of its application to practical machinery systems.

Reducing friction using CPBs and hence making daily-life electric appliances more durable and higher in performance

In the ACCEL project, we aim to apply CPBs on sliding parts of mechanical elements such as sliding bearings and seals. This allows us to attain high levels of both resilience and low friction that were hard to achieve with previous technology. Finally, we will establish a new concept, *Soft and Resilient Tribology (SRT),* realizing long-lasting, low power-consumption machinery products.

The CPB has the potential to inspire further innovation even in machinery products based on mature technologies, such as, compressors, automotive equipment, audio equipment, home electronics like refrigerators, and transport equipment.





Concentrated Polymer Brush

The CPB of special interfacial functions was first fabricated using precise polymerization allowing uniform growth of polymers, and hence accurate control of the brush structure and increased density. This research successfully created a micrometer-sized CPB ten times thicker than conventional ones, drastically reducing its friction resistance.

The CPBs of various thicknesses on the surface show different colors, depending on the CPB thickness.

Research Director

Yoshinobu Tsujii

Director/Professor, Institute for Chemical Research, Kyoto University

The surface of materials plays an extremely important role because it acts as the contact point between the materials and the outer world. Various phenomena related to material functions, such as friction, wear, adhesion, and adsorption, all depend on its surface characteristics. Our research is originally based on the idea that next-generation materials would be developed by dramatically changing such surface characteristics via special coating of functional thin films. I hope to tackle this based on my understanding of the laws and principles involved, and with the advantage of precision manufacturing.

In the ACCEL project, I am moving ahead with R&D toward CPB commercialization, focusing on its superior mechanical properties and ultra-low friction. This is being done in collaboration with seven research institutions, covering not only the material, but also the mechanical and computational science fields. I am engaged in processing CPB to make them easy to handle while maintaining resilience and low friction characteristics even under low viscosity, low velocities and high load environments.

Through my research on concentrated polymer brushes, I would like to develop new aspects of broad material science fields in terms of function and application, laying the foundations of a safe and secure society.

Program Manager

Kimihiro Matsukawa

ACCEL Program Manager, Japan Science and Technology Agency

I have been widely engaged in joint research with industry, and also have experience with technical support for companies and business-academia collaboration projects. By drawing on these experiences, I would like to demonstrate the usefulness of the CPB and present its practical use to society.

As a Program Manager of this project, I will promote strategic research management on outcome-focused research. My role is to establish the material and fundamental technology, focusing on characteristics as lubricating devices derived from SRT, and provide the path to connect basic research to applications in mechanical elements. Currently, with six companies who cover both the upstream and downstream areas of business, we are discussing among multiple working groups of fundamental science and applications to study how to commercialize this technology. I will achieve a range of mechanical systems that offer higher performance by incorporating CPBs.

My aim is that contributing to energy-saving and reducing environmental load through the reduction of friction and wear can become one of the pillars supporting the science and technology of the 21st century.

The equipment and electric appliances around us will offer higher performances, lower costs, and longer lives through the use of SRT materials.

PROFILE YOSHINOBU TSUJII

1988: Ph.D. (Engineering), Graduate School of Engineering, Kyoto University; 1989: Institute for Chemical Research, Kyoto University; 2008: Professor, Institute for Chemical Research, appointed to current post in 2018. Research into synthesis and physical properties of polymer thin film, basics and applications of polymer brushes, and material design of functional polymers.

PROFILE KIMIHIRO MATSUKAWA

1983: Ph.D. (Engineering), Graduate School of Engineering, Osaka Prefecture University; 1984: Osaka Municipal Technical Research Institute; joint research with companies, experienced in technical support for companies and in industry-academia cooperation projects.