Soft Chemical Robots and Machines

Shingo Maeda,
Smart Materials Laboratory, Shibaura Institute of Technology, Tokyo, Japan

Robots and machines are normally hard in character. They are typically constructed using technologies, such as mechanical engineering, control engineering, electronic and information engineering. They are quite useful in industries to produce large quantities of products in industries. Recently, soft robotics seems to get attention from both industries and academics. Soft robots are made from flexible and stretchable materials, and are capable of producing unique and dynamic motion.

We have proposed “Chemical Robotics”. We utilize chemical reactions to control soft robots. In biological system, living creatures use chemical reactions to make their motions. We are developing two types of chemical actuators. One is BZ gel actuators. We created self-walking gel robot, peristaltic gel actuators driven by the Belousov-Zhabotinsky (BZ) reaction. The BZ reaction is known as a dissipative system that produces dynamic patterns under stationary conditions (e.g. S. Maeda et al., Phys. Rev. E, 2016. S. Maeda et al., Adv. Mater., 2007.). We synthesized dynamic gels coupled with the BZ reaction, and the gels undergo peristaltic motion autonomously like a living organism. Furthermore we realized a locomotion of the gel (BZ gel). The other is soft EHD actuators. In industries, fluidic actuators are quite useful. Fluidic actuators are normally require external bulky devices like compressors. If we use fluidic actuators to make machines that bridge human and machines, conventional pumps limit the potential of soft fluidic actuators. We created soft electrochemical actuators and pumps driven by ElectroHydroDynamics. The pumping mechanism is based on charge-injection. The charge injection is a kind of an electrochemical reaction. In the process, a dielectric fluid is accelerated by an electric field. Thus fluidic flow can be controlled electrically. We then developed soft fluidic actuators without external device (V. Cacucciolo et al., Nature 2019. V. Cacucciolo et al., Adv. Sci., 2019. Y. Kuwajima et al., IEEE IROS, 2017.).

We believe that chemical reactions would serve as a new framework for soft robots.