Artificial Muscles —Soft and Wet Engine of the Next Era —

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Over the past number of years, we have proposed various kinds of biomimetic motility systems, focusing to reversible size and shape change of polymer gels, thereby realizing motion by integrating the molecular deformation[1, 2]. Later, we have also reported an adenosine triphosphate(ATP) fueled new-type bio-machine reconstructed from the chemically cross-linked muscle protein: actin and myosin gels **(Nanobiomachine**). This might be the first man-made machine fueled by ATP[3].

However, these are not enough to create the practical artificial motility system, because they are lack in mechanical toughness. Conventional hydrolgels are mechanically too weak to be practically used in any stress- or strain-bearing applications.

We discovered a general method to obtain very strong hydrogels by inducing a double-network (DN) structure for various combinations of hydrophilic polymers. The DN hydrogel exhibited fracture strengths as high as a few to several tens of megapascals, i.e., up to ~100 kgf cm^{-2}[4, 5].

Another very important point to be solved for a real artificial muscle system is to get the gels with low frictional properties. We have already demonstrated that the sliding frictions of gels are totally different from both solid friction and from liquid and proposed a “Repulsion-Adsorption Model”. We succeeded in reducing the frictional coefficient by introducing polyelectrolyte brushes on a hydrogel surface down to a value of 10^{-5} [6, 7]**.**

Thus, we have now novel hydrogel materials, showing fracture strengths as high as 9 MPa and frictional coefficients as low as 10^{-5} in our hand.

References

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