Actuating LCE-Particles of Complex Shape by Microfluidic Processing

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Liquid crystalline elastomers (LCEs) are known as smart materials. They are promising candidates for an application as artificial muscles in micro robotics. They are usually used either as a macroscopic object or as an array of jointly linked microstructures. As an alternative, actuating micron-sized particles can be made by microfluidic techniques.[1] The microfluidic process fulfills hereby two requirements at the same time. On one side it produces a multitude of equally sized, micro objects. On the other side it induces an orientation of the liquid crystalline director in these particles, which gives them a typical mode of actuation (elongation as well as contraction is possible, depending on the process parameters).[2]

Recently, we succeeded in making more and more complex LCE particles by using such a microfluidic approach. These include core-shell particles which consist of an LCE shell and a liquid core. Since the inner fluid is reversibly pumped out of the particles by heating them above the phase transition temperature, they can be seen as one-piece micro pumps.[3] Also LCE tubes with a potential application as micro pumps were produced. By heating or irradiation of one spot of these tubes, a cross-sectional tapering should be obtained which can move along the tube simultaneously to the trigger and thus enables perfusion of a liquid inside. As a third type, Janus-particles in which either only one part deforms, or both parts actuate under different conditions – like varying temperatures - were synthesized.[4] All these particles are accessible via a microfluidic double emulsion process or with a microfluidic coflow device based on two parallel capillaries.

In addition we succeeded in producing LCE particles which are photo-responsive. By incorporating azo-benzenes in the mesogens of a liquid crystalline network and using a redlight initiator for photo-polymerization, we obtained particles which showed a fast and strong deformation during irradiation with white (visible) light. This light-triggered actuation can be reversed either by irradiation with red light or by heating.[5,6] Recent developments focus especially on the possibility to actuate both parts of a "Janus-particles" independently and on the actuation of "Janus-particles" with light.

References

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