Applications of confocal–rheology in studies of synthetic and biological systems

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Reconstituted networks of natural extracellular matrices (ECMs), such as collagen or fibrin show a large increase in stiffness upon externally applied stress or deformation.[1]

Recently, a new biomimetic hydrogel, based on oligo(ethylene glycol)-grafted polyisocyanopeptide (PIC), was developed in our group.[2] These extremely stiff helical polymers form gels upon warming at concentrations as low as 0.005 %-wt polymer, with materials properties almost identical to those of intermediate filaments and natural ECMs.[2,3] The application of these materials in cell growth and drug therapeutics revealed the importance of polymer non-linear mechanics.[3]

Here we present the design principles used for the construction of a novel high-resolution instrument, the confocal–rheometer (Figure 1).[4] We elaborate on the instrument's fine measurement capabilities and applications in mechano-optical studies of synthetic ECM materials, where the influence of mechanical force applied on the material by the rheometer component can be concurrently visualized by the confocal microscope. We also show the application of this instrument in the study of various mechanosensitive processes in biological systems, such as focal adhesion formation kinetics as a function of externally applied force in 3D. We believe that this setup provides us with new means of studying natural and synthetic ECM materials, understanding the processes associated with mechanotransduction in biological model systems and as an end goal to understand in more detail the interface of ECM and cells.

Approaches on how to control the polyisocyanopeptide hydrogel properties, their detailed micro-rheological studies, and demonstration of the power of this instrument's capabilities in studies of both synthetic and biological systems will be presented.

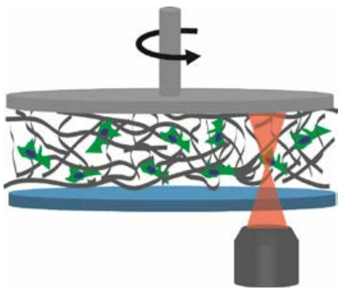

Figure 1: Schematics of a confocal–rheology experiment, where a soft polymer (in this case containing cells) is visualized by fluorescence microscope while simultaneously applying strain to the sample by the rheometer plate on top.

References

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