In situ Liquid Cell and Cryo-TEM Studies of Functional Microgels

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In the last few years, modern polymer sciences focused more and more on so called responsive materials, which will undergo a phase transition when changing the external parameters. Microgels are such responsive polymer materials, which are dispersed in an aqueous medium. They can be manipulated in size and shape by external parameters like temperature variation. Due to their functional properties, they establish an ideal basis for developing smart bio-inspired materials and to create a biologically active behaving system for medical applications.[1]

To design such new materials, direct visualization of the internal structure is necessary. Microgels can be prepared with various morphologies and functions in different compartments. To visualize the inner structure and the compartmentalization in the nanometer range under ambient conditions, powerful methods like *in situ*-liquid cell TEM are required. Due to lack of contrast between polymer structures and surrounding medium, in this work different compartments of the microgel particles were labelled by heavy metal nanoparticles. Such a combined system of a smart responsive material loaded with hard inorganic particles can be a perfect candidate for drug delivery in the human body. Furthermore, metallic nanoparticles are able to own superparamagnetic properties, which can be utilized for example for magneto-thermic therapies or imaging techniques like magnetic resonance imaging (MRI).[2]

Here, the challenges of imaging light elements in surrounding aqueous media are explained. A method to gain knowledge of and to estimate the thickness of the liquid layer is presented. In a second step, the direct visualization of different (stained) compartments within the microgels via *cryo*- and *in situ*- liquid cell TEM is shown. Different staining methods were applied. By considering the 2D projection image obtained by TEM, it is not easy to make a distinction of whether a nanoparticle is loaded into the intendent compartment of the microgel. A mathematical method to reveal 3D information out of the 2D radial distributions of nanoparticles in the TEM images is developed. In a last step the temperature-induced (reversible) shrinking behaviour of a microgel is recorded and validated.[3]

References

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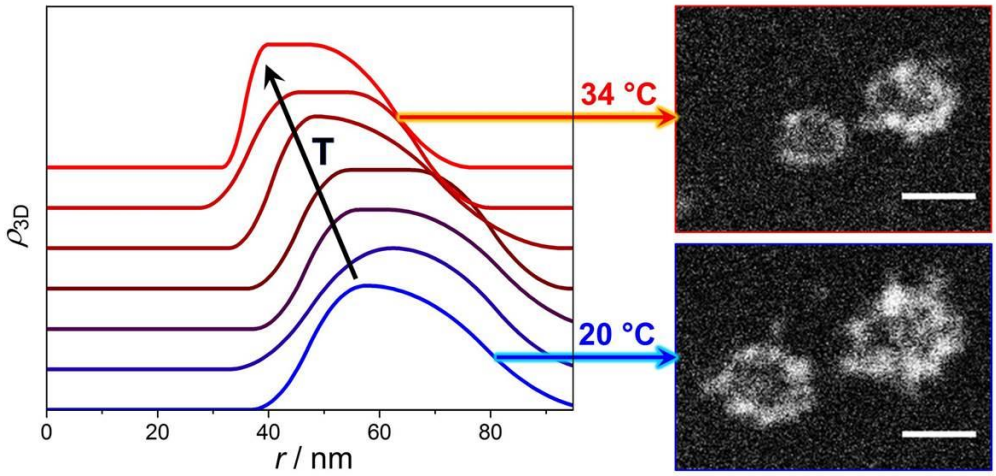

Figure 1: Temperature-dependent collapse of a PNIPAM-based microgel stained with AgNPs. Reprinted with permission from [3]. Copyright 2016 American Chemical Society.