

Behaviour of multi-responsive soft microgels

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Responsive microgels are very attractive soft colloidal systems with high sensitivity to external stimuli, such as temperature, pH, electric field, ionic strength, solvent, external stress or light. This novel class of smart materials has attracted great interest in the last years, since their effective volume fraction and their elastic properties can be changed by tuning their response to the environmental conditions. This high versatility allows to modulate the interparticle potential and their reversible Volume-Phase Transition (VPT) (swelling/shrinking behaviour), making them suitable candidates for possible medical applications, such as controlled drug delivery, design of biomaterials, tissue engineering or as carriers for metallic nanoparticles [1].

Their typical behaviour may be even more complex and exotic by using two homopolymeric networks with independent responsiveness to different external stimuli. In particular by interpenetrating a thermo-sensitive polymer, the poly (N-isopropylacrylamide) (PNIPAM), and a pH-sensitive polymer, the poly (acrylic acid) (PAAc), we have obtained an Interpenetrated Polymer Network (IPN) microgel, sensitive to both temperature and pH. In this way we are able to tune the delicate balance between polymer/polymer and polymer/solvent interactions by changing pH or by varying the PAAc concentration. This allows to directly control the microgel softness and to explore how the elastic properties affect the dynamic arrest and the phase behaviour.

We propose a novel phase diagram for PNIPAM-PAAc IPN microgels, obtained by combining different experimental techniques. A swollen-shrunk volume phase transition at low concentrations and an ergodic to non-ergodic transition at the highest investigated concentrations, strongly dependent on pH and PAAc content, have been observed through Dynamic Light Scattering (DLS) [2] and Differential Scanning Calorimetry (DSC). The microgel local structure [3] and the exact nature of the observed non-ergodic state (gel and/or glass) have been investigated through Small-Angle Neutron Scattering (SANS) and Small-Angle X-Ray Scattering (SAXS) respectively. Moreover a comparison with numerical simulation, as previously done for other colloidal systems [4,5], will provide more insight on the interparticle interaction potential.

[1] Z. Dai and T. Ngai, *J. Polym. Sci., Part A: Polym. Chem.* 51 (2013) 2995-3003.

[2] V. Nigro, R. Angelini, M. Bertoldo, V. Castelvetro, G. Ruocco, and B. Ruzicka. *J. Non-Cryst. Solids* 407 (2015) 361-366.

[3] V. Nigro, R. Angelini, M. Bertoldo, F. Bruni, M.A. Ricci, and B. Ruzicka. *J. Chem. Phys.* 143 (2015) 114904.

[4] B. Ruzicka, E. Zaccarelli, L. Zulian, R. Angelini, M. Sztucki, A. Moussaïd, T. Narayanan, and F. Sciortino. *Nat. Mater.* 10 (2011) 56-60.

[5] R. Angelini, E. Zaccarelli, F.A. de Melo Marques, M. Sztucki, A. Fluerasu, G. Ruocco and B. Ruzicka. *Nat. Commun.* 5 (2014) 4049.

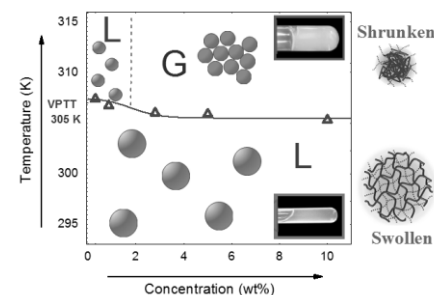


Figure 1. Phase diagram for colloidal suspensions of PNIPAM-PAAc IPN microgels in the investigated temperature and concentration range.