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Mechanical properties of polymeric capsules and films at the nanometer scale

The mechanical properties of complex objects at the nanometric scale are of great interest in many fields such as nanobiotechnology. Atomic Force Microscopy (AFM) is the ideal tool to measure forces at the nanometer scale and to perform indentation experiments onto isolated objects. This PhD work takes place in the context of the development of a nano-object intended to theranostic applications. These nanoparticules are composed of a glassy polymeric capsule containing a liquid fluorinated core. The mechanical properties of these capsules are fully deployed for the transportation in biological media as well as for the bouncing of ultrasound imaging and their localized destruction. The complexity of those systems, both in term of geometry and composite aspect, makes it difficult to assess their mechanical properties, in particular their elasticity.

Giving the fact that composite objects show a variation of their elasticity according to the indentation depth, a semi-analytical method (CHIMER : *Coated Half-space Indentation Model for Elastic Response*) has been implemented to interpret the apparent elasticity of such system. In order to support this method, polydimethylsiloxane (PDMS) based bilayers have been investigated by AFM nanoindentation. A good agreement between the model and the experimental data has been found and the elastic behavior of a rigid film laid over a soft substrate has been well described at the nanometer scale. This model has also been used to investigate the apparent elasticity of polymeric capsules. The influence of the shell thickness and of the bulk elasticity of the polymer has been therefore shown. Moreover, this original approach has been used to describe the effects of temperature and frequency on the apparent elasticity of polymeric capsules filled with a fluorinated liquid core.