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Micro and nano-object interaction analysis with femtonewton resolution by Atomic Force Microscopy and Optical Tweezers hybrid system

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Gaining knowledge of the solid-solid interactions and hydrodynamic and mechanical properties is crucial for understanding the processes and dynamics of molecular interactions, biological and nano- structures and also to find their future applications.

Atomic force microscopy (AFM) is a versatile technique for nanoscale imaging purposes and for quantify analysis of force at the nanonewton scale. Unfortunately, this technique cannot detect small forces on the femtonewton scale and analyse the stiffness of very soft materials such as biological tissues or hydrogels. AFM is also use to manipulate materials, however, AFM-based manipulation systems are slow and imprecise. To distinguish, Optical Tweezers (OT) are scientific instruments that can trap small particles and manipulate nano- and micro-materials with much higher precision. The AFM / OT hybrid system is a high-resolution imaging instrument with a lower force limit of detection. It is capable of non-invasively manipulating of nanomaterials, single molecules and living cells, measuring forces with femtonewton accuracy, detecting motion with nanometer (10^{-9} m) precision and to manipulate objects, but also to obtain images directly in the same sample. The combination of AFM with Optical Tweezers will provide significant advances in biophysical research and in the study of the mechanical properties of nanomaterials.

In our system we combine Optical Tweezers with commercial AFM to create an instrument capable of working in hybrid mode. It allows simultaneous manipulation of biological systems of greater complexity and the analysis of their properties. Performed by us, experiments showed that AFM/OT system is a unique technique for visualization of the analysed materials, trapping single micro-objects and measure the interactions (in the range of femtonewton) between single particles. The results obtained by AFM/OT confirm that this equipment is a very useful technique also for determination the mechanical properties of very soft materials.

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