PL1

Force Measurements between Single Molecules: Relation to Thermodynamic Data.

Torsten Strunz, Martin Hegner, Krisztina Oroszlan, Irina Schumakovitch und Hans-Joachim Güntherodt

University of Basel, Institute of Physica, Klingelbergstrasse 825, CH-4056 Basel, Switzerland

In recent years the development of sensitive force probe techniques, such as atomic force microscopy (AFM) or optical tweezers, allowed the measurement of forces between single molecules that form a weak non-covalent bond. It is, for instance, possible to measure the unbinding force between a single antigen/antibody complex. A question that immediately arises is, how these forces are related to the thermodynamic data that characterize an ensemble of complexes, like the affinity or on- and off-rates.

The relation between the unbinding forces and the thermal off-rate becomes evident if one considers how the unbinding forces are measured: The load, i.e. the force, on a complex increases until the complex unbinds. If one increases the load very slowly, the unbinding takes place at a very small force because the complex has a finite lifetime and dissociates during the experiment (even if no force is applied). Therefore, the observed unbinding forces depend on the loading rate, i.e. the rate of force increase prior to unbinding. It can be shown that the unbinding force as a function of the loading rate is related to the lifetime (or the off-rate) of a complex as a function of the applied force.

We demonstrate the above relationship by measurements of the unbinding forces of DNA duplexes and antibody-antigen complexes. The measurements show that the lifetime of these complexes decreases exponentially with force. Therefore, the lifetime at zero applied force, or the thermal off-rate, can be determined from measurements at finite forces where the lifetime is several orders of magnitude smaller.