A model for determination of viscoelastic parameters of living cells by means of magnetic manipulations

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It is well known that a primary signal to many cell types is mechanical. Senses of hearing and touch are initiated by forces rather than molecules impinging on the cell surface that are later transdused to the biochemical reactions leading to acute cellular responses. How the cytoskeleton, a heterogeneous network of dynamic filamentous proteins provides the cell with structural support is not well understood. Furthermore, microrheological properties are fundamental in the maintenance of the structural and functional integrity of the many cell types. Magnetic bead rheometry, which probe local mechanical properties, are suited to test existing hypothesis derived from in vitro models of reconstituted cytoskeleton networks.

For determination of viscoelastic parameters of the cytoplasm (shear elastic modulus, the effective viscosities, and the strain relaxation time) we develop a model, witch allows us to insight into cell mechanics and into the viscoelastic properties acting in vitro and in live cells.

The model considers rotation of magnetic chains consisting of 3-4 nanoparticles under the influence of rotating external magnetic fields. As the bead rotates, mechanical stresses opposing that rotation are developed within the cell, and then one can measure the angle displacement and extract viscoelastic properties of the cytoplasm by a fitting of the measured φ(t)-dependencies on the basis of the calculated ones. Rotational oscillations of a bead chain could by described as:

$$I \cdot d^2\varphi / dt^2 + \gamma \cdot d\varphi / dt + k \cdot \varphi = p_m \cdot B \cdot \sin(\omega \cdot t) \qquad (1)$$

where ω is the frequency of the applied magnetic field; φ is the angular displacement; γ is the dissipation coefficient; *I* is the moment inertia of the chain; *k* is the factor of mechanical elasticity; p_m is the chain magnetic moment; *B* is the magnetic induction.

Solving numerically Eq.1, with different creep compliance functions taken from literature [1,2], we obtain the time dependence of the displacements. The viscoelastic parameters of the cells may be obtained by fitting function of creep compliance to the observed creep response curves. The model gives possibilities for a general description of various phenomena in magnetorheological suspensions.

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