

Probing Visco-elastic Properties of Biological Cells by Oscillatory Optical Tweezers

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Abstract:

Mechanical stresses on biological cells change not only the cell's morphology, but also cell cycle, gene expression, and protein production in many biological systems; in general, the stress-strain relationship of biological cells depends on the mechanical integrity of the cells and the interaction of the cell with the extra-cellular matrix. For example, the mechanical influences are transmitted into biochemical signal pathway of Src proteins which correlate with the cytoskeleton on epithelial cells [1].

In this work, we probed the visco-elasticity of individual epithelial cells by optical trapping and optical forced oscillation of a submicron endogenous intracellular organelle. The experimental setup is shown in Fig. 1 (a). The storage and loss moduli (G' and G'') as a function of frequency, as shown in Fig. 1(b), were determined via the following two Eqs [2]:

$$G'(\omega) = \frac{k(\omega)}{6\pi a} = \frac{k_{OR}}{6\pi a} \left(\frac{A \cos \delta(\omega)}{D(\omega)} - 1 \right) \quad G''(\omega) = \omega \eta(\omega) = \frac{k_{OR}}{6\pi a} \left(\frac{A \sin \delta(\omega)}{D(\omega)} \right)$$

where a is the particle radius, A is the amplitude of the oscillatory trapping beam, k_{OR} is the optical spring constant, D is the oscillating amplitude of the trapped particle, and δ is phase shift of trapped particle relative to the phase of the oscillating tweezers. Optical trapping and oscillation of endogenous organelles allows us to probe both the steady-state and the dynamics of the intracellular mechanics.

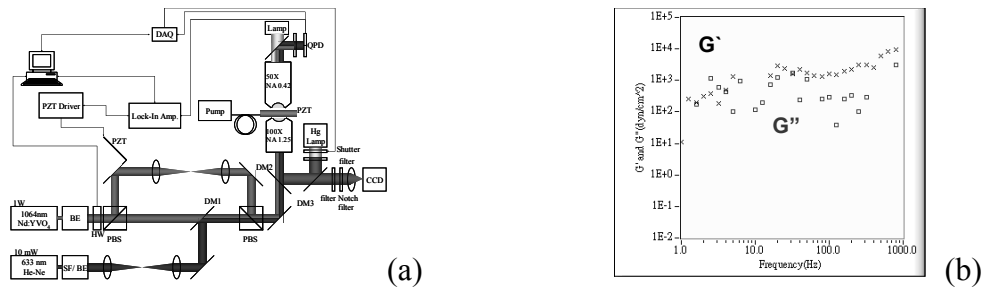


Fig. 1: (a) A schematic diagram of the experimental setup; (b) the storage and loss moduli G' (represented by "x") and G'' (represented by "□") as a function of frequency.

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