

MECHANICAL PROPERTIES OF INDIVIDUAL MICROTUBULES MEASURED USING AFM

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INTRODUCTION: Microtubules (MT) are self-assembling cylindrical protein structures that are present in almost all living cells as part of the cytoskeleton. Building a network across the cytoplasm, they perform various vital functions like providing mechanical support for the cell thus determining its shape; acting as a transport network; pulling apart chromosomes during cell division; involvement in movement of cells e.g. sperms etc. – they are essential for life.

Changes in the structure of microtubules under the influence of various diseased states and chemical agents could be probed by measuring their mechanical properties. Despite the inarguable importance of the knowledge of MTs stiffness and a significant number of performed experiments, there doesn't seem to be a consensus on the actual numerical values – values reported in the literature range between 1 MPa [1] and 1 GPa [2].

METHODS: using AFM, a method has been developed for elastically deforming microtubules (Figure 1). It consists of depositing microtubules on a porous surface and elastically deforming it with an AFM tip. Various procedures for fixing microtubules on substrates have been investigated and measurements in different conditions have been performed.

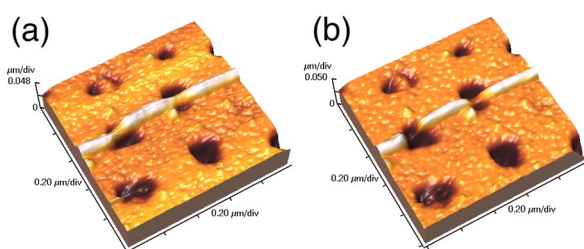


Fig. 1: Pseudo-3D renderings of a microtubule lying on a porous substrate under two different loading forces: (a) $F = 200$ pN (b) $F = 400$ pN

RESULTS: Two different kinds of elastic moduli have been reproducibly measured: bending and radial compression moduli. Furthermore, measurements on different temperatures between 5°C and 42°C have been performed. Results (Figure 2.) show a dramatic stiffening of microtubules on cooling. This effect can be explained by changes in the interaction between

the protofilaments building microtubules due to conformational changes of tubulin molecules.

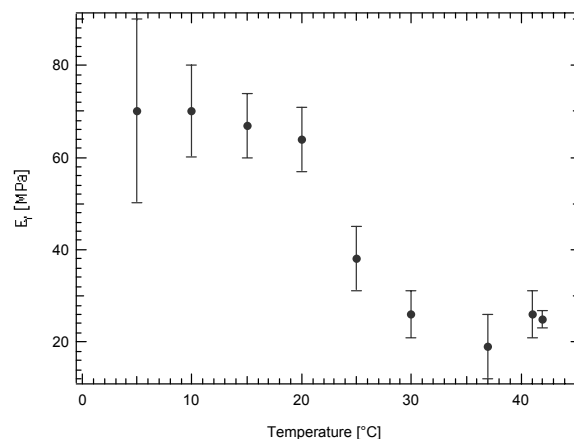


Fig. 2: Dependence of the bending modulus of microtubules on the temperature.

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