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Nematode epicuticle nanoscale morphology: insights from atomic force microscopy

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Here we report on imaging and nanomechanical characterisation of microscopic nematodes epicuticle using atomic force microscopy.

Caenorhabditis elegans nematode, as a typical and perhaps most studied nematode, is an extremely popular model organism in biomedicine and nanoscience. In addition, nematodes are among most dangerous human parasites and agricultural pests. All these facts outline the importance of fundamental research directed on *C. elegans*. Particularly important is establishing robust methodology to investigate the surface coat of cuticle, the external skeleton and armour of the microworms. We have recently introduced PeakForce Tapping non-resonance atomic force microscopy for imaging and nanomechanical mapping of *Caenorhabditis elegans* nematodes cuticle [1]. The animals were collected at various growth stages and imaged both in air and water at nanoscale resolution. Layer-by-layer glass surface modification was used to secure the adult and larvae microworms for imaging in water. We were able to resolve the microtopography of major body regions: head, annuli, furrows, lateral alae and tail region (Fig. 1). We have analysed the nanoscale surface features of three larval and adult hermaphrodite nematodes obtained during AFM imaging in natural environment. This allowed for numerical evaluation and comparison of annuli periodicity, roughness and furrows depth.

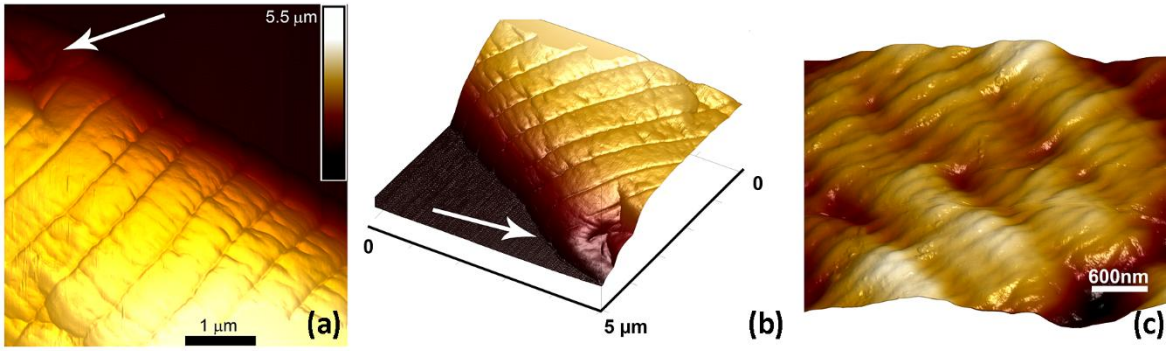

Figure 1. Typical Peak Force Tapping images of *C. elegans* nematode epicuticle taken at head region (a-b) (arrows indicate areas adjacent to sensory papillae) and body region (c) [1].

We have also performed nanomechanical mapping of surface deformation, Young modulus and non-specific adhesion, confirming that the mechanical properties of the nematode cuticle are non-uniform and differ depending on the age of the worms. We found that PeakForce Tapping AFM mode is a robust and simple approach applicable for nanoscale three-dimensional imaging and characterisation of *C. elegans* nematodes. We believe that this approach might be used for imaging of other nematode species and extended to imaging of live animals. This study was supported by Russian Science Foundation grant No 14-14-00924 and performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

1. G. Fakhrullina, F. Akhatova, M. Kibardina, D. Fokin, R. Fakhrullin *Nanomedicine: Biology, Medicine and Nanotechnology*, **13**, 483–491 (2017)