Nanoanalytics for Medicine

I. V. Yaminskii, P. V. Gorelkin, and E. V. Dubrovin

Physical Faculty, Moscow State University, Moscow, 119899 Russia
Chemical Faculty, Moscow State University, Moscow, 119899 Russia
Center of Advanced Technologies, Moscow, 119311 Russia

E-mail: yaminsky@nanoscopy.org

Received June 9, 2011

Abstract—The applications of atomic force microscopy and the methods based on atomic force microscopy that can be useful in medical nanoanalytics have been reviewed. The main fields of possible application of scanning probe microscopy in medicine have been outlined. Among these are studying the resistance of bacterial cells to modern antibiotics and drugs, morphological analysis of blood components, trichology, nanotoxicology, DNA sequencing, and biocompatibility of medicinal materials. Examples of application of atomic force microscopy for studies in these fields have been considered, and prospects for its use in medicine have been demonstrated.

Keywords: atomic force microscopy, atomic balance, DNA, bacteria, cells.

DOI: 10.1134/S0006350911050277

INTRODUCTION

To the field of nanoanalytics we can confidently assign at least three experimental methods that ensure spatial resolution in the nanometer range. These are electron microscopy, scanning probe microscopy (SPM), and also the novel kinds of optical microscopy with ultrahigh (nanometer) resolution. Electron microscopy is already efficiently used in modern clinics and hospitals, e.g., for histological analysis of human tissues. The first but impressive steps are taken by ultrahigh-resolution optical microscopy. Here we can mention the photoactivation laser microscopy, which permits locating point optical markers (fluorescent proteins, quantum dots, luminescent nanoparticles) to an accuracy of a few nanometers [1, 2].

Quite attractive for medicine are the SPM techniques, mainly owing to their inherent high spatial resolution (fractions of a nanometer), simple specimen processing, and the possibility of observing the objects in biologically natural media—air or liquid.

EXAMPLES OF APPLYING ATOMIC FORCE MICROSCOPY AND DERIVED METHODS IN MEDICAL NANOANALYTICS

The possibilities of SPM are vividly illustrated with examining red blood cell morphology. Figure 1 depicts...
an echinocyte (a stellate form of the erythrocyte), which before deposition of a glass support was subjected to electroporation (whereby the cell membrane is perforated by means of a local electric field). This method is actively used in the Institute of General Reanimatology to determine erythrocyte quality [3]. Before the advance of atomic force microscopy (AFM), attempts to ascertain the character of cell wall

---

**Fig. 3.** AFM images of *E. coli* cells: intact (a) or incubated with bacteriophage A157 at 37°C for (b) 5 min, (c) 30 min (magnified insets show individual phages), and (d) 60 min (arrows point out the phage release sites shown in magnified insets). Insets in (d) were recorded in the Height channel (height difference made 300 nm); the rest recorded in the Deflection channel. [Reproduced from [10] by permission of the American Chemical Society.]

**Fig. 4.** AFM images of *Synechocystis* 6803 mutant cells that have lost motility: (a) overview of a single cell (recorded in the contact mode in the Deflection channel); (b) thick and thin pili (recorded in the tapping mode in the Height channel). [Reproduced from [11] by permission of Springer Science + Business Media.]