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Photoinduced Thermal Desorption on an Atomic Force Microscope Platform Coupled with Mass Spectrometry for Multimodal Imaging

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The key to advancing materials is to understand and control their structure and chemistry. However, thorough chemical characterization is challenging since existing techniques characterize only a few properties of the specimen, thereby necessitating multiple measurement platforms to acquire the necessary information. The multimodal combination of atomic force microscopy (AFM) and mass spectrometry (MS) transcends existing analytical capabilities for nanometer scale spatially resolved correlation of the chemical and physical properties of a sample surface. The combination of AFM and MS using resistively heated cantilever tips for thermal desorption (TD) has been demonstrated as a promising pathway for multimodal chemical. However, the nano-TA heated probes limit the ability to carry out more standard AFM measurements such as PFM, KPFM and cAFM. To enable a more general application of chemical imaging into an AFM platform we have developed a novel closed cell sampling on a Oxford Instruments Cypher ES atomic force for in situ surface sampling/imaging analysis using photo-thermal heating of the AFM tip for thermal desorption (TD) coupled to Thermo Orbitrap Velos Pro with inline ionization by atmospheric pressure chemical ionization (APCI). This approach takes advantage of the newly developed laser induced cantilever heating technology developed by Oxford instruments for localized thermal desorption and demonstrates its applicability to multimodal chemical imaging using mass spectrometry. The ability to use photothermal heating of an AFM probe versus conventional resistive heating nano-TA technology opens up the possibility for carrying out multiple AFM measurement on a single AFM cantilever, for a true multimodal imaging approach to link chemical composition with material functionality. We show the use of photothermal heating as a means for thermal desorption surface sampling mass spectrometry. We illustrate the application of the AFM-MS coupling for the analysis of small molecules, i.e. pigment yellow 74 as a test substrate to show 500 nm achievable lateral resolution as well as show the application to pharmaceuticals, hair and other biologically relevant samples (Figure 1). Additionally, the ability to introduce fast heating rates for the TD through ps laser pulsing reduce the melting of sample material and improves the access to intact molecules [1].

References:

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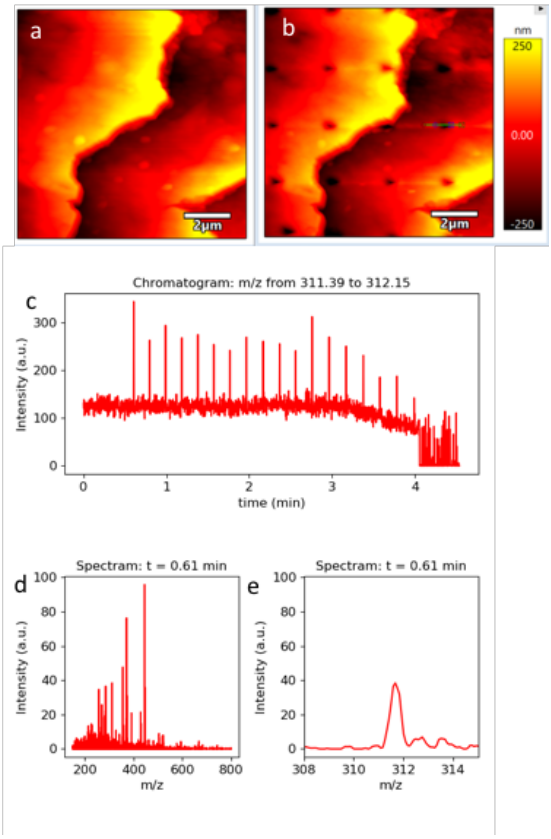

Figure 1. Multimodal chemical imaging of shampoo washed hair, (a) topography of hair before thermal desorption, (b) topography after thermal desorption, (c) extracted ion chromatrogram for bis-aminopropyl dimethicon, (d) background subtracted full scan mass spectrum, and (e) *m/z* 311 for bis-aminopropyl dimethicon.

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