

Looking Deeper into MALDI: Understanding and Predicting MALDI Phenomena using Numerical Models

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Recently developed quantitative models of UV-MALDI will be presented. Molecular dynamics (MD) gives microscopic insight into MALDI and demonstrates the interaction between ablation/desorption and ionization processes. The MD approach is especially helpful for visualizing the MALDI plume, and understanding the characteristics which are important for ion-molecule reactions that determine ion intensity distributions. Both desorption and ablation regimes generate free ions, and yields are in accordance with experiment. The first molecular ions are emitted at high velocities shortly before neutral desorption begins, due to surface charging caused by electron escape from the top of the sample. Later ions are entrained and thermalized in the plume of neutral molecules and clusters. Clusters are found to be stable on a nanosecond time scale, so the ions in them will be released only slowly, if at all.

The continuum model for MALDI is more computationally tractable than MD, and includes the entire event, not only a limited spatial and temporal region. It is based on thermodynamic and kinetic principles that have been validated by the MD model and experiment. Primary matrix ionization occurs by excitation pooling. Analyte ions are generated by reaction with the matrix ions. This model is capable of quantitative or semi-quantitative reproduction of numerous MALDI characteristics. It predicts such remarkable MALDI phenomena as the matrix and analyte suppression effects.

These models can help users to understand, interpret and plan MALDI experiments. For example, the predicted generality of the matrix suppression effect has recently been demonstrated in an industrial setting, and taken advantage of for routine analysis of low MW compounds by MALDI.