Desorption-Ionization Mass Spectrometry on Nanoporous Polymer

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Abstract:

Experimentation of desorption-ionization mass spectrometry was tested on nanoporous polymer. Matrix assisted laser desorption-ionization (MALDI) is used in a wide series of applications having the most use in specific biological experiments such as peptide sequencing and the analysis of small biomolecules. The goal of this experiment was to improve the accuracy of analyzing larger biomolecules as well as improve the sensitivity typically achieved with other matrices. In this experiment nanoporous polymer was substituted as an ultraviolet light absorbing matrix. In MALDI the matrix used typically absorbs in the frequency of the laser being used, and indirectly transfers the energy of the laser to the sample, causing the sample to sublimate and ionize. In our experiment the MALDI micro MX with a nitrogen laser (337 nm) was used to ionize each sample plated on our nanoporous polymer. The recipe for our nanoporous polymer was slightly modified throughout the experimentation in order to improve in its operation as a substituted matrix.

Introduction:

Mass spectrometry is a vital tool in modern biology. A specific form of mass spectrometry known as MALDI (matrix assisted laser desorption-ionization) is used today to analyze proteins, peptides, polysaccharides, nucleic acids, synthetic polymers, bacteria, and other small molecules. In MALDI, sample preparation involves mixing the organic molecule of your choice with a solvent, ie. acentonitrile or ethanol. The sample is then mixed with an ultraviolet absorbing compound, or UV matrix. After being placed in a vacuum chamber, the solvent evaporates leaving only the substrate and the matrix. The substrate is then shot with a pulse laser and the UV absorbing matrix absorbs the energy from the laser and transfers it to the analyte, causing it to sublimate and ionize. After ionization the analyte is placed in an electric field and accelerated towards the detector. By calculating the speed of the analyte and magnitude of the electric field, the mass/charge ratio can be determined.

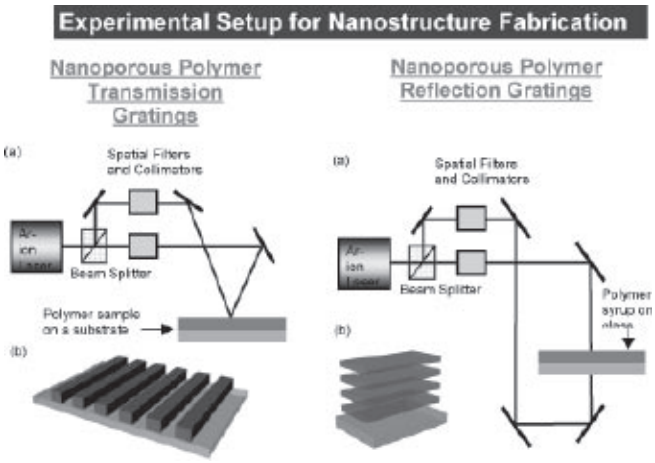

Figure 1

Currently there is much research in improving MALDI. One problem with MALDI is that there is a limit on the size of the molecule that can be accurately measured. Large biomolecules such as proteins, as well as small molecules such as monomers are difficult to measure with MALDI and other methods are typically used. While the use of a matrix is vital in MALDI, the added substrate causes background noise that interferes greatly in the lower mass region, and causes inaccuracies at the opposite end. The use of nanostructure particles as a substituted matrix has been seen with structures such as nanoporous Si, oxidized carbon nanotubes, nanostrucured-column void Si, and gold nanoparticles. With the success of these other nanostructures in mind, we developed a nanoporous polymer and tested its effectiveness as a substituted matrix. Through our nanoporous polymer we hope to facilitate future sample preparation, analyze larger and smaller biomolecules, and obtain more sensitive and accurate sample readings.

Experimental Procedure:

Our nanoporous polymer was created by mixing the following ingredients: anthracenetriol (polmer dye), a-cyano-4-hydroxycinnamic acid (peptide dye), vinyl-2-pyrrolidone, rose bengal, n-phenylglycine, liquid crystal,

acetone, sitane, and dipentaerythritor penta/hexa-acrylate (molymer). The polymer mixture was then plated onto a glass substrate and exposed to an argon laser for one minute; the setup is shown in Figure 1. The porosity of the polymer was determined by the angle of the beam splitter. After being exposed to the laser the polymer was cured under normal light for 24 hours. Our peptide was then plated onto our polymer substrate and analyzed with the MALDI micro MX.

Results and Future Work:

The results of our nanoporous polymer fabrication can be seen in Figures 2 and 3. No significant data was collected from MALDI experimentation; the only data points achieved were noise as seen in Figure 4. In the future we hope to construct a matrix substrate so that each organic material can be localized in a certain position. This would allow us to concentrate our organic material in a specific area for MALDI testing. This would not only facilitate localizing our laser pulses, but would also give us a more concentrated biospecies sample.

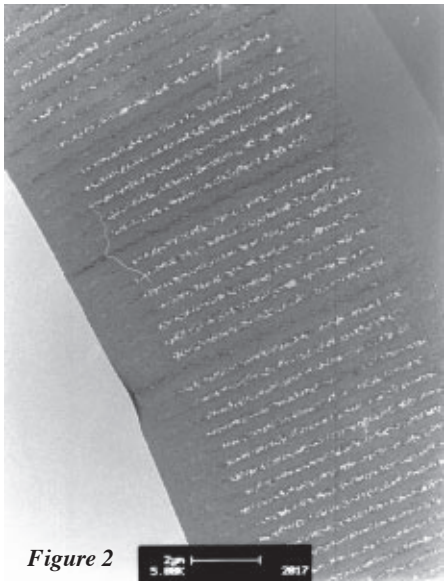

Figure 2

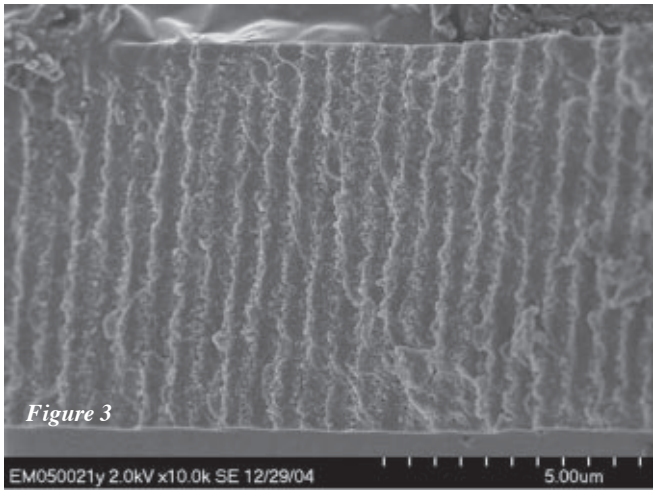

Figure 3

Conclusion:

The data collected did not show enough significance to support the role of nanoporous polymer as a substituted matrix in MALDI. However, this does not mean that nanoporous polymer will not work as a substituted matrix. In future work we would like to etch μL size wells into our glass substrate. This would prevent our peptide solution from dispersing and maintain a more concentrated solution in a smaller area, allowing the laser to better ionize our analyte. This, along with a better selection of peptides to perform initial testing, would be a great place to start in the future.

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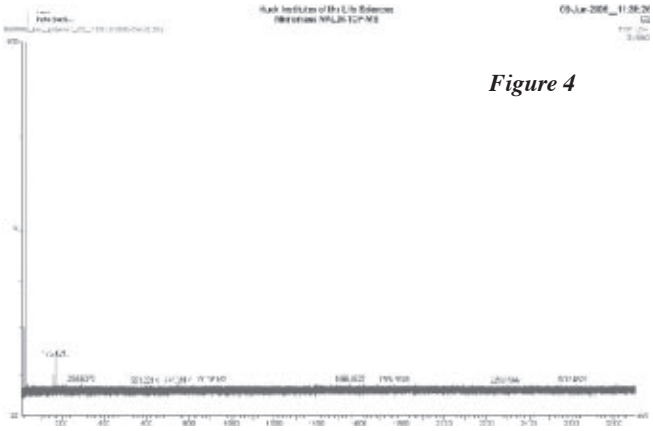

Figure 4