

A LASER-POLYMERIZED THIN FILM SILICA SURFACE MODIFICATION FOR SUPPRESSION OF CELL ADHESION AND ELECTROSMOTIC FLOW IN MICROCHANNELS

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Abstract

A laser-polymerized thin-film for silica surface modification is presented. This technique enables photopatterned surface charge modification consistent with optical tweezer techniques is presented. This charge modification may be applied for chip-based cell techniques and multi-dimensional separation techniques that require nonuniform zeta potential on a microfluidic chip.

Keywords: surface modification, zeta potential, capillary isoelectric focusing, two-dimensional separation, cell adhesion

1. Introduction

Silica surface charge interferes with a number of microfluidic chip-based techniques (*e.g.*, capillary isoelectric focusing (cIEF)) by inducing unwanted electroosmotic flow (EOF); this surface charge can also interfere with chip-based cell techniques by causing cells to electrostatically adhere to cell walls. Two-dimensional separations may require selectively eliminating zeta potential (?) on one part of a microfluidic chip while ? is retained in other sections. Use of optical tweezers for cell manipulation on-chip [1] further requires that surface modifications be nonabsorbent and nonscattering at the laser wavelength.

2. Surface Modification Mechanism

An aqueous mixture of 3-(trimethoxysilyl)-propyl acrylate (Aldrich) and acetic acid is applied to pretreat the silica surface (Figure 1), covalently bonding the acrylate intermediary to exposed surface charge sites. This intermediary affects ? only slightly, and hence does not inhibit electroosmotic flow. Following this pre-treatment, frequency-tripled Nd:YAG laser emission (355 nm) is used to locally polymerize acrylamide to the acrylate group on the intermediary. Flushing the acrylamide solution leaves a photopatterned acrylamide thin film. These coatings have shown no measurable effects when exposed overnight to pH between 2.7-10.3 or to acetone solvent, and have not degraded over a period of 2 months.

3. Measurements

Streaming potential was used to measure ? in silica capillaries with and without surface modifications. Results for phosphate-buffered potassium solutions on untreated surfaces compare well with previous investigations, *e.g.*, [3]. For 1 mM phosphate buffer solutions (pH 7.3 +/- 0.2), ? was measured at -83 +/- 3 mV, -75 +/- 3 mV, and 0 +/- 1 mV for untreated, pretreated, and polymerized surfaces, respectively; the photopatterned polyacrylamide thin film creates an uncharged (?=0) surface but the pretreat step does not significantly affect ?. A solution contain-

ing murine bone marrow mast cells ($d=10 \mu\text{m}$), glucose, and phosphate buffer was brought into contact with untreated and polymerized silica surfaces on glass cover slides and a wet-etched glass chip ($30 \times 150 \mu\text{m}$ channels). Cell adhesion was inferred from images after flushing with solution. On cover slides, cells appear post-flush only if adhered to the surface (Figure 2). In microchannels, adhered cells appear the same regardless of flow rate, while cells in the bulk appear only as a faint background in the flowing image. Figure 3 shows cell solutions in microchannels with and without flow (flowrates as high as 20 cm/s were used). For mast cells, adhesion on uncoated surfaces is prominent, while the polyacrylamide thin film inhibits adhesion.

References

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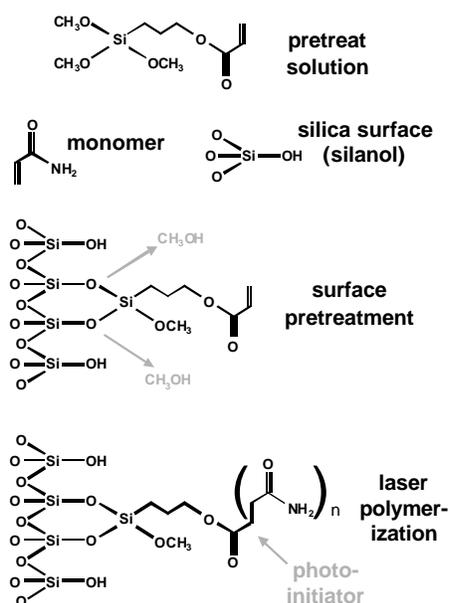


Figure 1. Surface pretreatment and laser-polymerization steps.

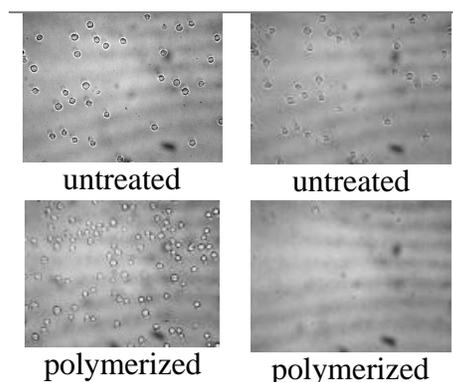


Figure 2. Cell adhesion on cover slides.

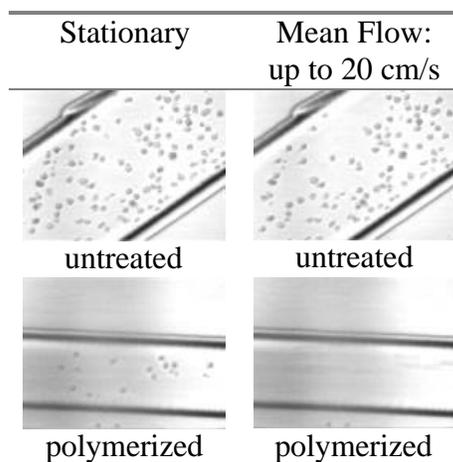


Figure 3. Cell adhesion in glass microchannels.

Before Flush	After Flush
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