

Electrical conductivity of polymer brush layers: solvent and temperature effect

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Polymer brushes show conformational changes depending on the environment and can be used as smart functional surfaces to control surface wettability, adhesion and other physical properties [1-3]. We demonstrate in our paper that in plane electrical conductivity of polymer brushes can be changed at least two orders of magnitude under exposure to water or organic solvent vapors. Four polymer brush systems were studied (Figure 1): *Poly(glycidyl methacrylate)* (PGMA), *polyacrylic acid* (PAA), *poly(2-vinylpyridine)* (P2VP) and *polystyrene* (PS). Monolayers of these polymers with the thickness of ~10 nm were grafted to a silicon oxide surface between lithographically patterned gold electrodes (0.6 μm or 1 μm gap between electrodes) via self-assembly approach. PGMA was used as an anchoring layer for the PAA, P2VP, and PS grafting.[1] Atomic force microscopy revealed a smooth uniform morphology of the films without pinholes. Conductivity of a brush film was reversibly changed under its exposure to saturated vapors (Figure 2). The response time was less than 30 seconds. The films under study display not only high sensitivity but also remarkable selectivity to organic solvents. Hydrophilic PGMA and PAA systems display high sensitivity to water and ethanol vapors, while hydrophobic PS brushes were more sensitive to chloroform and practically insensitive to water or ethanol exposure. Being a polar polymer, PVP material shows high sensitivity and selectivity to ethanol. Therefore, we demonstrate that polymer brushes can be used as an active component of multichannel gas analyzers ("electronic" nose). Conductivity properties of all brush films under study could be significantly enhanced with temperature increase. Such behavior is in tune with the proposed model of ionic type of electrical conductivity in the systems.

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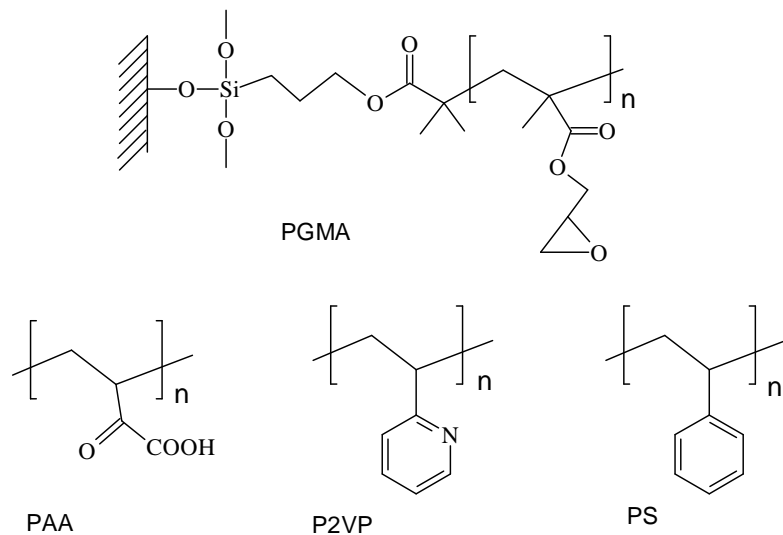


Figure 1. Chemical formulas of polymer brushes under study.

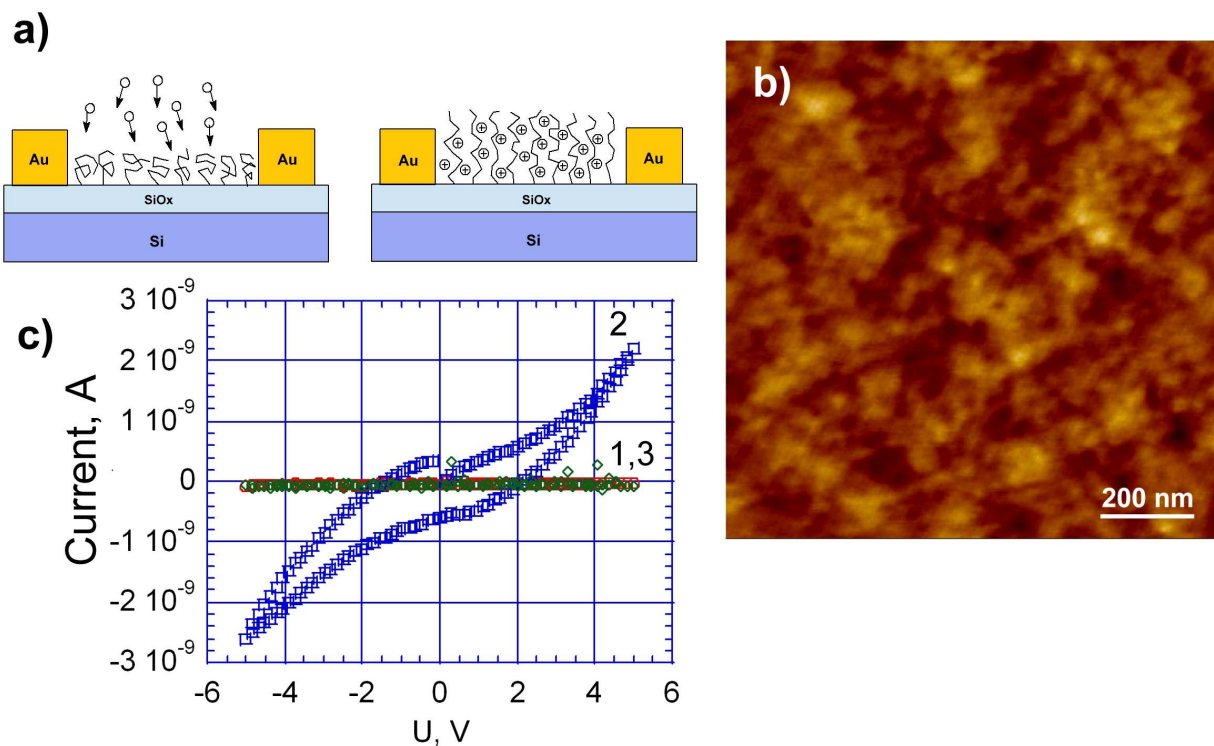


Figure 2. (a) variation of polymer brush (PAA) conformation under exposure to water vapors, (b) AFM topography image of a hydrophobic PS brush (film thickness 9 nm) showing uniform coverage of the silicon oxide substrate (vertical scale is 5 nm from peak to valley); (c) representative current response to an organic vapor exposure (chloroform) displayed by PS brush sample (I-V curves were recorded before the exposure of the brush sample to saturated chloroform vapor (1), during the exposure (2), and after the exposure in air (3)).