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Electronic Supplementary Information

Immobilization of highly-oriented filamentous viruses onto polymer substrates

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Detailed experiments

Isotactic poly(methyl methacrylate) (*it*-PMMA) was synthesized following conventional living anionic polymerization[1]. Methyl methacrylate (MMA, Wako) was distilled and then polymerized in distilled toluene at -78 °C with freshly prepared *t*-C_4H_9MgBr as an initiator. The number-average (M_n) and weight-average (M_w) molecular weights were measured by size exclusion chromatography (GPC-8020, Toshoh) on a TSKguard column SuperH-H with one column each of TSKgel SuperH2000 and SuperH4000 (Tosoh) at 40 °C at flow rate of 1.0 mL/min using tetrahydrofuran as an eluent. Calibration was demonstrated using commercially available PMMA standards (Polymer Laboratories). The tacticity (*mm*: *mr* : *rr*; where *mm*, *mr*, and *rr* represent iso-, hetero-, and syndiotacticities, respectively)) was determined by using ^{1}H NMR signals from the α-methyl protons at 1.0-1.5 ppm. The determined M_n, polydispersity, and stereoregularities were M_n 23200, M_w/M_n = 1.26, and *mm*:*mr*:*rr* = 97:3:0, respectively.

The *it*-PMMA was dissolved in chloroform with a concentration of 1.7 mg/mL. The *it*-PMMA solution was mounted on silicon wafer substrates (SUMCO), following spin-coating with 2000 rpm to prepare *it*-PMMA films. The film thickness was measured by quartz crystal microbalance (QCM, USI System) methods and determined to approximately 20 nm. Roughness was also characterized by atomic force microscopic (AFM, SPM-9600, Shimadzu) analyses in tapping mode in air at ambient temperature. Calculated surfaces roughness (R_a) was 0.7 ± 0.1 nm, suggesting smooth films. The *it*-PMMA films were dipped into a solution of c02 or WT phages (Tris-buffered saline, 50 mM Tris(hydroxy methyl)aminomethane, 150 mM NaCl, pH 7.5) with various concentrations for 1 h at ambient temperature. The films were swept up at precisely controlled speeds (10, 50, or 100 mm/min). The immobilized phages were observed by AFM analyses in tapping mode in air at ambient temperature.

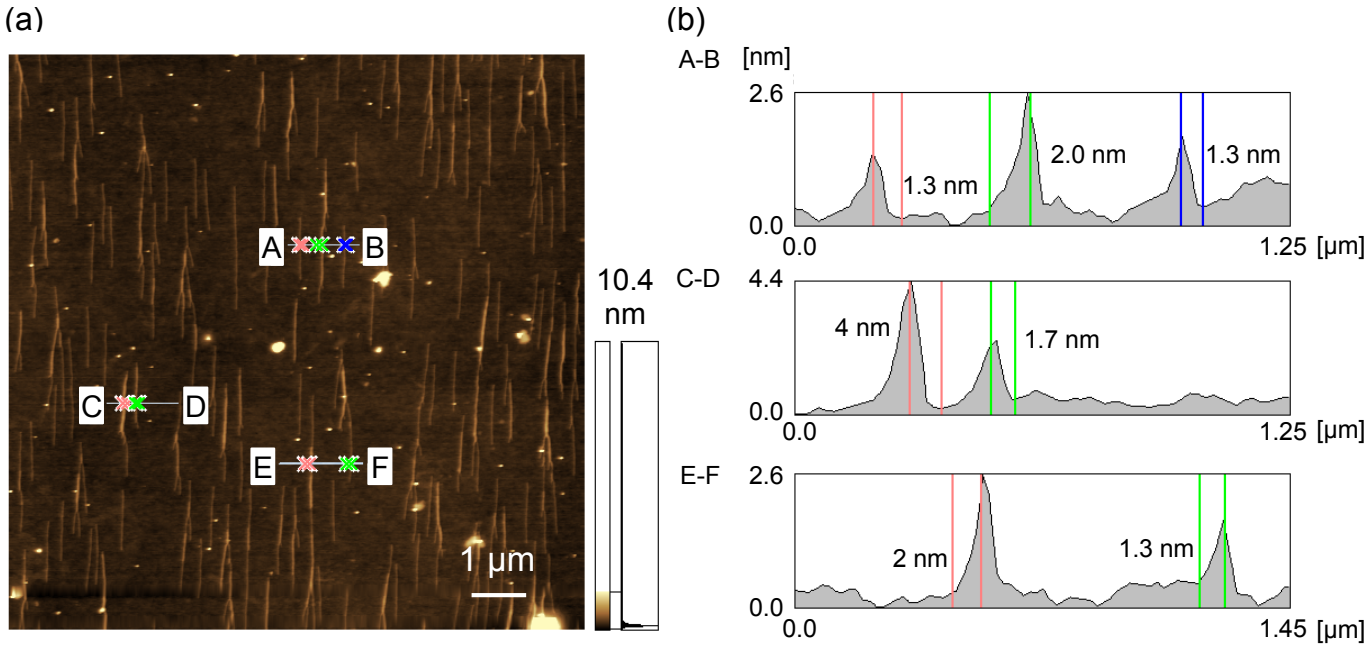

Figure S1. Height analyses of the c02 phages immobilized onto an *it*-PMMA film in an oriented manner. (a) AFM image and (b) cross-sectional image. The cross-sectional lines shown in (a) were analyzed in (b). The phage heights are shown in the Figure.

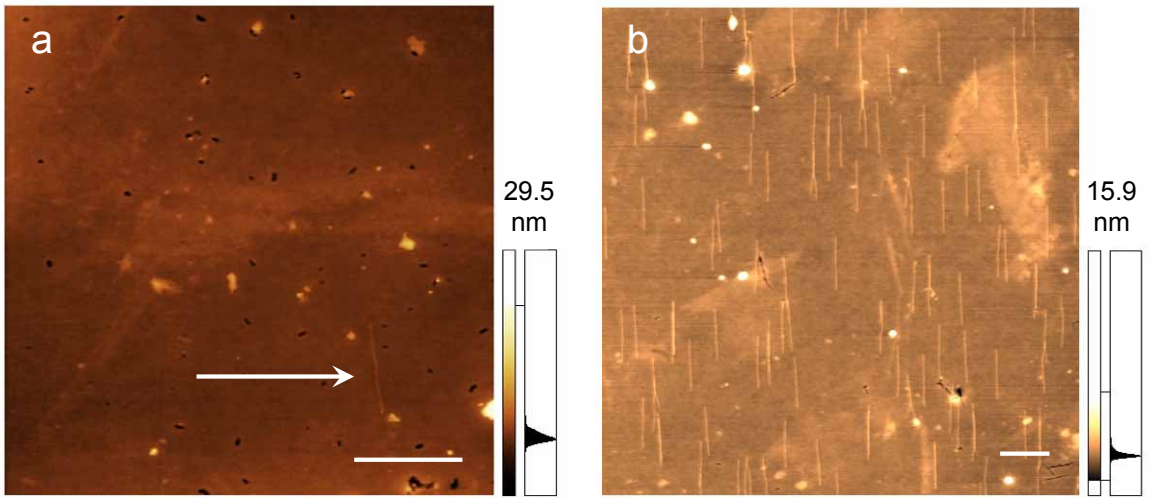

Figure S2. AFM images of the immobilized phages. (a) A 100 pM WT phage solution was immobilized onto the polymer substrate at a speed of 100 mm/min. The arrow indicates the phage. (b) A 25 pM solution of the c02 phage was also immobilized onto the substrate at a speed of 100 mm/min. Both scale bars represent 1 μm, and Z scales were shown in each image.

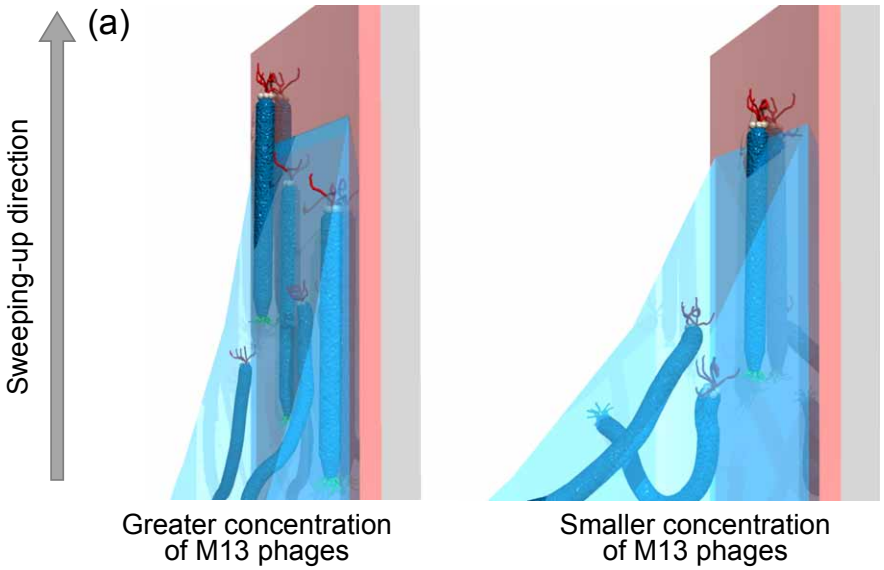

Figure S3. Schematic illustrations of the phages and substrates near the meniscus. (a) Faster and (b) slower speeds of sweeping-up caused differences in the capillary forces. Sweeping-up direction was shown in the figure.

References

1. K. Hatada, K. Ute, Y. Okamoto and T. Kitayama, *Polym. J.*, 1986, **18**, 1037.
2. T. Serizawa, T. Sawada, H. Matsuno, T. Matsubara and T. Sato, *J. Am. Chem. Soc.*, 2005, **127**, 13780.