Supporting information for

Construction of Catechol-Containing Semi-Fluorinated Asymmetric Polymer Brush via Successive RAFT Polymerization and ATRP

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Experimental Section

Materials

2,2,3,3,3-Pentafluoropropyl acrylate (PFA, TCI, 98%) was passed through a basic alumina column to remove the stabilizer prior to use. Copper(I) bromide (CuBr, Aldrich, 98%) was purified by stirring overnight over CH_3COOH at room temperature, followed by washing with ethanol, diethyl ether, and acetone prior to drying at 40°C *in vacuo* for one day. 2,2'-Azobis(isobutyronitrile) (AIBN, Aldrich, 98%) was recrystallized in anhydrous ethanol twice. Tetrahydrofuran (THF, Aldrich, 99%) and dioxane (Aldrich, 99.8%) were dried over CaH_2 and distilled from sodium and benzophenone under N_2 prior to use. *tert*-Butyl 2-((2-bromopropanoyloxy)methyl)-acrylate (*t*BBPMA)[1] and cumyl dithiobenzoate (CDB)[2] were synthesized according to previous literatures. Dopamine hydrochloride (Aldrich), methacryloyl chloride (TCI, 90%), poly(ethylene glycol) methyl ether methacrylate (PEGMEMA, M_n = 950 g/mol, Aldrich), 1,1,4,7,10,10-hexamethyltriethylenetetramine (HMTETA, Aldrich, 97%), triethylamine (TEA, Aldrich, 99.5%), *N*,*N*-dimethylformamide (DMF, TCI, 99.5%), and methanol (TCI, 99.8%) were used as received.

For QCM experiments, bovine serum albumin (BSA, Sangon Biotech., China) was used as received. For cell adhesion experiments, ITO glass substrate (Kaivo Optoelectronic Technology Ltd., China), human keratinocyte cell line (HaCaT, ATCC), DMEM medium (GIBCO/Invitrogen, USA), fetal bovine serum (FBS, BI Biological Industries Ltd., Isarel), and 1% penicillin-streptomycin (10,000 U/ml penicillin and 10 mg/ml streptomycin, Solarbio Life Science, China) were used as

received.

Measurements

All NMR analyses were performed on a Bruker Avance 400 spectrometer (400 MHz) in $CDCl_3$, $CDCl_2$, and DMSO-d_6; tetramethylsilane (^{1}H NMR) and $CDCl_3$ (^{13}C NMR) were used as internal standards, and CF_3CO_2H was used as an external standard for ^{19}F NMR. FT-IR spectra were recorded on a Nicolet AVATAR-360 spectrophotometer with a 4 cm^{-1} resolution. Relative molecular weights and molecular weight distributions were measured by conventional gel permeation chromatography (GPC) system equipped with a Waters 1515 Isocratic HPLC pump, a Waters 2414 refractive index detector, and a set of Waters Styragel columns (HR3 (500-30,000), HR4 (5,000-600,000) and HR5 (50,000-4,000,000), 7.8×300 mm, particle size: 5 μm). GPC measurements were carried out at 35^{o}C using THF as eluent with a flow rate of 1.0 mL/min. The system was calibrated with linear poly(methyl methacrylate) standards. Protein adsorption on polymer surface was monitored by a Biolin Q-Sense E1 quartz crystal microbalance with dissipation monitoring (QCM-D). Cells were imaged under a Nikon Eclipse Ci-L microscope. Atomic force microscopy (AFM) images were taken by a JPK NanoWizard Sense system in the AC mode via drop coating of the polymer solution onto the ITO glass substrate and QCM-D SiO_2 sensor.

Synthesis of *N*-(3,4-dihydroxyphenethyl) methacrylamide

In 250 mL three-neck flask, dopamine hydrochloride (8.00 g, 42.2 mmol) and triethylamine (5.8 mL, 4.30 g, 42.5 mmol) were dissolved in anhydrous methanol (80

mL), and cooled in an ice bath. THF solution (4.0 mL) of methacryloyl chloride (5.29 g, 50.8 mmol) and methanol solution (8.8 mL) of triethylamine (8.6 mL, 63.1 mmol) were alternately added dropwise to the hydroxytyramine solution, maintaining the pH of the solution above 9.5. The reaction mixture was stirred at room temperature for 2 h followed by removing methanol by rotary evaporation and extracting the residue with ethyl acetate. The solution was washed with 1 M hydrochloric acid (HCl) and brine, and dried over anhydrous $MgSO_4$ followed by filtration. The filtrate was slowly evaporated to 40 mL via rotary evaporation so that the white precipitate appeared. Next, the crude product was recrystallized in ethyl acetate, giving the product (white powder) of *N*-(3,4-dihydroxyphenethyl) methacrylamide (DOMA, 6.91 g, 52.0%). FT-IR: ν (cm^{-1}): 3353, 3135, 2918, 2850, 1646, 1579, 1544, 1455, 1355, 1268, 1222, 1150, 1116, 1060, 972, 941, 919, 782, 649, 602. ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm): 1.80 (s, 3H, CH_2CCH_3), 2.47 (t, J = 8.0 Hz, 2H, $C_6H_3CH_2CH_2$), 3.13-3.25 (m, 2H, $C_6H_3CH_2CH_2$), 5.26, 5.58 (s, 2H, CH_2CCH_3), 6.33-6.66 (m, 3H, C_6H_3), 7.89 (s, 1H, CONH), 8.59, 8.69 (s, 2H, OH). ^{13}C NMR (101 MHz, $CDCl_3$): δ (ppm): 17.4 (CH_2CCH_3), 34.5 ($C_6H_3CH_2CH_2$), 41.2 ($C_6H_3CH_2CH_2$), 114.9, 115.3, 119.5, 130.9, 143.2, 145.1 ($C_6H_3CH_2CH_2$), 118.7(CH_2CCH_3), 140.0 (CH_2CCH_3), 170.0 (CONH).

RAFT copolymerization of *t*BBPMA, PEGMEMA, and DOMA

AIBN (16.4 mg, 0.1 mmol), CDB (81.6 mg, 0.3 mmol), and DOMA (0.27 g, 1.2 mmol) were first added to a 25 mL Schlenk flask (flame-dried under vacuum prior to use) sealed with a rubber septum for degassing and kept under N_2. Next, *t*BBPMA

(0.88 g, 3 mmol), PEGMEMA (2.85 g, 3 mmol), and dry dioxane (3.5 mL) were added via a gastight syringe. The flask was degassed by three cycles of freezing-pumping-thawing followed by immersing the flask into an oil bath set at 70°C. The polymerization was terminated by immersing the flask into liquid N_2 after 30 h. Subsequently, dioxane was removed by rotary evaporation and the residue was diluted with methanol. Next, the solution was placed in a dialysis membrane ($MW_{cut\text{-}off}$ = 2.0 kDa) and dialyzed against methanol for 2 days. Methanol was removed by rotary evaporation and AIBN was used to remove the dithiobenzoate moiety of the copolymer at 65°C in THF according to previous report.[3] Finally, a light yellow liquid of P*t*BA-*co*-PPEGMEMA-*co*-PDOMA **1** was obtained using silica gel chromatography (ethyl acetate/methanol). GPC: M_n = 11,500 g/mol, M_w/M_n = 1.24. FT-IR: ν (cm^{-1}): 3377, 2870, 1729, 1660, 1517, 1451, 1369, 1349, 1252, 1145, 997, 952, 844. ^{1}H NMR (400 MHz, CD_2Cl_2): δ (ppm): 0.81, 0.96, 1.10 (3H, CH_2CCH_3), 1.43 (9H, $C(CH_3)_3$), 1.72 (2H, CH_2C), 1.83 (3H, CH_3CHBr), 3.30 (3H, OCH_3), 3.56 (4H, OCH_2CH_2), 4.05 (2H, $CH_2CCH_2O_2C$ and 2H, $CH_2CCO_2CH_2$), 4.40 (1H, CH_3CHBr), 6.80 (3H, $C_6H_3(OH)_2$), 7.26 (5H, C_6H_5). ^{13}C NMR (101 MHz, $CDCl_3$): δ (ppm): 21.8 (CH_2CCH_3), 28.1 ($C(CH_3)_3$), 32.9 (CH_2C and $C_6H_3(OH)_2CH_2$), 40.6 (CH_2C, CH_3CHBr, and $CONHCH_2$), 59.4 (OCH_3), 70.6 (OCH_2CH_2), 72.1 ($CH_2CCH_2O_2C$ and $CH_2CCO_2CH_2$), 82.6 ($C(CH_3)_3$), 105.1, 114.9, 120.4, 125.1 ($C_6H_3(OH)_2$ and C_6H_5), 169.6 (C=O).

ATRP Graft Copolymerization of 2,2,3,3,3-Pentafluoropropyl Acrylate

CuBr (3.16 mg, 0.022 mmol) was first added to a 10 mL Schlenk flask (flame-dried under vacuum prior to use) sealed with a rubber septum for degassing and kept under N_2. Next, P*t*BA-*co*-PPEGMEMA-*co*-PDOMA **1** ($M_{n,GPC}$ = 11,500 g/mol, M_w/M_n =1.24, $M_{n,NMR}$ = 12,100 g/mol, 31 mg, 0.022 mmol ATRP initiating group), PFA (2.27 g, 11.0 mmol), HMTETA (6.0 μL, 0.022 mmol), and DMF (2.0 mL) were charged via a gastight syringe. The flask was degassed by three cycles of freezing-pumping-thawing followed by immersing the flask into an oil bath set at 80°C. The polymerization lasted 6 h and was terminated by immersing the flask into liquid N_2. The mixture was diluted by THF and passed through a column to remove the residual copper catalyst. The solution was concentrated and precipitated into cold *n*-hexane. After repeated purification by dissolving in THF and precipitating in cold *n*-hexane three times, 97 mg of (P*t*BA-*co*-PPEGMEMA-*co*-PDOMA)-*g*-PPFA **2** heterogeneous polymer brush was obtained as a white powder after drying in *vacuo* overnight. GPC: M_n = 57,200 g/mol, M_w/M_n = 1.29. FT-IR: ν (cm^{-1}): 2924, 1759, 1453, 1401, 1374, 1352, 1260, 1204, 1151, 1107, 1059, 942, 800, 726, 659. ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm): 0.84, 1.25 (3H, CH_2CCH_3), 1.41 (9H, $C(CH_3)_3$), 1.58, 1.75, 2.01 (2H, CH_2C and 2H, CH_2CH), 2.44 (1H, CH_2CH), 3.36 (3H, OCH_3), 3.63 (4H, OCH_2CH_2), 4.51 (2H, $CO_2CH_2CF_2CF_3$). ^{13}C NMR (101 MHz, $CDCl_3$): δ (ppm): 29.7 ($C(CH_3)_3$), 34.3 (CH_2C), 40.8 (CH_2CHCO_2), 59.2 ($CO_2CH_2CF_2CF_3$ and OCH_3), 70.9 (OCH_2CH_2), 109.4, 111.8, 114.2, 117.2, 119.4, 122.2 (CF_2CF_3), 172.4 (C=O). ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm): -84.1 (3F, $CO_2CH_2CF_2CF_3$), -124.3 (2F, $CO_2CH_2CF_2CF_3$).

Preparation of polymer brush surfaces on ITO glass substrate and SiO_2-coated QCM-D sensor

The polymer brush surfaces for protein adsorption and cell adhesion experiments were prepared by drop coating method on SiO_2-coated QCM-D sensor and ITO glass, respectively. ITO glass substrate and SiO_2-coated QCM-D sensor were immersed in each of following solvents and sonicated for 1 h: aqueous solution of detergent, deionized water, acetone, and isopropanol, followed by drying in *vacuo* overnight. Next, methanol solution of (P*t*BA-*co*-PPEGMEMA-*co*-PDOMA)-*g*-PPFA **2** polymer brush (1.5 mg/mL) was prepared by stirring for 30 min before filtering through a 0.45 μm syringe filter. The filtrate was then dropped onto the freshly cleaned ITO surface and QCM-D sensor several times in a petri dish. After 3 h of adsorption, the surfaces were rinsed with a capacious amount of methanol and dried *in vacuo* overnight.

Protein adsorption experiment

QCM-D sensors with (P*t*BA-*co*-PPEGMEMA-*co*-PDOMA)-*g*-PPFA **2** polymer brush surfaces were placed in a flow cell and surfaces were allowed to hydrate for 1 h in flowing PBS (100 μL/min). A protein BSA solution in PBS (30 mg/mL) was introduced into the cell at a rate of 100 μL/min for 1 h. Finally, the surfaces were rinsed with PBS (100 μL/min) again. The frequency of the harmonics and dissipation at these frequencies were monitored as the protein adsorbed to the polymer brush surfaces. The temperature of the crystal was maintained at 25°C throughout the experiment. The shifts in frequency and dissipation, corresponding to 3rd, 5th, and 7th

overtones, were recorded and fitted to Voigt viscoelastic model in Q-Tools software to obtain the mass of adsorbed BSA.

Cell adhesion experiment

HaCaT cells were cultured at 37°C under a humidified 5% CO_2 atmosphere in DMEM medium supplemented with 10% FBS and 1% penicillin-streptomycin. Culture medium was replaced every day. After confluence, the cells were subcultured following trypsinization. Surface samples were transferred to a new 6-well plate and sterilized through exposure to ultraviolet for 8 h. HaCaT cells were then seeded onto 6-well micro-well plates in 2mL of DMEM medium at a density of 3×10^5 cell/well and cultured for 6 h. Cells were imaged in situ, after which the substrates were gently removed from the well and placed into new wells (pre-filled with cell culture medium) for further imaging. The new wells were imaged under Nikon Eclipse Ci-L microscope.

Table S1. RAFT Copolymerization of *t*BBPMA, PEGMEMA, and DOMA[a]

Entry	[*t*BBPMA]:[PEGMEMA]:[DOMA]:[CDB]:[AIBN]	$M_{n,GPC}$[b] (g/mol)	M_w/M_n[b]	$M_{n,NMR}$[c] (g/mol)	x:y:z [d]
1	30:30:12:3:1	11,500	1.24	12,100	8.6/9.3/2.3

[a] Polymerization temperature: 70°C, polymerization time: 30 h, solvent: dioxane. [b] Measured by GPC at 35°C in THF. [c] Obtained from ^{1}H NMR. [d] x, y, and z represent the number of *t*BBPMA, PEGMEMA, and DOMA repeat unit, respectively, obtained from ^{1}H NMR.

Table S2. Synthesis of (P*t*BA-*co*-PPEGMEMA-*co*-PDOMA)-*g*-PPFA **2** Polymer Brush[a]

Entry	Time (h)	$M_{n,GPC}$[b] (g/mol)	M_w/M_n[b]	N_{PFA}[c]	$M_{n,NMR}$[d] (g/mol)
2[b]	6.0	57,200	1.29	31.7	67,700

[a] Initiated by P*t*BBPMA-*co*-PPEGMEMA-*co*-PDOMA **1**, polymerization temperature: 80°C, [PFA]:[Br group]:[CuBr]:[HMTETA] = 500:1:1:1. [b] Measured by GPC at 35°C in THF. [c] The number of PFA repeat unit per PPFA side chain obtained from ^{1}H NMR. [d] Obtained from ^{1}H NMR.

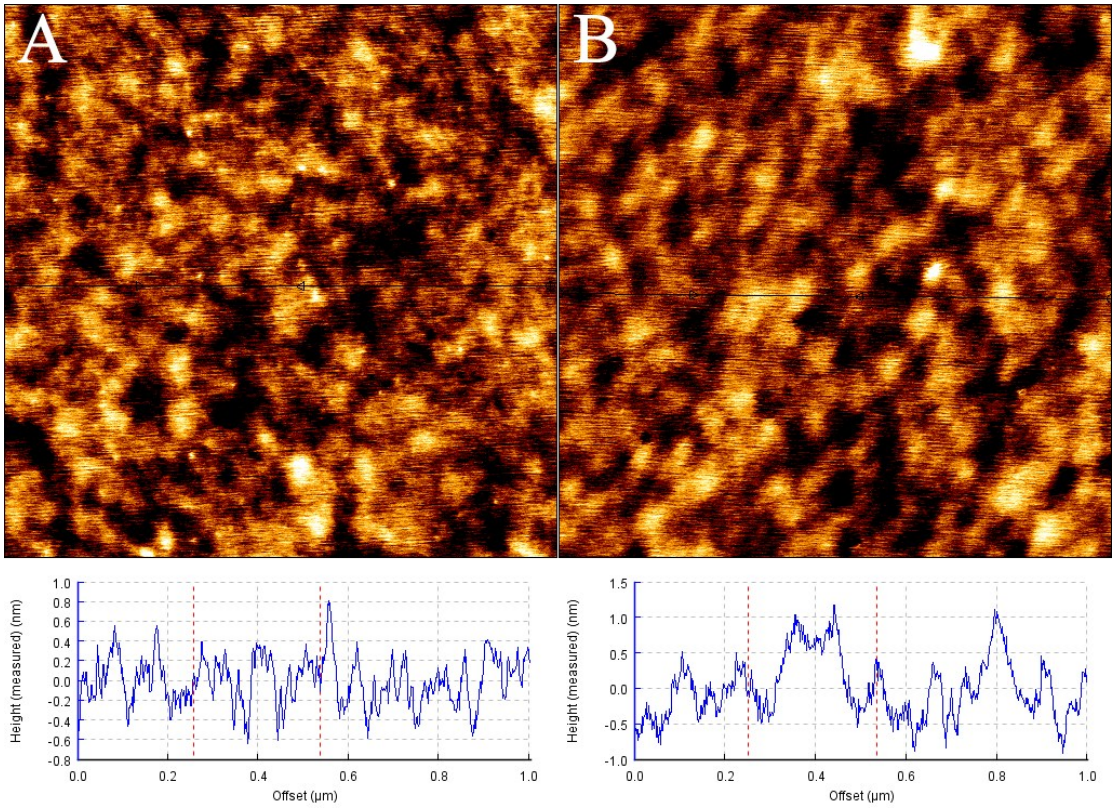

Figure S1. AFM height images for (P*t*BA-*co*-PPEGMEMA-*co*-PDOMA)-*g*-PPFA **2** polymer brush surfaces (A) on ITO substrates as cast coatings, scale: 1 µm × 1 µm, and (B) on SiO_2-coated QCM-D sensor as cast coatings, scale: 1 µm × 1 µm.

References

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