Simple Structured Polyetheramines, Jeffamines, as Efficient Cathode Interfacial Layers for Organic Photovoltaics Providing Power Conversion Efficiencies up to 9.1%

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Supporting Information

Device fabrication and characterization

ITO glass substrates [Sanyo, Japan (8 Ω/square)] were patterned lithographically, washed (detergent), treated ultrasonically [using acetone, water, and isopropyl alcohol (IPA)], dried (140 °C, 10 min), and further cleaned with O_2 plasma for 5 min. The zinc oxide (ZnO) layer (50 nm) was prepared from a 0.5 M zinc acetate precursor solution in 2-methoxyethanol (2-ME). The ZnO was annealed at 160 °C for 30min in air prior to use. Solutions of Jeffamine materials were prepared by dissolving each polymer in 2-ME to achieve a desired concentration. These solutions were deposited on top of the ZnO layers through spin-coating (5000 rpm) in air and then the samples were dried (100 °C, 10 min) in a glove box. Active layer solution of PTB7 and $PC_{71}BM$ (1:1.5) (10mg/ml for PTB7) was stirred in chlorobenzene (CB) (with 3vol% of 1,8-diiodooctane (DIO)) overnight, filtered through a polytetrafluoroethylene (PTFE; 0.2-

μm) filter, and then spin-coated (1000 rpm, 30 s) onto the ZnO layer (with or without IFLs). All devices were completed by depositing layers of MoO_3 (5 nm) and Ag (100 nm) at pressures below 10^{-6} torr. Each device had an active area of 10 mm^2. Cell performances were measured in a glove box. The current density–voltage (J–V) curves of the devices were determined using a computer-controlled Keithley 2400 source measurement unit and a Newport solar simulator (Oriel® Sol2A Class ABA) with AM 1.5 G illumination (1000 W m^{-2}). A standard Si secondary reference cell cover with a KG-5 filter was used to calibrate the illumination intensity. IPCEs were measured using an Enlitech QE-R spectral response measurement system to calibrate the current densities of the devices. The morphologies of the blend films were analyzed through AFM, using a Bruker Dimension Edge microscope operated in dynamic force mode at ambient temperature. We fabricated these SCLC electron-only devices using the optimal blend film conditions. When we applied a sufficient voltage to these devices, the transport of electrons through the BHJ layer was limited by the accumulated space-charge. The equation of SCLC is described by

$$J = \frac{9}{8}\varepsilon_r\varepsilon_0\mu_h\frac{V^2}{L^3}$$

where ε_r is the dielectric constant of PCBM (3.9), ε_0 is the permittivity of free space (8.85 × 10^{-12} F m^{-1}), μ_e is the electron mobility, V is the device's applied voltage, and L is the active layer thickness (120 nm). The work function of the ZnOs surfaces were

measured by an ultraviolet photoelectron spectrometer (UPS) using a ULVAC-PHI PHI 5000 Versaprobe II system with a windowless He discharge light source that provided He(I) emission at 21.2 eV. The take-off angle of the photoelectron was set at 90° and a pass energy of 0.58 eV was used. The samples were biased at −5 V dc to drive low-energy secondary electrons into the detector.
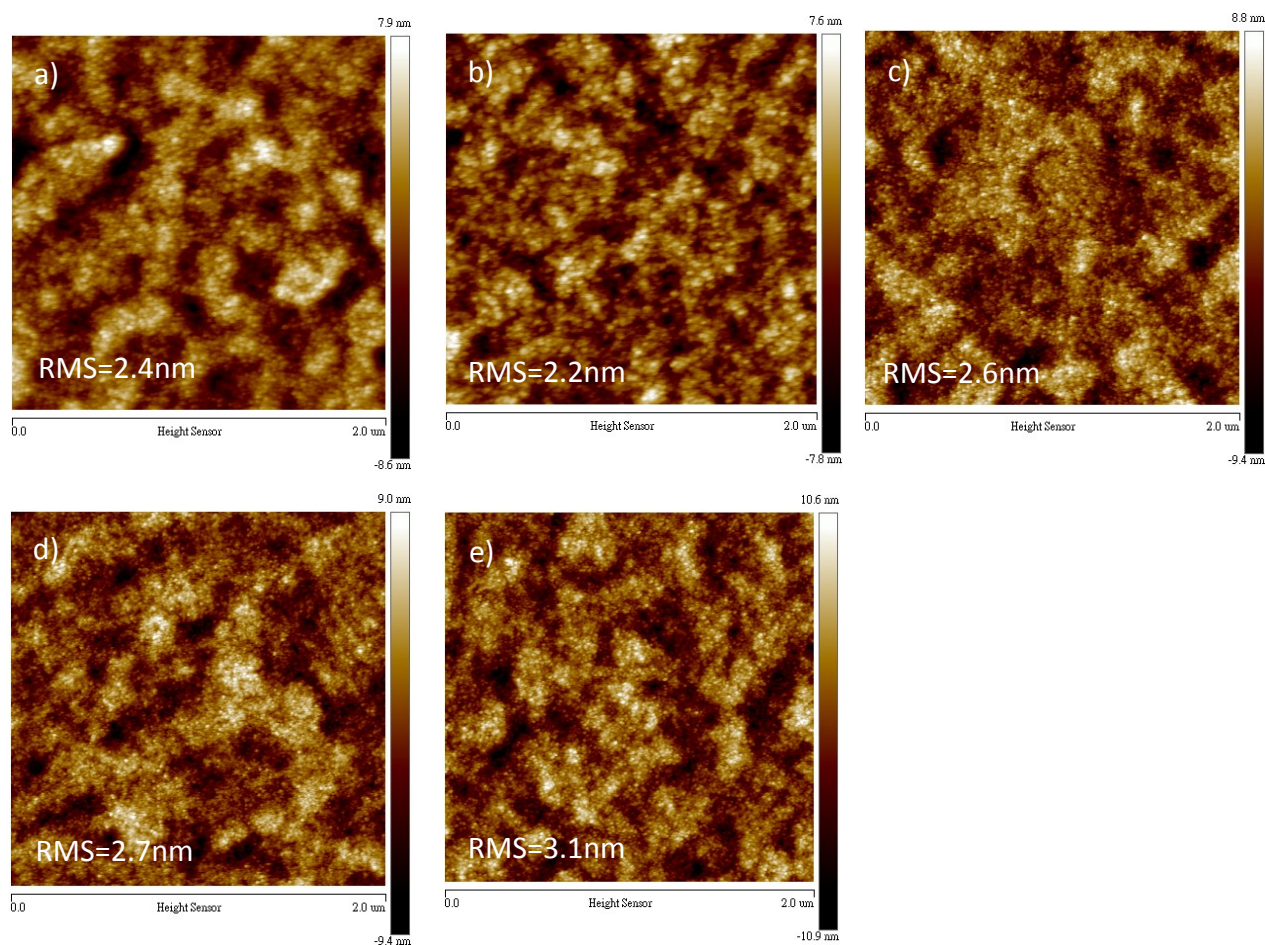
Figure S1. Tapping-mode AFM images of (a) a ZnO film and (b–e) ZnO films modified with (b) M2005, (c) M2070, (d) D2000, and (e) ED2003.
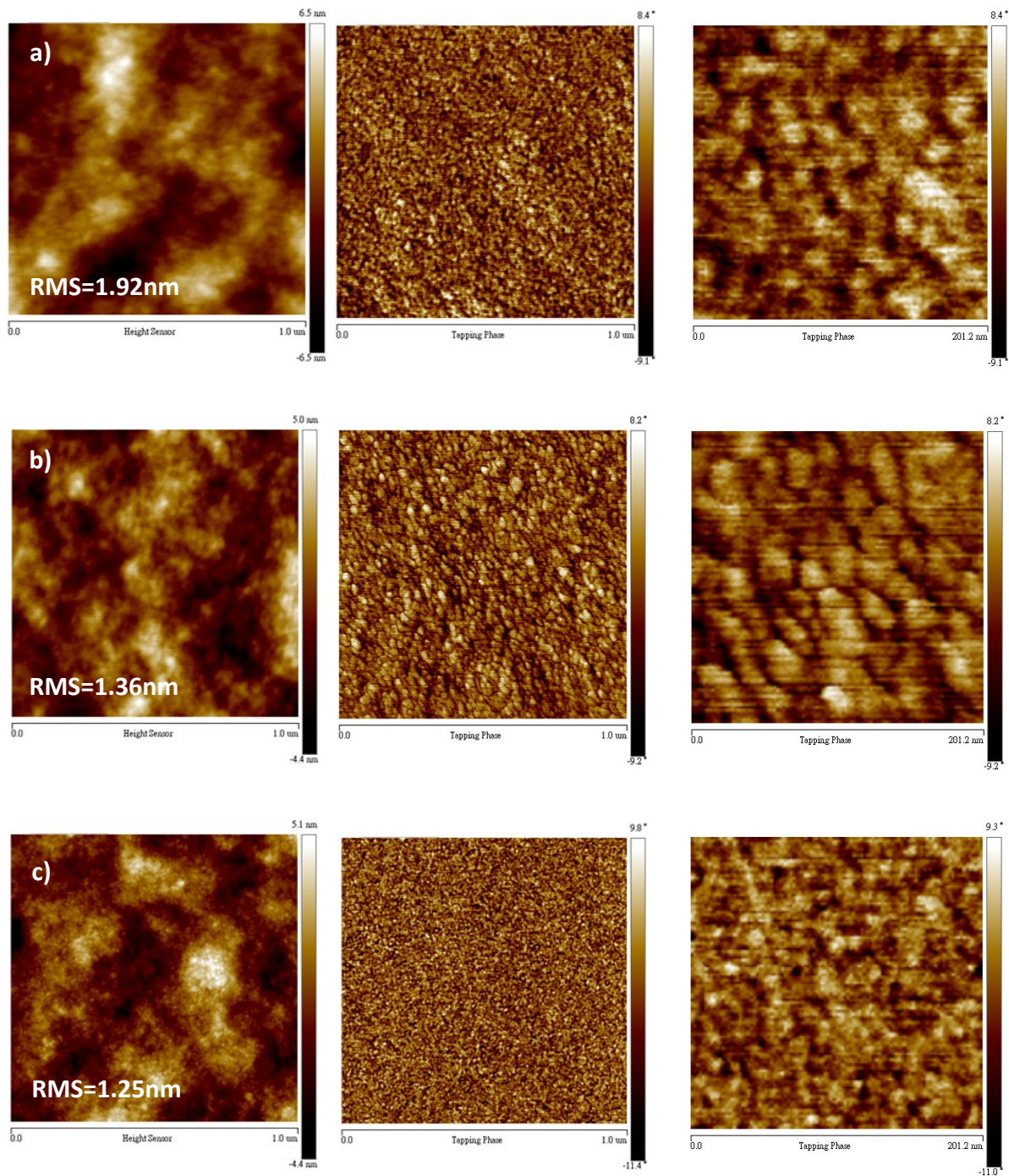
Figure S2. AFM topographic (1 μm × 1 μm) and phase (1 μm × 1 μm) and enlarge

phase images (200 nm × 200 nm) images of a) M2005, b) M2070, and c) ED2003.