Supplementary Information

Solvent Washing with Toluene Enhances Efficiency and Increases Reproducibility in Perovskite Solar Cells

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Experimental Section

Device fabrication:

Commercially, available ITO- coated glasses used as a substrate. After usual cleaning process

(10 minutes Water, Acetone and İsopropanol respectively) substrates exposed to oxygen

plasma treatment to activate the surfaces. After treatment PEDOT:PSS deposited on to ito-coated glasses as hole injection layer by spin coating at 5000 rpm for 40 s and annealed at 120 °C for 20 minutes. Methylamonioumiodide and leadiodide dissolved in γ- Butyrolactone (GBL) equimolar ratio 1,23 M and stirring at least 3 h at 80 °C. Perovskite layer deposited by spin coating system using prepared solution. The solvent which is employed to precipitation perovskite pre-cursors to surface drop during spin coating process at 3500 rpm for 40 s. In this study, we investigate that effect of different non-polar solvents which are used to washing on perovskite surface morphology. These non-polar solvents are differ from each other in terms of dipole moments. Afterward obtained perovskite layer annealled at 80 °C for 5 minutes and PCBM solution which is dissolved in choloroform : chlorobenzene (1:3) %3 wt, spin-coated as electron transport layer at 2500 rpm for 60 s and annealled 80 °C for 20 minutes to evaporate residual solvents. All of the fabrication stages realized in ambient condition. Finally 100 nm aluminum evaporated as cathode electrodes by glove-box integrated pvd system.

Solar cell characterization:

All measurements completed in MBraun M200 glove–box system under nitrogen atmosphere. Glove-box integrated ATLAS solar simulator used as AM1,5 light source. Photocurrent and voltage characterization done by Keithley 2400 source meter. Impedans measurements realized by Hioki IM5100 impedance analyzer. Surface characterizations are completed by NTMDT NTEGRA Solaris and Zeiss EVO instruments for AFM and SEM respectively. Optical absorption measurements done by Hitachi UV-Vis NIR. X ray diffraction (xrd) and small angle x-ray scattering (SAXS) measurements done by Bruker Advance D8 XRD instrument
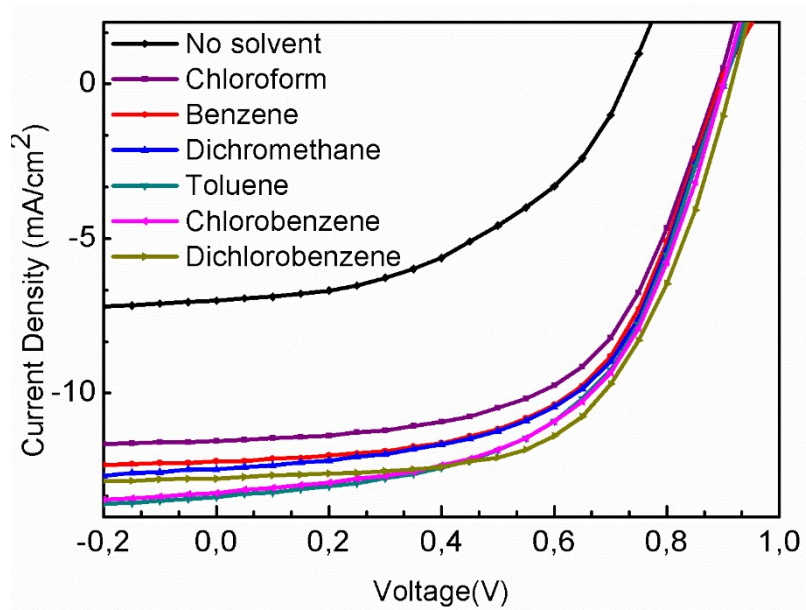
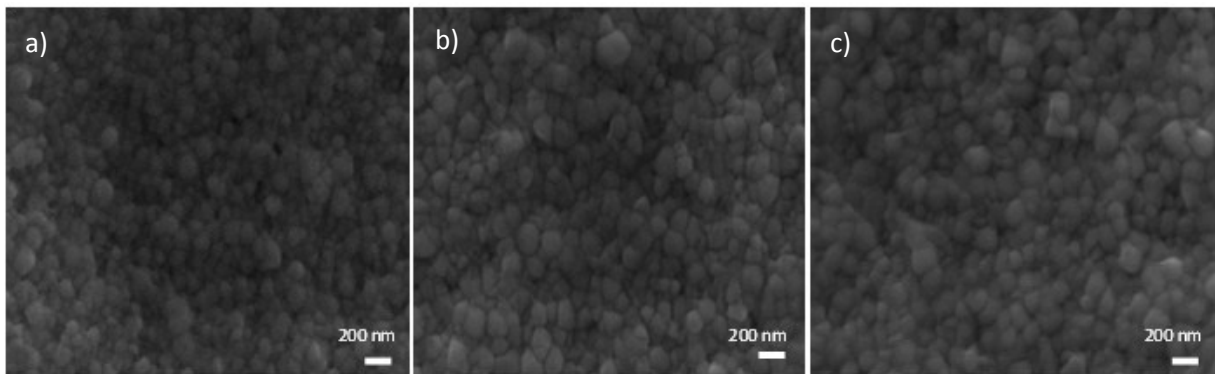**Figure 1.** Current-voltage characteristics up to different organic solvents.

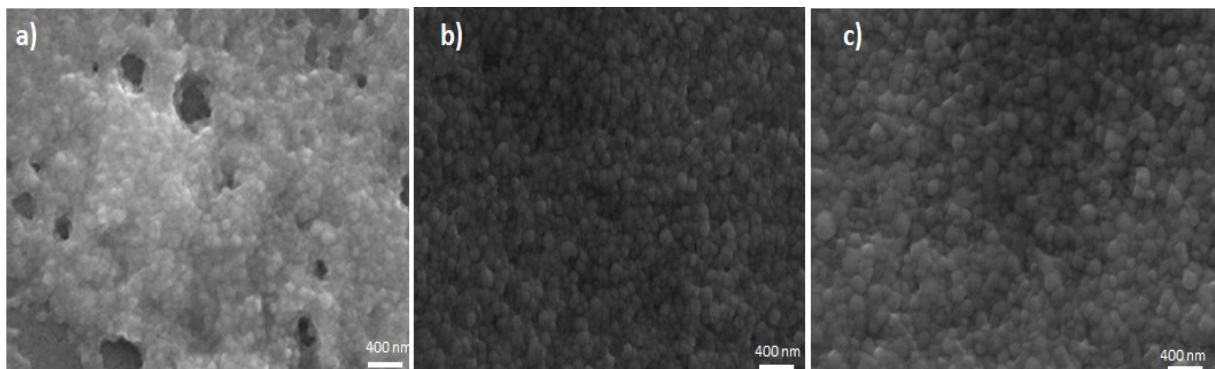**Figure 2.** Different amount of Toluen solvent 80 μl (a), 50 μl (b) and 20 μl (c)

Figure 3. The Sem images of perovskite surfaces with Chloroform (a), Toluene (b) and Dichlorobenzene (c) washing.
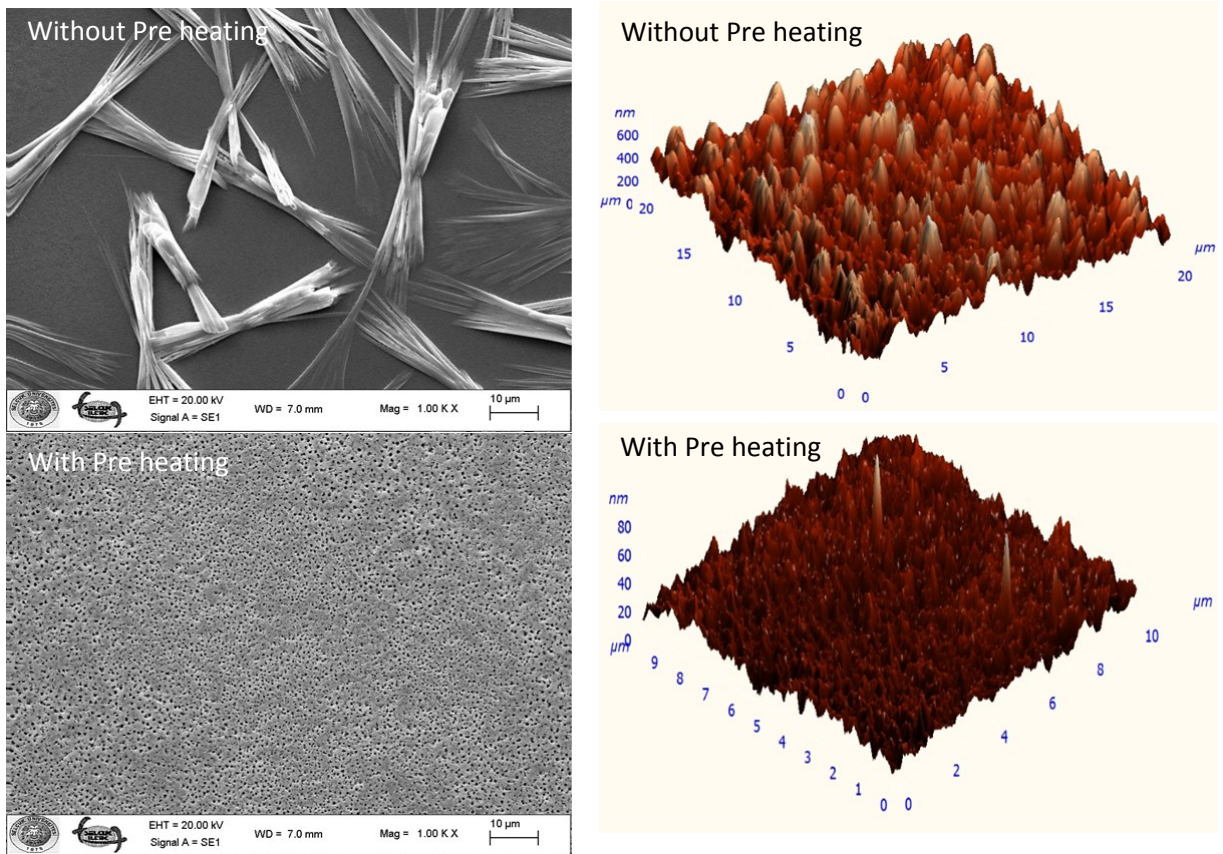
Figure 4. Difference between cold and hot surfaces for perovskite precursors solved in DMF could be clearly seen from SEM and AFM without and with pre-heating treatment of substrate.

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