

Support Information

Roll-to-roll boosting the energy storage of ultrathin biaxially-oriented polypropylene film

by soft-photon-induced crosslink implanted at industry scale

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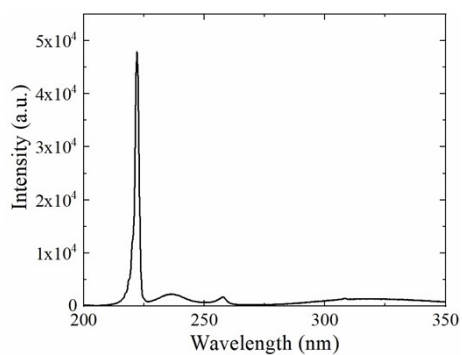


Figure S 1. Spectrum of the KrCl excimer UV source.

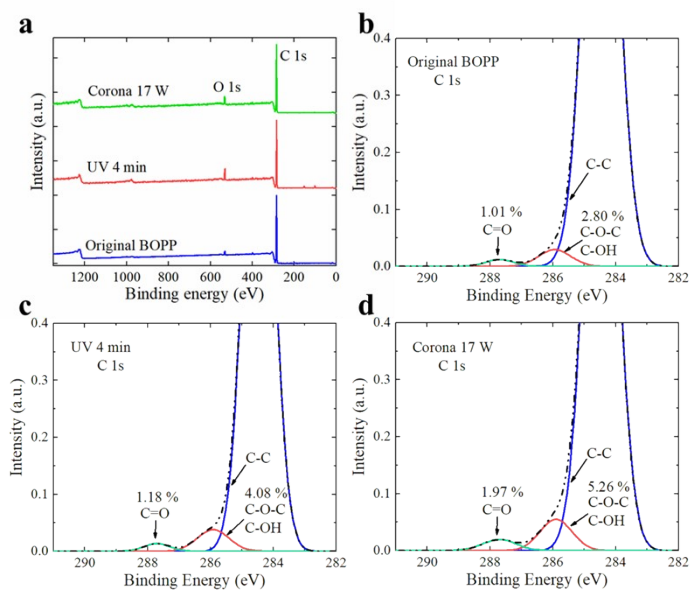


Figure S 2. (a) XPS spectra and (b)-(d) those with binding energy deconvolution for C 1s peak of BOPP samples.

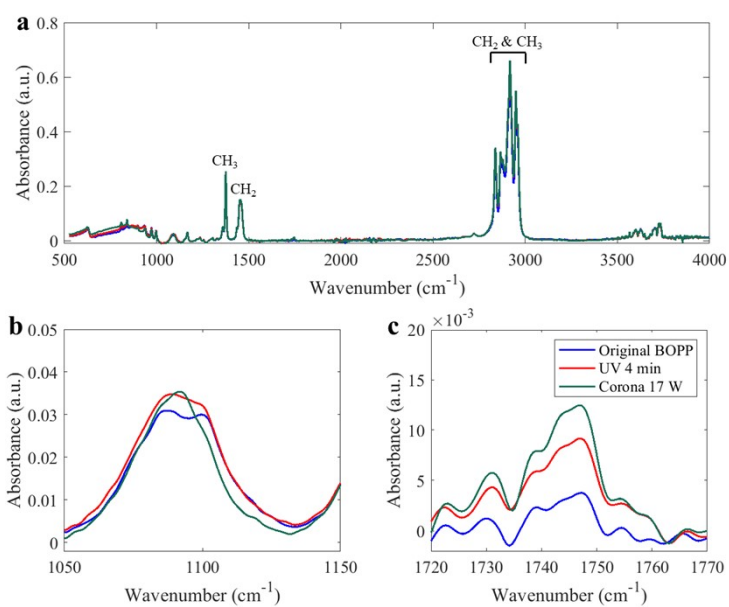


Figure S 3. FTIR spectra of BOPP samples with zoom-in.

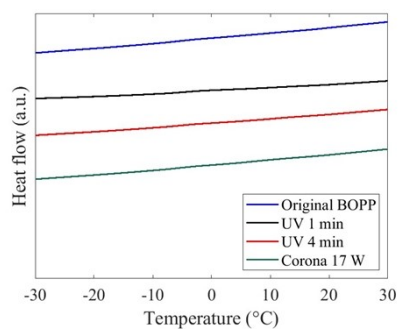


Figure S 4. DSC curves at low temperature.

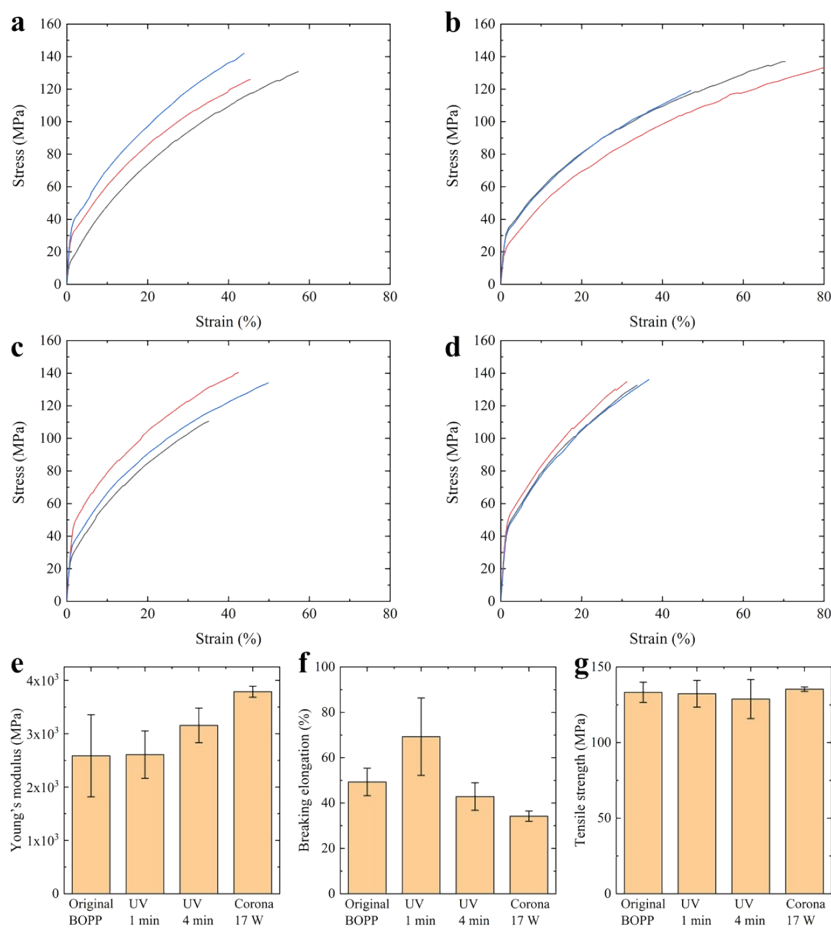


Figure S 5. (a)-(d) Stress-strain curves for original BOPP and that treated by UV 1 min, UV 4 min, and corona 17 W, respectively. (e)-(f) Comparison of Young's modulus, breaking elongation, and tensile strength of different BOPP samples.

Gel fraction

The gel fraction of the BOPP samples, reflecting their crosslink degree, is analyzed by Soxhlet extraction method [49]. Each BOPP sample (27.3 mg) is wrapped in a brass mesh and immersed into 10 mL xylene. In our test, after heated to 130 °C with magnetic stirring, all BOPP samples, *i.e.*, original BOPP and BOPP treated by UV and corona, are dissolved in xylene, which means that there is no insoluble component after these treatments at 130 °C extraction.

Therefore, we decrease the temperature of the xylene solution with BOPP and observe the precipitation process. Upon cooling to about 110 °C, the xylene solution containing BOPP treated by UV 4 min and corona 17 W starts to dissolve out, while that containing original BOPP and BOPP treated by UV 1 min remains quite clear with a little precipitation, which indicates the different solubility and gel fraction of BOPP samples. Next, we perform the extraction at a lower temperature of 120 °C for 1 h. The residual insoluble components are rinsed with anhydrous ethanol, dried, and weighted. The residual weight (and percentage) for original BOPP, BOPP treated by UV 1 min, UV 4 min, and corona 17 W is 0 mg (no residual), 0.5 mg (1.8 %), 22.7 mg (83 %) and 25.2 (92 %). In this work, it is safe not to give a quantitative statement on the gel fraction and the solubility of different samples indicates various crosslink degree, which is quite consistent with the trend of Young's modulus.

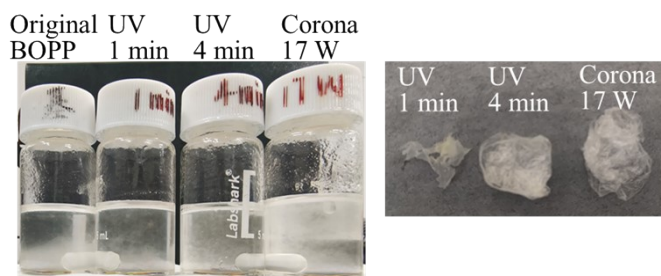


Figure S 6. The precipitation process of the xylene solution containing different BOPP samples and the residual insoluble components of extracted BOPP samples.

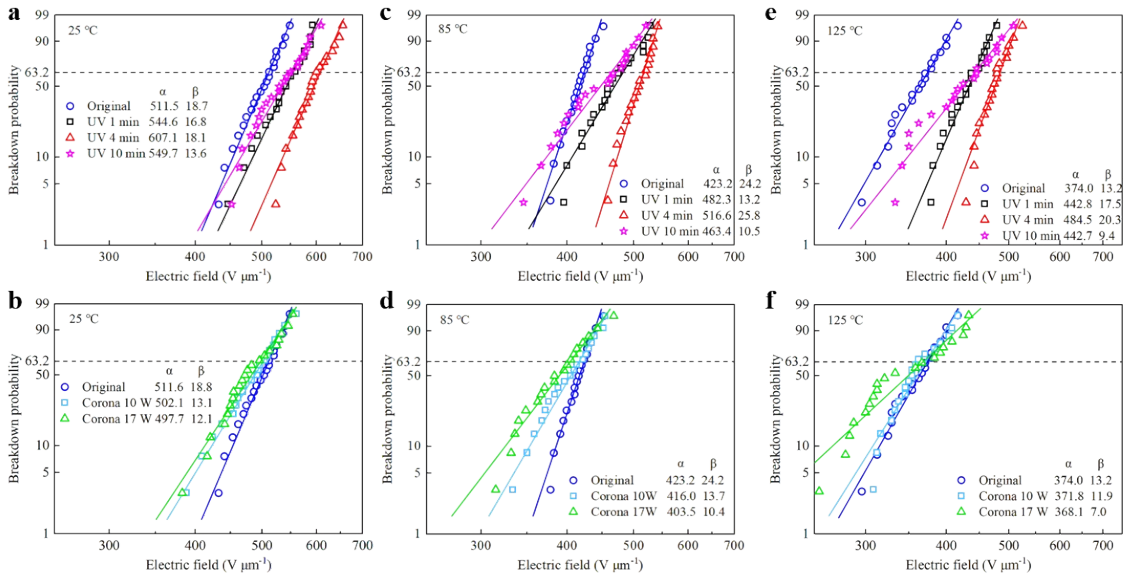


Figure S 7. Weibull plots of breakdown electric field (scale parameter, α) with shape parameter (β) for original BOPP and samples with UV irradiation and with corona treatment at 25, 85, and 125 °C, respectively.

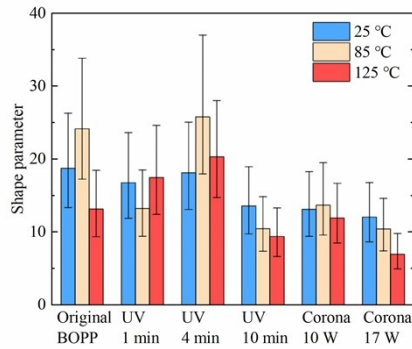


Figure S 8. Shape parameters of the Weibull distribution (with 95% confidence intervals) for BOPP samples at different temperatures.

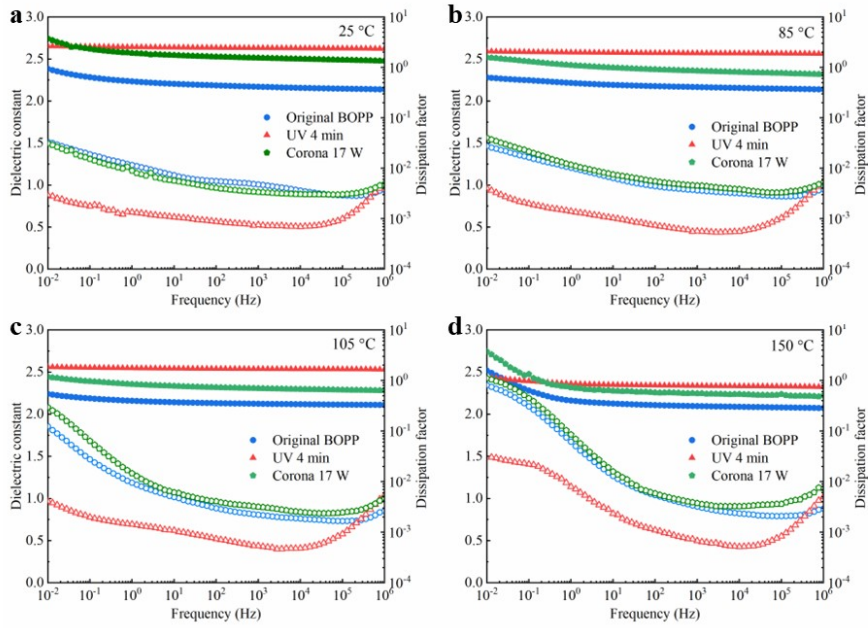


Figure S 9. Dielectric constant and dissipation factor for BOPP samples at different temperatures.

Trap level distribution

The analysis of trap level distribution based on ISPD curves is based the method given in [52–53]. The trap energy E_T is given by $E_T = k_B T \ln(v_{ATE} t)$, where k_B is the Boltzmann constant, T is the temperature, v_{ATE} is the attempt-to-escape frequency, and t is the time. v_{ATE} is given by $v_{ATE} = N_c S_t v$, where N_c is the density of states in the conduction band, S_t is the capture cross-section, and v is the thermal velocity.

The trap distribution function N_t is given by $N_t(t) = 4\epsilon_0 \epsilon_r / (eL^2 k_B T) \cdot |t \cdot dV_s(t)/dt|$, where ϵ_0 is the vacuum permittivity, ϵ_r is the relative dielectric constant of the material, e is the elementary charge, L is the sample thickness, and V_s is the surface potential. The measured ISPD curve $V_s(t)$ can be fitted with the summary of two exponential functions, *i.e.*, $V_s(t) = A_1 e^{-t/\tau_1} + A_2 e^{-t/\tau_2}$, corresponding to the shallow traps and deep traps, respectively. Based on the fitting of measured ISPD curves, the trap distribution function and trap center energy can be obtained.

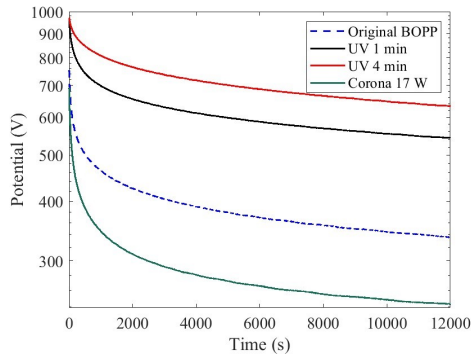


Figure S 10. Isothermal surface potential decay (ISPD) curves of different BOPP samples.

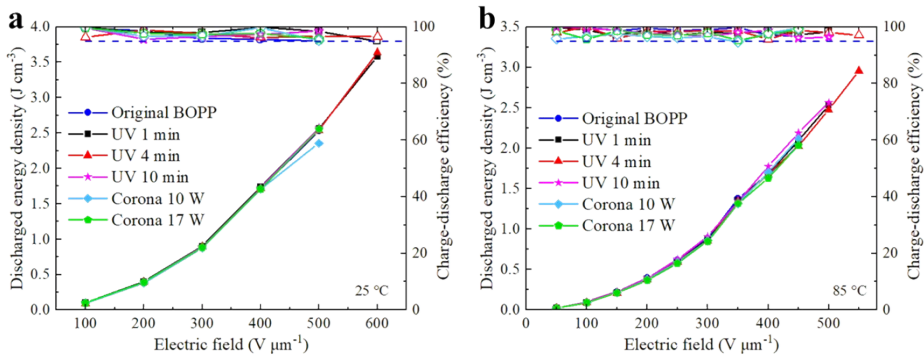


Figure S 11. (a)-(b) discharged energy density and charge-discharge efficiency for BOPP samples at 25 and 85 °C, respectively. The dashed line indicates the efficiency of 95%.

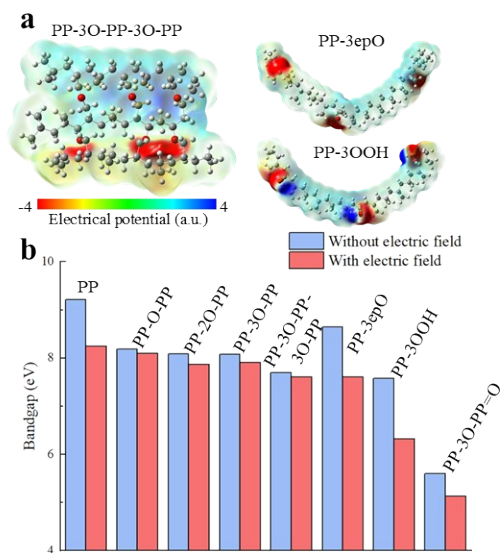


Figure S 12. (a) Simulated potential distribution of three-chain junction (PP-3O-PP-3O-PP), PP chain with epoxides (PP-3epO), and PP chain with peroxides (PP-3OOH). (b) Comparison of bandgap of different structures with and without electric field.