

**Efficient hole transport layers based on cross-linked poly(N-vinylcarbazole) for high-performance perovskite photodetectors**

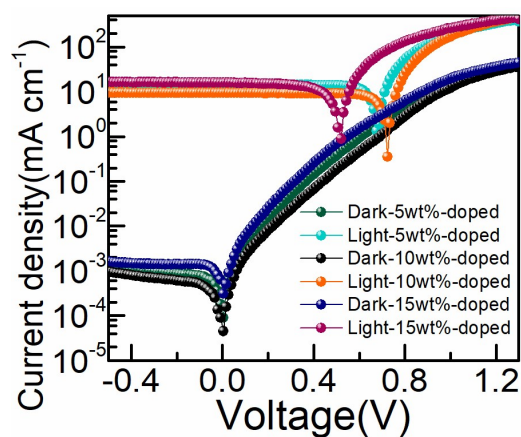
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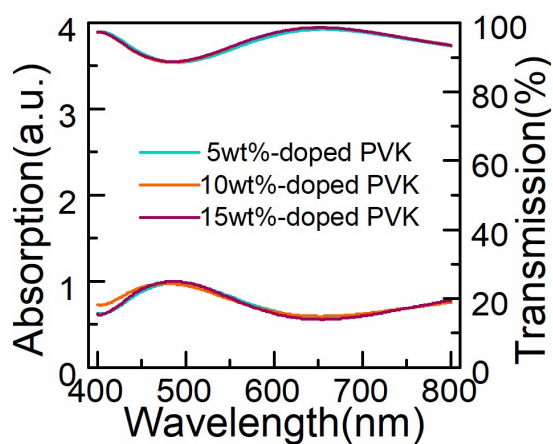
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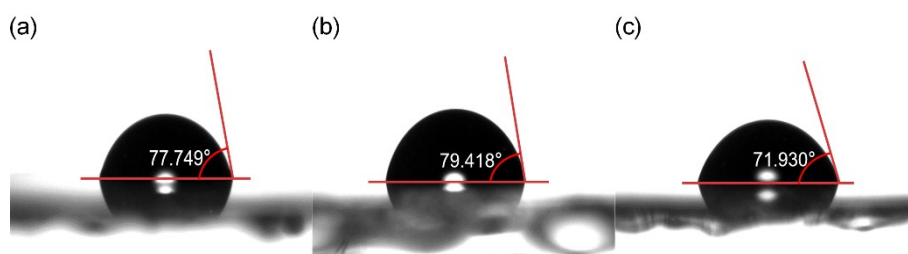
**Supporting Information**



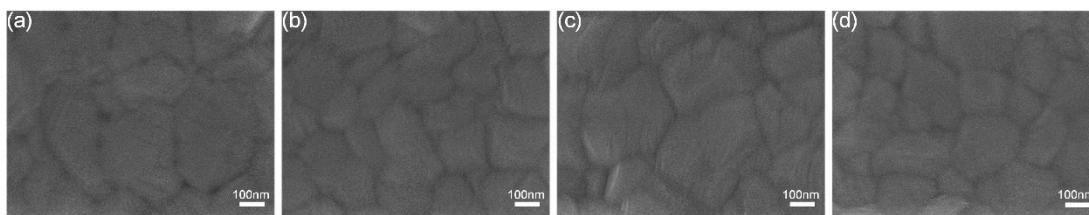
**Figure S1.** J-V characteristics curves of perovskite photodetectors on 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK HTLs, respectively.



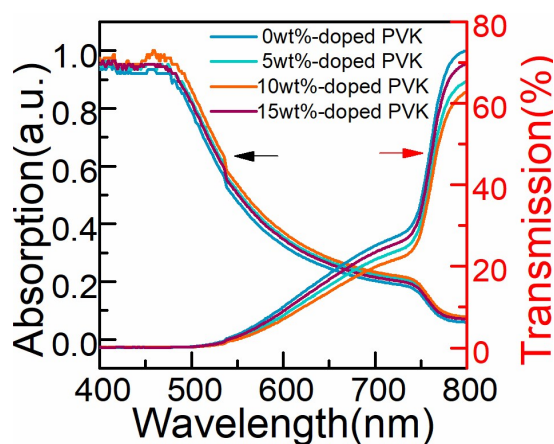
**Figure S2.** Absorption and transmission spectra of cross-linked PVK films with 5wt%, 10wt% and 15wt% F4TCNQ, respectively.



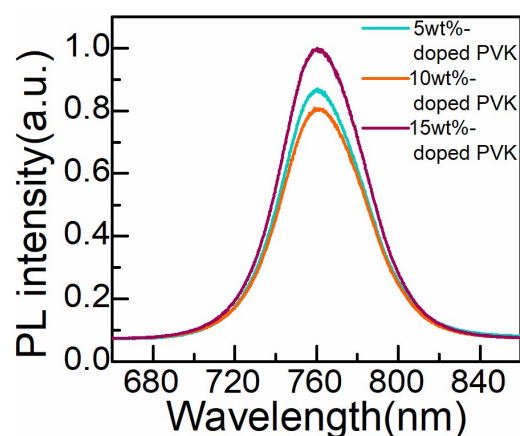
**Figure S3.** Contact angle images of water on (a) 5wt% F4TCNQ-doped PVK, (b) 10wt% F4TCNQ-doped PVK and (c) 15wt% F4TCNQ-doped PVK films.



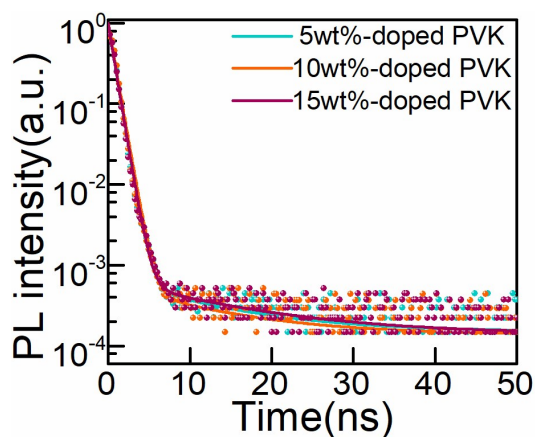
**Figure S4.** Top-view SEM images of perovskite films on (a) 0wt%, (b) 5wt%, (c) 10wt% and (d) 15wt% F4TCNQ-doped PVK layers, respectively.



**Figure S5.** Absorption and transmission spectra of perovskite films based on 0wt%, 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK layers, respectively.



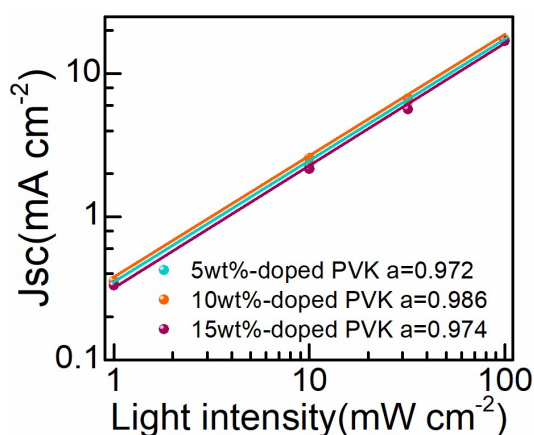
**Figure S6.** Photoluminescence (PL) spectra of perovskite films based on cross-linked PVK HTLs with different F4TCNQ doping concentration of 5wt%, 10wt% and 15wt%, respectively.



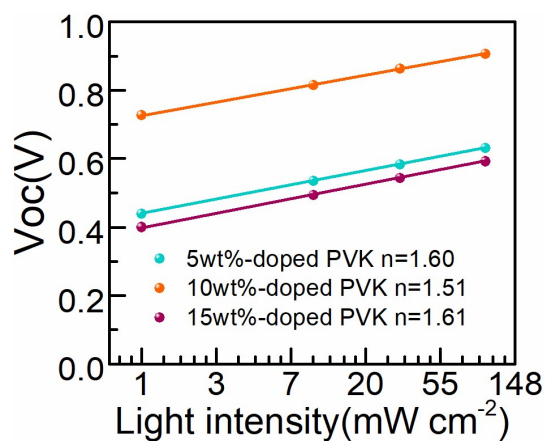
**Figure S7.** Time-resolved PL spectra of perovskite films based on 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK layers, respectively.

**Table S1.** PL decay lifetimes of perovskite films based on 0wt%, 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK layers.

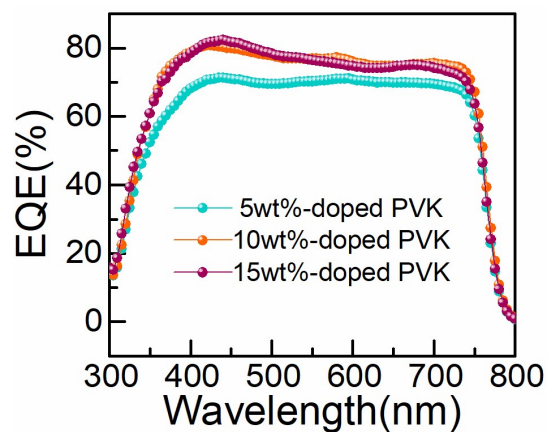
PVK treatment	0wt% F4TCNQ	5wt% F4TCNQ	10wt% F4TCNQ	15wt% F4TCNQ
$\tau_1$ (ns)	21.414	17.464	14.278	21.973
$\tau_2$ (ns)	26.173	21.345	17.452	26.856



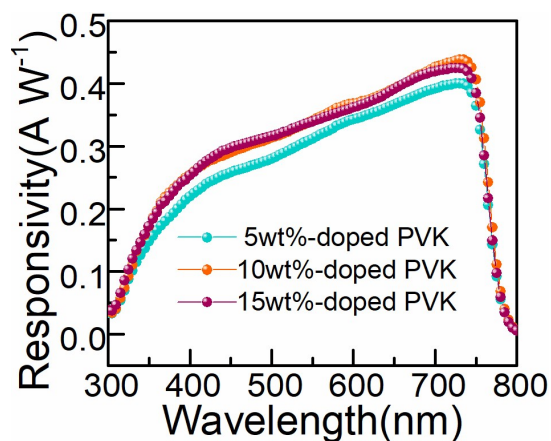
**Figure S8.**  $J_{SC}$  dependence of light intensity curves of perovskite photodetectors on 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK HTLs, respectively.



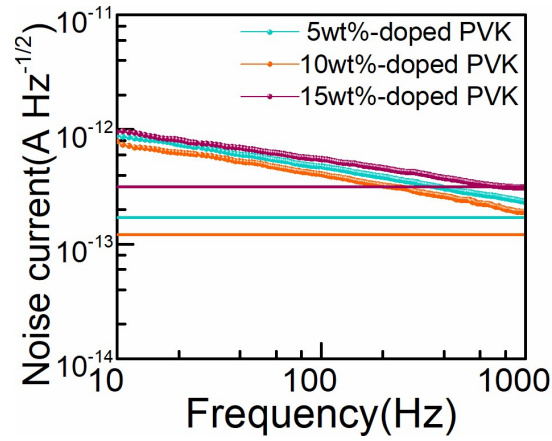
**Figure S9.**  $V_{oc}$  dependence of light intensity curves of perovskite photodetectors used 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK as HTLs, respectively.



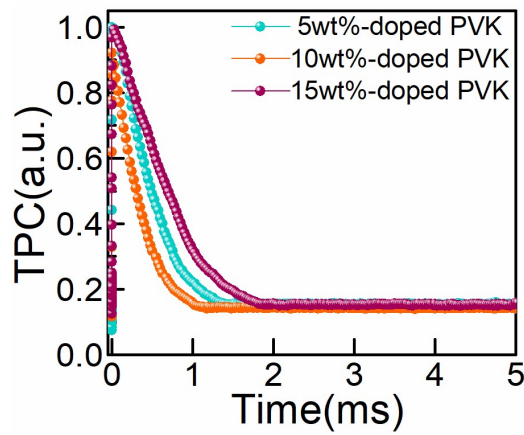
**Figure S10.** EQE spectra of perovskite photodetectors on 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK HTLs, respectively.



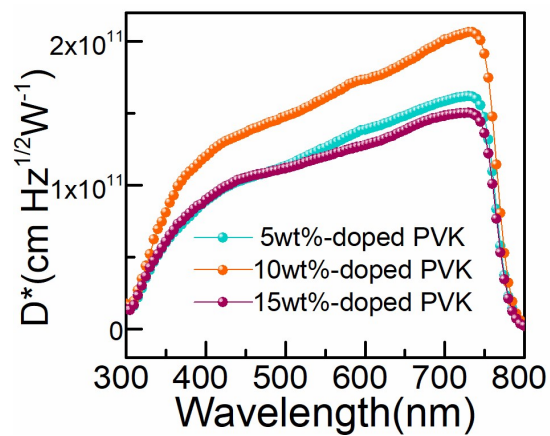
**Figure S11.** Responsivity ( $R$ ) curves of perovskite devices based on 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK HTLs, respectively.



**Figure S12.** Noise current curves of devices used 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK as HTLs, respectively.



**Figure S13.** Transient photocurrent (TPC) curves of perovskite devices with 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK HTLs, respectively.



**Figure S14.** Specific detectivity ( $D^*$ ) curves of perovskite devices with 5wt%, 10wt% and 15wt% F4TCNQ-doped PVK HTLs, respectively.