Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Support information

Rhodamine B dye as an efficiently multifunctional passivation for the improvement of perovskite solar cell performance

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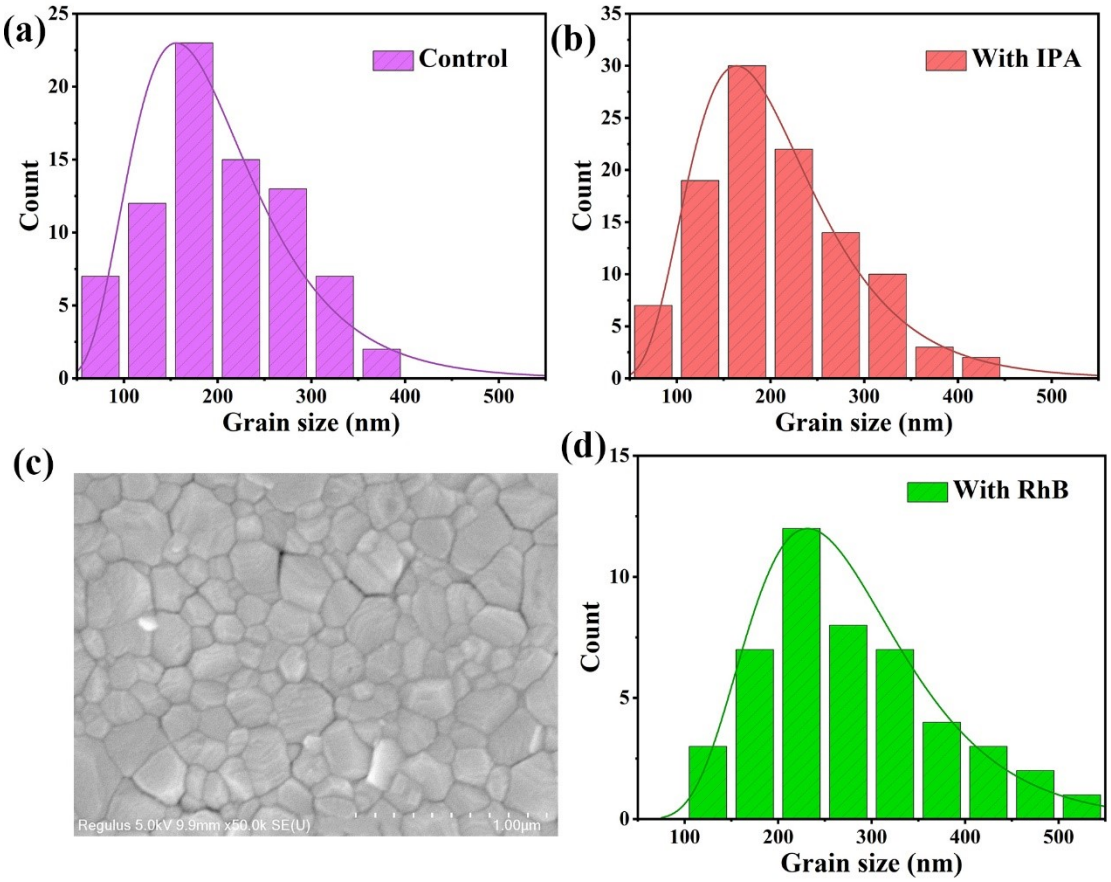

Fig. S1. The distribution histograms of grain sizes of (a) $MAPbI_3$, (b) $MAPbI_3$/IPA and (d) $MAPbI_3$/RhB. (c) The top-view SEM images of $MAPbI_3$/IPA.

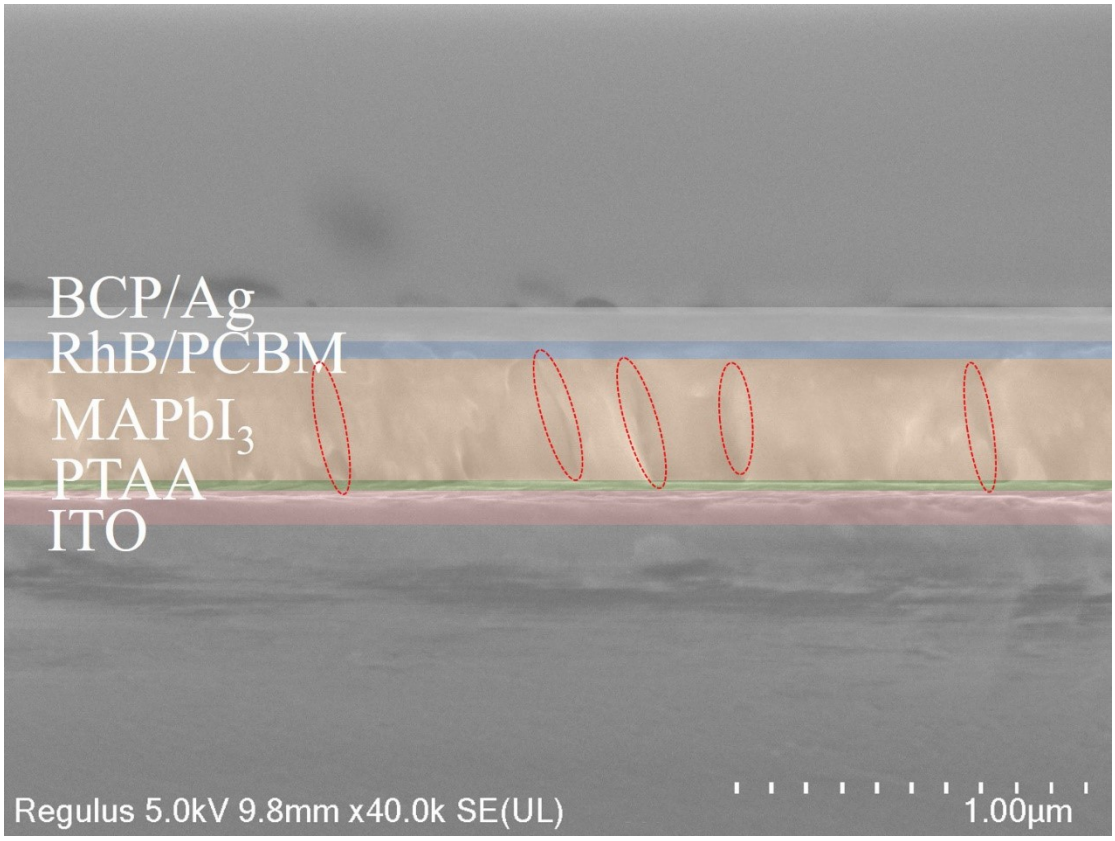

Fig. S2. Cross-sectional SEM images of $MAPbI_3$/RhB films. (Grain boundaries become less and blurred)

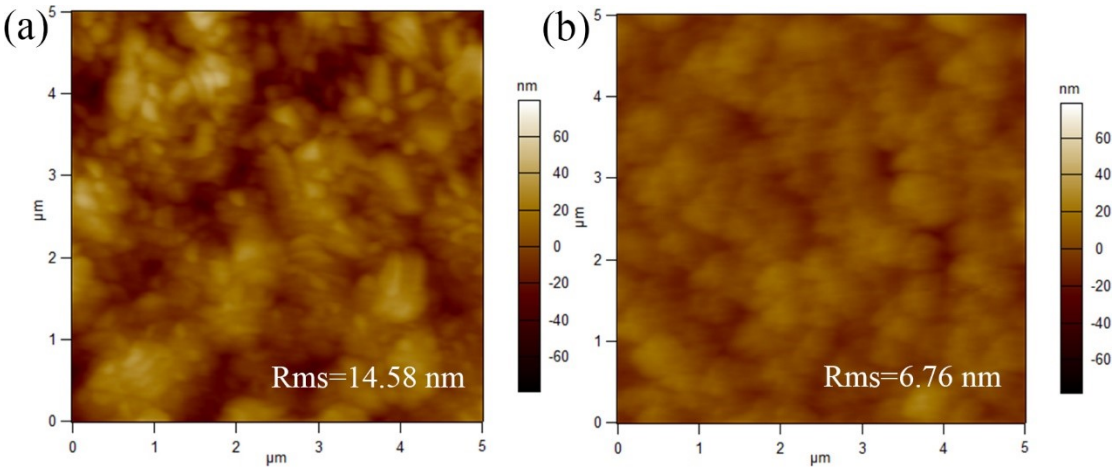

Fig. S3. The AFM images of the films (a) ITO/PTAA/$MAPbI_3$ and (b) ITO/PTAA/$MAPbI_3$/RhB.

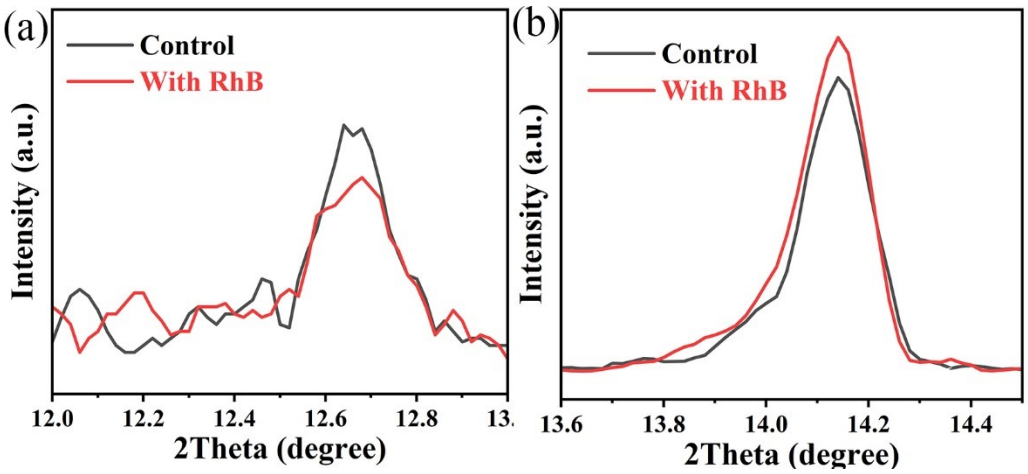

Fig. S4. (a) XRD peak of the PbI_2 at around 12.7°, (b) XRD of 110 planes of different films $MAPbI_3$ and $MAPbI_3$/RhB.

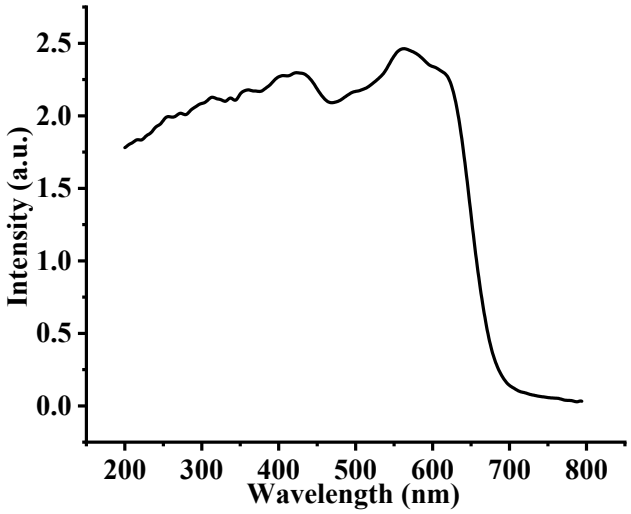

Fig. S5. The absorption spectra of RhB.

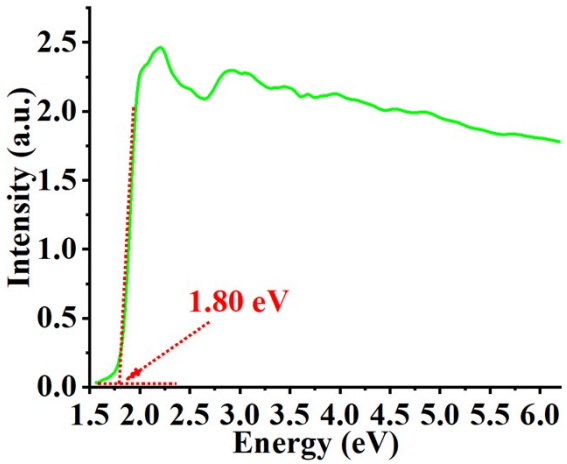

Fig. S6. Optical Bandgap Values of RhB

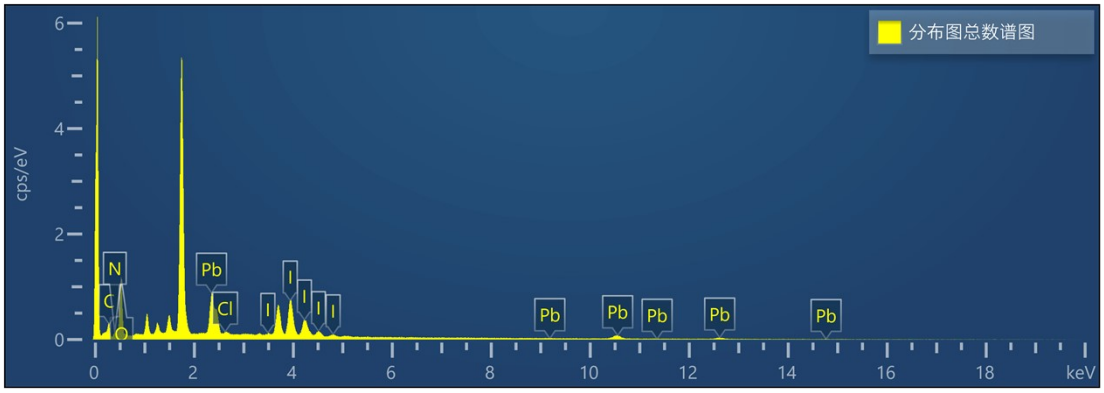

Fig. S7. The SEM−EDX analysis map of $MAPbI_3$/RhB

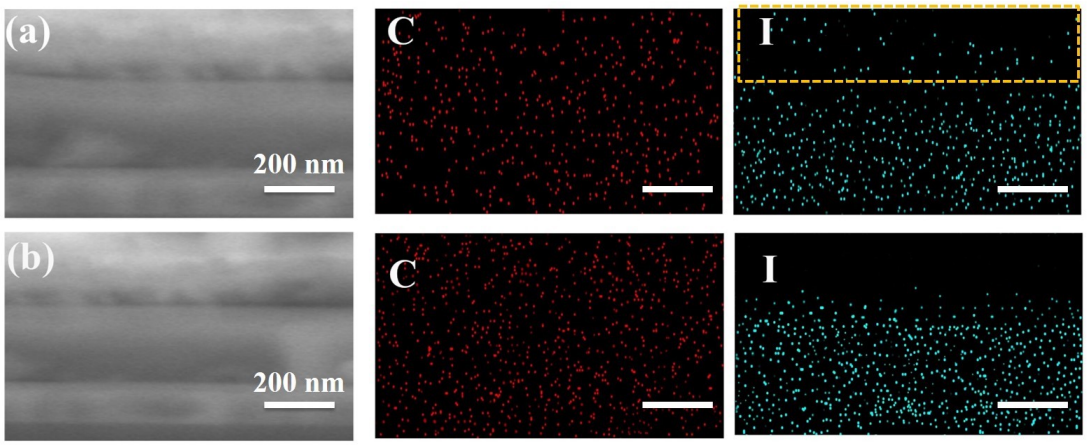

Fig. S8. EDS mapping spectra of C and I element distribution in the cross-section $MAPbI_3$ (a) and $MAPbI_3$/RhB (b) film. EDS mapping spectra of cross-section I elements after aging in air (55±5% RH at room temperature) for 120 h.

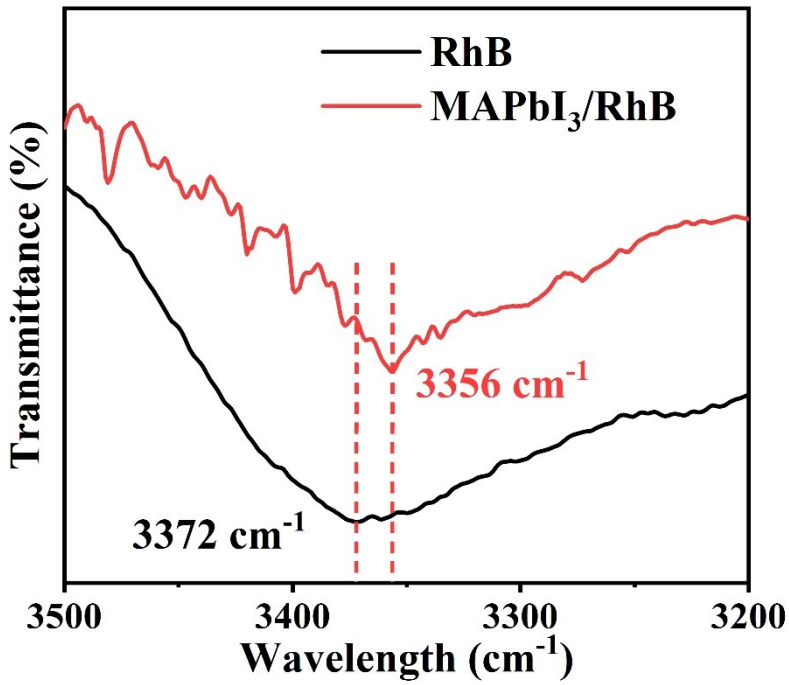

Fig. S9. -OH FTIR spectra of RhB and $MAPbI_3$/RhB

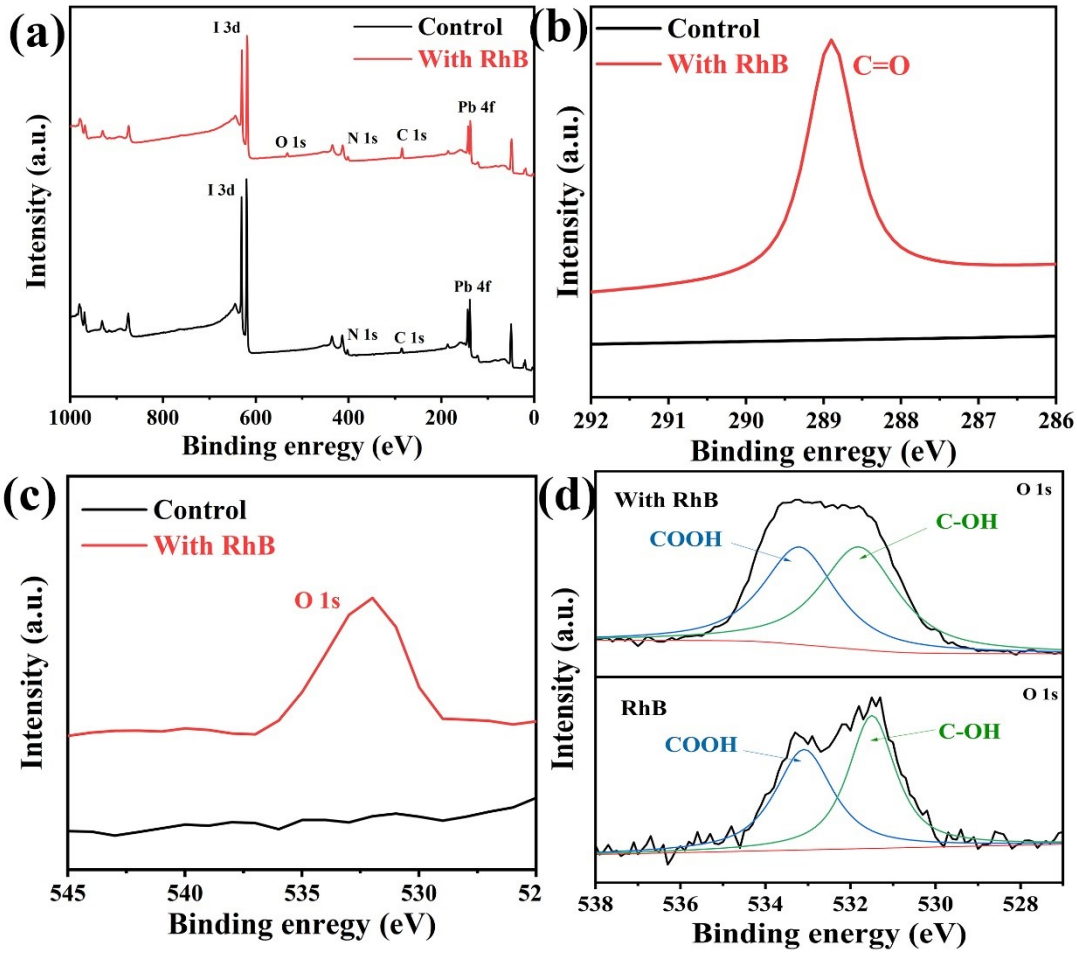

Fig. S10. (a) XPS spectra of $MAPbI_3$ and $MAPbI_3$/RhB films, (b) C=O, (c) O 1s, (d) the O 1s XPS spectra of RhB and $MAPbI_3$/RhB films.

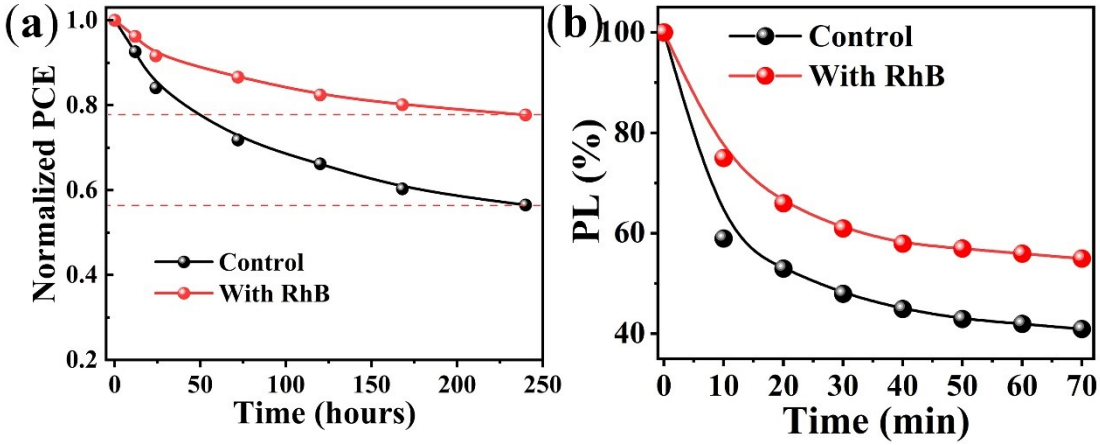

Fig. S11. (a) The stability of unsealed devices when subjected to thermal aging at 85 °C. (b) PL spectra of the $MAPbI_3$ and $MAPbI_3$/RhB film as a function of UV light irradiation time.

Table S1. The HI is calculated based on Equation: HI = ($PCE_{reverse}$ - $PCE_{forward}$)/($PCE_{reverse}$ + $PCE_{forward}$).

Sample	Direction	Voc (V)	Jsc (mA/cm^2)	FF (%)	PCE (%)	HI (%)	Average HI (%)
RhB	Forward	1.100	23.35	78.41	20.18	0.05	0.06
	Reverse	1.100	23.32	78.44	20.16		
	Forward	1.106	22.57	79.22	19.77	0.05	
	Reverse	1.104	22.54	79.55	19.79		
	Forward	1.101	22.30	79.35	19.48	0.07	
	Reverse	1.100	22.26	79.49	19.45		
Control	Forward	1.060	22.05	77.46	18.10	1.37	1.38
	Reverse	1.060	21.78	75.98	17.61		
	Forward	1.050	21.68	76.29	17.31	1.46	
	Reverse	1.040	21.61	74.51	16.81		
	Forward	1.059	21.41	76.15	17.26	1.32	
	Reverse	1.052	21.29	75.12	16.81		

Table S2. Fitting parameters of TRPL spectra of different perovskite films

Sample	**τ_1 (ns)**	**A_1 (%)**	**τ_2 (ns)**	**A_2 (%)**	**T_{ave} (ns)**
$MAPbI_3$	3.03	23.97	11.37	76.03	10.72
MAPbI3/RhB	5.22	20.32	18.96	79.68	18.06
$MAPbI_3$/PCBM	3.83	4.72	1.66	95.28	1.89
MAPbI3/RhB/PCBM	3.20	7.20	1.39	92.80	1.74

Table S3. The EIS parameters of $MAPbI_3$ and $MAPbI_3$/RhB devices, respectively

Sample	**Rs**	**R_{rec} (Ω)**	**CPE1-T**	**CPE1-P**	**R_{dr} (Ω)**	**CPE2-T**	**CPE2-P**
Control	17.3	7456	5.167×10^{-9}	0.96921	29924	1.064×10^{-6}	0.77301
Rhb	10.06	15087	8.555×10^{-9}	0.96751	39650	9.223×10^{-7}	0.75807