

Sustainability development of perovskite solar cells: keeping a balance between toxicity and efficiency

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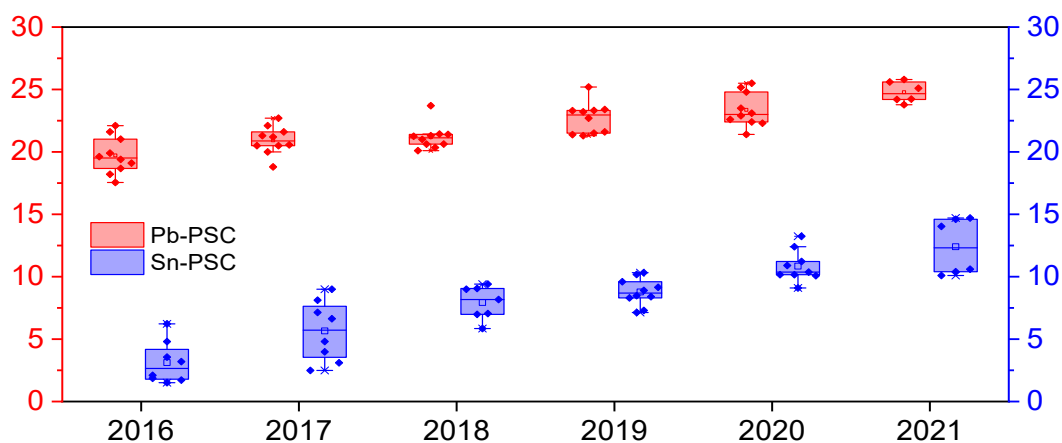


Figure S1 Summary of the state-of-the-art PSC at last six years literatures (Listed as below¹⁻⁶⁴).

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Table S1 Workers Hazard via inhalation route

Workers - Hazard via inhalation route (mg/m³)				
	Systemic effects		Local effects	
DNEL	Long term exposure	Acute/short term exposure	Long term exposure	Acute/short term exposure
DMSO	484		265	
GBL	130	958	no	no
DMAC	23	120	no	no
DMPU	0.411	hazard unknown	no	no
PEG	40.2	no	no	no
ACN	70	102	70	102
IPA/Water	500			
2-ME	0.31	no	no	no
Ethanol	950	no	no	no
NMP	14.4	no	40	
DMF	6	no	no	no

Table S2 Workers Hazard via dermal route and Workers Hazard for the eyes

DNEL	Workers - Hazard via dermal route (mg/kg bw/day)				Workers - Hazard for the eyes
	Systemic effects		Local effects		Local effects
	Long term exposure	Acute/short term exposure	Long term exposure	Acute/short term exposure	
DMSO	200		no-threshold effect and/or no dose-response information available		
GBL	19	no	no	no	high hazard
DMAC	11	42	no	no	low hazard
DMPU	0.233	no DNEL required	no	no	medium hazard
PEG	112	no	no	no	no
ACN	20	no	no	no	low hazard
IPA/Water	888				
2-ME	0.22	no	no	no	no
Ethanol	343	no	no	no	medium hazard
NMP	4.8	no	medium hazard	medium hazard	medium hazard
DMF	1.1	no	no	no	low hazard

Table S3 General Population Hazard via inhalation route

General Population - Hazard via inhalation route (mg/m³)				
	Systemic effects		Local effects	
DNEL	Long term exposure	Acute/short term exposure	Long term exposure	Acute/short term exposure
DMSO	120		47	
GBL				
DMAC	no	no	no	no
DMPU	0.072	hazard unknown*	no	no
PEG	7.14	no	no	no
ACN	2.4	22	no	22
IPA/Water	89			
2-ME	high hazard	no	no	no
Ethanol	114	no	no	no
NMP	3.6	no	4.5	medium hazard
DMF	1.1	no	no	no

Table S4 General Population - Hazard via dermal route

General Population - Hazard via dermal route (mg/kg bw/day)				
	Systemic effects		Local effects	
DNEL	Long term exposure	Acute/short term exposure	Long term exposure	Acute/short term exposure
DMSO	100			
GBL				
DMAC	no	no	no	no
DMPU	0.083	no DNEL required	no	no
PEG	40	no	no	no
ACN	1.2	no	no	no
IPA/Water	319			
2-ME	high hazard	no	no	no
Ethanol	206	no	no	no
NMP	2.4	no	medium hazard	medium hazard
DMF	low hazard	no	no	no

Table S5 General Population Hazard via oral route and General Population Hazard for the eyes

DNEL	General Population - Hazard via oral route (mg/kg bw/day)				General Population - Hazard for the eyes
	Systemic effects		Local effects		Local effects
	Long term exposure	Acute/short term exposure	Long term exposure	Acute/short term exposure	
DMSO	60				
GBL					
DMAC	2	no			no
DMPU	0.042	low hazard			medium hazard
PEG	40	no	no	no	no
ACN	0.4	0.6			low hazard
IPA/Water	26				
2-ME	0.11	no	no	0.025	no
Ethanol	87	no			no
NMP	0.85	no			medium hazard
DMF	0.16	no			low hazard

Table S6 Eco-toxicological Summary(water)

	Freshwater		Marine water	
	PNEC (mg/L)	Assessment factor	PNEC	Assessment factor
DMSO	17	1000	1.7	10000
GBL	0.056	1000	0.006	10000
DMAC	0.5	1000	0.05	10000
DMPU	0.103	1000	0.01	10000
THF				
PEG	273	50	27.3	500
ACN	10	10	1	100
IPA/Water	140.9	1	140.9	1
2-ME	10	50	1	500
Ethanol	0.96	10	0.79	100
NMP	0.25	50	0.025	500
DMF	NO		NO	

Table S7 Eco-toxicological Summary (sediment, soil & secondary poisoning)

	Sediment (freshwater)	Sediment (marine water)	Soil	Secondary poisoning (pred ators)
	PNEC (mg/kg sediment dw)	PNEC (mg/kg sediment dw)	PNEC (mg/kg soil dw)	PNEC (g/kg food)
DMSO	13.4		3.02	0.7
GBL	0.24	0.02	0.015	no potential for bioaccumulation
DMAC	3.25	0.325	0.356	no potential for bioaccumulation
DMPU	0.46	0.046	0.032	no potential for bioaccumulation
THF				
PEG	1030	103	46.4	no potential for bioaccumulation
ACN	40.5	4.05	2.23	no potential for bioaccumulation
IPA/Water	552	552	28	160
2-ME	36.8	3.68	1.87	7.3
Ethanol	3.6	2.9	0.63	0.38
NMP	1.09	0.109	0.07	no potential for bioaccumulation
DMF	111	11.1	NO	no potential for bioaccumulation

Table S8 Ecological and human toxicity data for MAI, FAI, Csl

	MAI	FAI	Csl	Unit
CC	3.81	2.74	2.03	(kg CO ₂ eq)
CED	4.63	1.98	0.541	MJ (megajoules)
HT	2.47	3.62	1.86	(kg 1,4-DCB eq)
HT-Cancer	3.53	3.04	3.35	(*10 ⁻¹⁰ CTU _h)/mol
HT-Non-Cancer	5.72	11.9	5.33	(*10 ⁻¹⁰ CTU _h)/mol
Eco-toxicity	19.7	39.2	20.5	(CTU _e)/mol