Supplementary Information (SI) for Journal of Materials Chemistry A.

A ductile and strong bioplastic film based on biodegradable polyurethane nanoparticle crosslinked chitosan

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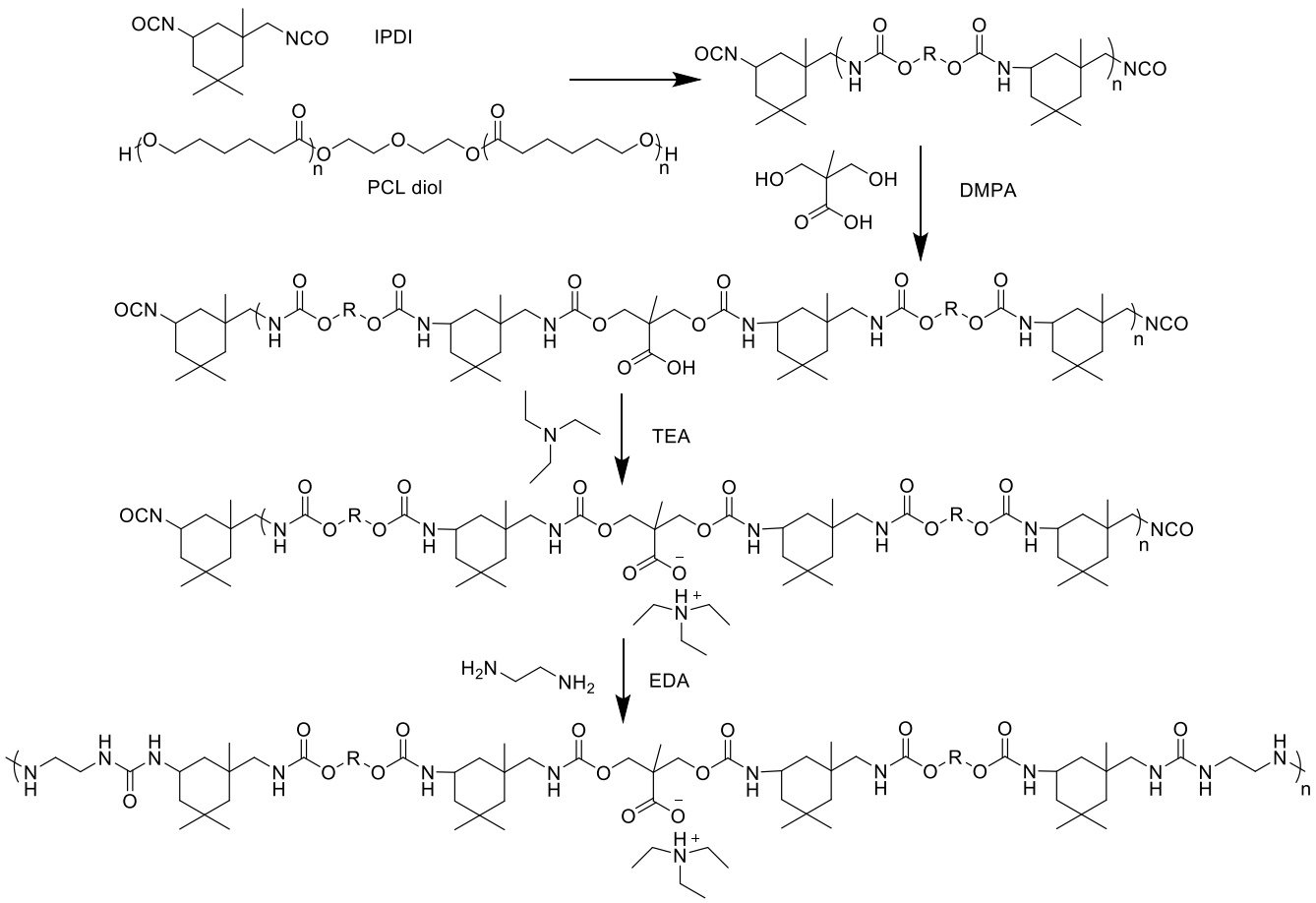

Scheme S1 The synthesis of PU NPs.

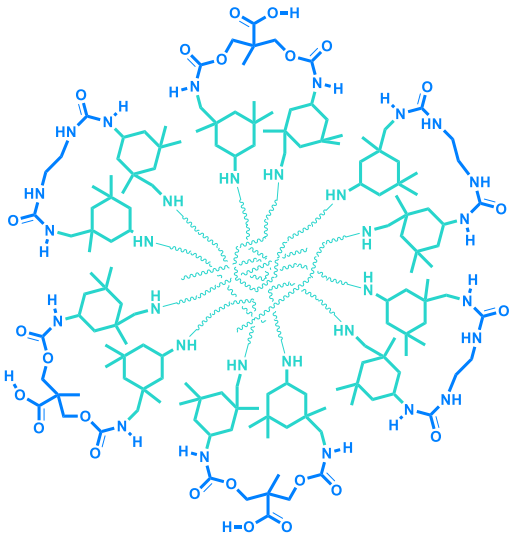

Fig. S1 Molecular formula of the as-fabricated PU NPs and its core-shell structure

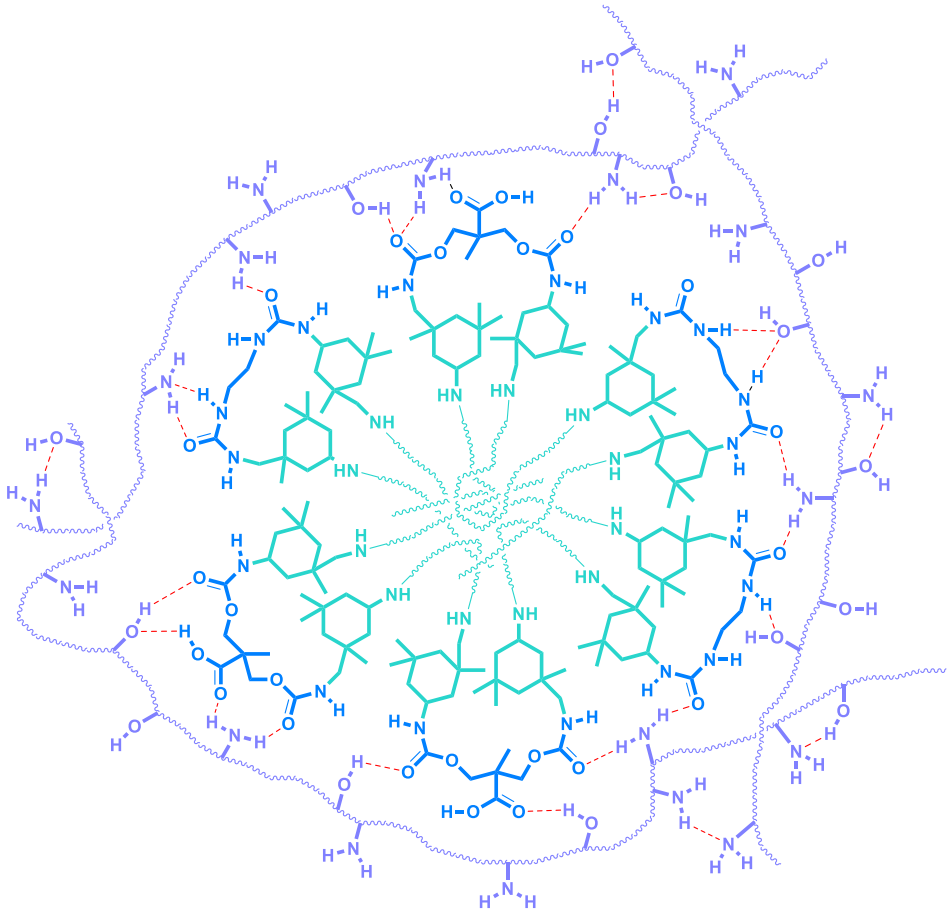

Fig. S2 Schematic representation of the intermolecular multiple hydrogen bonds among chitosan molecules and PU NPs

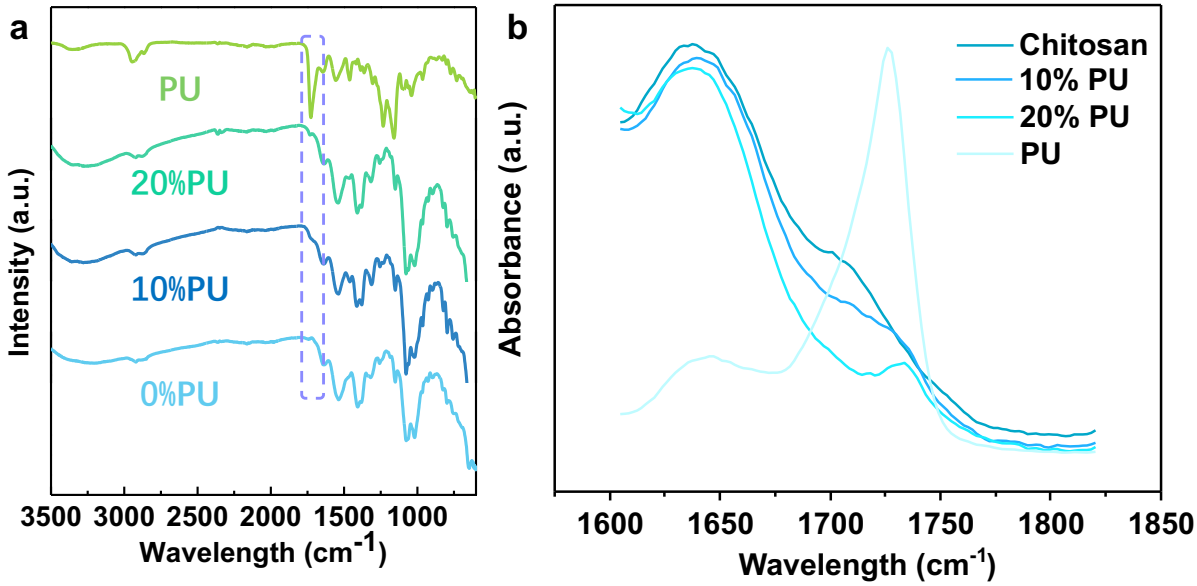

Fig. S3 FTIR spectra of chitosan, PU, and CS/PU films in the wavelength range from a) 650 to 3500 cm^{-1} (b) 1600 to 1800 cm^{-1}.

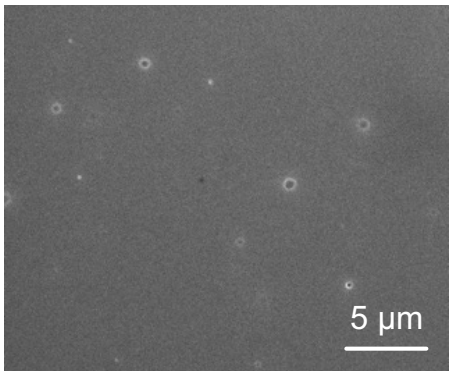

Fig. S4 An SEM image of the as-fabricated chitosan/PU NPs composite film.

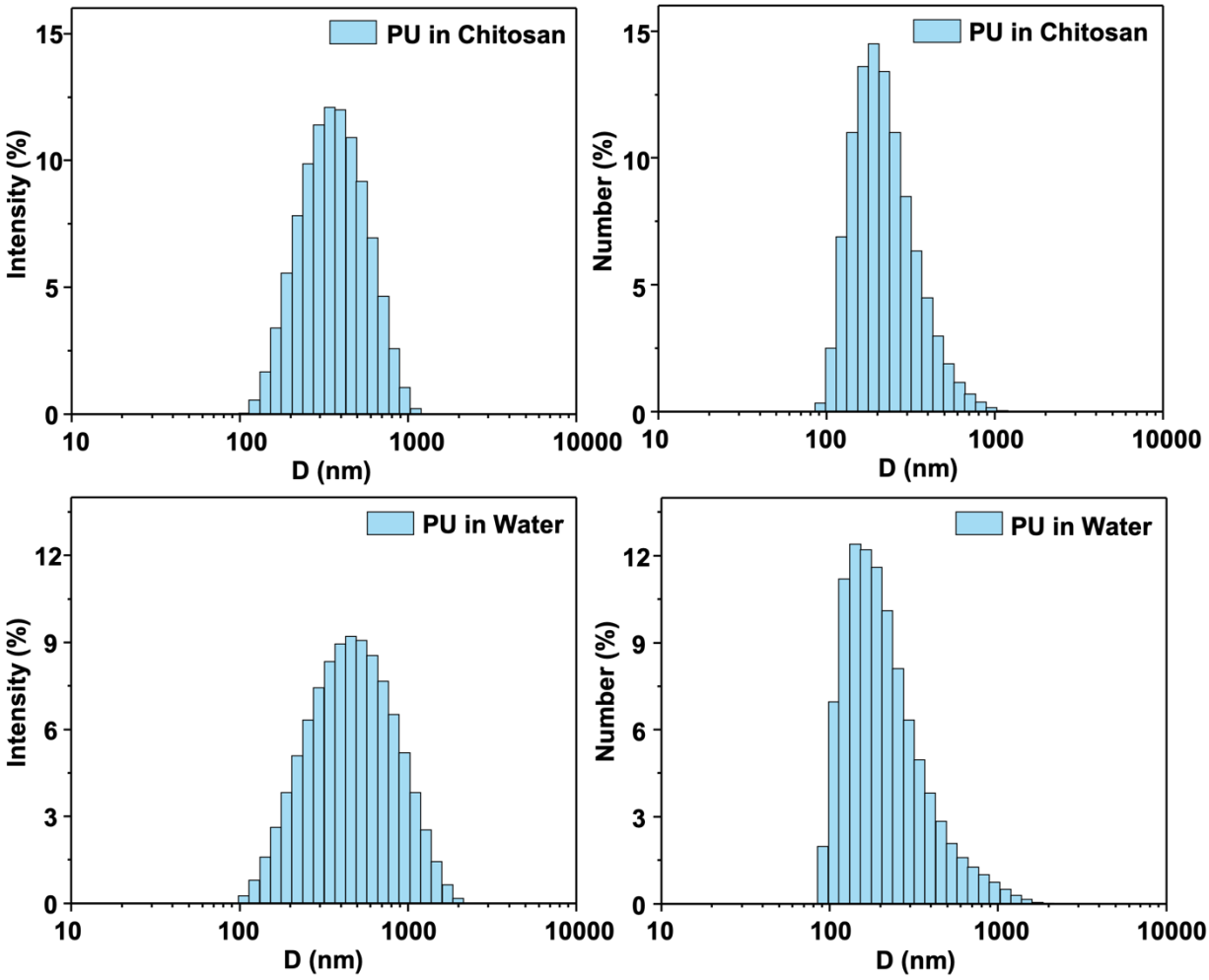

Fig. S5 Intensity-weighted and number-weighted DLS size distribution histogram of PU NPs in chitosan solution and water.

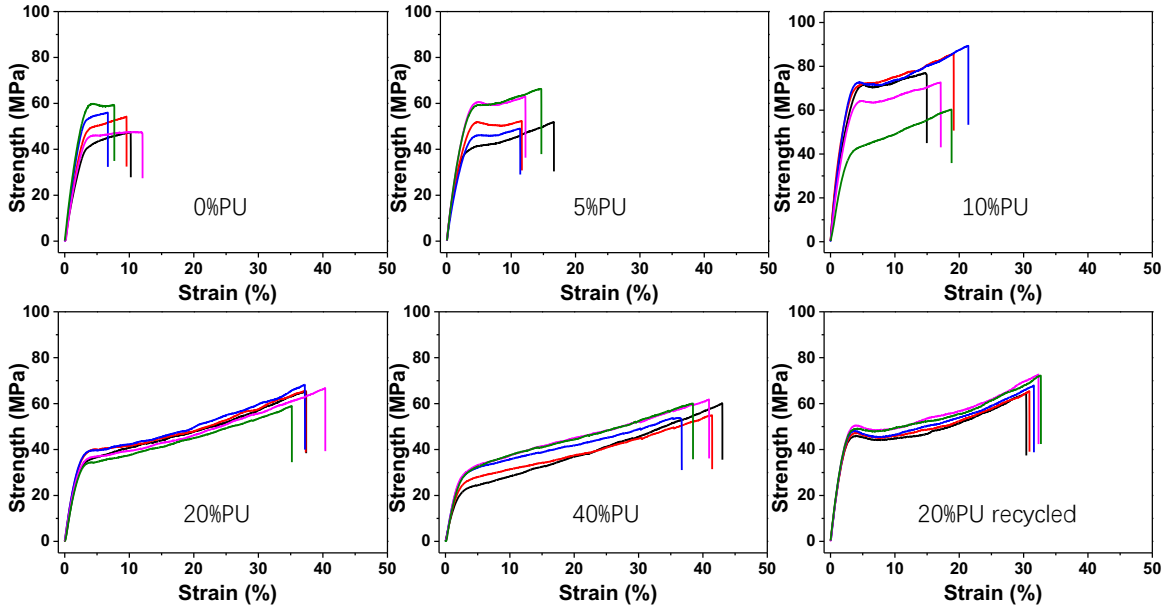

Fig. S6 Stress-strain curves of various composite films.

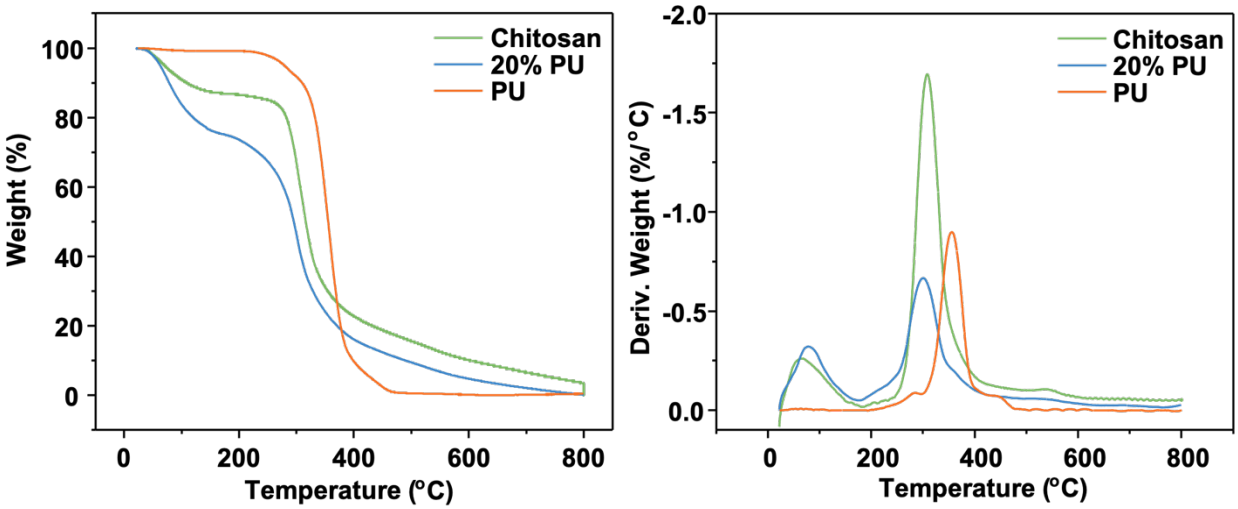

Fig. S7 TGA and DTG analysis of chitosan, PU, and CS/PU films.

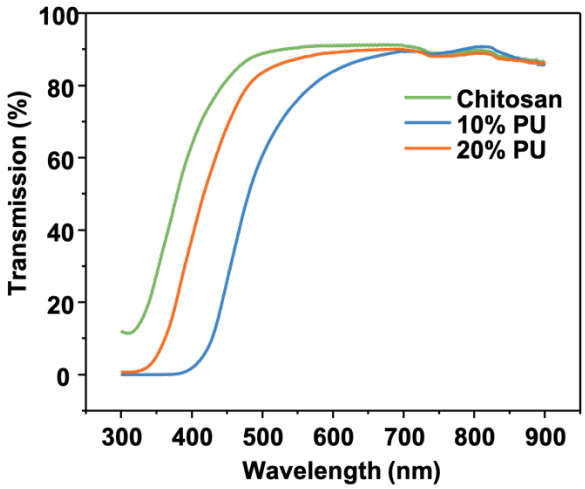

Fig. S8 UV-vis transmittance spectra of chitosan and CS/PU films.

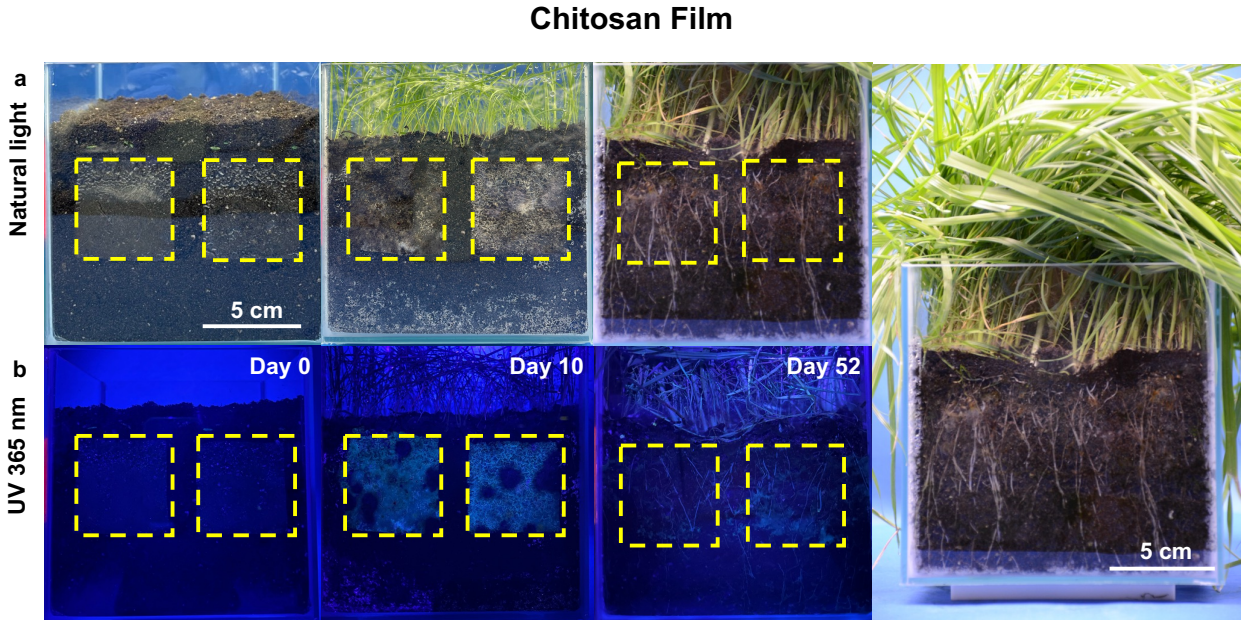

Fig. S9 Grass seed germination and plant growth tests to evaluate the biodegradability and ecotoxicity of the chitosan film.

Table S1 Mechanical properties, processing, and sustainability of various films made of chitosan, synthetic polymers, natural polymers, organic and inorganic nanoparticles.

Materials	Tensile Strength/MPa	Elongation/%	Toughness/ MJ m^{-3}	Processing	Sustainability	Ref
Chitosan/PU NPs	65	37	18	Solvent-free synthesis of NPs	Biocompatible, biodegradable	This work
Pure Chitosan	134	20	24	KOH/urea	Biocompatible, biodegradable	Zhang 2021[1]
Chitosan /PU	5.2	11		Synthesize and mix in DMF	Biocompatible, biodegradable	Saral 2019[2]
Chitosan /PVA	30	115			Incomplete biodegradable	Yu 2018[3]
Chitosan /PEG	24	12			Incomplete biodegradable	Zidan 2023[4]
Chitosan /CNC	63	14			Biocompatible, biodegradable	Corsello 2017[5]
Chitosan /Shellac NPs	40	17		Synthesize NPs in ethanol	Biocompatible, biodegradable	Yi 2021[6]
Chitosan /Bio-NPs	47	48			Biocompatible, biodegradable	Zijuan2022[7]
Chitosan /Mxene-AgNPs	64	12		Hydrofluoric acid treatment	Biotoxity	Nihal 2025[8]
Chitosan /CeNPs	65	5.5			Biotoxity	Shiv 2023[9]
Chitosan /ZnO NPs/Neem Oil	60	15			Biotoxity	Sanuja 2015[10]
Chitosan / TiO2 NPs	46	26			Biotoxity	Zhang 2017[11]
Chitosan /MWCNT	30	25			Biotoxity	Jie 2019[12]

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