Supplementary Information

A biocompatible silver-loaded zeolite hydrocolloid dressing with rapid antimicrobial efficacy

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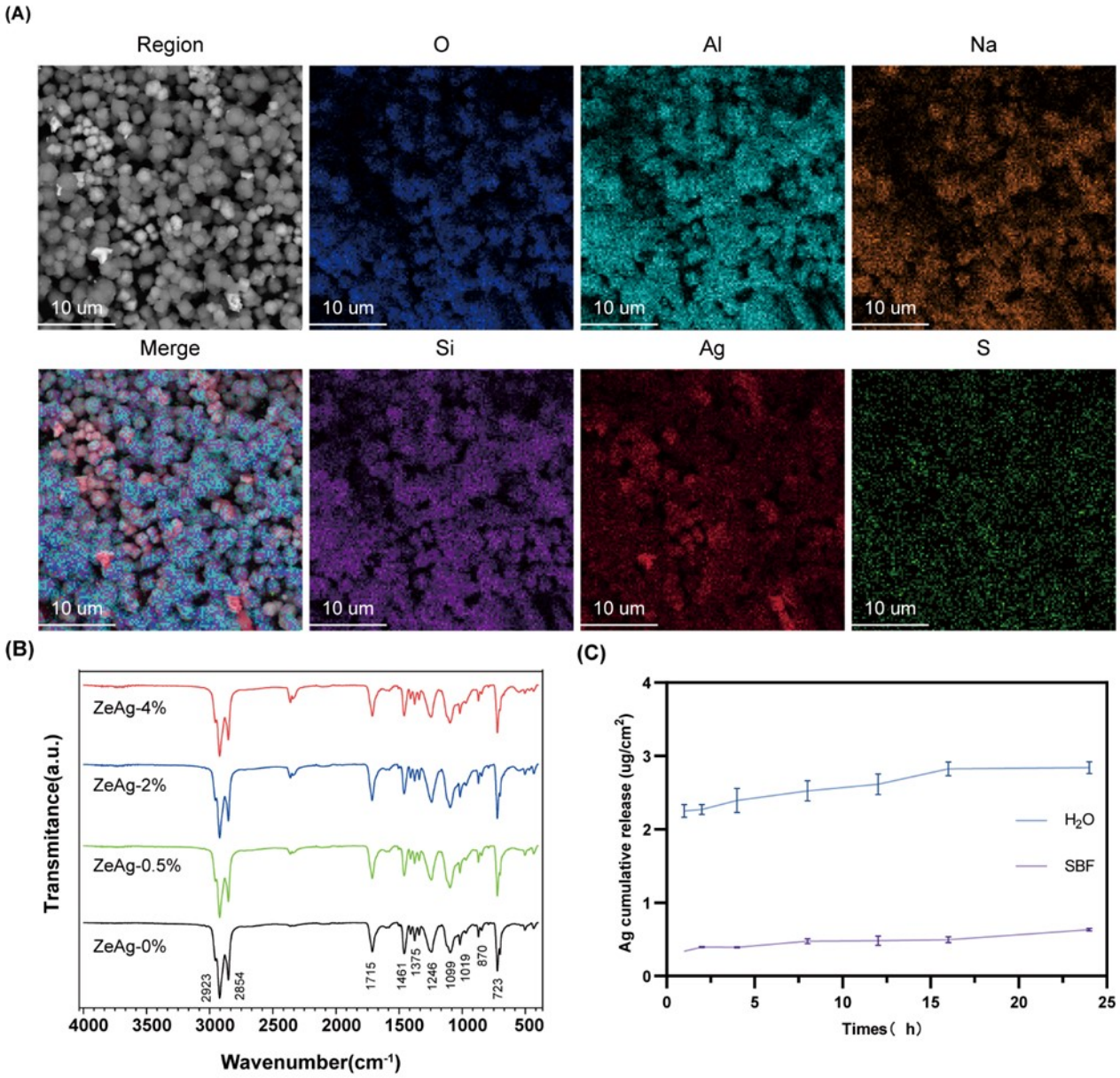

Fig. S1 (A) Phenom-EDS elemental maps of silver-loaded zeolite. (B) FT-IR spectra of silver-loaded zeolite integrated lipid-hydrocolloid dressings; (D) Ag^{+} release profiles of ZeAg-4.0 % dressing in H_2O and SBF.

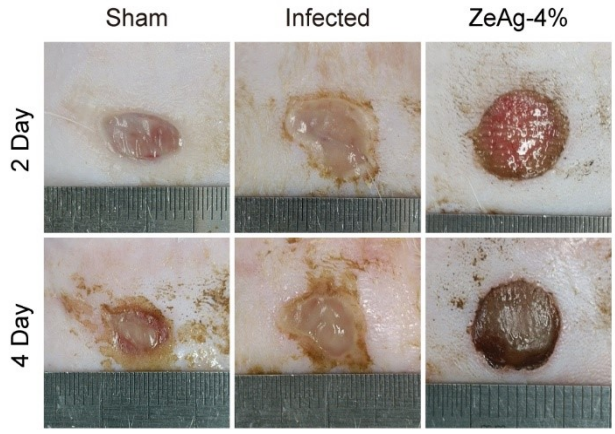

Fig. S2 Representative images of wound morphology in rats.

Table S1 Silver content of ZeAg and dressings.

Sample	ZeAg	ZeAg-2.0%	ZeAg-4.0%	Atrauman®Ag	Urgo®
Silver loading	14.98 ± 0.04%	26±2 ug/cm^2	52±3 ug/cm^2	400±100 ug/cm^2	283±47 ug/cm^2

Note: The ZeAg value represents the silver content (wt%) in the LTA zeolite. Dressing silver loadings are expressed as μg cm^{-2} to permit direct comparison with silver-dressing literature and commercial products.

Table S2 Hematological parameters from the acute systemic toxicity test(n = 3, mean ± SD)

Parameter	Parameter	Control	ZeAg-4%	Unit
WBC count	WBC	3.08±0.55	3.68±0.69	10^9/L
Neutrophil count	Neu#	0.35±0.05	0.29±0.11	10^9/L
Lymphocyte count	Lym#	2.49±0.50	3.08±0.69	10^9/L
Monocyte count	Mon#	0.21±0.03	0.29±0.08	10^9/L
Eosinophil count	Eos#	0.02±0.01	0.01±0.01	10^9/L
Basophil count	Bas#	0.01±0.01	0.00±0.00	10^9/L
Neutrophil percentage	Neu%	11.6±1.5	8.0±3.3	%
Lymphocyte percentage	Lym%	80±2	83±5	%
Monocyte percentage	Mon%	6.8±1.5	8.4±3.6	%
Eosinophil percentage	Eos%	0.9±0.4	0.4±0.3	%
Basophil percentage	Bas%	0.2±0.2	0.2±0.1	%
RBC count	RBC	5.67±0.23	6.05±0.21	10^12/L
Hemoglobin	HGB	135±2	144±2	g/L
Hematocrit	HCT	44.1±2.3	49.9±1.0	%
Mean corpuscular volume	MCV	78.0±6.8	82.6±3.3	fL
Mean corpuscular hemoglobin	MCH	23.9±1.3	23.9±0.9	pg
Mean corpuscular hemoglobin concentration	MCHC	307±11	289±4	g/L
Red-cell distribution width–CV	RDW-CV	15.0±1.0	16.5±0.6	%
Red-cell distribution width–SD	RDW-SD	46.4±6.6	54.3±2.2	fL
Platelet count	PLT	1016±84	1162±68****	10^9/L
Mean platelet volume	MPV	7.4±0.4	7.6±0.7	fL
Platelet distribution width	PDW	16.0±0.4	16.2±0.2	
Plateletcrit	PCT	0.75±0.04	0.845±0.058	%

Note: Data are mean ± SD (n = 3 rats/group, single measurement/rat). Significance vs. control by Student's t-test: *P < 0.05, **P < 0.01, ***P < 0.001, ****P < 0.0001. No symbol indicates not significant.

Table S3 Clinical biochemistry data from the acute systemic toxicity test (n = 3, mean ± SD)

Parameter	Abbreviation	Control	ZeAg-4%	Unit
Alanine Aminotransferase	ALT	56.281±7.238	53.211±6.804	U/L
Aspartate Aminotransferase	AST	167.393±18.640	162.795±31.446	U/L
Total Bilirubin	TBIL	18.422±2.083	17.871±4.084	μmol/L
Total Bilirubin	DBIL	3.171±0.438	3.552±1.527	μmol/L
Albumin	ALB	37.111±0.430	35.299±1.884	g/L
Alkaline Phosphatase	ALP	246.460±48.121	226.866±38.707	U/L
γ-Glutamyl Transferase	γ-GT	0.868±0.405	1.065±0.812	U/L
Total Bile Acids	TBA	27.224±10.473	11.704±5.059	μmol/L
Total Protein	TP	51.452±0.328	49.096±2.584	g/L
Urea	UREA	5.934±1.160	6.492±0.937	mmol/L
Creatinine	CREA	35.970±2.812	44.908±8.340	μmol/L
Uric Acid	UA	47.742±6.854	108.035±54.244**	μmol/L

Note: Data are mean ± SD (n = 3 rats/group, single measurement/rat). Significance vs. control by Student's t-test: *P < 0.05, **P < 0.01, ***P < 0.001, ****P < 0.0001. No symbol indicates not significant.

Table S4 Organ-to-body weight coefficients in the sub-acute systemic toxicity test (n = 3, mean ± SD)

Organs	Male		Female	
	control	ZeAg-4%	control	ZeAg-4%
Heart	0.334±0.011	0.263±0.004	0.328±0.014	0.317±0.021
Liver	3.630±0.331	3.465±0.274	4.245±0.153	3.703±0.335****
S*p*leen	0.166±0.028	0.167±0.005	0.205±0.009	0.197±0.011
Lung	0.306±0.011	0.301±0.017	0.397±0.019	0.368±0.026
Kidney	0.638±0.050	0.531±0.095	0.665±0.026	0.609±0.054
Thymus	0.116±0.017	0.146±0.009	0.210±0.044	0.224±0.042
Adrenal gland	0.011±0.004	0.013±0.004	0.026±0.003	0.024±0.003
Brain	0.300±0.047	0.350±0.020	0.534±0.029	0.541±0.020
Testis/Ovary	0.494±0.096	0.524±0.009	0.041±0.006	0.045±0.005
Epididymides/ Uterus	0.086±0.007	0.108±0.006	0.237±0.083	0.152±0.073

Note: Data are mean ± SD (n = 3 rats/group, single measurement/rat). Significance vs. same-sex control by unpaired t-test: *P < 0.05, **P < 0.01, ***P < 0.001, ****P < 0.0001. No symbol indicates not significant.

Table S5 Hematological parameters from the sub-acute systemic toxicity test (n = 3, mean ± SD)

Parameter	Male		Female		Unit
	Control	ZeAg-4%	Control	ZeAg-4%	
WBC	6.67±0.63	2.8±0.7	1.19±0.56	3.23±2.18	10^9/L
Neu#	0.58±0.10	0.27±0.05	0.17±0.07	0.45±0.24	10^9/L
Lym#	5.79±0.71	2.26±0.60	0.93±0.52	2.58±1.85	10^9/L
Mon#	0.26±0.03	0.22±0.05	0.09±0.01	0.17±0.09	10^9/L
Eos#	0.05±0.02	0.02±0.01	0.00±0.00	0.03±0.01	10^9/L
Bas#	0±0	0±0	0±0	0±0	10^9/L
Neu%	8.8±2.1	10.3±2.7	14.5±3.9	17.2±5.9	%
Lym%	86.6±2.4	80.8±2.7	74.3±7.6	74.5±8.9	%
Mon%	3.9±0.7	8.0±0.1	9.9±6.7	6.5±1.9	%
Eos%	0.7±0.2	0.8±0.2	1.1±0.3	1.8±1.1	%
Bas%	0±0	0.03±0.05	0.2±0.2	0.0±0.0	%
RBC	6.60±0.27	6.19±0.21	6.25±0.17	6.15±0.30	10^12/L
HGB	144±7	137±4	138±4	139±9	g/L
HCT	44.4±1.7	42.2±1.2	44.0±2.0	43.3±2.6	%
MCV	67.2±0.9	68.3±0.6	70.4±2.6	70.5±1.4	fL
MCH	21.8±0.2	22.1±0.7	22.1±0.5	22.5±0.3	pg
MCHC	324±3	324±7	315±6	319±4	g/L
RDW-CV	14.8±0.6	14.7±0.5	13.5±0.7	14.5±0.5	%
RDW-SD	38.9±1.8	39.5±1.0	37.6±3.5	40.3±2.2	fL
PLT	874±69	908±33	838±29	973±50****	10^9/L
MPV	7.0±0.2	7.3±0.5	7.70±0.36	7.20±0.24	fL
PDW	15.7±0.0	15.7±0.2	16.0±0.3	15.7±0.2	

Note: Data are mean ± SD (n = 3 rats/group, single measurement/rat). Significance vs. same-sex control by unpaired t-test: *P < 0.05, **P < 0.01, ***P < 0.001, ****P < 0.0001. No symbol indicates not significant.

Table S6 Clinical biochemistry data from the sub-acute systemic toxicity test (n = 3, mean ± SD)

Parameter	Male		Female		Unit
	Control	ZeAg-4%	Control	ZeAg-4%	
ALT	53.505±1.146	53.232±6.130	54.122±1.309	52.940±10.876	U/L
AST	128.839±10.519	175.474±35.209	108.570±5.548	101.869±16.918	U/L
TBIL	9.595±0.469	8.781±0.406	23.790±11.349	13.422±2.724	μmol/L
DBIL	4.699±0.433	4.615±0.400	11.571±6.263	7.164±1.275	μmol/L
ALB	38.306±0.920	38.035±1.229	43.174±1.769	43.789±1.529	g/L
ALP	301.179±36.571	232.864±61.226**	156.465±16.910	168.457±37.874	U/L
γ-GT	0.906±0.012	0.885±0.010	1.639±0.441	0.889±0.510	U/L
TBA	12.263±4.495	37.761±33.132	5.198±0.965	15.523±4.901	μmol/L
TP	55.754±1.732	53.681±3.190	59.064±3.807	60.080±2.503	g/L
UREA	19.190±1.702	18.067±0.682	14.291±1.493	11.596±0.493	mmol/L
CREA	39.381±3.787	37.117±1.141	46.287±4.519	44.554±0.543	μmol/L
UA	87.758±14.827	83.971±8.916	65.536±16.860	85.746±11.393	μmol/L

Note: Data are mean ± SD (n = 3 rats/group, single measurement/rat). Significance vs. same-sex control by unpaired t-test: *P < 0.05, **P < 0.01, ***P < 0.001, ****P < 0.0001. No symbol indicates not significant.

Table S7 ZeAg-4% vs. Representative Commercial Silver Dressings: Performance Comparison

Dressing / benchmark	Silver form / matrix	Ag loading	Evidence advantage / limitation	Best use in our argument
ZeAg-4%	Ag-exchanged LTA zeolite in lipid-hydrocolloid	52 ± 3 μg cm^{-2}	Direct data: inhibition zone, kill kinetics, Ag-release/killing correlation, biofilm, infected wound, cytocompatibility, irritation, sensitization, systemic toxicity	Low-silver loading + complete evidence chain
Promogran Prisma™	collagen/ORC + silver-ORC	20 μg cm^{-2}	Low-silver commercial benchmark; reported biofilm effects vary by model	Shows we acknowledge reviewer-recommended comparator
Aquacel Ag+ Extra™	Hydrofiber + Ag+ technology	0.17 mg cm^{-2} = 170 μg cm^{-2}	Commercial biofilm-targeting benchmark; contains additional biofilm-disrupting agents	Shows ZeAg-4% is lower silver than this benchmark
Urgo®	SSD lipid-hydrogel	283 ± 47 μg cm^{-2}	Direct comparator; comparable inhibition-zone activity, but higher silver loading	Shows ZeAg-4% improves apparent silver-utilization efficiency
Atrauman® Ag	Ag-containing ointment gauze	400 ± 100 μg cm^{-2}	Direct comparator; good cytocompatibility but much higher silver loading	Shows ZeAg-4% achieves antibacterial activity at lower silver
Acticoat™	nanocrystalline silver	1.70 mg cm^{-2} = 1700 μg cm^{-2}	High-silver rapid-kill benchmark	Shows ZeAg-4% avoids high-silver design