SUPPORTING INFORMATION

One-step aqueous route to prepare polyacrylonitrile-based hydrogel with excellent ionic conductivity and extreme low-temperature tolerance

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Table S1. The composition of different AAH.

Hydrogels	AN (g)	AMPS (g)	MBAA (g)	$ZnCl_2$ (g)	H_2O (g)	APS (g)	TEMD (μL)	Gel	Water content [a)] (%)
AAH-90-0	1.8	0.2	0	10.0	8.0	0.02	16	No	—
AAH-90-0.2	1.8	0.2	0.004	10.0	8.0	0.02	16	Yes	36.02±0.19
AAH-90-0.4	1.8	0.2	0.008	10.0	8.0	0.02	16	Yes	35.29±0.11
AAH-90-0.6	1.8	0.2	0.012	10.0	8.0	0.02	16	Yes	35.00±0.25
AAH-90-0.8	1.8	0.2	0.016	10.0	8.0	0.02	16	Yes	35.20±0.33
AAH-60-0.4	1.2	0.8	0.008	10.0	8.0	0.02	16	Yes	42.17±0.85
AAH-70-0.4	1.4	0.6	0.008	10.0	8.0	0.02	16	Yes	41.85±0.46
AAH-80-0.4	1.6	0.4	0.008	10.0	8.0	0.02	16	Yes	39.77±1.31

[a)] The water content (wt%) is defined as the mass ratio of the weight of water in the hydrogels to the total weight of the hydrogels.

Table S2. Summary of anti-freezing hydrogels.

References	Anti-freezing components	Conductive agents	Temperature tolerance /°C	Conductivity at low temperature / (S m^{-1})
This work	$ZnCl_2$	$ZnCl_2$	-50	1.16
14	Glycerol	Polyaniline	-20	0.32
17	Na^+	Sodium polyacrylate	-35	0.1
21	$CaCl_2$	$CaCl_2$	-57	≈0.30
23	EG [a)]	MXene[b)]	-40	≈0.002
25	Glycerol	MAANa[c)] & DMC [d)]	-20	1.00
26	EG+ glycerol	KCl	-18	Not mentioned
27	EG	LiCl	-40	≈0.2
28	Glycerol	$ZnSO_4$+$MnSO_4$	-20	1.45
29	EG	H_2SO_4	-40	0.45
30	EG	PEDOT: PSS [e)]	-40	≈0.0015
31	Glycerol, glycol, Sorbitol	N/A	-70 to -45	N/A
32	EG	LiCl	-20	0.071
43	EG	H_2SO_4	-40	0.48

[a)] Ethylene glycol; [b)] transition-metal carbide and carbonitride; [c)] Sodium methacrylate;

[d)][2-(methacryloyloxy)-ethyl] trimethyl ammonium chloride; [e)]Poly(3,4-ethylenedioxythiophene):polystyrene sulfonate.

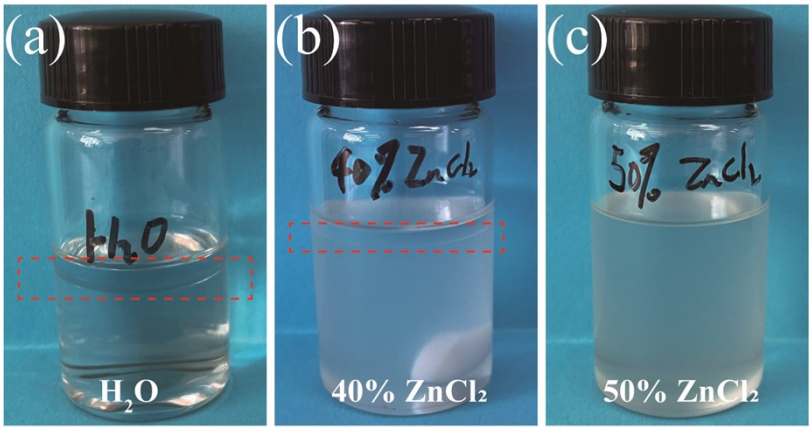

Figure S1. The dissolution ability of AN in pure water (a), 40 wt% (b) and 50 wt% (c) $ZnCl_2$ aqueous solutions.

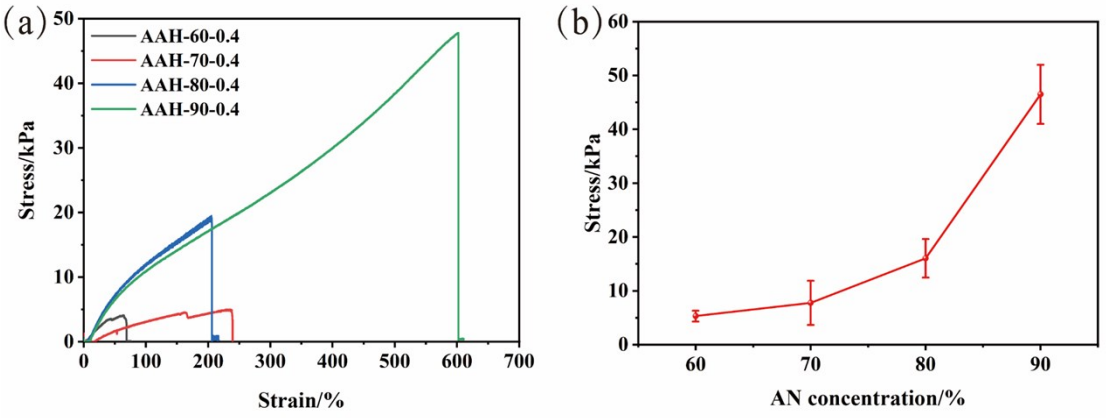

Figure S2. The tensile stress-strain curves (a) and the corresponding tensile stress (b) of the AAH with different AN concentration.

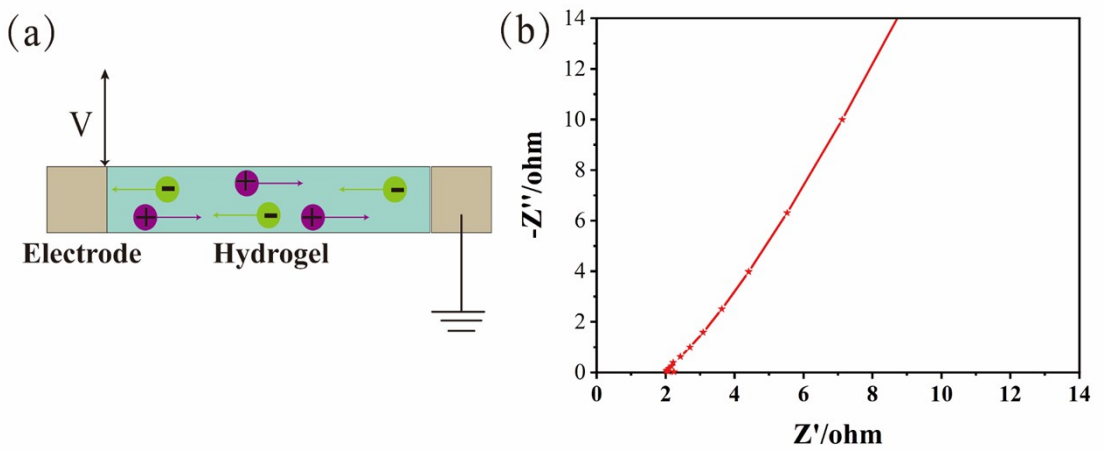

Figure S3. (a) Schematic illustration of conductivity of the AAH via ionic migration.

(b)The Nyquist plot of the AAH-90-0.4 at room temperature.

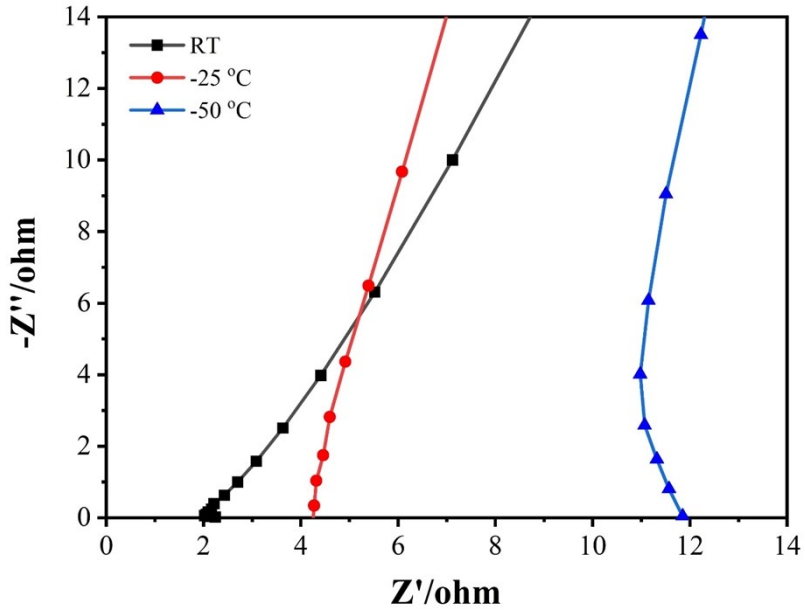

Figure S4. The Nyquist plot of the AAH at different temperatures.