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1. General and Materials (Supplementary Fig. 1)

A superconducting magnet JASTEC model JMTD-10T100 with a vertical bore of 100 mm was used for magnetic orientation of unilamellar metal oxide nanosheets. Photoinduced radical polymerization was conducted by using an USHIO model OPM2-502H high-pressure mercury arc lamp (500 W). Magnetization measurements were performed on a Quantum Design model MPMS-XL7S SQUID magnetometer. Transmittance spectra and polarized electronic absorption spectra were recorded on a JASCO model V-570 UV/VIS/NIR spectrophotometer. Zeta potentials were measured by using a Malvern model Zetasizer Nano ZSP zeta potential analyzer. Unless otherwise noted, all reagents were used as received from Tokyo Chemical Industry (TCI) [poly(vinyl alcohol) (PVA), degree of polymerization = 1750 ± 50], Kojin (N,N-dimethylacrylamide), and Aldrich Chemical [N,N’-methylenebis(acrylamide)]. Unilamellar metal oxide nanosheets of titanate(IV) (TiNS)\textsuperscript{31} and niobate(V) (NbNS)\textsuperscript{32} (Supplementary Fig. 1) were prepared according to literature methods.

![Supplementary Fig. 1](image)

**Supplementary Fig. 1 | Schematic structures of unilamellar metal oxide nanosheets.** a, b, Unilamellar nanosheets of titanate (TiNS) (a) and niobate (NbNS) (b). The nanosheets are negatively charged having tetramethylammonium (Me\textsubscript{4}N\textsuperscript{+}) counterions.

2. Method for Optical Transmission Spectroscopy

**Sample Preparation:** A quartz optical cell (10 mm × 10 mm), containing an aqueous dispersion of TiNSs (0.4 wt%) in the presence of N,N-dimethylacrylamide (8.0 wt%), was exposed at...
25 °C to a 500-W high-pressure mercury arc light, whereupon radical polymerization of \( \text{N,N-dimethylacrylamide} \), initiated by in-situ generated hydroxyl radicals\(^{11,33} \), proceeded nearly quantitatively in 30 minutes to afford poly(\( \text{N,N-dimethylacrylamide} \)), which served as a thickener for minimizing possible relaxation of oriented TiNSs upon transferring the sample from the bore of a magnet to a spectrometer. Likewise, an aqueous dispersion of NbNSs (0.4 wt\%) was prepared.

**Optical Transmittance Measurements:** A viscous dispersion of TiNSs, thus prepared in a quartz optical cell, was transferred to the bore of a superconducting magnet (10 T) and allowed to stand at 25 °C for 20 minutes in such a way that a side face of the optical cell was directed orthogonal to the magnetic flux. Then, the sample was quickly but carefully transferred from the magnet to an electronic absorption spectrometer for evaluating its optical transmittances in different directions at 25 °C. For investigating the switching effect of the magnetic flux direction, the sample was transferred back to the magnet bore and allowed to stand at 25 °C for 20 minutes in a magnetic flux orthogonal to that previously applied, and then subjected to optical transmission spectroscopy at 25 °C.

### 3. Method for Polarized Electronic Absorption Spectroscopy

A quartz optical cell (10 mm × 10 mm) containing an aqueous dispersion of TiNSs (5 \( \times 10^{-4} \) wt\%) in the presence of PVA (7.0 wt\%) as a thickener (advantage: wide absorption window) was placed in the bore of a superconducting magnet (10 T) in such a way that a side face of the cell was directed orthogonal to the applied magnetic flux and allowed to stand at 25 °C for 20 minutes. Then, the sample was transferred quickly but carefully to an electronic absorption spectrometer equipped with a polarizer for obtaining its polarized absorption spectrum at 25 °C.

### 4. Method for Preparation of Hydrogels Containing Metal Oxide Nanosheets

Typically, an aqueous dispersion of TiNSs (0.3 wt\%) in a rectangular-shaped glass cuvette, containing a mixture of \( \text{N,N-dimethylacrylamide} \) (8.0 wt\%) as a monomer and \( \text{N,N'-methylenebis(acrylamide)} \) (8.0 \( \times 10^{-2} \) wt\%) as a crosslinker, was placed in the bore of a superconducting magnet (10 T) in such a way that a side face of the cuvette was directed orthogonal to the magnetic flux and allowed to stand at 25 °C for 20 minutes. Then, the sample was exposed to a 500-W high-pressure mercury arc light in the magnetic flux, whereupon crosslinking radical polymerization, initiated by in-situ generated hydroxyl radicals\(^{11,33} \), proceeded almost quantitatively in 30 minutes, affording a self-standing hydrogel. Likewise, hydrogels containing TiNS (0.1, 0.6, etc.) were prepared.
0.8, and 1.0 wt%), NbNS (0.4 wt%), TiNS (0.8 wt%)/Me₄NOH ([Me₄N⁺] = 76, 100 and 124 mM) and TiNS (0.8 wt%)/ethylene glycol (50 vol%) were prepared.

5. Method for Preparation of Hydrogels Free of Metal Oxide Nanosheets

An aqueous mixture of \(N,\text{N}\)-dimethylacrylamide (8.0 wt%) as a monomer, \(N,\text{N}'\)-methylenebis(acrylamide) (8.0 × 10⁻² wt%) as a crosslinker and 2,2-diethoxyacetophenone (0.1 wt%) as an organic initiator in a rectangular-shaped glass cuvette was exposed at 25 °C for 20 minutes to a 500-W high-pressure mercury arc light, affording a hydrogel.


Small-angle X-ray scattering (SAXS) was carried out at BL45XU in SPring-8 (Hyogo, Japan) with a Rigaku imaging plate area detector model R-AXIS IV++. Scattering vector \( q = 4\pi\sin\theta/\lambda; 2\theta \) and \( \lambda \) = scattering angle and wavelength of an incident X-ray beam [0.90 Å], respectively) and position of an incident X-ray beam on the detector were calibrated using several orders of layer reflections from silver behenate (\( d = 58.380 \) Å). The sample-to-detector distance was 2.5 m, where recorded scattering/diffraction images were integrated along the Debye-Scherrer ring using Rigaku model R-AXIS Display software, affording a one-dimensional scattering profile. A hydrogel sample was sliced into films with a thickness of ~1 mm just before the SAXS measurements.

7. Method for Rheological Tests

Rheological tests of hydrogels were carried out at 25 °C by using an Anton Paar model MCR-301 rheometer. Storage moduli (\( G' \)) and loss moduli (\( G'' \)) were measured on frequency (\( \omega \)) sweep in a range of 0.1–7.5 rad s⁻¹ at a constant strain (\( \gamma \)) of 0.5% and on \( \gamma \) sweep in a range of 0.1–6.3% at a constant \( \omega \) of 6.28 rad s⁻¹. For the measurement of \( G' \) values, cube-shaped (10 mm × 10 mm × 10 mm) hydrogel samples were set under a 10-mm diameter parallel plate with a gap of 9 mm. For the measurement of \( G'' \) values, cylinder-shaped (25-mm diameter × 25-mm height) hydrogel samples were set under a 25-mm diameter parallel plate with a gap of 24 mm.
8. **Method for Compression Tests**

Compression tests of hydrogels were carried out at 25 °C by using a Shimadzu model EZ Test machine. A cube-shaped (10 mm × 10 mm × 10 mm) hydrogel sample was set under an upper plate connected to a 10-N load cell. Compressive stress was measured with applied compression strain ($\varepsilon$) = 0–50% at a constant compression rate of 20% min$^{-1}$. Tangent elastic moduli at 40% strain were calculated from an increase in load detected between $\varepsilon$ of 35% and 45%.

9. **Estimation of the Degree of Charge Neutralization on the TiNS Surface by ‘Contact Ion Pairing’ with Me$_4$N$^+$ (Supplementary Table 1)**

It is known that most ionic charges on vesicles (~95%)$^{35}$ and polyelectrolyte nanoparticles (~93%)$^{36}$ are electrostatically neutralized by ‘contact ion pairing’ with counterions. Otherwise, they are highly unstable due to an extremely large ionic density on the surfaces. TiNS carries one anionic site at every four oxygen atoms on its surface and therefore must have an exceptionally large ionic density if all the anionic sites are dissociated. The zeta potential of TiNS was evaluated as $-57.4$ mV (Supplementary Table 1), which is close to those of synthetic vesicles consisting of $N,N$-dialkyl-$N,N$-dimethylammonium bromides (~60 mV)$^{37}$. Although the degree of ‘contact ion pairing’ on TiNS cannot be evaluated from its zeta potential because of its 2D shape, one can conclude that a large portion (e.g., ~95%) of the anionic sites on TiNS is electrostatically neutralized via ‘contact ion paring’ with Me$_4$N$^+$. The zeta potential of TiNS changed only a little ($-57.4 \rightarrow -52.4$ mV) upon addition of external electrolyte Me$_4$NOH under conditions identical to those of Fig. 3e (Supplementary Table 1), suggesting that steric congestion on the TiNS surface possibly prevents further ‘contact ion pairing’.

**Supplementary Table 1 | Zeta potentials of TiNS at various concentrations of externally added Me$_4$NOH**

<table>
<thead>
<tr>
<th>Externally added Me$_4$NOH</th>
<th>Zeta potential*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 μM</td>
<td>$-57.4$ mV</td>
</tr>
<tr>
<td>240 μM</td>
<td>$-55.7$ mV</td>
</tr>
<tr>
<td>480 μM</td>
<td>$-52.5$ mV</td>
</tr>
<tr>
<td>720 μM</td>
<td>$-52.4$ mV</td>
</tr>
</tbody>
</table>

* [TiNS] = 0.008 wt% in water at 25 °C.
10. Theoretical Analysis for Diamagnetic Anisotropies of TiNS and NbNS

(Supplementary Fig. 2, Supplementary Table 2)

Uyeda reported that the magnetic orientation of tetrahedral silicates and octahedral metal oxides is primarily governed by diamagnetic anisotropy and further showed a quantitative correlation between orientation and calculated diamagnetic anisotropy values\textsuperscript{24}. This method is based on the Langevin–Debye formulation of diamagnetism, which predicts that (i) diamagnetic anisotropy of a crystal can be taken as a sum of all individual bond contributions and that (ii) the average radius squared of an electron orbital is proportional to its diamagnetic susceptibility in the bonding direction. Since SQUID measurements clearly showed that TiNS and NbNS as well as their layered crystals are diamagnetic (Supplementary Fig. 3), we applied Uyeda’s method\textsuperscript{24} to calculate the diamagnetic anisotropies of TiNS and NbNS.

For ordinary octahedral metal oxides, it is known that the contributions of H–O and alkali–O bonds to the overall diamagnetic anisotropy are much smaller than those of M–O bonds and therefore can be ignored\textsuperscript{38–40}. According to the method of Uyeda, an energy of each M–O bond in a magnetic field ($U_{M-O}$) is given by the following equation:

$$U_{M-O} = -(1/2)H^2 \left[ \chi_{M-O/\parallel} + (\chi_{M-O/\parallel} - \chi_{M-O/\perp})(a^2\alpha^2 + b^2\beta^2 + c^2\gamma^2) \right]$$  \hspace{1cm} (1)

$H$: external magnetic field

$\chi_{M-O/\parallel}$: magnetic susceptibility of a M–O bond parallel to the diamagnetic principle axis

$\chi_{M-O/\perp}$: magnetic susceptibility of a M–O bond orthogonal to the diamagnetic principle axis

$a, b, c$: direction cosines of the magnetic flux along the crystallographic $a, b$ and $c$ axes

$\alpha, \beta, \gamma$: direction cosines of a M–O bond along the crystallographic $a, b$ and $c$ axes

Based on equation (1), the overall diamagnetic anisotropy can be estimated from sums of the contributions of individual bonds ($\Sigma\alpha^2$, $\Sigma\beta^2$ and $\Sigma\gamma^2$) as follows:

$$\chi_a - \chi_b = (\chi_{M-O/\parallel} - \chi_{M-O/\perp})(\Sigma\alpha^2 - \Sigma\beta^2)$$  \hspace{1cm} (2)

$$\chi_b - \chi_c = (\chi_{M-O/\parallel} - \chi_{M-O/\perp})(\Sigma\beta^2 - \Sigma\gamma^2)$$  \hspace{1cm} (3)

$$\chi_c - \chi_a = (\chi_{M-O/\parallel} - \chi_{M-O/\perp})(\Sigma\gamma^2 - \Sigma\alpha^2)$$  \hspace{1cm} (4)

where $\chi_a$, $\chi_b$ and $\chi_c$ are magnetic susceptibilities along the crystallographic $a, b$ and $c$ axes. Uyeda \textit{et al.} empirically found that $\chi_{M-O/\parallel} - \chi_{M-O/\perp}$ is $-0.19 \times 10^{-6}$ emu mol$^{-1}$ for ordinary octahedral metal oxides\textsuperscript{41}.

In order to calculate the overall diamagnetic anisotropies of TiNS and NbNS from equations (2)–(4), atomic coordinates were taken from the crystal structures of the precursor layered crystals of TiNS\textsuperscript{42} and NbNS\textsuperscript{43} (for crystallographic axes and planes, see Supplementary Fig. 2). Sums of $\alpha^2$, $\beta^2$ and $\gamma^2$ were calculated for each bond, and the resulting values were used to estimate the overall diamagnetic anisotropy of the individual crystals.
Supplementary Table 2 | Theoretical prediction of the easy axis or plane of TiNS and NbNS*

<table>
<thead>
<tr>
<th>Nanosheet</th>
<th>Direction cosine sum‡</th>
<th>Diamagnetic anisotropy‡</th>
<th>Aspect ratio</th>
<th>Easy axis or plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiNS</td>
<td>3.7805 3.7813 4.4381</td>
<td>0.0001 0.12 0.12</td>
<td>10⁴ 1 10⁴</td>
<td>b axis</td>
</tr>
<tr>
<td>NbNS</td>
<td>3.8640 3.8640 4.2720</td>
<td>0 0.078 0.078</td>
<td>10⁴ 10⁴ 1</td>
<td>a–b plane</td>
</tr>
</tbody>
</table>

* For crystallographic axes and planes, see Supplementary Fig. 2.
† Sum of all M–O bonds in the unit cell.
‡ In 10⁻⁶ emu mol⁻¹.

$\beta^2$ and $\gamma^2$ were calculated over the unit cell (i.e., over $Z \times (\text{number of metal atoms per formula unit}) \times 6 \text{ M–O bonds}$) and divided by the number of formula units per cell ($Z$) in order to obtain molar values. Results of these calculations are shown in Supplementary Table 2. So long as the shape anisotropy is negligible, the smallest sum (or sums) among $\Sigma \alpha^2$, $\Sigma \beta^2$ and $\Sigma \gamma^2$ should correspond to the easy axis (or easy plane), which orients parallel to the applied magnetic flux.

In the case of TiNS, the order of sums $\Sigma \alpha^2 \approx \Sigma \beta^2 < \Sigma \gamma^2$ (Supplementary Table 2) suggests that the crystallographic $a$–$b$ plane is a likely candidate for the easy plane of this nanosheet. However, since the shape of TiNS with an aspect ratio ($a$-length/$b$-length) of $\approx 10^4$ is exceptionally anisotropic in its crystallographic $a$–$b$ plane, the shape anisotropy effect on the demagnetization energy should also be taken into account. Demagnetization energies along the crystallographic $a$ and $b$ axes ($U_{\text{demag},a}$ and $U_{\text{demag},b}$) are given by the following equations:

$$U_{\text{demag},a} = -(1/2)H^2 N_a \chi_a^2$$

(5)

$$U_{\text{demag},b} = -(1/2)H^2 N_b \chi_b^2$$

(6)

$H$: external magnetic field

$N_a, N_b$: demagnetization coefficients along the crystallographic $a$ and $b$ axes

$\chi_a, \chi_b$: magnetic susceptibilities along the crystallographic $a$ and $b$ axes
When the aspect ratio ($a$-length/$b$-length) of TiNS is $10^4$, $N_a$ and $N_b$ are calculated to be 0.000008 and 0.99984, respectively. Since the difference between in $\chi_a$ and $\chi_b$ is quite small (Supplementary Table 2), the order of demagnetization energies is $U_{\text{demag}_a} \gg U_{\text{demag}_b}$. Hence, the crystallographic $b$ axis is concluded to be the easy axis of TiNS (Supplementary Fig. 2).

In the case of NbNS, the order of sums $\Sigma \alpha^2 = \Sigma \beta^2 \ll \Sigma \gamma^2$ (Supplementary Table 2) suggests that the crystallographic $a$–$b$ plane is a likely candidate for the easy plane of this nanosheet. In sharp contrast with the case of TiNS, the aspect ratio of NbNS ($a$-length/$b$-length) is essentially unity, indicating that the shape anisotropy effect in the crystallographic $a$–$b$ plane on the demagnetization energy can be neglected. Hence, the crystallographic $a$–$b$ plane is concluded to be the easy plane of NbNS (Supplementary Fig. 2).
11. Supplementary Figures (Supplementary Figs 3–20)

**Supplementary Fig. 3** | **Magnetization profiles of TiNS and NbNS.**  
**a, b,** Magnetization at 300 K of TiNS (a) and NbNS (b) measured for layered crystals$^{31,32}$ (I) and solids (II).
Supplementary Fig. 4 | Magnetic responses of TiNS and NbNS.  

a, b, Optical transmittance spectra of aqueous dispersions of TiNSs (a) and NbNSs (b) (0.4 wt%) upon orthogonal (⊥) and parallel (∥) directions of a 10-T magnetic flux to the incident light.  

c, d, Changes in optical transmittances at 450 nm in a and b. The dispersions contained 8.0 wt% poly(N,N-dimethylacrylamide) as a thickener.
Supplementary Fig. 5 | Effects of the amplitude of an applied magnetic field on the degree of TiNS orientation.  a, Optical transmittance spectra of hydrogels (TiNS; 0.4 wt%) prepared in 0–10 T magnetic fields. The incident light was directed orthogonal to a magnetic flux applied during the hydrogelation. b, Changes in optical transmittance at 450 nm in a, where each point represents a single measurement.
Supplementary Fig. 6 | SAXS profiles of hydrogels prepared in a 10-T magnetic flux at different concentrations of TiNS (0.1–0.8 wt%) without externally added Me₄NOH.  a–c, 2D SAXS images (a), scattering intensity (0.044–0.300 nm⁻¹)–azimuthal angle plots (b) and 1D SAXS profiles (c) at [TiNS] = 0.1 (I), 0.3 (II) and 0.8 wt% (III). The incident X-ray beam was directed orthogonal to the magnetic flux applied during the hydrogelation. Miller indices (hkl) and d-spacings are provided for c.
Supplementary Fig. 7 | SAXS profiles of hydrogels (TiNS; 0.8 wt%) prepared in the presence of externally added Me₄NOH (24–72 mM) in a 10-T magnetic flux. a–c, 2D SAXS images (a), scattering intensity ($q = 0.044–0.300$ nm$^{-1}$)–azimuthal angle plots (b) and 1D SAXS profiles (c) at [Me₄NOH]$^*$ = 24 (I), 48 (II) and 72 mM (III). The incident X-ray beam was directed orthogonal to the magnetic flux applied during the hydrogelation. Miller indices ($hkl$) and $d$-spacings are provided for c.
Supplementary Fig. 8 | Effects of the concentrations of TiNS (0.1–0.8 wt%) and externally added Me₄NOH (0–72 mM) on the d-spacing of TiNSs in a hydrogel prepared in a 10-T magnetic flux. a, Summary of data. b, Plot of d-spacing versus \([\text{total Me}_4\text{N}^+]^{-1/2}\), where each point represents a single measurement. c, Plot of d-spacing versus \([\text{free Me}_4\text{N}^+]^{-1/2}\) estimated based on an assumption that 95% of the anionic sites on the TiNS surface are electrostatically neutralized by ‘contact ion pairing’ with Me₄N⁺, where each point represents a single measurement.
Supplementary Fig. 9 | SAXS profiles of a gel (TiNS; 0.8 wt%) prepared with water/ethylene glycol (50:50 in v/v) in a 10-T magnetic flux.  

- Supplementary Information
- Research

**a**–**c**, 2D SAXS image (**a**), scattering intensity (0.044–0.300 nm\(^{-1}\))–azimuthal angle plot (**b**) and 1D SAXS profile (**c**). The incident X-ray beam was directed orthogonal to the magnetic flux applied during the hydrogelation.
Supplementary Fig. 10 | Mechanical properties of hydrogels (TiNS; 0–1.0 wt%) prepared in a 10-T magnetic flux.  

**a, c**, Strain–stress curves at different [TiNS] (0–1.0 wt%) upon compression in orthogonal (a, ⊥) and parallel (c, //) directions to the magnetically oriented TiNS plane.  

**b, d**, Storage moduli ($G'$) at different [TiNS] (0–1.0 wt%) upon shear in orthogonal (b, ⊥) and parallel (d, //) directions to the magnetically oriented TiNS plane.
Supplementary Fig. 11 | Rheological properties of a hydrogel (TiNS; 0.8 wt%) prepared in a 10-T magnetic flux.  

a, b, Storage ($G'$) and loss moduli ($G''$) on frequency (a) and strain (b) sweeps upon shear in parallel ($//$) and orthogonal ($\perp$) directions to the magnetically oriented TiNS plane.
Supplementary Fig. 12 | Mechanical properties of hydrogels (TiNS; 0–1.0 wt%) prepared in the absence of magnetic flux.  

a, b, Strain–stress curves (a) and storage moduli ($G'$) (b).  
c, d, Effects of [TiNS] (0, 0.2, 0.4, 0.6, 0.8 and 1.0 wt%) on tangent elastic modulus ($E$) at compression strain ($\varepsilon$) = 40% (c) and storage modulus ($G'$) at frequency ($\omega$) = 1.33 rad s$^{-1}$ (d), where each point represents a single measurement.
Supplementary Fig. 13 | Mechanical properties of a hydrogel (NbNS; 0.4 wt%) prepared in a 10-T magnetic flux.  

a, Strain–stress curves upon compression in parallel (∥) and orthogonal (⊥) directions to an orientation vector of the magnetically oriented NbNS plane (azimuthal angles are not controlled).  
b, Storage moduli ($G'$) upon shear in parallel (∥) and orthogonal (⊥) directions to an orientation vector of the magnetically oriented NbNS plane (azimuthal angles are not controlled).
Supplementary Fig. 14 | Mechanical properties of a gel (TiNS; 0.8 wt%) prepared with water/ethylene glycol (50:50 in v/v) in a 10-T magnetic flux. a, Strain–stress curves upon compression in orthogonal (\(\perp\)) and parallel (\(/\)) directions to the magnetically oriented TiNS plane. b, Storage moduli (\(G'\)) upon shear in orthogonal (\(\perp\)) and parallel (\(/\)) directions to the magnetically oriented TiNS plane.
Supplementary Fig. 15 | Effects of externally added Me₄NOH (24 mM) on the mechanical properties of hydrogels (TiNS; 0.8 wt%) prepared in a 10-T magnetic flux.  

a, Strain–stress curves upon compression in orthogonal (⊥) and parallel (∥) directions to the magnetically oriented TiNS plane.  
b, Storage moduli ($G'$) upon shear in orthogonal (⊥) and parallel (∥) directions to the magnetically oriented TiNS plane.
Supplementary Fig. 16 | Rheological properties of hydrogels (TiNS; 0.8 wt%) prepared in a 10-T magnetic flux with larger amounts of the monomer (16 wt%) and organic crosslinker (0.4 wt%).  

**a**, **b**, Storage ($G'$) and loss moduli ($G''$) of hydrogels on frequency sweeps at [TiNS]/[monomer]/[crosslinker] = 0.8/16/8.0 × 10^{-2} wt% (**a**) and 0.8/8.0/0.4 wt% (**b**) upon shear in parallel (||) and orthogonal (⊥) directions to the magnetically oriented TiNS plane.
Supplementary Fig. 17 | Ion-diffusion kinetics upon immersion in physiological saline (volume of 2.0 mL, [NaCl] = 0.9 wt%) at 25 °C of a hydrogel (volume of 1.0 mL, TiNS; 1.0 wt%) prepared in a 10-T magnetic flux without any salt externally added. Time-course change in ion conductivity of the outer salty aqueous medium, where each point represents a single measurement.
Supplementary Fig. 18 | Mechanical properties of a hydrogel (TiNS; 1.0 wt%) prepared in a 10-T magnetic flux before and after one-week immersion in physiological saline (1,000 vol%) at 25 °C.  

**a**, Strain–stress curves upon compression in orthogonal (⊥) and parallel (∥) directions to the magnetically oriented TiNS plane. Hydrogels (TiNS; 1.0 wt%) before (solid curves) and after (broken curves) one-week immersion at 25 °C in saline were used. 

**b**, Storage moduli ($G'$) upon shear in orthogonal (⊥) and parallel (∥) directions to the magnetically oriented TiNS plane. Hydrogels (TiNS; 1.0 wt%) before (filled circles) and after (open circles) one-week immersion at 25 °C in saline were used. 

**c, d**, Pictures of a hydrogel before (**c**) and after (**d**) one-week immersion at 25 °C in saline.
12. Supplementary References


