Supplementary Information (SI) for Soft Matter.

Supporting Information: Tuning the Velocity of Thermophoretic Microswimmers with Thermo-Sensitive Polymers

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Table S1 summarizes important parameters (such as the type of the coating device, the coating rates, and the distance between substrate and coating source) of the fabrication process of the Janus particles.

Table S1: Parameters of the coating process.

Type	Coating rate / nm/min	Time / s	Distance to source / mm
CREAMET 300 V2	30 (Au)	100 [a]	270 - 320
	1.2 (Cr)	250 [b]	270 - 320

[a] for a layer of 50 nm Au; [b] for a layer of 5 nm Cr

SEM and EDX Analysis

Figure S1 shows an SEM image of an Au-PS Janus particle with the corresponding EDX analysis, where the yellow region represents Au (i.e., the Au cap) and the blue region maps carbon (i.e., the PS side).

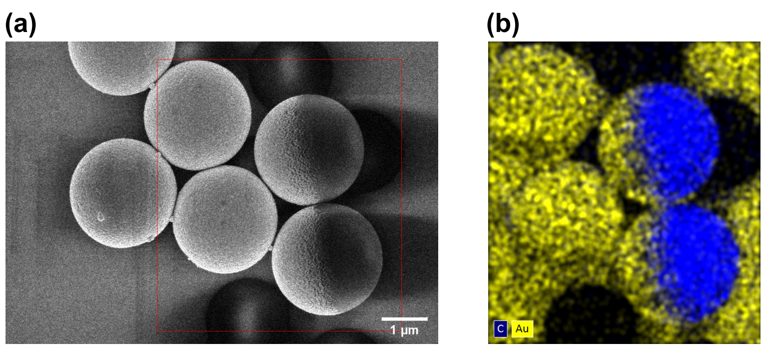

Figure S1: SEM image with corresponding EDX analysis of the Au-PS Janus particles. The yellow part corresponds to the Au cap and the blue part to the PS side.

Trajectories and MSD curves

Figures S2 - S6 display selected trajectories and MSD curves of the Janus particles in all solutions.

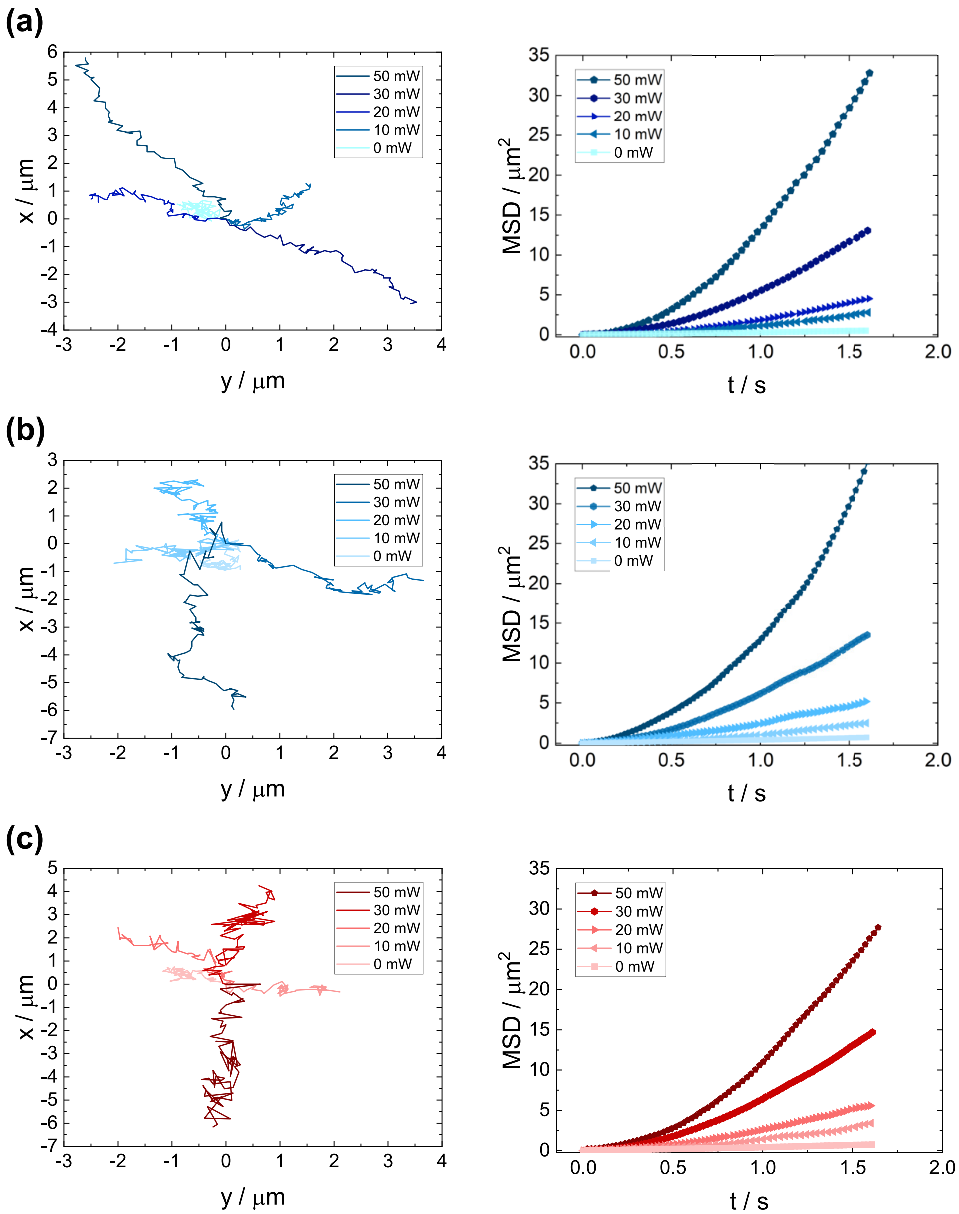

Figure S2: Selected trajectories and MSD curves in water at 21 °C (a), 28 °C (b), and 34 °C (c).

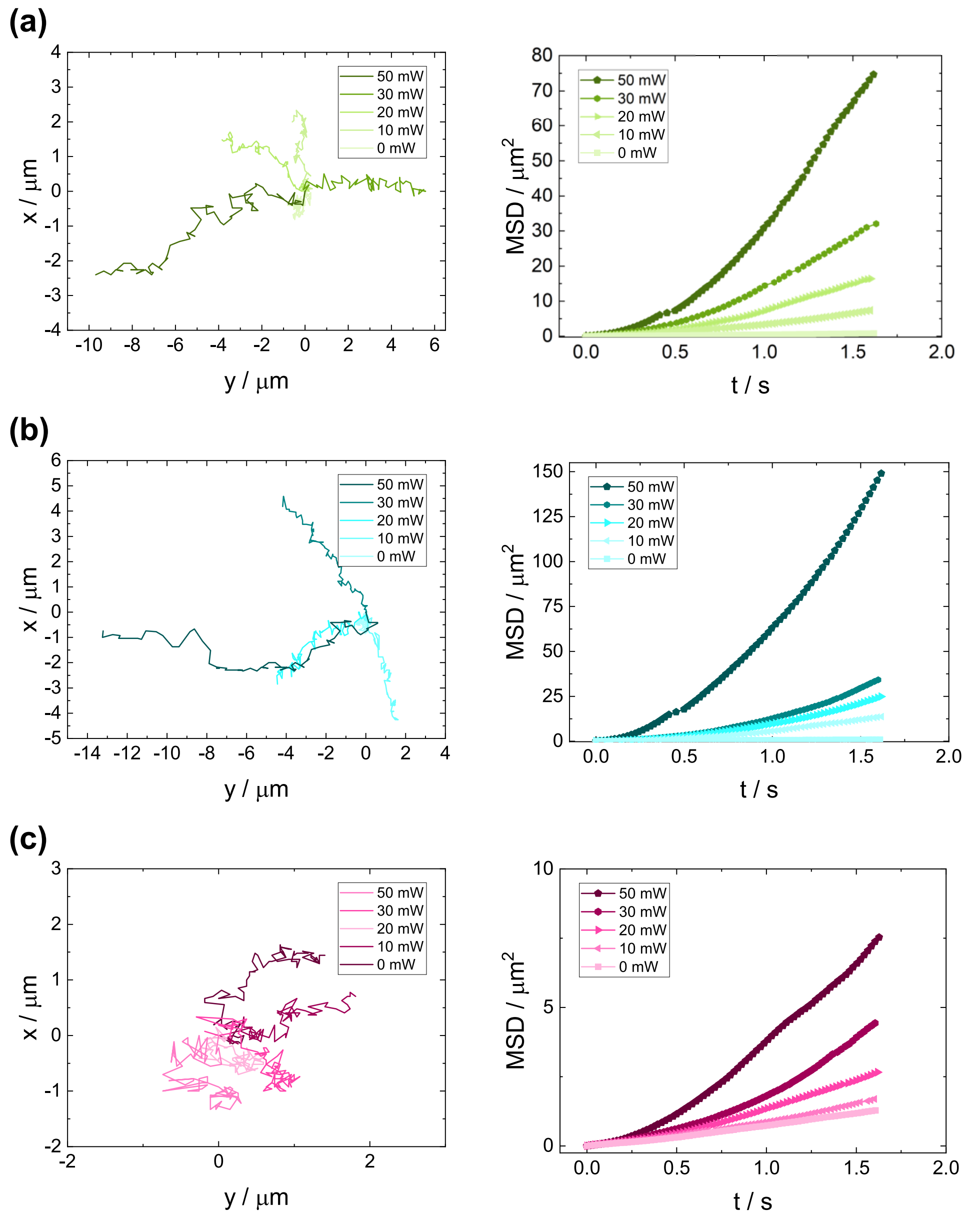

Figure S3: Selected trajectories and MSD curves in 0.05 wt% solutions at 21 °C (a), 28 °C (b), and 34 °C (c).

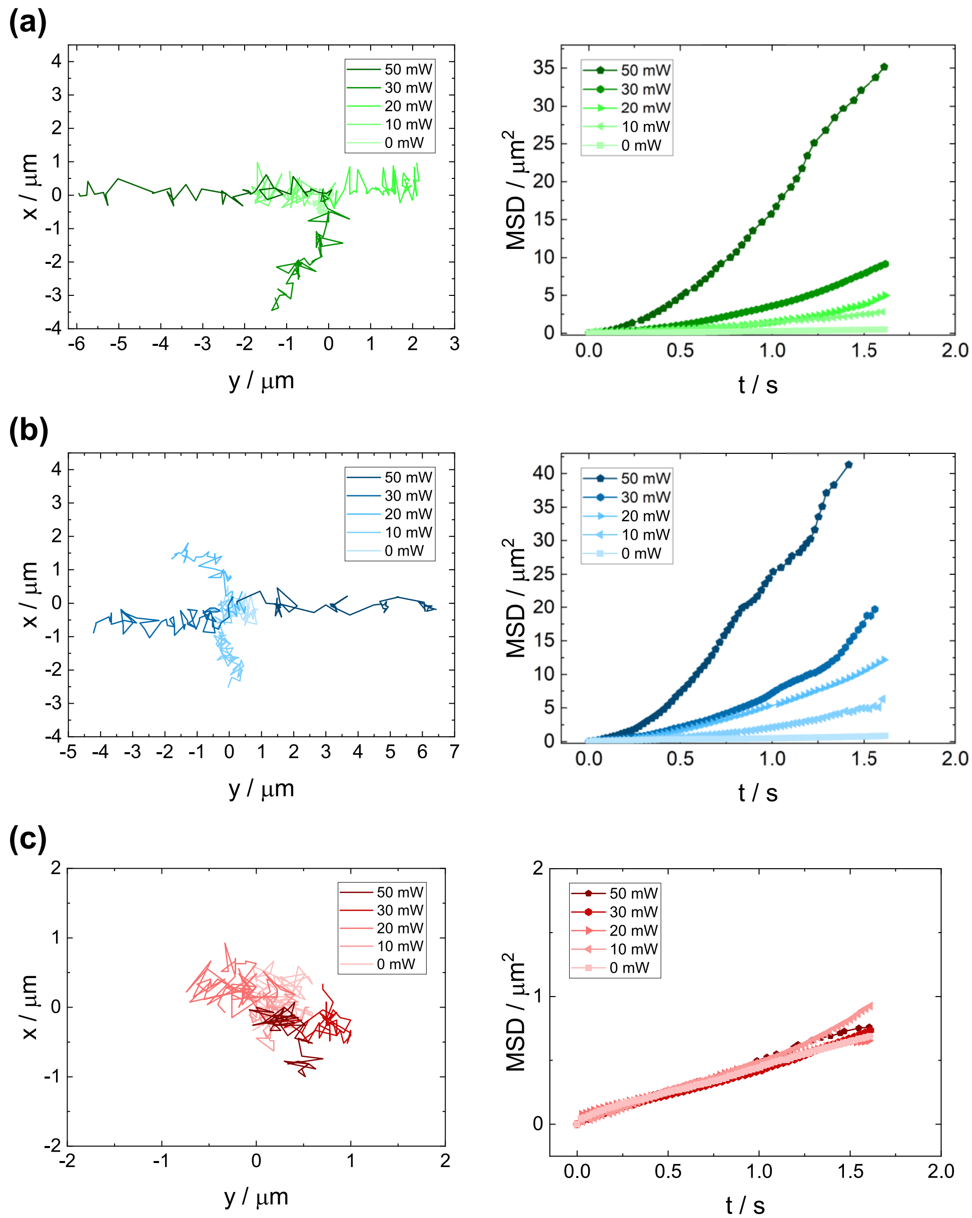

Figure S4: Selected trajectories and MSD curves in 0.5 wt% solutions at 21 °C (a), 28 °C (b), and 34 °C (c).

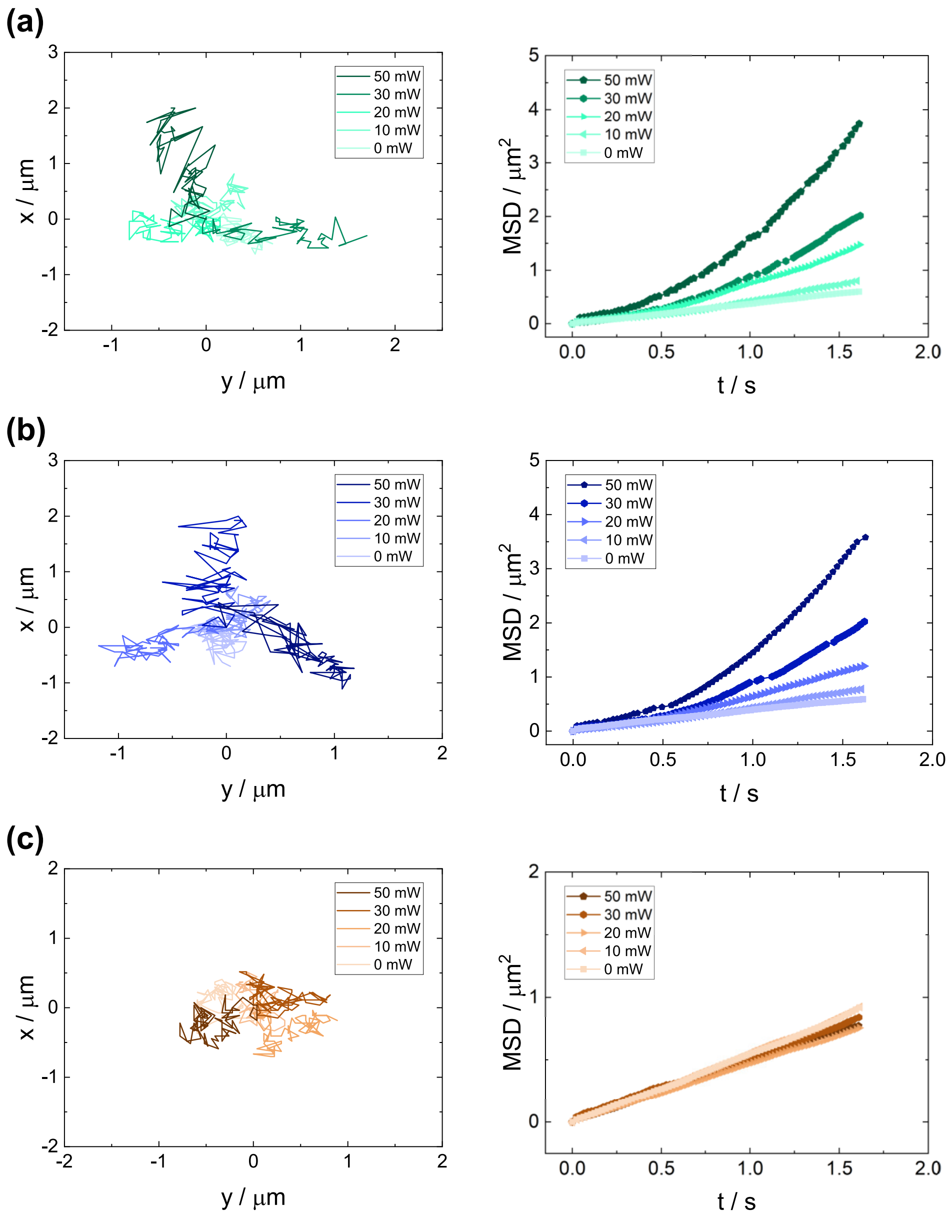

Figure S5: Selected trajectories and MSD curves in 1 wt% solutions at 21 °C (a), 28 °C (b), and 34 °C (c).

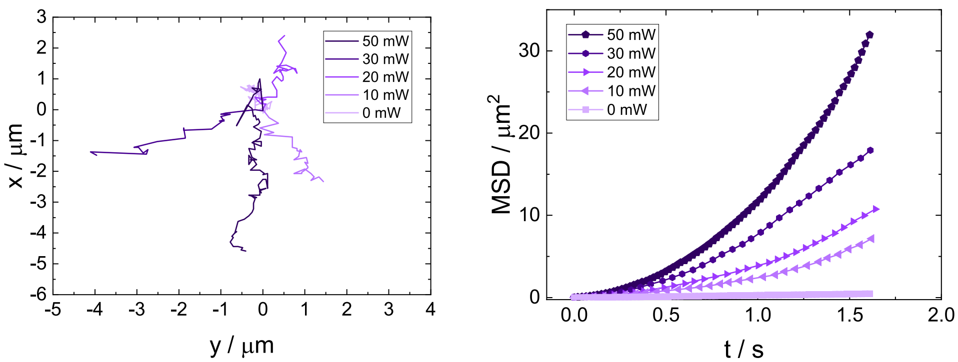

Figure S6: Selected trajectories and MSD curves in 0.5 wt% solutions at 28 °C after heating to 34 °C.

Diffusion coefficients

Figures S7 and S8 show the diffusion coefficients resulting from the self-propulsion measurements in water and the PNIPAM solutions for the analyzed temperatures. The filled symbols indicate the values at room temperature, while the open blue and open red symbols represent the measurements at 28 °C and 34 °C, respectively. The dotted lines correspond to the respective fit functions, where a constant line is fitted to the values.

In all cases, the diffusion coefficient increases with rising temperature.

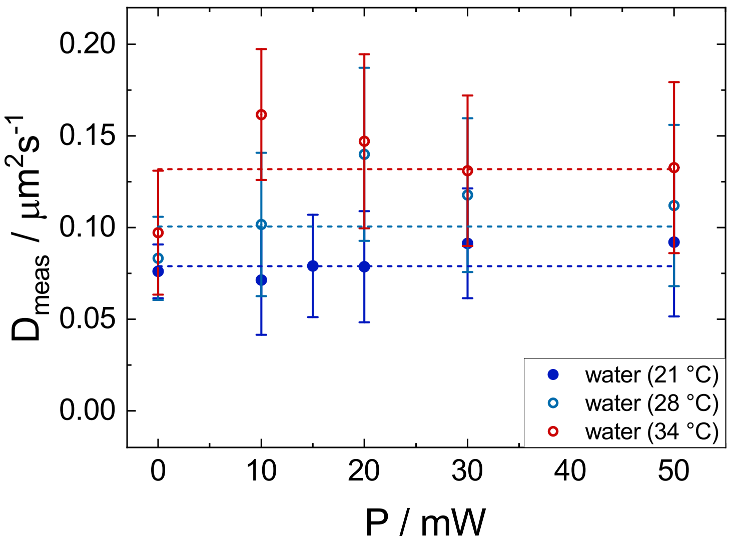

Figure S7: Diffusion coefficients in water as a function of laser power at different temperatures: 21 °C (blue circles), 28 °C (open blue circles), and 34 °C (open red circles). The dotted lines represent the corresponding fit functions, which are constant lines.

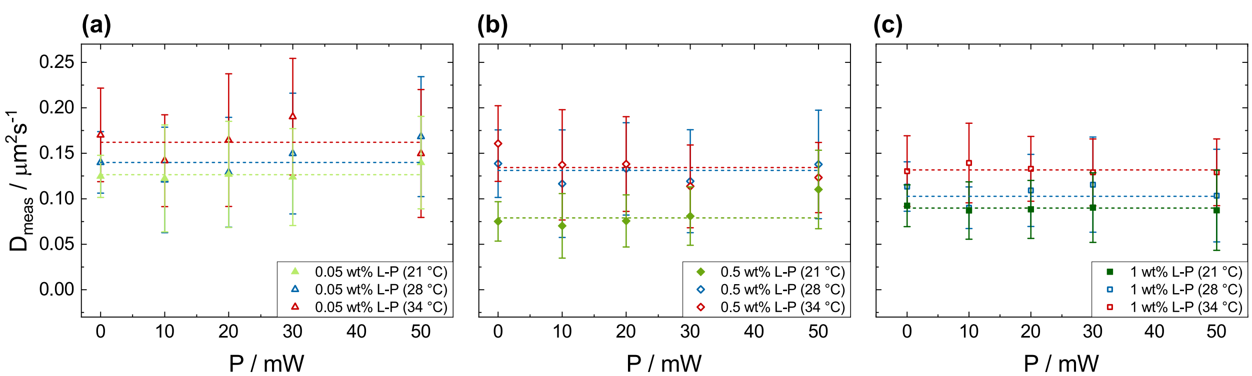

Figure S8: Diffusion coefficients in PNIPAM as a function of laser power at different temperatures across different concentrations: 0.05 wt% (a), 0.5 wt% (b), and 1 wt% (c). The dotted lines represent the corresponding constant fit functions.

Temperature-Dependent Viscosity with Rheometry

Figure S9 shows the temperature-dependent viscosities of water and the PNIPAM solutions. The blue circles represent water, while green symbols correspond to PNIPAM solutions at varying concentrations. Specifically, the light green triangles correspond to 0.05 wt%

PNIPAM, the medium green diamonds to 0.5 wt%, and the dark green squares to 1 wt%.

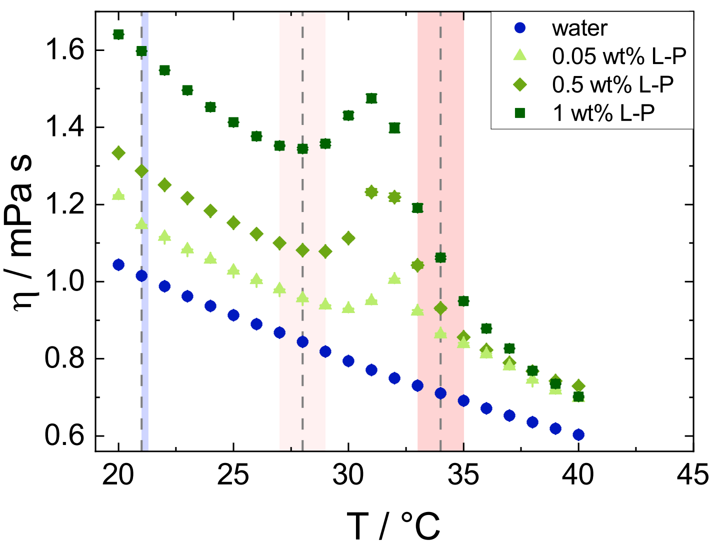

Figure S9: Viscosity as a function of temperature. The blue circles represent water, while the light green triangles, medium green diamonds, and dark green squares correspond to the 0.05 wt%, 0.5 wt%, and 1 wt% PNIPAM solutions, respectively. Each data point is obtained from a constant fit of the corresponding viscosity versus shear rate curve (see Figure S10), evaluated over a shear rate range of 300 - 750 1/s.

The viscosity of water decreases monotonically with increasing temperature. Although the viscosities of PNIPAM solutions generally decrease with increasing temperature, they exhibit a pronounced peak around the LCST, where the viscosity initially increases before declining again upon further temperature increase. Increasing the PNIPAM concentration shifts the viscosity peak to lower temperatures and results in overall higher viscosities. At all investigated temperatures, the viscosities of PNIPAM solutions exceed those of pure water.

The corresponding shear rate-dependent measurements are presented in Figure S10, showing the dynamic viscosity η as a function of shear rate for water (a) and the PNIPAM solutions at concentrations of 0.05 wt% (b), 0.5 wt% (c), and 1 wt% (d), as measured using a rheometer. Each colored line corresponds to a specific temperature. Across the examined shear rate range, the viscosity remains relatively constant at all temperatures, indicating Newtonian behavior. Only around the LCST (32 °C) of PNIPAM, a slight decrease in viscosity with increasing shear rate is observed (see dark pink curves). Nevertheless, these values were also fitted with a constant to obtain a shear rate-independent viscosity for each temperature, and the resulting values were used to extract the data points presented in Figure S9.

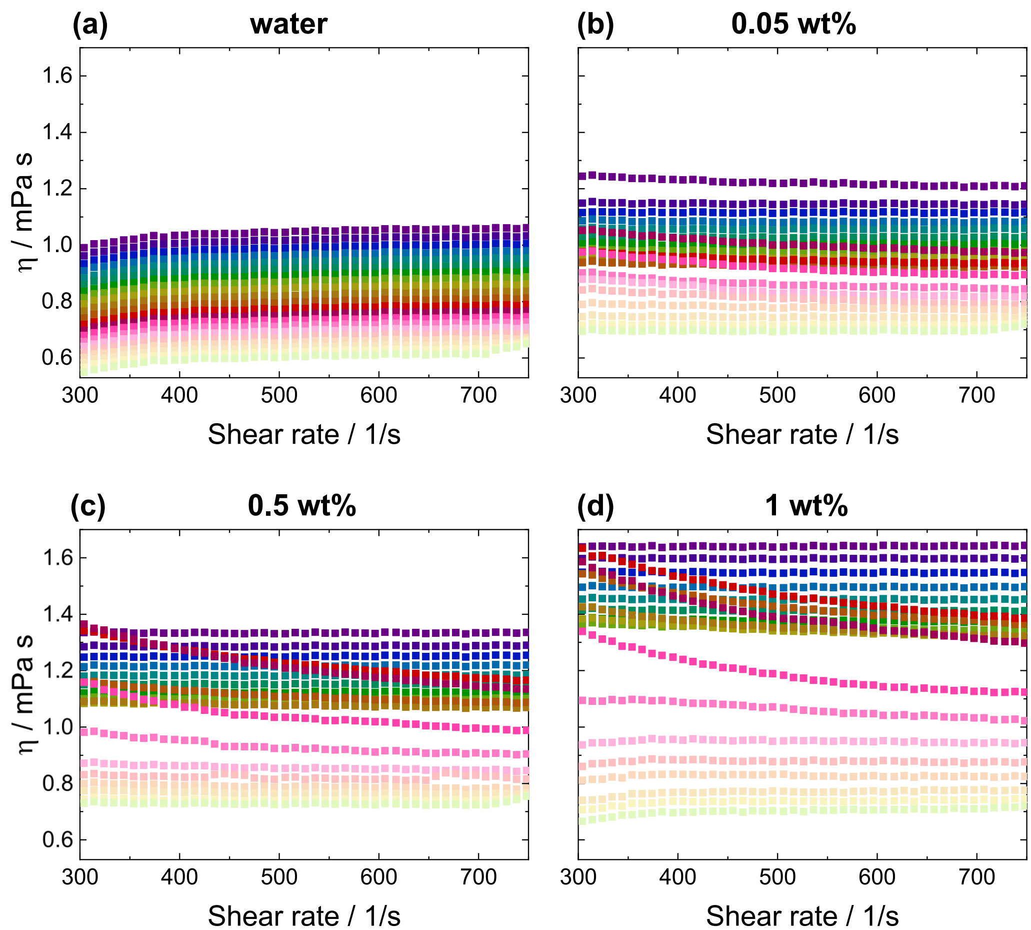

Figure S10: Viscosity as a function of shear rate for (a) water, (b) 0.05 wt % PNIPAM, (c) 0.5 wt % PNIPAM, and (d) 1 wt % PNIPAM. Each color represents a specific temperature, ranging from 20 °C (dark purple) to 40 °C (light green). Each data point is obtained from a constant fit of the corresponding viscosity versus shear rate curve, evaluated over a shear rate range of 300 - 750 1/s.

When the 0.5 wt% PNIPAM solution is cooled to 20 °C after heating (see Figure S11), its viscosity initially follows a similar trend to that observed during heating. This behavior remains consistent from 40 °C until the solution approaches the LCST of PNIPAM. Around and below the LCST, the viscosity during cooling is consistently lower and the peak is less pronounced than during heating.

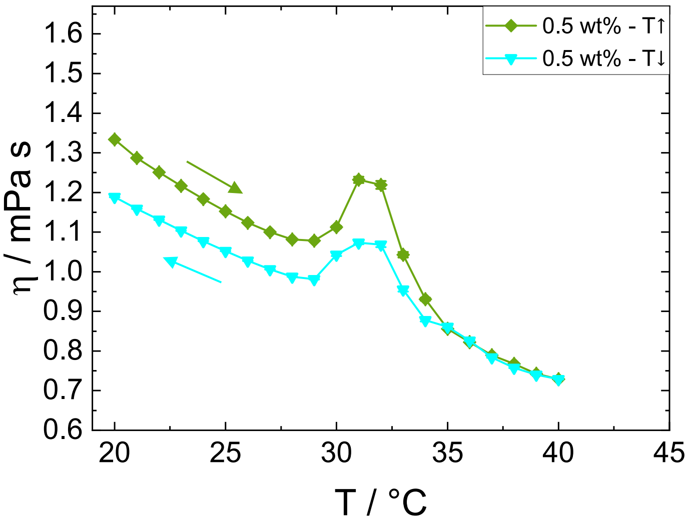

Figure S11: Viscosity as a function of temperature of a 0.5 wt% PNIPAM solution. The solution is first heated up from 20 °C to 40 °C (green diamonds) and then cooled down to 20 °C (blue triangles) again. Each data point is obtained from a constant fit of the corresponding viscosity versus shear rate curve, evaluated over a shear rate range of 300 - 750 1/s.

Ubbelohde Viscometer

Table S2 summarizes the kinematic viscosities of water and PNIPAM solutions measured at various temperatures using an Ubbelohde viscometer. The corresponding densities were determined with a densitometer. Using these values and equation 4 (material section of paper), the dynamic viscosities were calculated.

Table S2: Kinematic viscosities measured by an Ubbelohde viscometer and densities measured by a densitometer at selected temperatures.

Temperature	MilliQ Water	0.05 wt% PNIPAM	0.5 wt% PNIPAM
20 °C	$\nu = 1.0140 \pm 0.0001$ mm^2/s $\rho = 0.9982$ g/cm^3	1.05 ± 0.03 mm^2/s 0.9982 g/cm^3	1.241 ± 0.002 mm^2/s 0.9988 g/cm^3
28 °C	0.82 ± 0.02 mm^2/s 0.9963 g/cm^3	0.85 ± 0.03 mm^2/s 0.9963 g/cm^3	1.00 ± 0.01 mm^2/s 0.9968 g/cm^3
34 °C	XXX 0.9944 g/cm^3	0.77 ± 0.01 mm^2/s 0.9944 g/cm^3	– 0.9949 g/cm^3

Temperature	1 wt% PNIPAM
20 °C	1.50 ± 0.01 mm^2/s 0.9994 g/cm^3
28 °C	1.173 ± 0.003 mm^2/s 0.9974 g/cm^3
34 °C	– 0.9954 g/cm^3

$v_{\mathbf{th}}$ - After heating to 34 °C

Figure S12 presents the thermophoretic velocity in a 0.5 wt% solution obtained from the self-propulsion measurements. The open blue symbols indicate the measurements at 28 °C, while the light blue triangles represent the measurements at 28 °C after prior heating to 34 °C. The velocity values are slightly reduced after the sample has been heated to 34 °C.

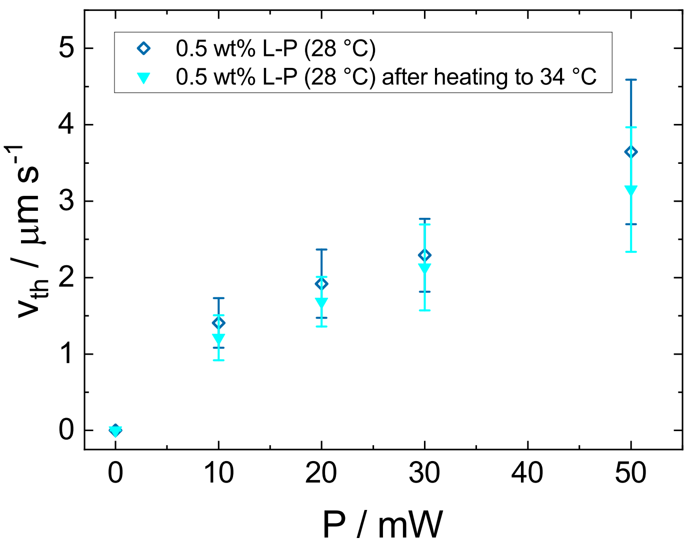

Figure S12: Velocity in PNIPAM as a function of laser power for the 0.5 wt% solution at 28 °C (open blue diamonds) and at 28 °C after heating to 34 °C before (light blue triangles).

Table S3 summarizes the zeta potential measurements of Janus particles in water and PNIPAM solutions, showing the effect of temperature and polymer concentration on surface charge properties before and after thermal cycling.

Table S3: Zeta potential values of the Janus particles dispersed in water and in PNIPAM solutions of varying concentrations at 20 °C, 40 °C, and at 20 °C after heating to 40 °C.

Sample	ζ-potential(20 °C) / mV	ζ-potential(40 °C) / mV	ζ-potential(20 °C) after 40 °C / mV
Water	-47 ± 8	-44 ± 1	-48 ± 7
0.05 wt% PNIPAM	-26 ± 6	-24 ± 2	-18 ± 3
0.5 wt% PNIPAM	-21 ± 3	-16 ± 1	-15 ± 1
1 wt% PNIPAM	-18 ± 3	-8 ± 1	-14 ± 2