Supplementary Information

Supramolecular gels based on a gemini imidazolium amphiphile as molecular material for drug delivery

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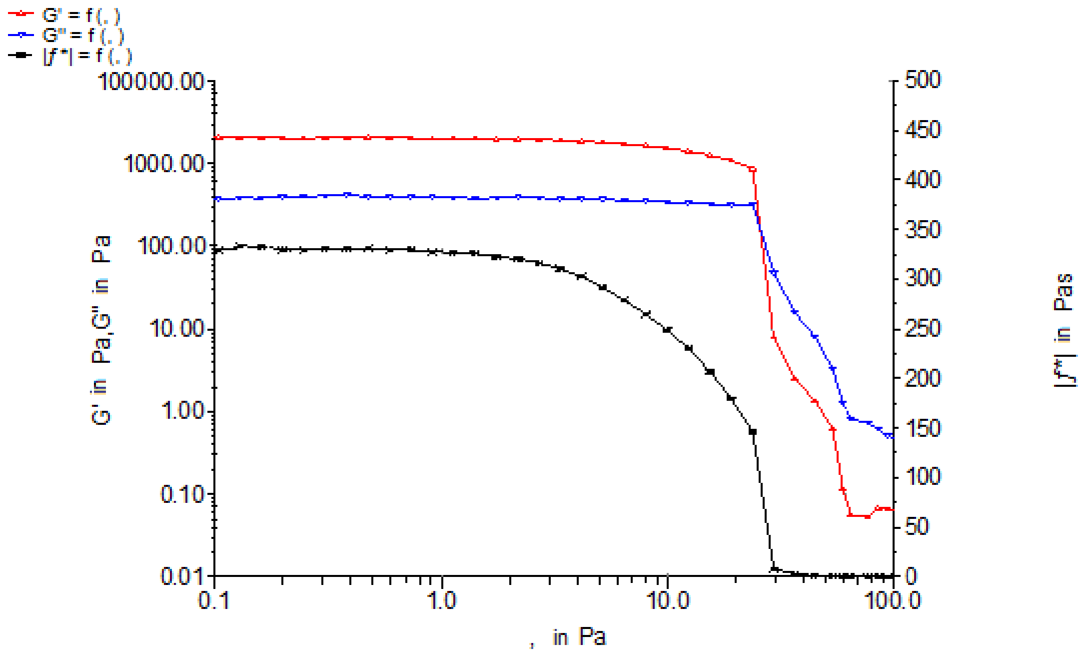

Fig. S1: Stress sweep of gel-**1** in water-ethanol. G' (elastic or storage modulus), G" (viscous or loss modulus), and |*f**| (viscosity) are defined as function of τ (shear stress).

Sensor: PP60 Ti
A Factor: 23580 Pa/Nm
M Factor: 29.991 (1/s)/(rad/s)
Inertia: 1.234e-05 kg m²
Damping: 30.00
Thermal expansion coefficient: 1.100 µm/°C
Compliance: 0.003157 rad/Nm
Groove: 1.0 mm
Driver version: 45

Element definition:

ID 2: 108; CS; 0.000 Pa; t < 300 s; ; T 32.00 °C <± 1.00 °C;
ID 8: 3; CS; 0.000 Pa – 500.0 Pa log; f 1.000 Hz; t ---; #50; T 32.00 °C;

Evaluation:

CROSSOVER: G' (storage modulus) = G" (loss modulus) = 165.0 Pa when Tau = 25.78 Pa

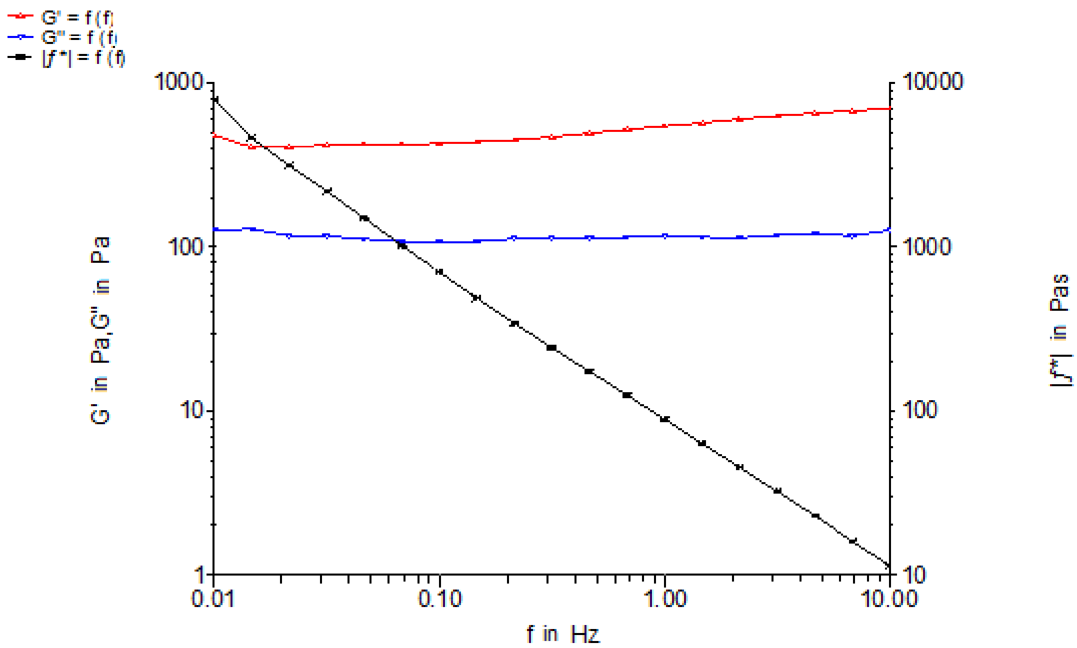

Fig. S2: Frequency sweep of gel-**1**: G’ (elastic or storage modulus), G” (viscous or loss modulus), and |*f**| (viscosity) defined as function of f (oscillatory frequency).

Sensor: PP60 Ti
A Factor: 23580.000 Pa/Nm
M Factor: 29.987 (1/s)/(rad/s)
Inertia: 1.234e-05 kg m²
Damping: 30.00
Thermal expansion coefficient: 1.100 µm/°C
Compliance: 0.003157 rad/Nm
Groove: 1.000 mm
Driver version: 45

Element definition:

ID 3: 2; CS; 0.5000 Pa; 10.00 Hz – 0.01000 Hz log; t ---; #6; T 32.00 °C;

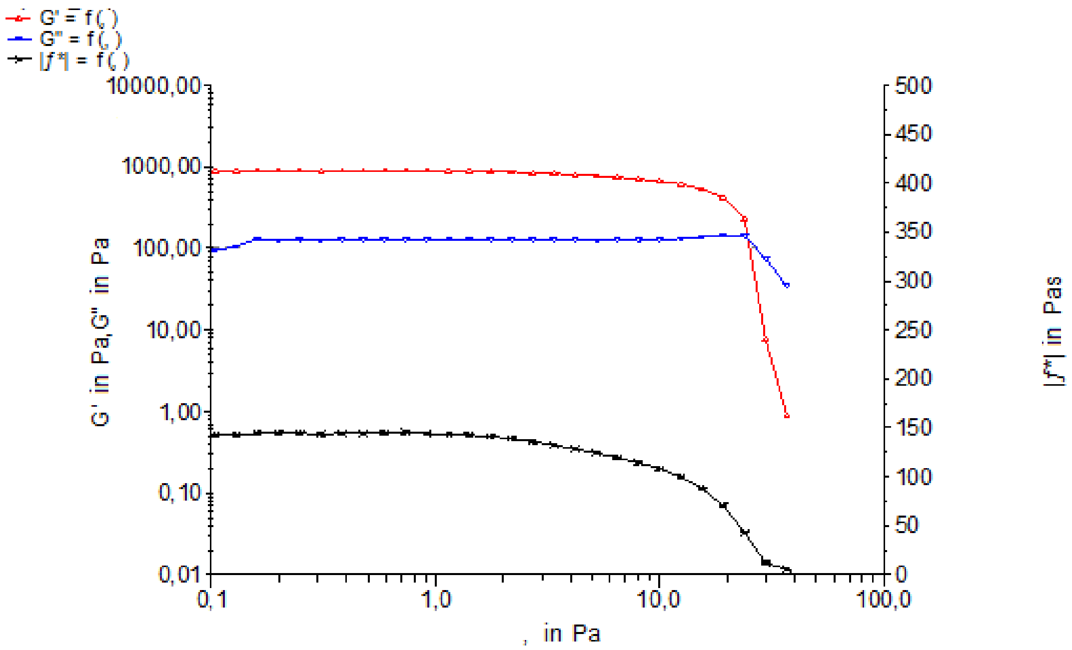

Fig. S3: Stress sweep of gel-**Ibu** in water-ethanol. G' (elastic or storage modulus), G" (viscous or loss modulus), and |*f**| (viscosity) are defined as function of τ (shear stress).

Sensor: PP60 Ti
A Factor: 23580 Pa/Nm
M Factor: 29.979 (1/s)/(rad/s)
Inertia: 1.234e-05 kg m²
Damping: 30.00
Thermal expansion coefficient: 1.100 µm/°C
Compliance: 0.003157 rad/Nm
Groove: 1.001 mm
Driver version: 45

Element definition:

ID 2: 108; CS; 0.000 Pa; t < 300 s; ; T 32.00 °C <± 1.00 °C;
ID 8: 3; CS; 0.000 Pa – 500.0 Pa log; f 1.000 Hz; t ---; #50; T 32.00 °C;

Evaluation:

CROSSOVER: G' (storage modulus) = G" (loss modulus) = 173.3 Pa when Tau = 25.29 Pa

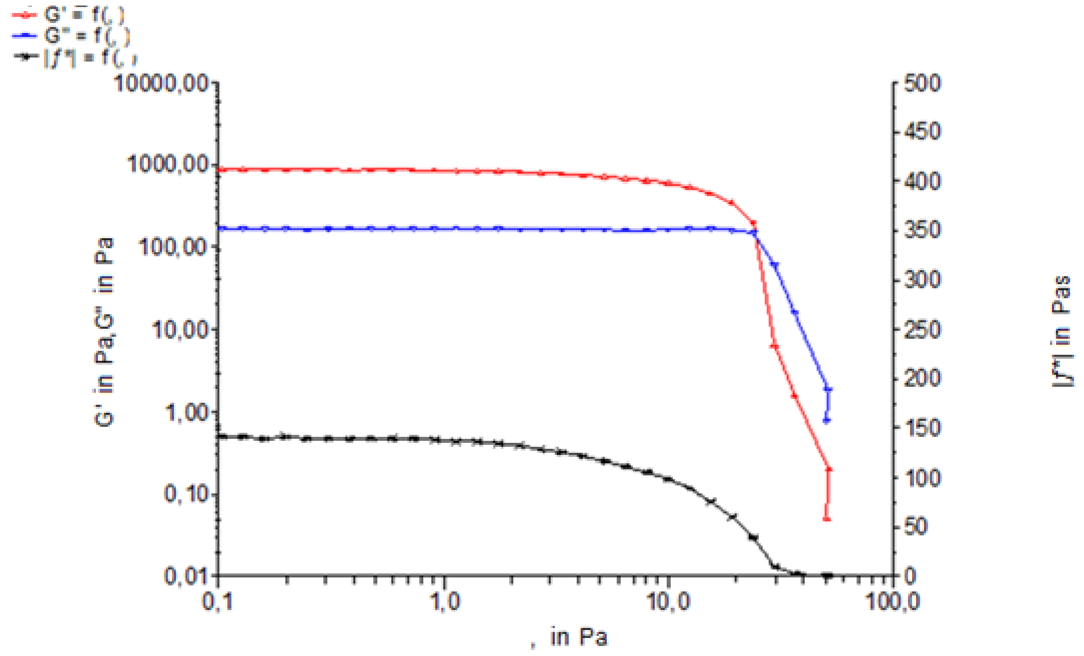

Fig. S4: Stress sweep of gel-**Ind** in water-ethanol. G’ (elastic or storage modulus), G” (viscous or loss modulus), and |*f**| (viscosity) are defined as function of τ (shear stress).

Sensor: PP60 Ti
A Factor: 23580 Pa/Nm
M Factor: 29.979 (1/s)/(rad/s)
Inertia: 1.234e-05 kg m²
Damping: 30.00
Thermal expansion coefficient: 1.100 µm/°C
Compliance: 0.003157 rad/Nm
Groove: 1.001 mm
Driver version: 45

Element definition:

ID 2: 108; CS; 0.000 Pa; t < 300 s;   ; T 32.00 °C <± 1.00 °C;
ID 8: 3; CS; 0.000 Pa – 500.0 Pa log; f 1.000 Hz; t ---; #50; T 32.00 °C;

Evaluation:

CROSSOVER: G’ (storage modulus) = G” (loss modulus) = 165.3 Pa when Tau = 24.87 Pa

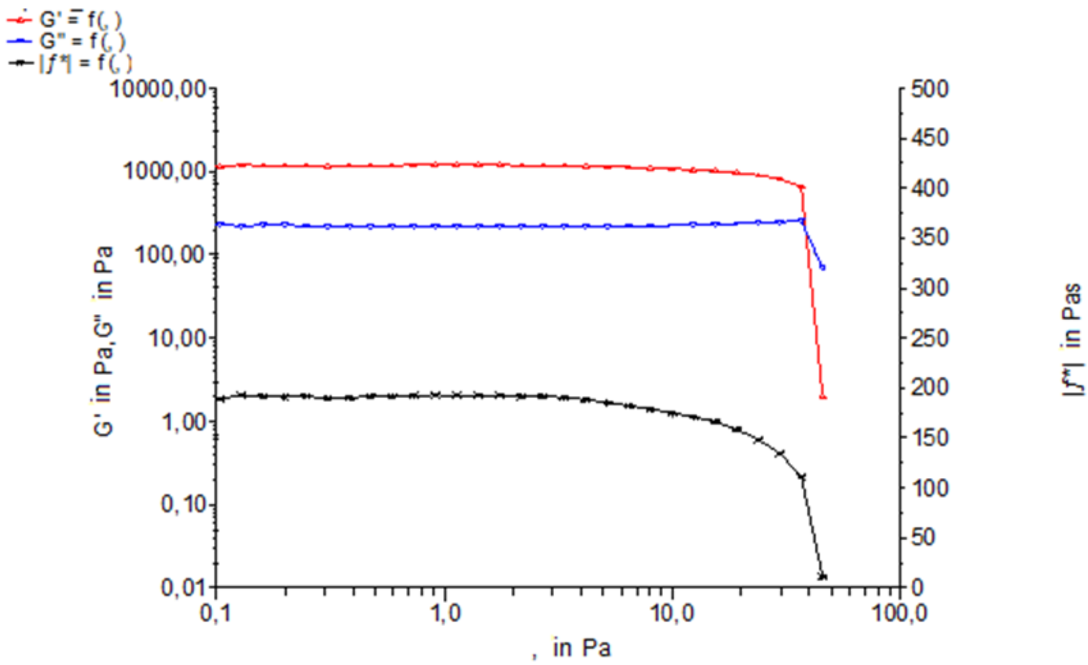

Fig. S5: Stress sweep of gel-**Mtx** in water-ethanol. G' (elastic or storage modulus), G" (viscous or loss modulus), and |*f**| (viscosity) are defined as function of τ (shear stress).

Sensor: PP60 Ti
A Factor: 23580 Pa/Nm
M Factor: 29.979 (1/s)/(rad/s)
Inertia: 1.234e-05 kg m²
Damping: 30.00
Thermal expansion coefficient: 1.100 µm/°C
Compliance: 0.003157 rad/Nm
Groove: 1.001 mm
Driver version: 45

Element definition:

ID 2: 108; CS; 0.000 Pa; t < 300 s; ; T 32.00 °C <± 1.00 °C;
ID 8: 3; CS; 0.000 Pa – 500.0 Pa log; f 1.000 Hz; t ---; #50; T 32.00 °C;

Evaluation:

CROSSOVER: G' (storage modulus) = G" (loss modulus) = 421.5 Pa when Tau = 39.96 Pa

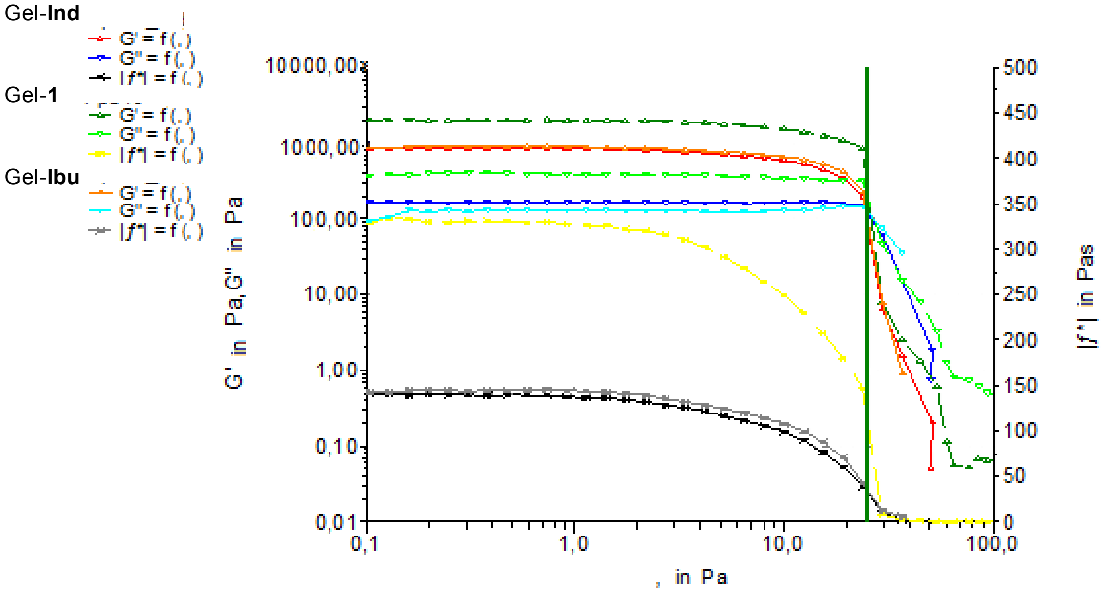

Fig. S6: Comparison of stress sweep of gel-**1**, gel-**Ibu** and gel-**Ind** in water-ethanol. G' (elastic or storage modulus), G" (viscous or loss modulus), and |*f**| (viscosity) are defined as function of τ (shear stress). Green vertical line marks the crossover for gel-**1**.

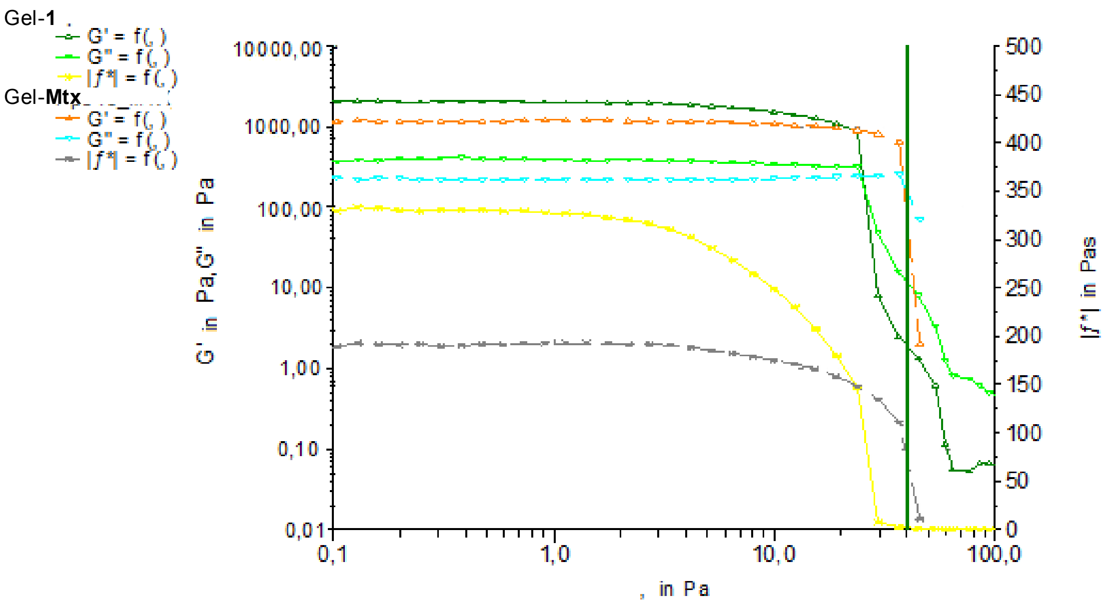

Fig. S7: Comparison of stress sweep of gel-**1** and gel-**Mtx** in water-ethanol. G' (elastic or storage modulus), G" (viscous or loss modulus), and |*f**| (viscosity) are defined as function of τ (shear stress). Green vertical line marks the crossover for gel-**Mtx**.

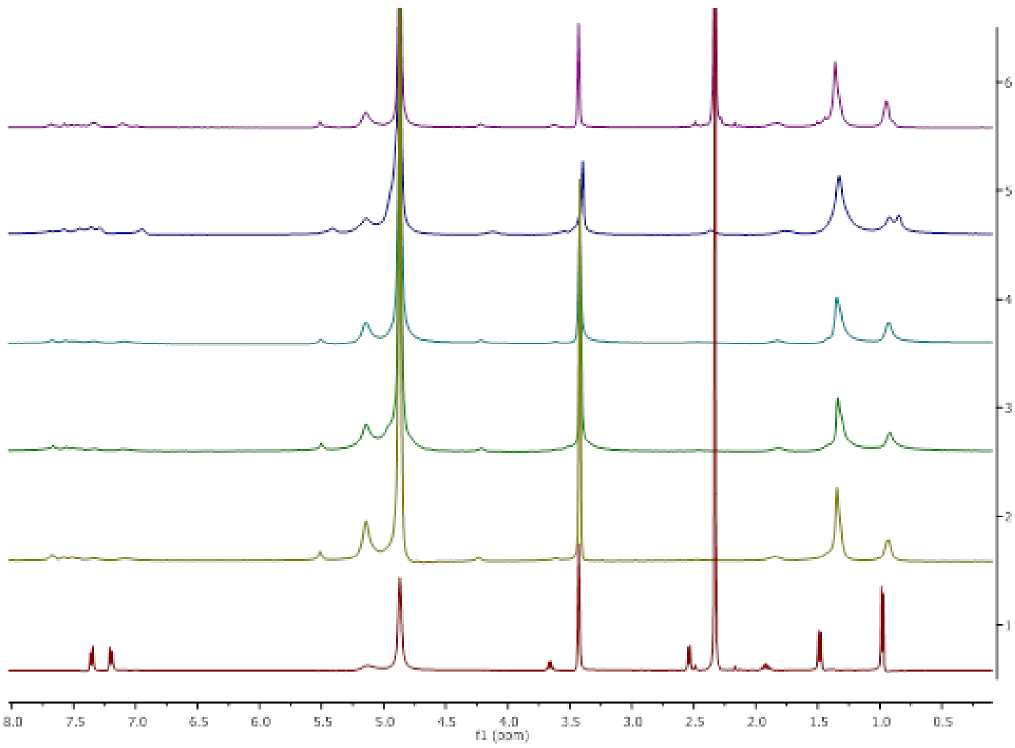

Fig. S8: ^{1}H NMR spectra of (1) sodium ibuprofenate in methanol/water (50:50) and of gel-**Ibu** containing increasing amounts of drug (2-6): **1**:ibuprofenate ratio (m/m) of 1:0.06; 1:0.08; 1:0.1; 1:0.15; 1:0.2.

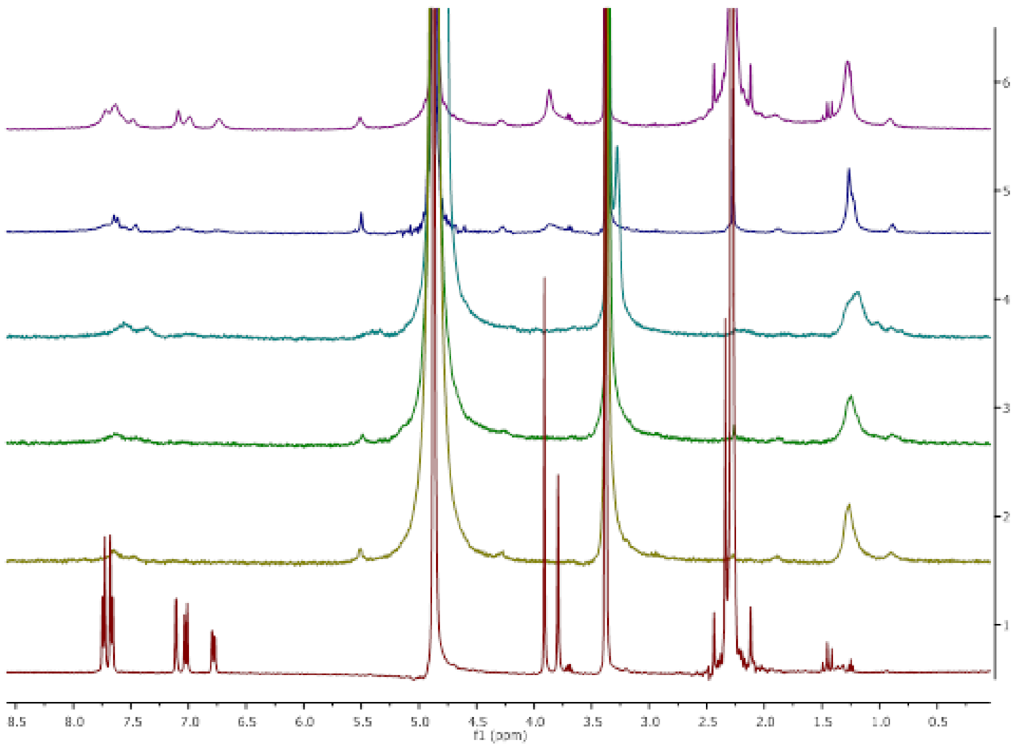

Fig. S9: ^{1}H NMR spectra of (1) indomethacin in methanol/water (50:50) and of gel-**Ind** containing increasing amounts of drug (2-6): **1**:indomethacin ratio (m/m) of 1:0.015; 1:0.030; 1:0.050; 1:0.10; 1:0.15.

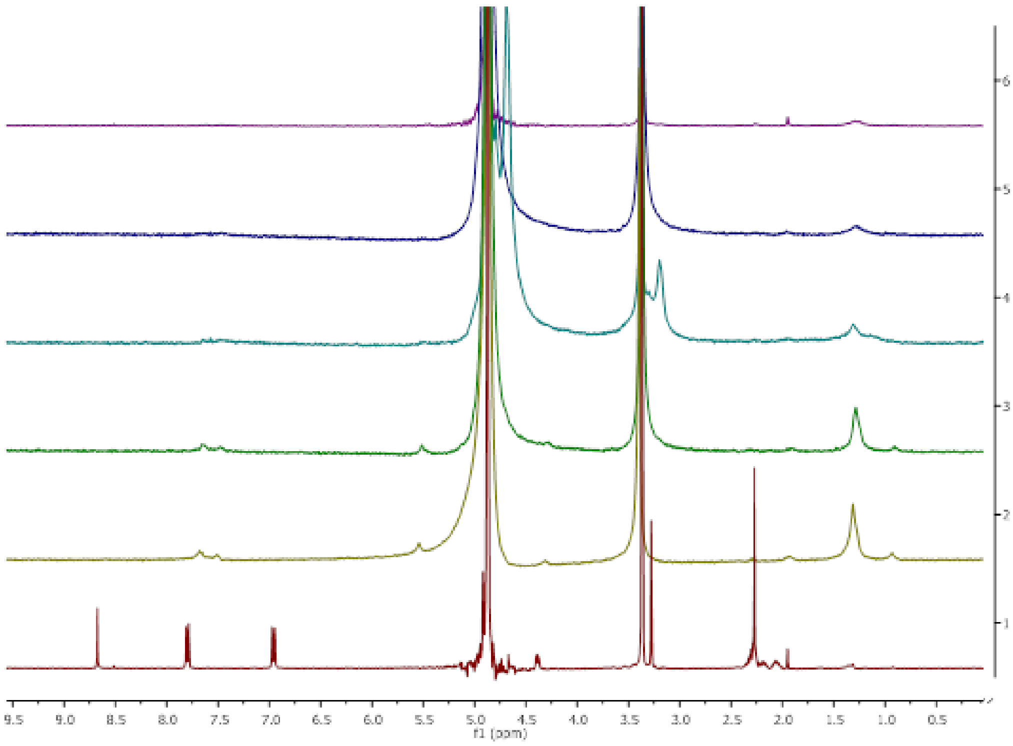

Fig. S10: [1]H NMR spectra of (1) methotrexate in methanol/water (50:50) and of gel-**Mtx** containing increasing amounts of drug (2-6): **1**:methotrexate ratio (m/m) of 1:0.011; 1:0.020; 1:0.040; 1:0.08; 1:0.10.

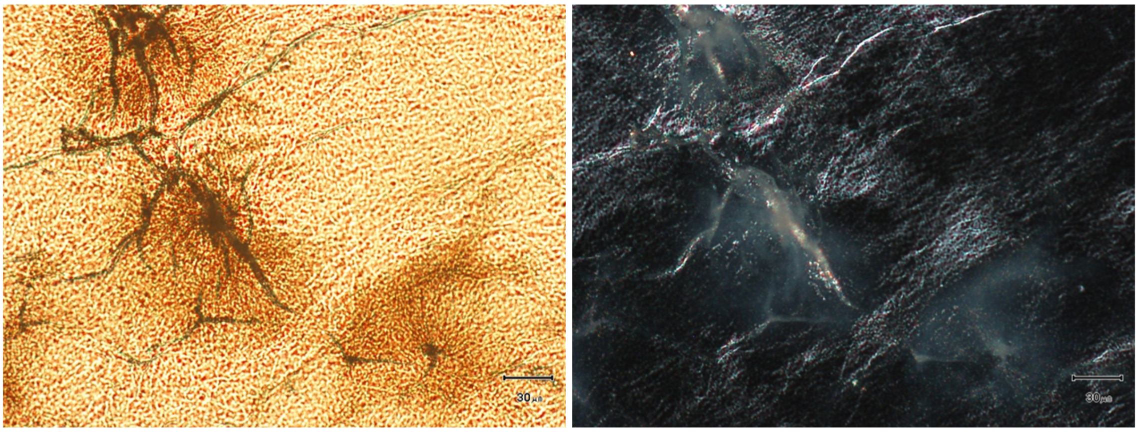

Fig. S.11: Optical microscopy photographs of gel-**1** in ethanol/water 35:65, taken with parallel polarisers and with crossed polarisers.

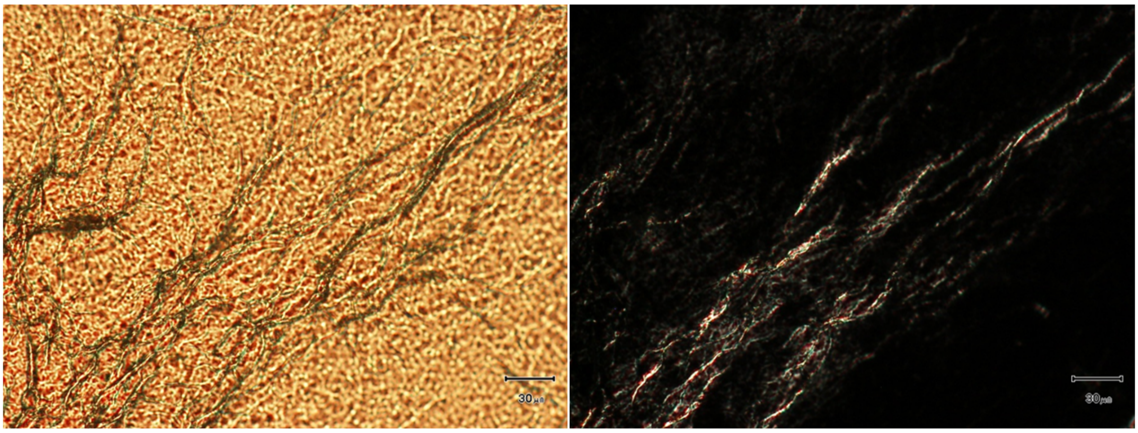

Fig. S.12: Optical microscopy photographs of gel-**1** in ethanol/water 45:55, taken with parallel polarisers and with crossed polarisers.

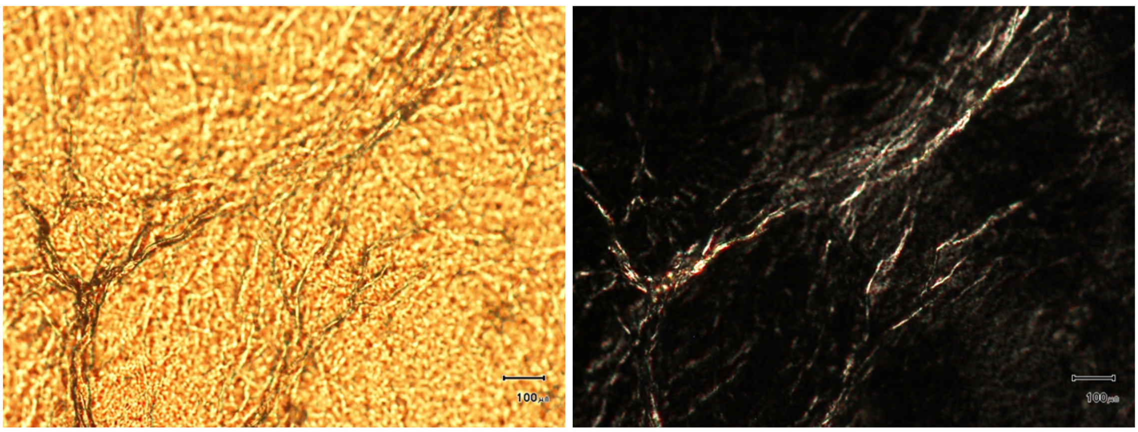

Fig. S.13: Optical microscopy photographs of gel-**1** in ethanol/water 50:50, taken with parallel polarisers and with crossed polarisers.

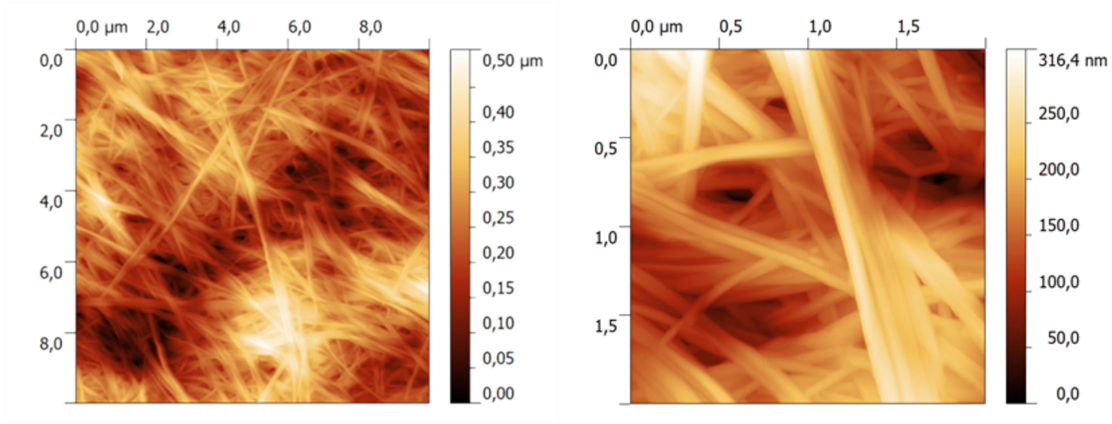

Fig. S.14: AFM image of gel-**1** in ethanol/water 40:60.

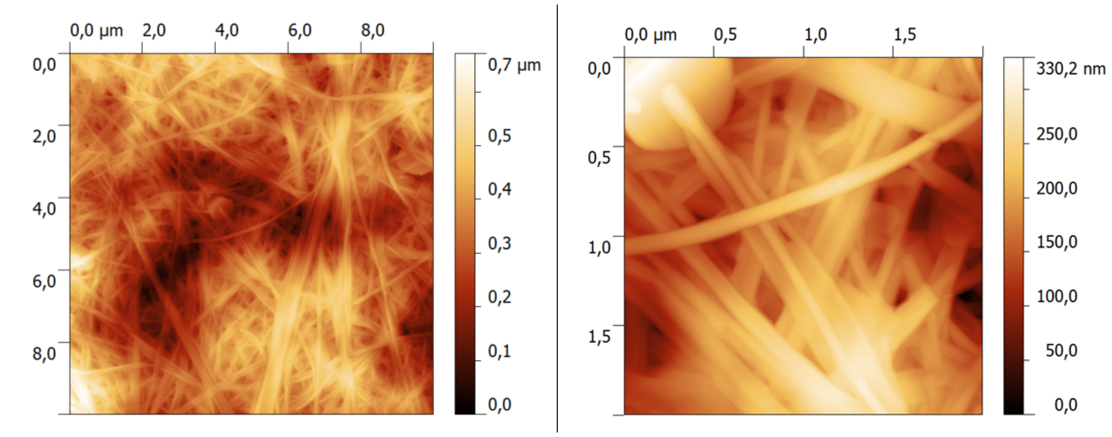

Fig. S.15: AFM image of gel-**1** in ethanol/water 45:55.

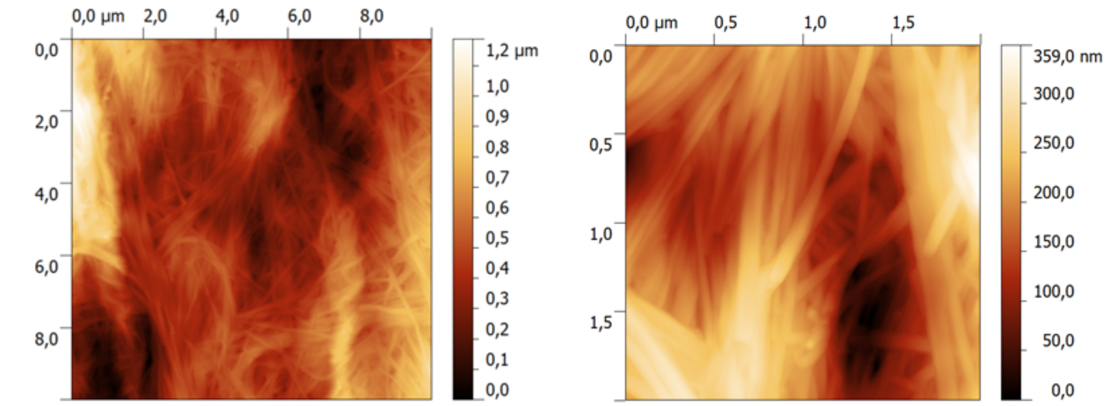

Fig. S.16: AFM image of gel-**1** in ethanol/water 50:50.

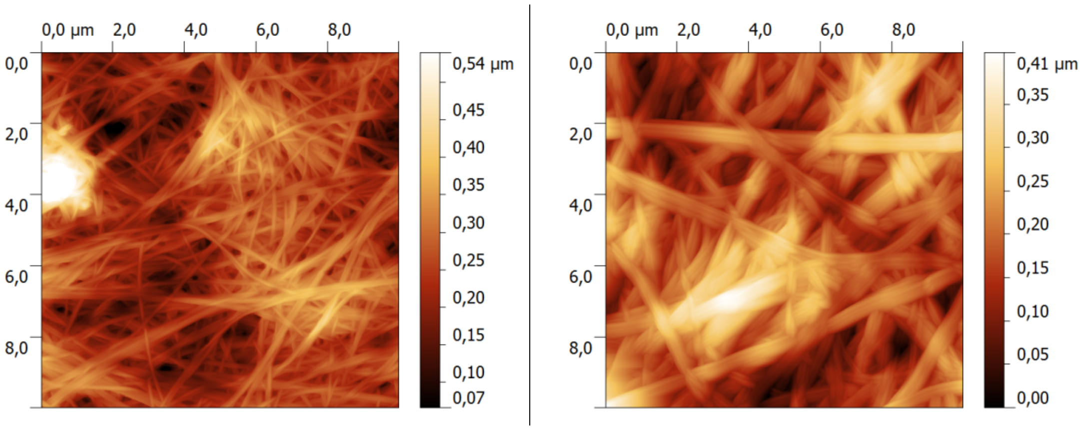

Fig. S.17: AFM image of gel-**Ibu** (10:1 w/w) (left) and gel-**Ibu** (10:2.5 w/w) (right) in ethanol/water 40:60.

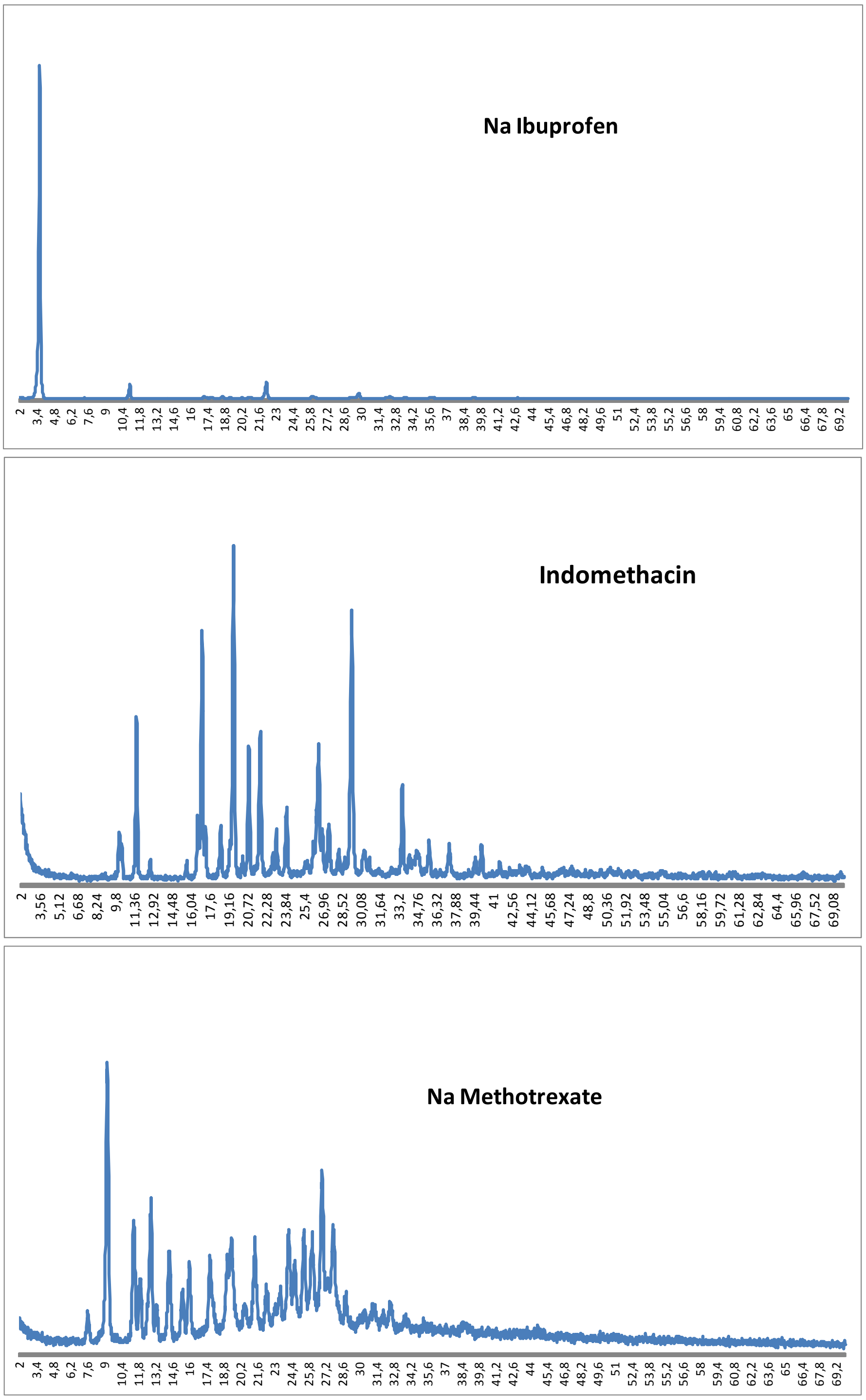

Fig. S18: X-ray powder diffractograms of sodium ibuprofenate (A), indomethacin (B), and methotrexate (C).

Table S1:

Kinetic models used to fit the data for the release of the different model drugs from the corresponding gel, and the respective AIC parameter:

Kinetic model	Equation	AIC		
		Gel-**Ibu**	Gel-**Ind**	Gel-**Mtx**
First Order	$Qt/Q\infty = 1 - e^{-Kt}$	**11.30**	**15.67**	**8.29**
Higuchi	$Qt/Q\infty = K * t^{1/2}$	33.29	52.30	26.68
Korsmeyer-Peppas	$Qt/Q\infty = K * t^{n}$	35.29	47.75	9.61

Qt is the amount of drug released at time t

Q∞ is the total amount of drug released

Qt/Q∞ is the fraction of drug released at time t

K is the release rate constant

P is the Plateau (Q at t∞) and S is the Span (the difference between Q_0 and P)

n is the diffusion release exponent that could be used to characterize the different release mechanism ($n \leq 0.43$ (Fickian diffusion), $0.43 < n < 0.85$ (anomalous transport), and ≥ 0.85 (case II transport; i.e. zero order release)

t_d is the time in which the 63.2% of the drug is released and β is the shape parameter