# Dendronized Ni-Porphyrins as Photoswitchable Contrast Agents for MRI

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# I. Experimental Section

## I.1 General Information

Commercially available solvents and starting materials were used as received. THF was distilled from benzophenone-Na. Column chromatography was carried out using 0.040–0.063 mm mesh silica gel (Merck). $R_f$ values were determined by thin layer chromatography on Polygram® Sil G/$UV_{254}$ (Macherey-Nagel, 0.2 mm particle size).

NMR spectra were measured in Schott Economic NMR tubes using deuterated solvents (Deutero). Chemical shifts of $^1$H-NMR spectra are calibrated to residual protonated solvent signals ($^1$H: δ (acetone-$d_6$) = 2.05 ppm, δ (methanol-$d_4$) = 3.31 ppm). Reference for $^{19}$F-NMR spectra is $CFCl_3$ to which the spectrometer is calibrated in an independent measurement. The signal multiplicities are abbreviated as s (singlet), d (doublet), t (triplet), q (quartet), quint (quintet), m (multiplet) and br (broad signal). $^{19}$F NMR spectra were measured $^1$H-decoupled. Measurements were performed with a Bruker DRX 500 ($^1$H NMR: 500 MHz, $^{19}$F NMR: 470 MHz). $^{13}$C-NMR assignment of the Ni-porphyrins was not possible due to low intensity.

The electro spray ionization (ESI) high resolution (HR) mass spectra were measuredwith an APEX 3 FT-ICT mass spectrometer with a 7.05 T magnet provided by Bruker Daltronics.

UV-visible absorption spectra were recorded on a Perkin-Elmer Lambda-14 spectrophotometer with a Büchi thermostat and on a PerkinElmer Lambda 650 spectrophotometer with an Oxford Instruments MercuryiTC thermostat using quartz cells of 1 cm path length.

Irradiation experiments were performed with LED light sources provided by Sahlmann Photochemical Solutions.

All magnetic resonance imaging (MRI) experiments were carried out on a 7 Tesla small animal MR system (ClinScan 7T, Bruker, Ettlingen, Germany).

## I.2 Synthetic procedures

The glycerol dendrimers (G[1.1] and G[2.1])[1] and the parent Ni-porphyrins (**1** and **2**)[2,3] were prepared according to previously published procedures.

### General Procedure A: Introduction of glycerol dendrimers to the Ni-porphyrin

4-5 equivalents of glycerol dendrimer (G[1.1], G[2.1]) were added to a suspension of 4-5 equivalents sodium hydride (60% in mineral oil) in dry tetrahydrofuran. The mixture was stirred for 15 minutes. One equivalent of the Ni-porphyrin (**1**or**2**) was added. The mixture was stirred for two days. The mixture was poured into water and extracted twice with dichloromethane. The combined organic layers were dried over magnesium sulfate and the solvent was removed under reduced pressure. The crude product was purified by column chromatography (silica gel 0.040-0.063 mm, dichloromethane/methanol = 99/1 → 97/3). The excess of glycerol dendrimer cannot be removed by this method. The products **1**-G[1.1], **1**-G[2.1], **2**-G[1.1] and **2**-G[2.1] were obtained as deep violet oils.

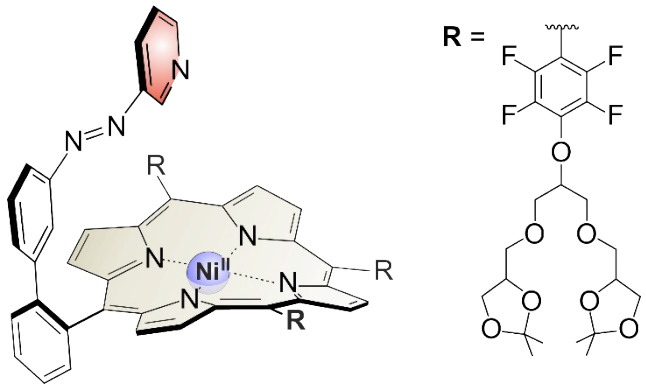
### General Procedure B: Removal of acetal protection groups

The glycerol functionalized Ni-porphyrins (**1**-G[1.1], **1**-G[2.1], **2**-G[1.1] or**2**-G[2.1]) were stirred at 40°C overnight in a mixture of methanol/acetic acid/water = 2/2/1. The solvents were removed under reduced pressure to obtain **1**-G[1.0], **1**-G[2.0], **2**-G[1.0] and **2**-G[2.0] as deep violet oils in quantitative yield.

**1-G[1.1]**

Ni-porphyrin **1** (12.6 mg, 12.3 µmol) and G[1.1] (15.8 mg, 49.3 µmol) were treated according to general procedure A.

Yield: 17.5 mg (8.65 µmol, 70%)



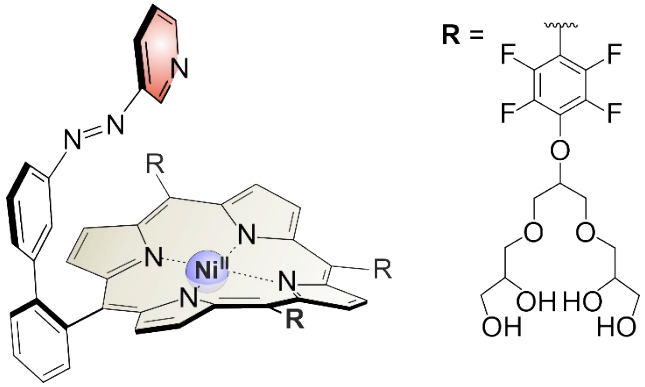

**$^{1}$H-NMR (500 MHz, acetone-d$_6$, 300 K):**δ = 9.48 (s, br, 1H, Py-*H*-2), 9.23 (s, br, 2H, Por-*H*), 9.22 (s, br, 2H, Por-*H*), 9.16 (s, br, 2H, Por-*H*), 9.11 (s, br, 2H, Por-*H*), 9.03 (s, br, 1H, Py-*H*-6), 8.32 (d, $^{3}J$ = 7.3 Hz, 1H, Por-CC*H*), 7.99 (t, $^{3}J$ = 7.7 Hz, 1H, Por-CCCHC*H*), 7.91 (d,$^{3}J$ = 7.6 Hz, 1H, Por-CCC*H*), 7.87 (t, $^{3}J$ = 7.5 Hz, 1H, Por-CCHC*H*), 7.63, (s, br, 1H, Py-*H*-4), 7.40 (s, 1H, $N_2CCHC$), 7.23-7.17 (m, br, 1H, Py-*H*-5), 7.12 (d, $^{3}J$ = 7.6 Hz, 1H, $N_2CCHCCH$), 7.07 (d, $^{3}J$ = 7.8 Hz, 1H, $N_2CCHCH$), 6.74 (t, $^{3}J$ = 7.7 Hz, 1H, $N_2CCHCH$), 4.94 (quint, $^{3}J$ = 4.8 Hz, 3H, $C_6F_4OCH$), 4.33-4.28 (m, 6H, $CHOC(CH_3)_2$), 4.11-4.07 (m, 6H, $CH_2OC(CH_3)_2$), 4.03-3.99 (m, 12H, $C_6F_4OC(CH_2)_2$), 3.81-3.76 (m, 6H, $CH_2OC(CH_3)_2$), 3.70-3.62 (m, 12H, $CH_2CHOC(CH_3)_2$), 1.38-1.36 (m, 18H, $CH_3$),1.31-1.27 (m, 18H, $CH_3$) ppm.

**$^{19}$F-NMR (470 MHz, acetone-d$_6$, 300 K):**δ = -141.40 to -141.50 (m, 2F, Por-Ar-*o*-F), -141.74 to -141.88 (m, 1F, Por-Ar-*o*-F), -142.01 to -142.13 (m, 1F, Por-Ar-*o*-F), -142.24 to 142.36 (m, 2F, Por-Ar-*o*-F), -157.12 to 157.32 (m,2F, Por-Ar-*m*-F), -157.41 to -157.66 (m, 4F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):** m/z $[M+H]^+$calcd for $C_{100}H_{102}F_{12}N_7O_{21}Ni$, 2022.628; found 2022.618.

**1-G[1.0]**

Preparation according to general procedure B.




**$^{1}$H-NMR (500 MHz, methanol-d$_4$, 300 K):**δ = 9.25-9.05 (m, br, 8H, Por-*H*), 8.34 (d, $^{3}J$ = 7.3 Hz, 1H, Por-CC*H*), 7.94 (t, $^{3}J$ = 7.8 Hz, 1H, Por-CCCHC*H*), 7.88 (d, $^{3}J$ = 7.7 Hz, 1H, Por-CCC*H*), 7.84 (t, $^{3}J$ = 7.5 Hz, 1H, Por-CCHC*H*), 7.30 (s, br, 1H, Py-*H*-4), 7.15 (d, $^{3}J$ = 7.7 Hz, 1H, $N_2$CCHCC*H*), 7.00 (d, $^{3}J$ = 7.9 Hz, 1H, $N_2$CC*H*CH), 6.90-6.87 (m, br, 1H, Py-*H*-5), 6.79-6.74 (m, 2H, $N_2$CC*H*C, $N_2$CCHC*H*), 4.96 (quint, $^{3}J$ = 4.8 Hz, 3H, $C_6F_4OCH$), 4.03-3.96 (m, 12H, $C_6F_4OC(CH_2)_2$), 3.87-3.84 (m, 6H, C*H*OH), 3.71-3.57 (m, 24H, $CH_2OH$, $OCH_2CHOH$) ppm. (Py-*H*-2 and Py-*H*-6 do not appear due to paramagnetic line broadening, HO-protons do not appear due to fast exchange with the solvent)

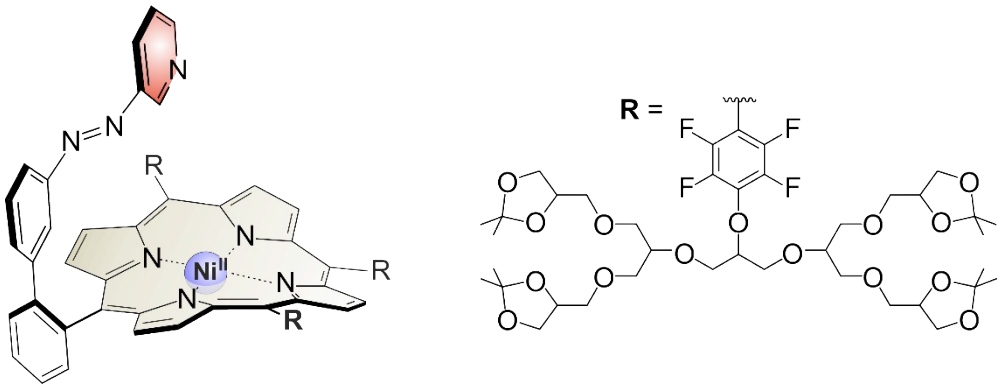
**$^{19}$F-NMR (470 MHz, methanol-d$_4$, 300 K):**δ = -141.73 to -141.84 (m, 2F, Por-Ar-*o*-F), -142.08 to -142.28 (m, 2F, Por-Ar-*o*-F), -142.52 to 142.61 (m, 2F, Por-Ar-*o*-F), -158.15 to 158.23 (m,2F, Por-Ar-*m*-F), -158.33 to -158.46 (m, 4F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):** m/z $[M+H]^+$calcd for $C_{100}H_{102}F_{12}N_7O_{21}Ni$, 2022.628; found 2022.618.

**1-G[2.1]**

Ni-porphyrin **1** (20.2 mg, 18.0 µmol) and G[2.1] (62.7 mg, 90.0 µmol) were treated according to general procedure A.

Yield: 51.0 mg (16.2 µmol, 90%)



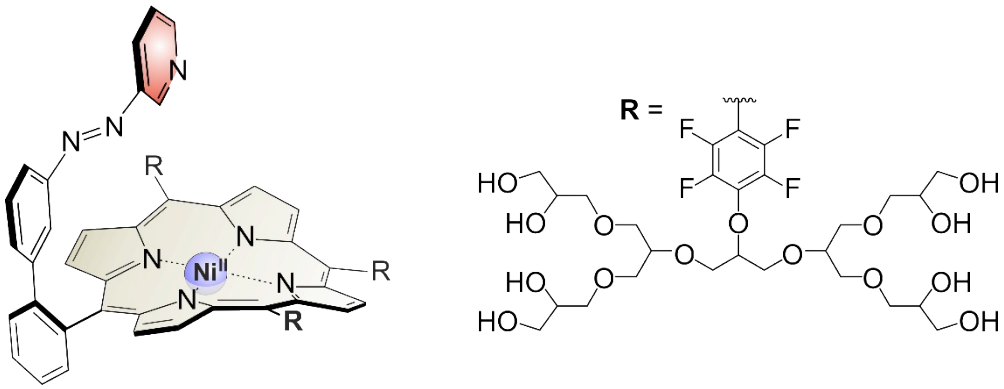

**$^{1}$H-NMR (500 MHz, acetone-d$_6$, 300 K):**δ = 9.67 (s, br, 2H, Py-*H*-2, Py-*H*-6), 9.22 (s, br, 2H, Por-*H*), 9.21 (s, br, 2H, Por-*H*), 9.14 (s, br, 2H, Por-*H*), 9.12 (s, br, 2H, Por-*H*), 8.36 (d, $^{3}J$ = 7.3 Hz, 1H, Por-CC*H*), 8.00 (t, $^{3}J$ = 7.7 Hz, 1H, Por-CCCHC*H*), 7.92 (d, $^{3}J$ = 7.6 Hz, 1H, Por-CCC*H*), 7.89 (t, $^{3}J$ = 7.5 Hz, 1H, Por-CCHC*H*), 7.71, (s, br, 1H, Py-*H*-4), 7.41 (s, 1H, $N_2CC$*H*C), 7.22 (s, br, 1H, Py-*H*-5), 7.12 (d, $^{3}J$ = 7.6 Hz, 1H, $N_2CCHCC$*H*), 7.08 (d, $^{3}J$ = 7.8 Hz, 1H, $N_2CC$*H*CH), 6.75 (t, $^{3}J$ = 7.7 Hz, 1H, $N_2CCHC$*H*), 4.93 (m, 3H, $C_6F_4OC$*H*), 4.29-4.23 (m, 12H, C*H*OC(CH$_3$)$_2$), 4.16-4.14 (m, 12H, $C_6F_4OC(CH_2)_2$), 4.05-4.01 (m, 12H, $CH_2OC(CH_3)_2$), 3.84-3.80 (m, 6H, OC*H*(CH$_2$)$_2$), 3.76-3.73 (m, 12H, $CH_2OC(CH_3)_2$), 3.70-3.64 (m, 24H, OCH(C*H*$_2$)$_2$), 3.60-3.53 (m, 24H, $CH_2CHOC(CH_3)_2$), 1.35-1.33 (m, 36H, C*H*$_3$), 1.29-1.27 (m, 36H, C*H*$_3$) ppm.

**$^{19}$F-NMR (470 MHz, acetone-d$_6$, 300 K):**δ = -141.35 to -141.52 (m, 2F, Por-Ar-*o*-F), -141.66 to -141.82 (m, 1F, Por-Ar-*o*-F), -141.97 to -142.15 (m, 1F, Por-Ar-*o*-F), -142.21 to 142.39 (m, 2F, Por-Ar-*o*-F), -156.89 to 157.05 (m,2F, Por-Ar-*m*-F), -157.06 to -157.32 (m, 4F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):** m/z $[M+3H]^{3+}$calcd for $C_{154}H_{200}F_{12}N_7O_{45}Ni$, 1051.091; found 1051.089.

**1-G[2.0]**

Preparation according to general procedure B.




**$^{1}$H-NMR (500 MHz, methanol-d$_4$, 300 K):**δ = 9.04 (d, $^{3}J$ = 4.9 Hz, 2H, Por-*H*), 8.99 (d, $^{3}J$ = 4.9 Hz, 2H, Por-*H*), 8.93 (d, $^{3}J$ = 4.9 Hz, 2H, Por-*H*), 8.89 (d, $^{3}J$ = 4.9 Hz, 2H, Por-*H*), 8.62 (d, $^{3}J$ = 5.3 Hz, 1H, Py-*H*-6), 8.33 (d, $^{3}J$ = 7.4 Hz, 1H, Por-CC*H*), 8.24 (s, 1H, Py-*H*-2), 7.88 (t, $^{3}J$ = 7.6 Hz, 1H, Por-CCHC*H*), 7.79 (d, $^{3}J$ = 7.6 Hz, 1H, Por-CCC*H*), 7.77 (t, $^{3}J$ = 7.8 Hz, 1H, Por-CCCHC*H*), 7.59 (dd, $^{3}J$ = 5.3, 7.8 Hz, 1H, Py-*H*-5), 7.27 (d, $^{3}J$ = 7.5 Hz, 1H, $N_2$CCHCC*H*), 7.04 (d, $^{3}J$ = 7.8 Hz, 1H, Py-*H*-4), 6.93 (d, $^{3}J$ = 8.0 Hz, 1H, $N_2$CC*H*CH), 6.81 (t, $^{3}J$ = 7.8 Hz, 1H, $N_2$CCHC*H*), 6.67 (s, 1H, $N_2$CC*H*C), ~5.00 ($C_6F_4$OC*H*), 4.16-3.97 (m, 12H, $C_6F_4$OCH($CH_2$)$_2$), 3.86-3.46 (m, 114H) ppm. (The $C_6F_4$OC*H* signal cannot be integrated due to overlapping with the water signal, HO-protons do not appear due to fast exchange)

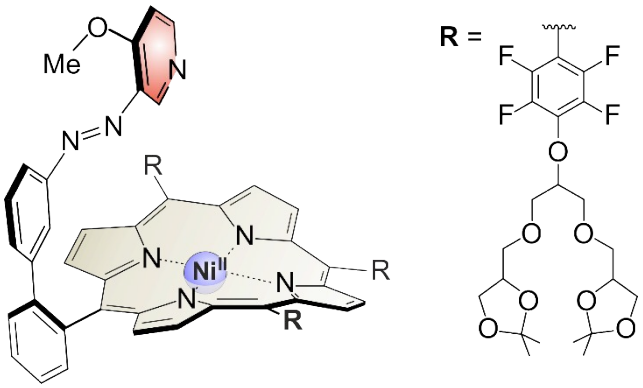
**$^{19}$F-NMR (470 MHz, methanol-d$_4$, 300 K):**δ = -141.35 to -141.52 (m, 2F, Por-Ar-*o*-F), -141.66 to -141.82 (m, 1F, Por-Ar-*o*-F), -141.97 to -142.15 (m, 1F, Por-Ar-*o*-F), -142.21 to 142.39 (m, 2F, Por-Ar-*o*-F), -156.89 to 157.05 (m,2F, Por-Ar-*m*-F), -157.06 to -157.32 (m, 4F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):** m/z $[M+2H]^{2+}$calcd for $C_{118}H_{151}F_{12}N_7O_{45}Ni$, 1335.945; found 1335.943.

**2-G[1.1]**

Ni-porphyrin **2** (18.0 mg, 15.6 µmol) and G[1.1] (20.0 mg, 62.5 µmol) were treated according to general procedure A.

Yield: 24.0 mg (12.0 µmol, 77%)



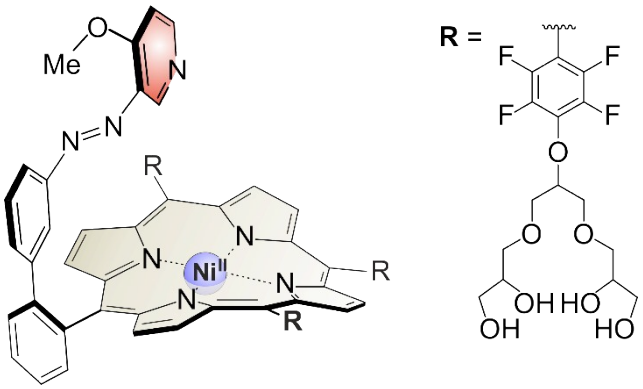

**$^{1}$H-NMR (500 MHz, acetone-d$_6$, 300 K):**δ = 9.19-9.01 (m, br, 8H, Por-*H*), 8.28 (d, $^{3}J$ = 7.4 Hz, 1H, Por-CC*H*), 8.00 (t, $^{3}J$ = 7.8 Hz, 1H, Por-CCCHC*H*), 7.91 (d, $^{3}J$ = 7.5 Hz, 1H, Por-CCC*H*), 7.87 (t, $^{3}J$ = 7.7 Hz, 1H, Por-CCHC*H*), 7.77 (s, 1H, $N_2CC$*H*C), 7.02 (d, $^{3}J$ = 7.7 Hz, 1H, $N_2CCHCC$*H*), 6.83 (d, $^{3}J$ = 7.8 Hz, 1H, $N_2CC$*H*CH), 6.71 (s, br, 1H, Py-*H*-5), 6.50 (t, $^{3}J$ = 7.8 Hz, 1H, $N_2CCHC$*H*),4.94 (m, 3H, $C_6F_4OC$*H*), 4.33-4.28 (m, 6H, C*H*OC(CH$_3$)$_2$), 4.11-4.07 (m, 6H, C*H*$_2$OC(CH$_3$)$_2$), 4.05-4.00 (m, 12H, $C_6F_4OC$(C*H*$_2$)$_2$), 3.85 (s, br, 3H, OC*H*$_3$), 3.80-3.76 (m, 6H, C*H*$_2$OC(CH$_3$)$_2$), 3.72-3.63 (m, 12H, C*H*$_2$CHOC(CH$_3$)$_2$), 1.38-1.36 (m, 18H, CH$_3$), 1.31-1.27 (m, 18H, CH$_3$) ppm. (Py-*H*-2 and Py-*H*-6 do not appear due to paramagnetic line broadening)

**$^{19}$F-NMR (470 MHz, acetone-d$_6$, 300 K):**δ = -141.40 to -141.50 (m, 2F, Por-Ar-*o*-F), -141.82 to -141.92 (m, 1F, Por-Ar-*o*-F), -142.06 to -142.16 (m, 1F, Por-Ar-*o*-F), -142.29 to 142.39 (m, 2F, Por-Ar-*o*-F), -157.21 to 157.36 (m,2F, Por-Ar-*m*-F), -157.48 to -157.72 (m, 4F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):**no result.

**2-G[1.0]**

Preparation according to general procedure B.




**$^{1}$H-NMR (500 MHz, methanol-d$_4$, 300 K):**δ = 9.43 (s, br, 8H, Por-*H*), 8.22 (d, $^{3}J$ = 7.2 Hz, 1H, Por-CC*H*), 7.93 (t, $^{3}J$ = 7.8 Hz, 1H, Por-CCCHC*H*), 7.87 (d, $^{3}J$ = 7.7 Hz, 1H, Por-CCC*H*), 7.81 (t, $^{3}J$ = 7.6 Hz, 1H, Por-CCHC*H*), 7.45 (s, br, 1H, Py-*H*-5), 6.99 (d, $^{3}J$ = 7.8 Hz, 1H, $N_2$CCHCC*H*), 6.85-6.81 (m, 2H, $N_2$CC*H*CH, $N_2$CCHC*H*), 6.49 (s, 1H, $N_2$CC*H*C), 4.95 (quint, $^{3}J$ = 4.8 Hz, 3H, $C_6F_4$OC*H*), 4.02-3.97 (m, 12H, $C_6F_4$OC($CH_2$)$_2$), 3.88-3.83 (m, 9H, C*H*OH, O$CH_3$), 3.72-3.53 (m, 24H, $CH_2$OH, O$CH_2$CHOH) ppm. (Py-*H*-2 and Py-*H*-6 do not appear due to paramagnetic line broadening, HO-protons do not appear due to fast exchange with the solvent)

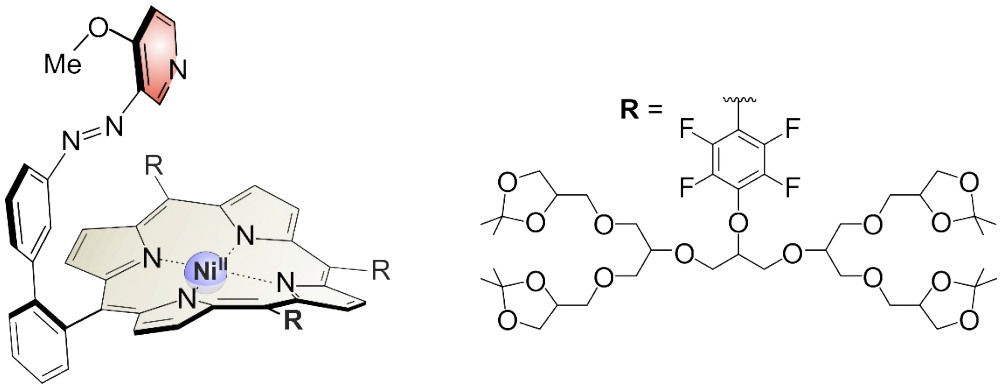
**$^{19}$F-NMR (470 MHz, methanol-d$_4$, 300 K):**δ = 141.77 to -141.91 (m, 2F, Por-Ar-*o*-F), -142.05 to -142.17 (m, 2F, Por-Ar-*o*-F), -142.37 to 142.47 (m, 2F, Por-Ar-*o*-F), -158.12 to 158.18 (m,2F, Por-Ar-*m*-F), -158.28 to -158.42 (m, 4F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):** m/z [M+H]$^{+}$calcd for $C_{83}H_{80}F_{12}N_7O_{22}Ni$, 1812.451; found 1812.454.

**2-G[2.1]**

Ni-porphyrin **2** (24.8 mg, 21.5 µmol) and G[2.1] (75.0 mg, 108 µmol) were treated according to general procedure A.

Yield: quant.




**$^{1}$H-NMR (500 MHz, acetone-d$_6$, 300 K):**δ = 9.38 (s, br, 8H, Por-*H*), 9.03 (s, br, 1H, Py-*H*-2),8.98 (s, br, 1H, Py-*H*-6), 8.31 (d, $^{3}J$ = 7.4 Hz, 1H, Por-CC*H*), 8.01 (t, $^{3}J$ = 7.7 Hz, 1H, Por-CCCHC*H*), 7.92 (d, $^{3}J$ = 7.6 Hz, 1H, Por-CCC*H*), 7.89 (t, $^{3}J$ = 7.6 Hz, 1H, Por-CCHC*H*), 7.78 (s, 1H, $N_2CCHC$), 6.99 (d, $^{3}J$ = 7.7 Hz, 1H, $N_2CCHCCH$), 6.80 (d, $^{3}J$ = 7.7 Hz, 1H, $N_2CCHCH$), 6.72 (s, br, 1H, Py-*H*-5), 6.46 (t, $^{3}J$ = 7.7 Hz, 1H, $N_2CCHCH$), 4.93 (m, 3H, $C_6F_4OCH$), 4.27-4.23 (m, 12H, $CHOC(CH_3)_2$), 4.16-4.14 (m, 12H, $C_6F_4OC(CH_2)_2$), 4.04-4.01 (m, 12H, $CH_2OC(CH_3)_2$), 3.84-3.80 (m, 9H, $OCH(CH_2)_2$, $OCH_3$), 3.74-3.64 (m, 36H, $CH_2OC(CH_3)_2$, $OCH(CH_2)_2$), 3.60-3.51 (m, 24H, $CH_2CHOC(CH_3)_2$), 1.34-1.32 (m, 36H, $CH_3$), 1.28-1.26 (m, 36H, $CH_3$) ppm.

**$^{19}$F-NMR (470 MHz, acetone-d$_6$, 300 K):**δ = -141.27 to -141.42 (m, 2F, Por-Ar-*o*-F), -141.56 to -141.72 (m, 1F, Por-Ar-*o*-F), -141.87 to -142.21 (m, 3F, Por-Ar-*o*-F), -156.84 to 157.36 (m,6F, Por-Ar-*m*-F) ppm.

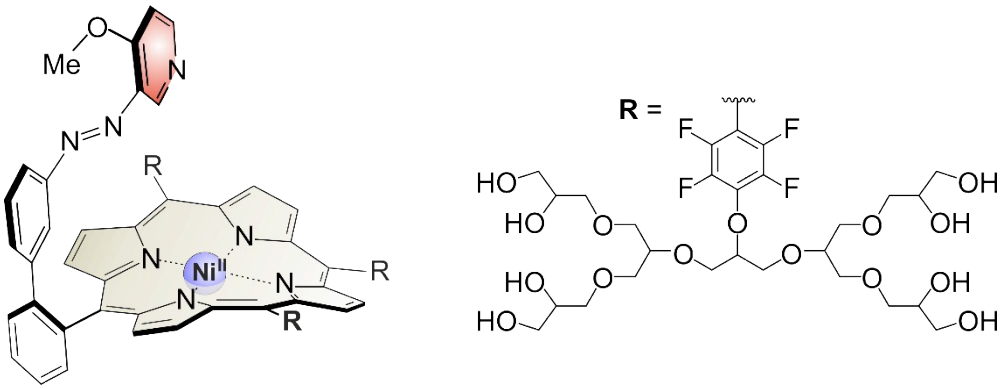
**HR-MS (ESI):**no result.

**UV-Vis** (MeOH, 435 nm): $\lambda_{max}$ (lgε) = 330 (4.4644), 408 (5.3929), 525 (4.2604), 557 (4.0240) nm.

**UV-Vis** (MeOH + 12 % piperidine): $\lambda_{max}$ (lgε) = 431 (5.4336), 556 (4.2603) nm.

**2-G[2.0]**

Preparation according to general procedure B.




**$^{1}$H-NMR (500 MHz, methanol-d$_4$, 300 K):**δ = 9.11 (s, br, 4H, Por-*H*), 9.03 (s, br, 2H, Por-*H*), 8.97 (s, br, 2H, Por-*H*), 8.62 (s, br, 2H, Py-*H*-6, Py-*H*-2), 8.21 (d, $^{3}J$ = 7.4 Hz, 1H, Por-CC*H*), 7.86 (t, $^{3}J$ = 7.6 Hz, 1H, Por-CCHC*H*), 7.80-7.75 (m, 2H, Por-CCC*H*, Por-CCCHC*H*), 7.68 (s, br, 1H, Py-*H*-5), 7.12-7.09 (m, 2H, $N_2$CCHCC*H*, $N_2$CC*H*CH), 6.74 (t, $^{3}J$ = 7.8 Hz, 1H, $N_2$CCHC*H*), 6.61 (s, 1H, $N_2$CC*H*C), ~5.00 ($C_6F_4$OC*H*), 4.15-4.04 (m, 12H, $C_6F_4$OCH($CH_2$)$_2$), 3.86-3.46 (m, 117H) ppm. (The $C_6F_4$OC*H* signal cannot be integrated due to overlapping with the water signal, HO-protons do not appear due to fast exchange)

**$^{19}$F-NMR (470 MHz, methanol-d$_4$, 300 K):**δ = -141.72 to -141.10 (m, 6F, Por-Ar-*o*-F), -157.50 to -157.74 (m, 6F, Por-Ar-*m*-F) ppm.

**HR-MS (ESI):** m/z $[M+2H]^{2+}$calcd for $C_{119}H_{153}F_{12}N_7O_{46}Ni$, 1350.950; found 1350.952.

**UV-Vis** ($H_2O$, 435 nm): $\lambda_{max}$ (lgε) = 327 (4.3729), 413 (5.1629), 527 (4.1562), 560 (3.9442) nm.

**UV-Vis** ($H_2O$ + 12 % piperidine): $\lambda_{max}$ (lgε) = 433 (5.4163), 558 (4.2244) nm.

## I.3 Preparation of Gels

**Agar Phantom** (Fig.3 and Fig. S11)

37 mL water were added to 370 mg agar in a glas vial (10 cm high, 2.5 cm diameter) and heated to 95°C until the gelator was dissolved. Two holes (4mm in diameter) were stamped in the corresponding lid for NMR tubes, which were inserted into the hot aqueous agar solution. The NMR tubes were located at the right height with a bracket and the solution was slowly cooled to room temperature. Both NMR tubes were filled with 0.60 mL of 5 mM aqueous solution of **2**-G[2.0] (Fig S11) or 0.50 mL of 5 mM solution of **2**-G[2.0] in blood serum (Fig 3). For more information see III (MRI Experiments).

**Methanol based gel**(Fig. 4 left, Fig. S13 left)

(±)-*trans*-1,2-bis(dodecylureido)cyclohexane was chosen as gelator for methanol. It was synthesized applying the method of Kellogg and Feringa et al. using dodecylisothiocyanate and *trans*-1,2-cyclohexyldiamine in toluene.[4] The minimum gel concentration of the bisurea derivative is 3 mg/mL.[5]
The record player gel sample was prepared as followed:
A 0.80 mM solution of **2**-G[2.1] in methanol with a gelator concentration of 4.0 mg/mL was heated to 60°C, filled in a 1 mm cuvette and cooled down in an ice bath for one minute. After warming up to room temperature the Ni-porphyrin-gel sample was suitable for switching experiments.
The cuvette was irradiated with green light (505 nm) through a pattern of the CAU (Christian-Albrechts-University of Kiel) logo. The switching of the Ni-porphyrin was visible with the bare eye and was also investigated by MRI.

**Hydrogel with Agar**(Fig. 4right, Fig. S13 right)

A 5 mM solution of **2**-G[2.0] in water with an agar concentration of 10 mg/mL was heated to 95°C, filled in a 1 mm cuvette and cooled down slowly to room temperature. After preparation switching experiments as described above and MRI investigations followed.

# II. UV-vis experiments

## II.1 Switching in Organic Solvents

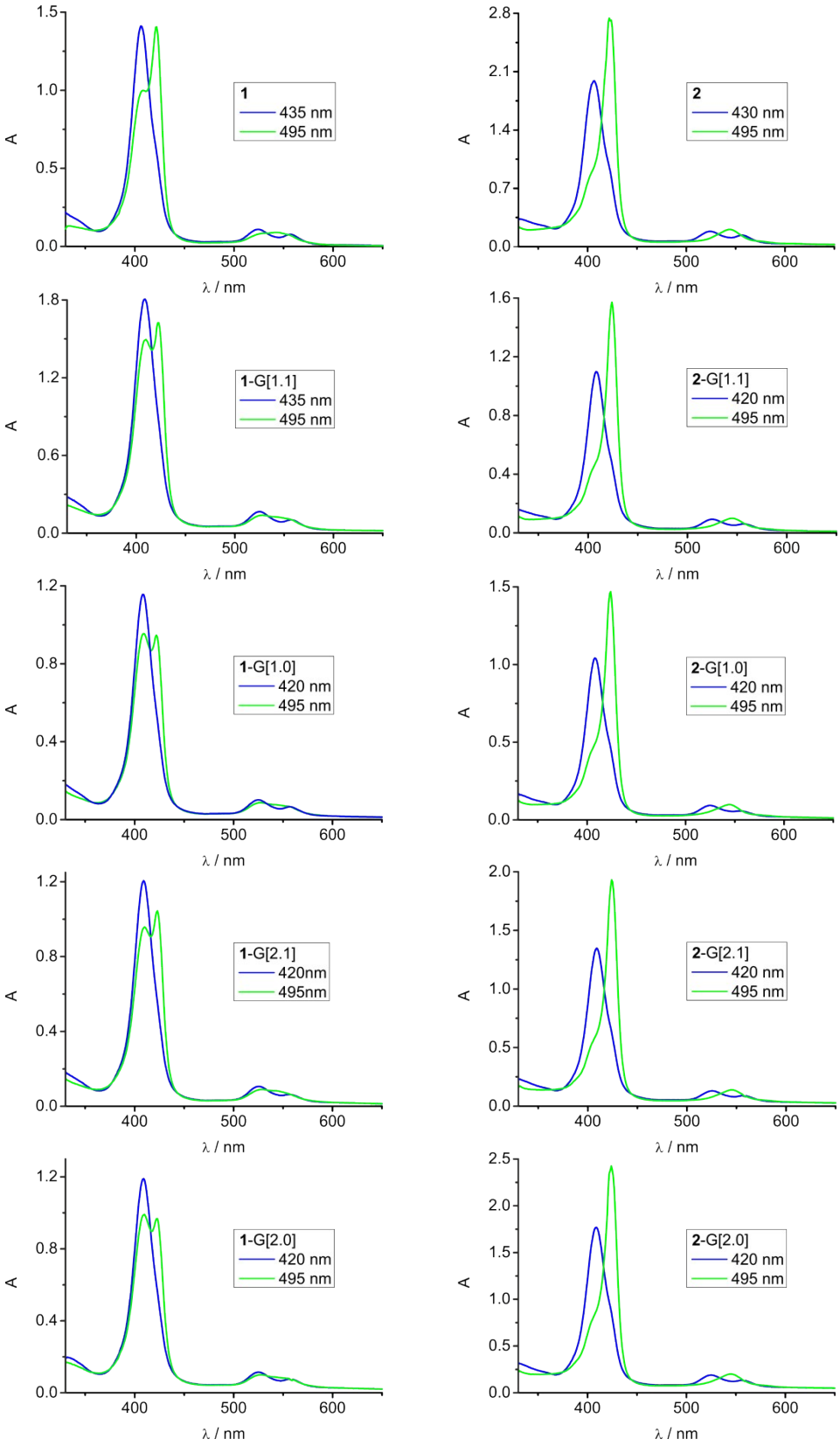



**Fig. S1:** UV-vis spectra (acetone) of **1**, **1**-G[1.1], **1**-G[1.0], **1**-G[2.1], **1**-G[2.0], **2**, **2**-G[1.1], **2**-G[1.0],**2**-G[2.1] and **2**-G[2.0] after irradiation with blue (420-435 nm) and green light (495 nm).

The irradiation experiments in acetone (Fig. S1) reveal that the *trans* to *cis* somerisation of the derivatives of **1** (pyridine ligand) strongly depend on the *meso*-*p*-aryl substituent. A strong decrease is found for the introduction of the dendrimers: **1**-G[1.1] and **1**-G[2.1] exhibit worse PSS@495nm than **1**. A slight decrease is found for the acetal deprotection: **1**-G[1.0] and **1**-G[2.0] exhibit worse PSS@495nm than **1**-G[1.1] and **1**-G[2.1]. All derivatives of **2** (methoxy pyridine ligand) exhibit a similar PSS@495nm suggesting that the stronger ligand is overcompensating the loss of binding affinity.

## II.2 Switching in Gels

The UV-vis experiments in gel reveal that the gel is not decreasing the switching efficiency compared to the solution (Fig. S2). The switching efficiency of **2**-G[2.0] in water is reduced to ~15-20% compared to >90% in organic solvents as acetone (Fig. S1, bottom right).

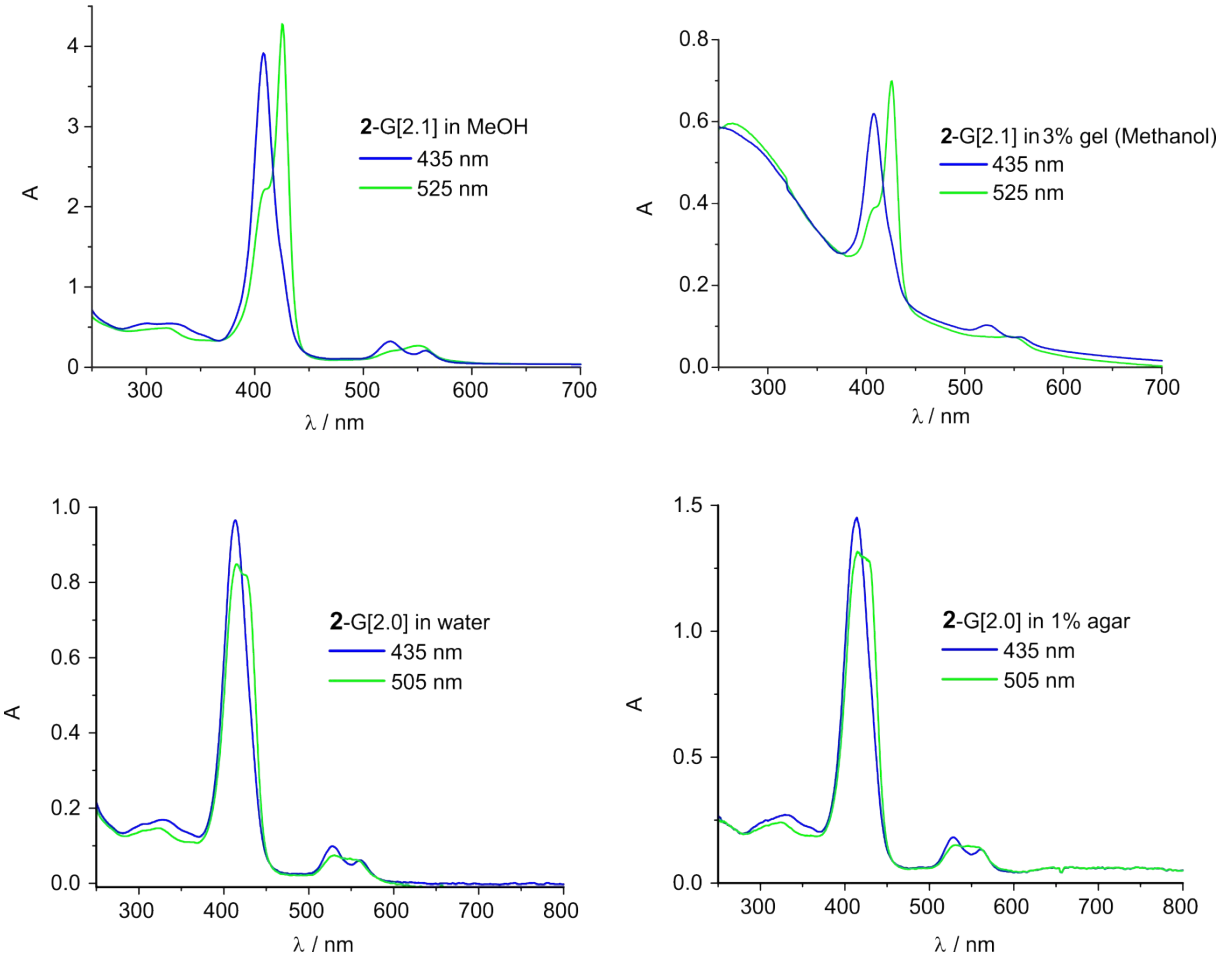



**Fig. S2:** Top: UV-vis spectra of **2**-G[2.1] in methanol and methanolic gel (gelator: (±)-*trans*-1,2-bis(dodecylureido)cyclohexane). Bottom: UV-vis spectra of **2**-G[2.0] in water and agar gel.

## II.3 Long-term Switching Stability

Additional fatigue experiments were carried out to prove the compounds' long-term stability. Measurements were carried out with an in-house built automatic switching unit (Fig. S3). Two light sources were used, 435 nm and 505 nm. The light output power and irradiance was measured in several distances. 30 mW/cm² were chosen as a maximum of one of the LED units. For measurements a light power meter (SV120C + PM100D, Thorlabs, Newton, NJ, USA) was used. Each wavelength irradiated the sample for 2 min (4 min per cycle). In total 50 cycles were used (Fig. S4).


**Fig. S3:** In-house built automatic switching unit (left) connected to two light sources (435 nm and 505 nm, right).

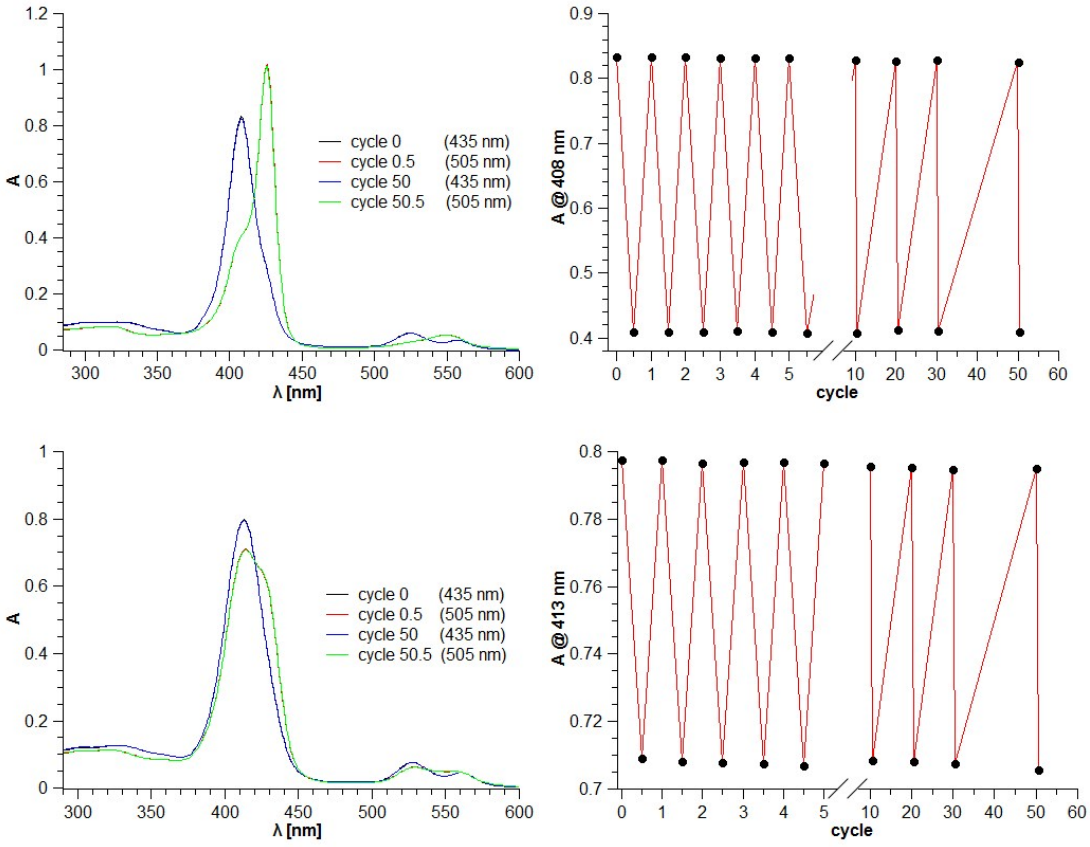



**Fig. S4:** UV-vis spectra after the first and the 50th cycle (left) and the absorption at a specific wavelength (408 nm or 413 nm) after several cycles (right) of **2**-G[2.1] in methanol (top) and of **2**-G[2.0] in water (bottom).

## II.4 Switching Efficiency in Methanol and Water

To determine the percentage of the paramagnetic species of **2**-G[2.1] in methanol and of **2**-G[2.0] in water after irradiation with green light (505 nm) the extinction coefficients of both record players were determined via UV-Vis spectroscopy (Fig. S5 and S7). Because of incomplete switching to the cis isomers piperidine was added to calculate the extinction coefficient of the paramagnetic soret band (Fig. S6 and S8).

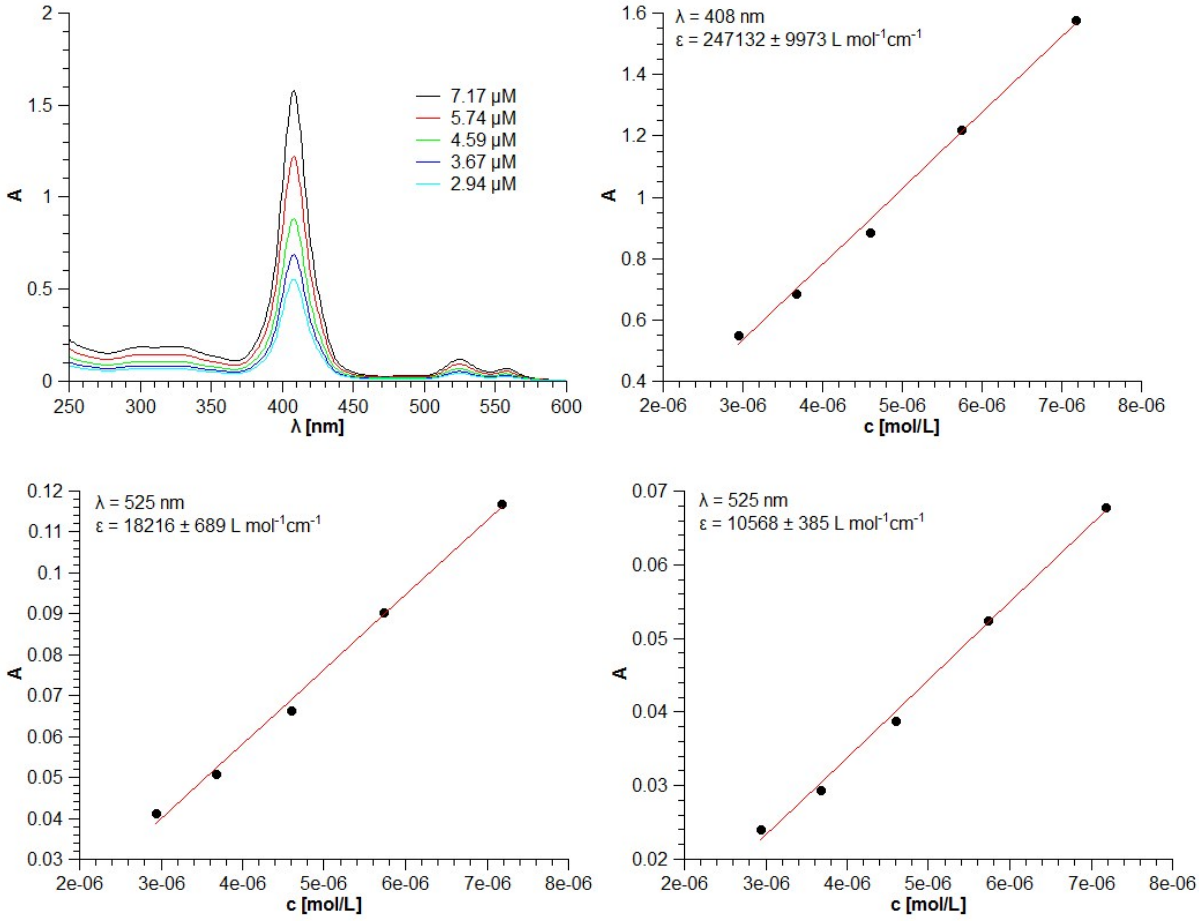



**Fig S5:** UV-Vis spectra (top left) and extinction coefficients of **2**-G[2.1] in methanol after irradiation with blue light (435 nm).

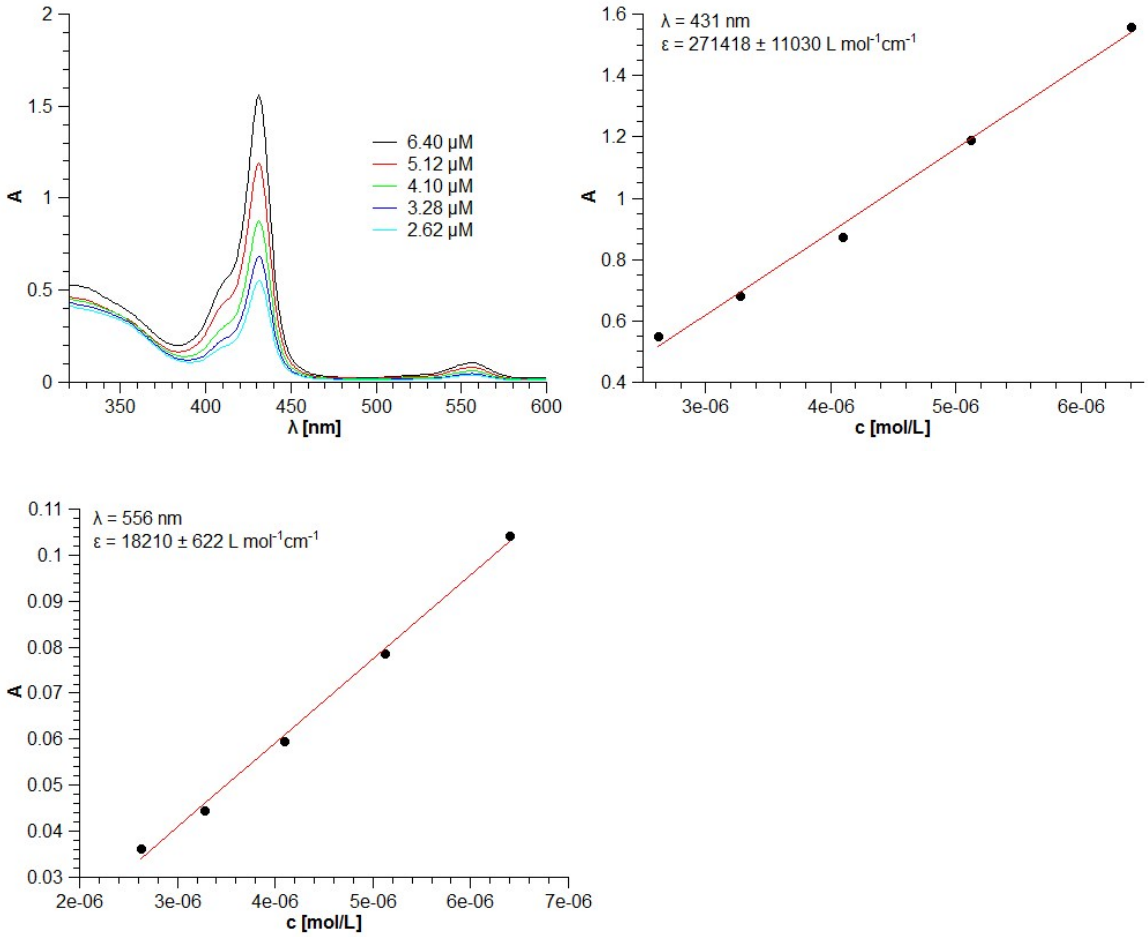



**Fig S6:** UV-Vis spectra (top left) and extinction coefficients of **2**-G[2.1] in methanol + 12% piperidine.

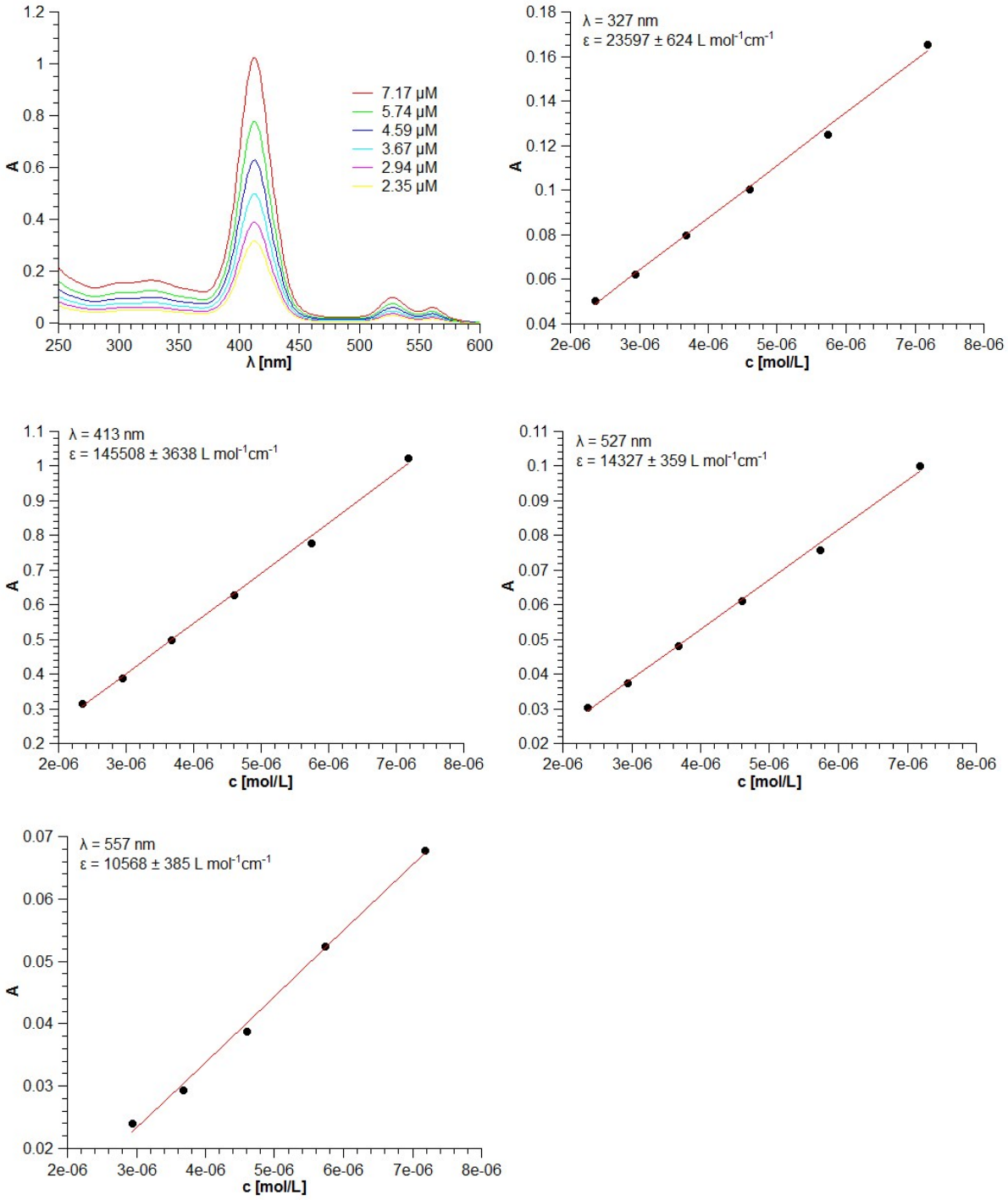



**Fig S7:** UV-Vis spectra (top left) and extinction coefficients of **2**-G[2.0] in water after irradiation with blue light (435 nm).

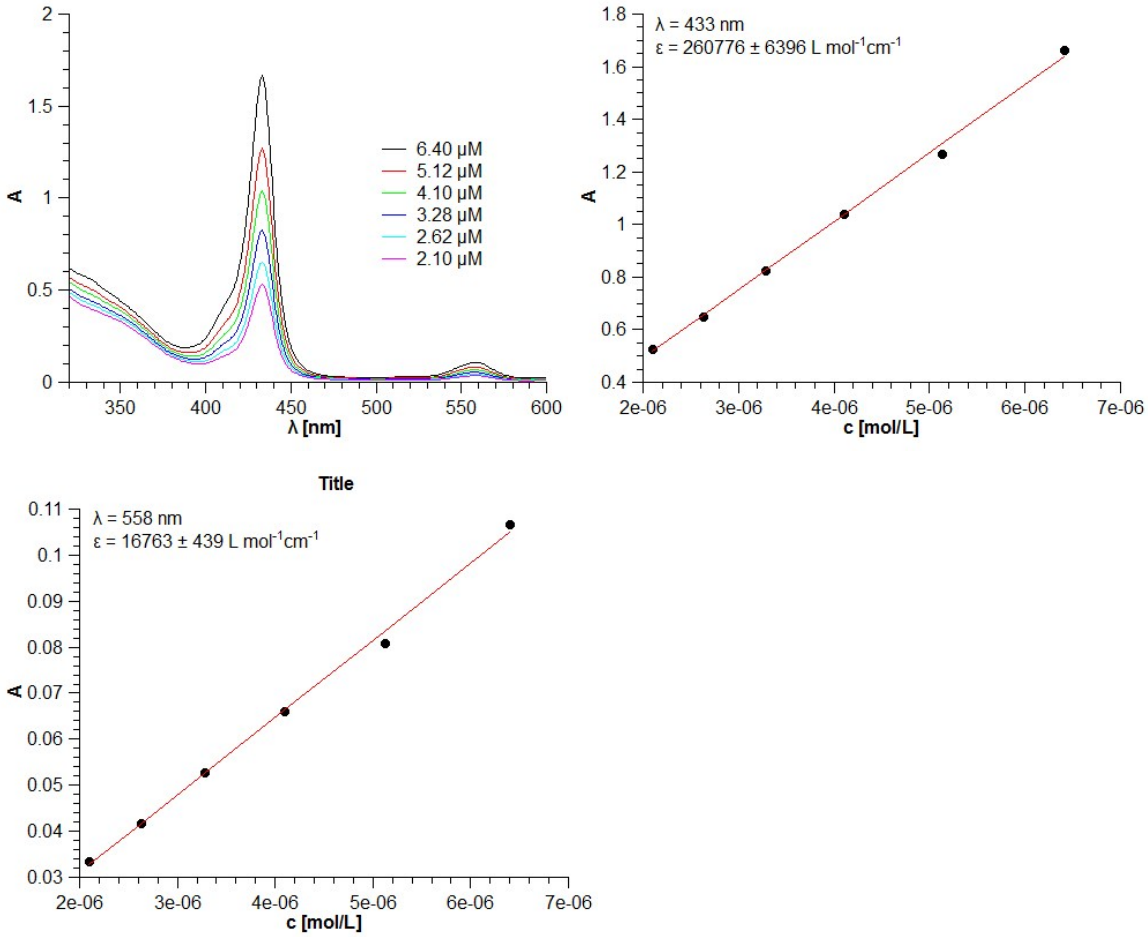



**Fig S8:** UV-Vis spectra (top left) and extinction coefficients of **2**-G[2.0] in water + 12% piperidine.

For the calculation of the paramagnetic percentage after switching with green light (505 nm) the extinction coefficient of the paramagnetic soret band is needed. We assume that the extinction coefficient of the paramagnetic *cis* isomer and of the record player piperidine complex are equal:

$\varepsilon_{431\ nm,\ G2.1,\ MeOH}$ = 271418 $Lmol^{-1}cm^{-1}$ and $\varepsilon_{433\ nm,\ G2.0,\ water}$ = 260776 $Lmol^{-1}cm^{-1}$(Fig. S6 and S8).

100% switching efficiency at a known concentration in a 1cm cuvette will lead to:

G[2.1] in MeOH (c = 4.59 µM): $A_{para\ max} = \varepsilon_{431\ nm} \cdot c \cdot d = 1.25$

G[2.0] in water (c = 5.74 µM): $A_{para\ max} = \varepsilon_{433\ nm} \cdot c \cdot d = 1.50$

The observed absorption ($A_{obs}$) after incomplete switching with green light (505 nm) is the sum of the absorption of the diamagnetic *trans* isomer ($A_{dia}$) and the paramagnetic *cis* isomer ($A_{para}$). x is the percentage of the diamagnetic *trans* isomer.

$A_{obs} = A_{dia} + A_{para}$

$A_{dia} = A_{dia\ max} \cdot x$

$A_{para} = A_{para\ max} \cdot (1-x)$

$A_{obs} = A_{dia\ max} \cdot x + A_{para\ max} \cdot (1-x)$

$x = (A_{obs} - A_{para\ max})/(A_{dia\ max} - A_{para\ max})$

**Calculation for 2-G[2.1] in methanol:**

λ = 426 nm

$A_{obs}$ = 1.10, $A_{para\ max}$ = 1.25, $A_{dia\ max}$ = 0.261

x = (1.10 - 1.25)/(0.261-1.25) = 0.152

After switching (505 nm): 15% dia- and 85% paramagnetic species.

**Calculation for 2-G[2.0] in water:**

λ = 428 nm

$A_{obs}$ = 0.634, $A_{para\ max}$ = 1.50, $A_{dia\ max}$ = 0.434

x = (0.634 - 1.50)/(0.434-1.50) = 0.812

After switching (505 nm): 81% dia- and 19% paramagnetic species.

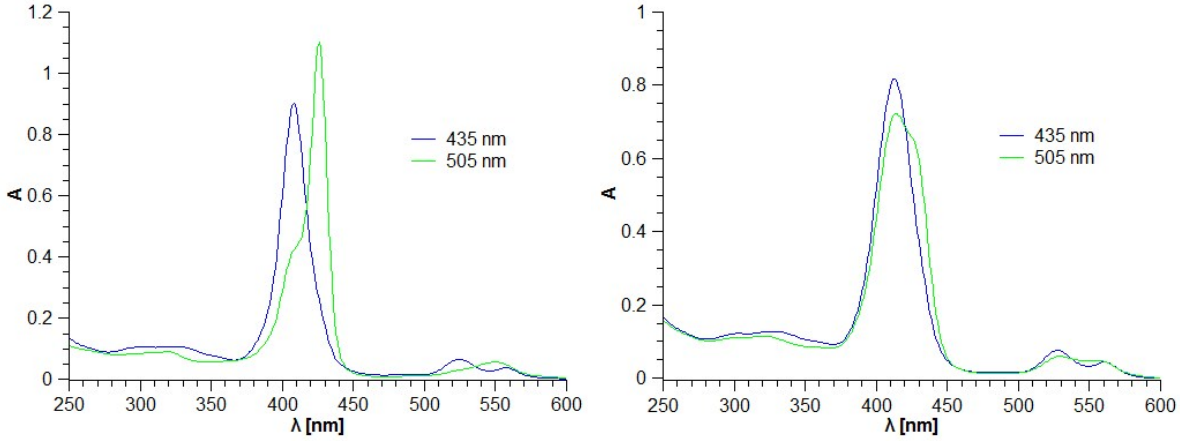



**Fig. S9:** UV-Vis spectra of **2**-G[2.1] in methanol (4.59 µM, left) and **2**-G[2.0] in water (5.74 µM, right) after irradiation with blue (435 nm) and green (505 nm) light. The amount of paramagnetic species after switching with green light (505 nm) is 85% in methanol (**2**-G[2.1]) and 19% in water (**2**-G[2.0]).

## II.5 Half-life at Physiological Temperature

The thermal half-life of the *cis* isomer of **2**-G[2.0] in water at 37 °C was determined by UV-vis spectroscopy (Fig. S10). The record player was irradiated with green light (505 nm) and the measurement was started immediately. In several time intervals the absorption of the cis isomer at 426 nm was measured. The half-life of **2**-G[2.0] in water at 37 °C is 39 days (Fig. S11).

$A = A_0 \cdot \exp(-kt)$ with A: absorption
$\ln A = \ln A_0 - kt$ $A_0$: absorption at t = 0
$t_{1/2} = (\ln 2)/k$ k: velocity constant
t: time
$t_{1/2}$: thermal half-life

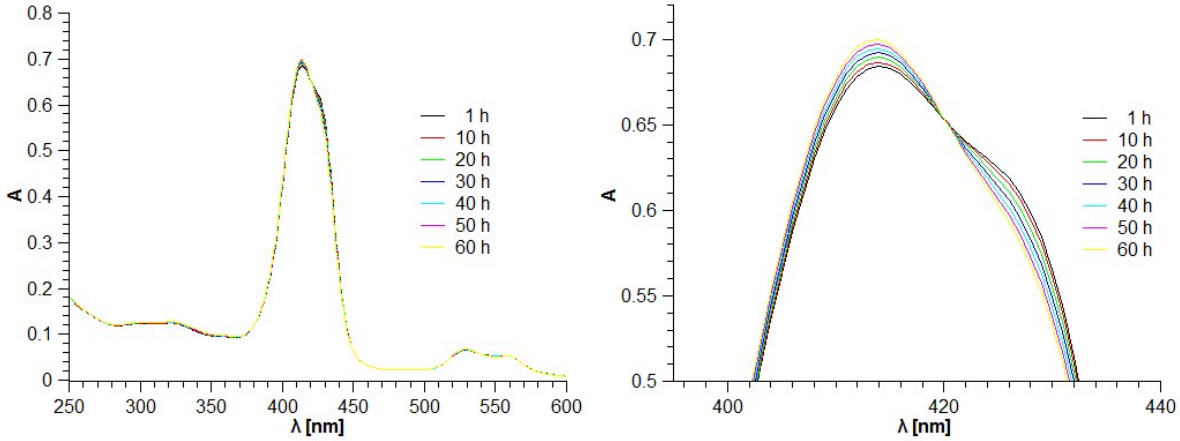



**Fig. S10:** UV-vis spectra of *cis*-**2**-G[2.0] in water at 37 °C after several time intervals (left) and a zoom of the soret bande (right).

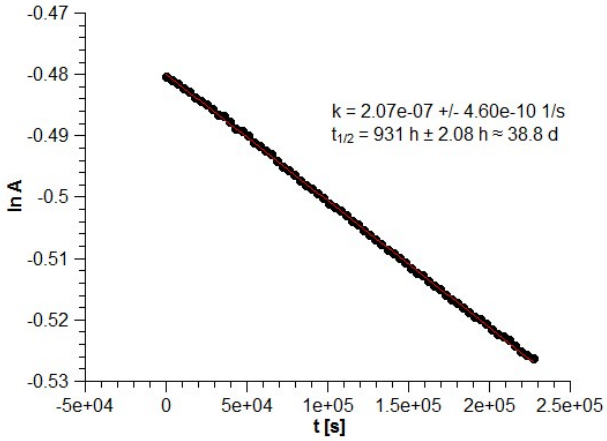



**Fig. S11:** Logarithmic absorption as a function of the time.

# III. MRI Experiments

## III.1 Switching in Water and Blood Serum

All magnetic resonance imaging (MRI) experiments were carried out on a 7 Tesla small animal MRsystem (ClinScan 7T, Bruker, Ettlingen, Germany) using inversion recovery pulse sequences.For Fig. 3 and S10 inversion recovery spin echo sequenceswere used. Due to different relaxation times of human serum (Fig. 3) compared to water (Fig. S13) different inversion times were chosen. Both samples (serum and water) were irradiated identically. Both samples were irradiated in a small glass vial with a photo reactor providing both wavelengths (Figure S12) for 15 min and afterwards filled into the NMR tubes already placed in the agar phantom (see I.3). The samples were given time to cool down to room temperature (22 °C) when imaging took place. Other parameters were not altered. TI = 1810 ms (Fig. S11), TI = 1550 ms (Fig 3) TR = 10 s, TE = 5.7 ms, TA = 15:54 min, res = 0.083 × 0.083 × 1 mm³, averages = 32.


**Fig. S12:** Image of the photo reactorby Sahlmann Photochemical Solutions consisting of four single LED units (each comprising 3 LEDs of one wavelength) aligned in a 90° angle. Three different wavelengths can be selected (365 nm, 435 nm and 505 nm). The total light intensity in the center of the photo reactor (area: 5 ×5 cm²) amounts to 85 mW/cm².

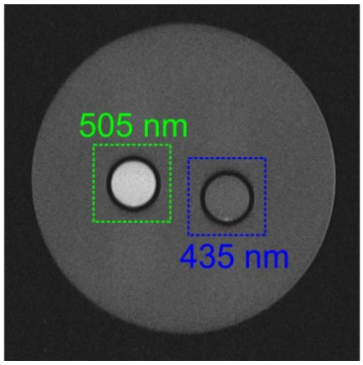



**Fig. S13:** MR image of 5 mM aqueous solutions in NMR sample tubes of **2**-G[2.0] irradiated with green (505 nm, left) and blue light (435 nm, right) in agar phantom.

Figure S13 and figure 3 in the main manuscript were acquired in addition to a T1 relaxation time mapping protocol with a varying inversion times (1000 - 3000 ms, increment: 100 ms). Following phase corrected IR-TSE sequence parameters were used: TR = 10 s, TE = 5.7 ms, TI = 1800 ms, TA = 15:54 min, Matrix: 384 × 384 px, turbo factor / echo train length: 128 (one third of all $k$ space lines recorded during one TR), Res = 0.083 × 0.083 × 1 mm, averages: 32, Bandwidth: 450 Hz/px. T1 relaxation times of the compound irradiated with 505 nm ("switched on") amount to 1790 ms in human serum and 2340 ms in water. T1 relaxation times of the compound irradiated with 435 nm ("switched off") amount to 2020 ms in human serum and 2600 ms in water. The T1 relaxation times of the outer agar phantom amount to 2980 ms. Figure S14 shows fitted signal curves from agar, the "switched on" and "switched off" RP solution to calculate T1 relaxation times according to following equation[6]:

$$M(TI) = M_0\left(1 - 2e^{\frac{-TI}{T1}} + e^{\frac{-TR}{T1}}\right)$$

$M$(TI) depicts the measured MRI signal amplitude according to each inversion time point (TI), $M_0$ characterizes a fitting parameter consisting of proton density and scaling factors (e.g. amplifier gain, image scaling factors). TR depicts the experiments repetition time.

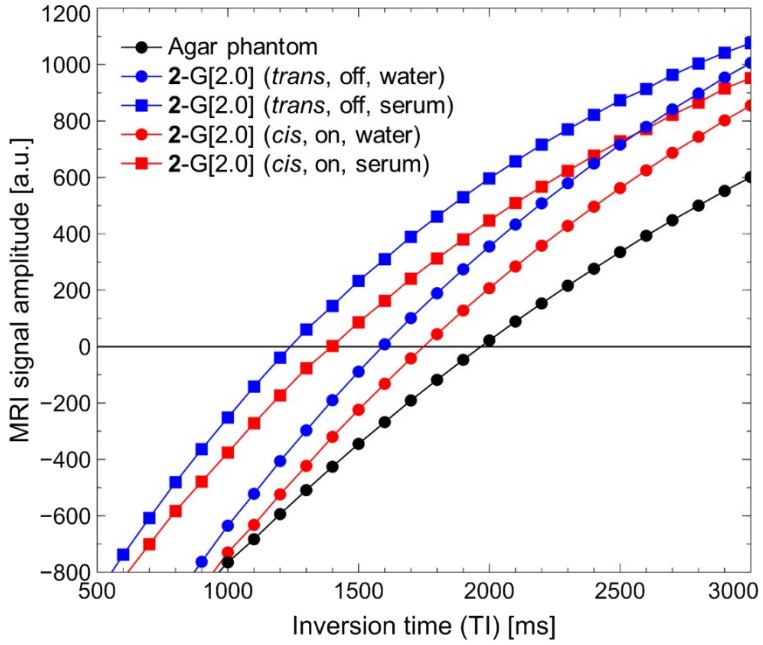



**Fig. S14**: MRI signal as a function of the inversion time. Each data point was acquired during MR image analysis via a region of interest (ROI) of 9.61 mm² (154 pixels). Three ROIs were placed inside the agar phantom and both NMR tubes. Serum or plasma is known to have shorter relaxation times[7].

### III.2 Spatiotemporal Resolution of MRI Contrast Switching - CAU logo in Gels

To expose the cuvette partially to green light (505 nm), a template was made from printable overhead projector sheets. The cuvette was placed in a distance of 5 mm to the LEDs (Fig S15). The MeOH gel filled cuvette (see I.3) was irradiated 1 min with 505 nm via the high-power LED unit (LXML-PE01-0070, Luxeon Rebel, Lumileds Holding B.V., Amsterdam, The Netherlands). The total light intensity amounts to 60 mW/cm² in 5 mm distance. Intensity was measured via an optical power meter (SV120C + PM100D, Thorlabs, Newton, NJ, USA).The agar/water gel filled cuvette (see I.3) was irradiated for 10 min due to limited switching capabilities in water (see main manuscript). The distance remained the same. For *deleting* the letters a photo reactorwas used (435 nm, Figure S16).Exposure times for *deleting* amount to 1 min for both gel types.

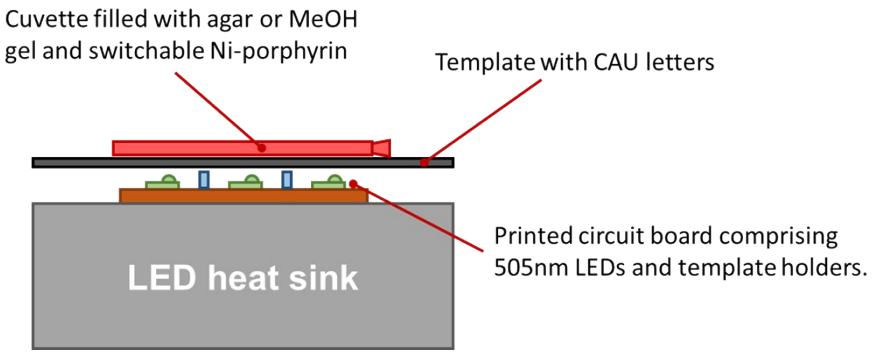



**Fig. S15:** Schematic representation of the exposure unit to be used with the CAU template. The distance from the LEDs to the cuvette amounts to 5 mm.

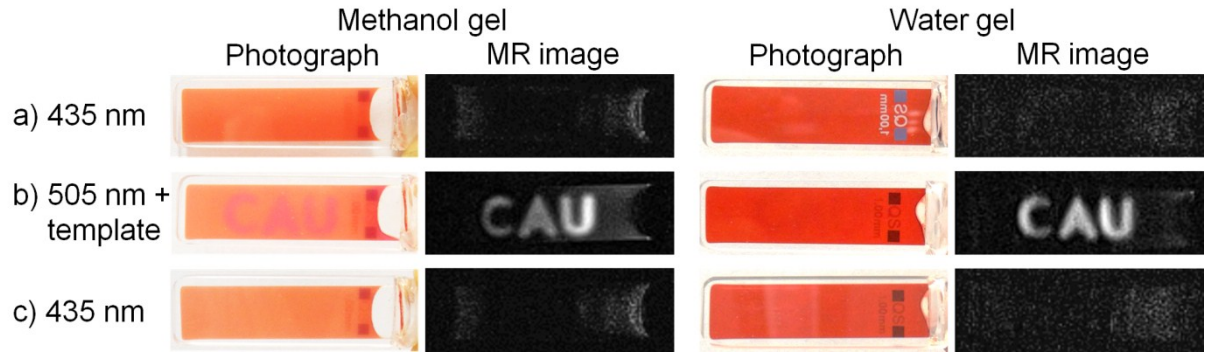



**Fig. S16 (Fig. 4 in main manuscript):** Photographs and MR images of the experiments in gel using acuvette (30 × 10 × 1 mm). TheMeOH gel (left) contains Ni porphyrin **2**-G[2.1] (0.8 mM, see I.3). The aqueous agar gel (right) contains Ni porphyrin **2**-G[2.0] (5.0 mM, see I.3). Top row: whole cuvette irradiated with blue light (435 nm). Middle row: partially irradiated (505 nm) cuvette showing CAU letters. Bottom row: whole cuvette irradiated with blue light (435 nm) to delete the letters. The nominal resolution of all MR images amount to 0.33 × 0.33 × 1 mm.

For image acquisition a *turbo*spin echo inversion (IR-TSE) sequence was used: TI was set 2.39 s (MeOH)and 1.73s (agar/water) to supress non-irradiated image parts. Bright image parts apart from the CAU writing are the result of susceptibility transitions inside the cuvette (gel → air) and limited shimming capabilities of the MR system (only first order shims available). Complete sequence parameters for Fig 4 (Fig S16): TR = 10 s, TE = 5.1 ms, TI = 2390 ms (MeOH), TI = 1730 ms (agar/water), TA = 20 s for each MR image, for all six MR images: TA = 120 s, Matrix: 128 × 128 px, turbo factor / echo train length: 128 (all *k* space lines recorded during one TR), Res = 0.33 × 0.33 × 1 mm, averages: 2, Bandwidth: 460 Hz/px.

### III.3 Relaxivity Measurements

Longitudinal relaxation times ($T_1$) were measured of **2**-G[2.1] in methanol, **2**-G[2.0] in water and using an inversion recovery spin echo sequence (2D, TE/TR = 1.3/10000 ms, 21 inversion times (TI = 200 - 9000 ms), spatial resolution 313 x 313 $\mu m^2$, slice thickness 2 mm) at a 7 T MRI scanner (ClinScan, Bruker, Ettlingen Germany). Relaxation follows first order decay:

$$I(t) = I(0) + P \cdot \exp(-t/T_1)$$

with
- $I(t)$: intensity
- $I(0)$: intensity after 180° pulse
- $P$: pre-exponential factor
- $T_1$: relaxation time

To determine the influence of our contrast agents **2**-G[2.0] and **2**-G[2.1] on the relaxation time of solvent protons concentration series were prepared (sample 1-4, Fig. S17). For preparation of agar phantoms (glass vial with agar gel and four NMR tubes) see I.3.

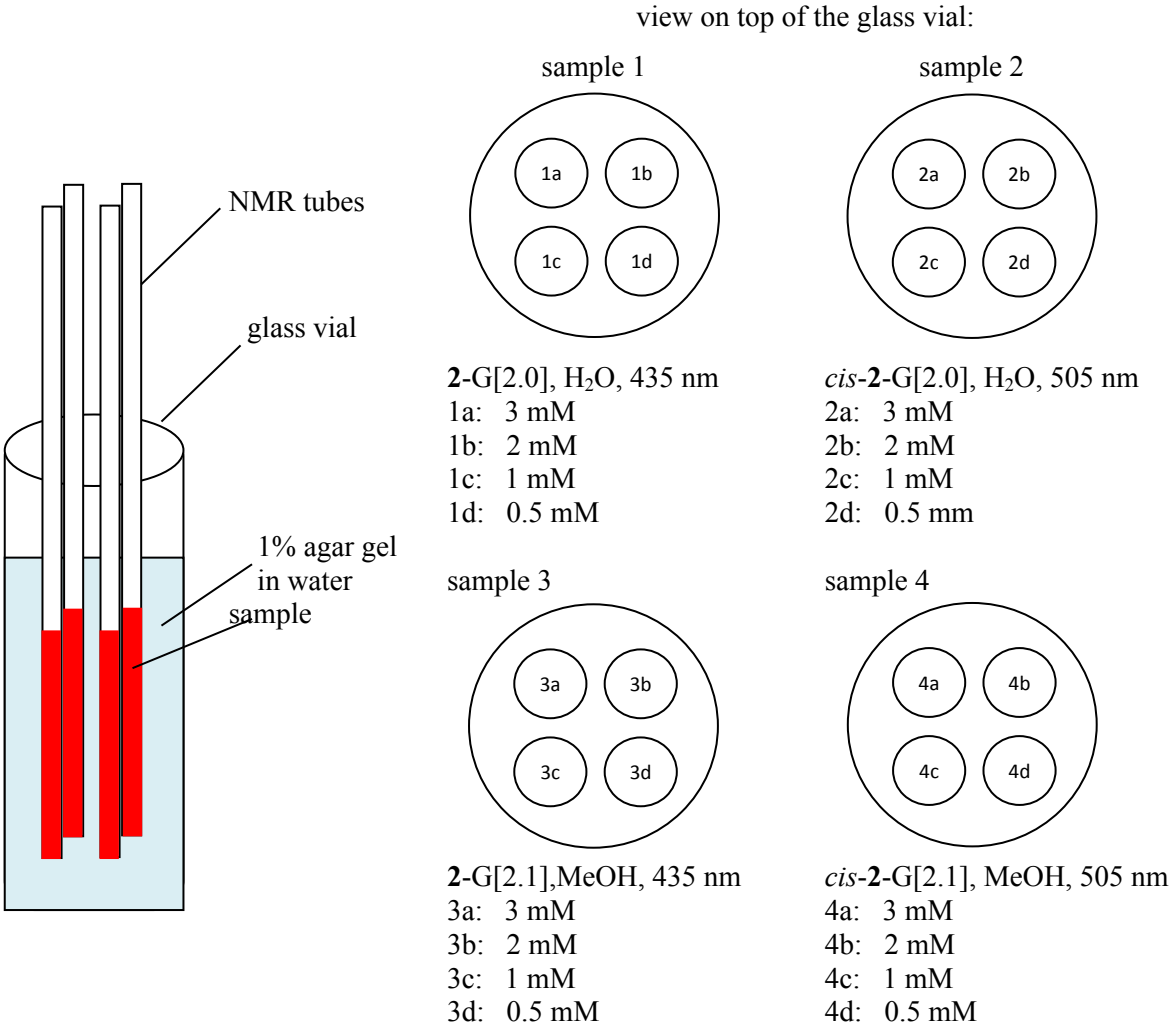



**Fig. S17:** Scheme of the agar phantom with four NMR tubes (left) and definition of the prepared samples (samples 1 and 2: **2**-G[2.0] in water irradiated with blue light (435 nm) and green light (505 nm) respectively, samples 3 and 4: **2**-G[2.1] in methanolirradiated with blue light (435 nm) and green light (505 nm) respectively).

**Tab S1:** Relaxation times ($T_1$) and relaxation rates ($1/T_1$) of the samples 1-4.

| **Samples** | **$T_1$ [ms]** | **$1/T_1$ [$s^{-1}$]** |
|---|---|---|
| 1a | 2193 | 0.456 |
| 1b | 2265 | 0.441 |
| 1c | 2308 | 0.433 |
| 1d | 2337 | 0.428 |
| 2a | 1948 | 0.513 |
| 2b | 2135 | 0.468 |
| 2c | 2193 | 0.456 |
| 2d | 2279 | 0.439 |
| 3a | 2005 | 0.499 |
| 3b | 2063 | 0.485 |
| 3c | 2077 | 0.481 |
| 3d | 2164 | 0.462 |
| 4a | 1068 | 0.937 |
| 4b | 1313 | 0.762 |
| 4c | 1876 | 0.533 |
| 4d | 2092 | 0.478 |

The plot of the relaxation rate ($1/T_1$) versus the concentration of a molecule shows a linear relation. The slope is defined as relaxivity ($R_1$). The relaxivity of **2**-G[2.0] and **2**-G[2.1] were determined after irradiation with green (505 nm) and blue (435 nm) light (Fig. S17).

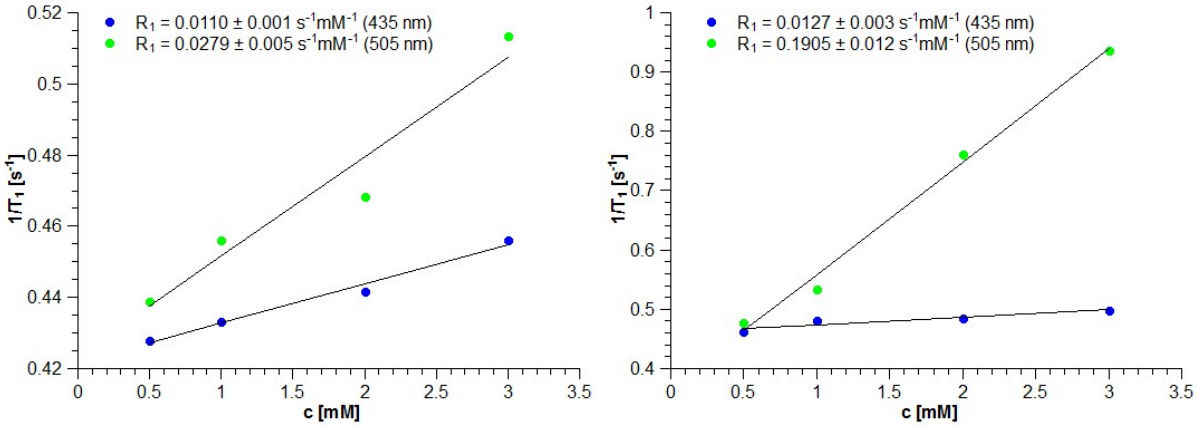
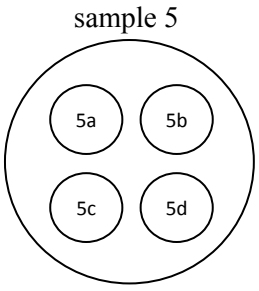



**Fig. S18:** Linear fitting of the relaxation rate ($1/T_1$) versus the concentration for **2**-G[2.0] in $H_2O$ (left) and for **2**-G[2.1] in MeOH (right).

To show the gelator's effect on relaxation time sample 5 was prepared (Fig. S19). A 1 mM solution of **2**-G[2.1] in methanol with a gelator concentration of 4.0 mg/mL ((±)-*trans*-1,2-bis(dodecylureido)cyclohexane) was heated to 60°C, filled in an NMR tube, cooled down in an ice bath for one minute and warming up to room temperature (sample 5a and 5b).

A 1 mM solution of **2**-G[2.0] in water with an agar concentration of 10 mg/mL was heated to 95°C, filled in an NMR tube and cooled down slowly to room temperature (sample 5c and 5d). After preparation switching experiments followed (5a+5c: 10 min with 435 nm, 5b+5d: 10 min with 505 nm).




record player (RP) + gelator

5a: *trans*-**2**-G[2.1] in methanol gel ($c_{RP}$ = 1mM, $c_{gelator}$ = 4 mg/mL)
5b: *cis*-**2**-G[2.1] in methanol gel ($c_{RP}$ = 1mM, $c_{gelator}$ = 4 mg/mL)
5c: *trans*-**2**-G[2.0] in agar gel ($c_{RP}$ = 1mM, $c_{gelator}$ = 10 mg/mL)
5d: *cis*-**2**-G[2.0] in agar gel ($c_{RP}$ = 1mM, $c_{gelator}$ = 10 mg/mL)

**Fig. S19:** Definition of the prepared samples (9a+9b: **2**-G[2.1] in methanol gel and 9c+9d: **2**-G[2.0]in agar gel).

**Tab S2:** Relaxation times ($T_1$) and relaxation rates ($1/T_1$) of the observed samples 5a-d.

| **Samples** | **$T_1$ [ms]** | **$1/T_1$ [$s^{-1}$]** | **$T_1$ [ms] of comparable samples (1mM solutions without gelator)** |
|---|---|---|---|
| 5a | 2395 (prolongation of 15%) | 0.418 | 3c : 2077 |
| 5b | 1962 (prolongation of 5%) | 0.510 | 4c: 1876 |
| 5c | 721 (shortening of 69%) | 1.386 | 1c: 2308 |
| 5d | 519 (shortening of 76%) | 1.925 | 2c: 2193 |

We observed a light prolongation (~5-15%) of $T_1$ using the gelator(±)-*trans*-1,2-bis(dodecylureido)cyclohexane in methanol in combination with the record player **2**-G[2.1]. In contrast the agar gel led to a massive shortening (~70-75%) of $T_1$.

# V. Literature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