

# **Novel magneto-responsive membrane for remote control switchable molecular sieving**

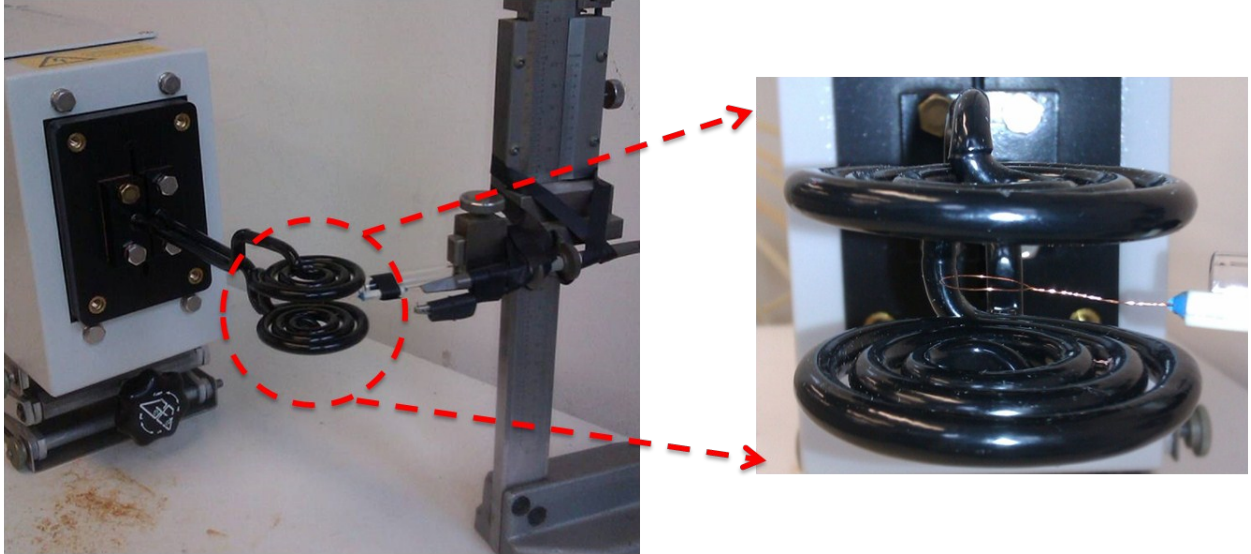
**Xi Lin, Rong Huang, Mathias Ulbricht\***

Lehrstuhl für Technische Chemie II, Universität Duisburg-Essen, 45117 Essen, Germany,  
and CENIDE – Center for Nanointegration Duisburg-Essen, 47057 Duisburg, Germany.

\*Corresponding author, e-mail: [mathias.ulbricht@uni-essen.de](mailto:mathias.ulbricht@uni-essen.de)

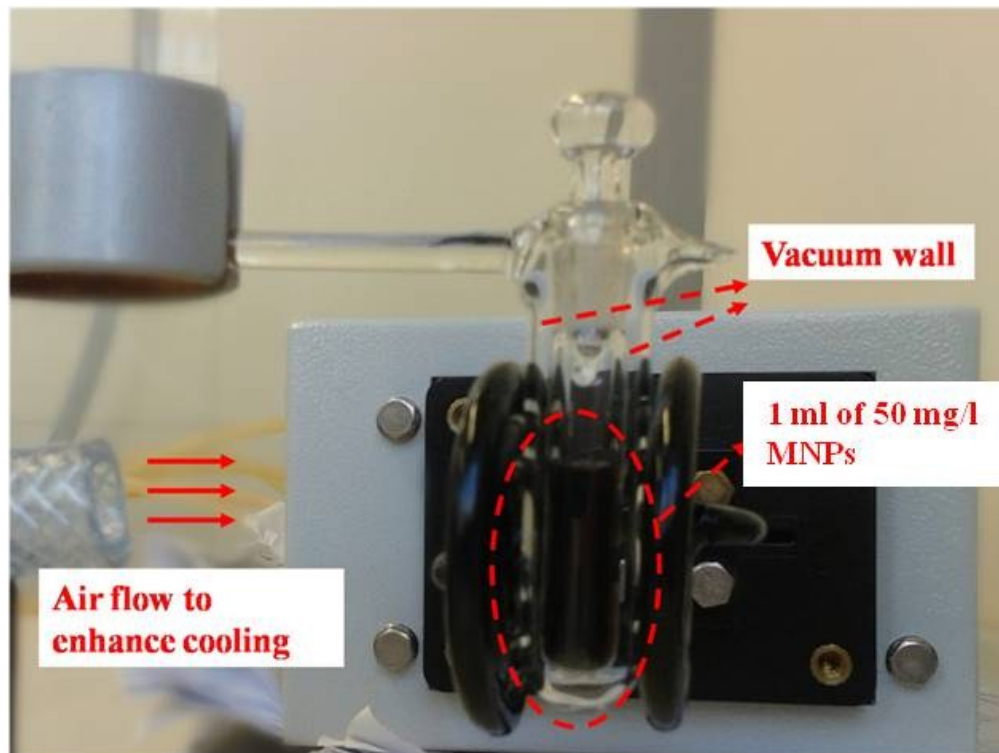
## Supporting Information

### S1 Setup to measure AMF distribution



**Figure S1:** Field amplitude inside the sandwich coil inductor was measured by a self-made pickup probe (2 loops made of fine copper wire with a diameter of 7.3 mm).

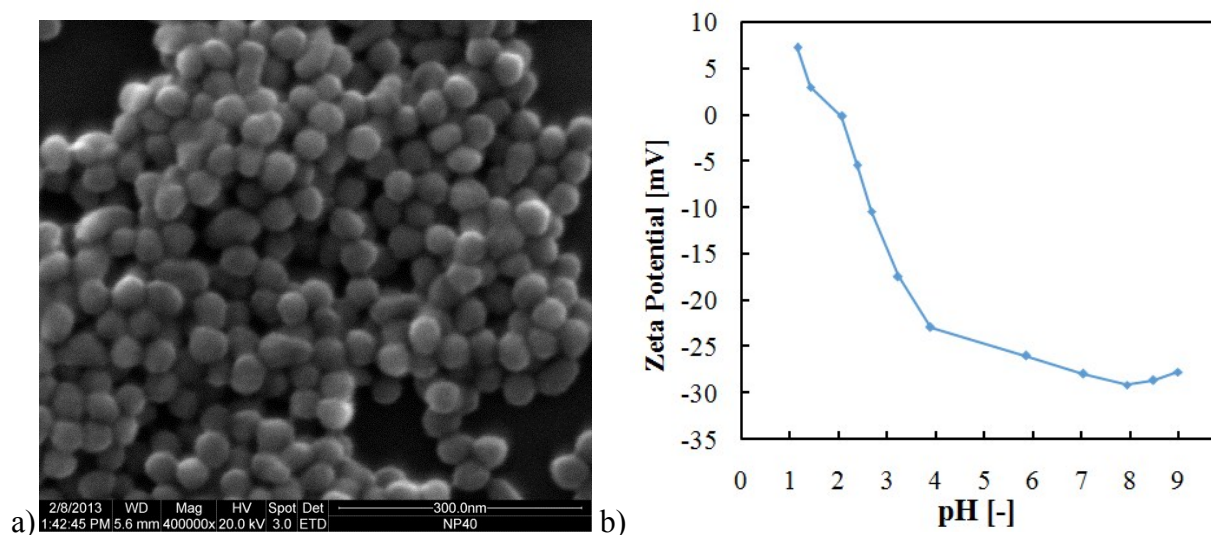
## S2 Setup for the measurement of SLP of MNPs



**Figure S2:** Closed glass vial with vacuum walls, containing 1 ml of a 50 mg/l MNPs aqueous dispersion has been placed between the inductor coils and the temperature of the solution has been measured before and after 5 minutes of AMF (current 15.6 A, frequency 745 kHz) exposure by contact thermometer.

### S3 MNP characterization

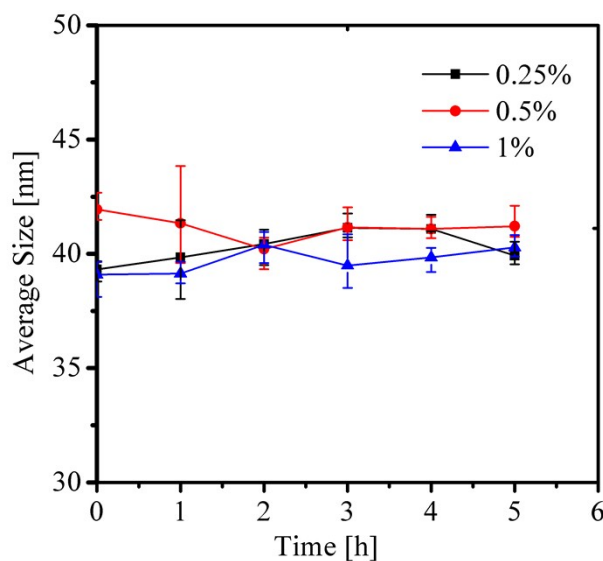
The morphology and surface charge of the commercial iron oxide nanoparticle has been investigated by SEM and zeta-potential measurement (Zetasizer, Malvern). The zeta-potential of MNPs as the function of pH has been measured by stepwise decreasing the pH from 9 to 1 by automatic titration. As shown in **Figure S3a**, the MNPs have very good sphere morphology and an average diameter around 40 nm, which correlates well with the supplier's data. Because the surface of the MNP has been functionalized with carboxylic acid groups, it has an isoelectric point (IEP) around pH 2.2 and its zeta potential is below -25 mV when the pH is above 4 (**Figure S3b**). The sufficient surface charge of such MNPs ensures its stability within a wide range of pH values.



**Figure S3:** Characterization of commercial MNPs: a) SEM image, b) zeta potential as function of pH value.

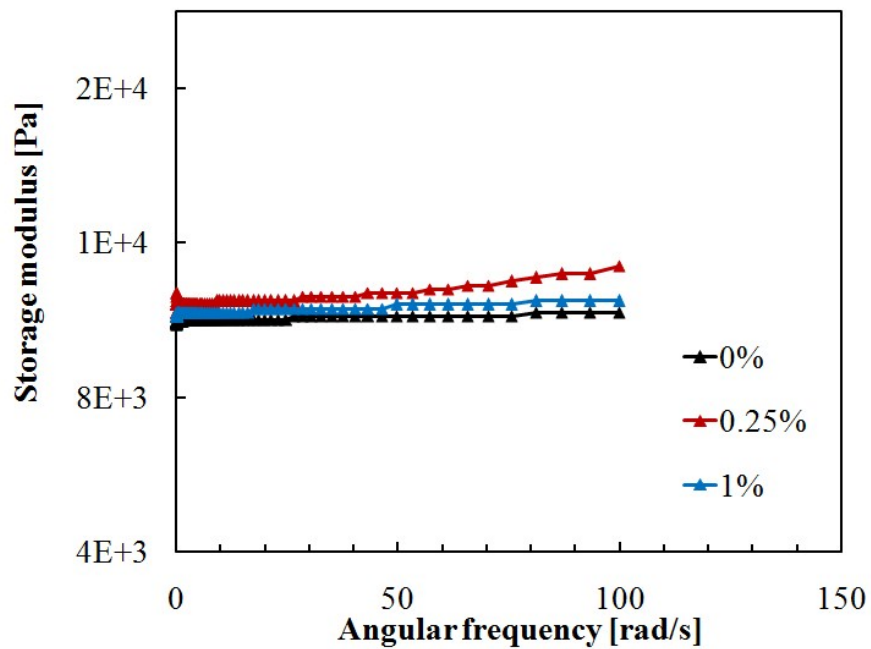
## S4 Stability of MNPs in monomer solutions

Further, the stability of MNPs in monomer solution has been studied with dynamic light scattering (DLS) measurement (Stabisizer, Particle Metrix). Monomer solutions (1 mol/l NIPAM and 0.02 mol/l MBA) with different MNPs concentrations have been prepared and sonicated for 10 minutes before DLS measurements. Samples were measured every 1 hour within a period of 5 hours. For each time point, the sample was measured three times over a period of 60 s for each run to get the number average diameter  $D_n$ . And the result is the average of the three measurements. As shown in **Figure S4**, there is no apparent aggregation within 5 hours, indicating the excellent stability of MNPs in monomer solution.



**Figure S4.** Dispersibility and dispersion stability of MNPs in monomer solution analyzed by DLS.

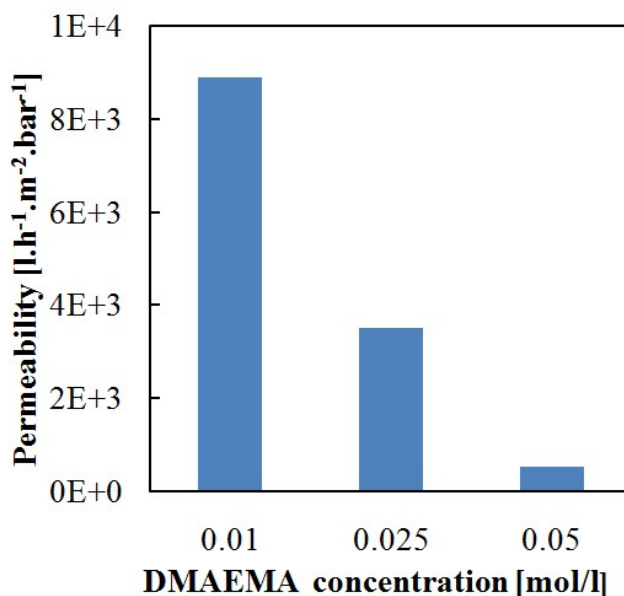
## S5 Rheological study of hydrogels prepared by redox initiation



**Figure S5.** Storage modulus at 21°C as a function of shear frequency for hydrogels prepared with different MNPs concentration.

## S6 Influence of DMEAEMA concentration on water permeability of pre-modified membrane from “method 2”

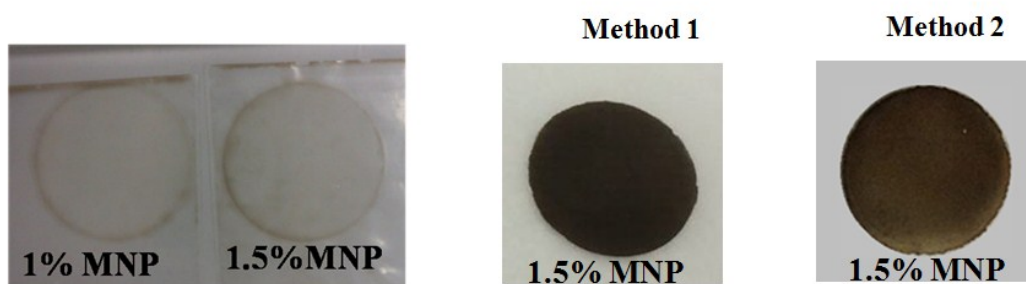
For pre-modification using “method 2”, on the basis of 0.2 mol/l of NIPAM, different concentrations of comonomer DMAEMA were used and the water permeability of pre-modified membranes was investigated. As shown in **Figure S6**, with increase of DMAEMA fraction, the water permeability of membranes decreased significantly. This could be related to a higher degree of grafting because of higher total monomer concentration used, more effective partitioning of DMAEMA compared to NIPAAm on the carboxyl-functional PET surface, but also because the increasing fraction of tertiary amino groups in the chains which will be protonated in pure water (pH ~ 6) will cause reduction in effective pore diameter due to expansion of grafted polymer chains. Therefore, 0.01 mol/l of DMEAEMA was chosen to reach similar water permeability as for membranes obtained from “method 1” and to provide moderate surface charge.



**Figure S6.** Influence of DMEAEMA concentration in the reaction mixture with 0.2 mol/l NIPAAm on water permeability of pre-modified membrane obtained by “method 2”.

## S7 MNP loading before and after optimization procedures

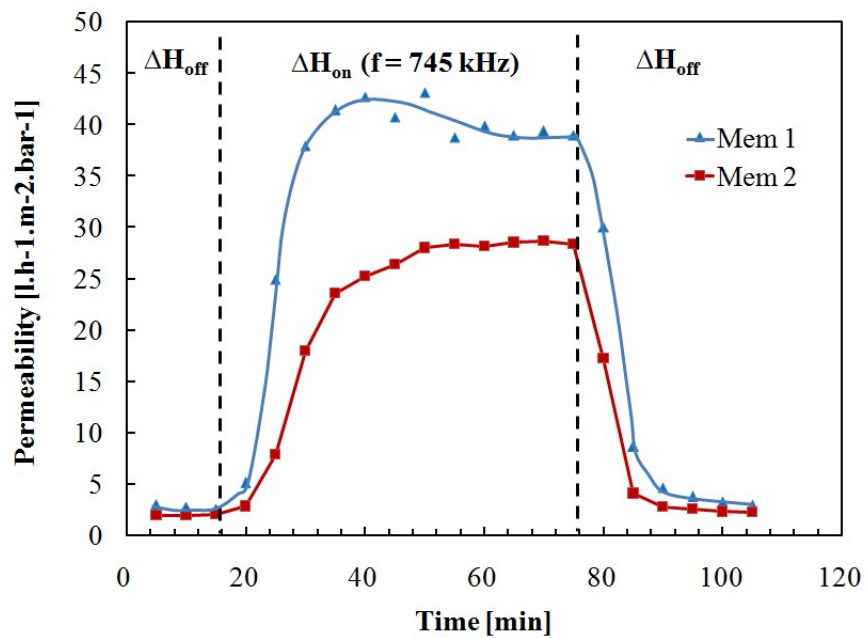
Initially, before optimization, the pre-modified membranes (“method 1”) were soaked in reaction solution (1 mol/l NIPAM, 0.02 mol/l MBA) containing 1% or 1.5% of MNPs and shaken for 1 hour with speed of 300 rpm. For the membrane loading according to optimized procedure, 1.5% of MNPs and 50 mmol/l NaCl were added step-wise increase and the loading time was increased to 3 hours, as described in section 2.4.2 of main paper. Visual inspection already reveals large differences in MNP uptake (**Figure S7**); more details are given and discussed in section 3.4 of main paper.



**Figure S7.** Influence of the procedure on obtained MNP loading; left: membranes pre-functionalized according to “method 1”, loading in one step and without addition of NaCl; right: membranes pre-functionalized according to “method 1” or “method 2”, loading on three steps and with addition of NaCl.



## S8 Magneto-responsive water permeability of membranes pore-filling functionalized with 1.1 mol/l NIPAM concentration



**Figure S8.** Water permeability with AMF off and on for two membranes prepared according to “method 1” at higher NIPAAm concentration (1.1 vs. 1.0 mol/l).

