

SUPPLEMENTARY MATERIAL

Membranes for the Capture and Screening of Waterborne Plutonium Based on a Novel Pu-Extractive Copolymer Additive

James C. Foster ^{1,2}, Timothy A. DeVol ^{2,3} and Scott M. Husson ^{1,*}

¹ Department of Chemical and Biomolecular Engineering, Clemson University, 127 Earle Hall, Clemson, SC 29634, USA; jcf@clemson.edu

² Nuclear Environmental Engineering Sciences, Radioactive Waste Management Center, Clemson University, Clemson, SC 29625, USA; devol@clemson.edu

³ Department of Environmental Engineering and Earth Sciences, Clemson University, 342 Computer Court, Anderson, SC 29625, USA

* Correspondence: shusson@clemson.edu

CONTENT

Table S1: Isotopic fractions of the stock 147 Bq/mL solution used in the study

Table S2: Ion content of the synthetic seawater used in the direct filtration ²³⁸Pu uptake studies

Table S3: Treatments for each batch 10 wt.% PVDF-*g*-EGMP membrane tested in the permeability study

Figure S1: Flux data for each 10 wt.% PVDF-*g*-EGMP batch tested in permeability study

Figure S2: Alpha spectrum of the 5 Bq ²³⁸Pu smear efficiency calibration sample

Figure S3: Alpha spectra of the 0.5 mL samples taken for the ²⁴²Pu uptake study

Figure S4: Sessile drop contact angle measurements of 100% PVDF membranes

Figure S5: Sessile drop contact angle measurements of PVDF membranes casted with 10% PVDF-*g*-EGMP.

Table S1: Isotopic mass fractions of Pu isotopes present in the 147 Bq/mL ²⁴²Pu stock solution.

Isotope	Mass Fraction [%]	Specific Activity [Ci/g]	Mode of Decay [-]	E α [keV]
²³⁸ Pu	0.003	1.70E+01	alpha	5499 (71%), 5456 (29%)
²³⁹ Pu	0.005	6.20E-02	alpha	5157 (71%), 5144(17%), 5106 (12%)
²⁴⁰ Pu	0.022	2.30E-01	alpha	5168 (73%), 5124 (27%)
²⁴¹ Pu	0.006	1.00E+02	beta	...
²⁴² Pu	99.962	3.90E-03	alpha	4902 (77%), 4858 (23%)
²⁴⁴ Pu	0.002	1.80E-05	alpha	4589 (81%), 4546 (19%)

Table S2: Ion content of the Instant Ocean aquarium salt used to prepare Pu-bearing solutions for the synthetic seawater trials.

	Instant Ocean [ppm]	Typical Seawater [ppm]			Instant Ocean [ppm]	Typical Seawater [ppm]
<i>Ion</i>				<i>Ion</i>		
Chloride	19290	19353		Chromium	<0.015	<0.01
Sodium	10780	10781		Cobalt	<0.015	<0.01
Sulfate	2660	2712		Copper	<0.015	<0.01
Magnesium	1320	1284		Nickel	<0.015	<0.01
Calcium	400	523		Selenium	<0.015	<0.01
(Bi)Carbonate	200	126		Vanadium	<0.015	<0.02
Bromide	56	67		Zinc	<0.015	<0.01
Strontium	8.8	7.9		Molybdenum	<0.01	0.01
Boron	5.6	4.5		Aluminum	<0.006	<0.001
Fluoride	1	1.28		Lead	<0.005	<0.001
Lithium	0.3	0.173		Arsenic	<0.004	0.002
Iodide	0.24	0.06		Cadmium	<0.002	<0.001
Barium	<0.04	<0.014		Nitrate	0	1.8
Iron	<0.04	<0.001		Phosphate	0	0.2
Manganese	<0.025	<0.001				

Table S3: Tabulated list of treatments for each 10 wt.% PVDF-g-EGMP membrane batch used in the permeability study.

<i>Sample ID:</i>	Vacuum treatment	Percent Glycerol	Casting Time
#1	Yes	0 wt.%	5 s
#2	No	0 wt.%	5 s
#3	Yes	2 wt.%	5 s
#4	No	2 wt.%	5 s
#5	Yes	0 wt.%	30 s
#6	No	0 wt.%	30 s
#7	Yes	2 wt.%	30 s
#8	No	2 wt.%	30 s

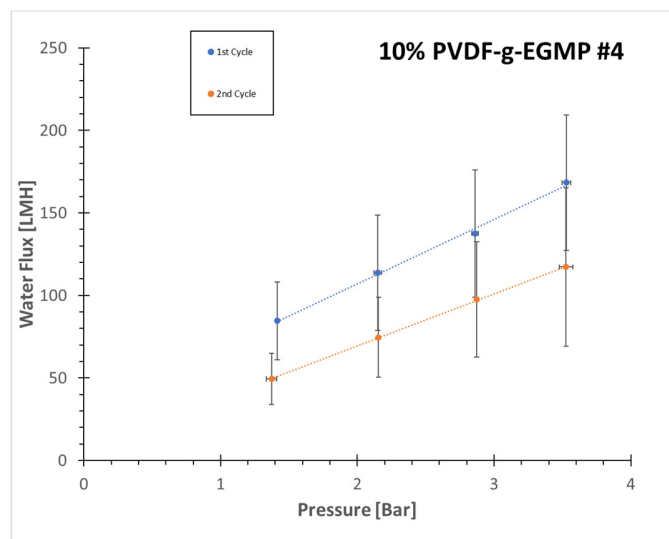
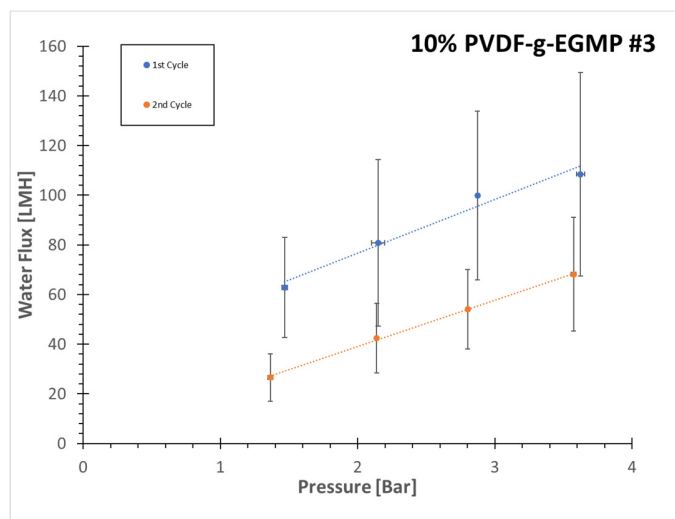
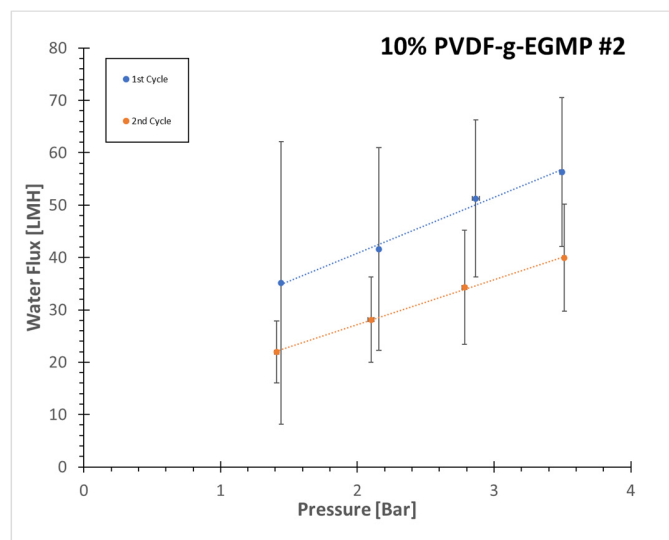
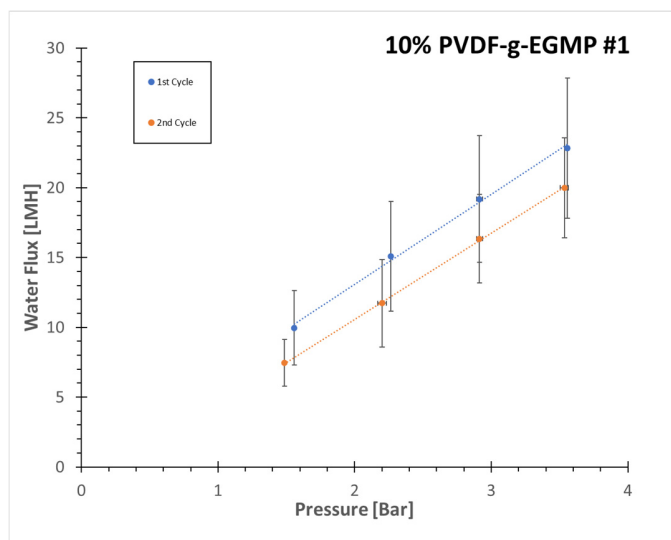


Figure S1: Resulting water flux data of the 10 wt.% PVDF-g-EGMP membranes from the permeability study.

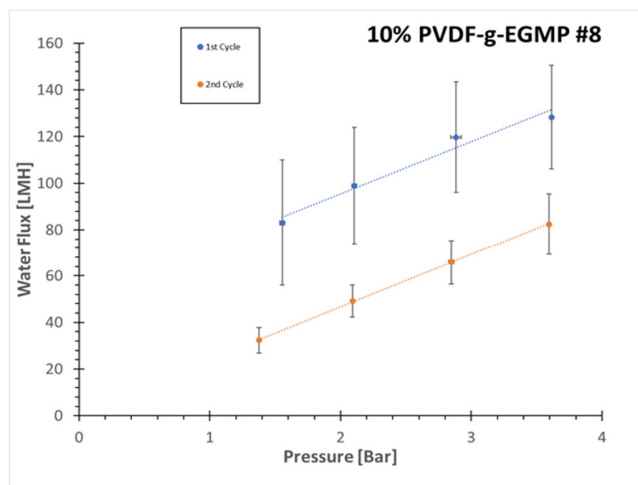
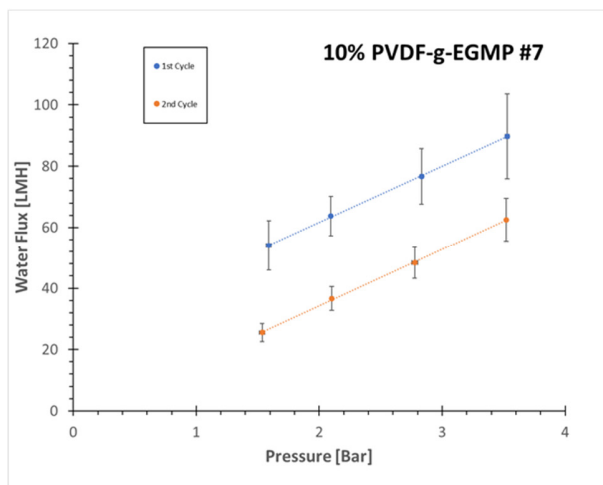
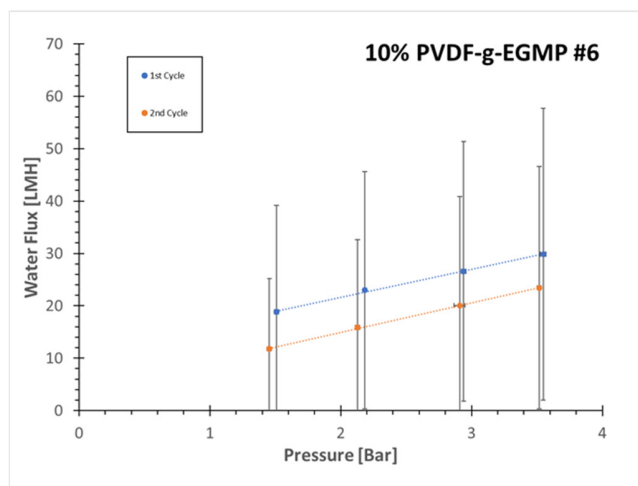
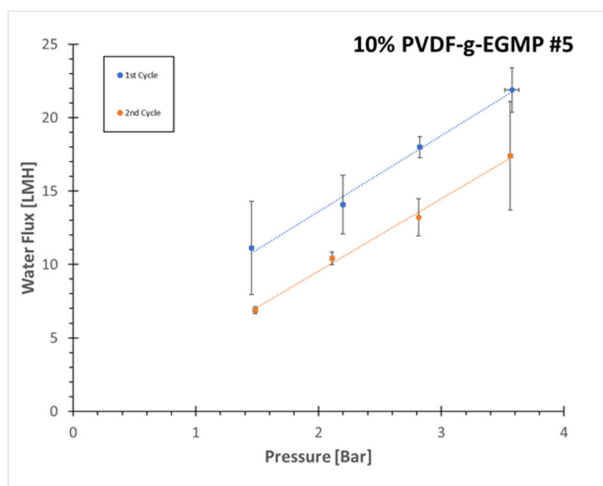


Figure S1 (Cont.): Resulting water flux data of the 10 wt.% PVDF-g-EGMP membranes from the permeability study.

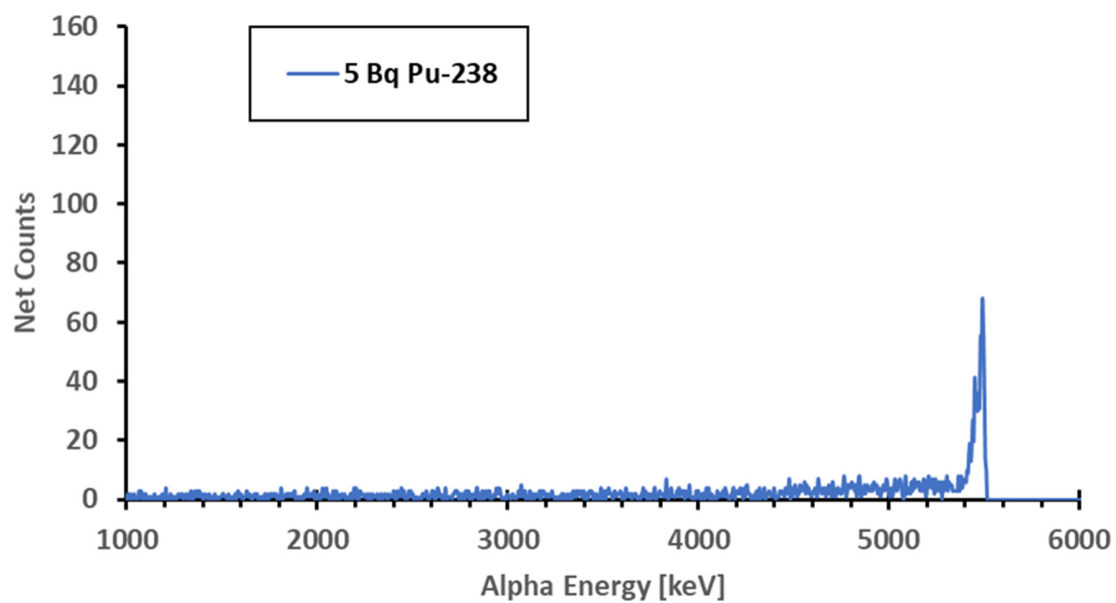


Figure S2: Alpha spectra of 5 Bq ^{238}Pu smeared over a 45 mm diameter PVDF membrane. The sample was dried and placed 5 mm from a 25 mm diameter PIPS detector and counted for 90 min, resulting in an absolute efficiency of 3.65% for the sample geometry.

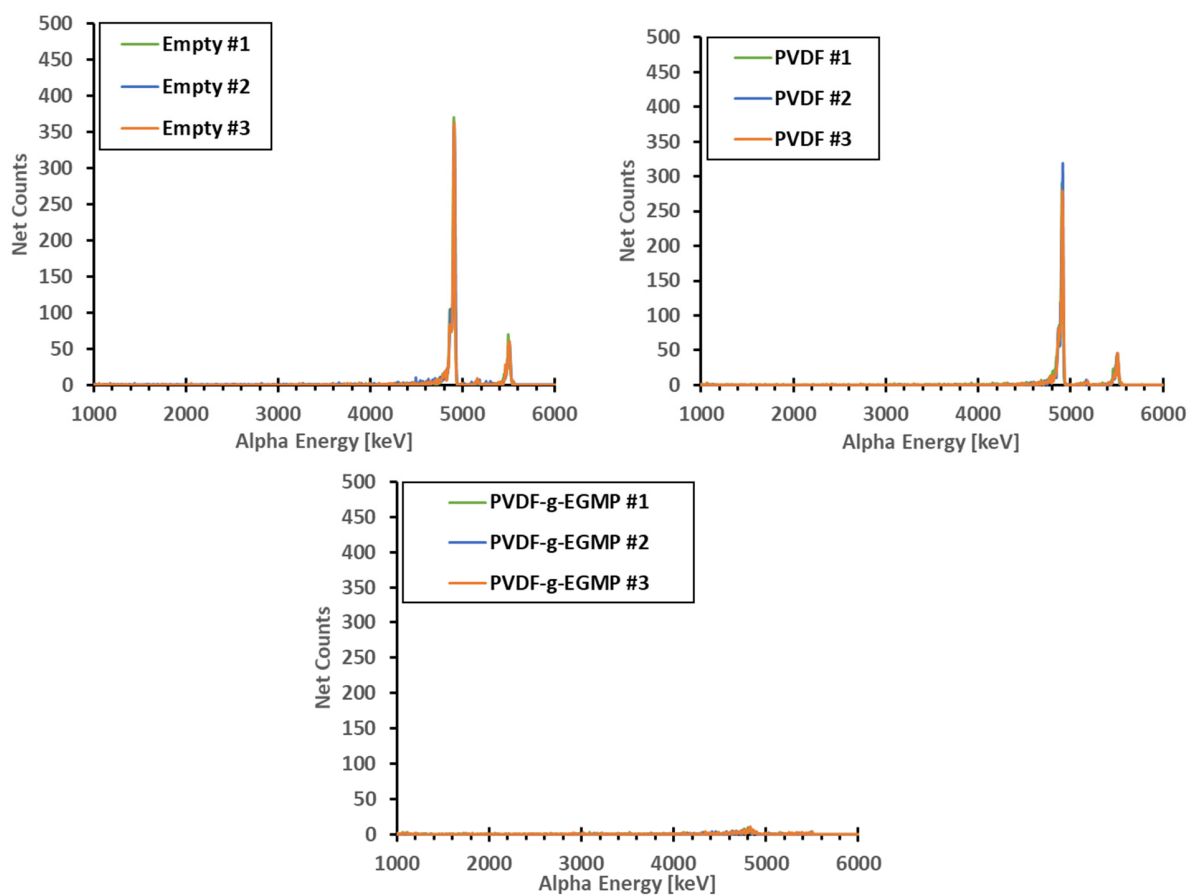


Figure S3: Resulting 5 h alpha spectra of the 0.5 mL ^{242}Pu solution samples collected after 24 h exposure to the (1) empty centrifuge vials; (2) 100 mg of PVDF resin; (3) 100 mg of PVDF-g-EGMP.

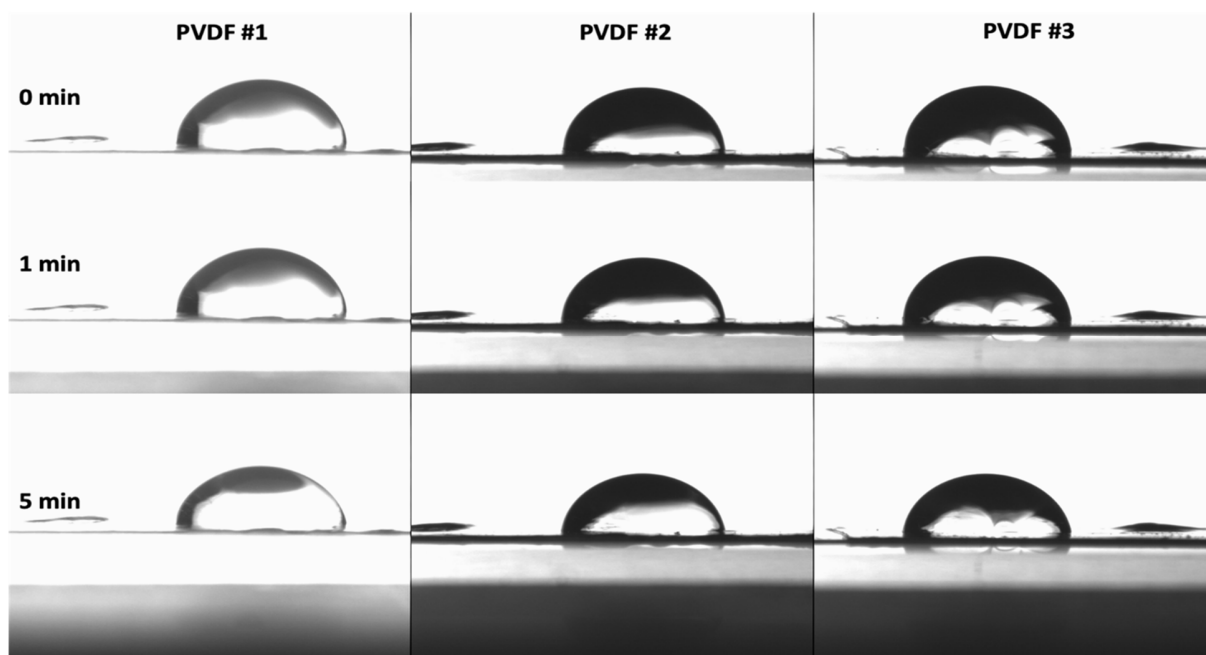


Figure S4: Contact angle measurements of 100% PVDF membranes using a 25 μ L droplet of DI water on the surface. Theta angle measurements (Θ) were measured at 0, 1, and 5 min intervals on three separate positions of the membrane.

Sample [-]	Time [min]	Θ [degree]
100% PVDF 1	0	88.6
...	1	88.6
...	5	85.3
100% PVDF 2	0	90.8
...	1	90.3
...	5	86.1
100% PVDF 3	0	91.7
...	1	90.3
...	5	85.5
Time	Mean (Θ)	Std. Dev. (Θ)
0 min	90.4	1.59
1 min	89.7	0.98
5 min	85.6	0.42

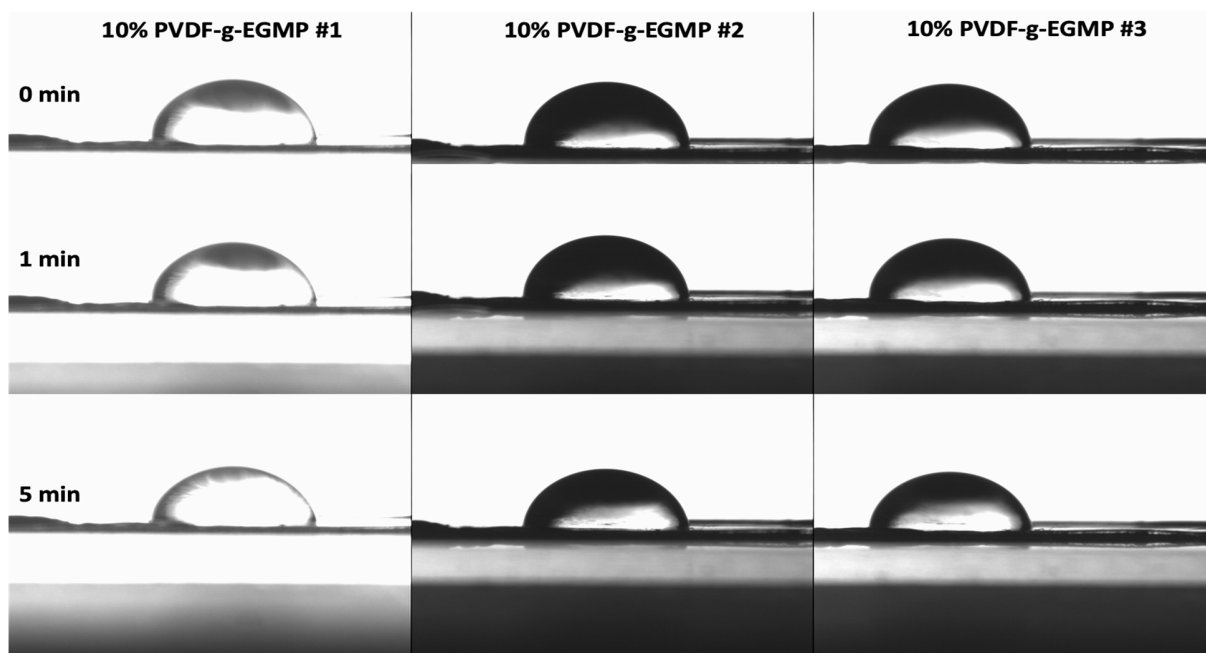


Figure S5: Contact angle measurements of PVDF membranes containing 10 wt.% PVDF-g-EGMP using a 25 μ L droplet of DI water on the surface. Theta angle measurements (Θ) were measured at 0, 1, and 5 min intervals on three separate positions of the membrane.

Sample [-]	Time [min]	Θ [degree]
100% PVDF 1	0	85.6
...	1	85.1
...	5	81.8
100% PVDF 2	0	85.5
...	1	84.5
...	5	80.4
100% PVDF 3	0	84.6
...	1	83.7
...	5	79.6
Time	Mean (Θ)	Std. Dev. (Θ)
0 min	85.2	0.55
1 min	84.4	0.70
5 min	80.6	1.11