Supporting Information Section

Phosphorimetric Characterization of Solution-Processed Polymeric Oxygen-Barriers for the Encapsulation of Organic Electronics

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KEYWORDS phosphorimetry, oxygen permeation, barrier materials, organic solar cells, organic electronics, stability, degradation

System	Thickness [nm]	Solvent(s) used	Annealing temperature, annealing time	Film preparation conditions
PNB:PtOEP	370	cyclohexane:toluene, 1:1	as spun	Spin-coated from 20 mg/ml solution of PNB, 1000 rpm/60 s
PNB:PtOEP	520	cyclohexane:toluene, 1:1	as spun	Dip-coating in 20 mg/ml solution: 1× dip, speed 3 mm/s, dwell time 3 s
PNB:PtOEP	6200	cyclohexane:toluene, 1:1	as spun	Dip-coating in 20 mg/ml solution: 4× dips, speed 3 mm/s, dwell time 3 s
PS:PtOEP/PNB	Before PBN700 deposition: 800; after PNB deposition: total film thickness 5000	PS layer from toluene, PNB layer from cyclohexane	PS layer annealed at 90°C, 30′; PNB layer as spun	PS: spin-coated from 60 mg/ml solution, 1000 rpm/60 s; PNB: dip-coated in 20 mg/ml solution, 3× dips, 3 mm/s, dwell time 1 s
PMMA120:PtOEP	1100	toluene	100°C, 30′	Dip-coating in 60 mg/ml solution: 3× dips,3 mm/s, dwell time 3 s
PMMA350:PtOEP	1900	toluene	100°C, 30′	Dip-coating in 60 mg/ml solution: 3× dips, 3 mm/s, dwell time 3 s
PMMA996k:PtOEP	2400	toluene	100°C, 30′	Dip-coating in 60 mg/ml solution: 2× dips, 3 mm/s, dwell time 3 s
Zeonex:PtOEP	2300	toluene	as spun	Dip-coating in 60 mg/ml solution 3× dips, 3 mm/s, dwell time 3 s
PS:PtOEP	800	toluene	80°C, 30′	Spin-coated from 60 mg/ml solution of PS, 1000 rpm/60 s
PS:PtOEP/Zeonex	Before Zeonex deposition: 800; after Zeonex deposition: total film thickness 6800	PS layer from toluene; Zeonex layer from cyclohexane	PS layer annealed at 80° C, 30′; Zeonex, as spun	PS: spin-coated from 60 mg/ml solution, 1000 rpm/60 s; Zeonex: dip-coated in 60 mg/ml solution, 3× dips, 3 mm/s, dwell time 1 s

Table S 1. The technical details for the fabrication protocol of all samples studied in this work.

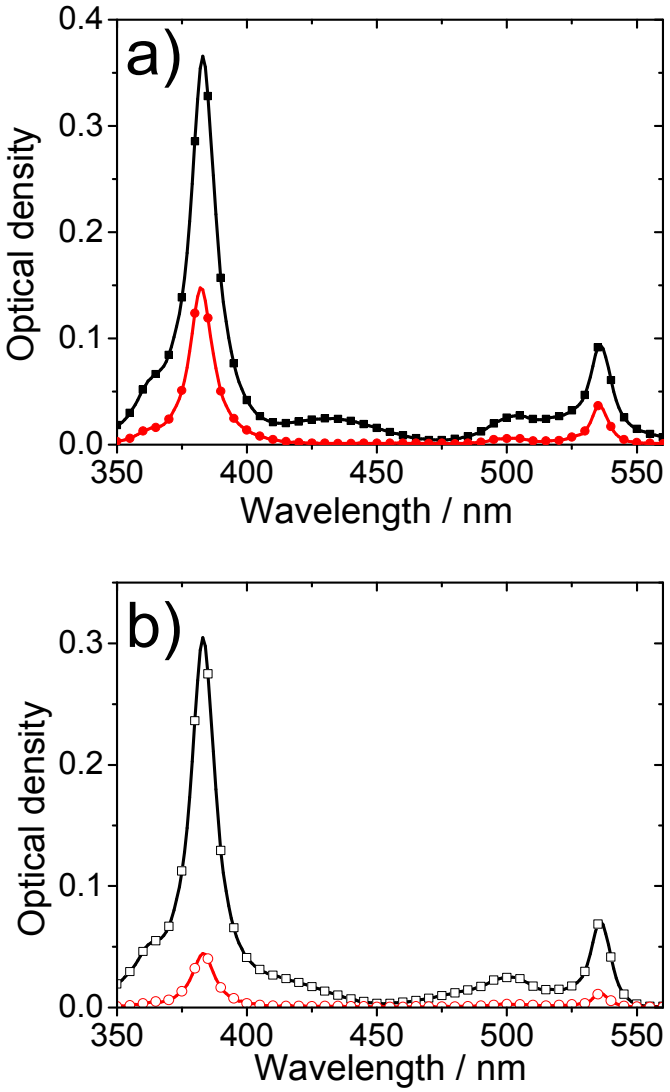

Figure S 1. UV-Vis spectra of a) a PS:PtOEP 1 wt% blend film (filled squares) and a PS:PtOEP 1 wt%/PNB bilayer film (filled circles), b) a PS:PtOEP 1 wt% annealed blend film (open squares) and a PS:PtOEP 1 wt% (annealed)/Zeonex bilayer film (open circles).

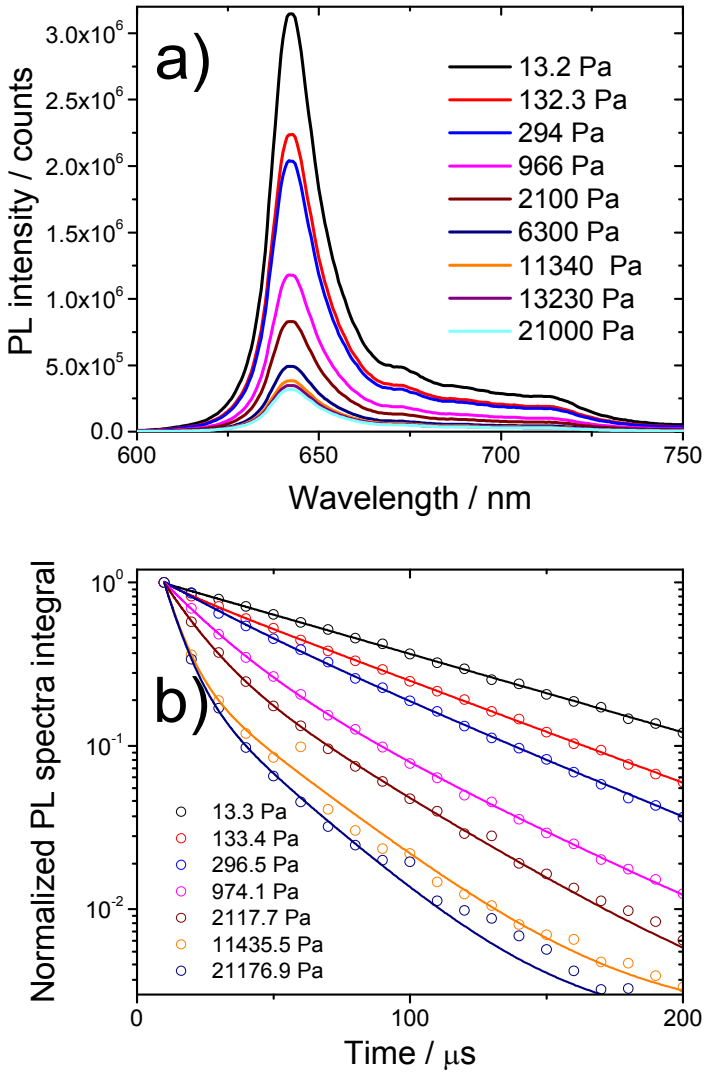

Figure S 2. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a 370 nm thick PNB:PtOEP 1 wt% film on quartz.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
8.47×10^{-5}	1.018 ± 0.005	91.14 ±1.10	-	-	91.14	0.9991
13.3	0.990 ± 0.003	90.37±0.41	-	-	90.37	0.99965
133.4	0.916 ± 0.011	69.25 ± 0.84	0.081± 0.012	13.13 ± 2.52	68.32	0.99983
296.5	0.731 ± 0.224	63.22 ± 8.23	0.279 ± 0.224	28.05 ± 10.65	58.12	0.99886
974.1	0.406 ± 0.032	52.41 ± 2.17	0.594 ± 0.032	19.00 ± 0.68	40.84	0.99987
2117.7	0.387 ± 0.019	42.29 ± 1.26	0.610 ± 0.019	12.44 ± 0.33	32.83	0.99987
6353.1	0.354 ± 0.018	30.47 ± 1.05	0.643 ± 0.018	6.97 ± 0.23	23.57	0.99976
11435.5	0.714 ± 0.030	6.3 ± 0.40	0.283 ± 0.029	33.83 ± 2.74	25.01	0.9987
13341.5	0.263 ± 0.011	30.20 ± 0.88	0.735 ± 0.011	6.84 ± 0.13	21.15	0.9999
21176.9	0.747 ± 0.015	6.49 ± 0.16	0.251 ± 0.014	29.40 ± 1.19	20.32	0.99982

Table S 2. Fitting results of the pressure-dependent phosphorescence intensity decay for a 370 nm thick PNB:PtOEP 1 wt% film on quartz.

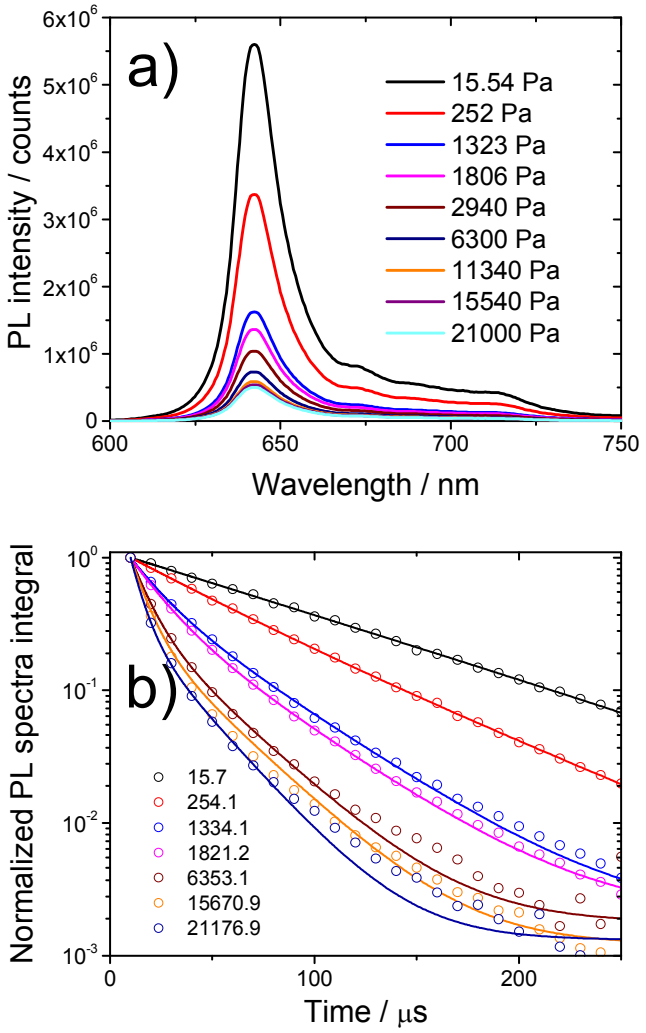

Figure S 3. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a 520 nm thick PNB:PtOEP 1 wt% film on quartz.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
1.6×10^{-5}	1.004 ±0.003	94.31±0.68	-	-	94.31	0.99969
15.7	1.004 ± 0.003	90.59 ± 0.73	-	-	90.59	0.99959
254.1	0.617 ± 0.335	45.66 ± 6.68	0.385 ± 0.334	77.06 ± 18.72	61.78	0.99988
1334.1	0.522 ± 0.023	42.60 ± 0.98	0.476 ± 0.023	14.52 ± 0.49	35.94	0.99992
1821.2	0.424 ± 0.030	41.29 ± 1.50	0.573 ± 0.030	14.72 ± 0.52	32.64	0.99988
6353.1	0.336 ± 0.018	30.66 ± 0.97	0.662 ± 0.018	8.59 ± 0.21	22.80	0.99988
11435.5	0.714 ± 0.009	7.61 ± 0.11	0.285 ± 0.010	29.87 ± 0.64	21.19	0.99995
15670.9	0.279 ± 0.011	27.86 ± 0.71	0.725 ± 0.011	6.98± 0.11	19.53	0.99994
21176.9	0.707 ± 0.014	5.83 ± 0.14	0.291 ± 0.014	24.96 ± 0.78	18.04	0.99989

Table S 3. Fitting results of the pressure-dependent phosphorescence intensity decay for a 520 nm thick PNB:PtOEP 1 wt% film on quartz.

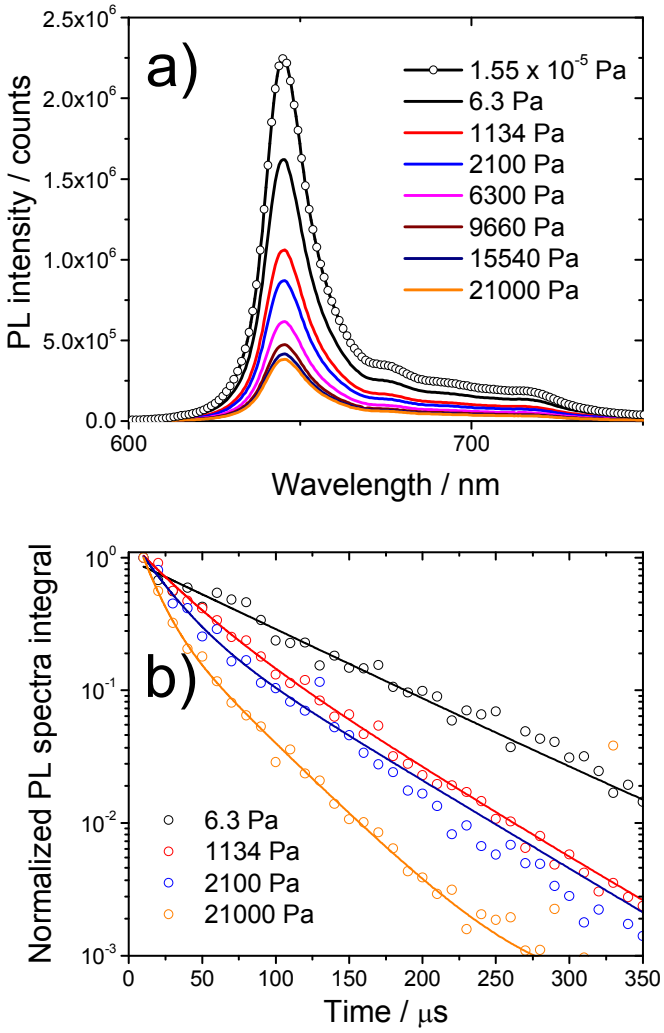

Figure S 4. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PS:PtOEP 1 wt%/PNB bilayer film on quartz.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
1.55×10^{-5}	0.964 ± 0.026	111.33 ± 8.41	-	-	111.33	0.97214
6.3	0.856 ± 0.028	82.70 ± 4.10	-	-	82.69	0.96103
1134	0.483 ± 0.490	64.69 ± 23.66	0.550 ± 0.485	29.37 ± 13.05	52.66	0.99012
2100	0.379 ± 0.189	65.53 ± 16.93	0.644 ± 0.186	20.86 ± 5.03	49.87	0.98683
6300	0.089 ± 0.082	85.70 ± 46.77	0.941 ± 0.080	23.07± 2.02	39.31	0.99334
15540	0.490 ± 0.121	33.84 ± 5.10	0.501 ± 0.121	9.43 ± 2.11	28.42	0.99442
21000	0.636 ± 0.064	11.38 ± 1.08	0.365 ± 0.065	40.37 ± 4.08	30.82	0.99786

Table S 4. Fitting results of the pressure-dependent phosphorescence intensity decay for a PS:PtOEP 1 wt%/PNB bilayer film on quartz.

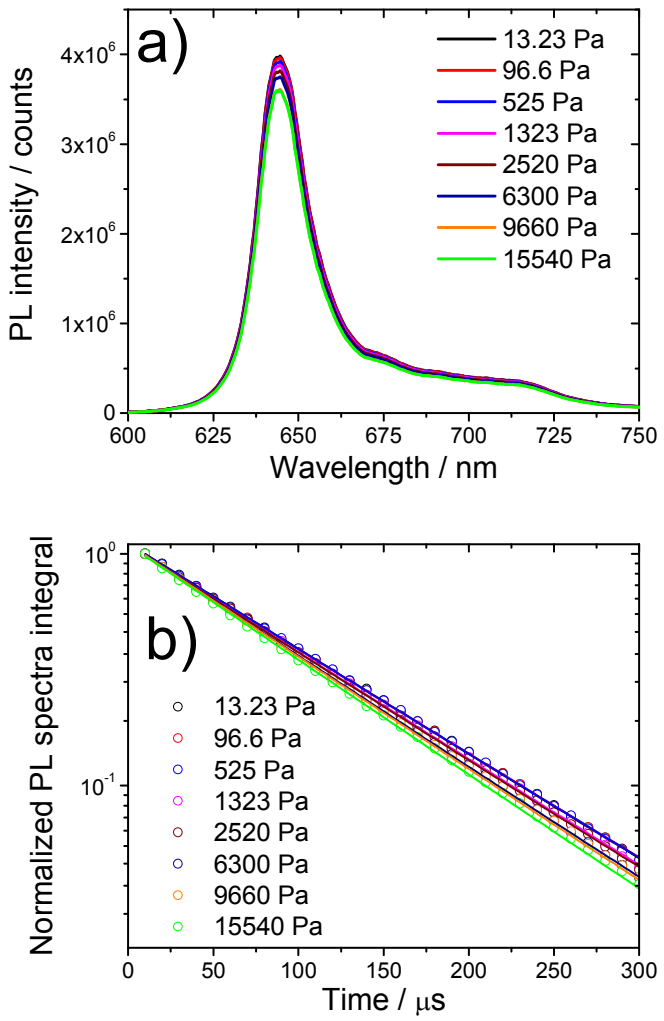

Figure S 5. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PMMA120k:PtOEP 1 wt% annealed film on quartz.

pO_2 (Pa)	A ± dA (%)	τ ± dτ (μs)	<τ> (μs)	Adj. R-Square
1.32×10^{-5}	0.981 ± 0.003	96.83 ± 0.45	96.83	0.99964
13.23	0.997 ± 0.002	95.36 ± 0.32	95.36	0.99982
96.6	0.984 ± 0.002	96.13 ± 0.36	96.13	0.99978
525	0.992 ± 0.002	95.70 ± 0.25	95.70	0.99989
1323	0.980 ± 0.003	93.77 ± 0.44	93.77	0.99965
2520	0.983 ± 0.003	93.08 ± 0.38	93.08	0.99974
6300	0.983 ± 0.003	90.18 ± 0.39	90.18	0.99971
9660	0.983 ± 0.003	89.28 ± 0.38	89.28	0.99972
15540	0.976 ± 0.004	87.26 ± 0.52	87.26	0.99947
21000	0.977 ± 0.003	85.90 ± 0.47	85.90	0.99955

Table S 5. Fitting results of the pressure-dependent phosphorescence intensity decay for a PMMA120k:PtOEP 1 wt% annealed film on quartz.

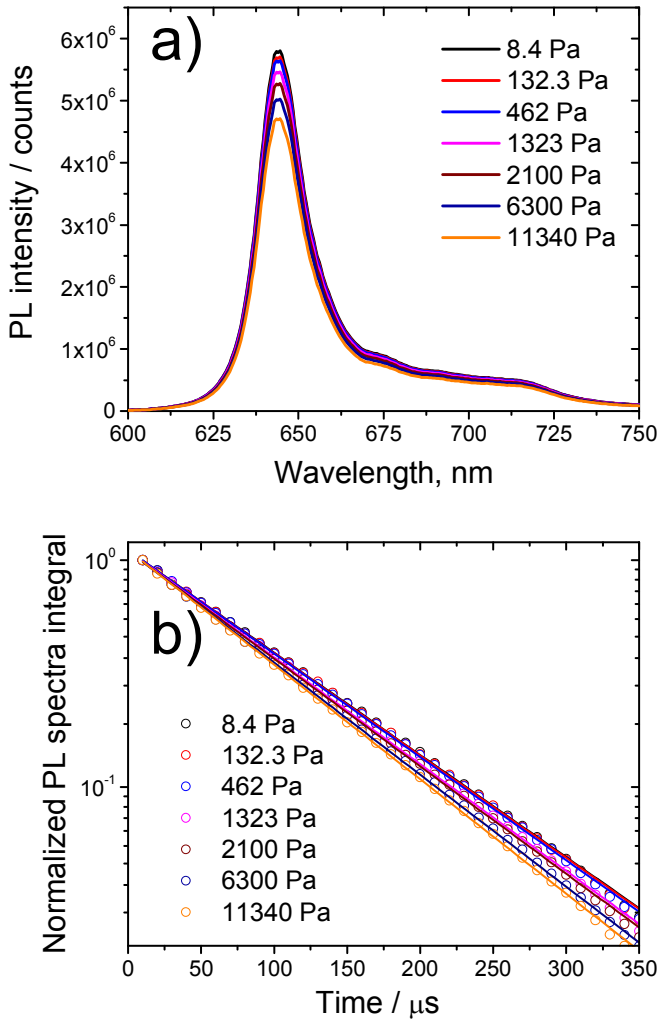

Figure S 6. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PMMA350k:PtOEP 1 wt% annealed film on quartz.

pO_2 (Pa)	A ± dA (%)	τ ± dτ (μs)	<τ> (μs)	Adj. R-Square
2.1×10^{-5}	0.988 ± 0.003	95.78 ± 0.42	95.78	0.99965
8.4	0.994 ± 0.002	96.36 ± 0.285	96.36	0.99984
132.3	0.992 ± 0.002	96.20 ± 0.302	96.20	0.99982
462	0.994 ± 0.002	95.34 ± 0.248	95.34	0.99987
1323	0.988 ± 0.002	92.26 ± 0.299	92.26	0.99981
2100	0.982 ± 0.003	91.58 ± 0.405	91.58	0.99965
6300	0.984 ± 0.002	87.88 ± 0.346	87.88	0.99973
11340	0.985 ± 0.002	85.98 ± 0.261	85.98	0.99984
15540	0.969 ± 0.004	83.31 ± 0.547	83.31	0.99926

Table S 6. Fitting results of the pressure-dependent phosphorescence intensity decay for a PMMA350k:PtOEP 1 wt% annealed film on quartz.

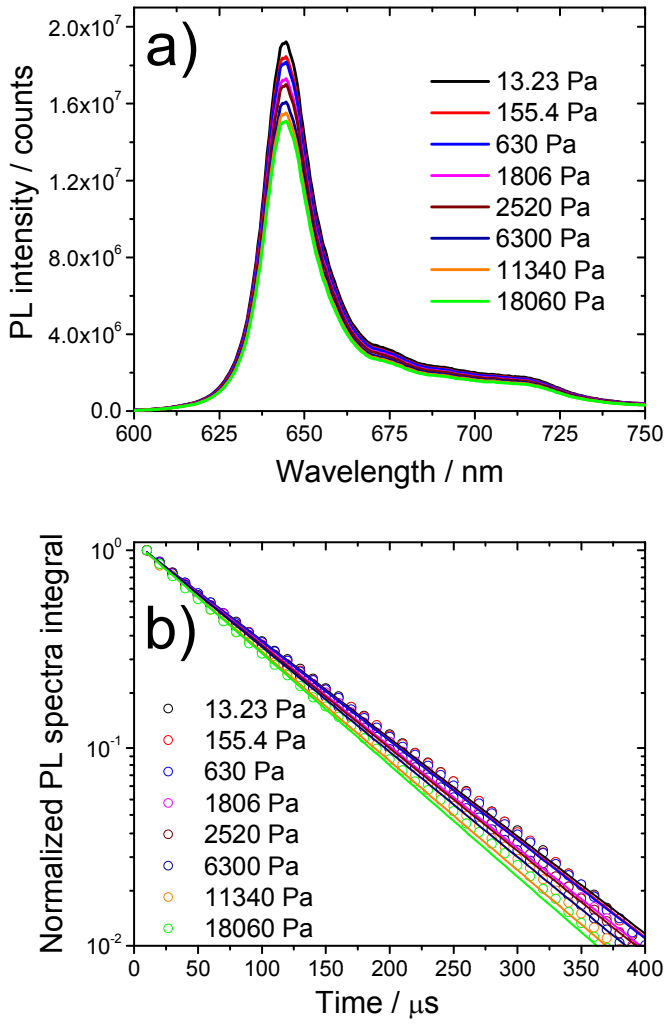

Figure S 7. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PMMA996k:PtOEP 1 wt% annealed film on quartz.

pO_2 (Pa)	A ± dA (%)	τ ± dτ (μs)	<τ> (μs)	Adj. R-Square
1.32×10^{-5}	0.968 ± 0.004	87.14 ± 0.61	87.14	0.99913
13.23	0.973 ± 0.004	87.72 ± 0.51	87.72	0.9994
155.4	0.971 ± 0.005	86.97 ± 0.62	86.97	0.9991
630	0.976 ± 0.004	86.52 ± 0.49	86.52	0.99942
1806	0.976 ± 0.004	84.11 ± 0.45	84.11	0.99949
2520	0.973 ± 0.004	83.40 ± 0.49	83.40	0.9994
6300	0.979 ± 0.003	81.59 ± 0.43	81.59	0.99952
11340	0.967 ± 0.005	78.47 ± 0.58	78.47	0.99908
18060	0.971 ± 0.004	76.78 ± 0.51	76.78	0.99928
21000	0.973 ± 0.004	76.53 ± 0.49	76.53	0.99933

Table S 7. Fitting results of the pressure-dependent phosphorescence intensity decay for a PMMA996k:PtOEP 1 wt% annealed film on quartz.

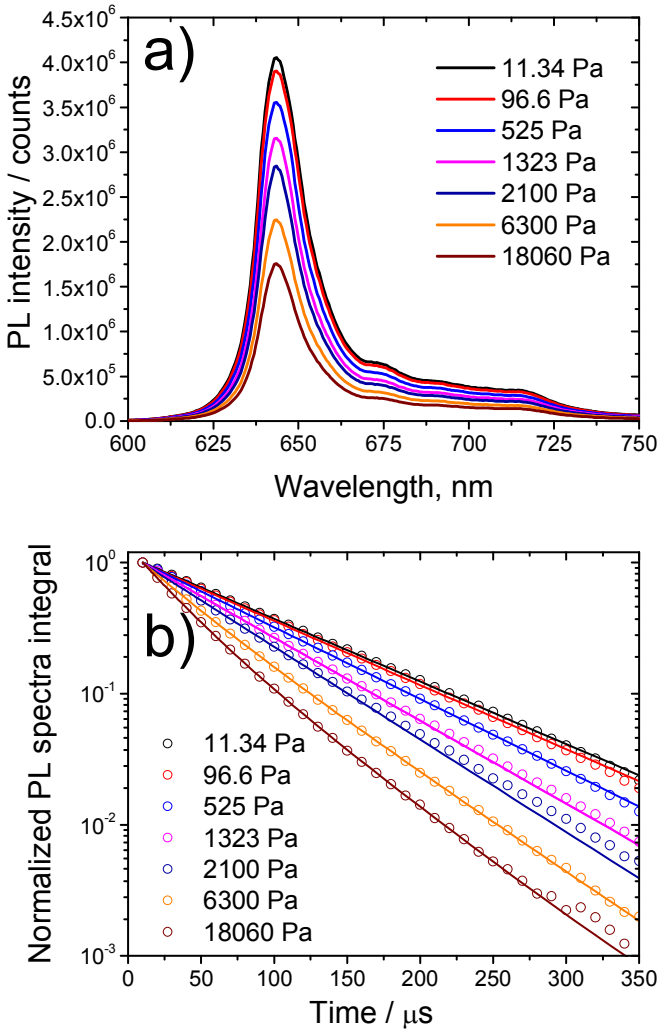

Figure S 8. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a Zeonex®:PtOEP 1 wt% film on quartz.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
2.94×10^{-5}	1.002 ± 0.002	90.73 ± 0.25	-	-	90.73	0.99985
11.34	1.001 ± 0.001	90.90 ± 0.18	-	-	90.90	0.99993
96.6	0.989 ± 0.002	88.74 ± 0.26	-	-	88.74	0.99985
525	0.997 ± 0.001	79.36 ± 0.18	-	-	79.36	0.99992
1323	0.992 ± 0.002	68.57 ± 0.20	-	-	68.57	0.99986
2100	0.985 ± 0.003	61.42 ± 0.28	-	-	61.42	0.99969
6300	0.366 ± 0.064	33.50 ± 1.88	0.632 ± 0.064	58.15 ± 1.50	51.98	0.99998
11340	0.268 ± 0.029	23.91 ± 1.18	0.730 ± 0.030	49.63 ± 0.67	45.77	0.99998
18060	0.513 ± 0.041	27.75 ± 0.86	0.488 ± 0.042	52.47 ± 1.32	43.64	0.99998
21000	0.161 ± 0.018	13.41 ± 1.15	0.838 ± 0.017	42.76 ± 0.45	41.09	0.99992

Table S 8. Fitting results of the pressure-dependent phosphorescence intensity decay for a Zeonex®:PtOEP 1 wt% film on quartz.

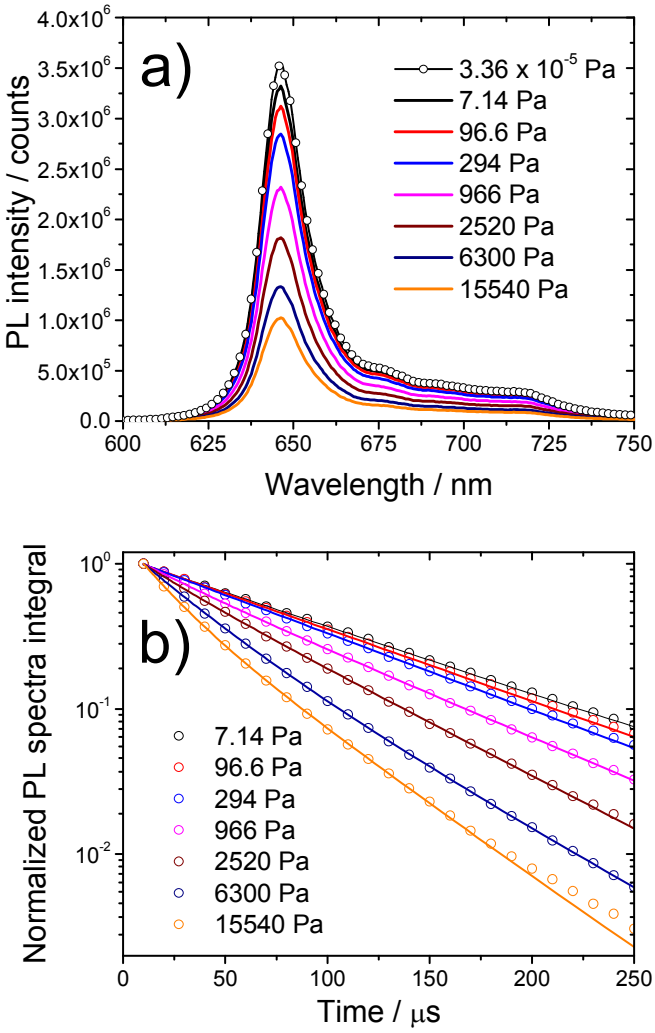

Figure S 9. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PS:PtOEP 1 wt% annealed film on quartz.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
3.36×10^{-5}	0.986 ± 0.002	92.00 ± 0.34	-	-	92.00	0.99978
7.14	0.977 ± 0.003	91.67 ± 0.48	-	-	91.67	0.99957
96.6	0.985 ± 0.003	87.81 ± 0.44	-	-	87.81	0.99962
294	0.988 ± 0.002	82.27 ± 0.28	-	-	82.27	0.99983
966	0.863 ± 0.019	72.83 ± 0.67	0.136 ± 0.027	28.79 ± 2.42	70.25	0.99997
2520	0.842 ± 0.046	59.50 ± 1.35	0.154 ± 0.031	24.21 ± 4.28	57.05	0.99987
6300	0.480 ± 0.039	54.11 ± 1.30	0.520 ± 0.018	28.50 ± 0.82	44.80	0.99999
13230	0.538 ± 0.036	46.31 ± 1.08	0.461 ± 0.046	21.58 ± 0.79	39.25	0.99997
15540	0.561 ± 0.028	43.29 ± 0.83	0.438 ± 0.039	18.35 ± 0.63	37.09	0.99996
21000	0.562 ± 0.031	92.00 ± 0.34	0.437 ± 0.035	18.34 ± 0.68	35.85	0.99997

Table S 9. Fitting results of the pressure-dependent phosphorescence intensity decay for a PS:PtOEP 1 wt% annealed film on quartz.

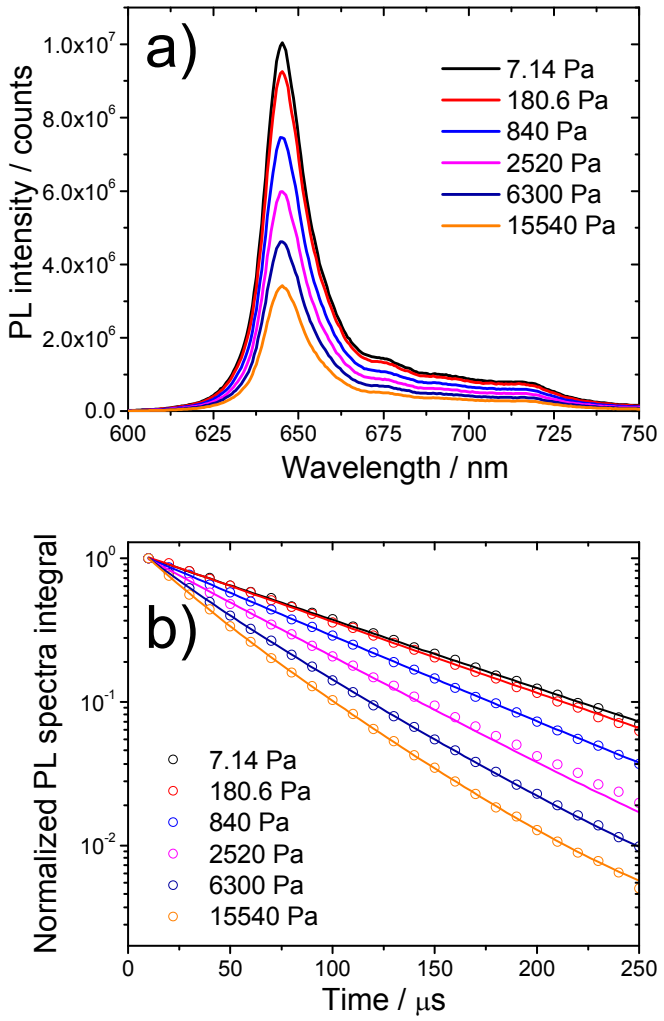

Figure S 10. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PS:PtOEP 1 wt%/ Zeonex® bilayer film on quartz.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
4.2×10^{-5}	0.998 ±	90.54 ± 0.31	-	-	90.54	0.99981
7.14	1.007 ±	90.39 ± 0.30	-	-	90.39	0.99982
180.6	1.019 ± 0.003	86.64 ± 0.43	-	-	86.64	0.99961
840	1.001 ± 0.002	71.98 ± 0.21	-	-	71.98	0.99988
2520	0.988 ± 0.004	57.35 ± 0.36	-	-	57.35	0.99949
6300	0.748 ± 0.039	52.53 ± 0.97	0.252 ± 0.039	24.43 ± 1.82	48.72	0.99996
9660	0.533 ± 0.143	30.13 ± 2.68	0.466 ± 0.143	53.16 ± 4.30	44.11	0.99989
15540	0.643 ± 0.085	46.45 ± 1.99	0.356 ± 0.085	23.06 ± 2.34	41.40	0.99988
21000	0.695 ± 0.023	42.34 ± 0.65	0.303 ± 0.023	16.61 ± 0.72	38.58	0.99997

Table S 10. Fitting results of the pressure-dependent phosphorescence intensity decay for a PS:PtOEP 1 wt%/ Zeonex® bilayer film on quartz.

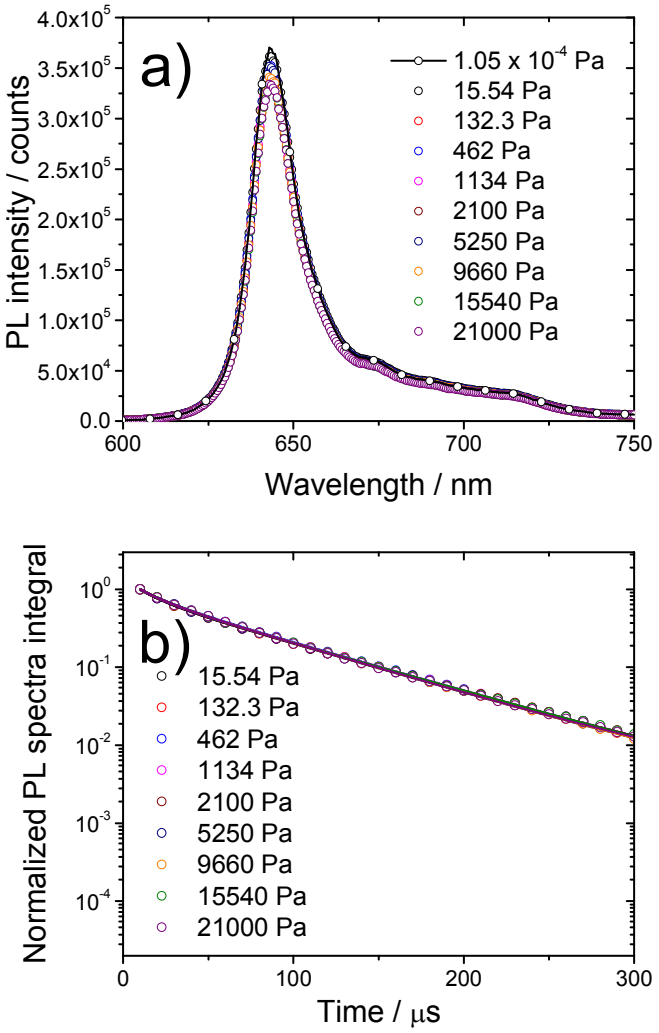

Figure S 11. Pressure dependent a) time-integrated phosphorescence spectra and b) phosphorescence decay transients of a PS:PtOEP 1 wt% film on quartz encapsulated with glass/epoxy.

pO_2 (Pa)	$A_1 \pm dA_1$ (%)	$\tau_1 \pm d\tau_1$ (µs)	$A_2 \pm dA_2$ (%)	$\tau_2 \pm d\tau_2$ (µs)	<τ> (µs)	Adj. R-Square
1.05×10^{-4}	0.786 ± 0.008	66.50 ± 0.53	0.212 ± 0.008	11.48 ± 0.68	64.06	0.99984
15.54	0.759 ± 0.009	67.90 ± 0.72	0.238 ± 0.009	14.20 ± 0.66	64.60	0.99991
132.3	0.737 ± 0.011	69.33 ± 0.88	0.259 ± 0.012	16.01 ± 0.76	65.33	0.9999
462	0.773 ± 0.010	68.59 ± 0.79	0.223 ± 0.011	15.49 ± 0.82	65.34	0.99991
1134	0.745 ± 0.010	70.00 ± 0.79	0.253 ± 0.010	16.29 ± 0.70	66.06	0.99993
2100	0.738 ± 0.011	69.54 ± 0.93	0.259 ± 0.011	14.21 ± 0.74	65.84	0.99986
5250	0.752 ± 0.013	68.38 ± 1.06	0.243 ± 0.014	14.44 ± 0.94	64.93	0.99982
9660	0.772 ± 0.012	67.58 ± 0.94	0.226 ± 0.013	14.80 ± 0.95	64.40	0.99986
15540	0.725 ± 0.012	70.87 ± 0.87	0.275 ± 0.012	18.56 ± 0.75	66.15	0.99994
21000	0.773 ± 0.01	67.08 ± 0.75	0.224 ± 0.011	15.28 ± 0.78	63.87	0.99992

Table S 11. Fitting results of the pressure-dependent phosphorescence intensity decay for a PS:PtOEP 1 wt% film on quartz encapsulated with glass/epoxy.