**Supplementary Information**

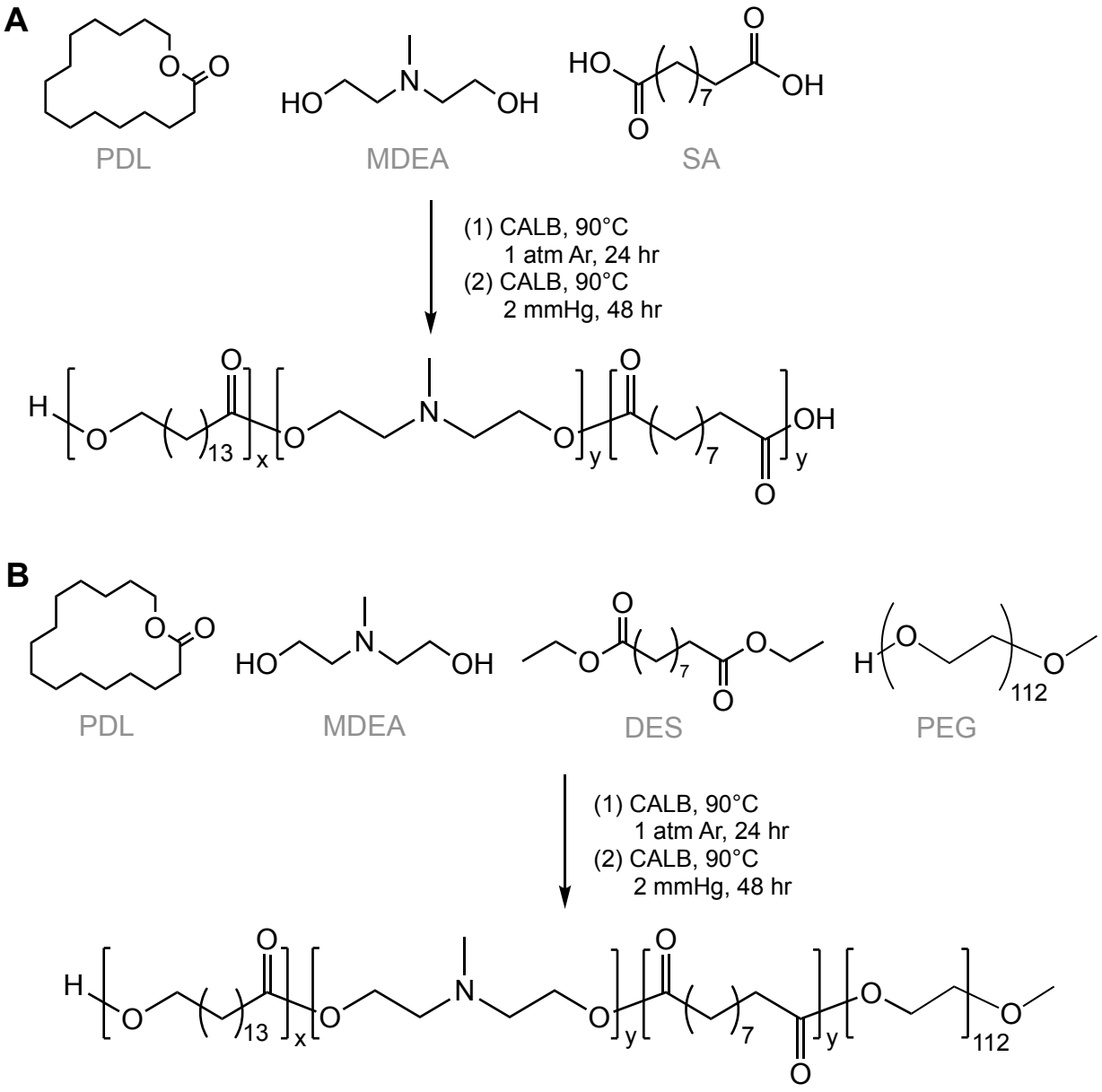


**Figure S1:** The synthetic routes for **(A)** PACE and **(B)** PACE-PEG. Polymers were synthesized by enzymatic copolymerization.

| PACE-PEG content (wt%) | PEG content (wt%) |
|---|---|
| 0 | 0 |
| 0.01 | 0.0046 |
| 0.025 | 0.011 |
| 0.05 | 0.023 |
| 0.1 | 0.046 |
| 0.25 | 0.11 |
| 0.5 | 0.23 |
| 1 | 0.46 |
| 2.5 | 1.1 |
| 5 | 2.3 |
| 10 | 4.6 |
| 50 | 23 |

**Table S1:** Calculation of theoretical PEG weight percentage corresponding to PACE-PEG content in blended polyplexes.

| Polymer | $M_n$ (Da) | $M_w$ (Da) | PDI |
|---|---|---|---|
| PACE | 9000 | 17500 | 1.93 |
| PACE-PEG | 8200 | 15000 | 1.84 |

**Table S2:** Molecular Weight and PDI of PACE and PACE-PEG by GPC.

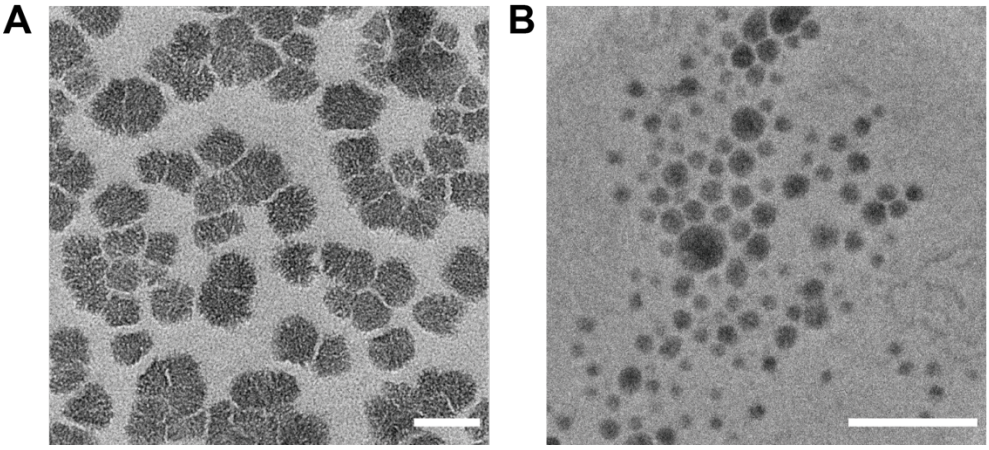


**Figure S2:** TEM images of (**A**) non-PEGylated PACE polyplexes and (**B**) polyplexes made with 100% PACE-PEG (scale bar, 200 nm).

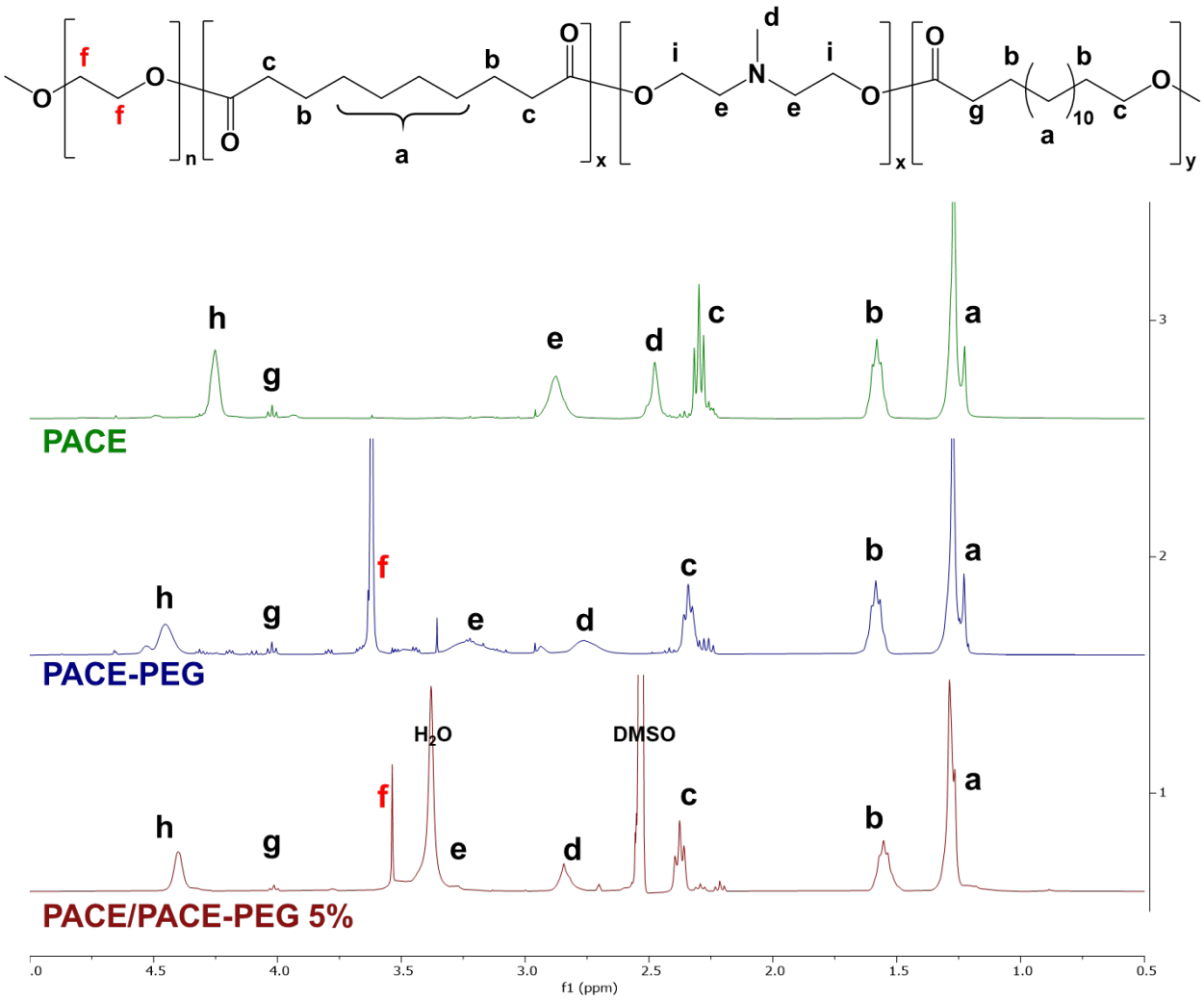


**Figure S3:** Confirmation of PACE-PEG integration into polyplexes. mRNA-loaded polyplexes with 5% PACE-PEG by weight were formulated and washed twice in a filter centrifuge tube (100 kDa MWCO, Amicon Ultra, Millipore Sigma) to remove excess polymer and salts. Washed polyplexes were lyophilized and analyzed by NMR and compared to PACE and PACE-PEG polymer.

| | molar ratio PDL:MDEA:SBA(DES) | | | wt% of monomer | | | | wt% PACE to PEG | |
|---|---|---|---|---|---|---|---|---|---|
| | PDL | MDEA | SBA(DES) | PDL | MDEA | SBA(DES) | PEG | PACE | PEG |
| PACE | 7.6 | 45.8 | 46.7 | 12.1 | 30.8 | 57.1 | | 100.0 | |
| PACE-PEG | 10.8 | 44.1 | 45.1 | 9.1 | 15.7 | 29.3 | 45.8 | 54.2 | 45.8 |
| PP5% | 10.1 | 41.5 | 48.4 | 15.1 | 26.0 | 55.2 | 3.7 | 96.3 | 3.7 |

**Table S3:** NMR analysis of mRNA-loaded polyplexes with 5% PACE-PEG by weight (PP5%) compared to PACE and PACE-PEG.

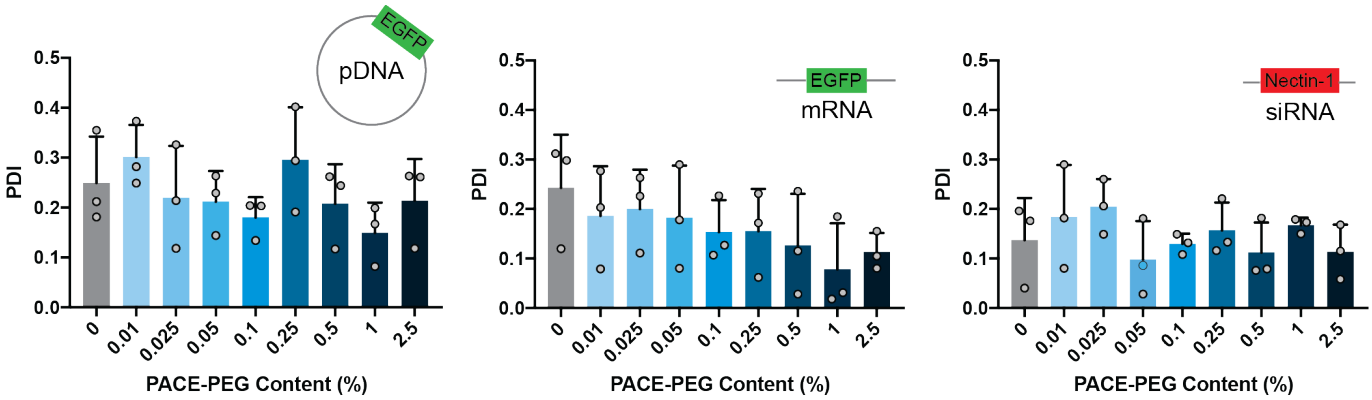


**Figure S4**: PDI of PACE polyplexes blended with PACE-PEG.

| PACE-PEG content (wt%) | N:P (pDNA polyplexes) | Zeta Potential (mV, pDNA polyplexes) | N:P (mRNA polyplexes) | Zeta Potential (mV, mRNA polyplexes) | N:P (siRNA polyplexes) | Zeta Potential (mV, siRNA polyplexes) |
|---|---|---|---|---|---|---|
| 0 | 94:1 | -7.1 ± 5.2 | 98:1 | -11 ± 3.1 | 96:1 | -12.5 ± 4.3 |
| 0.01 | 94:1 | -5.9 ± 1.1 | 98:1 | -9.6 ± 3.7 | 96:1 | -12.4 ± 3.4 |
| 0.025 | 94:1 | -5.3 ± 2.4 | 98:1 | -9.4 ± 2.2 | 96:1 | -13.3 ± 2.5 |
| 0.05 | 94:1 | -7.7 ± 5.1 | 98:1 | -12.9 ± 3.6 | 96:1 | -14.3 ± 3 |
| 0.1 | 94:1 | -7.6 ± 3.8 | 98:1 | -12.6 ± 3.2 | 96:1 | -14 ± 4.3 |
| 0.25 | 94:1 | -8 ± 2.8 | 98:1 | -11.3 ± 3.3 | 96:1 | -14.6 ± 3.2 |
| 0.5 | 94:1 | -7.5 ± 5.7 | 97:1 | -12.3 ± 5.1 | 96:1 | -16.3 ± 6.4 |
| 1 | 94:1 | -6.8 ± 6.4 | 97:1 | -13.9 ± 2.8 | 96:1 | -15.9 ± 2.9 |
| 2.5 | 93:1 | -10.3 ± 6.4 | 96:1 | -13.2 ± 4.5 | 95:1 | -18.1 ± 4 |

**Table S4:** Comparison of PACE polyplex zeta potential and corresponding N:P ratios for a range of PACE-PEG concentrations.

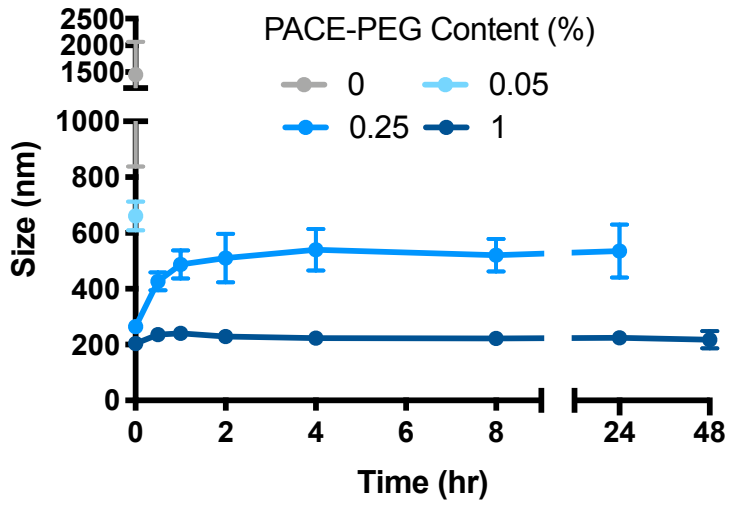


**Figure S5**: Stability of mRNA-loaded PACE polyplexes in sodium acetate buffer (25 mM, pH 6) with 10% FBS at 37°C while shaking.