

**Figure 1:** Comparison of Detergent (DDM) vs non-detergent α-olefin-maleic acid copolymers (αMAs) PSI oligomer isolation.

- A. Sucrose density gradient gels of solubilized protein complex extracts following incubation and protein solubilization using  $\alpha$ MA copolymers, a DDM control, and DIBMA. The labels PSI-m and PSI-t correspond to the monomeric and trimeric species of PSI, respectively (from Workman et al., 2023).
- **B-E.** Characterization of the trimeric PSI band isolated using different αMAs PSI-SMALPs isolated from the sucrose density gradients using: B) UV/Vis Spectroscopy, C) low-temperature fluorescence, D) SDS-PAGE, E) BN-PAGE.
- **F.** The size of different  $\alpha$ MAs isolated trimeric PSI-containing nanodiscs determined by dynamic light scattering and plotted against the total lipid number/mg/protein as determined by MS/MS. Analysis shows a clear correlation with DLS size with lipid content but does not correlate with length of the  $\alpha$ MA copolymers.
- **G.** Micrograph of trimeric PSI-nanodisc solubilized with **C**<sub>14</sub>**MA**<sup>5.6</sup> from *T. elongatus* thylakoids as imaged by transmission electron microscopy. The negatively stained particles are visible under different views. The top section shows 2D class averages of corresponding PSI-SMALPs, mainly PSI trimers. resulting from extensive image analysis of the dataset.
- **H.** SANs based model of *T. elongatus* PSI-DDM (left) and PSI-SMALP trimers (right) isolated using SMA-1440 from Brady et al. 2022, with some modifications. The comparison highlights a noticeable size difference between the DDM micelle and the SMALP with PSI inside. Additionally, there is a distinct, oversized maintenance belt made of thylakoid lipids surrounding the oligomeric particle.

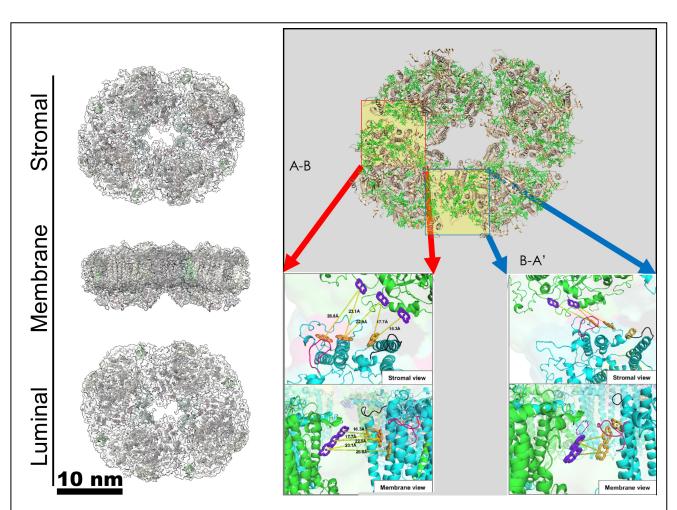
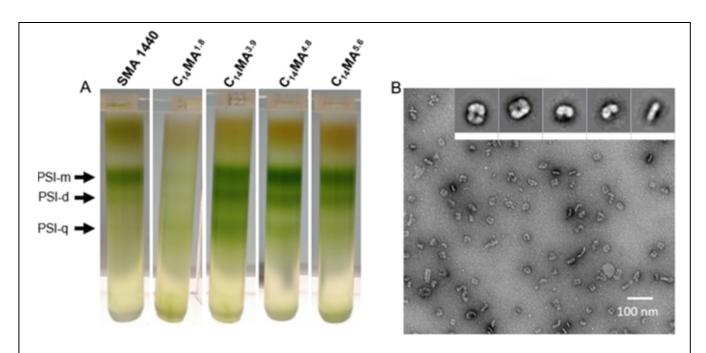


Figure 2. Structure of TS-821 PSI tetramer and its two interfaces.

- **A.** Cryo-EM 3D map of TS-821 PSI tetramer (EMD-13898) with a fitted build-up model (PDB: 7QCO) at 3.7 Å resolution from Semchonok et al. 2022, with some modifications. In the center of PSI tetramer, the pore, which is disrupted by detergents clearly visible.
- **B.** A closer look of the interfaces from Semchonok et al. 2022, with some modifications: in B'—A and A—B, the black and red loops are part of PsaB with sequences QPKFRPS and MYRTNFGIGHS, respectively. The distances are shown by yellow lines. The missing Chl a at the B—A' interface is shown by a purple dashed pyrrole ring at a position relatively similar to that in the mono-A—B interface.



**Figure 3.** Images of **A**) sucrose density gradients of the species extracted from TS-821 using a novel polymer  $C_{14}MA$  samples in comparison with SMA 1440 polymer, and **B**) isolated tetrameric PSI-nanodiscs solubilized with  $C_{14}MA^{3.9}$  negatively stained and imaged by transmission electron microscopy. PSI-m, PSI-d, and PSI-q refer to nanodiscs containing monomeric, dimeric, and tetrameric PSI, respectively. Modified from Workman et al. 2023.