Electronic Supplemental Information (ESI)

Title
Short Polyethylene Glycol Chains Densely Bound to Soft Nanotube Channels for Inhibition of Protein Aggregation

Authors
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Fig. S1 (a) Release of the encapsulated lysozyme (3.0 mg/ml) in the PEG<sub>8</sub>-NT channel to the bulk solution by cooling to 25 °C. The sample solution was prepared by heating at 90 °C of the mixing dispersion of the PEG<sub>8</sub>-NT (25 mg/ml) and lysozyme (3.0 mg/ml). (b) Release of the encapsulated lysozyme (3.0 mg/ml) in the PEG<sub>8</sub>-NT channel to the bulk solution by standing at 25 °C. The sample solution was prepared as follows: The lysozyme solution (3.0–9.0 mg/ml) was added into the lyophilized PEG<sub>8</sub>-NT (25 mg/ml). The resultant mixture was filtered by the polycarbonate membrane with 200 nm pore size. The residual PEG<sub>8</sub>-NT was washed several times with PBS buffer to remove lysozyme existing outside of the PEG<sub>8</sub>-NT.
Fig. S2 (a, b) CD spectra of the 1-glyPEG₈-NT and the PEG₈-NT dispersed in water at 25 °C and 80 °C. The wavelength region of the Cotton bands corresponds to the absorption band of the conjugated amide linkages in co-assembly of 1 with the chiral source (α-glucose moiety), achiral glyPEG₈ and 2 with the chiral source (β-glucose moiety). The decrease of the CD intensity of the 1-glyPEG₈-NT at 80 °C means that the chiral molecular packing is destructed by the gel-to-liquid crystalline phase transition of the nanotube monolayer membrane. (c, d, e, f) Temperature dependence of the CD intensities at 195 nm for the 1-glyPEGₙ-NTs and the PEGₙ-NTs dispersed in water. The gel-to-liquid crystalline phase transition temperatures ($T_{g-l}$) of the 1-glyPEGₙ-NTs were estimated to be about 50 °C. All PEGₙ-NTs showing no decrease of the CD intensities have higher thermal stabilities.
Fig. S3 TEM images of the PEGₙ-NTs after sonication. The nanochannels of the nanotubes were visualized with 2wt% phosphotungstate as a negative staining reagent.
Fig. S4 IR spectra for the amide-I, amide-II, CH$_2$ scissoring, CH$_2$ rocking, CH deformation and CH skeletal bands of the PEG$_n$-NTs. The appearance of the CH$_2$ deformation and CH$_2$ skeletal shows that 1 and glyPEG$_n$ forms a polyglycine-II-type hydrogen bond network. The single sharp peak of the CH$_2$ scissoring and CH$_2$ rocking indicates that the lateral chain packing (subcell structure) of the oligomethylene spacer of 1 and 2 has a triclinic parallel (T$_{\text{a/a}}$) structure.
Fig. S5 (a, b) Fluorescence spectra of the encapsulated 1,8-ANS in the PEG₈-NT channel and the free 1,8-ANS in the presence of glyPEG₈ unit in bulk solutions at 25 °C and 50 °C. (c) Relationship between the variation of the fluorescence intensity and the elevating temperatures. (d) Relationship between the variation of the fluorescence intensity and the cooling temperatures.

Fig. S6 Enzymatic activities of lysozyme (0.2 mM) with different concentrations of the glyPEGₙ unit or arginine after heating at 90 °C for 30 min.