

Fig. S1 FTIR spectra of the reference sodium alginate and CSAD

FTIR measurement of CSAD was performed on a FTIR Analyzer (Bruker T27, Germany) using KBr pellets. A stretching vibration peak was detected at 1738 cm⁻¹, which was attributed to C=O ester bond; a stretching vibration peak of methyl of cholesteryl was detected at 2855 cm⁻¹.

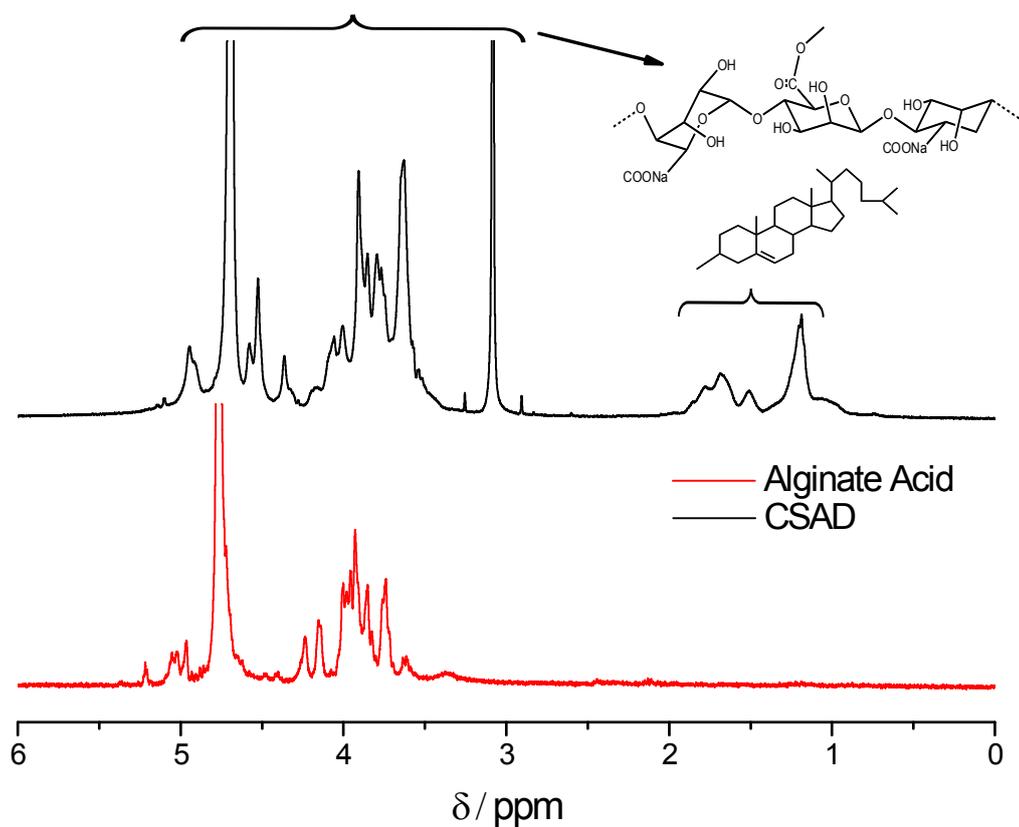


Fig. S2. ¹H-NMR spectra of the reference alginate acid and CSAD in D₂O solvent

¹H-NMR spectra (D₂O) were obtained using an NMR spectrometer (Bruker AV400, Switzerland). The signal peak in the range of δ 3.5-5.5 is the proton vibrational peak on the main chain of sodium alginate. Most protons of cholesterol are methylene protons, and their resonance signals should be scattered between δ 0.5-2.5. Compared with ¹H-NMR spectra of sodium alginate, ¹H-NMR spectra of CSAD has a new signal peak in the range of δ 1.0-2.0 coming from the resonance of methylene protons of cholesterol.

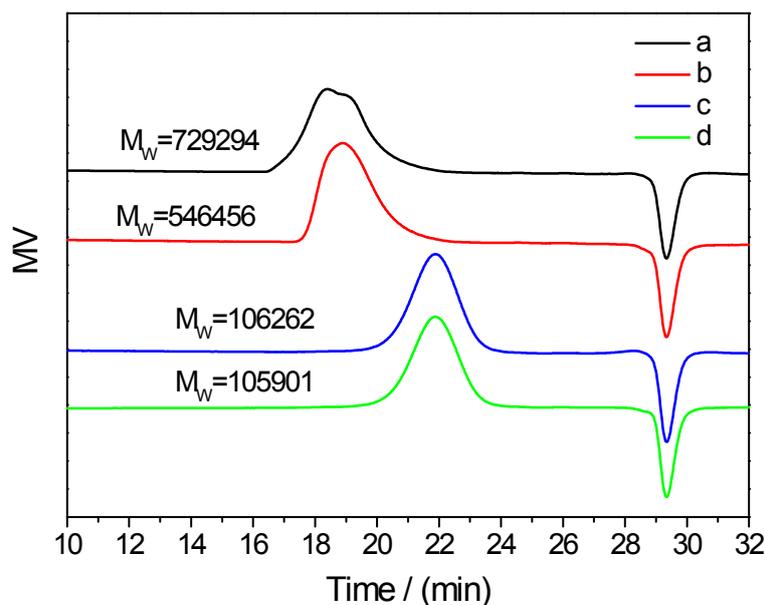


Fig. S3. GPC spectra of the reference sodium alginate and CSAD: (a): sodium alginate, (b): sodium alginate after ultrasonic, (c): CSAD, (d): CSAD after ultrasonic.

The GPC spectra was performed on gel permeation chromatography which is conducted by a Waters 2695 (USA) high performance liquid chromatography. It can be known from Fig. S3 that the molecular weight (M_w) of sodium alginate has a significant decrease, while the molecular weight (M_w) of CSAD only has an ignorable change. Ultrasonic depolymerization proceeds by mechanical force. Propagation of acoustic energy causes rapid pressure variation to form small bubbles in the liquid. Formation of bubbles (cavitation) and subsequent bubble collapse is responsible for the breakage of polymers by the generation of large velocity gradients¹. From the study about the degradation of polysaccharide by ultrasonication^{2, 3}, it can be found that first the reduction of molecular weight proceeds rapidly, then slows down and levelled off asymptotically approaching a constant value. This so-called limiting molecular weight (M_{lim}) is defined as a critical length of macromolecule that can diffuse the loaded stress without a breakage of covalent bonds^{4, 5}. In other words, reaching M_{lim} molecules are too small to be cleaved by ultrasound and further exposure to ultrasonic waves will not induce any degradation. During modification process, the molecular weight (M_w) of sodium alginate has decreased significantly, so that the molecular weight ($M_w=1.1 \times 10^5$) of CSAD is supposed to be the M_{lim} . In addition, the valid time of ultrasonication was only 4.3 min which so short, that the structure of CSAD was not broken.

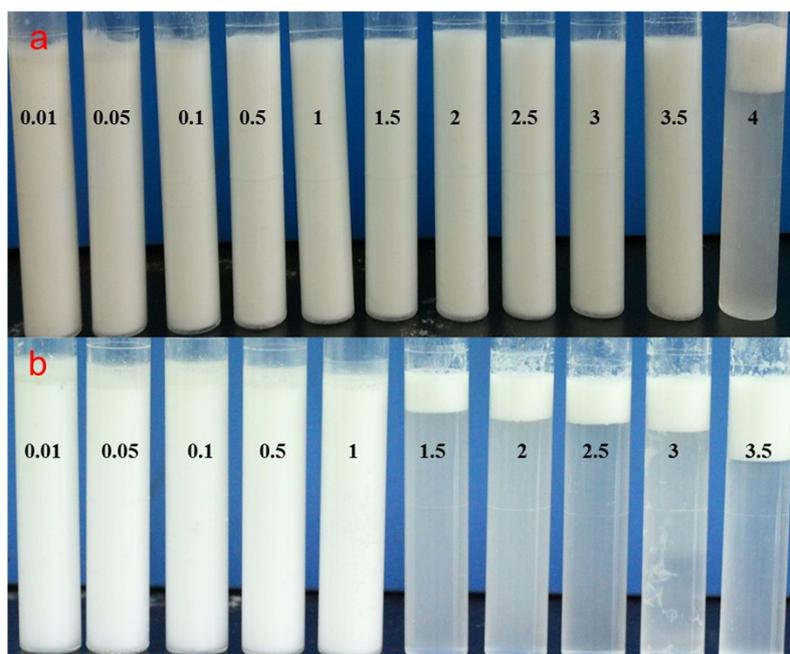


Fig. S4. Effect of DGP concentration (shown in the tubes) on the macroscopic phase separation of o/w emulsions after 12 h of storage at room temperature: (a) without NaCl and (b) with $0.1 \text{ mol}\cdot\text{L}^{-1}$ NaCl.

The effect of DGP concentration on the macroscopic phase separation of o/w emulsions after 12 h of storage at room temperature is illustrated in Fig. S4. As can be seen in the figure, at a DGP concentration of $0.1 \text{ mmol}\cdot\text{L}^{-1}$, some oil appeared in the tubes. The emulsions are stable within a DGP concentration range of $0.1\text{--}3 \text{ mmol}\cdot\text{L}^{-1}$. As the DGP concentration increases, the stability of the emulsion becomes poor. Barely observable in the picture, flocculation occurs at the DGP concentration of $3.5 \text{ mmol}\cdot\text{L}^{-1}$. In Fig. S4b, oil–water separation is evident in the emulsion with $0.1 \text{ mol}\cdot\text{L}^{-1}$ NaCl. High NaCl concentration can weaken emulsion stability because the shielding effect of NaCl reduces electrostatic repulsion between CSAD.

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