Polysaccharide based nano/micro-gel for the food application

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Contrast matching small-angle neutron scattering (SANS) over an extended Q range to reveal the morphology of complexes formed by protein and polysaccharide and the effects of encapsulation of the vitamin D3 in the complexes was carried out.

キーワード Keywords：polysaccharide-protein complex, VD3 encapsulation, CV-SANS

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１．目的 Objectives

The main objective of the experiment was to use the technique of contrast-matching small-angle neutron scattering (SANS) over an extended Q range to reveal the microstructural characteristics of a multicomponent systems composed of protein and polysaccharide and the effects of encapsulation of the vitamin D3 in the complexes on their internal structure by matching out the scattering from a polysaccharide or protein. The complex morphology was investigated under the application relevant pH, T and concentration conditions.

２．方法 Methods

SANS measurements were performed on the SANS-J-II instrument of JRR-3 on λ-carrageenan/BSA complexes with and without the encapsulation of vitamin D3. Thanks to the combination of pinhole and focusing methods using MgF_3 lenses and a high-resolution position-sensitive detector, the SANS-J-II beamline provided covering a wide Q range between $2x10^{-4}$ and 1.0 $Å^{-1}$. The solution samples were measured in Banjo-type quartz cuvettes applying a tumbling device meant to keep the sample homogeneous during the neutron data acquisition. The raw data were corrected for the contributions of the empty cuvette and dark current and for the sensitivity of the detectors. The corrected data were radially averaged and then calibrated in absolute units and corrected for solvent scattering to be transformed into the scattering cross section of the system under study. Contrast conditions were used that allowed either full contrast (in D_2O), protein matching (deuterated protein in 100% D_2O), or carrageenan matching (30% D_2O - 70% H_2O).

３．結果及び考察 Results and Discussions

To identify the structural role of each component in the complex, contrast-matching SANS over the broad range of Q was used. This method allows selective suppression of scattering from either the protein or the polysaccharide, making it possible to highlight the structural features of the remaining component. Contrast matching was achieved by varying the H_2O/D_2O ratio or using partially deuterated protein in 100% D_2O.

Fully protonated BSA and its analogue HSA was used for full contrast, while 75% deuterated HSA in 100% D_2O matched out the protein's scattering. Similarly, 75% deuterated HSA in 30% D_2O was used to match out the scattering of carrageenan.
As shown in Figure 1, the scattering pattern with the protein matched out showed a much lower intensity, while the carrageenan-matched data retained most of the structural features. This indicates that the overall structure of the complex is mainly formed by the protein.

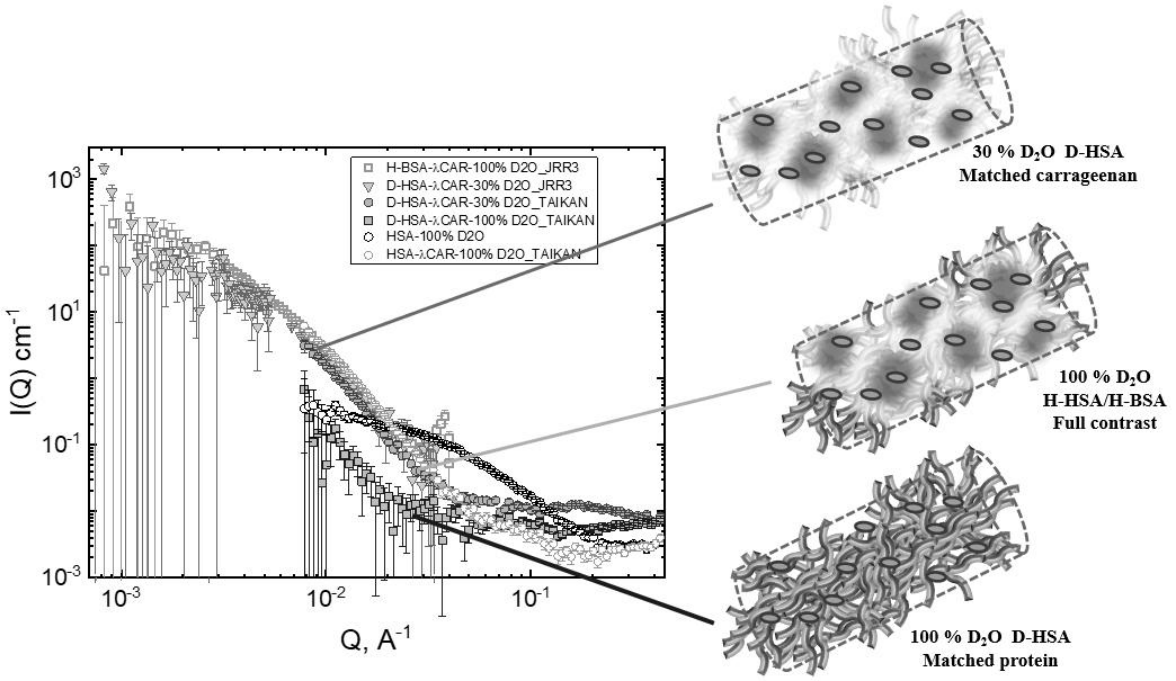

Figure 1. SANS profiles under different contrast conditions: from D-HSA-λCAR complexes in 30% D2O (pink and red), D-HSA-λCAR complexes in 100% D2O (blue), H-BSA(HSA)-λCAR complexes in 100% D2O (green and orange) and H-HSA in 100% D2O (black)

The interpretation of the forward scattering with assumption that all the material dissolved in the initial solutions is contained in formed aggregates and that the most scattering arises from the protein according to the contrast matched experiment yielded the volume fraction of the aggregates occupied by the material values suggesting that complexes represent a solvent-swollen flexible particles what prove that formed complexes are gel-like structures.

Detailed modeling of the scattering data and manuscript preparaton are in progress,