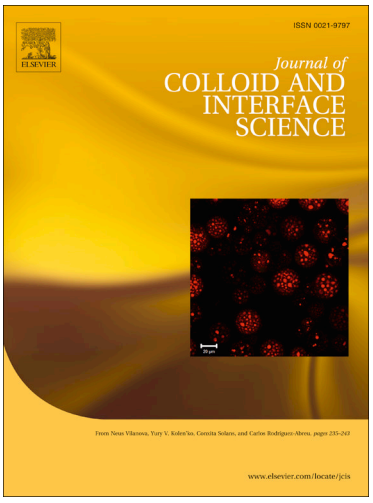

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Yongmin Zhang, Fei Qin, Xuefeng Liu, Yun Fang

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Switching worm-based viscoelastic fluid by pH and redox

Yongmin Zhang, Fei Qin, Xuefeng Liu,* and Yun Fang

Key Laboratory of Synthetic and Biological Colloids, Ministry of Education, School of Chemical & Materials Engineering, Jiangnan University, Wuxi 214122, P. R. China

Corresponding author: Xuefeng Liu

Address: School of Chemical & Materials Engineering, Jiangnan University, No.1800 Lihu Avenue, Wuxi 214122, P. R. China

E-mail: xfliu@jiangnan.edu.cn

Abstract

Hypothesis

The smart responsive behavior of wormlike micelles (WLMs) depends on a special group in the monomer. Surfactant bearing selenium atom and the carboxylic acid group is expected to be redox- and pH- responsive. Hence, the redox- or pH- induced transition in molecular structure should allow a tuning of the morphology of the aggregates, thereby affecting macroscopic viscoelasticity.

Experiments

A viscoelastic fluid based on WLMs was fabricated by mixing potassium benzylselanylundecyl carboxylate (BSeUK), and commercially available sulfobetaine surfactant (C_{16}DSB) with a stoichiometric ratio of 1:1 in a guanidine hydrochloride solution. The fluid was systematically characterized with rheology measurements, cryo-TEM, dynamic light scattering, surface tension and NMR.

Findings

The addition of H_2O_2 induced the transition of BSeUK from its reduced form (selenide) to its oxidized form (selenoxide) transition, thereby resulting in a transition of the aggregates from an entangled WLM to a small spherical ones as verified by a dramatic decrease in viscosity. The decrease in pH induced a transition of BSeUK from its dissociated form (surfactant) to an oil-soluble fatty acid form (non-surfactant), with the consequent loss of viscoelasticity and the transformation from a gel-like fluid to an emulsion. Both the redox and pH-responsive processes are reversible and at least 0.4 equiv. of H_2O_2 with respect to selenium, or 13% oil-soluble fatty acid, were required to decrease the viscosity to its minimum value.

Keywords: redox-responsive, pH-responsive, selenium-containing fatty acid soap, viscoelastic fluid, wormlike micelles