Towards Efficient and Sustainable Arctic Oil-Spill Response:

Green Dispersing and Herding Agents Derived from Northern Bioresources

Introduction

The climate change is opening the Arctic region from permanent ice coverage and makes it more attractive for several industrial activities including oil production and transport. Therefore, also the risks for the accidental oil-spills have increased significantly in the Arctic region. The harsh climate, ice-affected waters and the logistic challenges make the oil-spill response demanding in these regions. Mechanical methods are too slow to respond and chemical surfactants are potentially harmful to the environment in case of large oil-spills. Therefore, new green and sustainable chemical surfactants, which can rapidly be applied from aircrafts, may be the most feasible response option. The surfactants, which typically possess amphiphilic characteristics (i.e. both hydrophilic and hydrophobic moieties), can be used as the oil-spill response in two different ways: either the surface active dispersing agents can enhance the natural biodegradability of oil by breaking oil down the small droplets or the herding agents can thicken the thin oil slick sufficiently to enable in- situ burning of the oil.

Objectives

The aim of the present research is to investigate aspects of production and use of new efficient and sustainable chemical oil-spill response techniques for the Arctic conditions. Within the project, green, non-toxic surfactants from renewable biopolymers, cellulose and chitosan, will be fabricated using sustainable chemical modifications. Toxicity and biodegradability of the sustainable surfactants will also be investigated, and their performance will be demonstrated in the Arctic conditions.

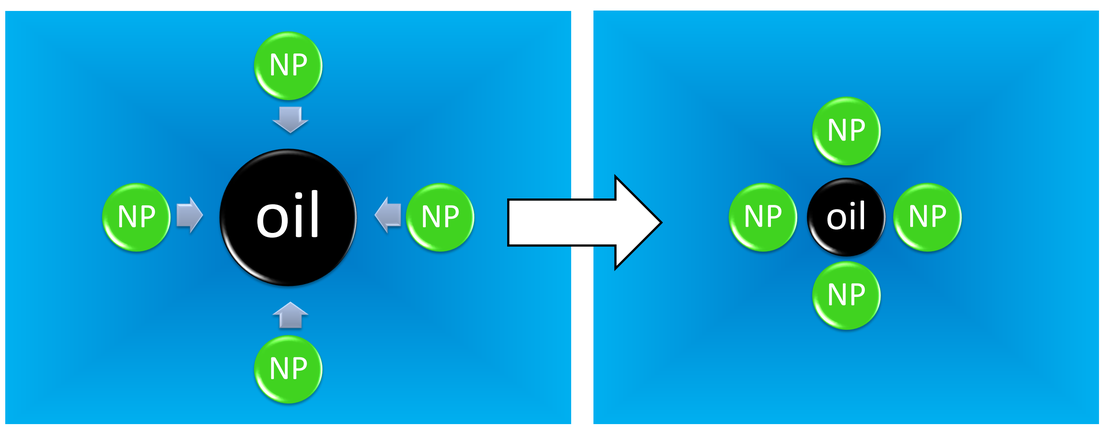

Fig. 1 Schematic illustration of how chitosan nanoparticles (NP) work on oil.

Expected outcome

As outcomes of the research project, significant new scientific information of the phenomena and techniques on fabrication of green surfactants and their performance in the Arctic oil-spill response are expected to be obtained. This information will enhance awareness of available and feasible oil-spill response techniques for the Arctic conditions. Thus, it is likely that the results of this research project will also have a high practical significance for sustainable use and refining of Arctic natural resources.

Green surfactants may be included in the oil-spill response strategy of the Arctic countries. Furthermore, this information will reinforce the Finnish oil-spill response know-how, which is currently focused on mechanical response methods.

Research methods

Chitosan based chemicals for oil spill response

Amphiphilic chitosan nanoparticles (NP) are prepared based on the ionic gelation of chitosan with sodium tripolyphosphate (TPP) anions used as cross-linking agent. Amphiphilic character is introduced to chitosan via reductive amination using long chain aldehydes and aldehydes containing hydrophilic and or ionic groups. Amphiphilic chitosan nanoparticles have been shown to function as herding agents for oil films on water surface (Fig.1).

Cellulose based chemicals for oil spill response

Novel bifunctionalized cellulose nanocrystals (CNCs) with amphiphilic nature are fabricated through chemical modification in aqueous environment. Sequential periodate and chlorite oxidation is employed as a pretreatment to enhance the nanocrystal fabrication. Hydrophobic *n*-butylamino groups are introduced before cellulose crystallites are liberated through homogenisation process. Butylamino-functionalized cellulose nanocrystals have been successfully tested as a dispersant in oil-in-water emulsion. Fig. 2 illustrates the reduced particle size in oil-in-water emulsion stabilized with green and sustainable nanocellulose surfactant.

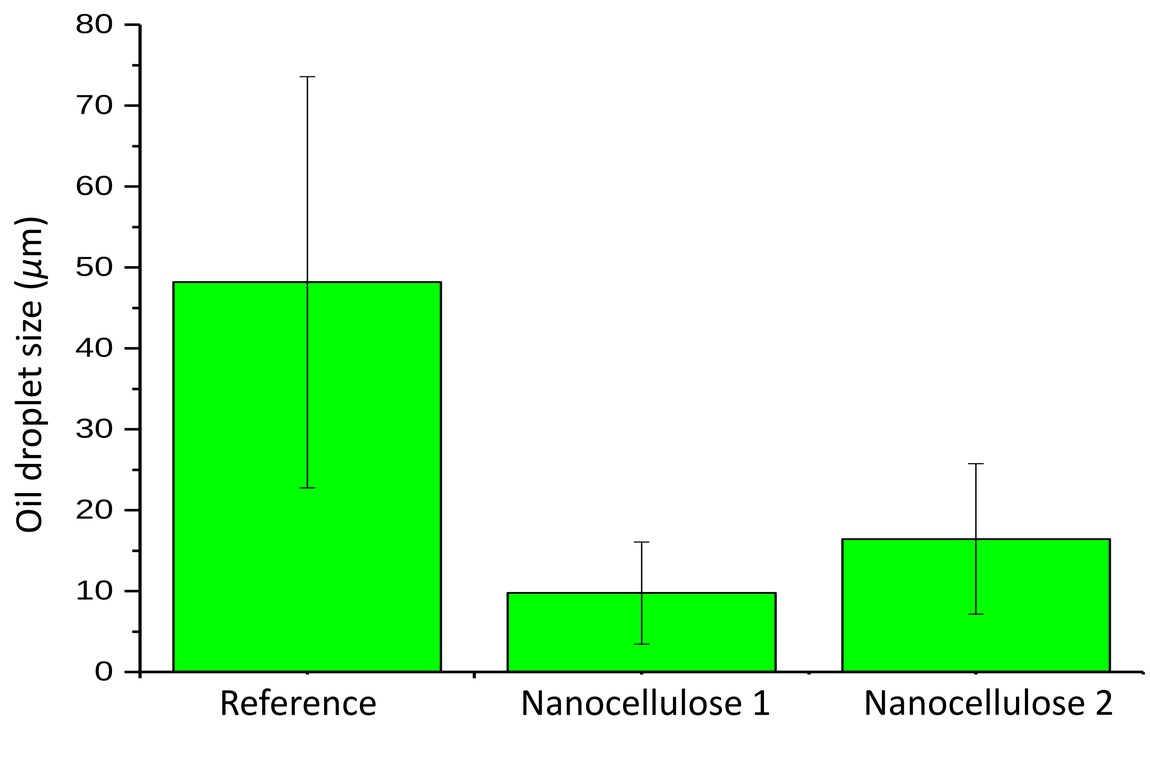

Fig. 2 The average particle size of oil droplets in oil-in-water emulsion. Reference emulsion is dispersed without surfactant addition. Two different butylamino-functionalized nanocellulose surfactants improved the dispergation efficiency and reduced oil droplet size.

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