ARCRESPO

TOWARDS EFFICIENT AND SUSTAINABLE ARCTIC OIL-SPILL RESPONSE

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In this Academy of Finland –funded project, novel dispersing and herding agents from natural bioresources for Arctic oil-spill response will be developed. The studied processes are based on green chemistry and targeting into sustainable and efficient use of Arctic natural resources, cellulose and chitosan. The project partner in ARCRESPO is Lappeenranta University of Technology.

BACKGROUND

Arctic region has long possessed low general appeal for industrial activities and sea transport due to the ice-affected waters and harsh climate conditions. However, the climate change will slowly release the region from permanent ice coverage and thus making it more attractive for several industrial activities including oil production and transport.

Arctic areas have vulnerable and slowly recoverable eco-system which should be protected and ensure that it remains unharmed. The risk of accidental oil-spill will increase significantly when oil production and transportation activities start. These risks have been recognized by the citizens and there is a growing societal and political pressure to address risks related to Arctic oil industry. Therefore, the Arctic oil-spill response is one the most crucial items when considering sustainable use and refining of Arctic natural resources.

Within the Arcrespo -project, green, nontoxic surfactants from renewable biopolymers, cellulose and chitosan, will be fabricated using sustainable chemical modifications.

OBJECTIVES AND HYPOTHESES

The principal objectives of this project are 1) *to use Northern cellulose based bioresources to fabricate green surfactants*, 2) *to investigate their toxicity and biodegradability for marine organisms*, and 3) *to address their performance as dispersing and herding agents for oil spill response in the Arctic conditions in a lab-scale*.

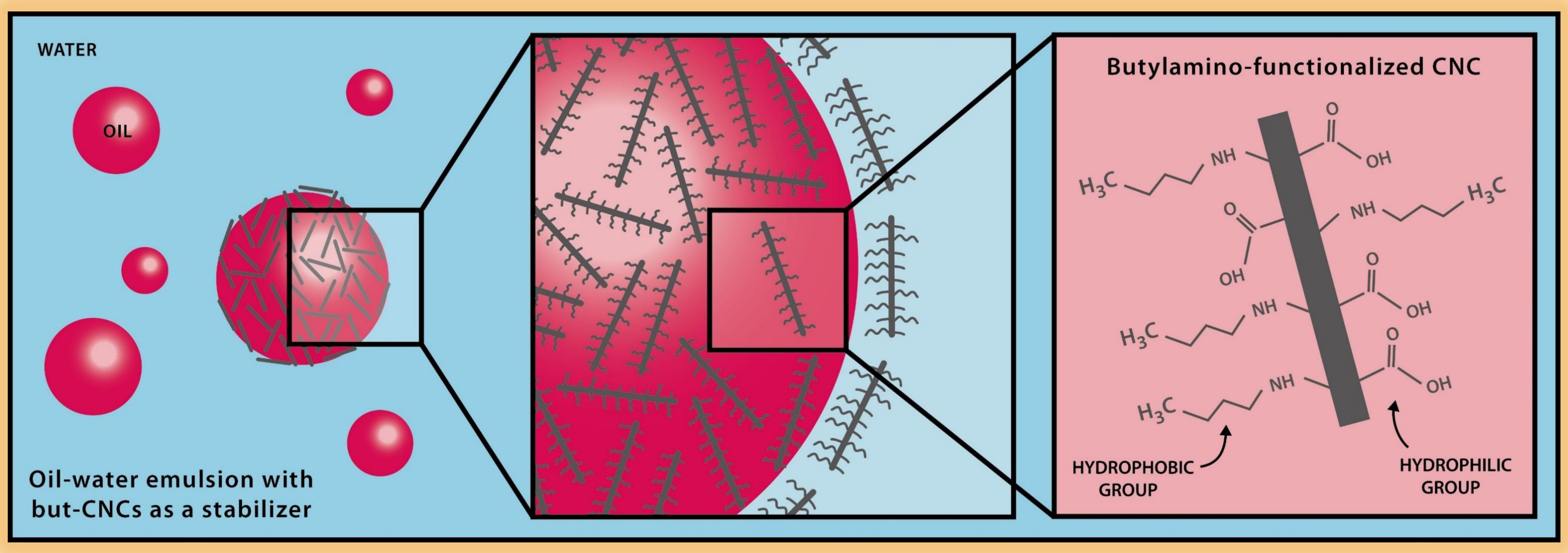

FIGURE 1: A SCHEMATIC ILLUSTRATION OF THE DISPERSAL MECHANISM WITH UTILIZATION OF BIFUNCTIONALIZED CELLULOSE NANOCRYSTALS AS STABILIZERS IN O/W EMULSION.

MATERIALS AND METHODS

This project research is based on experimental study. Cellulose raw materials were conducted through a oxidative chemical modification routes to obtain cellulose with different surface functionalities. Naturally hydrophilic cellulose needs hydrophobic groups attached to enable the particle adsorption at oil/water interface (Figure 1), and therefore the n-butylaminogroups were introduced into the cellulose backbone. The liberation of individual cellulose nanocrystals (CNCs) was done via homogenization phase with microfluidizer. The synthesized cellulose derivative suspensions were then characterized according to their optical and morphological properties. The suitability of these biochemicals in the oil spill response technologies was tested with oil dispersion studies. The diesel oil-in-water emulsions were prepared with mechanical stirring at different CNC concentrations and emulsion formation and stabilization properties of bifunctionalized CNCs were studied. Also the effect of background electrolytes (NaCl) on the oil droplet and the emulsion stability were studied.

This project is about to investigate the aspects of the utilization of new, efficient and sustainable chemical oil-spill response techniques specially in the Arctic conditions.

RESULTS

The bifunctionalized CNCs have found to be efficient in stabilizing the diesel oil-in-water emulsion. Already at low concentrations, CNCs reduced the oil droplet size and stabilized the oil-water emulsion for a longer period of time than with non–functionalized nanocellulose. Without any addition of CNC stabilizer, the coalescence of oil occured rapidly as illustrated in the figure 2.

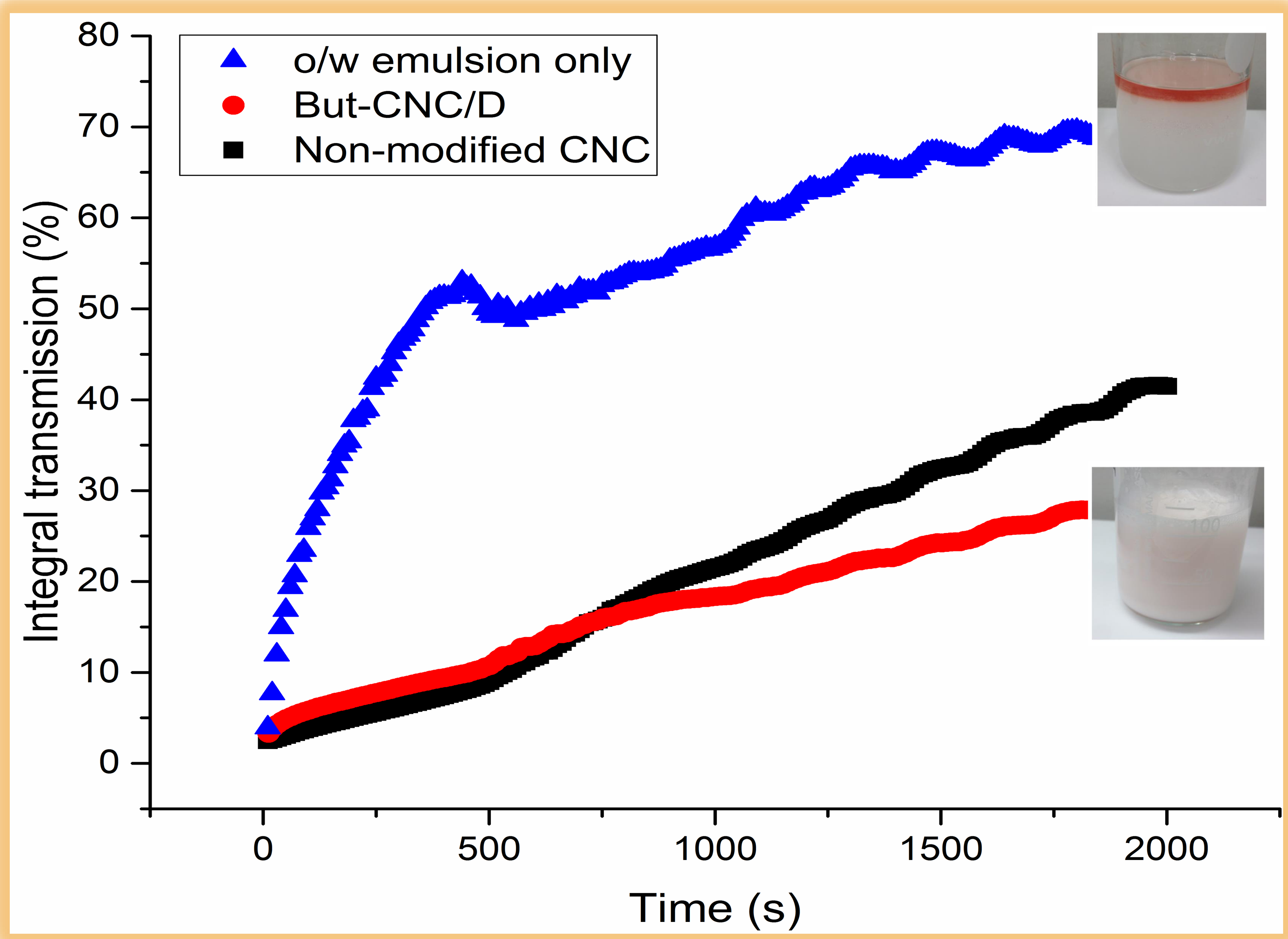

FIGURE 2: THE STABILITY AGAINST THE CREAMING OF O/W EMULSION USING BIFUNCTIONALIZED CELLULOSE NANOCRYSTALS (SAMPLE BUT-CNC/D), NON-FUNCTIONALIZED CELLULOSE NANOCRYSTALS AND NO STABILIZERS AT ALL (O/W EMULSION ONLY) WAS DONE WITH ANALYTICAL CENTRIFUGE.

The effect of background electrolytes (that simulated the sea water environment) was minor on the oil droplet size in the emulsion. The oil droplet size remained small enough for microbial degradation even at a salt concentration of 3.5% which corresponds to the average salt concentration of the marine water.

As a conclusion, the bifunctionalized CNCs with hydrophobic butylaminogroups attached, were effective in stabilizing the diesel oil-in-water emulsion. This phenomena allows the natural microbial attack to occur in the case of oil–spill. The oil droplet size was reduced from approximately 50μm (in oil/water emulsion only without stabilizers) to the level of 10-20μm depending on the studied concentration and the differences in the chemical modification of the CNCs. In addition, the emulsion stability improved and the creaming effect was slower in the presence of bifunctionalized CNCs which demonstrates the potential of chemically modified cellulose nanoparticles to act as a emulsifier thus enabling its use in oil destruction activities.

RERERENCES

Ojala, J., Sirviö, J.A., Liimatainen, H. (2016) Nanoparticle emulsifiers based on bifunctionalized cellulose nanocrystals as marine diesel oil-water emulsion stabilizers. Chemical Engineering Journal, 288 (2016) 312-320.

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