Effects of oil dispersants on the environmental fate, transport and distribution of spilled oil in marine ecosystems

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This presentation summarizes our research results on effects of model dispersants on: 1) sediment sorption/desorption of polycyclic aromatic hydrocarbons (PAHs), 2) settling properties of suspended sediment particles and the associated transport of oil, and 3) formation of marine oil snow (MOS) and the associated transport of oil hydrocarbons.

Batch sorption kinetic tests showed that the dispersant Corexit EC9500A (10-18 mg/L) enhanced the uptake of various PAHs by sediments by 3%-8%. Desorption kinetic tests indicated that the presence of the dispersant (18 mg/L) hindered PAH desorption by 4-5% compared to the control when the dispersant was absent. Sorption isotherm tests revealed that PAH uptake increases with increasing dispersant concentration. Significant sorption hysteresis (i.e., irreversible desorption) was observed when the dispersant was present during the desorption process. The presence of the dispersant also facilitated transferring of more PHAs into the sediment phase. The same hysteretic effect of the dispersant on PAH desorption was observed udner simulated deepwater conditions (4 °C and 160 atm). While the deepwater low temperature enhances the sediment uptake of PAHs, the high pressure reduces the sorption. Overall, the temperature effect outweighed the pressure effect, resulting in an elevated PAH uptake under deepwater conditions than under surface water conditions. The information is useful for understanding roles of dispersants on the fate and transport of petroleum PAHs in marine systems.

We found that sediments serve as important sinks for persistent oil components (e.g., PAHs) and interact strongly with oil dispersants and dispersed oil. Using three model dispersants (Corexit EC9500A, Corexit 9527 and SPC 1000) and four model sediments, we investigated effects of the dispersants and dispersed oil on the settling properties of suspended sediment particles under various environmental conditions. The results showed that all dispersants significantly accelerated the settling velocity of the sediments at neutral or alkaline pH, and the effects were more profound for sediments of a higher organic matter content. The nonionic surfactants (Tween 80 and Tween 85) in the dispersants played most critical roles for the enhanced settling rate. While increasing salinity in seawater remarkably increased sediment settling, the effect was alleviated in the presence of the dispersants. Combining the dispersant with humic acid showed synergistic acceleration of the settling velocity. The dispersant effect on sediment settling became less significant at the simulated deepwater temperature (4 °C). The presence of dispersed oil remarkably increased the settling rate. While all the sediments were able to adsorb the dispersants, those of higher organic content offered much greater sorption capacity. The presence of dispersants and dispersed oil transferred more PAHs to the sediment phase and inhibited desorption of PAHs, which may prolong the transformation of the oil hydrocarbons.

We also explored the formation mechanism of marine oil snow (MOS) and the associated transport of oil hydrocarbons in the presence of Corexit EC9500A. We found that both oil and the dispersant greatly promoted the formation of MOS, and MOS flocs as large as 1.6-2.1 mm (mean diameter) were developed within 3-6 d. Natural suspended solids and indigenous microorganisms play critical roles in the MOS formation. The addition of oil and the dispersant greatly enhanced the bacterial growth and extracellular polymeric substance (EPS) content, resulting in increased flocculation and formation of MOS. The dispersant not only enhanced dissolution of *n*-alkanes (C9-C40) from oil slicks into the aqueous phase, but facilitated sorption of more oil components onto MOS. The incorporation of oil droplets in MOS resulted in a two-way (rising and sinking) transport of the MOS particles. More lower-molecular-weight (LMW) *n*-alkanes (C9-C18) were partitioned in MOS than in the aqueous phase in the presence of the dispersant. The information can aid in our understanding of dispersant effects on MOS formation and oil transport following an oil spill event.