Transport of Microplastic-Oil-Dispersant Agglomerates in the Marine Environment

Min Yang[1], Baiyu Zhang[1]*, Kenneth Lee[2], Bing Chen[1]

[1] Northern Region Persistent Organic Pollutant Control (NRPOP) Laboratory, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, NL A1B 3X5, Canada

[2] Fisheries and Oceans Canada, Ecosystem Science, Ottawa, ON K1A 0E6, Canada

*Corresponding Author: Dr. Baiyu Zhang, E-mail: bzhang@mun.ca **Contact: bchen@mun.ca**

Oil spill in oceans is a global concern. Among various oil spill treating agents, chemical dispersants were paid much attention as they could disperse oil into small oil droplets (Merlin et al. 2021). In the Deepwater Horizon accidental spill, nearly 7.9 million liters of chemical dispersants were used to disperse 780 million liters of crude oil at seawater surface and subsea (Pan et al. 2017). Studies have shown that dispersant efficiency could be influenced by suspended particles such as minerals (Li et al. 2007, Stoffyn-Egli and Lee 2002). Since 2020, several studies have investigated how microplastics (MPs) interacted with oil dispersion, as MPs have been frequently detected in oceans (Feng et al. 2021, Yang et al. 2021). The existence of MPs reduced the dispersion effectiveness of oil, and they interacted with oil to form microplastic-oil-dispersant agglomerates (MODAs) when dispersants were involved (Yang et al. 2022). However, the transport of MODAs in the marine environment remained largely unknown.

This study explored the MODA transport and the effects of MODAs on oil dispersion in oceans. Corexit EC9500A, one of the most adopted commercial chemical dispersants, was used to treat Newfoundland Offshore and Low Sulfur crude oil. Polyethylene (PE) MPs with three sizes (7 μm, 40 μm, 90 μm) were selected as the tested MPs. Experiments regarding MODA transport and oil dispersion were carried out in the MP-oil dispersion system proposed by Yang et al. (2021). In brief, a 100 μL oil was injected into 120 mL of synthetic seawater, followed by the addition of 4 μL Corexit EC9500A to reach a DOR of 1:25. After that, 400 mg/L PE MPs were added. The flask was shaken for 10 minutes at 200 rpm and kept still for another 10 minutes. MODA samples were taken from different seawater layers, and the dry weight of the sample in each layer was obtained to investigate MODA transport. The effects of MODAs on oil dispersion were analyzed, followed the method described by Yang et al. (2021). The experiments were run in triplicate.

Results showed that MPs interacted with oil to form two MODAs, i.e., MODA-1 (MP fully covered by oil slick) and MODA-2 (MP and oil droplet embedded), owing to the surface free energy minimization principle. Small MPs only formed MODA-1, while large MPs could form MODA-1 and MODA-2. In addition, MODA transport was primarily affected by oil types. MODAs formed by Low Sulfur mainly floated on seawater surface (over 95% in mass proportion) as they had a larger buoyancy. MODAs formed by Newfoundland Offshore were distributed throughout the seawater column. MODA transport, especially MODA resurfacing, caused the decrease of oil dispersion effectiveness. Under Low sulfur crude oil, MODAs decreased oil dispersion effectiveness by around 20-36%. For example, 7 μm MPs formed MODAs reduced oil dispersion effectiveness from 88.03% to 52.27%. Under Newfoundland Offshore, MODAs also affected oil dispersion effectiveness to a certain degree. The 90 μm MPs formed MODAs caused a reduction of 11.17%.

This study provided fundamental knowledge on MPs, oil, and dispersant interactions. The formation mechanism and transport of MODAs were revealed, and the effects of MODAs on oil dispersion were explored. Findings from this research would facilitate decision-making on offshore oil spill response operations in the presence of MPs and provide essential data on developing models for predicting MODA transport.

References

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