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Photodegradation of bitumen-derived organics in oil sands process-affected water

Jonathan K. Challis[12], Angelique Parajas[1], Julie C. Anderson[1], Evelyn Asiedu[3], Jonathan W. Martin[4], Charles S. Wong[156], and Matthew S. Ross[7]

[1]*Department of Chemistry, Richardson College for the Environment, The University of Winnipeg, Winnipeg, MB R3B 2E9, Canada*

[2]*Department of Chemistry, University of Manitoba, Winnipeg, MB R3T 2N2, Canada*

[3]*Department of LaboratoryMedicine and Pathology, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB T6G 2R7, Canada*

[4]*Department of Environmental Science and Analytical Chemistry, Stockholm University, Stockholm, Sweden*

[5]*School of Environment, Jinan University, Guangzhou 510632, China*

[6]*Southern California Coastal Water Research Project Authority, Costa Mesa, CA*

[7]*Department of Physical Sciences, MacEwan University, Edmonton, AB T5J 2P2, Canada*

ABSTRACT

The chemical composition of water-soluble organics in oil sands process-affected water (OSPW) is primarily composed of natural constituents of bitumen that are solubilized and concentrated during aqueous extraction of oil sands. OSPW organics are persistent and acutely toxic, and a leading remediation strategy is long-term ageing in end-pit lakes, despite limited data available on its photochemical fate. Here, direct photolysis of whole OSPW, or of its constituent fractions, was examined at environmentally relevant wavelengths (>290 nm) in bench-top studies. Changes in the chemical profiles of whole OSPW, acid- (AEO), and base-extractable organics (BEO) were characterized by liquid chromatography with ultra-high resolution mass spectrometry in negative (-) and positive (+) ionization modes. Following 18 d of irradiation, photolysis reduced the total ion intensity in all samples in both modes. The most photo-labile species included the O2-, O3-, O4-, O2S-, and O4S- chemical classes, which were depleted in whole OSPW by 93–100% after only 5 d. In positive mode, detected species were more recalcitrant than those detected in negative mode, with an average reduction across all heteroatomic classes of 75 +/- 11.0% after 18 d. Estimated environmental half-lives for heteroatomic classes ranged from 57 d (O4S-) to 545 d (O3N+), with a greater recalcitrance for classes detected in positive mode compared to negative mode. Under field conditions in end-pit lakes, natural photolysis may be an important mechanism for effective OSPW remediation, and we suggest that future end-pit lakes be shallow to maximize light penetration and natural photolysis in ageing OSPW.