Detailed Compositional Characterization of the 2014 Bangladesh Furnace Oil Released into the World's Largest Mangrove Forest

Chen, H. (NHMFL, Chemistry); Nelson, R.K. (Woods Hole Oceanographic Institution); Swarthout, R.F. (Appalachian State U.); Shigenaka, G. (National Oceanic and Atmospheric Administration); de Oliveira, A.H. (Federal U. of Ceará); Reddy, C.M. (Woods Hole Oceanographic Institution), McKenna, A.M. (NHMFL)

Introduction

On December 9, 2014, ~94,000 gallons of furnace oil spilled into the Shela River in Bangladesh, a designated World Heritage Site by the United Nations Educational, Scientific and Cultural Organization. It was the largest recorded oil spill in the Sundarbans region. However, little is known about the chemical composition of furnace oil in chronic and acute releases.

Experimental

For the first time, we catalog the molecular-level composition of a relatively unknown furnace oil collected immediately after the 2014 Bangladesh spill, and compare it to a well-characterized intermediate fuel oil (IFO) spilled in Texas City, Texas (USA) in March 2014. Through a combined technique approach, we apply comprehensive two-dimensional gas chromatography (GC×GC) analysis and Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) on the 9.4 Tesla instrument to contrast the unknown furnace oil to IFO.

Results and Discussion

Combined, these techniques capture the continuum of oil components and access the less volatile, highly complex non-GC amenable compounds. GC×GC analysis provides biomarker signatures that suggest the furnace oil likely originated in the Middle East and is a refined product (Fig1).

Figure 1

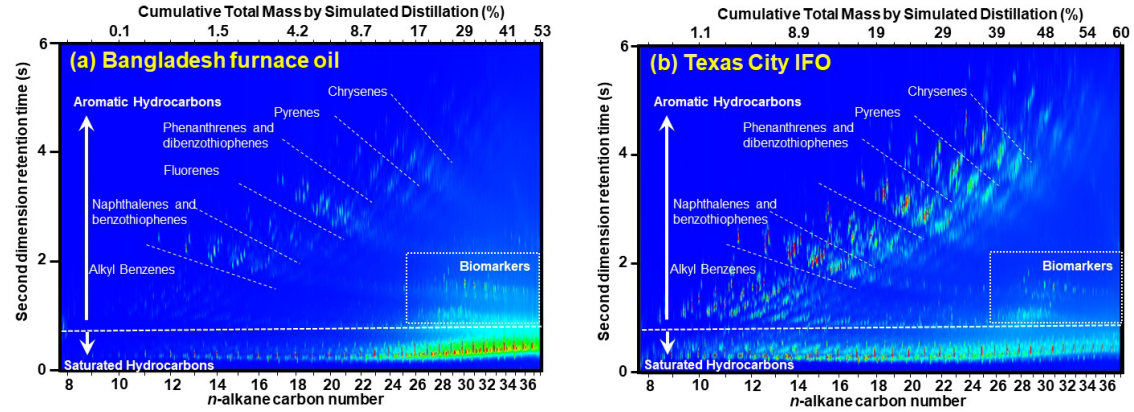

Fig 1. GC×GC-FID chromatograms of the (a) Bangladesh furnace oil and (b) Texas City IFO. First dimension axis is expressed in terms of n-alkane carbon number and the corresponding cumulative mass recovered at each carbon number in the HTSD analysis.

We further compared the furnace oil with the Arabian light crude from Middle East origin (WP681) and revealed remarkable similarities between the two oils. Simulated distillation for the furnace oil showed that 42% of the oil mass is not volatile below 478 °C (equivalent to C40; the upper limit for GC-based techniques), whereas the IFO contained 38% of the total mass >C40. Furthermore, FT-ICR MS extends the carbon number range and unlocks the molecular composition of non-GC amenable compounds. Atmospheric Pressure Photoionization (APPI) and Electrospray Ionization (ESI) FT-ICR MS resolve and identify tens of thousands of molecular formulae in each oil, and report furnace oil composition similar to whole heavy crudes. To the best of our knowledge, this is the first report of the detailed compositional characterization of any furnace oil.

Acknowledgements

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References

[1] Chen, H.*et al.*, Energy & Fuels, ***32***(3), 3232-3242 (2018).