New Aromatic Hydrocarbons Characterization Method of Unconventional Oil Based on Multi-Dimensional Fluorescence Spectroscopy

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ABSTRACT

Sources of unconventional oil will be increasingly relied upon when conventional oil becomes more expensive due to depletion. The geochemistry understanding of the unconventional oils has grown to a hot topic over the past several years. But as the traditional Gas Chromatography-Flame Ionization Detector (GC-FID) and Chromatography-Mass Spectrometry (GC-MS) are limited in their characterization of the heavy components of crude oil, it is extremely valuable to develop new analytical methods to pursue more complete and detailed knowledge of the chemical compositions of heavy and unconventional crude oil. Fluorescence-based techniques featuring high sensitivity, good diagnostic potential, inexpensive instrumentation, easy sample preparation, rapid analysis and less affected by weathering, are particularly applicable to the analysis of the samples containing high fluorescent polycyclic aromatic hydrocarbons (PAHs), such as heavy crude oil, asphalt and oil sand. However, so far fluorescence techniques have not been well applied to oil characterization. The main reasons are that the fluorescence spectra of PAHs are seriously overlapping and easily distorted by the inevitable undulation of the solution concentration value. This work reports development of a new oil characterization method using the Multi-Dimensional-Fluorescence Spectroscopy (MDFS). The concentration of samples was applied as a new dimension to Fluorescence spectroscopy, by which the analysis uncertainty due to concentration was greatly reduced and more spectral information from lower ring PAHs to higher ring PAHs was obtained. A large number of crude oils, oil sands bitumen, and refined petroleum products including diesel, heavy fuel oils and lubricating oils were analyzed by MDSF, along with GC-FID and GC-MS, respectively. Simulation experiments of different oil geologic evolution processes were also carried on and the results indicate PAHs have high resistance to weathering, thermal evolution and biodegradation. Also a Multi-Dimensional data processing strategy was applied in this work to better solve the spectra overlapped problem. The results show that the MDFS is a rapid and reliable method for unconventional oil identification and characterization.