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Abstract

Custom-Made Sorbent-Based Sensors for Subsurface Microseepage of Volatile Organic Markers of Oil and Gas Fields †

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The geochemical exploration of oil and gas fields offers a cost-efficient approach to reservoir prospecting through the remote and subsurface detection of volatile organic compounds (VOCs), which are markers of underlying fossil fuel deposits. Hydrocarbon indicators can manifest as surface seeps of visible oil and gas (macroseeps) or as traces detectable by sophisticated analytical methods (microseeps). An effective geochemical exploration method involves absorbing hydrocarbon molecules using specially developed materials buried up to a few meters deep, followed by gas chromatography/mass spectrometry (GC-MS) analysis of the accumulated VOCs. Given the variety of absorbents available, it is essential to identify the most effective material.

We developed a method to compare and test adsorbents for their affinity to mixed hydrocarbons and N,O,S-derivatives, evaluating them using natural oil samples in a laboratory microseepage setup. This approach enabled us to screen a library of commercial and custom-made sorbents to identify the best materials for absorbing oil markers. The adsorbate often consists of a complex mixture of components, making chemical analysis challenging. To address the difficulties of separating and identifying complex mixtures, we proposed using two-dimensional HR-GCxGC-TOF-MS. This technique involves first separating mixed analytes on a long polar column followed by a short non-polar one with consequent high-resolution TOF-MS analysis of resulted probes.

Thus, a variety of adsorbent types was screened for their affinity towards the accumulation of potential hydrocarbon markers. The most efficient sorbents were identified based on the maximum number and diversity of analytes detected through thermal desorption/HR-GCxGC-MS and Brunauer/Emmett/Teller (BET) surface area analysis. Two top-performing custom-made sorbents, composed of carbon nanomaterials, showed significantly higher adsorption capacity compared to a commercial reference sorbent, when exposed to model hydrocarbon mixtures, and were selected for further development.

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