Kerogen Properties Controlled by Thermal Maturity

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Kerogen is solid, insoluble, non-volatile organic matter, and the largest global reservoir of sedimentary organic carbon. Kerogen is the source of fossil petroleum resources produced both from conventional sandstone and carbonate reservoirs, as well as more recently from unconventional source rocks (commonly termed shale). The composition of kerogen dictates the amount and quality of oil and gas generated during geological burial and heating (thermal maturation). However, kerogen is not amenable to traditional compositional analysis such as gas chromatography. Instead, aspects of kerogen composition and structure can be examined using, for example, novel solid-state spectroscopy and gas intrusion techniques.

Here, we present compositional and microstructural properties of kerogen, including carbon, hydrogen, sulfur, and oxygen bonding environments, absolute density, and specific surface area, as obtained using a combination of infrared spectroscopy, X-ray absorption near-edge structure, helium intrusion, and nitrogen adsorption techniques. These fundamental compositional and structural properties vary substantially, but we demonstrate that they evolve systematically as a function of the level of thermal maturation (i.e., amount of heating of kerogen over geological time) for kerogens of current interest to the oil and gas industry. In this way, estimates of thermal maturity can be used to predict composition and structure of kerogen without the need for extensive laboratory studies. This compositional characterization of kerogen is critical, for example, to: accurately construct and interpret downhole petrophysical models (e.g., formation volumetrics); constrain molecular dynamics simulations of kerogen structure; and to provide insights to oil and gas storage and transport in unconventional shale resources.