Exogenous H_2 generation and organic matter alteration in source rocks under γ irradiation

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Radioactive elements (e.g. uranium) and high-quality source rocks are often intimately distributed in a sedimentary basin, which is considered a proof of genetic dependence and organic-inorganic interactions.

In order to study the main factors affecting H_2 generation and organic matter (OM) alteration characteristics under irradiation by radioactive elements, comparative experiments were conducted by irradiating aqueous solutions (NaCl, KCl, $CaCl_2$ and K_2SO_4 solutions) representing formation water and OM (decane, bitumen and kerogen) using γ rays irradiation. GC, GC-MS, GC-IRMS and FTIR were used to confirm the characteristics of the products. Results show that: 1) H_2 yields are controlled by radiation dose. Low dose rate but long-time irradiation by radioactive elements in source rocks can also produce huge dose to give the posibility to generate large amounts of H_2 promoting hydrocarbon generation. 2) The addition of Na^+, K^+, Ca^{2+} and Cl^- ions abundant in formation water and the increase of their concentrations can greatly promote the H_2 yields of water radiolysis, while oxygen-rich ion, SO_4^{2-}, will suppress the generation of H_2. 3) Both degradation and polymerization occur in decane radiolysis leading to the production of H_2 and n-alkane, isoalkane and unsaturated hydrocarbons of C_1-C_{20}. 4) Kerogen and bitumen radiolysis is a process in which the H/C and O/C ratios decrease, the branches are reduced and aromatization increases similar with the thermal maturation.

This experiment verifies that besides thermal evolution and biological process, radiation of radioactive elemtents in source rocks can radiate OM directly to generate hydrocarbon. Radiation dose can be used as a parameter to evaluate its contributions to hydrocarbon generation. Formation water radiolysis can generate noticeable H_2 to provide exogenous H_2 for hydrocarbon generation. This work is useful to guide the evaluation and exploration of oil and gas resources and complement the traditional theory of hydrocarbon generation.

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