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Molecular Hydrogen Generation Potentials and light Hydrocarbon Gases from the Nigerian Cretaceous Coal and shales: Insights from Thermal Simulation Experiment

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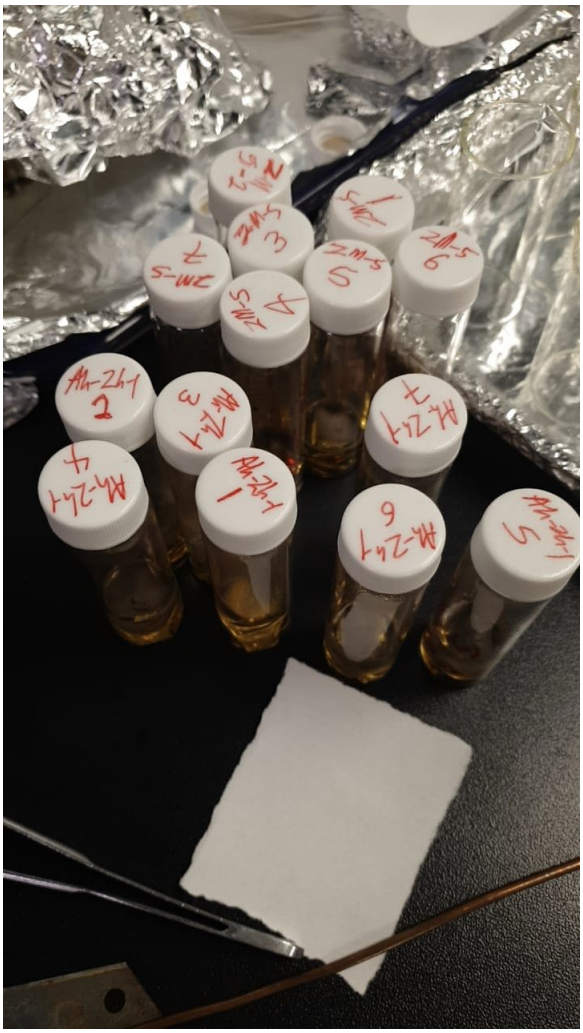

The global push towards achieving net-zero carbon dioxide emissions by 2050 shows the urgency of transitioning to a hydrogen-based economy, with clean hydrogen fuel emerging as a fundamental component of future energy consumption. In the present research, the potentials of Cretaceous coal and shales from the Nigeria Frontier Basins to generate molecular hydrogen (H_2) and light hydrocarbon gases are investigated using thermal simulation experiments. The study aims to improve our understanding of molecular hydrogen (a potentially important clean energy component of the energy mix) and other light hydrocarbon generation mechanisms, yields, and compositional evolution during thermal maturation of organic-rich rocks. Representative shales and coal were subjected to a controlled high-temperature and pressure conditions within sealed gold tubes, ensuring chemical inertness and preventing external contamination. The confined system allows accurate simulation of geological processes such as kerogen cracking, devolatilization, and secondary gas generation over a range of maturities. From the results, it was revealed that both the coal and shales can generate measurable quantities of hydrogen alongside low-molecular-weight C_1, C_2, C_3 and C_4 during thermal evolution. H_2 generation increases with temperature and maturity and is closely associated with dehydrogenation and cracking reactions of organic matter. All the samples generated the same quantities of H_2 at lower temperatures. The total organic carbon (TOC) and maceral abundances control the quantities of H_2 generated by the samples. Source rocks with higher TOC and liptinite maceral produced more H_2. The light hydrocarbon gas yields also drastically increased with rising heating temperatures (maturity). After exceeding 450°C (about EasyRo of 2.0%), methane and ethane gases were the dominant components in the pyrolyzates, this indicates that oil in the products gradually cracked into gas during the high-temperature stages. The $\delta^{13}C$ of C_1, C_2 and C_3 from the pyrolyzates are similar to those generated from the Niger Delta, and this could be a result of marine connections among the basins. The research provides experimental evidence supporting co-generation of molecular hydrogen and light hydrocarbons in sedimentary basins through thermal simulation experiment and offers insights into potential natural hydrogen resources and unconventional gas systems.