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ON THE EVOLUTION OF COAL POROSITY DURING PYROLYSIS

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Hydrogen provides a potential source of clean energy. Thus, cleaner conversion of solid fuels to H_2 fuel is part of a long-term sustainable energy production strategy. However, hydrogen is rarely found on earth in its elemental form. Thus, it must be produced from a hydrogen-containing feedstock. One potential source of hydrogen is gasification, commonly from coal, but several factors needed for plant design and implementation remain uncertain, as syngas production via pyrolysis entails complex fluid dynamics and thermal decomposition processes. A detailed, multiscale understanding of these processes including experimental data that quantify changes in porosity, density, surface area and chemistry as a function of temperature. is required for optimal design.

The objective of this work was to characterize how the chemistry, mineralogy and pore structures of coals evolve during pyrolysis. Two coals were selected: Usibelli sub-bitumenous from the Usibelli coal mine, Healy, AK, and lignite from the Center coal mine, Center, ND. Samples were pyrolyzed at 200 to 1000 °C in stainless-steel foil holders. These were introduced into the furnace, connected to an Ar gas inlet, and temperature was then ramped to the target at 20 °C/min, held at temperature for 20 min, then cooled by turning off the furnace power. Resultant materials were analyzed by small angle neutron scattering and small and ultra-small angle X-ray scattering, as well as several complementary techniques. SEM imagery showed a significant number of new open pores in the high-temperature material but, on heating, the coals become progressively denser, and the concentration of hydrogen decreased. Cumulative porosity curves show a clear change at 6-700 °C due to very small pores in the char. This is also reflected in changes in density and fractal structures. Pyrolysis increased the lateral size of coal crystallites, decreased the amorphous fraction, and increased the fraction of aromatics and overall coal rank. Comparison of small and ultra-small angle neutron and X-ray scattering data showed that pre-dried coals can re-hydrate rapidly on exposure to air. Quantitative fits to the cumulative porosity curves provide a method by which these data can be used for modelling modular gasification reactors.