

PRESS RELEASE

Process concept for a zero-emission route to clean middle-distillate fuels from coal

A novel process configuration has been developed for producing clean middle-distillate fuels from coal with minimal emissions. The EMS Energy Institute at Penn State University has developed and tested a solvent extraction process for making liquids from bituminous coals, and has shown the successful use of these fuels in small jet engines, a diesel-engine pickup truck, and a solid oxide fuel cell. The core of the process involves extracting coals with light cycle oil, a refinery byproduct, separating the residual solids, hydrotreating the liquid to remove sulfur, hydrogenating to eliminate aromatic compounds, and finally distilling to obtain the fuel products, which represent the majority of the liquid yield. The optimum yield of the raw extract, after three stages of extraction, is as high as 75%. The recovery of middle-distillate fuels from the hydrotreated and hydrogenated extract is up to 80%. A solvent stream would be recycled back to the front end of the process.

The liquid product is of particular interest as an aviation fuel. It appears to be suitable as a potential drop-in replacement for Jet A or JP-8 fuels. In addition, it has a much greater resistance to pyrolytic breakdown at high temperatures than either Jet A or JP-8. The fuel could be considered for thermal management on high-performance aircraft such as the F-35. The middle-distillate is also fully compatible with conventional petroleum-derived diesel for light-duty applications such as in light road vehicles. It has not yet been tested in other diesel applications.

Coal conversion to liquid fuels has many potential environmental issues. A conceptual process design has been developed in which the successfully-demonstrated core processes of extraction, separation, hydrotreating and hydrogenation, and distillation have been augmented with other operations selected to reduce total process emissions nearly to zero.

Most of the hydrogen needed for the hydrotreating and hydrogenation steps would be produced by electrolysis of water using non-carbon electricity, e.g. from photovoltaics. Hydrotreating the extract inevitably produces hydrogen sulfide. New catalytic processes for H₂S splitting are recommended for destruction of this material, recycling the hydrogen back into the process, and recovering the sulfur as a marketable byproduct.

Additional hydrogen could be produced by gasifying the residual partially extracted coal recovered after the final extraction step. Gasification at high temperature would melt the mineral constituents of the coal, allowing the resulting slag to be vitrified into a glassy product that could be used as, e.g. fill material for road construction. Heavy distillation residua or biomass material from CO₂ capture could also be co-fed to the gasification unit.

Likely sources of CO₂ include emissions from fired process heaters and from the gasification unit, after shifting the raw gas to a CO₂-H₂ mixture and separating the desired hydrogen. The intended approach for carbon capture would use algae photobioreactors. Algae would be harvested for production of a bio-oil that could be blended with the coal-derived oil product. "Spent" algae would be consumed in the gasification unit.

Overall inputs to the process would be coal, water, non-carbon electricity, and make-up solvent for extraction. The outputs would be clean liquid fuel, with a bio-component, suitable for use in jet or diesel engines; sulfur for sale to various chemical applications, and a vitrified slag. Other emissions would be minimal.

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The sequence of images illustrates (1) a process schematic for multistage extraction of coal; (2) pilot-scale hydrotreating and hydrogenation of the coal liquid; and (3) comparative resistance hydrotreated coal fuel (right side) and JP-8 fuel (left side) to pyrolytic degradation at 480°C for two hours in nitrogen.

Image 1. A diagram of laboratory-scale multistage coal extraction system.

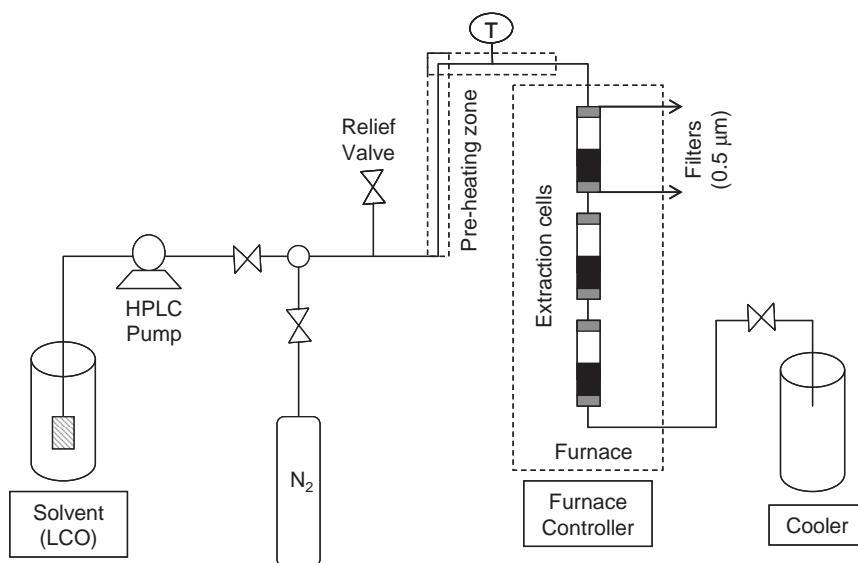
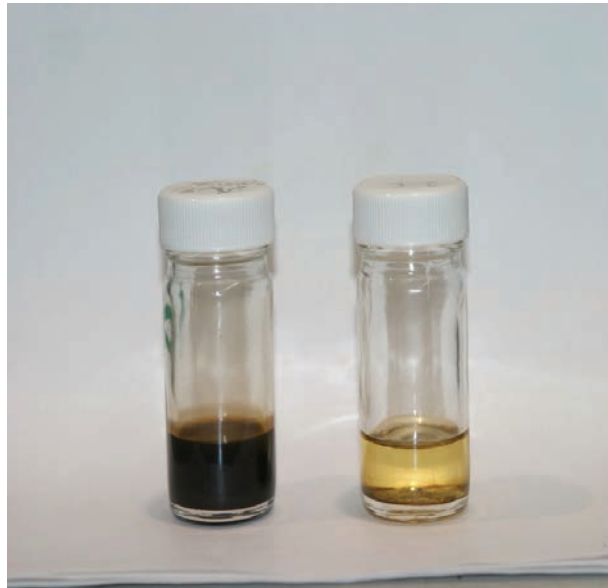


Image 2. Pilot-plant hydrotreating, conducted at Intertek-PARC, Harmarville, Pennsylvania.



Image 3. After thermal stressing at 480°C for two hours under nitrogen, the coal-derived liquid (on the right) shows little sign of the pyrolytic decomposition that has deteriorated JP-8 fuel (on the left).



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