

TECHBRIEF

HYDROPHOBIC ALKYL-ESTER PHYSICAL SOLVENTS FOR CO₂ REMOVAL FROM H₂ PRODUCED FROM SYNTHESIS GAS

OPPORTUNITY:

The invention is a family of hydrophobic, low viscosity, low vapor pressure physical solvents with molecular structures consisting of two or more alkyl-ester functional groups on a central hydrocarbon chain. These solvents have been shown to possess high carbon dioxide (CO₂) solubility and absorption selectivity, which make them well suited for the removal of CO₂ from hydrogen (H₂) produced from synthesis gas. This technology is available for licensing and/or further collaborative research from the U.S. Department of Energy's National Energy Technology Laboratory.

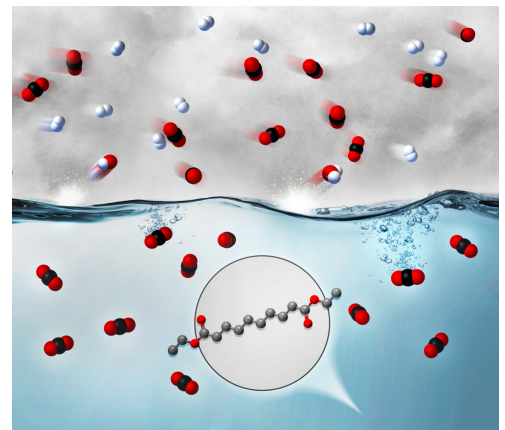
CHALLENGE:

Future integrated gasification combined cycle (IGCC) power plants and steam methane reforming (SMR) chemical plants have the potential to reduce the cost of CO₂ capture. These power and chemical plants generate high-pressure CO₂ gas streams from the in-situ water gas shift reaction when producing H₂ used to power the electrical turbines. A variety of methods have been proposed to capture CO₂, including solvent, sorbent, and membrane technologies, with continuous solvent looping systems currently considered to be the most advanced. Precombustion capture of CO₂ is typically accomplished using physical solvents.

State-of-the-art precombustion CO₂ capture processes predominantly employ hydrophilic physical solvents. Current commercial physical solvents touted for IGCC CO₂ capture were developed for removing acid gases from raw natural gas streams. Therefore, they were designed to remove significant amounts of water from the process gas. As such, the focus was on the purification of the process gas with less concern for generation of high-purity CO₂ streams suitable for pipeline transmission and sequestration. While water removal is important for natural gas pipeline applications, it is not favorable for applications in which the fuel stream is directly combusted on-site, as would be encountered in IGCC systems.

OVERVIEW:

Researchers at NETL have developed a family of hydrophobic, low viscosity, low vapor pressure physical solvents with molecular structures consisting of two or more alkyl-ester functional groups on a central hydrocarbon chain. These solvents have been shown to possess high CO₂ solubilities at high CO₂ partial pressures (such as ~ 25 bar) and high CO₂/H₂ absorption selectivity and are well suited for the removal of CO₂ from H₂ produced from synthesis gas. The NETL-developed solvents offer attractive properties for applications involving CO₂ capture from high humidity H₂ gas streams containing elevated partial pressures of CO₂, particularly in IGCC processes. The rare combination of low toxicity, high CO₂ capacity, high selectivity, and low water affinity of these solvents provide opportunities for more efficient, cost-effective and environmentally friendly CO₂ mitigation.



(continued)



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ADVANTAGES:

- The CO₂ absorption of the solvents listed in the invention compare favorably to currently used solvents such as Selexol, Purisol and Fluor Solvent.
- The solvents listed in the invention exhibit a greatly reduced tendency to absorb water, which imparts advantages in reduced cost and complexity when used in gasification systems.
- This solvent family exhibits excellent CO₂ absorption and good CO₂/H₂ selectivity.
- Solvents listed in the invention are non-toxic and are non-corrosive.
- The solvents are prepared from common chemical reagents easily sourced in large quantities at relatively low cost.
- The tri-esters and tetra-esters reported in this work were all prepared in high yields (>85%).

APPLICATIONS:

Applications of Hydrophobic Alkyl-Ester Physical Solvents include:

- Pre-combustion CO₂ separation and capture at IGCC power facilities
- CO₂ removal during generation of H₂ from reformed natural gas or from syngas
- Adjusting CO₂/H₂ ratio for coal and biomass to liquids
- The removal of CO₂ from syngas for coal and biomass to ammonia/fertilizer
- Natural gas sweetening

PATENT STATUS:

U.S. Patent Pending (provisional patent application)

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Title: Hydrophobic Alkyl-Ester Physical Solvents for CO₂ Removal from H₂ Produced from Synthesis Gas

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