TECHBRIEF

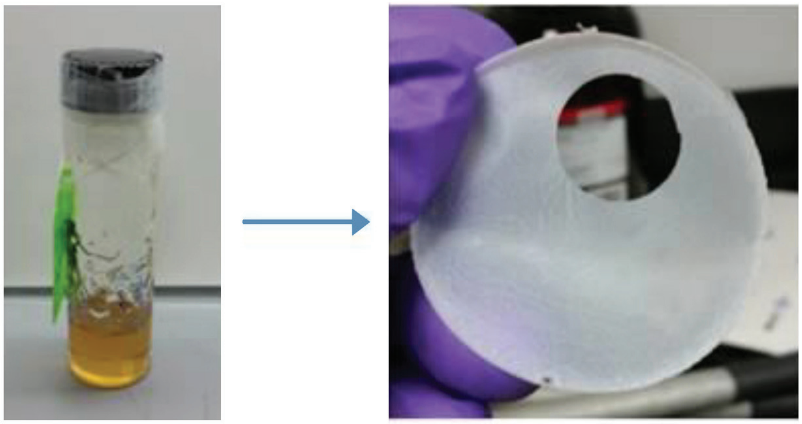
POLYPHOSPHAZENE BLENDS FOR GAS SEPARATION MEMBRANES

OPPORTUNITY:

These technologies are high-performance CO_2 separation membranes made from polyphosphazene polymer blends. NETL's technology was originally developed to aid in separating CO_2 from flue gas emitted by fossil-fuel power plants. The NETL membrane is cross-linked chemically using low intensity UV irradiation, a facile technique that improves the membrane's mechanical toughness compared to its uncrosslinked polyphosphazene constituents. Membranes fabricated with this technique have demonstrated permeability of up to 610 barrer, with CO_2/N_2 selectivity in excess of 30, at a practical separation temperature of 40 °C. NETL's patent-pending technology is being bundled with Idaho National Laboratory's (INL) patented technology, with NETL handling licensing. NETL would work with a potential licensee and INL to license the technology.

CHALLENGE:

Membrane-based separation is one of the most promising solutions for CO_2 removal from post-combustion flue gases produced in power generation. Technoeconomic analyses show that membranes aimed for this application must possess high gas permeability; however, most high permeability materials suffer from poor mechanical properties or unacceptable loss in performance over time due to physical aging. This technology is a successful attempt to turn one of these high-performance materials with poor mechanical properties into one amenable for use in practical separation membranes with virtually no physical aging issues.



Effectively turns semi-solid polyphosphazenes into usable, high performance membranes.

OVERVIEW:

INL's technology is a novel class of phosphazene polymers that effectively removes CO_2, acid gases, and water vapor for permanent gases such as methane, O_2, and N_2. The phosphazene membranes exhibit a high degree of selectivity and throughput for CO_2. Challenges to membrane materials not only come from the gas contaminants, but the temperatures, pressures, and corrosiveness of the process. This technology is particularly well-suited to applications such as flue gas remediation, the cement industry, and others with point source CO_2 capture needs. INL's phosphazene membrane will operate in a variety of environments ranging in temperature from -50 °C to 150 °C.

NETL researchers have discovered a method for stabilizing a polyphosphazene polymer containing alkoxy side groups in the form of robust, free-standing films through blending and chemically cross-linking. Polyphosphazenes are a class of hybrid inorganic-organic polymers constructed around a backbone consisting of alternating phosphorous and nitrogen atoms, with two organic side groups attached to each phosphorous atom. One particular polyphosphazene, Poly[bis(2-(2methoxyethoxy)ethoxy]phophazene (MEEP), has excellent gas separation characteristics as a membrane material, but the mechanical stability is so poor that it cannot be used in practical applications in its pure form. Cross-linking is a common method for improving the mechanical properties of a polymer. However, until NETL's invention, there have not been effective methods for cross-linking pure MEEP without significant sacrifice to gas separation performance.

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ADVANTAGES:

- Less decrease in performance to the pure polymer compared to other cross-linking methods (such as thermal) since the amount of added thiol cross-linker is relatively small, and the condition (UV curing using low intensity source) is mild.
- Successfully converts MEEP formulations that have never been made into successful membranes previously owing to poor mechanical properties, resulting in gas permeability higher than any polyphosphazene ever reported in the literature.
- INL's Phosphazene Membranes for Gas Separations provide a simpler process, lower operating costs, significantly lower temperature operation, and significant material system flexibility.

APPLICATIONS:

- Gas separation membranes, most likely in the form of thin coatings on a porous support.
- CO_2 separation applications like capturing CO_2 from fossil fuel post-combustion flue gas, or CO_2 separation from natural gas.
- Membrane separation activities like water purification and organic solvent separations.
- Flame-resistant coatings.
- Solid electrolytes for battery applications.

PATENT STATUS:

U.S. Patent Pending (non-provisional patent application)

Filed: 08/19/2019

Title: Crosslinked Polyphosphazene Blends for Gas Separation Membranes

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Title: Phosphazene Membranes for Gas Separations

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BEA/INL Reference No: B-385

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