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ISSN: 2155-9589
Journal of Membrane Science & Technology

Perspective

# General Study on Improvements in Membrane Technology for Natural Gas Purification

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## DESCRIPTION

Membrane technology has received a lot of attention recently for gas separation technologies, particularly for sweetening natural gas. The inherent qualities of membranes make them suitable for process escalation, and this adaptability may be the key factor driving membrane technology in the majority of gas separation applications. Depending on the applications, different materials were used to create membranes. One of the areas of membrane technology with the quickest growth was polymeric membrane production.

Unfortunately, due to flaws, polymeric membranes were unable to accomplish separations as needed, especially under high operating pressure. Since inorganic membranes shown promising results for gas separation, the chemistry and structure of these support materials, such as inorganic membranes, became one of the main topics of study. To achieve the separation performance criterion, the materials are a little short. An intriguing method for improving separation performance is Mixed Matrix Membrane (MMM), which combines polymeric and inorganic membranes. However, due to the fact that the material combinations are still in the research stage, MMM has not yet been commercialized.

After oil and coal, natural gas can be regarded as the main fuel source needed. Natural gas is now widely used in transportation and power generation as well as industry. Natural gas consumption is no longer just confined to industry. While natural gas is said to produce less-toxic gases like carbon dioxide and nitrogen oxides upon combustion, these events reinforced the idea of moving towards sustainability and green technology. Nevertheless, because it has unwanted pollutants like carbon dioxide and hydrogen sulphide, pure natural gas at the wellhead cannot be used right away. All of these undesired materials must be eliminated because they could erode the pipeline because $CO_2$ is extremely corrosive when there is water present. Moreover, the presence of $CO_2$ may waste pipeline capacity and lessen the energy content of natural gas, ultimately lowering its calorific value.

### Early membrane development

Since the beginning of the 1990s, membrane development for $CO_2/CH_4$ separation has been underway. In the early stages of this membrane gas separation, numerous membranes were made utilizing various materials. The desired material must be well adapted to the separation performance, as different materials behave differently when it comes to gas separation. High separation performance with tolerable high permeability, high resilience, strong chemical, thermal, and mechanical properties, and rational production costs should be characteristics of excellent gas membrane separation. The practical usage of polymeric membrane and inorganic membrane, as well as a comparison of the two in gas separation involves the employment of two different types of materials. Higher separation performance from an inorganic membrane like SAPO-34 than from a polymeric membrane is possible, however the separation performance is inversely related to the pressure loaded.

### Conventional mixed matrix membrane

Several studies have been conducted to address the demand for gas separation using both polymeric and inorganic membranes. Due to the drawbacks of existing membranes, researchers have been working to create an alternative membrane material that is high in separation performance, more economically feasible, and mechanically stable. The notion of Mixed Matrix Membrane (MMM), a blend of organic and inorganic materials, was then put out in an effort to improve membrane gas separation performance while keeping costs down.

The creation of MMM was a promising technological development since this composite material's mechanical and electrical properties have increased, and it combines the superior separation power and agreeable stability of molecular sieves with improved processability of organic membrane. The continuous phase of the polymeric material, which can be almost any polymeric material, such as polysulfone, polyimide, and polyethersulfones, is where the inorganic material is dispersed into the MMM.

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**Received:** 27-Jan-2023, Manuscript No. JMST-23-20340; **Editor assigned:** 30-Jan-2023, Pre QC No. JMST-23-20340 (PQ); **Reviewed:** 13-Feb-2023, QC No. JMST-23-20340; **Revised:** 20-Feb-2023, Manuscript No. JMST-23-20340 (R); **Published:** 02-Mar-2023, DOI: 10.35248/2155-9589.23.13.331

**Citation:** Amitra Z (2023) General Study on Improvements in Membrane Technology for Natural Gas Purification. J Membr Sci Technol. 13:331.

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Different membrane materials can be chosen depending on the needs of the process. In a variety of applications, certain materials can be "tailored-made" to achieve the desired separation goal. Beginning a few decades ago, there were numerous attempts to build polymer-inorganic membranes.

## Recent development of membrane gas separation

**Ionic Liquid-Supported Membrane (ILSM):** It has been demonstrated that ILSMs outperform several neat polymer membranes in terms of increased permeability. When used under high pressure conditions, ILSMs made from poly (vinylidene fluoride) (PVDF) and 1-butyl-3-methylimidazolium tetrafluoroacetate (BMImBF4) shown strong $CO_2$ permeation capability and mechanical stability. Particularly for 1-R-3-methylimidazolium (R-mim)-based RTILs, which are preferred because they are less viscous than other RTILs, consumption of RTILs increased. In addition, RTILs based on Rmim showed good solubility for gases like $CO_2$, nitrogen ($N_2$), and other hydrocarbons.

**Polymerized Room Temperature Ionic Liquid Membrane (Poly(RTIL)):** In contrast, because of their modular design, RTIL, particularly those based on imidazolium, can also be polymerized into a solid, thick, and thin film membrane. When the researchers discovered that polymer made from ionic liquid monomer had a larger $CO_2$ absorption capacity and faster absorption and desorption rate than the plain RTIL, it was a significant scientific advance. Moreover, poly(RTIL) is said to have greater mechanical strength. These individuals have demonstrated the potential of polymerized ionic liquid (poly(RTIL)) as a material for membrane gas separation.