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Inorganic Membranes: An Intensified Approach to Transforming Chemicals Separations

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The urgent need to reduce greenhouse gas emissions has increased interest in more efficient and compact separation technologies. Inorganic membranes, particularly metallic and molten-salt membranes, offer a promising alternative to conventional separation processes for hydrogen and ammonia, two key industrial chemicals [1-2]. Hydrogen-selective membranes, such as Pd-based membranes, enable the direct production of high-purity hydrogen in a single unit operation [1]. Although these membranes can achieve hydrogen fluxes exceeding U.S. Department of Energy targets [3], their widespread application is still limited by insufficient long-term stability. Microstructural degradation of thin metallic layers at high temperature and pressure can lead to cracks and loss of selectivity, highlighting the need for more robust membrane materials.
Ammonia separation is traditionally achieved through energy-intensive cooling and recycling steps. Recent studies indicate that alternative membrane-based approaches could enable ammonia recovery at lower pressures and support carbon-free ammonia production [4]. In particular, immobilized molten-salt membranes based on metal chlorides have shown strong ammonia affinity. Among these, ZnCl2-based membranes have recently demonstrated high thermal stability and excellent selectivity for ammonia over hydrogen and nitrogen [2].
This work reviews recent advances in inorganic membrane technologies for hydrogen and ammonia separation. New ternary Pd-based membranes for hydrogen permeation and ZnCl2 immobilized molten-salt membranes for ammonia separation are presented. Membrane permeance and selectivity are discussed as a function of temperature and pressure and compared with reported literature values.

References

Dr. Simona Liguori is an Assistant Professor in the Department of Chemical and Biomolecular Engineering at Clarkson University, where she also serves as an Affiliate Faculty with the Institute for a Sustainable Environment. Her research focuses on membrane reactor technologies, hydrogen and ammonia production, and carbon capture and utilization, integrating materials innovation with process intensification to enable low-carbon and sustainable chemical transformations. Before joining Clarkson in 2020, Dr. Liguori held research appointments at Worcester Polytechnic Institute, Colorado School of Mines, and Stanford University, working on clean energy and carbon management technologies. She began her academic career at the Institute on Membrane Technology (ITM-CNR) in Italy, where she also completed her Ph.D. in Chemical Engineering.
Dr. Liguori has authored more than 70 peer-reviewed publications, several book chapters, and two patents in the field of catalytic and membrane reactors. Her work has received over 2,900 citations (h-index 31) and has been recognized with multiple awards, including the Scialog Fellowship in Negative Emission Science (sponsored by the Alfred P. Sloan Foundation and RCSA). Her research has been supported by the U.S. Department of Energy, NSF, and the Carbontech Development Initiative, and she serves as an Editor for the Chemical Engineering Journal, as well as on the Editorial Boards of *Membranes, Frontiers in Climate*, and *Scientific Reports*.
Dr. Liguori is an active member of AIChE, ACS, and the North American Membrane Society (NAMS), and has organized and chaired numerous technical sessions on process intensification, hydrogen technologies, and sustainable systems.