**Molecular driven membranes for clean energy separation.**

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Clean energy fuels such as hydrogen, methanol, syngas and methane require separation and purification before they can be transported and stored. This processing requires low cost and efficient separation technologies to ensure these clean fuels are competitiveness with conventional fossil fuels. Membrane separation presents a distinct advantage over other separation technologies for the clean energy applications, as the membrane is essentially a film that enable some chemical species to transverse through while other chemical experience a barrier. Hence, membrane technology has demonstrated significant potential for clean fuel processing; however current membrane technology has now reached a limitation in performance because they are based on rigid passive separation processes (e.g. size exclusion). To ensure clean fuels are competitive, there is a clear need for membrane separation to be developed that disrupts the traditional trade-off limitation of flux (permeance) versus chemical selectivity. This paper discusses one such approach that utilises doping chemical motifs within the nano-structure of the membranes that interact with external magnetic fields. This interaction is through orientation alignment and/or phase change. Hence, this enables the nano-structure of the membranes to be tuned by changing the phase/orientation of these chemical motifs through varying the external magnetic field. This subsequently alters the membrane morphology the gas species experience, which can be used to help or hinder the transportation of selective chemical species. Importantly, this enables the membrane performance to be adapted in-situ for changing processing conditions. This has strong application for clean fuels, given the small size of hydrogen as well as the strong chemical affinity methanol and syngas have for various chemical functional groups. Applying a variable magnetic field to these doped chemical motifs results in them undertaking rotational motion within the membrane. This is analogous with a molecular motor that can be visualised as driving the transport of chemical species through the membrane structure. This results in a dynamic separation mechanism within the membrane that selectively increases the diffusivity of chemicals, enhancing performance. This paper will present a detailed discussion on the progress of molecular driven membranes, including the advantages of the technology, as well as the current challenges in developing them for viable clean fuel separation technology.