Abstract

The basic objective of the research was to fabricate the series of membranes that modify the permeability of gases to maintain the selectivities and also fabricate the membranes for carbon capturing application. The improvement of gas transport properties, mainly the permeability which causes the reverse effect on the separation factor. It was aimed to improve selectivity of desired gas pairs with gain in the permeability. Although the novel composite membranes recline within MMM region of Robeson plots 1991 and 2008. Researchers are work to develop new composite membranes, however, their working vicinity needs to tend towards the attractive region of the Robeson plot. For the vast industrial applications, the trade-off parameters must be linearly lifted up towards the commercial interesting region. For this purpose, a unique structural design micro-voids need to be generated within such membranes by variety of ways including thermal rearrangement or polymer intrinsic microscopy. Thus, the integration of various modification techniques may lead the membrane technology for a long-term pilot scale industrial application.

Chapter 1 describes the fundamentals of membrane technology and the literature review. **Chapter 2** describes the types of materials used in present study and the details of various experimental techniques. The information regarding to the analytic instruments and their sources are explained in this chapter.

In **Chapter 3**, discussed about detailed study of polyimides composites with silica nanoparticle and also thermal rearrangement process has been described. It was observed that the permeability of glassy polymers decreases with increasing kinetic diameter of gases. The permeability of the polyimide changes by incorporation of silica nanoparticles, and this was more substantial for all gases. The composition of the silica nanofillers and heat change of the HAB-6FDA coating resulted in remarkable performance. Silica nanoparticles play a critical role in improving H_2 molecule transport modes in these nanocomposite polyimides. This novel membrane material removes H_2 from a gas combination and maintains the H_2/CO_2 selectivity. Some of the materials that cross Robeson's 1991 or 2008 upper-bound limit were being developed.

In **Chapter 4.1**, focuses about hydrogen gas permeation application. It includes, study of dispersed graphene oxide (GO) in a polymer blend of polystyrene (PS) and poly(methyl methacrylate) (PMMA) nanocomposite membranes. The permeability measurements indicate that the GO nanofillers in blends of PS/PMMA have shown higher permeability for hydrogen gas than that of pure polymers. Graphene provides greater access to the penetrant to make them soluble in the membrane material, resulting in a higher permeability. The result were plotted for Robeson's 2008 upper bound for nanocomposite membrane separation tends for all of the gas pairs for H_2/O_2 and it is an excellent example of a gas pair whose composition fits perfectly inside the upper bounds for gas separation membrane compositions. The hydrogen molecules are formed soluble within the membrane matrix for the GO nanocomposite, which creates a new pathway. The modification maintains the selectivity while allowing for the separation of hydrogen from carbon dioxide.

Chapter 4.2 includes the study of polymer material that gives low permeability properties of material that will use as packaging material in the food industry. In chapter 4.2, study of gas permeability, thermal stability and mechanical properties of pure polyethylene terephthalate (PET), polyethylene glycol (PEG), their blends with weight percentage ratios of PET: PEG (50/50 w/w%) and blend of PET/PEG composite with different weight percent of DES/TiO_2 nanofillers included. According to studies on the permeability of O_2, etherified samples are less permeable in case of PET/PEG-DES/TiO_2 material compared to Amul Milk and Amul Butter Milk bags. The permeability of all membranes for O_2 decreases as the weight percentage of DES/TiO_2 polymer increases in PET/PEG-DES/TiO_2 blend composites. This study provides information on the development of heat management polymeric materials that are relevant for food packaging applications. Moreover, the blend composite of PET/PEG-DES/TiO_2 material is more effective for packing material than current packing material that Amul uses.

In **Chapter 5.1**, study of combination of glassy and rubbery composition for the gas transport process has been analysed by using blend of polystyrene (PS) and polydimethylsiloxane (PDMS) blend. However, to make further modification the blends has been composite with CNT nanofillers to fabricate blend-composite membranes and analyses in terms of solubility, diffusivity, permeability and selectivity. It can be inferred from the results that a blend of rubbery and glassy polymers can combine high permeability among with high selectivity, which may not be adopted by the pure polymer membrane. By increasing DES/CNT and CNT loading into blend composition separation performance of various gas pairs has inclined to a large extent with increasing the DES/CNT, the optimised composition tends towards Robeson upper bounds of 1991 and 2008 which keeps them into the novel category.

In **Chapter 5.2**, characterization of blend of polystyrene (PS) and polydimethylsiloxane (PDMS) blend composites with graphene oxide (GO) nanofillers as well as deep eutectic solvent (DES) based DES/GO nanofillers membranes are outlined along with a single gas permeation. The combination of glassy and rubbery polymers along with different wt% ratio of GO and DES/GO nanofillers has been analysed for gas permeability, structural property, mechanical property, thermal property and porosity of membrane. The performance of the membranes for H_2 separation gains attention towards energy as well as industrial applications. Moreover, the highest selectivity has been obtained for CO_2/CH_4 which is applicable for carbon capturing application.

Chapter 6 summarises of various studies in different chapters and describes the scope of upcoming studies on glassy and rubbery polymer with different nanocomposite membranes for various industrial applications.