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A REVIEW OF POLYMERIC - INORGANIC COMPOSITE MEMBRANES: CHARACTERISTS,CLASSIFICATIONS , ANDITS APPLICATIONS IN WATER PURIFICATION PROCESS

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ABSTRACT- A selective barrier is a thin membrane or contact that blocks material from moving from one phase to another. The specific physical and chemical properties of some materials, both natural and man-made, govern how much of them may be penetrated by thin sheets of solution. Polymeric-inorganic composites are presently at the forefront of engineered material development due to their numerous benefits over conventional membranes. To make synthetic membranes, polystyrene, polyvinyl chloride, tungstate, metal phosphate, arsenate, and a range of other metal oxides can be used. The bulk of synthetic membranes available today are polymer-polymer composites used for separation. They are classified based on their shape, bulk structure, surface chemistry, and production technique. Differentiating elements include the driving force behind membrane separation techniques and the physical and chemical features of synthetic membranes. Artificial membranes can be made of inorganic materials such as metals or ceramics, organic materials such as polymers or liquids, or a combination of the two. Liquids, homogeneous polymer sheets, or heterogeneous solids (such as polymeric mixes or mixed glasses) may be used to make these composite materials. Coherent ion-exchanger gel membranes on a disk and a ribbon are the same. The combination of an inert binder and a colloidal ion-exchanger results in histologically distinct membranes. Food and medicines, fuel cells, water purification, biotechnology, textiles, and other multibillion-dollar businesses might all benefit from membrane-based technologies.

Keywords: Polymeric-inorganic composite, Membrane characteristics, Membrane classification, Membrane applications, Water purification process.

1. INTRODUCTION

A membrane works as a selective barrier, preventing molecules from transitioning between phases. A membrane, as previously said, prevents huge amounts of material from passing through it to divide two sections or compartments. The ability of particle species to overcome physicochemical barriers between neighboring phases or compartments is determined by their features and makeup.

Adobe, a macroscopic composite substance made of clay and straw, had a tremendous impact on the evolution of our planet. The smaller the particles in composite mixtures, the greater the microscopic interphone. Micro composites and nanocomposites require materials from this distinct class. Composite membranes must be exceedingly conductive, physically and chemically durable, ultra-shock-resistant, and highly selective to satisfy the demands of demanding applications. An adequate polymer (binder) and inorganic chemical must be chosen to meet the requirements. Common composite materials used to manufacture membranes include nylon, cellulose acetate, polyamide, polysulfone, polyvinyl alcohol, and polytetrafluoroethylene.

The materials used are polypropylene and plastic. Inorganic compounds with specific qualities that are utilized to make composite membranes include oxides, tungstate, carbonate, metal phosphate, and arsenate.

The sol-gel method is a simple way to make membranes out of a mixture of polymers and inorganic materials. Mixed methods, in-situ polymerization, co-precipitation, molecular self-assembly, and intercalation are further techniques. The creation of hybrid anion exchange membranes utilizing silane coupling agents in liquid or sol-gel coupling has received considerable attention . The ionic conductivity of the membrane influences the application procedure. Sulfonic and phosphonic acids, as well as quaternary ammonium salts, are examples of strong functional groups that promote this. Weak ionic functional groups such as carboxylic acids, hydroxyls, and primary, secondary, and tertiary amine groups are also involved. Ionic conductivity does not create high ionic conductivity membranes with high porosity, as evidenced by the evidence. The porosity of a composite membrane can be altered by employing the appropriate inorganic and organic materials and synthesis processes. The hybrid membrane's conductivity or ionic migration is boosted by adding more water. Only materials with high ionic conductivity and low water content can boost industrial applications. As a result, commercial composite membranes must have a lower water content and stronger ionic conductivity.

2. MEMBRANESEPARATIONTECHNOLOGIES

The pore size distribution of a polymeric-inorganic composite membrane can be altered to control particle flow across it. Particles are prevented from entering through the cell membrane by larger capillary diameters. As a result, pore size distribution has little effect on membrane filtration [16]. Given that the primary parameters determining these membranes' mass transfer barriers are their thickness and porosity, a thicker membrane will theoretically prevent transferred particles from going through. Surface gradients, in general, kick off a membrane's response. Potential gradients are ideal for dialysis, ultrafiltration, microfiltration, or nanofiltration; pressure gradients are ideal for these procedures; and concentration gradients are ideal for reverse osmosis employing any of these four methods. The succeeding step at each is determined by the membrane's pore diameter.

While there are many attributes that can be used to build membranes, electrical conductivity is the one that researchers are most interested in. Species transfer must be considered when designing membranes for electrochemical processes such as water electrolysis or fuel cell batteries. The improvement of membrane functioning is fundamental to electrochemical devices. Membranes serve as molecular sieves in reverse osmosis, nanofiltration, and ultrafiltration processes. Electrochemical membranes, in addition to acting as conducting channels and molecular sieves, prohibit the mixing of fuel and oxidant. When exposed to a gradient of electric fields, membranes encounter a number of diverse challenges. Figure 1 depicts membrane separation mechanisms.

The mass separation advantages of a membrane are determined by its mass transit rate,

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mechanical strength, thermal stability, and selectivity. Membrane material makes separating substances with equivalent electrical or chemical properties and nearly equal molecular quantities more challenging. A composite membrane's lifetime is determined by its mechanical, chemical, and thermal stability. This becomes critical when dealing with fluctuations in the pH of the feed solution, frequent membrane cleaning, or high process temperatures. In ultrafiltration and reverse osmosis, pressure is the major driving force behind the mechanical properties of the membrane. The features of a membrane should remain constant regardless of time or how much the feed solution varies. To maximize membrane utilization, improved transport characteristics, greater flux rates, and longer lifespan can be introduced to mass separation systems.

3. CLASSIFICATIONOFMEMBRANES

It is commonly known that membrane technology can produce surface, brackish, marine, and well water. Using pressure-driven membrane technology, it is feasible to make water safe to drink. The best membrane technology to use is determined by the size of the water contaminants and additives. Potable water is regularly taken from salty areas like the ocean or subsurface aquifers. Many previously inaccessible areas now have access to environmentally safe water because to advancements in reverse osmosis, renewable energy, pretreatment, and technology. It is exacerbated by a lack of potable water. Water is purified by removing disinfection precursors using reverse osmosis (RO) and, to a lesser extent, nanofiltration. Reverse osmosis, heavy metal removal, arsenic, fluoride ions, membrane bioreactors, electro dialysis, and donnan dialysis have all been used to remove inorganic micro contaminants. Water can be filtered using high-pressure membrane technologies such as reverse osmosis (RO) and nanofiltration (NF) to remove dissolved organic contaminants. Membrane technology is likely to be used more frequently as a result of a combination of environmental limitations, scarcity of water, and common sense.

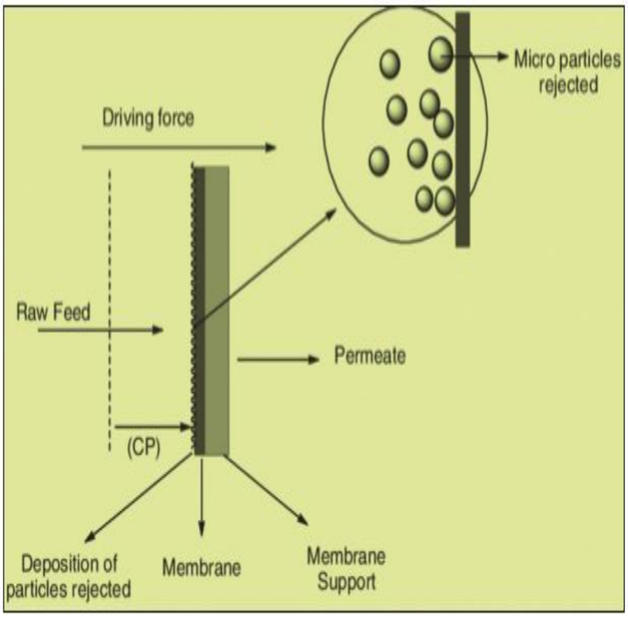

Figure1: Schematic representation of composite membrane separation processes.

Colloidal ion-exchanger particles are contained in an inert binder. So, cation exchange membranes can only let positively charged ions through, whereas anion exchange membranes

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can let negatively charged ions through. For a membrane to be considered homogeneous, its charges must disperse uniformly over its surface. To create cation selective membranes with consistent composite distribution, cross-linked polystyrene and metallic phosphate or tungstate are utilized. Anion selective membranes are composed of mixes of polystyrene and metal containing quaternary ammonium (NR+4) groups. The chloromethyl group can be inserted into the benzene ring and trirnethylamine can be generated from quaternary ammonium by post-treating polystyrene with mono chloromethyl ether and aluminum chloride, resulting in an anion exchange substance.

The dispersion of the finely powdered ion-exchange particles is not uniform in heterogeneous membranes. An inorganic ion exchanger and polymer plastisol mixture creates a long-lasting heterogeneous membrane with a finer and more uneven distribution of ion exchange particles. Some examples of membrane types include polymeric, liquid, microfiltration, ultrafiltration, nanofiltration, reverse osmosis, ion-exchange, and polymeric-inorganic composite. These types of membranes are further divided according to particle dispersion and porosity. Membrane classification is schematically shown in Figure 2.

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4. POLYMERIC-INORGANIC COMPOSITE MEMBRANES

Polymeric-inorganic composites are the most useful engineered materials. Composite membranes use a certain ratio of inorganic and organic polymers. Inorganic and polymeric characteristics characterize these membranes. Polymers are flexible and bond, while inorganic materials exchange ions and are thermally stable. Polyvinyl chloride, polystyrene, and polyaniline are the most prevalent membrane materials because to their stability and flexibility. Chemistry, pharmacology, and material engineering use composite membranes. Most industrial processes use solid polymeric and inorganic ion-exchange composite membranes to clean, separate, and disinfect water and other ion-containing fluids. Resins, zeolites, montmorillonite, clay, and soil humus are common membrane ion exchangers . Polymeric inorganic composite ion-exchange membranes are used in fuel cell storage batteries, electrochemical separation, electrodialysis, electrodeionization, and other applications due to their high cation exchange performance. Researchers seeking ion selective membranes are interested in these materials. Researchers have studied cationexchange membranes extensively because they are utilized commercially, but anion exchangers, which are employed in environmental science to separate, identify, and detect dangerous anions from industrial waste and drinking water, have received less attention. Many amphoteric exchangers exchange ions and cations simultaneously. Selective or nonselective ion exchangers bind ions by chemical and physical properties.

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5. APPLICATION OF POLYMERIC-INORGANIC COMPOSITE MEMBRANES

New developments in membrane-based technologies may have far-reaching consequences for multimillion-dollar companies across several sectors. They find usage in fuel cells, biotechnology, medications, textiles, water purification, and food manufacture. Reverse osmosis, gas separation, electrodialysis, hemodialysis, microfiltration, and ultrafiltration are some of the many applications of polymeric-inorganic composite membranes. Fuel cell, battery, and water electrolysis membranes can also think about species transfer. When compared to more traditional forms of filtering, the electrochemical membrane performs far better. When it comes to reverse osmosis, ultrafiltration, microfiltration, and nanofiltration, membranes play the role of molecular sieves. In electrochemical devices, the membrane serves as a molecular sieve, separates the anode and cathode, and stops fuel and oxidant from mixing. Membranes face additional difficulties due to electric field gradients. The government, lab, office, and home all find numerous uses for it as well. The environmental benefits of composite membranes include their ion-exchange capacity, selectivity for heavy metal ions, and stability. The following industries make use of these membranes:

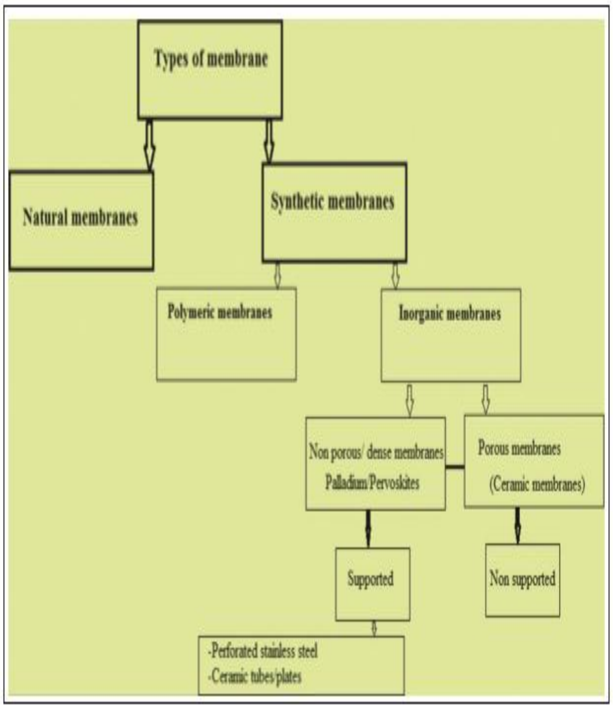

Figure 2: The schematic representation of membrane classification

5.1. For Preparation of Qualitative Water

This technology is extensively utilized for the production of water of many qualities, including surface, well, brackish, and ocean water. The purification of potable water is the primary application of pressure-driven membrane technologies. The choice of membrane process is determined by the size of the water contaminants and admixtures. Desalination is a common process for making potable water from saltwater and brackish groundwater. Recent developments in technology, design, alternative energy sources, pretreatment, and application materials have made reverse osmosis a viable, eco-friendly option for obtaining potable water in areas where supplies are scarce. The water is softened, product precursors and micro

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pollutants are removed, and reverse osmosis (RO) and nanofiltration are employed. To eliminate inorganic micropollutants such as nitrate, fluoride ions, boron, arsenic, chromium, and heavy metals, several techniques including as electrodialysis, donnan dialysis, nanofiltration, membrane bioreactors, and ultrafiltration with polymers and surfactants have been employed. Removing dissolved organic compounds (DOC) from natural waters is achieved by high-pressure membrane techniques, specifically RO and NF. Multiple uses for extended membrane technology are necessitated by water scarcity, environmental concerns, and the obvious reasoning behind water recycling rather than release.

5.2. Removal of Specific Constituents

To filter out particles and dissolved compounds, membrane technology is being used more and more in urban wastewater systems for RO, nanofiltration, micro- and ultra-filtration, and other similar processes. Prior to RO treatment, RO is pretreated with immersed micro and ultra filtration membranes to extract various dissolved substances. Membrane technology and ultraviolet oxidation for disinfection are essential in water reclamation.

5.3. Nuclear Industry

In clean technology, membrane processes have the potential to lessen the need for energy, trash, and raw materials. Nuclear technology problems are just one of several environmental ones that they can resolve. Treatment of liquid radioactive waste is a common practice at many nuclear power plants throughout the world. Protective against radiation, heat, and chemicals, ceramic and composite membranes are top priorities. For the purpose of determining the radioactive waste content, the thermal method of membrane distillation using resistant porous membranes was examined. Electric procedures that make use of ion exchange membranes and liquid membranes are now in the development phase for potential use in the nuclear industry. One potential substitute for traditional recycling and reuse methods was the use of membranes.

5.4. Pulp and Paper Industry

There is a modern pulp and paper industry that use membrane filtering. Protecting the environment, saving energy, and recovering valuable products are three reasons why membrane filtration is becoming more popular. These membranes have found extensive use in the paper and pulp industry for a variety of purposes, including water treatment, chemical recovery, and bleaching effluent treatment. More water can be recycled and the loop closed in the pulp and paper industry with the help of membrane technology. Effluent treatment, concentration, and fractionation are all processes that make use of membranes. They are making an effort to lessen the environmental impact of pulp and paper mills by recovering and recycling important compounds, decreasing water usage, and so on.

5.5. Food Industry

Membrane technology is increasingly used in food processing and separation. New foods and items can be processed using membrane separations. Green technology includes membrane separations. This method concentrates food solutions by applying high pressure to reverse flow, avoiding phase shift and preserving nutrition. Additionally, RO or ultrafiltration membrane energy is efficiently used. This method extracts low-molecular-weight salts, mono saccharides, and fragrance compounds from food. Enzymes, fermented liquors, vegetable oils, and fruit juices can be concentrated and purified using membrane technology. Pressure-

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driven membrane processes segregate particle sizes. Because of this, they are used in various food preparation sectors.

5.6. Solvent Purification

Solvents are essential in many process sectors, including microelectronics, biotechnology, food, petrochemical, pharmaceutical, and chemical. Bringing back used solvents contaminated with any and all pollutants, both mild and severe. Distillation is an energy-intensive process that is used in many solvent purification and production procedures to create or recover liquid substances. Expensive, wasteful, and inefficient, this processing procedure is not worth it. Consequently, it is superseded by methods that separate molecules using membranes at room temperature. It is anticipated that product cost, energy consumption, waste, materials usage, and risks and hazards will all decrease as a result of chemical process intensification in solvent recovery and purification.

5.7. Reagent Purification

All of these acids—ammonia, hydrochloric, nitric, perchloric, and sulfuric—can be refined via membrane distillation. A microporous hydrophobic membrane is used in membrane distillation to separate two water solutions that are at different temperatures. A gas-liquid interface is formed because the hydrophobicity of the membrane prevents the mass transfer of liquids. Due to the difficulty in regenerating the starting material, membrane purification is only applicable to a small number of chemical derivatives. In addition to removing volatile organic chemicals such as benzene and tri chloroethylene, membrane distillation may concentrate and separate non-volatile components such as ions, acids, colloids, and macromolecules. It can also extract alcohols from diluted aqueous solutions.

5.8. Pharmaceutics and Medicine

In the medical field, membrane technology is vital. Some methods for purifying and concentrating both large and small molecules include microfiltration, ultrafiltration, and reverse osmosis. There are a plethora of modern separation, concentration, and purification applications for membrane technology. To lessen the need for cremation, pharmaceutical waste streams can be treated using nanofiltration or evaporation. A wide variety of applications employ membranes, including drug administration, bio separations, diagnostics, tissue regeneration, artificial organs, and medical device coatings. Microfiltration and ultrafiltration are two examples of the membrane separation methods used in the purification and separation of biopharmaceuticals in the downstream processes. A new technique for effective purification of monoclonal antibodies has emerged: membrane chromatography. Bioreactors, accelerated oxidation, membrane filtration (RO and nanofiltration), and other processes are used to remediate pharmaceutical effluent. Organic solvent-based drug synthesis of medicinal compounds/intermediates can be accomplished through solvent exchange and catalyst recovery with the use of stable-membrane nanofiltration. In the pharmaceutical business, hollow fiber membranes facilitate the crystallization of therapeutic compounds.

5.9. Soil Science and Technology

Soil remediation of toxic metal and organic pollutants is required for regulatory compliance. The wash liquor, which is a byproduct of washing soil with water, contains contaminants that were originally present in the solid matrix. It is unusual to use membranes for wash liquor

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concentration. Several approaches involving membranes show promise. Concentrating contaminants with greater volume reduction is the goal of these approaches. Soil heavy metal removal methods included acid leaching, microfiltration, and nanofiltration. Soil particles were isolated from leachate containing metals via microfiltration. The volume of the leachate was reduced and the wasted acid was recovered from the slurry by nanofiltration. Based on the results of the bench-scale study, membrane techniques for soil remediation should be able to remove metals more quickly and thoroughly while also producing less waste.

6. CONCLUSIONS

Membrane separation uses electrodialysis, hemodialysis, microfiltration, gas separation, reverse osmosis, and pervaporation. Poor groundwater quality in India necessitates water filtration before consumption. Desalination turns seawater and brackish water into drinking water. This page briefly describes membrane distillation (MD) and reverse osmosis (RO), two useful desalination methods. Reverse osmosis (RO) membranes are preferred for desalinating groundwater and seawater due to their ability to remove contaminants and their hopeful future. Desalination RO membranes, a polymeric-inorganic composite, have become the preferred material for new plants in the last 40 years. This membrane was made by die casting molten metal into a mold chamber. Organic and inorganic polymers are mixed in exact proportions. Type and application classify synthetic membranes.

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