Membranes containing polymerised ionic liquids for use in gas separation

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Invention

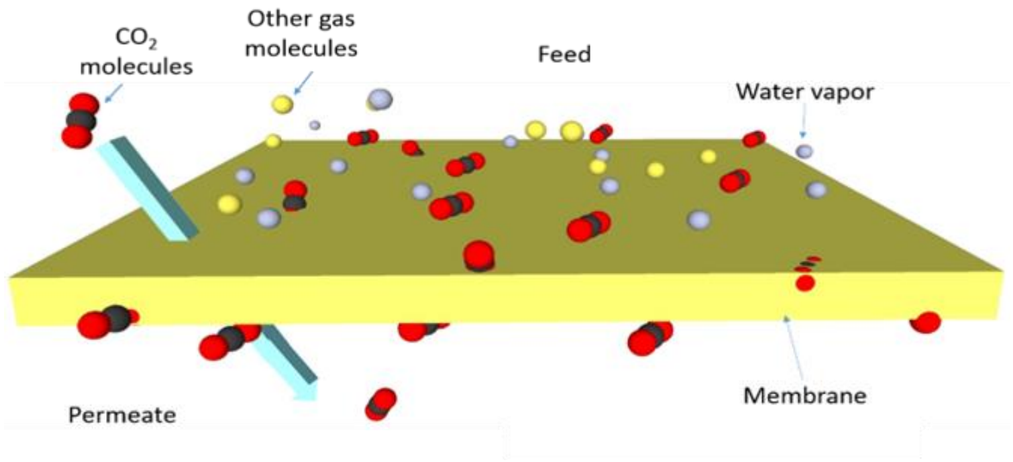
The invention relates to the production and the use of **innovative membranes for the separation of gases**, in particular for the efficient separation of carbon dioxide (CO_2) from gaseous mixtures saturated with water vapour, which is one of the most important issues in the gaseous mixtures separation at industrial level.

The proposed method uses **new dense membranes** based on the photopolymerization of an innovative combination of materials, which includes **polymerizable ionic liquids (PILs)**.
The selectivity of the dense polymer membranes for the separation of CO_2 is due to the presence of specific ionic liquids within the polymer matrix. Appropriate modifications of the chemical structure of the polymerizable ionic liquid, and in particular by increasing the length of the three alkyl chains on the ionic liquid phosphonium group, it is possible to obtain a clear improvement in the selectivity of the membranes for carbon dioxide. This feature represents a further innovative aspect of the produced membranes compared to the state of the art.

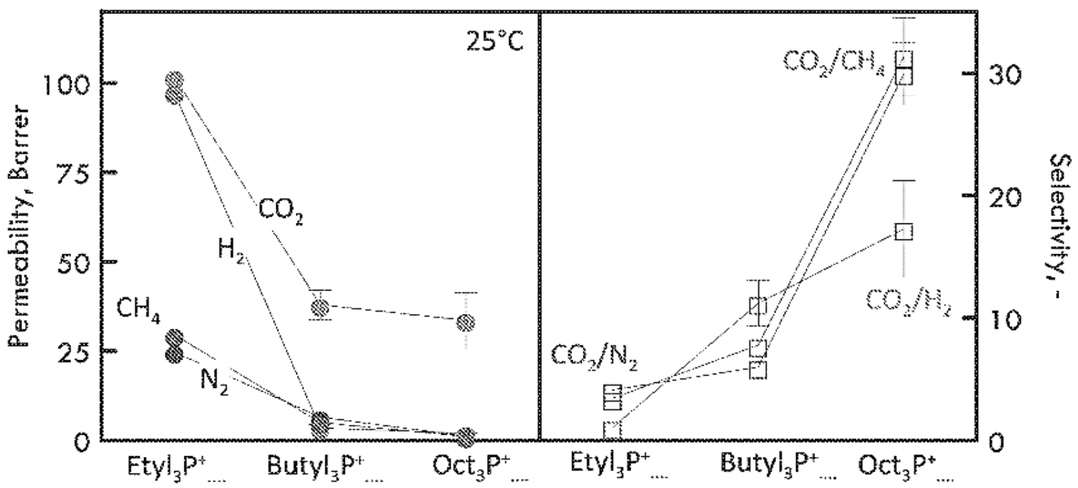
The technology finds application in the context of **circular economy and waste streams recovery**.

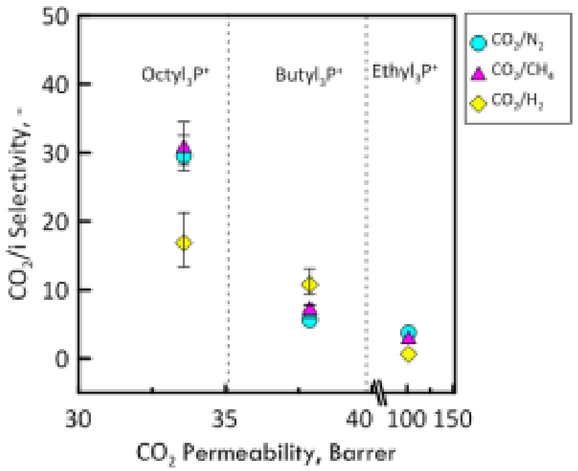
CNR - CONSIGLIO NAZIONALE DELLE RICERCHE, UNIVERSITY OF CALABRIA are also patent applicants.

Drawings & pictures



Picture showing the membrane selectivity and photo of a membrane sample.





Selectivity and permeability of different membranes in relation to CO_2 and other gases.

Industrial applications

Gas separation through membranes with increasingly high selectivity is becoming an important unitary operation in **chemical engineering**, replacing traditional technologies with clear advantages in terms of efficiency and energy saving. The development of new materials capable of separating different gas species will lead to the modification and improvement of many existing industrial processes in many sectors, from petrochemistry to green chemistry.

The industrial application therefore concerns all areas in which an effective separation of Carbon Dioxide from gaseous mixtures is required (i.e. natural gas upgrading; biogas upgrading; flue gas treatment).

The industrial field of greatest application is probably the **energy** one, since the method can allow an efficient separation of CO_2 both in "pre-combustion" and "post-combustion" mixtures.

The patented dense membranes have the following innovative technical features compared to the state of the art:

- **resistance to aqueous** or water vapor saturated environments;
- **easy scale-up** of the membrane preparation system; the system can be merged with any plant working with a common UV lamp;
- the starting solution does **not require high temperatures or long preparation times**;
- the membranes prepared in the present invention do not require the use of toxic solvents such as DMF or DMA (generally used for the solubilization of polymerizable ionic liquids (PILs) nor the need to use volatile solvents for the preparation of dense membranes by the evaporation phase inversion technique. The PILs are dispersed, by means of a surfactant, in a **UV-curable matrix**.
- Another innovative aspect compared to the state of the art concerns the **improvement in CO_2 separation selectivity** with increasing chain length on the phosphonium group of the PIL.

Possible developments

Membranes were prepared by photo-polymerization of a mixture of acrylates containing 3 ionic liquids (ILs) with different alkyl chain lengths (ethyl to octyl): $Ethyl_3P^+$, $Butyl_3P^+$ and $Octyl_3P^+$. The permeability of all the gases considered decreases as the alkyl chain length increases. $Ethyl_3P^+$ has the highest permeability - three times higher than $Octyl_3P^+$. The selectivity follows a positive trend as the alkyl chain length increases.

The new membranes are selective for Carbon Dioxide due to ILs that promote CO_2 solubility, preferentially favoring its permeability, compared to other gases whose transport is mainly influenced by diffusion phenomena. The **mild operating conditions required, the reduced overall volume, the modularity, the absence of absorbing solvents, the easy scalability** are among the most relevant advantages that make membrane technology competitive and, in many cases, successful compared to traditional separation technologies, such as adsorption, cryogenics, etc.

The membranes produced are very stable, but obviously an eventual industrial application will require an appropriate LCA study.

The reference market for the proposed technology and method concerns all industrial sectors, in particular the energy sector, which are involved in the separation of carbon dioxide from gaseous mixtures, also in a high humid environment.

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