Ceramic membranes to capture CO_2 from flue gas at high temperature

Clara Casado, Masashi Asaeda
Department of Chemical Enginnering. Hiroshima University. 1-4-1 Kagamiyama. 739-8527 Higashi-Hiroshima
Tel. : **082-424-7719** - Fax. : **082-424-7191**
E-mail : ingquim@hotmail.com

Résumé :
Près du 80% de l'énergie qu'on use dans le monde provient de la combustion des combustibles fossiles, qui n'arrête pas de monter selon les prévisions jusqu'a l'année 2020. Cette combustion rend du CO_2 à l'atmosphère, ce qui est considère comme une des causes du chauffage global. Les technologies usées par les centrales thermiques sont développes continuellement pour arriver aux standards environnementales sur les émissions des gaz, en causant la réaction de l'efficacité thermique et en précisant des équipes additionnelles ou nouveaux components. Le propos de mon stage de recherche au Japon est de développer des membranes sélectives pour la saturation de CO_2 à haute température, a partir des mélanges simulant les gaz résiduels provenant des centrales thermiques. Les membranes inorganiques offrent par contre un potentiel a ce sujet, mais elles ne se trouvent pas aujourd'hui qu'au niveau expérimentale au laboratoire. La méthode de préparation sera la méthode sol-gel colloïdale, utilise avec succès par le Groupe du Prof. Asaeda, parce qu'elle permet d'obtenir des membranes microporeuses en profitant l'élevée perméabilité de la silice avec la stabilité requise pour l'application, apportée par d'autres matériaux.

Abstract :
The purpose of this research is the knowledge generation on the mechanism of the diffusion of CO_2 through thin supported inorganic membranes, as well as improving the stability, thus going ahead on the mass production and sustainability of membrane technology in industrial processes, where its advantages regarding maintenance cost, environmental regulation, and so on are not yet fully acknowledged.

Introduction :
About 80% of the energy used world-wide comes from fossil fuels, and this share is expected to increase until at least 2020 (Bredesen *et al.*, 2004). Combustion of fossil fuels leads to CO_2 into the atmosphere, which is believed to contribute to undesired global warming. Available conventional power generation technologies using fossil fuels are being continuously developed to meet environmental requirements regarding gases emissions (Aaron *et al.*, 2005), thus reducing thermal efficiency and requiring additional equipment and/or design of new components. Polymeric membranes for gas separation are commercially available, but these have so far not been an alternative for facilitated CO_2 capture in large-scale power production due to their insufficient flux and selectivity and a lack of high-temperature stability. Inorganic membranes thus seem one of the most promising technologies for high temperature separation of gas mixtures in power plants. However, much more work is needed to make them a reality. The initial interest attired by ceramic membranes has gradually decreased due to the high investment costs and the difficulty of mass production of thin supported membranes. At present, most focus is on the development of inorganic membranes for hydrogen separation and oxygen separation. High-temperature CO_2 -selective membranes have been investigated over the last 10-15 years, but these are still in an early technological stage. Porous silica membranes prepared by sol-gel methods allow fine tuning of pore size and structure control, but silica is not very stable in water vapour, thus its doping with other materials is considered, starting from the experience in the field of the Laboratory of Membrane Technology at the University of Hiroshima. The purpose of my research in Japan will be focused on the latter application, looking for deepening the knowledge on membrane performance and those topics such as long-term stability and production technology, indispensable to make these membranes economically viable in the real world.

Materials & Methods:
First of all, an experimental apparatus is being assembled in order to test the CO_2 separation from mixtures containing other gases present in real flue gas mixtures, such as CH_4, N_2, and H_2, and in the presence in water vapour, as this component may affect the microstructure of the silica-based membrane at high temperature. Simultaneously, research is being done to find alternative materials (Ciora *et al.*, 2004; Kawamura *et al.*, 2005) that can be used to improve the stability of silica in the operating conditions in power stations.

References
Aaron D and Tsouris C (2005) Separation of CO_2 from flue gas: a review. *Separation Science and Technology*, 40: 321-348

Asaeda M and Yamasaki (2001) Separation of inorganic/organic gas mixtures by porous silica membranes. *Separation and Purification Technology*, 25: 151-159

Bredesen R, Jordal K, Bolland O (2004) High-temperature membranes in power generation with CO2 capture. *Chemical Engineering and Processing*, 43: 1129-1158

Ciora RJ, Fayyaz B, Liu PKT, Suwanmethanond V, Mallada R, Sahimi M, Tsotsis TT (2004) Preparation and reactive applications of nanoporous silicon carbide membranes. *Chemical Engineering Science*, 59: 4957-4965

Kawamura H, Yamaguchi T, Nair BN, Nakagawa K, Nakao S-i (2005) Dual-Ion Conducting Lithium Zirconate-Based Membranes for High Temperature CO_2 Separation. *Journal of Chemical Engineering of Japan*, 38(5): 322-328

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