New Generation of Nanomaterials for Green House Gases Adsorption

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Abstract

The Green House Gases (GHG) capture and storage could play a significant role in reducing emissions in the atmosphere. Carbon dioxide (CO_2) is the most important gas by volume and so it has been widely studied and captures the focus in most of the reports on global warming. [1]. However, there are other GHGs with lower volume emissions but which contribute 40% of the radiation from GHGs. Thus, Schulze et al. (2009) emphasize the importance in future emissions of methane (CH_4) and nitrous oxide (NO_2) in the GHG balance in Europe [2].

There are several technologies for CO_2 capture including adsorption, absorption and through membranes, among others [3]. They include several adsorbents such as: active carbon [4] zeolites [5] and mesoporous silica [6]. The above technologies based on adsorption processes, are limited regarding retention capabilities of GHG per absorber mass. In this regard, there is widespread interest in the development of advanced absorbent materials with better characteristics than conventional materials and incorporating appropriate functionality for each specific pollutant. Nanotechnology can be the solution. Recently, there have been some studies that used nanomaterials for CO_2 removal. For instance, the use of carbon nanotubes (CNTs) and nanotubes functionalized with amines by physical adsorption processes. The comparison of these materials with commercial adsorbents such as active carbon and zeolite suggests that these compounds are good candidates for CO_2 absorption [7]. One of the other hand, some technologies used to capture CO_2 at high concentrations is the combustion of solid carriers oxygen ("Chemical Looping Combustion,"CLC) which is an alternative to the conventional combustion with subsequent separation of CO2 (capture in post-combustion). In this technology, metal oxides are used as transporters oxygen as Fe_2O_3, NiO and Mn_2O_3 among others, on inert supports. However this technology has not yet carried out on a large scale, although the results are promising, mainly by low energy costs required in the process [8]. A very few results were found for the use of inorganic nanoparticles (NPs) for CO_2 removal and even less for the removal of other GHGs such as NO_2, CH_4 and fluorinated compounds.

While in the field of gas treatment research has not been widely studied, in the field of environmental engineering and water treatment processes it is seen more research. Thus, some work developed by our group and others for removal of heavy metals [9] or of nutrients [10] by using inorganic NPs show the potential of nanotechnology for contaminant removal applications.

In this sense, it has been studied in this work the adsorption of CH_4 on different type of NP and nanomaterials including: iron oxide (Fe_3O_4) NPs, titanium oxide (TiO_2) NPs, ZrO_2 NPs as well as Fe_3O_4 and $MnFe_2O_4$ NPs stabilized [11] in sulfonated polymers or zeolites among other porous supports of interest. The synthesis and characterization of various types of nanomaterials was studied in order to present an improvement in adsorption capacity compared to the materials currently in use. They have been used for removal CH_4 in continuous experiment. The results obtained so far showed an increase in the adsorption kinetics for both Fe_3O_4 NPs and those stabilized in polymer in comparison with commercial Activated Carbon or Zeolites.

References

1) S. Pacala, R. and Socolow R, Science 13, 968-972 (2004).

2) E.D. Schulze, S. Luyssaert, P. Ciais, A. Freibauer and I. A. Janssens. Nature Geoscience 2, 842-850 (2009)
3) D. Aaron and C. Tsouris., Separation ScienceTechnology 40, 321–348 (2005).
4) R.V. Siriwardane, M.S. Shen, E.P. Fisher and J.A. Poston., Energy Fuels 15, 279–284 (2001).
5) J. Prezepiórski, M. Skrodzewicz and A.W. Morawski., Applied Surface Science 225, 235–242 (2004)
6) F. Zheng, D.N. Tran, B.J. Busche, G.E. Fryxell, R.S. Addleman, T.S. Zemanian and C.L. Aardahl, Industrial Engineering Chemistry Research 44 3099–3105 (2005).
7) S.K. Smart, A.I. Cassady, G.Q. Lu and D.J. Martin.Carbon 44, 1034–1047 (2006).
8) A.A. Olajire.Energy 35, 2610-2628 (2010).
9) S. Recillas, J. Colón, E. Casals, E. González, V. Puntes, A. Sánchez and X. Font., Journal of Hazardous Materials, 184, 425-431 (2010).
10) S. Choe, Y.Y. Chang, K.Y. Hwang and J. Khim. Chemosphere 41, 1307-1311 (2000).
11) A. Alonso, Development of polymeric nanocomposites with enhanced distribution of catalytically active or bactericide nanoparticles, Thesis 2012, Universitat Autònoma de Barcelona