Adsorption separation of CO_2 from CH_4/CO_2 mixture by Low Silica X zeolite and Recovering of Adsorption Heat for Further Applications

Akihiko Matsumoto[1], Keiichi Hasegawa[1], Yuji Hasegawa[1]

[1] Department. of Applied Chemistry and Life Science, Toyohashi University of Technology, Tempaku-cho,Toyohashi 441-8580, JAPAN
email for correspondence: aki@tut.jp

Biogas produced by anaerobic fermentation of sludge contains approximately 60% of methane (CH_4), and 40 % of carbon dioxide (CO_2) with small impurities. The biogas has been attracting attention as a clean energy because it is carbon neutral unlike fossil fuels. It is important to separate of CO_2 from the biogas. The low-silica X zeolite (Na-LSX) is one of useful candidate to the adsorbent because of its strong adsorption ability of CO_2 by the strong interaction between the quadrupole of CO_2 and the strong electric-field gradient by cation in zeolite cavities. However, the strong interaction brings about high heat evolution which reduces adsorption efficiency. This study focus on the recovering of the adsorption heat by CO_2 adsorption from a model biogas of the CO_2-CH_4 mixture (CO_2/CH_4 = 2/3). The laboratory-made heat recovering apparatus in a flow adsorption system is applied to reduce the temperature rise by adsorption. In this apparatus, an adsorption tube containing Na-LSX is placed in a water tank and the heat evolved by CO_2 adsorption was efficiently conducted in water. The amount of recovered heat was estimated by the temperature change of water.

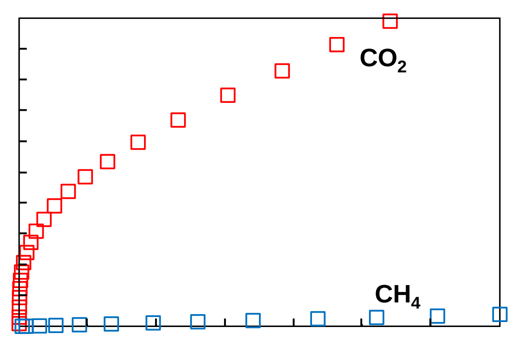

Figure 1 Adsorption isotherms of CO_2 and CH_4 on Na-LSX at 298 K

The adsorption isotherm of CO_2 on Na-LSX at 298 K is of type II as shown in Figure 1; the adsorption uptake steely increases by 3 mmol/g at the equilibrium pressure p_e of 0.8 kPa and increased linearly till p_e = 55 kPa and attained 10 mmol/g. On the other hand, the zeolite scarcely adsorbs CH_4. It indicates that CO_2 can be successfully separated from the mixed gas by Na-LSX. The differential heat of adsorption of CO_2, Q_{diff}, is 55 kJ/mol at the initial stage of adsorption and gradually decreases with increasing the uptake by 10 mol/g since CO_2 adsorption takes place from high energetic sites. In this experiment, about 60 % of adsorption heat is recovered from the temperature change of water and the CO_2 uptake estimated by the breakthrough curve.

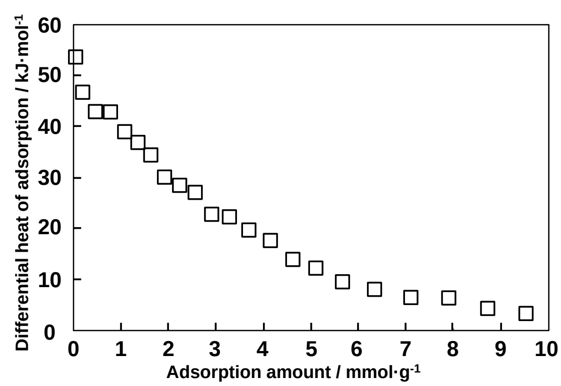

Figure 2 The differential heat of CO_2 adsorption on Na-LSX at 298 K.