Natural Rubber Foam for Carbon Dioxide Adsorption

Krittaya Panploo[1], Benjapon Chalermsinsuwan[1], Sirilux Poompradub[1,2,*]

1 Department of Chemical Technology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand;
2 Center of Excellence on Petrochemical and Materials Technology, Chulalongkorn University, Bangkok 10330, Thailand

**Corresponding author: sirilux.p@chula.ac.th*

Highlights

- Natural rubber foam with high porosity was prepared by different techniques.
- Natural rubber foam was used to adsorb CO_2 at atmospheric pressure and ambient temperature.
- The different morphology of natural rubber foam, the different CO_2 adsorption performance was obtained.

1. Introduction

Carbon dioxide (CO_2) emission associated with human activities is mainly due to the burning of fossil fuel and various chemical processes. Currently, the global energy demand is being supported by the burning of fossil fuels over 85%. As the CO_2 levels in the atmosphere continue to increase, considerable concern has been raised regarding the impact of CO_2 emissions on the environment and its contribution to global climate change. Nowaday, CO_2 capture is the most practical method to reduce CO_2 emission in the atmosphere. In CO_2 capture processes, adsorption on solid media such as zeolites, activated carbon, metal-organic frameworks and silica is considered as one of the most efficient methods owing to the regeneration with low energy[1]. In this research, the alternative material is presented to replace previous adsorbents which have shape limitation and non-biodegradable property. Accordingly, natural rubber (NR) was applied for development of CO_2 adsorption material. NR is a natural commodity that has tremendous economic and strategic importance due to its unique characteristics such as high strength, flexibility, elasticity[2] and good absorption property[3,4]. In addition NR is a renewable, biodegradable material and easy to form to various shapes. In this study, the design of NR foam to produce the CO_2 adsorption material using various techniques, i.e. overhead stirrer (OS) and cake mixer (CM) was reported. The morphology of NR foam was investigated by Scanning Electron Microscopy (SEM). Finally, CO_2 adsorption of NR adsorption material was investigated by using a fixed bed reactor at atmospheric pressure and ambient temperature.

2. Methods

Rubber foam preparation

The compounding of NR latex with 60% dry rubber content (DRC) was prepared using two techniques of OS and CM. 100 part by weight per hundred part of rubber (phr) of NR latex was mixed with 15 phr of 10% foaming agent, 4 phr of 50% sulphur, 2 phr of 50% zinc diethylthiocarbonate, 2 phr of 50% zinc 2-mercaptobenzothiazone, 2 phr of 50% wingstray L, 2 phr of 33% diphenyl guanidine, 10 phr of 50% zinc oxide and 8 phr of 12.5% gelling agent, respectively. The suspension was stirred by OS or CM for totally 12 min. Finally, the rubber foam was poured into glass mould and cured in a hot air oven at 100 °C for 2 h. Then, the cured foam was washed by water and dried in a hot air oven at 70 °C for 20 h.

Morphology

The morphology of NR latex foam was studied by SEM using a JEOL, JSM-6480LV, Japan at an accelerating voltage of 15 kV. The samples were placed on a stub and coated by gold before measuring.

CO_2 adsorption

The adsorption process was operated at atmospheric pressure under an ambient temperature. A CO_2 release from the reactor was measured via a sensor. In the typical measurement procedure, 2.0 g dried sorbent were packed into the stainless steel reactor. The sorbent was firstly treated under N_2 at the flow rate of 0.3 lite/min. Then, the gas was switched to a gas mixture (12% vol CO_2/N_2) at the flow rate of 0.3 lite/min. The CO_2 adsorption capacity was calculated from the CO_2 breakthrough curve.

3. Results and discussion

Morphology of NR latex foams

Figure 1 shows the SEM micrographs of NR foam with different methods (OS or CM). The cell structure of NR foams was in the spherical shape with open cell. The cell size of OS foam was smaller than that of CM foam (Table 1). Considering for one cell, the CM foam structure was contained many pores and each pore showed the large pore size compared to the pore of OS foam. Accordingly, the difference of mixer with different blade resulted in the different morphology of NR foam.

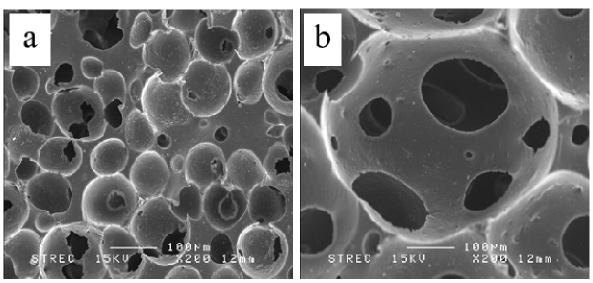

Figure 1 SEM micrographs of NR foam (a) OS foam (foam by overhead stirrer) and (b) CM foam (foam by cake mixer)

Table 1 Foam properties and CO_2 adsorption capacity of NR foam

Sample	Average cell size (µm)	Average pore size (µm)	CO_2 adsorption capacity (mg/g)
OS foam	140-160	35-55	2.63
CM foam	390-410	70-90	0.89

CO_2 adsorption performance of NR latex foams

The corresponding total CO_2 adsorption capacity of OS and CM foams was 2.63 and 0.89 mgCO_2/gNR, respectively (Table 1). The results show that the OS foam gave the high CO_2 capture performance compared to the CM foam. It is because the morphology of NR foams affected to CO_2 capture performance. The CM foam had large cell size including various numbers of pores per cell. CO_2 could move in and easily move out from the cell, resulted in the low CO_2 adsorption capacity. While, OS foam had a small cell size with a few number of pore per cell. Therefore, CO_2 could move in and hardly move out from the cell.

4. Conclusions

NR was designed as a rubber foam in order to be a CO_2 adsorption material. Two methods used to prepare NR foam were OS and CM, respectively. The different morphology of NR foam affected to CO_2 adsorption capacity. NR foam with a low number of pore per cell showed the high CO_2 adsorption capacity. Accordingly, NR could applied as a new CO_2 adsorption material that can be used at ambient temperature.

References

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Keywords
CO_2 capture; Adsorption; Natural rubber