



Adsorption of CO₂ on the special adsorbents

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Abstract:

Biogas is one of the most important renewable energy sources in the Czech Republic (together with solid biomass, hydro-, solar- and wind energy). Biogas stations are working environmental friendly according to the emissions of greenhouse gases and other pollutions generated by production of heat and electricity from biogas. Biogas can be also used as a fuel in engines of motor vehicles.

For using in motor vehicles CO₂ and H₂S have to be removed from biogas to achieve similar properties compared with natural gas (methane content higher than 95 % and compared calorific value).

Theoretical part:

Carbon dioxide can be separated from biogas by adsorption, absorption, membrane separation or condensation. Using of the adsorption process is favourable due to its simplicity. The application of this technology at various pressures eases the desorption process using vacuum or adsorbent heating to the elevated temperature.

For using of adsorption methods in practice it is important to find a suitable type of adsorbent which can be used at pressures up to 30 bar and is able to capture a sufficient quantity of CO₂. Very important is the finding of suitable method for regeneration of saturated adsorbents which enables to recover CO₂ at high concentration from the saturated adsorbent and to use the regenerated adsorbent in the following adsorption step.

For adsorption tests in the laboratory scale were used special adsorbents based on carbon molecular sieves. (produced in cooperation with research institute VÚHU, a.s. Most).

Aim of the work:

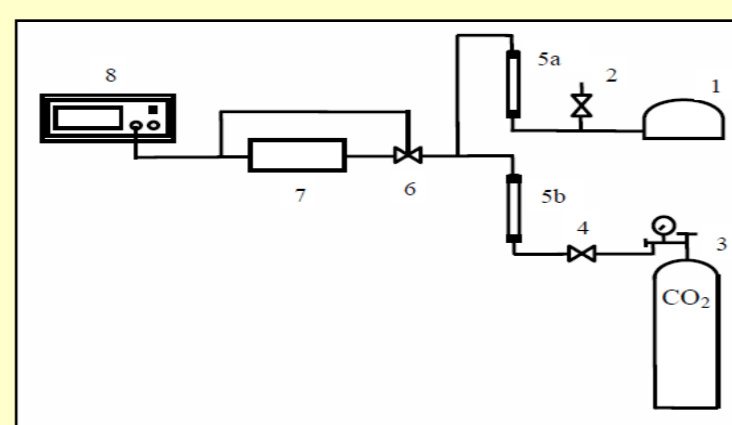
The aim of this work is testing of special types of adsorbents based on carbon molecular sieves. These adsorbents were tested for the removal of CO₂ from model gas mixtures at pressures up to 30 bar.

The next objective is measurement of BET surface area, pore volume, and pore size distribution of used adsorbents.

Experimental part:

For the laboratory tests were used six kinds of special adsorbents of the trademark Petsorb[®] based on carbon molecular sieves. These adsorbents were prepared by pyrolysis of waste PET (polyethylene terephthalate) and its following activation using the water steam.

Laboratory apparatus:



Legend: 1 - air pump, 2 - governing valve, 3 - pressure bottle with CO₂, 4 - governing valve, 5 - rotameter for air, 5b - capillary flow meter for CO₂, 6 - three-port valve, 7 - glass adsorber 8 - CO₂ analyzer

Fig. 1 Laboratory apparatus used for the adsorption of CO₂.

PET:

Polyethylene terephthalate is a thermoplastic linear polymer which is produced by the reaction terephthalic acid with ethyleneglycol or ethyleneglycol with dimethylterephthalate.

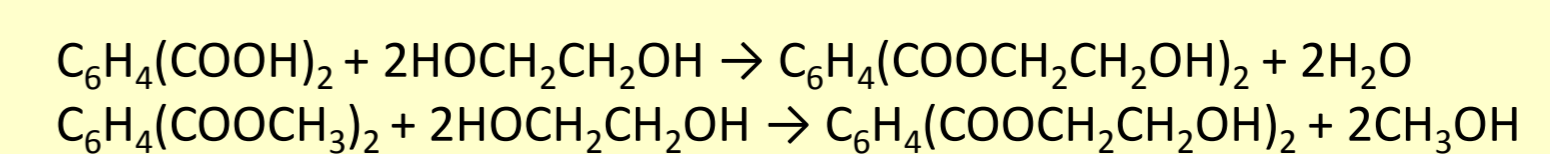


Photo of adsorbent:



Fig. 2 Adsorbent Petsorb 1hS

Results:

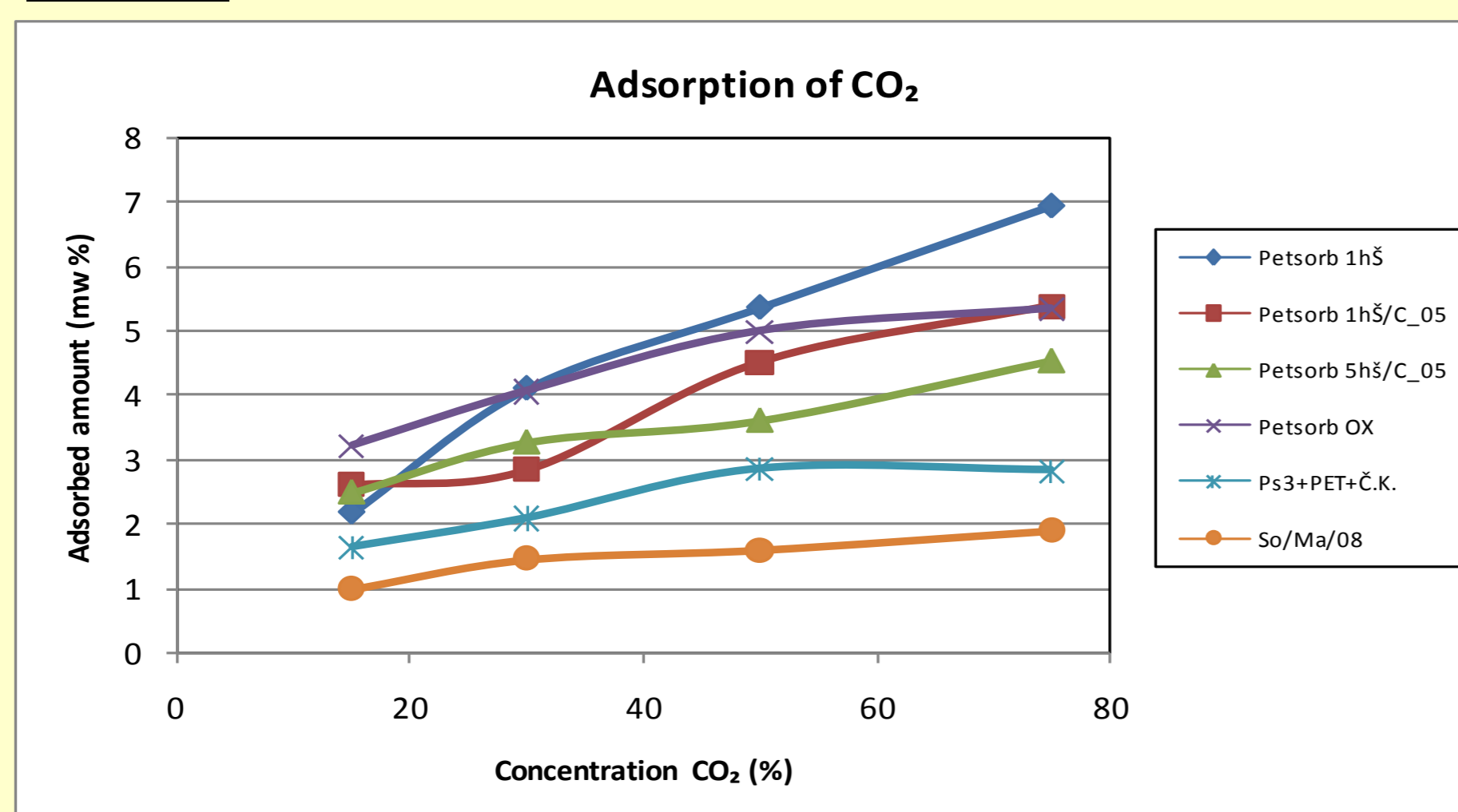


Fig. 3 Adsorption of CO₂.

Properties of adsorbents:

Adsorbents	BET surface area (m ² /g)	Total pore volume (ml/g)	Pore size distribution (%)							
			Under 6 (nm)	6 - 8 (nm)	8 - 10 (nm)	10 - 12 (nm)	12 - 16 (nm)	16 - 20 (nm)	20 - 80 (nm)	Over 80 (nm)
Petsorb 1hS	438,18	0,2157	56,71	22,54	0	0,36	0,62	1,32	13,98	4,48
Petsorb 1hS/C ⁰⁵	405,70	0,2149	79,28	3,10	1,61	1,66	1,90	1,83	8,23	2,38
Petsorb 5hS/C ⁰⁵	728,78	0,4185	52,22	10,01	5,85	6,59	7,64	7,05	9,48	1,17
Petsorb OX	506,50	0,2585	74,58	4,16	2,12	2,10	2,26	2,28	9,68	2,82
P ₃ + PET + Č.K.	244,31	0,1626	54,65	5,72	3,31	3,68	4,46	4,92	19,24	4,02
So/Ma/O8	236,04	0,1778	57,53	5,63	3,15	3,63	4,18	4,5	17,34	4,03

Fig. 5 Properties of adsorbents

Conclusion:

The laboratory tests were provided for CO₂ concentrations of 15 %, 30 %, 50 % and 75 % resp. in the gas mixtures with the air.

From tested adsorbents the best adsorption capacity for CO₂ shows the Petsorb 1hS. Its adsorption capacity is 7 wt. % of CO₂. The adsorbents Petsorb 1hS/C⁰⁵ and Petsorb OX adsorbed roughly the same amount of cca 5 wt. % CO₂. Carbon adsorbent Petsorb 1hS/C⁰⁵ showed higher increase of adsorbed amount at 30 % of CO₂ in the gas mixture. Higher growth of adsorption capacity for CO₂ at the gas concentration 30 % is visible for adsorbent Petsorb 5hS/C⁰⁵. The adsorption capacity at concentration 75 % of CO₂ was 4.5 wt. %. Combined adsorbent consists of P₃+PET+Č.K. has the highest adsorption capacities at concentrations 15 %, 30 % and 50 % of CO₂. Its accrual was almost 3 wt. % of CO₂. At 75 % of CO₂ the adsorption capacity wasn't changed. The lowest adsorption capacity of these adsorbents showed adsorbent So/Ma/O8. The adsorption capacity at concentration 75 % of CO₂ was cca. 2 wt. % of CO₂.

The highest desorption efficiency shows the adsorbent Petsorb 1hS, whose efficiency was 99 % by the desorption of saturated adsorbent using gas mixture containing 75 % of CO₂. Adsorbent So/Ma/O8 had 57 % efficiency by the desorption of saturated adsorbent (at concentration 15 % of CO₂). Desorption efficiency was higher by growth of concentrations. At 50 % of CO₂ this efficiency was 90 % at 75 % CO₂ efficiency was 94 %. For Petsorb 5hS/C⁰⁵ the desorption efficiency at 15 % of CO₂ was almost 95 %. In this case, the desorption efficiency was lower because of the increase 44 % at the concentration 50 % of CO₂. At concentration 75 % of CO₂ desorption efficiency was 47 %. Desorption efficiency for adsorbents Petsorb OX and P₃ + PET + Č.K. were almost the same. The lowest desorption efficiency of about 39 % was measured for adsorbent Petsorb 1hS/C⁰⁵ at 75 % of CO₂.

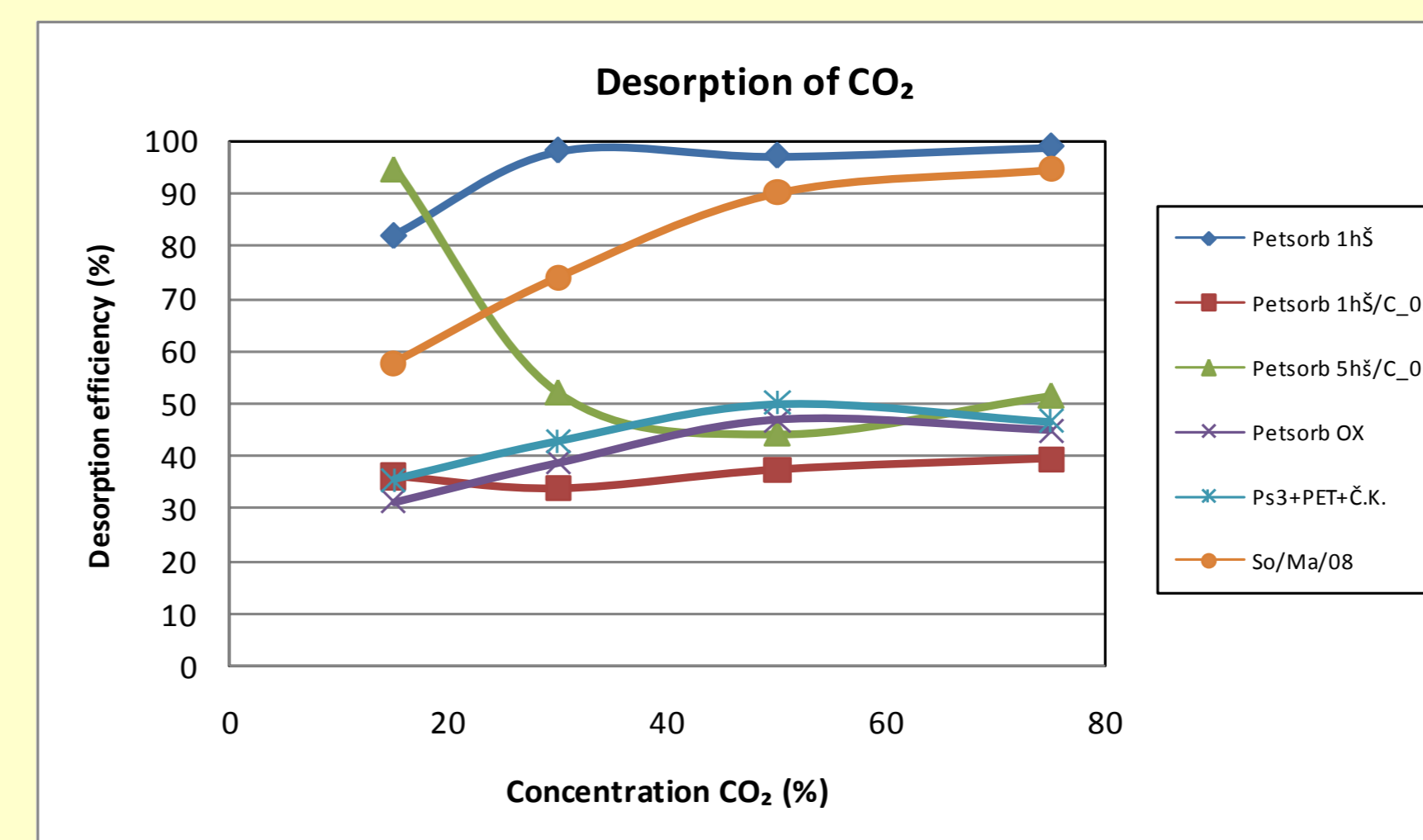


Fig. 4 Desorption of CO₂.

Elemental analysis:

Adsorbents	Content (mass. %)			
	Nitrogen	Carbon	Hydrogen	Sulphur
Petsorb 1hS	0,0607	91,5589	0,5772	0,0075
Petsorb 1hS/C ⁰⁵	0,0845	84,1642	0,5260	0
Petsorb 5hS/C ⁰⁵	0,0839	93,9092	0,6222	0,0032
Petsorb OX	0,0585	91,8326	0,6483	0,1690
P ₃ + PET + Č.K.	0,2568	52,9569	0,3676	0,3094
So/Ma/O8	0,1432	37,0672	0,3169	0,3834

Fig. 6 Elemental analysis