

Sorption capacity of Activated Carbon

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Sorption capacity of Activated Carbon

Storage and transport of (bio)gas

Petten
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Content

- The EDGaR Project
- Adsorbed Natural Gas
- Porous material: Activated Carbon
- Surface area and Porosity measurement
- Effect of P and T on adsorption: Magnetic Suspension Balance
- Results & Conclusions

The EDGaR project

Energy Delta Gas Research

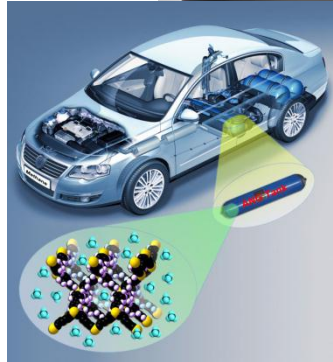
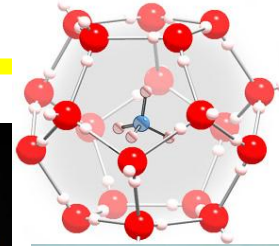
- Consortium of 10 research institutes
- Research Gas and sustainability
- Improve position of Dutch gas industry in Europe



The EDGaR project - ECN

- Decentralized Biogas Storage
- Match fluctuations in local gas demand
- Advanced gas storage technologies:

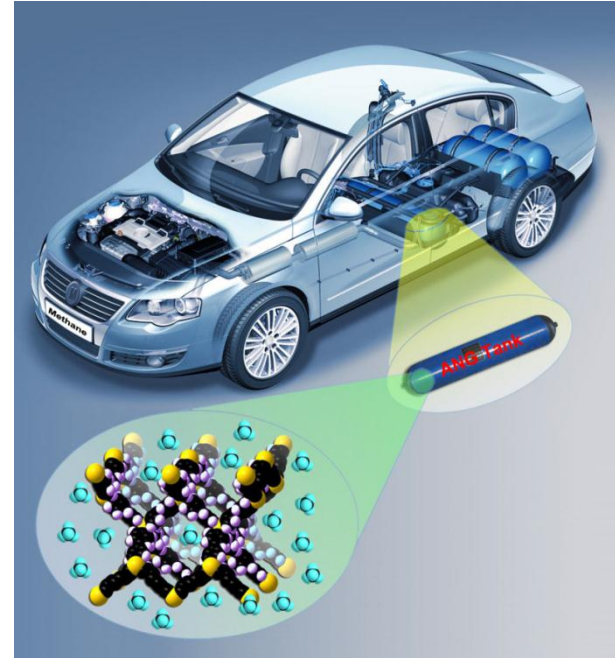
- Gashydrates
- Cooling (LNG)
- Compression (CNG)
- **Adsorption (ANG)**



Adsorbed Natural Gas

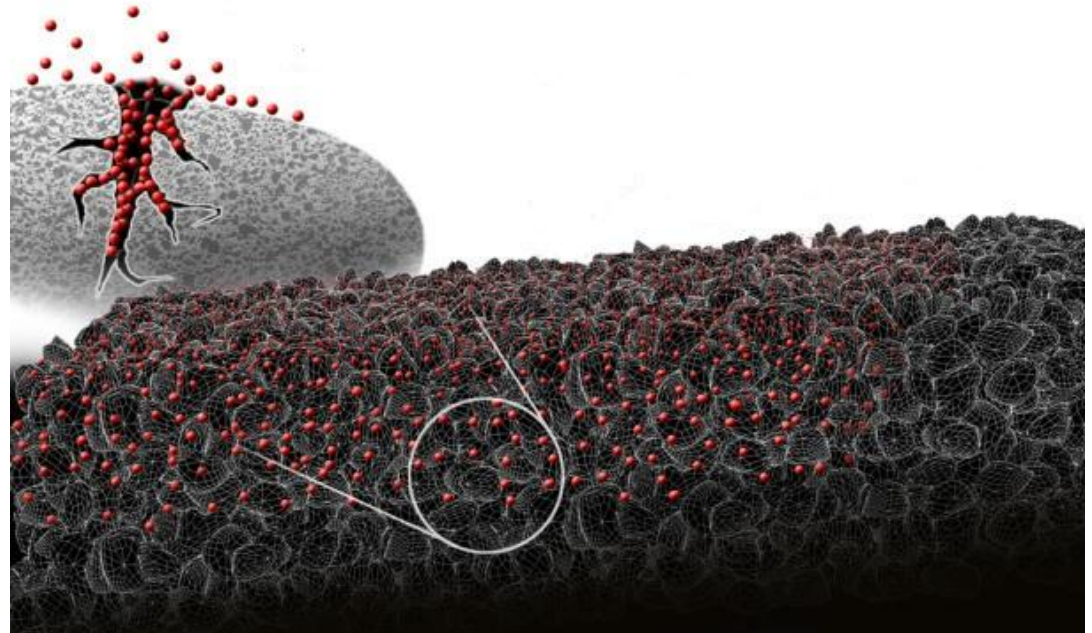
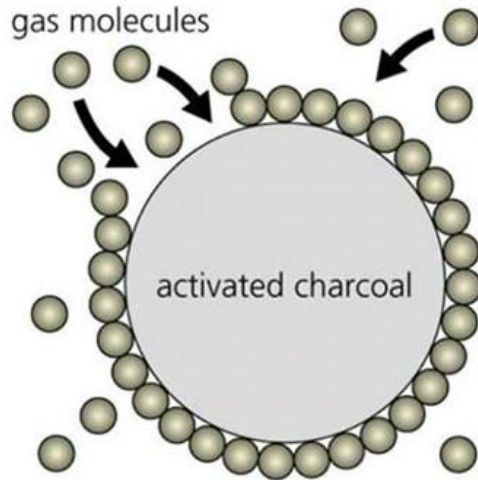
Advantages of ANG:

- Low pressure (35 bar)
- Room temperature
- Safe transportation and storage
- More cost effective



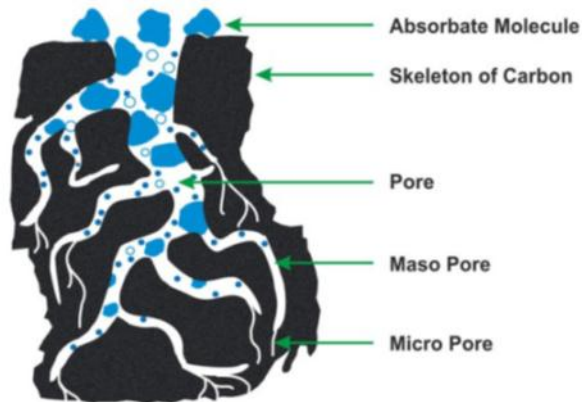
Adsorbed Natural Gas

Adsorption process: Van der Waals forces



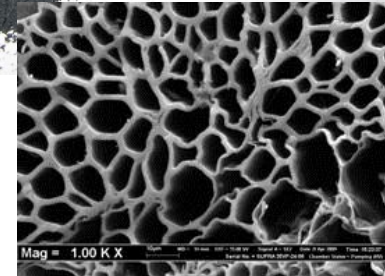
Porosity

	Poresize / nm
Micropores	< 2
Mesopores	$2 \sim 50$
Macropores	> 50



Activated Carbon (AC)

- Pores: 1-5 nm
- High surface area: Up to 2000 m²/g
- High adsorption capacity
- Applications:
 - Gas purification
 - Medicine
 - Chemical purification
 - **Gas storage**
- Characterization:
 - Surface area
 - Porosity
 - Adsorption capacity



ECN – Physical Characterization

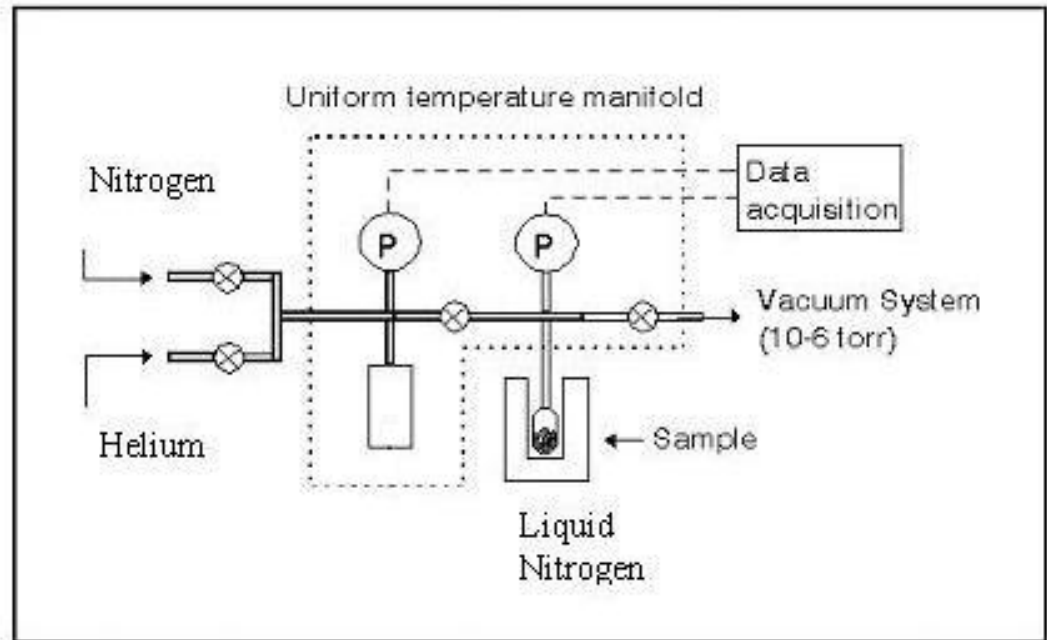
Internal and external customers

- Porosity
- Heat capacity
- Particle Size
- Surface Area
- Glass Transition Temperature
- Density
- Melting
- (De)hydration
- Chemical composition
- Sorption
- Softening
- Decomposition
- Thermal expansion
- Visco-elastic behaviour
- Etc...

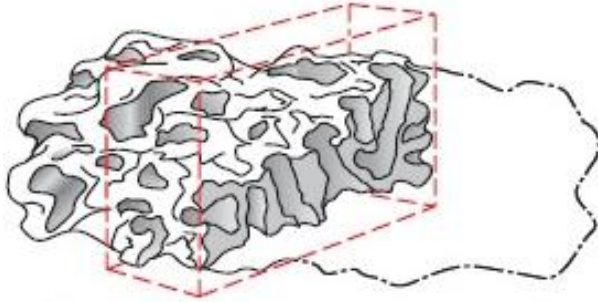


AC: Surface area & porosity measurement

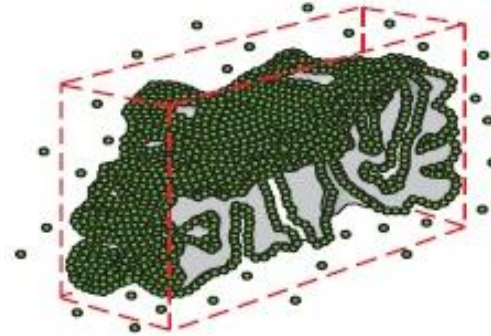
Static Volumetric Gas Adsorption



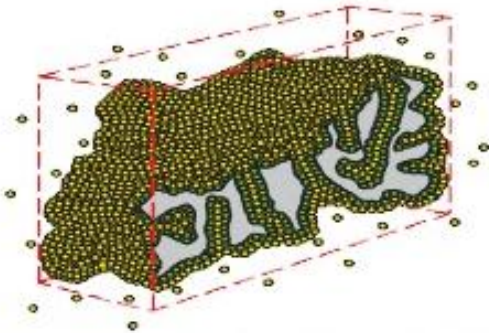
Surface area & porosity measurement



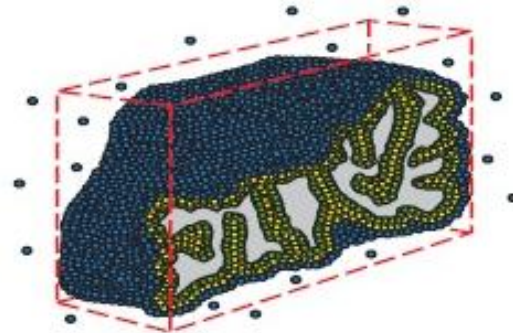
1: porous material



2: monolayer



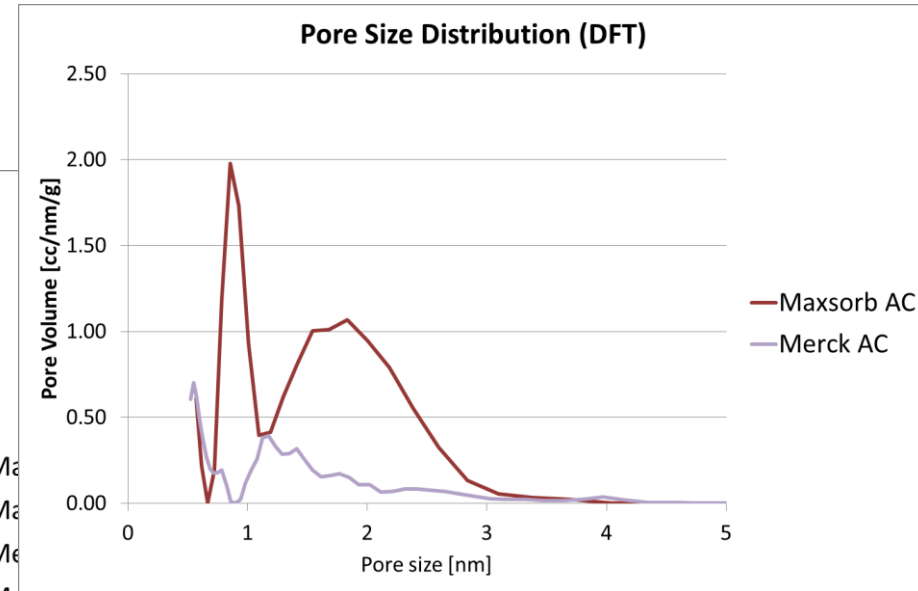
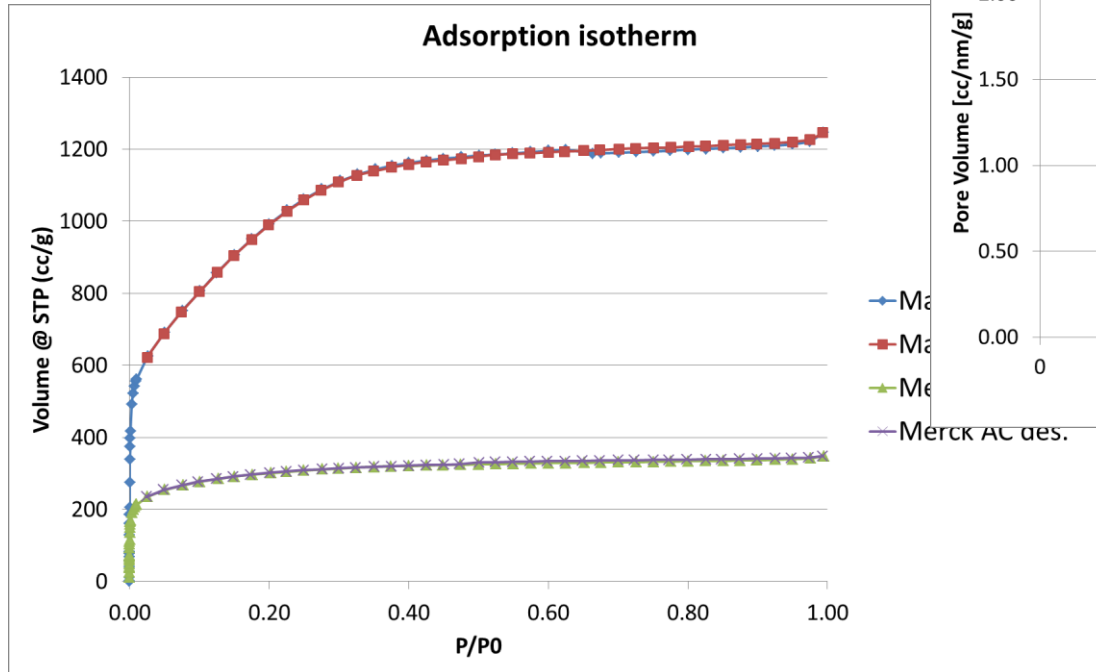
3: Multilayer capillary
condensation



4: total pore volume filling

AC: Surface area & porosity measurement

Samples: - Maxsorb AC
- Merck AC



Adsorption only > 1 bar and 77 K

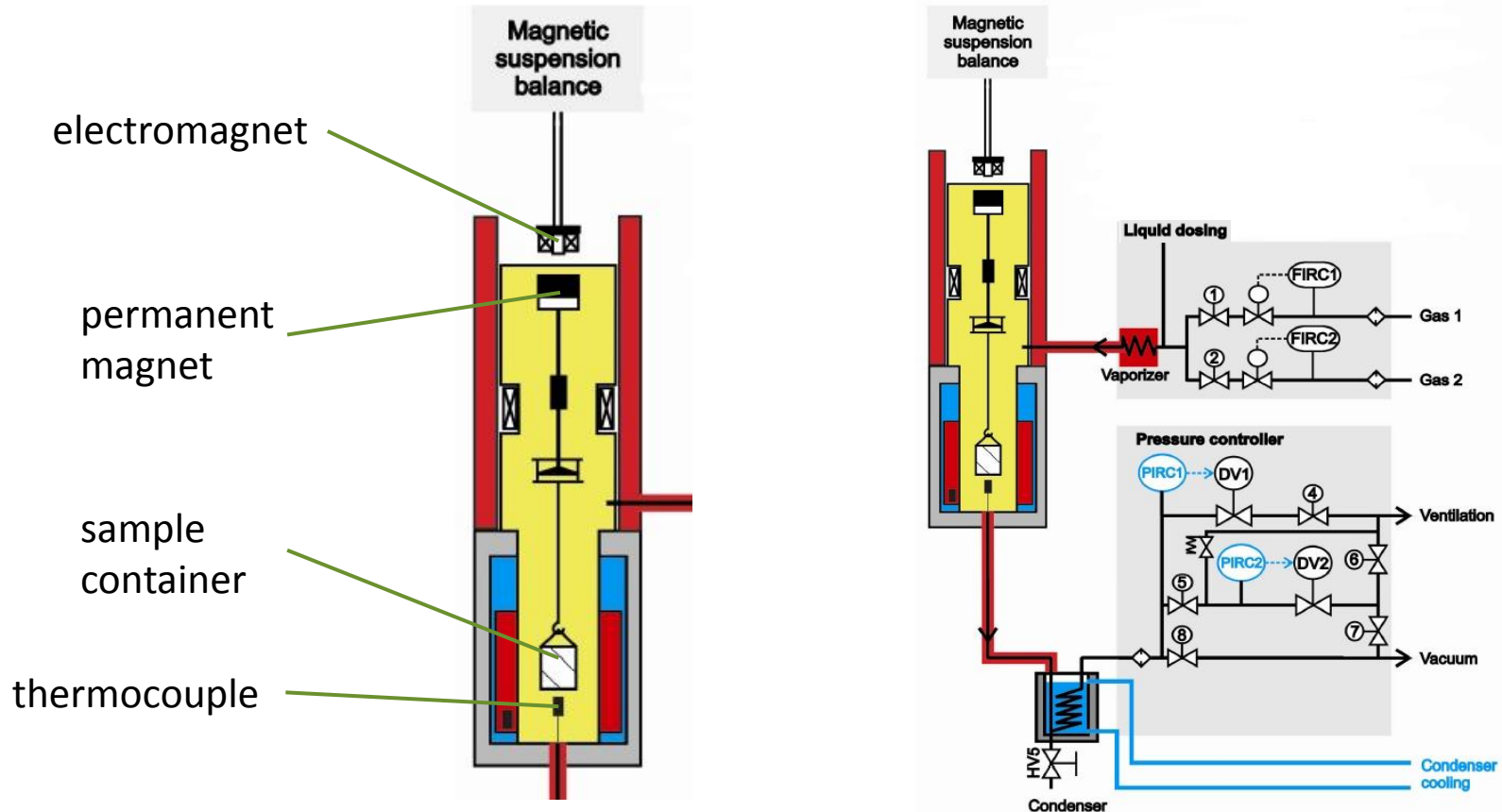
Effect of pressure and temperature on ECN sorption behavior

- How much biogas (CH_4) can be stored in Activated Carbon
- Influence of temperature and pressure
- Adsorption isotherm



Magnetic Suspension Balance

Magnetic Suspension Balance



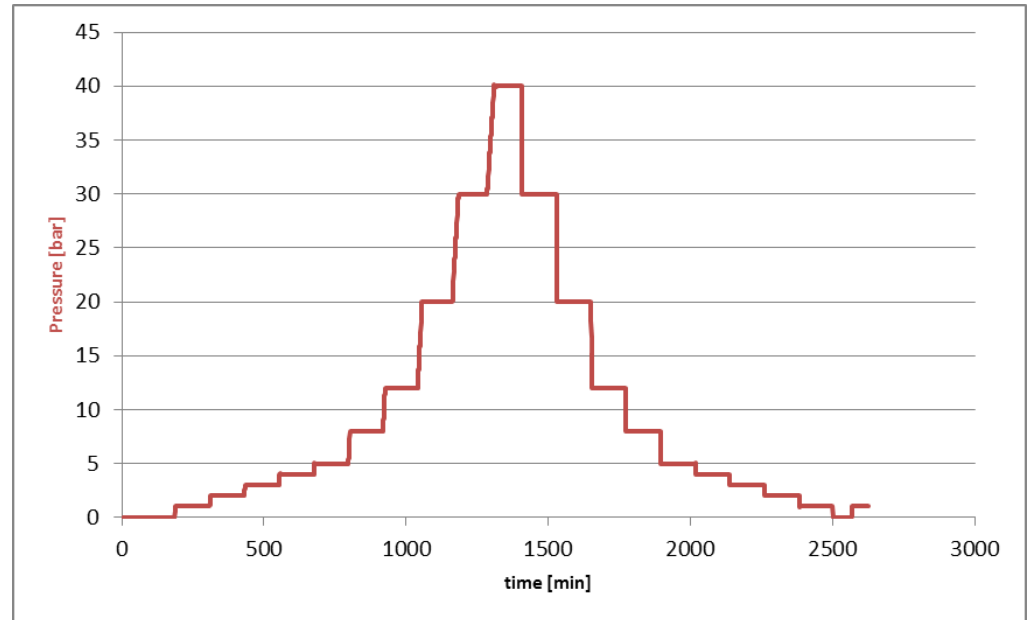
Magnetic Suspension Balance

- High pressure: max. 150 bar
- High temperature: max. 800°C
- Reactive gas:
 - NH₃
 - CO₂
 - H₂
 - Steam
 - Vapour
 - **CH₄**



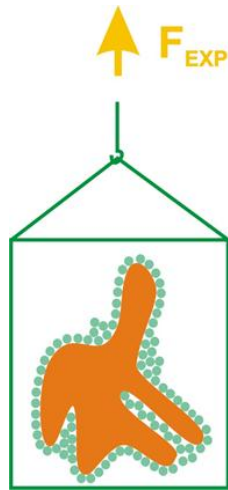
Measurement of adsorption isotherms

- Sample: Maxsorb AC (75 mg)
- Measurement program:
 - Isothermal 12°C; 60°C and 100°C
 - Stepwise increase/decrease of CH₄ pressure:
 - Recording of (apparent) weight
- Corrections:
 - Blank: sample cup and suspension
 - Buoyancy: forces caused by change in gas density

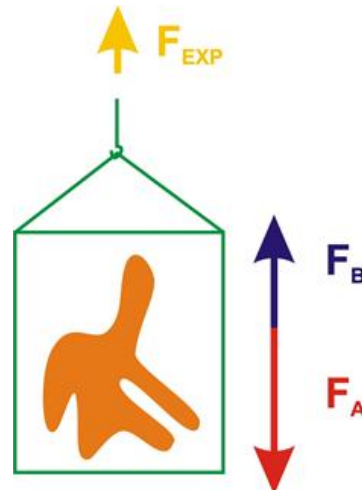


Blank and buoyancy correction

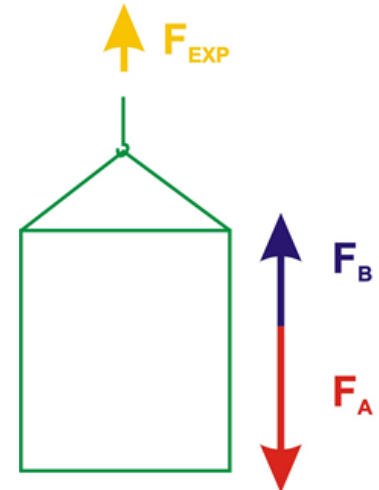
Weight measurement = equilibrium of forces:



- Sorption
- Reactive gas

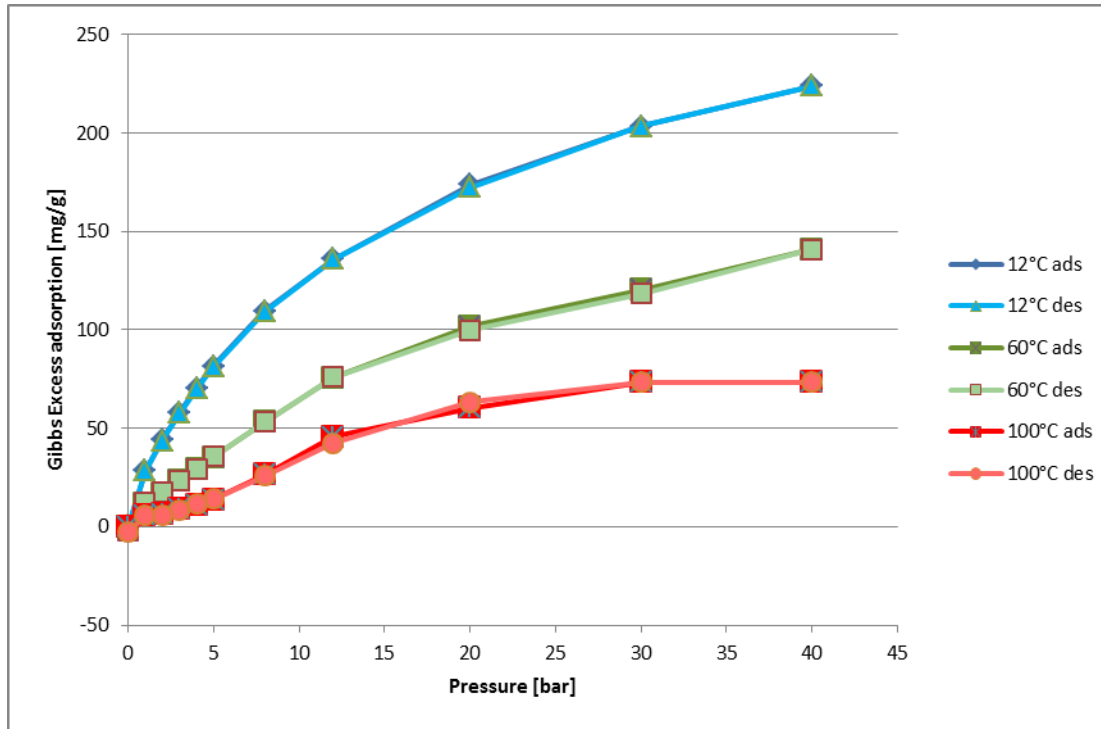


- Buoyancy
- Inert gas



- Blank
- Reactive gas

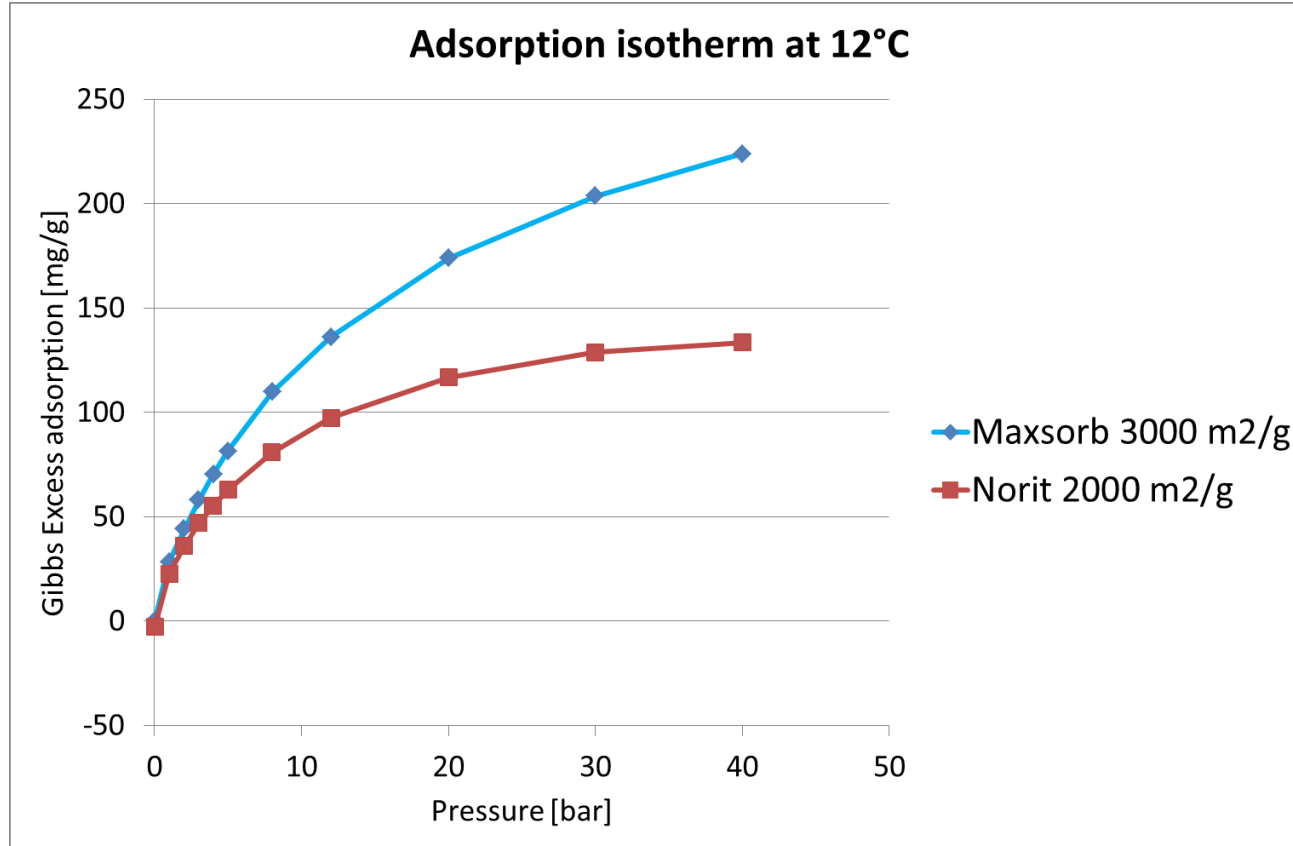
Adsorption isotherm: Maxsorb AC



- higher temperature: less CH₄ adsorption capacity
- adsorption = desorption
- no additional adsorption above 30 bar at 100°C

Adsorption is exothermal process → disposal of heat is required

Comparison to Norit AC 2000 m²/g



Conclusions

- Different types of AC → different capacities of CH₄ uptake.
- Increased temperature → drop in uptake capacity of more than 35%.
(heat disposal is necessary)
- Adsorption isotherms → adsorption = desorption; no hysteresis.
- At 100°C → saturation at 30 bar CH₄.
- Maxsorb suitable for ANG, although...



Questions???

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