Kinetic of adsorption of water vapour on activated carbons

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Microtomography

Contains activated carbon { Porous and chemical properties

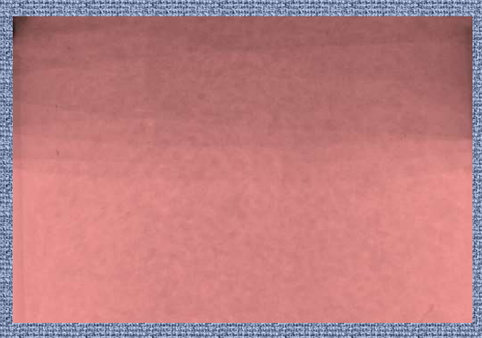
In continuous contact with humidity present in the air

Coadsorption issues in the presence of other vapours (toxic) RH = 10% = 4200 ppm

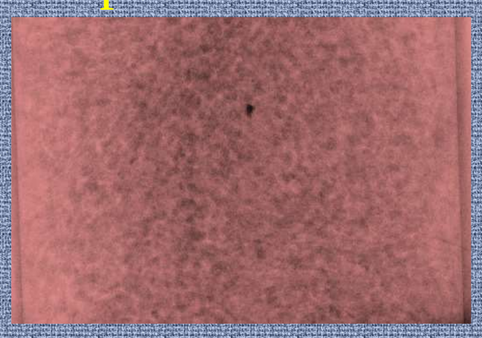
Importance of the evaluation of Water vapour adsorption

The influence of 5 different parameters (Air flow, Relative humidity, particle size, carbon type and temperature) is assessed

Water vapour adsorption

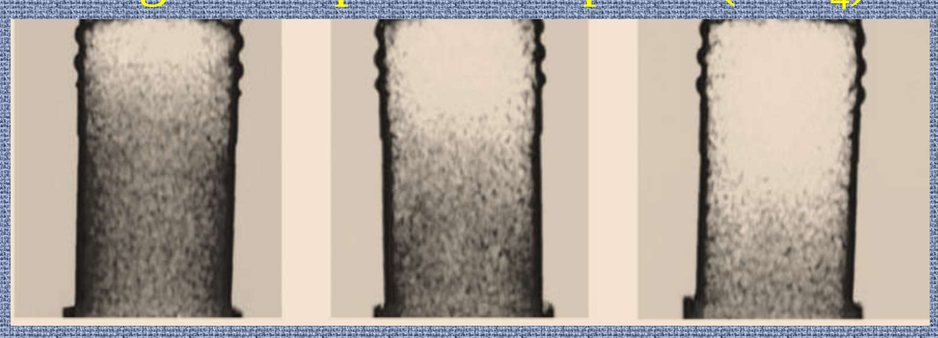


t0 (virgin carbon)



t =20 secondes

Organic vapour adsorption (CCl_4) [1]



At 3min, 6 min and 9 min of adsorptioon

contrary to organic vapour adsorption, there is no adsorption front in the case of water vapour adsorption => immediate breakthrough => Consequently, gravimetry is used to follow the adsorption of water vapour.

Experimental tests and modeling

A linear driving force model is used fot the correlation of the experimental results

$$\frac{\Delta W(t)}{\Delta W max} = (1 - e^{-a.t})$$

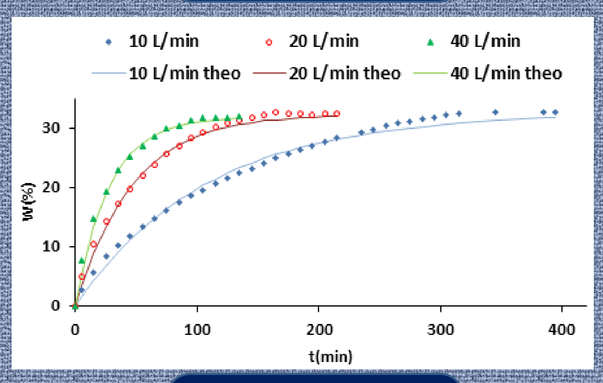
$\Delta W(t)$: The mass gained as a function of time (g/g_{carbon})
ΔW_{max} : The maximum weight gained at saturation (g/g_{carbon})
a : A kinetic constant (min^{-1})

Activated carbons used

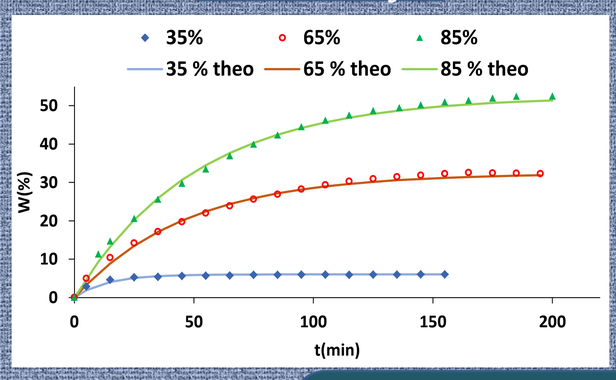
Sample	Sample designation	Shape	particle size (mm)	S_{BET} (m^2/g)	$V_{microporous}$ (cm^3/g)	V_{total} (cm^3/g)	[O] [2] (%)
Norit CGranular1	**CG1**	Granular	1-2	1427	0.51	1.13	18.9
Norit CGranular2	**CG2**	Granular	0.5-0.8	1409	0.46	1.13	18.9
Norit R1	**NR1**	extruded	0.5-5 length 0.8 diameter	1358	0.47	0.64	13.0

Results

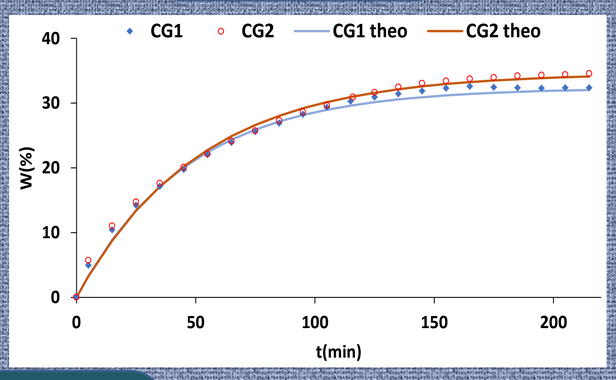
Air flow



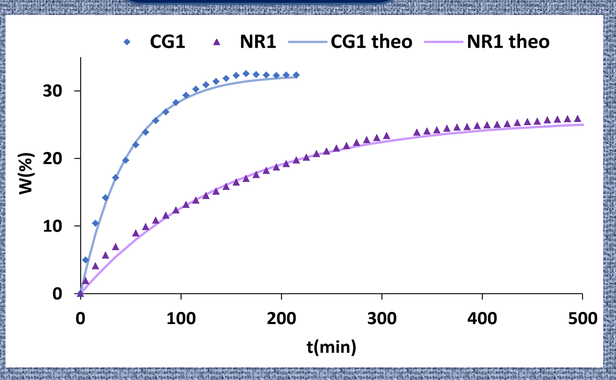
Relative Humidity



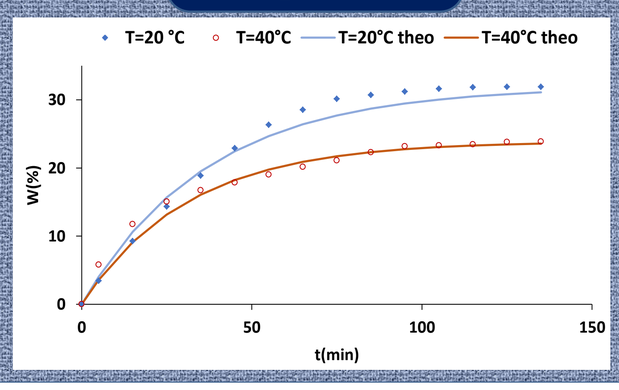
Particle size



Carbon type



Temperature



Kinetic Results

RH(%)	a (min^{-1})	Max uptake (%)	Air flow (L/min)	a (min^{-1})	Max uptake (%)	T(°C)	a (min^{-1})	Max uptake (%)
35	0.0750	14.78	10	0.0093	32.71	20	0.0270	31.92
65	0.0215	18.45	20	0.0215	32.35	40	0.0320	23.88
85	0.0195	21.25	40	0.0360	31.92			

Particle size	a (min^{-1})	Max uptake (%)	Carbon type	a (min^{-1})	Max uptake (%)
CG1	0.0215	32.35	CG1	0.0215	32.35
CG2	0.0195	34.56	NR1	0.0067	25.90

Tomography Results

Sample	Shades of grey
Virgin carbon	40.09
20 sec exposition	40.48
20 min exposition	46.86
40 min exposition	49.22
Saturated carbon (100 min)	49.41

Conclusions

- Water vapour breakthrough is instantaneous
- Adsorption of water vapour shows a flat profile and a very slow kinetics contrary to organic vapours characterised by an adsorption front.
- The parameters affecting the kinetic of water vapour adsorption are, Air flow, Relative humidity, Carbon type (carbon properties) and temperature. Particle size does not seem to have a relevant influence.
- The kinetic of water vapour adsorption may be correlated by a Linear Driving Force model.
- The three steps of water vapour adsorption may be correlated by this model by using a different kinetic constant

[1] P. Lodewyckx, E. Raymundo-Pinero, M.Vaclavikova, I. Berezovska, M. Thommes, et al. Carbon, 60. 556-558 (2013)/ [2] P. Lodewyckx, S. Blacher, A. Léonard. Adsorption 12. 19-26 (2006)