Coating open-cell polyurethane foams with granulated activated carbon

Stefan Kämper

The expansion of Talamon's product portfolio last year to include a standard line of adsorptive foams with granular activated carbon (GAC) to complement the premium line based on polymer-based spherical activated carbon (PBSAC) and ion exchangers (IX) was successfully completed. A new plant to produce open-pore polyurethane foams coated with granular activated carbon was commissioned. A media matrix with various porosities, thicknesses and adsorbent contents was qualified in terms of production technology by running pilot series and in terms of performance technology by carrying out toluene breakthrough and pressure loss measurements.

The new line of GAC adsorptive foams opens up new markets for air filter applications from an economic point of view. These include odour filtration in the home, pollutant filtration in indoor air filtration systems, purification of contaminated breathing and process air, and cabin air filtration in special-purpose vehicles. It also includes product solutions with impregnated granular activated carbon, from acidic to basic functionalisations and broad-band impregnations for a wide range of problems in the purification of air and gas streams.

Selecting the appropriate media

The adsorptive foam filter media of the Standard and Premium lines stand for highly efficient gas filtration combined with low flow resistance. Almost any requirement profile for adsorptive applications can be met by selecting the appropriate media. The media can be varied in terms of adsorbent type, capacity, shape, and thickness. The features and benefits of the Standard Line are shown in **Table 1**.

The media qualification of the Standard Line has been performed on the media types listed in **Table 2** in thicknesses from 5.5 mm to 24 mm. Basic characteristics such as porosity class, weight per unit area, pressure drop and adsorptive performance characteristics such as filter efficiencies and capacities are shown. Filter qualifications have been realised in accordance with ISO 11155-2 under standard conditions of 20 °C / 50 % relative humidity. Toluene, commonly used in gas applications, was used as the test substance, here at a raw gas concentration of 80 ppm. Using appropriate mathematical models, it is therefore possible to calculate performance against many other hydrocarbons. **Figure 1** shows the pressure drop characteristics at 20 mm media thickness as a function of porosity class or adsorbent content and flow velocity, which are essential for a basic filter design. The influence of adsorbent content and flow velocity on the pressure drop can be clearly seen. The pressure drop characteristic is also directly related to the achievable adsorption performance. **Figure 2** and **Figure 3** show the toluene breakthrough behaviour for 20 mm media thickness at 0.35 m/s flow velocity and 40 mm media thickness at 0.73 m/s flow velocity as a function of the porosity class.

Table 1: *Features and benefits of the Standard Line*

FEATURE	ADVANTAGE
Pressure drop	low low noise level and best energy efficiency
Adsorption characteristics	good kinetics, good ratio of performance/ capacity to available filter volume/thickness
Other features	wide range of modifications very good price-performance ratio self-sealing
Shape forming	easy handling during filter production any custom geometry possible
Design	multifunctional by combining different functional layers e.g., against VOC, aldehydes, acidic and basic gases

The filter design

Increasing media porosity or surface weight/adsorbent content results in higher pressure drops and longer filter life, but also reduces the initial breakthrough - clearly seen with 20 mm filter thicknesses. In order to achieve close to 100 % filter efficiency, for example, with a maximum possible thickness of 20 mm, the filter design must take into account a lower flow velocity (resulting in large filter volumes) or the possibility of using dense filter media (resulting in higher pressure drops). If the application allows for larger filter media thicknesses, e.g. 40 mm, initial efficiencies are close to 100 %, even at higher inflow velocities. Longer filter life can also be achieved with denser media.

Figure 4 shows the adsorbed mass of toluene for a filter area of 610 cm² as a function of porosity class or surface weight/adsorbent content. It is well recognisable that in the initial range, for the same filter thickness and flow rate, the adsorption characteristics over time are comparable for open and dense media. Only after longer filter run times do the adsorption curves diverge depending on the porosity class or surface weight/adsorbent content of the media.

With the performance characteristics included in the qualification (see **Table 2**) it is possible to carry out basic

Table 2: *Media overview for Standard Line foam filters with granular activated carbon.*

foam structure		very open	open	medium dense	dense	very dense
medium type		**109523**	**109525**	**109527**	**109530**	**109529**
thickness	[mm]	**10mm** also in **20mm (109524)** qualificated	**10mm** also in **20mm (109526), 15mm (109564)** and **24mm (109565)** qualificated	**10mm** also in **20mm (109528)** qualificated	**10mm**	**5.5mm**
area weight	[g/m²]	1100±200	1800±200	2100±250	2300±300	1400±250
carbon content	[g/m²]	approx 55%	1250±200	1550±250	1750±300	1100±250
flammability DIN53438/2+3	[Class]	K2 / F1	K1 / F1	K1 / F1	K1 / F1	K1 / F1
pressure loss	[Pa]	**2x10mm**	**2x10mm**	**2x10mm**	**2x10mm**	**2x5.5mm**
@0.35m/s		<3 / ∅1.5	<12 / ∅7	<25 / ∅15	<30 / ∅20	<17 / ∅11
@0.73m/s		<10 / ∅6	<36 / ∅20	<70 / ∅50	<90 / ∅60	<52 / ∅35
@1.0m/s		<16 / ∅10	<65 / ∅35	<120 / ∅80	<150 / ∅100	<85 / ∅60
@1.5m/s		<35 / ∅20	<130 / ∅70	<220 / ∅160	<300 / ∅200	<160 / ∅120
typical adsorption data ISO 11155/2 23°C / 50% r.h.						
@80ppm toluene / 0.35m/s / 20mm			**2x10mm**	**2x10mm**	**2x10mm**	**4x5.5mm**
initial efficiency	[%]	currently not yet measured	95	99	99.9	99.9
time @ 90% efficiency	[min]		37	73	67	62
time @ 70% efficiency	[min]		80	118	104	
time @ 50% efficiency	[min]		108	154	135	112
capacity @610cm³@ 50% breakthrough	[g]		32	47	41	36
@80ppm toluene / 0.73m/s / 40mm			**4x10mm**	**4x10mm**	**4x10mm**	**4x5.5mm**
initial efficiency	[%]		99	99	99.9	86
time @ 90% efficiency	[min]		58	85	62	23
time @ 70% efficiency	[min]		84	111	86	
time @ 50% efficiency	[min]		100	131	103	51
capacity @610cm³@ 50% breakthrough	[g]		67	89	67	32

Applications

- Cabin air filtration in aircraft, agricultural and landfill vehicles
- Odour removal in households, such as in kitchen hoods, refrigerators, and vacuum cleaners
- Surgical smoke purification
- Purification of contaminated breathable and process air
- Filtration of hazardous substances in air conditioning systems
- Indoor air purifiers
- Solvent recovery systems

Foam filter

- Variable dimensions, shapes, and adsorbent content
- High adsorbent capacity at very low pressure drop

Pleatable filter media

- Very well suited for limited construction space
- Combined solutions with particle filters or different covers

Customized coating of sorptive composite materials

- Variable layer structure and widths
- Carrier, cover material and roll size according to customer specifications
- Provision of the required materials possible: spherical and granulated activated carbon, ion exchangers, zeolite, superabsorber etc.

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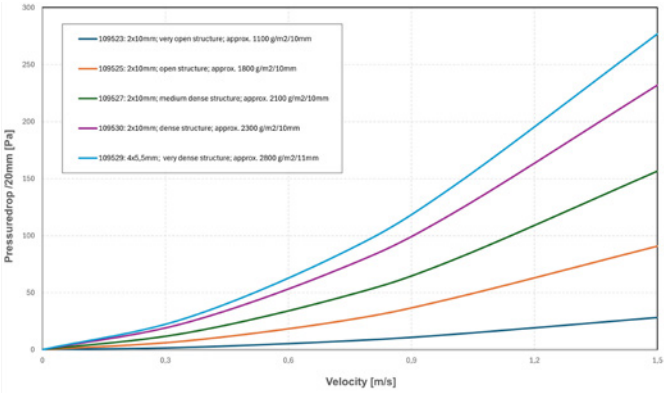

Figure 1: *Pressure drop characteristics of different foam structures/ carbon loading at 20 mm.*

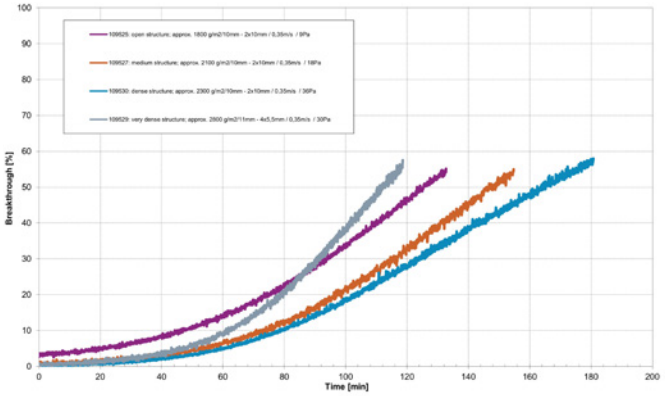

Figure 3: *Breakthrough characteristic of different foam structures/ carbon loading: 40 mm at 0.73 m/s; Toluene 80 ppm / temperature 23 °C / relative humidity 50 %*

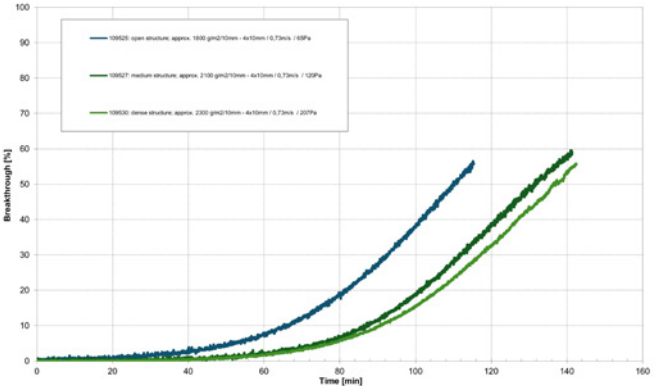

Figure 2: *Breakthrough characteristic of different foam structures/ carbon loading: 20/22 mm at 0.35 m/s; Toluene 80 ppm / temperature 23 °C / relative humidity 50 %*

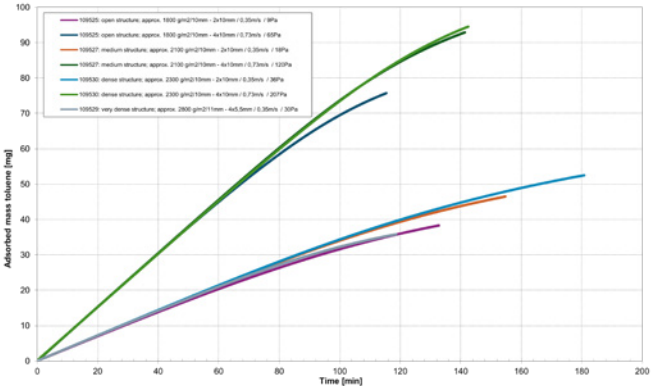

Figure 4: *Adsorbed mass of different foam structures/carbon loading: 20/22mm at 0.35m/s / 40mm at 0.73m/s; Toluene 80 ppm / temperature 23 °C / relative humidity 50 % / 610 cm²*

designs for most applications of adsorptive filters under standard conditions (20-23°C / 40-60% rel. humidity) for various pollutants and odorous substances (VOC). Performance data for other conditions, e.g. different pollutant concentrations and types, can be derived if appropriate adsorption isotherms are available.
For most applications, e.g. odour filtration in domestic and indoor applications, the open structure filter (e.g. media 109525/109526/105964/109564) is a good compromise between pressure drop, adsorbent content (service life) and adsorptive breakthrough characteristics (filter performance). Compared to the medium-density structure, the pressure drop is almost halved, the adsorbent volume is only reduced by about 15-20% and the initial efficiency at 40mm/0.73m/s is still in the region of 99%. For very critical applications in the field of pollutant filtration, where initial breakthrough is not permitted and filter volumes are limited, the medium to dense porosity classes are preferable as they can meet most requirement profiles.

For non-standard applications and specific pollutant types, modified GAC types, e.g. acidic, basic and broadband functionalisations, can also be used for a variety of air and gas filtration problems. Corresponding performance data for filter designs can be determined.

With the adsorptive foam filter media of the new Standard Line, Talamon now offers the complement to the Premium Line in order to meet all requirement profiles from a technical and economic point of view. The products from both lines will be presented at Filtech 2024. The Talamon team can be found on booth E38 in Hall 8.

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