PREPARATION AND CHARACTERIZATION OF POLYMER BASED SPHERICAL ACTIVATED CARBONS ON AN INDUSTRIAL SCALE

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Introduction

Activated carbons (AC) are widely used as adsorbents in many applications. Spherical activated carbons (SAC) are a specialty amongst them. The SAC presented here are made by carbonisation of a cross linked polymer with subsequent activation.

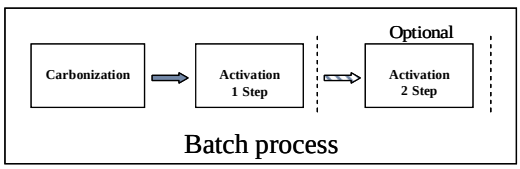
Picture 1: Cross linked polymer (left), PBSAC (right)

So called polymer based spherical activated carbons (PBSAC) have numerous advantages. These advantages arise from their special product characteristics, such as extremely low pressure drop per volume, high inner surfaces up to 2300 m²/g (ASTM D6554-04) and unique mechanical and chemical properties.

As a result of innovative production techniques combined with the polymeric precursor, these product characteristics can be further selectively tuned, adjusted and designed for a vast range of diverse applications.

Production process

Production process takes place discontinuously and indirectly heated in batches. The batch process consists of the carbonization step and the activation step.



Picture 2: Production process; PBSAC

The activation can be done as a 1-Step activation or as a 2-Step activation. The 1-Step activation uses only medium 1 as activation medium. Medium 1 creates a mainly microporous pore system with a portion of meso-/ macropore volume.

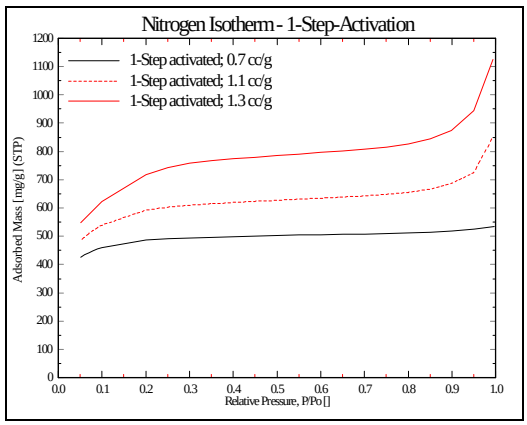


Figure 1: N_2 Isotherms; PBSAC, 1-Step activated

In contrast the subsequent, optional 2nd step uses medium 2 as activation medium. Medium 2 creates a clear meso-/ macroporous pore system.

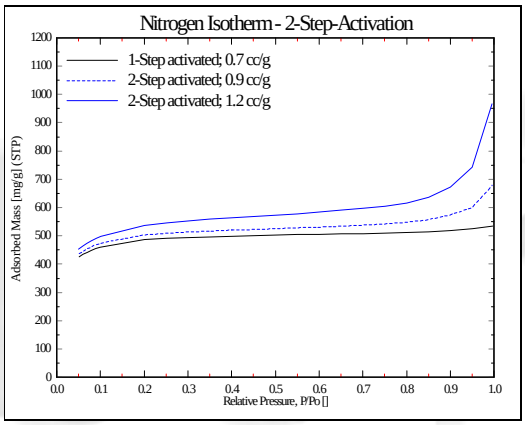


Figure 2: N_2 Isotherms; PBSAC, 2-Step activated

Due to the combination of medium 1 and medium 2, within the 2-Step activation, the already existing mainly microporous pore volume can be supplemented by means of clear meso-/ macropore volume which, in turn, can be functionalized, such as a transport- or a carrier pore system.

Characterization

Particle size distributions of PBSAC can be adjusted in the range of 0.05–0.7 mm. Polydispersed and monodispersed particle size distributions can be produced.

Superior abrasion performance and the high crush strength for PBSAC are unique amongst AC. PBSAC can be described as nearly dust free. The abrasion resistance is higher than 97 % (ASTM D3802–05) and does not correlate with the total pore volume, which is an indicator of the activation degree. Although a correlation can be seen between crush strength and degree of activation, but the crush strength is at an exceptionally high level of up to 4 kg/PBSAC.

The mechanical properties are strongly connected to the structure. For PBSAC a porous shell like structure can be introduced. It physically protects the inner pore system. Beside of the impressive mechanical properties the porous shell like structure enables high activation degrees up to total pore volumes of 3.5 cm³/g (by applying the Gurvich rule).

The pore size distribution, determined by N_2 isotherm (model: QSDFT) in combination with Hg penetration, can be adjusted specifically using different activation media. This is demonstrated using two activation media, medium 1 and medium 2.

The activation with medium 1 creates a bimodal pore size distribution with micro-/ mesopore volume at <3 nm and a portion of meso-/ macropore volume at 10-100 nm.

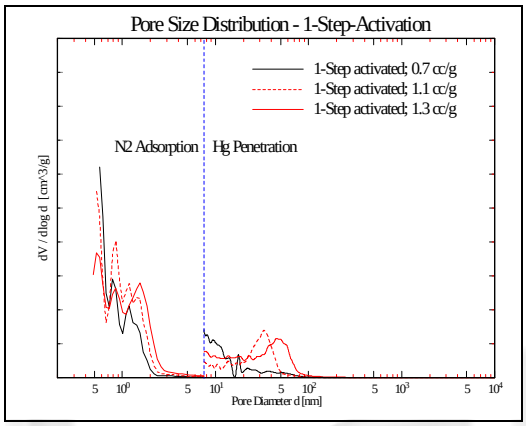


Figure 3: Pore size distributions; PBSAC, 1-Step activated

The activation with medium 2 establishes a monomodal pore size distribution with clear meso-/ macropore volume at 10-100 nm while it maintains the given micro-/ mesopore volume at <3 nm, previously created by medium 1.

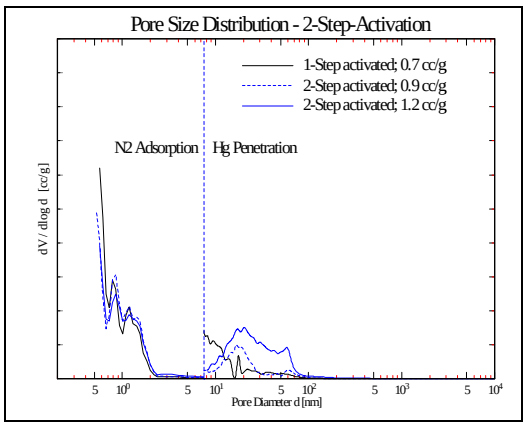


Figure 4: Pore size distributions; PBSAC, 2-Step activated

PBSAC have a low metal content but also have a low amount of surface oxygen and thus polarity at the surface.

The metal amount, determined by elementary analysis (EA), is lower than 0.5 wt.%.

Ag	Al	As	Be	Ca	Cd
[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]
<0.001	<0.001	<0.001	<0.001	<0.010	<0.001
K	Mg	Mn	Mo	Na	Ni
[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]
<0.001	<0.005	<0.005	<0.001	<0.010	<0.010
Co	Cr	Cu	Fe	Hg	P
[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]
<0.001	<0.010	<0.001	<0.100	<0.001	<0.001
Pb	Si	Sn	Zn	-	-
[wt.%]	[wt.%]	[wt.%]	[wt.%]	-	-
<0.001	<0.100	<0.001	<0.001	-	-

Table 1: EA; PBSAC, 1-Step activated

The amount of surface oxygen, which consists of O=C and O-C, determined by x-ray photoelectron spectroscopy (XPS), is lower than 5.0 wt.%.

	O1s Total	O=C	O-C
Sample	[wt.%]	[wt.%]	[wt.%]
1-Step act.; 0.7 cm³/g	4.8	1.4	3.4
1-Step act.; 1.1 cm³/g	4.0	1.0	2.9
1-Step act.; 1.3 cm³/g	3.4	0.9	2.5

Table 2: XPS; PBSAC, 1-Step activated

As a result hardly any humidity and ageing effects appear and there is a very high resistance to acidic and alkaline influences.

Due to the low polarity at the surface, PBSAC exhibit strong hydrophobic surfaces.

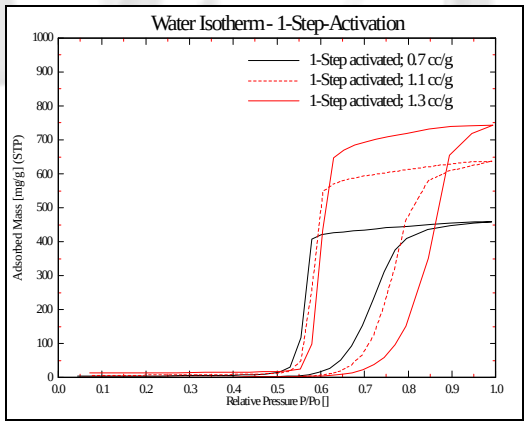


Figure 5: H_2O Isotherms; PBSAC, 1-Step activated

Conclusions

The combination of polymeric precursors and the unique production process creates a broad spectrum of diverse applications. The product characteristics can be modified within the scope of the production of PBSAC, specifically to suit the applications.