PROTECT FROM CONTAMINANTS WITH AUSTRALIAN-MADE INNOVATION

SORBSEAL® HYBRID GEOSYNTHETIC CLAY LINERS

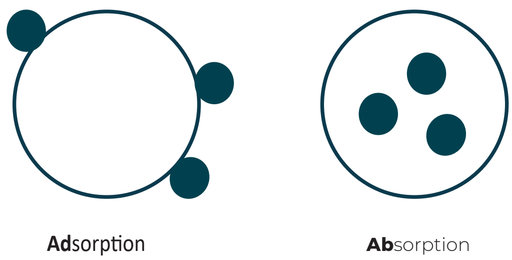
TECHNOTE: **ACTIVATED CARBON AND PFAS**

Activated Carbon (AC) is a carbonaceous adsorbent with a large internal surface area. It is commonly used to adsorb natural organic compounds and to remove taste, odour, and synthetic organic chemicals in drinking water treatment systems. It has also been one of the most studied treatments for the removal of Per- and Poly-fluoroalkyl Substances (PFAS).

PFAS are a large group of fluorinated chemicals which have been used for more than 50 years to add nonstick, waterproof, and/or stain-resistant properties to clothing, furnishings, carpeting, cookware, food contact paper, cosmetics, and other consumer products. Due to their widespread use, they are found all over the world in soil and drinking water and have been found ubiquitously in landfill leachate (Gallen, et al., 2017; Busch, et al., 2010; Li, et al., 2012; Weber, et al., 2011; Hamid, et al., 2018).

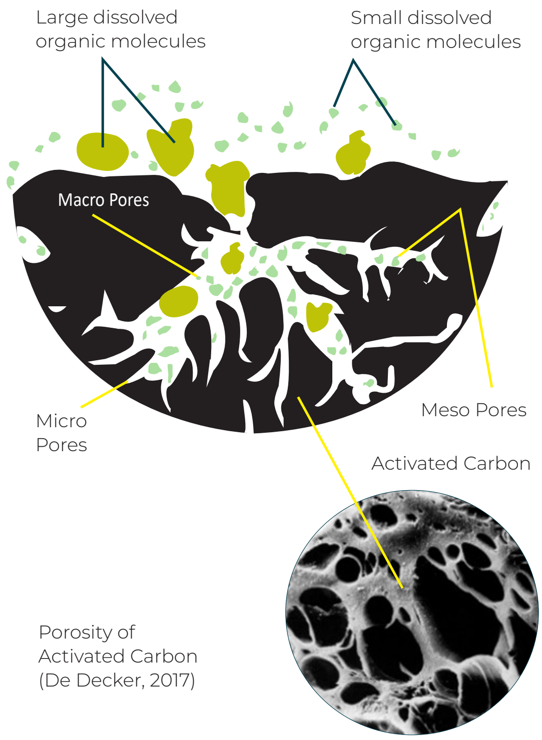
THE POWER OF ADSORPTION

AC works by the process of adsorption. Adsorption is the attachment or adhesion of atoms, ions and molecules (adsorbates) from a gaseous, liquid or solution medium onto the surface of an adsorbent such as AC. The porosity of AC offers a vast surface on which this adsorption can take place. There are a number of adsorption interaction mechanisms in relation to organic compounds, such as ligand exchange, electro donor–acceptor interactions, oxidative coupling, hydrophobicity, Lewis acid–base reactions, H-bonds, electrostatic interaction, and covalent bond formation (Kah, et al., 2017). From these there is strong consensus that both hydrophobicity and electrostatic interaction are the primary mechanisms involved in the adsorption of two of the main long-chain PFAS (PFOS and PFOA) onto AC (Goss, 2008; Gagliano, et al., 2020; Saeidi, et al., 2020). For adsorption to be effective it is important to match the adsorbate molecule size with the pore size and pore size distribution of the AC.



POROSITY AND PORE SIZE DISTRIBUTION (PSD)

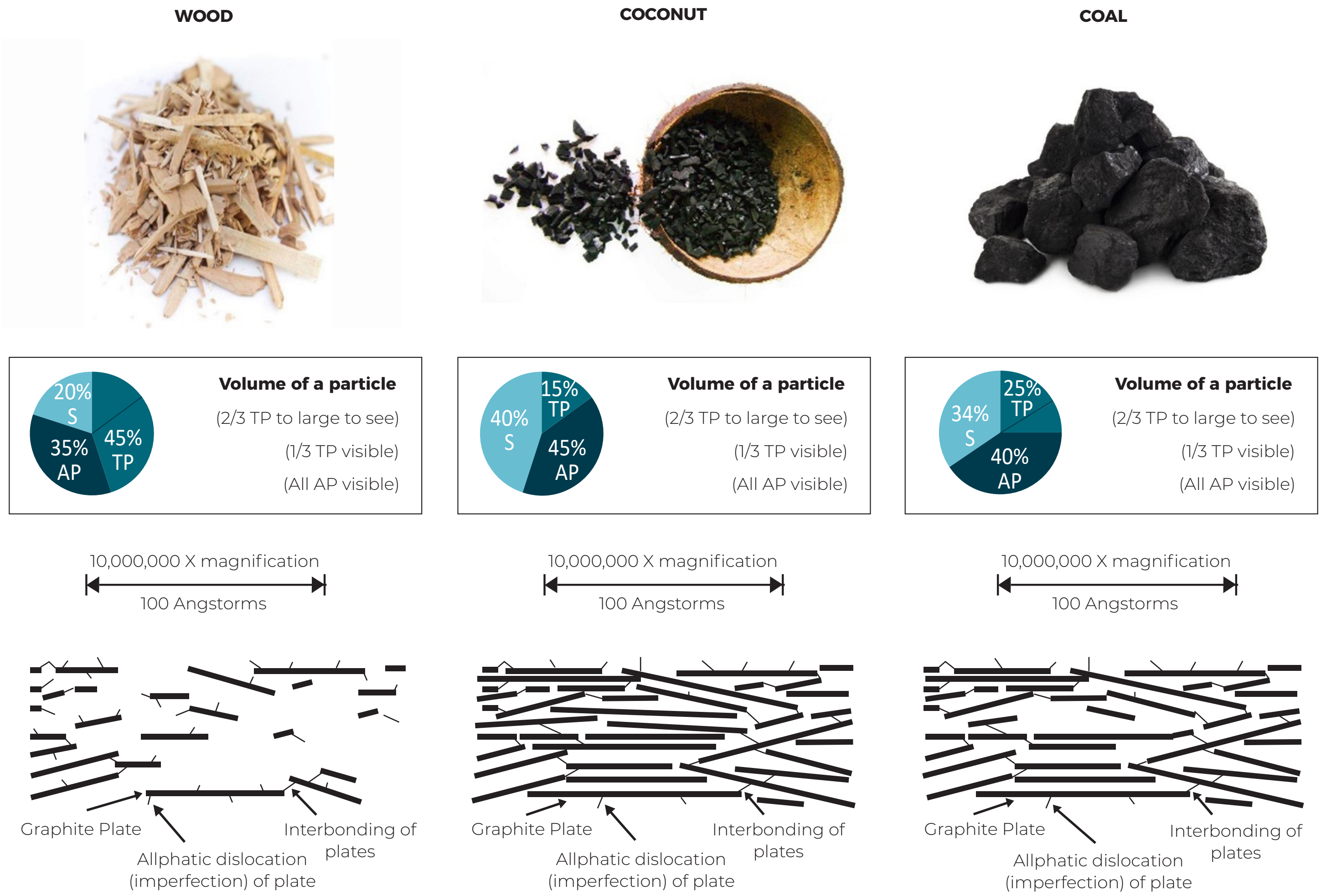
According to Zdravkov, et al. (2007), AC pores are roughly classified into three groups: Macropores (> 50 nm diameter), Mesopores (2-50 nm diameter), and Micropores (< 2 nm diameter). Micropores generally contribute a major part of the internal surface area. The larger macro and mesopores are regarded as the highways into the carbon particle. The combined surface area of AC is typically between 500 – 1500m2/g (Bansal & Meenakshi, 2005). The higher the porosity can mean a higher pollutant loading capacity, but it is highly dependent on the pore size distribution. For example, a high level of micropores may result in a large surface area but may not have enough entry points and transport pathways for larger molecules to take advantage of this. On the other hand, too many macropores and not enough meso and micropores may result in a lower adsorption capacity. When looking at PFAS, generally a good balance of each size category results in optimized adsorption.



Porosity of Activated Carbon (De Decker, 2017)

THE IMPORTANCE OF ORIGINS

AC can be manufactured from virtually any organic material. Because of their high carbon contents however, wood, coconut shells and coal are the most commonly used raw materials. Activation may be carried out by chemical means or, more commonly, by high temperature steam (>700°C) in a controlled atmosphere. There are important differences between AC produced from wood, coconut shells and coal. Wood-based AC generally has a higher level of macropores whereas coconut-based AC has a higher level of micropores. Coal-based AC is comprised of a good balance of micro (small), meso (medium) and macro (large) pores making it a solid contender for efficient adsorption of certain organic molecules, such as PFAS (Nowicki, et al., 2014).



Pore Size Distribution of Activated Carbon from different sources (Nowicki, et al., 2014)

Coals are classified according to their age. Lignite, or brown coal, is the youngest type of coal followed by Sub-Bituminous, Bituminous, and finally Anthracite. The origin and age of the coal is a key factor in producing an AC with a very high specific surface area and a good PSD. Bituminous coal-based activated carbons have been shown to have superior performance in trapping a wide range of perfluorinated compounds over other activated carbon varieties (McNamara, et al., 2018).

ATTENUATION OF PFAS

There are more than 4,700 PFAS compounds which have been identified (OECD, 2018). There have been numerous studies on the uptake of PFAS in water using activated carbon as this is the traditional technology employed by water authorities showing excellent attenuation of a wide range of long and short chain versions (McNamara, et al., 2018; Appleman, et al., 2013; Bartell, et al., 2010; Yu, et al., 2009). The level of performance is directly related to the specific activated carbon (quality, type, origin, adsorption kinetics, surface area, pore size distribution, etc), PFAS type, chain length and concentration, organic co-contaminant loadings, liquid pH, flow rates etc. Hybrid Geosynthetic Clay Liners (hGCLs) such as SORBSEAL, containing a blend of high quality, polymerised sodium bentonite powder and a high surface area AC, have been shown to effectively trap a wide range of PFAS from liquids containing other organic contaminants, such as landfill leachates (Gates, et al., 2020). While bentonite clay itself has been shown to be relatively ineffective in containing some organic pollutants due to its hydrophilicity (Bouazza, 2021), it is effective in slowing the rate of liquid transmission down to very low levels, while the high performing AC can attenuate a wide range of these organic contaminants, including PFAS.

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