



Activated Carbon: Black Magic

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ABSTRACT

We are living in technological world and new innovations are popping up like mushrooms. Activated Carbon is one of such novice creations given to mankind by mankind only which is well-known for its adsorption properties. Activated Charcoal which is technically famous as activated carbon is originated from carbon element. Trade gurus indicated that it is one of the most exploited agents in the 21st century which is used almost in everything be it medicines, textiles, cosmetics, fishery, purification purposes and many more. Activated charcoal, activated coal, activated carbon or activated biochar-the new green charcoal, all are just essential pure forms of carbon. Realizing the need to explore more on this issue, author made an endeavor to know about carbon and activated carbon. Further it emphasizes its properties panorama with the structural outlook. It also draws attention towards production process. At the end, applications of activated carbon have been discussed.

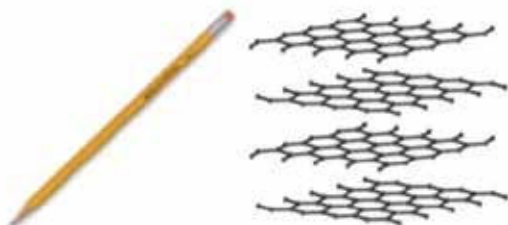
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Activated carbon is the new sapling coming from the rich and old fraternity of carbon. It is widely popular for its adsorbents and porous structure with immense surface area which may be as large as 1500 m²/gm. Since it has tremendous adsorption qualities, activated carbon is extensively used in process intended to purify, discolor, recuperate and remove odours at low cost and superior efficiency. Adsorption is an interfacial route connecting the collection of gaseous or solute components on the surface of adsorbent solids. This occurrence is coupled with physical attractive forces that bind gaseous and solute molecules which are universally known as Van-der-Waals forces. The adsorption clout and rate is resolute by the kind of activated carbon, the particle size, the pore size and its distribution. Since it is flourishing the family of carbon, before discussing activated carbon, let's discover the term Carbon first.

1. CARBON

Carbon is a chemical element with symbol C and having atomic number 6. The word carbon comes from Latin word for coal. Graphite, the mainly thermodynamically stable form of carbon like it is pencil lead, lies in layered sheets, which cast off effortlessly one from another (Figure 1). It is soft, black and a very good electrical conductor.

Figure 1: Lead in pencil and closer view of carbon sheets



Another form of carbon is diamond the sparkle for any jewel. Diamond is exceedingly see-through and transparent with

very low electrical conductivity; however the carbon atoms are so arranged (Figure 2) that it is amongst the hardest materials known.

Figure 2: Diamond and its arrangement



Now a day, the talk of the town is about the very much form of carbon-charcoal. According to Encarta World English dictionary 1999-'Charcoal (Figure 3) is a black or dark gray form of carbon, produced by heating wood or another organic substance in an enclosed space without air'. Scratching the history it has been revealed that charcoal has been made from wood, both softwood and hardwood. Its first application (circa 1750 B.C.) was as a fuel for smelting ore. Charcoal burns hotter and cleaner than wood and so wood was converted to charcoal.

Figure 3: Charcoal



What makes charcoal so distinct from the other forms of pure

carbon is from its original configuration; the pea available for adsorption or chemical reactions. Adsorption is an ability to bind atoms or molecules to a surface.

2. ACTIVATED CARBON

Activated carbon (Figure 4) is a form of carbon processed to be conundrum with small, low-volume pores that augments the surface area obtainable for adsorption or chemical reactions usually derived from charcoal. It is also called activated charcoal, activated coal, or carbo activatus. The term activated is at times proxy with active. Just one gram of activated carbon got surface area in excess of 500 m², since determined by adsorption isotherms of Carbon dioxide gas at room or 0.0 °C temperature and this is due to its high degree of micro-porosity.

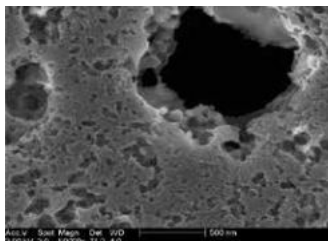
Figure 4: Activated Carbon



Activated carbon is an amorphous structure of elemental carbon primed by destructive distillation of any one of a variety of carbonaceous raw materials like wood, coal or coconut shells.

2.1 Structure-Underneath an electron microscope (50,000 magnifications); the high surface-area structures of activated carbon are more evident with the Figure 5. Particles are hugely convoluted, complicated and intricate individually with micro porosity in the range of a few nanometers. And these microscopic pores act exquisitely which engineered to propose binding spots for thousands of diverse chemicals.

Figure 5: Microscopic view of Activated Carbon



Opening of various pores in carbon structure happens due to activation in carbon element (Figure 6).

Figure 6: Pore structure of Activated Carbon



Pores with diameters beyond 500 Å are called macro-pores or transport pores. They are larger but not responsible for adsorption in direct manner although they work as wide paths through which organic molecules penetrate. And pores with diameter below 50 Å are called micro-pores or the adsorption pores. These are located inside the carbon

particle where the adsorption actually takes place and are finest pores. Methylene blue adsorption is used as regular and most common parameter to check the adsorption power of activated carbon.

1.2 Properties

Table 1: Different Types of Activated Carbon Properties

Property	Coconut Activated Carbon	Coal Activated Carbon	Lignite activated Carbon	Wood activated Carbon (powder)
Micropore	High	High	Medium	Low
Macropore	Low	Medium	High	high
Hardness	High	High	Low	n/a
Ash	5%	10%	20%	5%
Water Soluble Ash	High	Low	High	medium
Dust	Low	Medium	High	n/a
Reactivation	Good	Good	Poor	none
Apparent Density	0.48 g/cc	0.48g/cc	0.4 g/cc	0.35 g/cc
Iodine No.	1100	1000	600	1000

Table 1 illustrates the properties adhere by activated carbon. It reveals that the activated carbon manufactured out of carbon have high micropore and hardness which gives 10% ash. It is evident that activated carbon from coal is better option than any other activated carbons.

2.3 Classifications-AC or Activated Carbons are primarily and generally divide into three categories which are based on their physical characteristics which are as follows:

- Powdered Activated Carbon (PAC) - PAC is made up of crushed or ground carbon particles (Figure 4) and 95–100% of which will pass through a 50 to 80 mesh sieve. Conventionally, active carbons are prepared in meticulous type as powders or fine granules with an average diameter between .15 and .25 mm.

Figure 7: Powdered Activated Carbon



- Granular Activated Carbon (GAC)-It has a comparatively larger particle size judged against powdered activated carbon. Since GAC has a smaller external surface area than PAC it is frequently mistakenly understood that GAC has less total surface area. GAC can be in either form granular or extruded as pellets.

Figure 8: Granular Activated Carbon



- Extruded Activated Carbon (EAC)-It comprises extruded and cylindrical shaped activated carbon having diameters between 0.8 to 45 mm.

Figure 9: Extruded Activated Carbon



- Impregnated Activated Carbon (IAC)-IAC is porous activated carbon impregnated with certain inorganic elements like iodine, silver, or cations such as Al, Mn, Zn, Fe, Li, and Ca.
- Polymers Coated Activated Carbon (PCAC) - To give a smooth and permeable coat without blocking the pores the concerned process is applied to a porous carbon can be coated with a biocompatible polymer. And this is useful for hemoperfusion -a treatment technique to remove toxic substances from the blood with adsorbent stuff.
- Activated Carbon Cloth (ACC)-Activated carbon is as well accessible as cloths and fibers. It is used by the military for Nuclear Biological Chemical (NBC) as protective clothing, socks and gloves. Other availabilities are in wound dressings, protective masks, for the protection of artifacts from tarnish and degradation, oil mist filters for compressors, gas sensors, electrodes, water purification etc.

Figure 10: Activated Carbon Cloth



- Biochar Activated Charcoal (BAC) -Current and topical addition to the activated carbon fraternity is Biochar which is produced by pyrolysis process with tremendously low carbon emissions, a carbonization route that takes raw products without delay through to the activation stage in less than an hour depending on the temperature range.

3. PRODUCTION

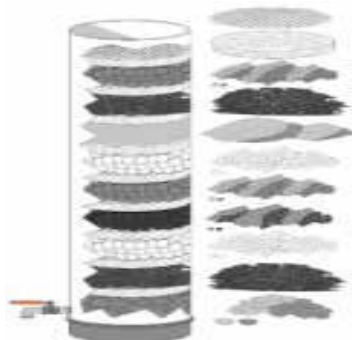
Activated carbon is carbon created from carbonaceous source resources such as nutshells, coconut husk, peat, wood, coir, lignite, coal and petroleum pitch. It can be produced by one of the following processes:

- Physical reactivation: The source material is developed into activated carbon using hot gases. This is generally done by using one or a combination of carbonization and activation or oxidation.
- Chemical activation: The raw sources are drenched with certain chemicals preceding carbonization. Chemical activation is favoured over physical activation due to the lower temperatures and shorter time required for activating the concerned material.

4. APPLICATIONS

a. Environmental applications -Activated carbon is usually used in water filtration systems. Figure 11 makes it evident; the activated carbon is in the fourth level (counted from bottom).

Figure 11: Activated Carbon in water filtration system



- Sewage Treatment
- Helps to control snow avalanches
- Soil Enhancement and Toxic soil clean up
- Utilization in volatile organic compounds from painting, dry cleaning ,gasoline etc
- Recycling of solvents
- Useful in Rye Grass seed industry
- Effluent treatment plant to reduce BOD/COD/Colour from industrial waste water
- Groundwater remediation
- Air purification

b. Medical applications-Activated carbon is used for medicinal purposes (Figure 12).

Figure 12: Activated charcoal for medical use



- In the early 19th century, charcoal biscuits were sold as an antidote to flatulence and stomach trouble in England.
- Tablets and capsules of activated carbon are used in many countries as an over-the-counter drug to treat diarrhea, indigestion and flatulence.
- Activated carbon is used to remove plaque as well as to whiten the teeth (Figure 13).

Figure 13: Using Carbon to Whiten Teeth and Remove Plaque



c. Apparel and textile applications-Activated carbon is used to manufacture activated carbon fibers, fabrics like artificial silk and apparels (Figure 14).

Figure 14: Apparels and fabrics can be manufactured by activated carbon and carbon fibers



d. Cosmetics applications-Few examples are shown in Figure 15, which have uses activated carbon to cleanse the dirt from skin.

Figure 15: Cosmetics containing activated carbon such as soaps ,facial cleansers etc



e. Other applications like Food colouring, Gold purification, Metal extraction and finishing Commercial Printing Inks ,to De-chlorinate soft drink plant process water & swimming pools Decolourisation of Plasticizer, Glycerin & fine Chemicals, Dyes Intermediates, and many more.

5. CONCLUSION

At this point of time we can see the vivid and prominent up-

coming prospects of activated carbon in diverse fields. With the immaculate and flawless efforts of experts, research scholars and skilled people, activated charcoal has been used in producing, manufacturing and purifying, a number of products. Endeavours are required to explore more possibilities of this element which can make more wonders in the field of technology, in the stream of science, on the pitch of home and in the race of life.

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