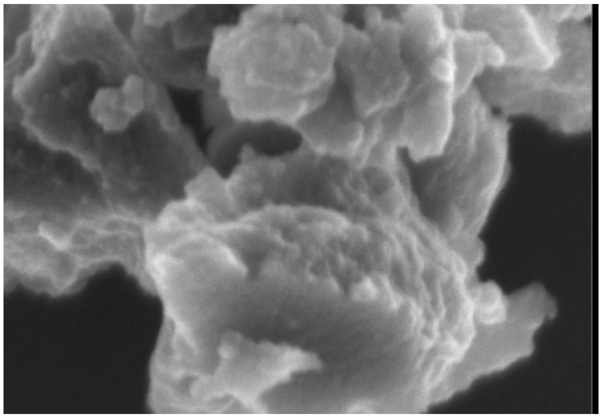
PMC Connection



What is Activated Carbon and how does it work?

By Janet Alexander

There are actually over 150 types of granular, powdered, and pelleted activated carbons. The different carbon types are created for different purposes. Some are made to absorb organic chemicals, pollutions, or filter liquids. For example, carbons with large holes are used for filtering fish tank water, while carbons with small holes are used in air filters. We use it to capture fumes while sintering metal clay. Not all activated carbons are of the same quality. This is why it's important to buy activated carbon from suppliers who has completed extensive tests on the carbon they sell.

After completing tests, the PMCC along with Hadar Jacobson have found that coconut activated carbon which has been acid-washed and has a high hardness is the best for use with metal clay.

At first glance, this photo may look like a thunderstorm or smoke from a fire, but it is actually a micro photo of steam activated carbon made from coconut shell. I was asked to write about the carbon we use in the process of sintering metal clay, so I set out to find out more information on activated carbon. I've heard it called acid carbon, coal carbon, activated carbon, acid-washed carbon, steam-washed carbon, rainbow carbon, and coconut carbon etc. So, what is it anyway?

What is activated carbon?

Activated carbon can be manufactured from any organic material. Commercial carbons are made from sawdust, wood, charcoal, peat, lignite, petroleum coke, bituminous coal, and coconut shells. We use activated coal carbon and activated coconut carbon in the sintering process for metal clay. Activated carbon is a carbon which is chemically treated or steamed to enhance its absorbing properties.

Coal Activation

According to Calgon Carbon, a manufacturer of activated carbon, "the coal is pulverized to a very fine particle, about the size of talcum powder. The powdered coal is mixed with a binder to "glue" it back together and pressed into briquettes. These ,in turn, are crushed and classified to the size of the desired end product." [1]

The coal is heated in an oxygen-free oven to remove the unstable components of the coal. The carbon then is activated by heating it again in an oxygen and steam environment. The activation process creates a highly porous coal with remarkable surface area. [1]

Chemical Activation

Wood-type products are activated using chemical activation. The material is mixed with activating and dehydrating chemicals (acids) and then heated between 932 - 1472˚F. The acid causes the wood to swell, opening the cellulose structure and stabilizes this structure, keeping it open. The acid is then washed out of the carbon.[2]

Steamed Activation

Peat, coal, coconut shells, lignite, anthracite, and wood are activated using steam activation. The material is converted to carbon through heating. Then it is cut into 0.35nm thick chips (looks like potato chips). They are placed in a jumbled pile and are heated to 1835˚F and at the same time they are blasted with steam heated to 266˚F. The steam creates pores in the carbon. Depending on the original material used, the pores are very small or can be large. The pores in hard coconut shell carbon are very small, micro pores. The pores formed in peat are usually meso-sized pores. [2]

The performance of a carbon is based upon the types and number of internal pore sizes, the internal surface area, and percent of ash in the carbon. The most important determining factor for carbon use and performance is pore structure.

There are three sizes of pore measurements.

- Micro pores have a radius of less than 1 nanometer* (nm) and are the smallest of openings in the carbon, or less than 40 angstroms.**
- Meso pores have a radius of 1 -25 nm.
- Macro pores have a radius of larger than 25nm, or above 5,000 angstroms.

Since the carbon we use is pulverized, it only has micro and meso pores.
Carbon is pulverized into various mesh sizes. On her blog site, Hadar Jacobson[3] refers to using a size 12 x40 coconut shell-based carbon, such as what the PMC Connection sells. Additionally, she states, "…we want carbon that does not produce a lot of ash and does not stay hot a long time after firing."

What do these pores do?

Now that the carbon has been activated (made more porous), what does that have to do with how it works? The smaller pores that are very close together create an energy field. This energy field, on a molecule level, attaches to the contaminant and adsorbs the contaminant. It is a chemical attraction.[1]

The more surface area in the activated carbon, the more it can absorb contaminants. In essence, the activated carbon (both coconut and coal) work the same. After reviewing the processes of activation, we now know that the activated coconut carbon has many more total pores and micro pores than the activated coal carbon. So the activated coconut carbon may be more efficient at absorbing fumes than the activated coal carbon. Their only differences are their PH levels, ash content, and the volume they can absorb. The ash content reduces the overall activity of the carbon and the efficiency of reactivation. The PH level is only important when using activated carbon for filtering liquids, as the PH level of the activated carbon can change the PH level of the filtered liquid. The hardness is also important. The harder the activated carbon, the less it crushes, making more dust.

During the metal clay sintering process, the activated carbon traps oxygen from inside the container it's placed in and free radicals from the metal sintering.[4] Sintering is basically heating the metal clay particles so that they fuse together. The activated carbon keeps the tiny metal particles in the metal clay from oxidizing while they are heated. If they oxidize too much ,they can't join together.
So, what makes the coal activated carbon make the rainbow colors on the bronze clay? I haven't found an answer yet. Why is it better to use coconut activated carbon when sintering copper clay and PMC Pro clay? My theory is that the coconut activated carbon is able to absorb faster than the activated coal carbon since it has more total pores to work with.

What is spent carbon and reactivation?

Over time, the carbon pores fill up with the contaminant (now called adsorbate) and its absorbing power is gone. The carbon is "spent," and no longer works. Reactivation is a process of cleaning the pores so that the carbon can work again.

There are three processes used for reactivation.

- Use heat (thermal recycling).The heat vaporizes or burns off the adsorbate inside the pores. The carbon is reactivated between 1292 -1832˚F. [2]
- Use steam (steam recycling). Steam is hard for the amateur to process at home.
- With boiling water. [2]

To reactivate the carbon using heat, place it inside the stainless steel container, cover with the lid, and fire for 30 minutes at 1750°F. Allow it to cool in the oven with the lid on. Then sift out the ash by pouring it from pan to pan while blowing on it lightly, or take it outside with a light breeze blowing and pour it from pan to pan.

Warning! It can catch fire in an oxygen environment at 392˚F and above! It is best to keep it covered to avoid a fire.

To reactivate the carbon with boiling water, place it into a sauce pan of boiling water (ratio 2 to 1), stir with a spoon. Soak the carbon until it sinks to the bottom of the pan and then pour off excess water. Repeat 4 -5 times. Place the carbon again into boiling water and allow it to soak for 24 hours. [2] Dry the carbon by placing it on a flat tray in the kitchen oven or toaster oven and heat at a low temperature (150˚F) until dry.

I've been told to keep the activated carbon in an air-tight container. Several artists have stated to me that they don't do this and haven't had any problems. However, if you think about it, the carbon is made to absorb airborne particles and fumes, so by keeping it in an air-tight container, it cannot become spent by simply sitting in open air.

General Instructions for firing metal clay in activated carbon

- Always test your kiln's temperature accuracy and adjust the kiln's temperature accordingly. The PMC Connection sells a testing unit.
- It's always best to test fire samples before actually firing your creations.
- Find the cool and hot spots in your kiln by using testing sample or using a temperature tester.
- Place same-size pieces in the stainless steel container. If firing smaller pieces with larger pieces, place the smaller pieces in the cooler area to compensate for their size.
- To evenly heat the container, elevate it approximately 1" above the kiln floor by sitting it on top of fire bricks or kiln feet and place it in the center of the kiln.
- Place at least 1" of activated carbon under your pieces and ½" to 2" above them.
- Keep the pieces at least ½ " apart.
- Follow the manufacturer's instructions for firing the clay.
- Allow 1" of air above the activated carbon if using a lid on the container.

References

[1] http://www.calgoncarbon.com/carbon_products/faqs.html

[2] Gert Strand, "*Activated Carbon for Purification of Alcoho*l."

[3] Hadar Jacobson, "Instruction manual for Hadar's Clay ™" http://artinsilver.com/Quick-fire_clay_instruction_manual.pdf

[4] Gary Busby, chemical engineer.

*** nanometer**: One nanometer is one billionth of metre(1/1000000000 of a metre, or 0.000000001 m). It is often used to express dimensions on the atomic scale.

** **angstroms**: A unit of length equal to 1/10000000000 (one ten billionth) of a meter.