Coconut Shell Based Activated Carbon *with* NO GREEEN HOUSE GAS EMISSION

by Dr P A Shankar

THE use of Activated Carbon to remove harmful impurities like organic contaminants from water has been practiced since Roman Times. Activated carbon is the generic term used to describe a family of carbonaceous adsorbents with a highly crystalline form and extensively developed internal pore structure.

Activated Carbon is extremely porous with a very large surface area, which makes it an effective adsorbent material. This large surface area relative to the size of the actual carbon particle makes it easy to remove large amount of impurities in a relatively small-enclosed space.

An approximate ratio is 1 gram = 1000 meter square of surface area. The intermolecular attractions in the smallest pores result in adsorption. The molecules of the contaminants in the water are adsorbed on to the surface of the Activated carbon by either physical or chemical attraction

The two mechanisms by which the chemicals are adsorbed onto Activated Carbon are either it "dislikes" water or it attracts into the activated carbon. Activated carbon adsorption proceeds through three basic steps:

1) Substances adsorb to the exterior of the carbon surface,
2) Substances move into the carbon pores
3) Substances adsorb to the interior walls of the carbon.

Many natural substances are used as base material to make activated carbon. The most common of these used in water purification are lignite, bituminous, peat and coconut shell.

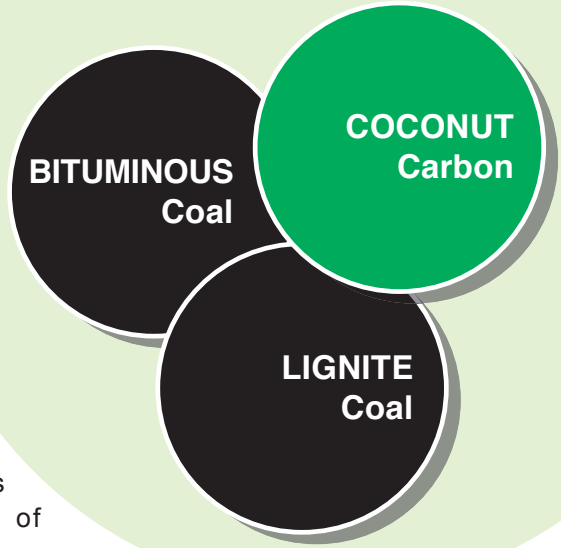
Different base materials and the activation process results in unique pore size and pore distribution. The pore size grouping in carbon are commonly described by its pore diameter:

Macro pores (above 50 nm diameter), Meso pores (2-50 nm diameter) and Micro pores (under 2nm diameter).

Coconut Shell based activated carbon is predominately micro porous and is well suited for organic chemical adsorption. Coconut shell based carbon are least dusty and has the most hardness compared to other type of activated carbons which makes it the ideal carbon for water purification

In terms of base material, Coconut shell is **renewable resources** compared to Lignite, Bituminous and wood. Coconut plantations with millions of acres of land continue to provide all the benefits of green trees to our environment in spite of using billions of coconut shell per year for activation.

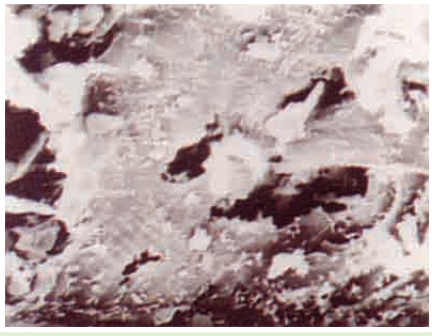
In nut shell the GREEN choice is coconut shell based activated carbon



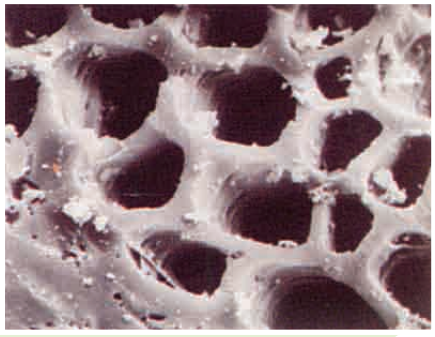
Activated carbon is produced from coconut shells by a two-step process.

The first step in activation is to carbonize the shells to drive out about two thirds of the volatiles out of the shells creating carbonaceous mass full of tiny pores.

This carbonized base material in the second stage is activated at high temperature (1100 degree C) in steam. Activation temperature and the amount of activation (time) are important to create internal pore network and to impart certain surface chemistries (functional group) inside each particle. In essence, the total activation process gives carbon the unique adsorption characteristics.



Carbonized Coconut Shell - 2000x



Activated Coconut Shell - 3000x

Current Carbonization Process

The process of carbonization is to convert coconut shells to Char or charcoal.

The charring process (making of charcoal) is known as the Pyrolysis, which is chemical decomposition of the shell by heating in the absence of oxygen.

During the carbonization of coconut shells, volatiles amounting to 70% of the mass of coconut shells on dry weight basis are released to the atmosphere, yielding 30% of coconut shell mass of charcoal. The volatile released during the carbonization process is Methane, CO2 and wide range of organic vapors.

Coconut shells are carbonized in an old-age process commonly known as open pit method. In this process earth is used as an insulator and to heat the shells in the absence of oxygen. The pit Charcoaling cycle consists of three stages:

1. Pyrolysis phase of over 12 hours when gases are released
2. Pacification phase of 12 hours when the pit is closed and the char is cooled for 12 hours.
3. Unloading of charcoal and loading of fresh shells for the next cycle.

Temperature in the pits is vital for complete pyrolysis. Experiments have shown that the charcoal yield is directly proportional to the temperature in the pit.

The amount of Methane released into the atmosphere is directly related to the temperature in the pit.

By and large pits yield 30% char, which means they maintain the temperature of 500 degrees. Several experiments have been conducted to measure the amount of gases released and for coconut shells on an average one 1MT of coconut shells releases about 12 to 15 Kg of Methane into the atmosphere.

Green House Gases Emitted by Current Charring Process

The Greenhouse gases insulate the Earth from the cold of space. As incoming solar radiations is adsorbed and re-emitted back from the Earth's surface as infrared energy, greenhouse gases (GHGs) in the atmosphere prevents a portion of this heat from escaping into space, instead re-emitting the energy back to further warm the surface.

Human activities are amplifying the natural greenhouse effect. Our emissions of GHGs are modifying the Earth's energy balance between incoming solar radiation and the heat released back into space, resulting in climate change.

It is well-established fact that climate change altars temperature, precipitation and sea levels and will adversely impact human and natural systems including water resources, human health, human settlements, and ecosystems/biodiversity.

The unprecedented acceleration of climate change model over the last 50 years and the increasing confidence in global climate model results add to the compelling evidence that climate is being effected in greenhouse gas (GHG) emissions from human activities.

There are several GHGs of which Water vapor, methane and carbon dioxide are naturally accruing and also generated by industrial processes. CO2 and methane are emitted primarily from fossil fuel combustion. Land use change and deforestation are significant sources of CO2 emission.

India, Philippines, Sri Lanka, and Indonesia are the primary countries that char coconut shells for activation to be used in water and air purification. Several countries in the ASEAN region in the recent years have also started charring coconut shells for activation process.

A conservative estimate is that in the four leading countries: India, Philippines, Sri Lanka and Indonesia about 350 Million MT/year of Methane is emitted to the atmosphere by these pits method of charring. This is equivalent to the CO2 emitted by 350,000 midsize cars (driven 20,000 miles/yr).

The Disruptive Technology in the Charring process to Prevent Green House Gas Emission

In the pit method of charring coconut shells, the GHGs are emitted to the atmosphere with out any control and treatment of effluent gases. Global Ecocarb Pvt Ltd (Division of Filtrex Technologies Pvt Ltd) has developed a novel process working along with Indian Institute of Science, Bangalore to char the coconut shells in a reactor capturing the GHGs and using them under controlled conditions for the production of thermal energy.

Coconut shells contain cellulose, hemicelluloses and lignin, with an average composition of $C_6H_{10}O_5$, with slight variations depending on the nature of the biomass. Theoretically, the ratio of air-to-fuel required for the complete combustion of the shells, defined as stoichiometric combustion is 6:1 to 6.5:1, with the end products being CO_2 and H_2O.

In this new process the combustion is carried at sub-stoichiometric conditions with air-to-fuel ratio being 1.5:1 to 1.8:1. The gas so obtained is called producer gas, which is combustible. This process is made possible in a device called "char reactor", in a limited supply of air. In this process two reactions takes place and they are called, oxidation and reduction processes.

These processes occur under sub-stoichiometric conditions of air with shells. The first part of sub-stoichiometric oxidation leads to the loss of volatiles from the shells and is exothermic; it results in peak

temperatures of 800 degrees C and generation of gaseous products like carbon monoxide, hydrogen in same proportions and carbon dioxide and water vapor which in turn are reduced in part to carbon monoxide and hydrogen by the hot bed of charcoal generated during the process of gasification. Reduction reaction is an endothermic reaction to generate combustible products like CO, H_2 and CH_4 as indicated below.

$C + CO2 \longrightarrow 2CO$

$C + H2O \longrightarrow CO + H2$

$C + 2H2 \longrightarrow CH4$

Since char is generated during the gasification process the entire operation is self-sustaining.

Global Ecocarb Pvt Ltd has developed the state-of-the-art technology where in the shells are fed from the top with twin air entry, re-burn process. This process consists of a fuel and ash handling system, gasification system - reactor, gas cooling and cleaning system. The process is unique to prevent the formation of tar during pyrolysis.

The char produced in this process is consistently of good quality compared to the char produced by the pit method. This char will have consistent high iodine value and free from contaminants coming from the pit such as soil, silica and pebbles. This char forms a good base material for activation process enabling high performance.

Global Ecocarb manufacures GAC (GREENCARBON™) and carbon blocks (GREENBLOCKS ™) using the char produced by the above process. Global Ecocarb Pvt Ltd is registering this technologies as the CDM under the Kyoto Treaty (UNFCCC).

Every small contribution in decreasing the GHGs helps in the climate change issue that we all collectively have to address. Please join us in being a change agent to do our part in reducing the GHGs. Insist on having your coconut shell activated carbon with NO GREEN HOUSE GAS EMISSION.

About the Author:
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1 Ton GAC produced by pit method of charring emits 4000kg of CO2 = driving mid-size car for 2000miles

10 inch Carbon Block emits 1.3kg CO2 in the pit method