

Broadening biochar usage: Product size and form



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Confidential

Biochar offer unique breadth

• Biochar Applications

- Soil remediation
- Soil enhancement
- Poultry bedding



• Key characteristics

- High porosity
- High carbon content
- Particle distribution



• Activated Carbon Applications

- Decolorization
- Raw material for advanced carbons
- Sequestration of chemicals

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• Graphite and Coke Applications

- Friction materials
- Lubricants and greases



• Key characteristics

- High carbon content
- Environmentally compatible
- Low contaminant levels

• CASE/Rubber Applications

- Reinforcement
- Pigmentation
- Synthetic materials



• Key characteristics

- High carbon content
- Natural spring back
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- Approved for incidental food contact

Positive attributes to expand biochar use



- High carbon content: >90% carbon
- Low contaminant levels: <4.5% ash
- High porosity: >420 m²/g nitrogen surface area
- Low Moisture levels: <4% moisture

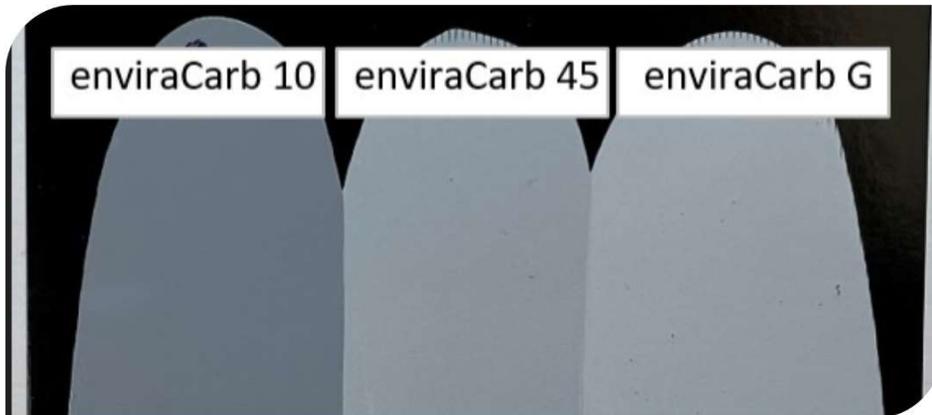
Typical Values*	Value ¹	Unit
Carbon Content	> 90	%
Moisture Content ²	< 4.0	%
Volatile Matter	< 8.0	%
Ash	1.75 to 4.5	%
BET Surface Area	~ 420	m ² /g
Iodine Number	~ 240	mg I ₂ /g
OAN	> 70	cm ³ /g

¹Appropriate ASTM test methods routinely used.
²As packaged.

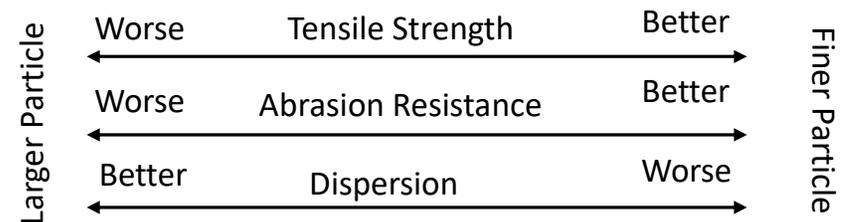
Limits to biochar expansion

- Particle size impacts key properties in many applications
 - Rubber – particle size drives tensile properties, abrasion resistance
 - Coatings – particle size drives tinting strength
 - Concrete – particle size drives compression strength, decreases permeability
- Dust in biochar impacts industrial processes
 - Hygiene – fugitive dust creates unclean environment
 - Flow properties – dust can impact precise metering and flow of materials

Particle size impact



Typical impact of particle size in rubber applications:



Particle Size impact on tint strength for pigmentation:

- enviraCarb[™] 10 has d90 of 10 microns
- enviraCarb 45 has d90 of 45 microns
- enviraCarb G is a 3 mm granule

The finer powdered biochar provides improved tint performance

Typical biochar granule will not perform well in a rubber application

N762 carbon black has a particle size of 70 nm

3 mm biochar granule is > 42,500x that size

Grinding to 10 micron reduces that ratio to 140x; rubber studies have shown these materials to supplement or displace N762 types and N990 types of carbon black

Rubber test findings

- Common positive findings
 - Reduced energy consumption to incorporate and disperse the enviraCarb materials
 - Reduced compound specific gravity when replacing carbon black
- Specific study findings

Study	<i>Motor Mount</i>	<i>Conveyor Belt</i>	<i>Pipe Gasket</i>	<i>Hose Cover</i>
Polymer	<i>Natural Rubber</i>	<i>SBR/BR</i>	<i>Polyisoprene</i>	<i>EPDM</i>
Reference Black	<i>N990</i>	<i>N774</i>	<i>N774</i>	<i>N762</i>
Performance Observations	Good heat aging	Good tear	Improved compression set	Decreased volume swell
	Modulus increase	Improved low end modulus	Good extrusion properties	

enviraPAC materials provide a sustainable supplement to semi-reinforcing black while potentially impacting two key areas:

- Weight reduction due to lower specific gravity
- Reduced hysteresis given larger particle size

Additional fine powder benefits

- enviraChar[™] 10 suspends well in solution allowing aqueous applications
 - Allows targeted application of biochar; reducing economic impact
 - Can be mixed with aqueous nutrient/fertilizer packages for all-in-one application

- The impact of finer particle biochar should extend to other target markets
 - 10-micron product should improve compressive strength and afford a more homogeneous mixture in concrete and other construction applications versus larger biochar materials

Product form

- Pelletized biochar provides many benefits in application
 - Dust control
 - Particle consistency for blends
 - Accurate metering in mixing systems
- Micronized powders demonstrate the ability to be successfully pelletized (prilled) on commercially available equipment



Size and form change the market

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