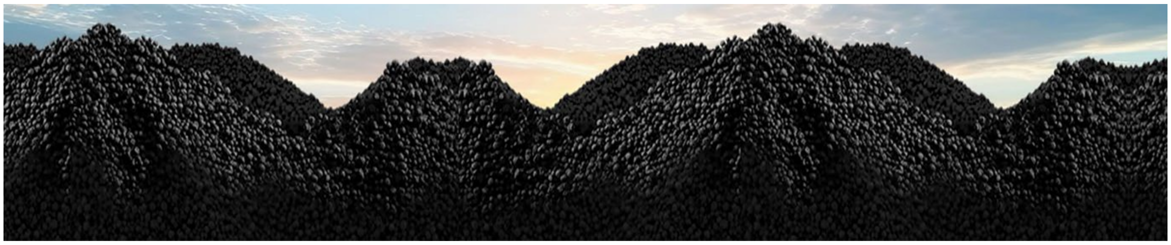

Powder Properties Critical for Wet Pelletization: Comparing Carbon Black, Recovered Carbon Black, and Biochar

By Craig Vaughan, Mars Mineral

Wet pelletization is crucial in materials engineering, transforming powders into uniform, manageable pellets. This process not only facilitates easier handling and transportation but also enhances the performance characteristics of the materials in their end-use applications. Understanding the specific powder properties that influence pelletization is essential for optimizing production and ensuring quality in the context of carbon-based materials like carbon black, recovered carbon black (rCB), and biochar. Here, we delve into the key powder properties relevant to wet pelletization and compare how carbon black, rCB, and biochar measure against these criteria.

Particle Size and Distribution

Particle size and distribution are paramount in determining pelletization efficiency and the quality of the final pellets. Typically, finer powders are easier to pelletize than coarser powders. While the primary particle sizes of virgin carbon black are in the 10-500 nm range to optimize specific performance properties, particularly mechanical properties, the aggregate particle size is relatively uniform in the 20–40 micron range. In this very fine particle size range, carbon black powder is very dusty and can pose significant challenges in bulk handling, packaging, and transport. Virgin carbon black, which is nearly 100% carbon, pelletizes easily with water or aqueous binders containing organic adjuncts such as lignosulfonate or sugars.

In contrast, rCB, derived from the pyrolysis of tires, is fundamentally a blend of the various grades of carbon blacks used in the different structural components of the tire. Being a recycled material, rCB typically contains about 80-85% carbon and 15-20% other impurities, particularly silica, zinc, and sulfur. The char resulting from pyrolysis is jet milled to a fine powder containing a relatively broad distribution of aggregate particle sizes, with a typical D_{50} < 10 microns and D_{99} < 20 microns. Water is typically used as the binder to pelletize rCB powders. However, these powders may contain up to 4% carbon as residual organic carbon, a contaminant that makes the particles more hydrophobic and therefore more difficult to pelletize with water alone.

In contrast, biochar, produced from biomass at lower pyrolysis temperatures than rCB, typically features a more heterogeneous particle size with higher residual organic carbon, which might require additional processing steps, including milling, to achieve a suitable size for effective pelletization.

Surface Area and Porosity
A powder's surface area and porosity significantly impact its ability to absorb moisture and binders during the wet pelletization process. A higher surface area can lead to better binder adsorption, critical for pellet integrity and strength. Carbon black has an extremely high surface area, making it very effective at binder absorption but also requiring careful control of moisture content to avoid over-saturation. Recovered carbon black tends to have a lower surface area than virgin carbon black due to thermal degradation during recovery, potentially leading to different binder requirements. Biochar's surface area is generally lower than that of carbon black but can vary widely based on the feedstock and production conditions, affecting its interaction with binders.

Chemical Composition
The chemical composition of a powder affects its reactivity and interaction with binders during pelletization. Virgin carbon black, derived from the pyrolysis of oil byproducts at very high temperatures, is primarily pure carbon, making it relatively inert and compatible with various aqueous binders. Consequently, pellets made with water alone as the binder are generally very weak and require the addition of an organic adjunct such as sodium lignosulfonate or sugars to facilitate surface wetting and increase pellet strength.

Recovered carbon black, derived from the pyrolysis of off-spec or end-of-life tires at lower temperatures than virgin carbon black, often contains residual contaminants from the original rubber material, such as sulfur and ash, which make the surface more polar and more reactive toward water as the binder. This higher surface reactivity influences optimal binder selection, loading, and pelletization dynamics.

Biochar, derived from the pyrolysis of biomass at lower temperatures than rCB, with its variable composition, including potential inorganic elements like potassium or calcium, might require specific binders that can cope with these variations to ensure pellet stability and functionality. In general, the pelletization of biochar requires an aqueous binder containing a surfactant to wet the particle surfaces, promote pelletization, and increase pellet strength.

Moisture Content

Moisture content is critical in wet pelletization, as it directly influences the powder's agglomeration and pellet formation ability. Powders with too low moisture content might not form pellets effectively, leading to excessive residual fines content, while adding too much moisture can lead to an inability to form discrete pellets or to pellets that are too large or too strong (hard). Pelletization of each of these carbon-based powders requires careful moisture management. Recovered carbon black and biochar, with their potentially higher organic and inorganic impurity levels, generally exhibit different moisture retention characteristics than virgin carbon black, impacting the pelletization process and the quality of the pellets. For each of these powders, there is an optimal green pellet moisture range that balances pellet size and pellet strength needed for their respective end-use applications.

Conclusion

In summary, when comparing carbon black, recovered carbon black, and biochar in wet pelletization, it is clear that each material presents unique challenges and requirements based on its inherent properties. Understanding these properties is essential for selecting the appropriate pelletization strategies and technologies. For a company like Mars Mineral, leveraging this knowledge can lead to more efficient and effective pelletization processes, ultimately enhancing pelletized product quality and performance in diverse applications.

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