Carbon

Make Sure

The Great Activated

You're Comparing

Carbon Dilemma

Apples with Apples

By Neal Megonnell

Summary: *A recent study comparing the performance of lignite-based activated carbons to bituminous-based carbons for drinking water treatment indirectly pointed out the performance differences between offshore, direct activated carbons and high performance, reagglomerated carbons.*

Many municipal drinking water treatment professionals have long held fast to the belief that granular activated carbon (GAC) based on bituminous coal provides the best performance for their demanding application. That's why, when an article in 1999 cited evidence that a lignite-based GAC outperformed a bituminous-based carbon, industry experts were surprised and more than a bit skeptical.

The claims were in direct contradiction to what we had experienced and everything that we had been reading for years," one water treatment professional recalls.

The results of the study, published in April 1999 in a leading water quality magazine, detailed how the Fresno Sole Source Aquifer, which supplies water to more than 500,000 Californians, selected lignite-based carbon after reviewing a manufacturer's comparison test. It offered evidence that lignite-based GAC treated 35 percent more water than the bituminous GAC before reaching saturation. Furthermore, the test showed that lignite GAC had a 30 percent longer life than bituminous GAC.[1]

While the data in the study were 100 percent correct, the report failed to note that the study compared lignite-based carbon with bituminous-based carbon that was produced offshore through a direct activation process. Carbons made through a direct activation process exhibit vastly different properties than the reagglomerated carbons commonly used in municipal water treatment.

Direct activated vs. reagglomerated

There *is* a difference.

Most of the contrasts between coal-based carbons made by reagglomeration and those made by direct activation can be attributed to different raw material coals and variations in the manufacturing processes.

Reagglomerated carbons are manufactured through the following process:

1. A high-grade raw material is pulverized to a powder.

2. A binder is added.

3. The product is reagglomerated into briquettes.

4. The briquettes are crushed.

5. The briquettes are sized.

6. The carbon is baked.

7. Finally, the carbon is thermally activated.

Offshore carbons are often produced through a cost-cutting manufacturing process. Direct activation begins with an inexpensive raw material and usually proceeds directly to crushing, sizing, baking and activation. To save production costs, the pulverizing, binding and reagglomerating steps are eliminated. While direct activation results in a lower price-per-pound carbon, it compromises long-term product performance in most applications.

Several municipal drinking water operators have seen this performance difference first hand. "People who've used both direct activated and reagglomerated carbons believe there's a difference," says Bob Little, water quality supervisor for the City of Fresno, who has evaluated both types of carbons.

The extra steps in making high performance carbon—the reagglomeration process—means a lot to us," says John Yoshumara, manager at Stockton East Water District in California.

How well a carbon performs is directly related to its internal pore structure. The internal pore structure of a carbon granule can be compared to the infrastructure of roads in the United States. There are superhighways (macropores), highways (mesopores), regular roads and dirt roads (micropores). The larger pore structures (super highways and highways) provide faster access to where the organic removal occurs. The tighter pore structure (regular roads and dirt roads) is where the majority of the organic molecules are removed through adsorption. By eliminating the steps of grinding, binding and reagglomerating, offshore carbons exhibit fewer superhighways and highways that allow organics to travel to the dirt roads, where adsorption takes place. In many demanding applications, the lack of additional carbon pure infrastructure equates to reduced performance and shorter bed life.

Differences between high-performance and offshore products affect different applications to varying degrees. Offshore products initially can be less expensive on a dollar-per-pound basis; however, by removing fewer organic contaminants, they generally require more frequent change-outs. The adsorption capacities of many offshore carbons are significantly lower. Typically, they are less resistant to abrasion, which results in higher transfer losses (backwash) and fines. The offshort products have approximately 6 percent fines, compared to 0.2 percent for high-performance carbon. In addition, offshore carbons can have higher ash cuntent, resulting in more leachables and lower adsorption capacities. They have approximately 14 percent ash, compared to 5-7 percent for high-performance carbon. Based on fines (lost in backwash) and ash, the offshore products offer 6 percent + 7 percent = 13 percent unusable product—or 13 percent higher cost based on pounds, based on an evaluation over the past several years.

A quick comparison of typical adsorptive and physical properties between reagglomerated and direct activated carbons made from bituminous coal is shown in Table 1.

While both types of carbon exhibit similar iodine numbers, iodine number isn't an effective test for gauging or controlling a carbon's performance at adsorbing trace levels of contaminants that are commonly seen in many drinking water applications. Newer test methods such as the Trace Capacity Number are more indicative of real world performance in organic removal applications. Table 2 shows the capacity differences between reagglomerated and direct activated carbons for several common organic compounds.

Table 1: Typical properties for 12x40 mesh bituminous coal based carbons

Parameter	Reagglomerated	Direct activated
Iodine number (mg/g)	1,000	1,000
Trace capacity number (mg/cc)	12-16	6-8
Bulk density (lb./cu. ft.)	29	25
Abrasion number	80	75
Ash content	7-10%	10-14%

Source material

Bituminous coal, anthracite, lignite, peat, wood and coconut each affect a carbon's inherent pore structure, influencing its properties and performance. Nevertheless, the consistency and quality of the source material is also extremely relevant. Water treatment professionals need to go beyond simply specifying coal based carbon for a given project, and know the source of the base for any activated carbon under consideration.

Water treatment professionals should go beyond simply specifying coal-based carbon for their job. The source of the base for any activated carbon under consideration needs to be identified. Carbon suppliers should always disclose the source of the starting base of their products, along with details on their manufacturing process, so that buyers can make intelligent comparisons.

"Our top concern has always been the quality of the product," says Yoshumara, whose Stockton, Calif., treatment facility remains loyal to reagglomerated bituminous carbons for their water treatment applications. Some offshore suppliers say they only have one or two sources of carbon, and you always think, 'How many offshore carbon plants are there?[7] There's got to be more than one or two. We want to verify the quality of the source material."

Another California treatment facility with experience in both types of carbon maintains that it's often a challenge to discbver details about offshore carbon. "Both the offshore and high performance carbons I used were based on coal, but that's about all I know about the offshore product," says Bob Hay-ward, general manager of Lincoln Avenue Water Company in Altadena, Calif.

Performance you can count on

The problem that's most often associated with direct activated carbon performance is uniformity, "At Fresno, we've seen a lot of offshore carbon situations where one load will last 15 months at a station and the next load will last 22 months—and nothing's changed as far as the water quality or concentration of the contaminant," says Little. "At some of our multiple-vessel sites, we've seen one or two of our vessels reach detectable organic breakthrough at port 4, while another vessel is still non-detect at port 2. Supposedly it's all the same carbon, but the offshore performance is widely variable." Performance inconsistency is most likely caused by lack of control and adherence to standards during the carbon activation process.

A water superintendent at another California treatment facility concurs, "We tried using carbon that came from China. One bulk bag would meet the specs and the next five wouldn't. You have to understand there are hundreds of facilities in China that process carbon. You may get a partial load from this facility and a partial load from that facility and the consistency and the quality isn't there. I'm not saying all offshore carbon is bad carbon, I'm just saying I haven't seen it consistently meet the specs the way high performance carbon does."

Reagglomeration plants take advantage of technology, such as digital readouts to ensure temperature and other variables remain constant. Offshore carbons are often produced using more manual labor. It's the difference between fine-tuning the control of the process (maintaining established quality standards) vs. mass production of carbon.

A clean comparison

At the request of the City of Fresno, an alternate supplier duplicated the lignite vs. bituminous test using a reagglomerated bituminous-based product instead of the offshore media. Column studies using samples of the Fresno water were done in 1999. This time, the results were much different. The reagglomerated bituminous carbon was outperforming the lignite material by a factor of three when the column test concluded—and it was still running at the time," noted the researcher.

Although the original study was undertaken as a way to show the advantage of lignite over coal, it actually succeeded in proving the true difference between offshore, direct activated GAC and high performance reagglomerated carbon.

Learning from the past

These test results come as no surprise to many California water treatment professionals. The experiences of Altadena's Lincoln Avenue Water Company attest to the performance of reagglomerated carbon. "We used both. The high performance carbon lasted longer than the offshore carbon—in fact, we experienced twice the carbon life from the reagglomerated product over the direct activated GAC," claims Bob Hayward, general manager. "We suspected from the start that the offshore carbon wouldn't deliver the same kind of performance as the product we had been using, but I guess we had to experience it for ourselves."

Meanwhile, the City of Fresno and its lignite vs. coal test? One year after the carbon dilemma began, Fresno is again purchasing bituminous coal-based GAC. Now, though, it's taking care to use high performance, reagglomerated carbon.

Conclusion

It has long been understood that activated carbons made from different starting materials (bituminous coal, lignite, coconut, etc.) will perform differently for a given application. Yet, many water treatment professionals are beginning to realize that—even among an individual starting material such as bituminous coal—performance differences can exist. By understanding the starting material source as well as the manufacturing process used to produce the activated carbon, one can be confident that the best and most consistently performing carbon is being selected to fit the application.

References

1. Hasbach, A., "CASEBOOK: Utility Selects Lignite-Based Carbon After Study," *Pollution Engineering,* April 1999, website: www.pollutionengineering.com/archives/1999/pol0401.99/049case.htm

About the author

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Table 2: Adsorption capacity comparison—reagglomerated vs. direct activated

Compound	Concentration	Reagglomerated carbon capacity (8/1 OOg)	Direct activated carbon capacity (9/100g)
Geosmin	100 ppt	0.000817	0.000266
Chloroform	**10** ppb	0.05	0.02
Trichloroethylene (TCE)	**10** ppb	0.66	0.34
Phenol	**10** ppb	1.78	1.04