

## A Further Look at PAC and GAC Based Remediation Programs

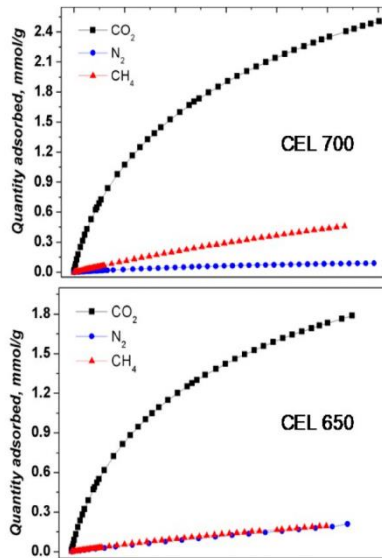
The response to last month's "REMEDICATION NEWS": "A Look at PAC and GAC Based Remediation Programs was overwhelming! Our email filled and the IET phones never stopped ringing. Without naming individuals, I'd like to thank everyone for their comments, contributions and field observations. Without exception, my discussions with everyone responding provided further evidence that the use of PAC and GAC based in-situ programs for chlorinated solvents is a subject ripe for review. Below is a follow-up and summary of those discussions.

A closer look at the activation processes utilized for the individual PAC and GAC products is necessary. The activation of carbon occurs at high heat, usually in the presence of steam, carbon dioxide, or air. This creates a structure that is extremely porous, giving it a very large surface area of between 500 and 1,500 square meters per gram. Certainly, each of these activation processes plays a role in the behavior of the PAC and GAC when applied in situ for the treatment of chlorinated solvents and how the activated carbon may inhibit biological degradation of the targeted compounds.

1) The feedstock of the GAC and PAC certainly plays a role in the behavior of the individual products. Bituminous coal activated carbons have a broad range of pore diameters. Since these carbons have both a fine and wide pore diameter, they are well-suited for general dechlorination and the removal of a wider variety of organic chemical contaminants from water, including the larger color bodies. Coconut-based carbon tends to exhibit greater microporosity, which is more suited for removal of low concentrations of organics such as in drinking water applications. This property can be deduced when comparing iodine numbers on the activated carbons. Carbons with higher iodine numbers will tend to have larger surface area; therefore, they will have higher capacity for comparatively weakly adsorbed organics. On the other hand, carbons with lower iodine numbers may still have wider pores, which could be favored for removal of large organic molecules.

2) The ash content of the GAC and PAC should be considered. Ash content can play an important role in situ and how the product inhibits biological activity. The water soluble ash fraction may be liberated on contact with the activated carbon; this may lead to undesirable effects.

3) Biochar is close cousin to activated carbon. How does biochar compare to activated carbon products? Further, what do the most recent biochar CO<sub>2</sub> adsorption and separation studies tell us about the CO<sub>2</sub> concentration effect on methane production and reductive dechlorination inhibition (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6196957/>)?

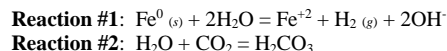


Equilibrium CO<sub>2</sub>, N<sub>2</sub>, and CH<sub>4</sub> uptakes at 25 °C of selected biochars.

4) How do we substantiate and assess the efficacy of iron impregnation on the GAC and PAC products? Specifically, Remediation Products, Inc. (RPI) Boss product claims:

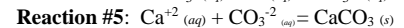
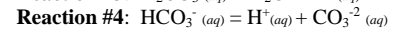
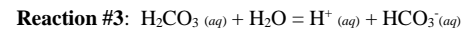
*"During manufacturing of BOS 100<sup>®</sup>, granular activated carbon is impregnated with an iron salt and heated to a high temperature to create a highly active, large remediation surface area within the activated carbon granules. It contains approximately six percent (wt) metallic iron in the form of microscopic deposits within the pore network of the activated carbon. BOS 100<sup>®</sup> works approximately 50 times faster than conventional iron products used for treatment of chlorinated solvents."*  
<http://www.trapandtreat.com/tech-bulletins/bos-100-faq/>

These are bold statements. In several phone discussions the efficacy of the iron deposition process and its effect on reductive dechlorination occurred. Some basic chemistry with regard to the entrained CO<sub>2</sub> and the elemental iron interactions resulted. Specifically, how the microenvironment within the GAC/PAC pores resulting from the elevated dissolved CO<sub>2</sub> and iron most probably results in a carbonate deposition on the GAC/PAC surface, inhibiting CVOC adsorption:



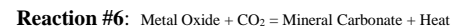
In general, carbonates go into solution in an acid solution and precipitate in a basic solution. Therefore,

in the micropores of the GAC and PAC, with the addition of Fe<sup>0</sup>, where OH<sup>-</sup> is produced (**Reaction #1**) and CO<sub>2</sub> is elevated as a function of the adsorption features of the GAC and PAC for CO<sub>2</sub>, carbonic acid is formed (**Reaction #2**).



Moreover, with the dissociation of the carbonic acid in the presence of dissolved calcium (**Reactions #3, #4 and #5**) carbonate precipitation most certainly occurs within the microenvironments within the pores of the GAC and PAC. Effectively blinding the CVOC adsorption into the GAC/PAC micropores. In totality, the elevated pH from the hydrolysis of water at the surface of the ZVI (Fe<sup>0</sup>) facilitates the precipitation of mineral carbonates on the surfaces of the GAC/PAC.

The question then turns to the delivery process of metal bearing GAC and PAC products. In the mixing and injection process the agitation and injection procedures cannot (without the addition of oxygen scavengers) prevent ferric oxide formation on the surface of the Fe<sup>0</sup>.



The presence of the ferric oxide in conjunction with the increased CO<sub>2</sub> entrained in the GAC and PAC raises the question of further "plating-out" of mineral carbonates within the micro pores of the GAC and PAC products (**Reaction #6**).

*I'd like to thank everyone who offered their comments to the previous Newsletter. It is my hope that with this follow-up discussion, our industry begins to examine the claims made by product vendors. We are a well-educated, generally well informed and maturing industry. The conversations I participated in over the past several weeks demonstrate that there is a need for an active forum for us all to better discuss and share our collective experiences.*

About the author: Michael Scalzi is President and founded Innovative Environmental Technologies, Inc. (IET) in 1998. Mr. Scalzi has participated in the design and implementation of over 1500 in situ remediation programs across the United States. Mr. Scalzi holds a Masters Degree in Biology from the State University of New York, he is the primary author of 11 current United States Patents and 5 pending United States Patents. Mr. Scalzi has authored numerous papers and has presented at dozens of symposiums since 1994.

