

## **GREEN NANO ZERO-VALENT IRON (GNZVI) AS A NOVEL REDUCTANT AND CATALYST FOR THE REMEDIATION OF ENVIRONMENTAL CONTAMINANTS**

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VeruTEK Technologies, in cooperation with the US EPA and the University of Connecticut, has developed and patented a novel biosynthesis technique to form Green nano scale Zero-Valent Iron (GnZVI) using natural plant extracts such as sorghum and green tea. This new production technique results in significantly reduced manufacturing costs and increased performance for a broad range of environmental cleanup applications. Zero-valent iron (ZVI) is an effective reducing agent, used in environmental remediation and wastewater treatment to eliminate contaminants such as chlorinated solvents, a wide range of pesticides, and arsenic. ZVI is often implemented as part of permeable reactive barrier (PRB), or is injected into the subsurface with an emulsifier or capping agent.

Traditional methods for producing ZVI are expensive, hazardous and environmentally destructive. Top down methods involve grinding bulk materials into smaller particles, which is highly energy intensive and expensive. The particles formed using the top down method tend to be macro scale and irregularly shaped, which results in low specific surface area and poor reactivity. Bottom up methods, where iron particles are constructed from molecular iron, rely on harsh reductants (e.g., sodium borohydride) which have to be washed from the final product, creating a waste stream which has to be treated. The effectiveness of traditionally manufactured nano ZVI products is limited by short lifespan and combustive reaction to oxygen (air). Most commercially available ZVI is so reactive it must be stored in an oxygen-free atmosphere and mixed with water with extreme caution before being used. Once in contact with water and air, the ZVI oxidizes before it reacts with contaminants, and aggregates to form larger particles.

VeruTEK's GnZVI is formed adding cationic iron (Fe(II) or Fe(III)) to an aqueous solution of green, plant-based polyphenols. The polyphenols reduce the cationic iron to form nano-scale ZVI particles with three layers; (1) an inner core consisting of ZVI, (2) an intermediate layer of iron oxides and oxyhydroxides, and (3) an outer reductive cap consisting of polyphenols that polymerized during the reaction. The GnZVI particles thus formed have a diameter ranging from 100-300 nm and do not aggregate because of the outer biopolymer layer. GnZVI is a highly effective reductant because the polyphenols enhance the reductive capacity of the ZVI, and the nano scale particles increase the specific surface area available for reaction. The cationic iron and polyphenols can be mixed together before being injected into the subsurface, or can be mixed in the ground to form the GnZVI in situ. Because of the biopolymer coating the GnZVI particle solution may be exposed to air without oxidizing, and in fact is so stable that it may be safely combined with strong oxidizing agent for in situ catalyzed oxidation.

VeruTEK has used GnZVI on its own, and combined with catalyzed peroxide in a variety of bench scale studies to treat hydrocarbons, PAHs and chlorinated solvents. The results from these laboratory experiments will be presented. Results and experiences from field injections of GnZVI will also be presented.

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