Make it with

NTeC™

Superior Performing Materials Hybridized at Nanoscale

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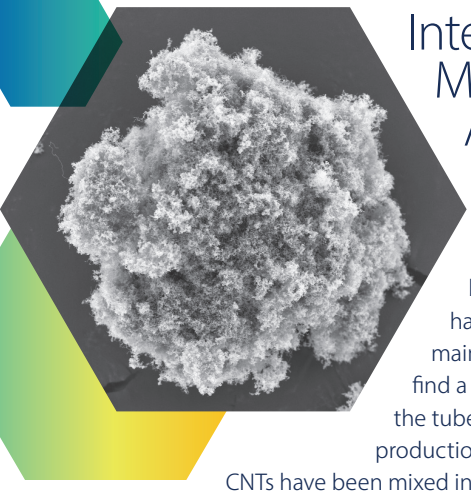

Integral to the Material, Not an Additive

Discovered in 1991, carbon nanotubes (CNTs) and later graphene were heralded as "wonder materials" because of their amazing properties, but have never really made it to mass adoption mainly because no one has been able to find a way to precisely and consistently make the tubes needed and to functionalize them at production scale. Treated mainly as an additive, CNTs have been mixed into a variety of materials including tires, batteries, composites and even cement but the tendency of CNTs to naturally agglomerate made achieving proper distributions in the mix difficult if not impossible to overcome. Sufficient loadings of CNTs required to register an appreciable effect also could not be achieved as this predisposition to agglomerate precipitously forced CNTs out of solution from the mixtures.

Hybridizing advanced materials at the nanoscale, CHASM NTeC platform grows CNTs in-situ ONTO a variety of particles so they are integral with the base material, not merely an additive. Grown on the base material, the CNTs are automatically dispersed and can achieve any desired loading to impart dramatic improvements in material properties. The NTeC platform has proven dramatic improvements in fuel efficiency and long-wearing tires, rapidly charging and ling lived batteries, and crack free and smart concrete structures. From carbons to cement, the NTeC platform is revolutionizing one particle after another to dramatic effect.

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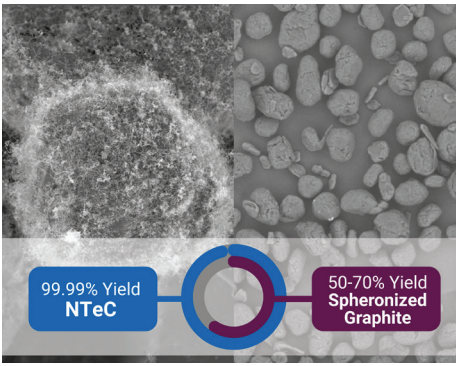
Enhancing Particles



Enhancing raw materials with particles that offer improved strength and resilience such as carbon nanotubes (CNTs) is not a new idea, but the methods of doing so have only been able to bring modest commercial success. There have been high expectations in applications like tires, batteries and cement but cost and usability issues have impeded adoption - until now. Whether the goal is improving charge capacity for batteries or seeking a way to improve the strength and durability of concrete or composites - CHASM has a better way.

CHASM's NTeC is not a simple additive. The platform delivers truly enhanced particles where specialized carbon nanotubes are grown onto other particles such as carbon black, cement, silicon and a variety of other materials. The NTeC synthesis process is fast, dramatically reducing manufacturing time and expense compared to traditional approaches.

For example, graphite used in battery anodes is "spheronized" by a milling process that takes the jagged graphite and grinds it until it is round. This process takes time and energy, resulting in a good portion of the graphite being thrown away as dust –giving only 50-70% yield. In contrast to existing methods, NTeC particles are carpeted in a matter of seconds producing manufacturing yield approaching 100%.

Growing the CNT's directly onto the particles improves performance with more control, precision and exacting results. Only CHASM is positioned to offer these enhanced particles. Our extensive experience in nanomaterials and nanotube hybrid manufacturing capabilities are unique within the industry.

Breakthrough Solutions

CHASM's NTeC platform is built on a series of nanotube hybrid materials that offer improved performance metrics that address the pitfalls of incumbent materials. NTeC is making breakthrough in the following areas:

Battery Materials

The next generation of mobile devices, vehicles and renewable energy storage systems will require material solutions that are more capable and more versatile. NTeC improves the power density, cycle life and charge/discharge capacity of battery anode materials.

Building Materials

Cement is critical to the modern world and has contributed to much of our infrastructure. However, it can crack and split under making it vulnerable in certain conditions. It is also the source of about 8% of the world's carbon dioxide (CO_2) emissions. NTeC dually addresses these concerns by drastically increasing the strength cement while reducing the considerable carbon footprint.

Composites

Plastics and composite materials are used in applications large and small. NTeC enhances the strength, conductivity and thermal performance of composite materials used for advanced applications such as aerospace or other extreme environments where superior performance is required.

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Better Batteries

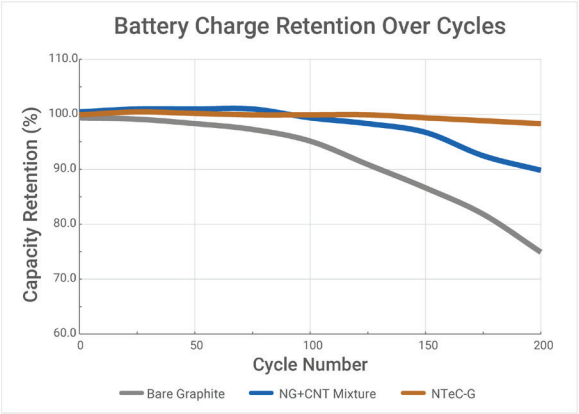
Portable, on-demand electrical power – batteries are integral to the availability of advanced technology of how we communicate, navigate the world, and consume the vast amounts information pervasive in our lives. NTeC enhanced batteries charge faster, last longer, and operate at temperature extremes beyond other commercially available chemistries. One of the first product releases driven by NTeC is for a variety of applications including Li-ion, traditional lead-acid, or start-stop batteries. NTeC is a nanotube hybrid that is low cost, easy to handle, and capable of the precise dispersions required to tune exact performance.

In this type of hybridized material, a "carpet" layer of CNTs are grown directly on the exterior of particles, providing a highly porous surface on a solid core. The growth process for these nanotube hybrid particles utilizes readily available commercial reactors for scalable production with high yield and low cost.

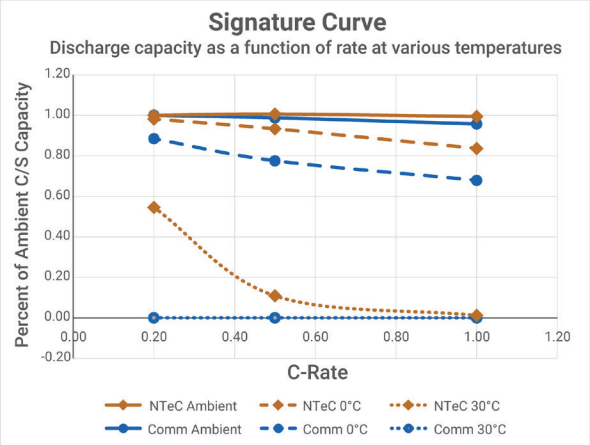
Benefits:

- Lower internal resistance than bare graphite for faster charging
- Higher thermal conductivity for better discharge capacity even down to -30°C
- Greater Li+ storage and robust interparticle connections for longer cycle life

This nanotube hybrid material is quite easy to handle and integrate into cylindrical battery cells, coin cells, and pouch cells. As the material is in the solid state, it can be mixed with a surfactant and binder to form a slurry. This slurry can then be spread onto a copper foil and dried, yielding a porous film with low resistance. No specialized processes are required to integrate these materials with other standard battery materials.



NTeC in batteries demonstrates longer life than traditional or simple mixture chemistries



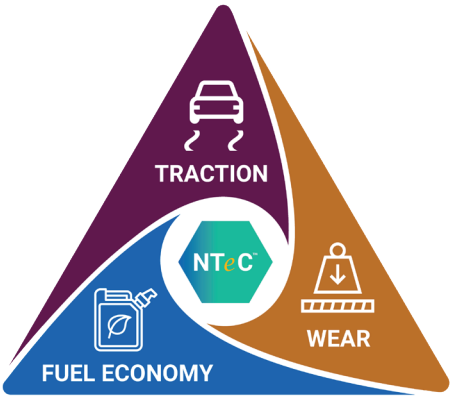
NTeC in batteries perform better at all temperatures.

Less Tiresome Tires

Since many of the more than 3 billion tires demanded annually worldwide end up in landfills, even small improvements in their performance can have dramatic impact on global climates. Carbon black is a common additive used in all tires to not only enhance color, but to improve wear resistance. In it's current form however, adding carbon-black compromises another desired characteristic of tires – traction. The "unattainable triad" for tire design balances the three characteristics of fuel economy, traction, and wear resistance. Adding carbon-black can increase wear resistance, but is does so at the expense of traction as the tire compound is hardened. When considering material compositions for tires, the common adage is you can achieve two of the triad, but not three.

The synthesis of NTeC grows CNTs directly on the carbon-black particles so they are automatically dispersed by nature eliminating the potential of agglomeration of CNT only slurries. Precise control over the synthesis process enable fine tuning of dispersion loading achieving a balance not possible with traditional mixtures.

The resulting composite offers a solution to finally delivering on improvements to all three legs of the triad – better traction, longer wear, and increased fuel economy. Enabled by NTeC enhanced compositions, longer wearing tires that consume less fuel are not just a benefit to consumers, but also lower emissions from factories producing fewer tires annually and are kinder to the environment from fewer ending up in landfills.



Now Possible: The "unattainable triad" for tire design balances the three characteristics of fuel economy, traction, and wear resistance.

Crack-free and Smarter Concrete

One of the most pervasive and widely used building products in the world, concrete is used in nearly every commercial and residential dwelling on the planet. Worldwide consumption exceeds 10 billion tons annually, it is used more than any other manmade material, and is second in material consumption only behind water. Despite its widespread use, concrete's porous nature makes structures prone to cracking, scaling, spalling, erosion, and corrosion of internal steel rebar leading to reduced life and potentially catastrophic failure.

Long desired as an additive to concrete, CNTs alone have shown limited application due to the difficulty in achieving even dispersions and sufficient loading. Just as done with the carbon particles in the NTeC platform, NTeC-C synthesizes CNTs directly on cement particles to overcome these challenges. Hybridized at the nanoscale, NTeC-C particles act as microscopic rebar, stopping cracks at the nucleation phase before reducing the likelihood of propagation. Environmentally durable, the carbon of CNTs encapsulates steel rebar increasing corrosion resistance and extending the useful life of structures. Conductive and evenly dispersed, the NTeC-C particles can be used as a conductive network to monitor and report on structural properties.

The benefits of hybridization of NTeC also extend to physical properties. With an estimated 50% increase in flexural strength, concrete structures activated with NTeC can utilize less concrete while providing comparable load carrying capabilities. More efficient use of this critical building product can trigger a downward trend in the concrete industry's CO_2 output lowering the impact of climate change.

Accelerating Progress Through Partnerships

"Collaborate Enthusiastically" is a core value at CHASM and a key driver that is being used to accelerate the development and commercialization of the NTeC product line. The best example of this is the strategic partnership that CHASM has formed with Birla Carbon, one of the largest manufacturers of carbon black in the world.

In November 2019, CHASM announced a Joint Development Agreement with Birla Carbon to focus on the development of the NTeC product, a CNT-carbon black hybrid. Birla Carbon's largest market is providing carbon black for the manufacture of automobile tires, generating close to $2 billion in annual revenue. Tires are one of the world's most highly engineered products and it is believed that the addition of NTeCwill show significant benefits that will enhance the durability, performance and lifespan of tires.

In addition to NTeC for tires, the partners are also collaborating on the development and commercialization of NTeC for battery materials. These initiatives are consistent with and supportive of Birla's strategic move towards becoming a major provider of materials for the battery and energy storage industry. After just one year of collaborating under the Joint Development Agreement, substantial progress has been demonstrated and clear value is being created by this partnership.

CHASM's agility, innovation and deep expertise in nanomaterials and Birla Carbon's world-leading technical abilities, manufacturing scale and commercialization experience form a powerful combination that leverage the unique strengths and abilities of both organizations.

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NTeC for Concrete

CHASM is collaborating with a university located in the US that recently established a research center for the development of advanced construction materials. The goal of this collaboration is to evaluate and validate the effectiveness of a. NTeC CNT-cement hybrid, for construction applications. The addition of CNTs to cement has been demonstrated to provide significant improvements in mechanical strength and will enable new capabilities for "smart concrete" that can be used to detect stresses and microcracks.

Challenges that have inhibited commercialization are primarily related to the cost of CNTs and usability issues, such as attaining uniform dispersion. The collaboration partners believe that NTeC is the best option yet developed for addressing both of these challenges and are designing a work program that is intended to conclusively show that this is the case. CHASM believes that the results of this collaboration will facilitate the process of attracting one or more commercialization partners to bring this product to market.

Commercialization Opportunities

CHASM has a number of other development efforts underway that will broaden the universe of applications for NTeC and accelerate the drive to commercialization. We are continuing to seek additional partnerships across all three NTeC product lines and look forward to collaborating enthusiastically with an expanding group of partners.

For more information please visit: www.chasmtek.com

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