MARKET ASSESSMENT

PHENOLIC AND CARBON MICROSPHERES

PRESENTED TO

[redacted], NORTH AMERICA

BY

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EXECUTIVE SUMMARY

The markets for phenolic and carbon microspheres are small in comparison to the larger commercial market for more commodity product categories, especially glass. In a study released in early 2005 that defined microspheres to be a $300MM market these two categories received little to no mention.

As an engineered material, each category could be ranked rather high in value relative to industries and applications that require exceptional performance in extreme environments. This would appear to be compatible with the [redacted] market positioning relative to glass microspheres.

While there is US government support for local sourcing for materials deemed critical to national defense, there is not significant commercial demand for these two engineering materials. Commercial ventures have failed. Most work currently is relegated to a few universities. These universities are seeking investment from private industry to expand their capabilities and support increases in research. What exists shows promise but is not definitive in capability or capacity.

Short-term value to for [redacted] would lie in competitive positioning and small, profitable sales gains. Brand equity will improve. There may be significant sales opportunity for engineered phenolic microspheres in the short term in Europe and North America, but not carbon microspheres. Long term the value would rest in the ability to demonstrate that [redacted] is the dominant authority for microspheres. Both short and long term results will require aggressive marketing and application efforts coordinated with development of manufacturing and technology.

Market

In the arena of engineered materials, microspheres, solid and hollow is a niche market served by 15-20 suppliers. Both direct and distribution-based channels are used to reach the market's end users. Principia Partners issued a report March 2005 that covered this market segment.

The report provides the most definitive market value information, although I learned by their own admission they did not cover carbon microspheres and only gave passing mention to the phenolic version. Also they did not investigate the traditional applications that include reflective media for traffic paint, lightweight fillers for automotive and marine putties, and density modifiers for explosives. They ranked these as commodity markets.

The results of the study put the North American demand for microspheres to exceed $300MM with a potential 10%/year growth for the next five years. Implied in Principia comments is that this does not cover either phenolic or carbon microsphere market sizes.

They did identify eleven markets as specialty markets that had significant growth, high value potential. According to their estimates the eleven accounted for 1/3 of the market or about $100MM. These were:

- Adhesives
- Automotive underbody coatings
- Cosmetics
- Specialty coatings
- EMI shielding
- Offshore products
- Paper/paperboard
- Thermoplastics
- Reinforced thermosets
- Specialty sealants
- Wood-plastic-composites

Principia identified EMI shielding and offshore products as smaller in volume but high-value applications because of the specialty microspheres consumed. They denoted paper/paperboard and wood-plastic-composites as small markets but with excellent growth potential.

These eleven markets are said to have an average selling price "over $2.00/lb. They also pointed out the hollow glass microspheres dominate demand in these market which I am sure will not surprise the client. Next in demand were ceramic microspheres and third were plastic microspheres.

In my interviews of users, they generally consider glass microspheres a commodity item that is readily available and works without flaw for most of their applications. This would

confirm the Principia observations. While glass spheres fit the “engineered material” category they are viewed by the buyers as low cost items that are part of the bill of material. Acquisition is based upon supplier price and availability and there seems to be little brand loyalty. All indications are that 3M is the dominate supplier of glass microspheres globally.

Applications for phenolic and carbon microspheres center around advanced applications that involve extreme chemical reaction, heat, stress, and weight demands. That makes three markets primary targets, ie, aerospace, automotive, and subsurface applications. In each market these two materials offer performance improvement potential if engineered applications can leverage several or all of the performance characteristics.

The recent Los Alamos Laboratory order is atypical of current demand. The purchase was a “life of program purchase” of some 100,000 lbs. That volume of purchase is unlikely to be duplicated for years. Honeywell FM&T, Kansas City produced a carbon microsphere for this order. Honeywell also produces product for internal consumption mainly military applications. Honeywell operates a 20-year government funded project of undisclosed nature that provides the funding for this program.

Another example of market opportunity is the [redacted] missile projects for a 6.0, 6.5, and ultimately a 7.0 Mach projectile. They must reduce weight to increase fuel storage capacity while providing increased heat resistance. They have been using organic surface fillers that carburize during exposure to the heat, thus insulating the missile. It is a typical ablative application that is single use. This approach lacks precise control and thereby offers no potential to move to the 7.0 Mach model. They have evolved to considering carbon microspheres for the application and are currently testing the option.

The point is that use of any microsphere requires engineering application and development to enable commercial consumption, thus the definition of engineering commodity. Markets must be evaluated based upon engineering requirements and innovative process needs, not the microsphere itself.

Commodities have no differentiation in the marketplace except for price and availability. Engineering commodities do have a differentiation—application knowledge and assistance provided by the supplier. That application component will drive market acceptance toward the ultimate goal of specific source specification.

The final point is that consumption of phenolic and carbon microspheres will be created by supplier application engineering expertise in contrast to offering a product sheet with price and delivery information. Consumption will start in research and development laboratories targeted for high unit value low commercial value products. This skill coupled with product availability, usually small quantities for testing purposes, will win market share. This leads to the conclusion that phenolic and carbon microspheres will be relegated to single digit percentages of the total microsphere market. That trend would continue until significant applications are developed that would boost consumption.

To date the market for these two niche microsphere materials are very small because few companies supply the product on the basis of differentiated application engineering skills. Growth is metered by the user's ability to locate the sources, define the advantages, test the product and develop overall competency with the use.

When that happens, the market for phenolic and carbon microspheres will grow and will be dominated by the company that takes the leadership roll in application of the materials. In short the dominant market supplier will have provided differentiation that cannot be matched by other suppliers. Given the client's participation in the premium glass microsphere market, these two materials could provide added market reach and incremental sales.

Summary-Market

Category	Buyer	Size	Margins	Role	Supplier	Needs
Phenolic Commodity	Multi Industries	>10%	Small	Replace for performance or cost	Single Source	-Dometic Mfg. -Mfg. Process
Phenolic Engineered	Performance Industries	>5%	Moderate	Replacement for performance and carbon conversion base	Single Source	-Domestic Mfg. -Process Refinement - Appl. Engrg
Carbon Engineered	Performance Industries, esp Aeropace, Mil, Gov't	>2%	High	Replacement for premium performance	None	-Domestic Mfg. -R&D -Process Development -Appl. Engrg

Pricing

Demand and thus production of phenolic microsphere is not significant in the market. Most orders will be satisfied for evaluation applications with small amounts. The current market price for phenolic microspheres ranges from $55-$70/lb. Conversely there are prices for phenolic microspheres marketed via the web in the $5-$20/lb range, hence commodity items.

Due to the lack of other suppliers there is little limit on pricing to value instead of being caught in pricing to cost. In the case of carbon microspheres, the yields are such that minimum doubling the phenolic price is realistic. Again, pricing to value for critical applications is supported when few options are available.

Category	Price Range
Acrylic	$8-$10/lb.
Glass	$5-$8/lb.
Phenolic	$5-$75/lb.
Carbon	$150-$200/lb.

The only counter pricing strategy that could apply for such an engineered commodity is one of establishing low unit prices to remove the incentive for other firms to invest in the technology needed to develop and build production capability. This pricing strategy is only valid if a clearly superior and proprietary production capability is in place. Loss of the exclusive production superiority would undermine this strategy as volume builds, thus carries significant risk.

Summary

Except for the engineered versions of phenolic and carbon microspheres there is no significant pricing premium available for these categories.

High Value Markets

The demands for higher performance in the oil & gas industry primarily centers around improving strength to density ratios while enhancing resistance to degradation from exposure to salt water over extended periods of time. The market would seem to offer the largest early market for phenolic and unlikely any for carbon microspheres. Since 3M has a significant share of the glass spheres in this market, the phenolic version could offer considerable marketing and technical leverage for the client.

Category	Low Value	High Value
Glass	Commodity-High volume	Engineered syntactic additive-Low volume
Phenolic	Commodity-Low volume	Premium version for conversion to carbon microsphere-Low volume
Carbon	None	Engineered syntactic additive-Low volume

For the aerospace, missile and other defense applications, advanced resistance to heat at high levels of stress that normally leads to catastrophic failure is critical. In electronic applications more attention is being placed upon developing plastics that have enhanced thermal conductivity so that conventional metals and ceramics can be replaced. This is an area where carbon microspheres may succeed. Another area where carbon microspheres has been used is for advanced mold tooling needed for producing aircraft and aerospace parts.

The automotive industry has a constant battle with weight and component strength for non-metal parts. The trend favors increased use of composite and non-metallic materials where environmental concerns and material strength is key. High performance motorsports are continually working on improved carbon fiber solutions for chassis construction. For consumer oriented automotive uses, carbon microspheres may have outlets for research in brakes and engine components.

Medical applications offer an emerging opportunity for microspheres where chemical inert materials that have high wear resistance are required for prosthetic devices. There are likely applications for other medical applications such as metering medicine dosages and advanced treatment techniques for diseases might advance with innovative use of microspheres.

In all cases, penetration of these markets is dependent upon not only being able to supply a quality microsphere, but the technical assistance required to develop the application. There is no reason to have a commodity phenolic microsphere except to offset 3M share or provide a base for conversion to carbon microspheres. Likewise there is no reason to invest in producing a high value phenolic microsphere solely for the low value commodity market.

Summary

The carbon microsphere offers the highest value in terms of serving exclusive markets and creating a scenario for attractive margins that will support investment in this segment. To a lesser extent the same will apply for phenolic versions, but margins will likely be depressed. Balancing this tendency will be the likelihood of finding applications that have higher volume demands.

The commodity phenolic market offers little value other than volume and the ability to offer an alternative to glass microspheres.

Phenolic and Carbon Microsphere Suppliers

The client is familiar with the Texas Tech interest in building a pilot processing facility for phenolic microspheres. They have had limited experience producing phenolic microspheres, but Dr. [redacted] expresses confidence that he can produce a pilot operation in 6 months that has the capacity of 12lbs/hr of phenolic microspheres. His target is to produce small diameter product with excellent size control. They will also be able to produce carbon microspheres as some lesser volume with several degrees of carbon purity. They have limited experience producing either category but as you know are very interested in developing the resource.

By his own admission, they are still working with quality and yield issues. More research will be needed to produce a superior product to Asia Pacific.

Working with Texas Tech and the Lubbock community would appear on the surface to be the best option for [redacted] to initiate manufacturing in North America. It would provide a production base and research for product improvement. Many of the initial applications, especially for the carbon microspheres will be early stage development so this would add to the value delivered to the customer. The concern should be linking a commercial enterprise to a university program. A university professor's goal is always to publish papers, not ship product.

[redacted], spokesman for CQ Technology, Asia Pacific Microspheres confirmed they produce phenolic microspheres, but no longer have a conversion source for carbon microspheres. They used Carbospheres, Inc, Fredericksburg, VA, PO Box 8119. Contact voice mail phone number is 540-898-4040. No reply has been received. Mr. [redacted] stated that their source is no longer in business and have not plans to integrate carbonization into their present business. They would be interested in any proposal.

Honeywell, FM&T, Kansas City produces carbon microspheres from phenolic versions and will cooperate with any firm interested in commercial expansion for use of the product. [redacted], Honeywell, South Bend, IN (574-231-2986) is the contact for Honeywell.

Foxfire Enterprises, Pocatello, ID 208-237-7976 has 80 drums @ 50lbs each priced at $125.00/drum. This is NASA surplus material purchased for the Advanced Space Shuttle Project. The government paid $125/lb for the material new—it is now surplus priced at a fraction of the original value.

[redacted], CEO of [redacted] Industries, Fort Collins, Co (970)-207-1720, ext 118), has produced limited amounts of carbon microspheres from a coal tar pitch pyrolyzing process. Scion is a producer of foam shapes, tooling and other fabrication services. In the process of manufacturing aerospace mold tooling, they needed carbon microspheres.

He claims low cost of production with 80-90% yield. His process would require funding to develop a reliable production system. He sited all the technical problems others have

discovered in attempting to product carbon microspheres. Mr. [redacted] reported production cost of $0.70/lb and 80% yield. He also admitted that it was a labor intense process at this time if quality microspheres were required.

[redacted], Tuscon, AZ has also produced carbon microspheres from a phenolic source. They have the capability of developing the technology for phenolic and carbon microspheres, but it would require significant investment. Currently they provide carbon foams for the oil industry, but use solid carbon spheres. Mr. [redacted], (520)-[redacted] has an excellent grasp of the technology required, but little motivation to pursue commercially. As do others, he observes the market for carbon microspheres is solely in the aerospace and defense industries.

He did confirm that Asia Pacific did not deliver the quality of microspheres they advertise.

Another involved university is the University of Alabama-Birmingham. I have had discussion regarding microspheres with Dr. [redacted] (205)-[redacted] regarding their involvement. They are focus upon physical properties of microspheres. They are in the process of publishing papers about the characteristics and properties of phenolic and carbon microspheres. They will be forming a special investigative section for syntactic investigations as a result of interest found in their works. They have little to offer regarding manufacturing or the marketplace, other than to measure results of others work. He did note that he has done work for 3M regarding glass spheres. If the client was to pursue development of microspheres it would be helpful to employ their knowledge and laboratory expertise.

Summary

Participation in either the phenolic or carbon microsphere market will require development or otherwise acquiring manufacturing capacity. Since there are obvious negative aspects of acquiring Asia Pacific facility, one must be established in North America or Europe. Producing carbon microspheres are not necessarily locked to securing an engineered phenolic microsphere, but would require investment in an R&D and a manufacturing site.

Technical vs Marketing Need

All of this analysis boils down to the question of strategic value phenolic and carbon microspheres offer [redacted]. You cannot answer the investment question regarding Texas Tech or any other source until the value of superior market position and branding is explored. Deciding to be the only North American source for these two niche engineered materials has no relevance other than to relate to the government's desire to have a domestic source for a pseudo-strategic material located in an off shore location with a tattered reputation. It is a typical cloud that other critical material's supply has successfully operated under for years without having significant domestic manufacturing capability.

Of course it is understood that the acquisition of technology and sales effort will likely go hand-in-hand. It is important to value the marketing aspects for entering the phenolic and carbon microspheres and not just focus upon the technical implications of such a project.

Two components of industrial products are key—selling the product and then protecting the product's market position to build a solid sales base. Also it is important to understand that in today's markets the most powerful sales argument is reduction of risk to the customer. In selling an engineered product, especially a commodity product, it is critical that a company is strategically positioned to leverage each of these components and add the argument that your business relationship offers the lowest risk to the customer.

Solution	Payoff
Technical-Acquire mfg capability in NA and fund development of the process	• Exclusive NA manufacturing capacity • Ability to sell and ship phenolic & carbon microspheres
Marketing-Expanded product base with engineering application superiority	• Accelerated share gain • Incremental sale of glass products • Brand identification as leading technical solution for microspheres

Having a single solution, in the case of the client, a selection of glass-based microspheres does not meet either criterion nor does it speak to low customer risk. Price and availability can always be matched or beat by a competitor and since it is viewed as a commodity there is no risk of switching suppliers at any moment. Sans clear differentiation in these categories there is no stability. Only a firm's clear application engineering superiority is differentiation that makes achieving the sale and protecting the sale a commodity feasible. The customer will not risk loss of the differentiation.

[redacted] strategic position would enhanced by offering not only glass but phenolic and carbon microspheres. Application opportunities would be expanded; offering premium application materials could protect the base business; and the customer

would be assured that they are working with the most knowledgeable and competitive firm in the marketplace.

This superior product offering then enhances brand recognition for [redacted] as well as the market value of the company. The math is simple—a firm with three advanced engineering materials is more valuable than one with a single material.

Summary

These two product categories and the markets they serve create a paradoxical situation. The entry question requires a balance of policy decisions for both the technical aspects and marketing implications. Paradoxes are never solved by maximizing one issue, but by finding balance among the best of several options.

Recommended Actions

If the corporate objective is maximizing profits and return on invested assets, these two markets offer limited reward for the risk needed to acquire a position in the market. On the other hand, if market position in the microsphere market past glass is a corporate objective, then these two markets would be the best investment opportunities.

[redacted] uses the phrase "engineering excellence in a global market" as a defining statement in its literature. From that strategic perspective [redacted] should proceed to secure sourcing of phenolic and carbon microspheres in North America. There should be clear technical and marketing objectives settled within the organization so that this entry can be productive rather than abortive.

This recommendation would enable establishing [redacted] as having the highest market value because of its differentiated position via offering microspheres made from multiple high performance materials. Engineering and technical superiority as opposed to manufacturing capability are always value builders in commodity markets.

Without a clear strategy, investment of time, talent and financial resources for technology development would be a poor option. Technical commitment would be only part of the solution.

APPENDIX

Case Study-Industrial Diamond Cutting Tools

The similarities between a previous client and the Emerson & Cuming situation are so similar I wanted to relate their experience as a way of illustrating the observations I have made in this report.

My client developed a new technology for depositing diamond on tungsten carbide tools (CVD). They based their business model upon displacing the current commodity diamond tools (PCD) by proving lower tool costs via superior performance. The strategy did not work for two reasons; (1) superior performance was difficult to prove in all cases, and/or (2) cost savings did not always offset the risk of changing to the new technology. They were struggling in the marketplace because every lost customer opportunity was without an alternative and the quite frankly looked like a looser that had bet on a new technology that was not paying off.

I recommended a new strategy. First, acquire the existing commodity PCD. They did that by purchasing a small Midwestern company that had a good product line and limited sales. The other recommendation was to acquire the third of the three diamond technologies called TFD. They found and purchased a small Canadian research company--the only in North America. Both were very leveraged purchases.

Their model changed from a single engineered material source to one with all three sources. Their model changed from replacing existing PCD to one offering engineering expertise that would find the best solution, even if that meant just improving the existing product's performance with comparable product. If that did not work, they still had two other options to offer. No other competitor in the marketplace had that differentiation. They moved from having to change a customer's buying habits entirely to improving the customer's performance with some modified behavior. Lower risk, more reward.

The value and differentiation they created accomplished three important goal, increased sales, profitable operations, and outside investors that would support further development. They now have a Japanese and a US investor/customer and are a going enterprise with a solid future. I hope so because I bet part of my fees for my recommendations by accepting stock as partial payment. I think it was a good bet.

Bottom line, industrial commodity products will always struggle until both engineering excellence and multiple solutions are offered to the customers. Then you have leverage and real differentiation.