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Custom Design & Manufacturing

Strategies for using nanomaterials in product development

Article by: Landon Mertz, CEO, Cerion Nanomaterials

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Landon Mertz, CEO of Cerion, looks at the options for bringing nanomaterials from development to commercialization.

The benefits of nanomaterials are in the unique behaviors they exhibit at nanoscale. How these are leveraged in a product can add significant performance benefits. However, as with all advanced materials, to bring a nano-enabled product to market one must consider the product development roadmap from beginning to end. Planning today for successful commercialization tomorrow is key.

An often-overlooked aspect of working with nanomaterials is that one size does not fit all. Off-the-shelf materials are rarely a ready-made solution to achieve specific research goals. The design of a nanomaterial can radically alter its behavior, and small changes (no pun intended) can have an outsized influence on its performance.

Thus, if you are not seeing the experimental outcome you expected in your lab testing, your theory could be wrong, but more often than not a myriad of other issues are inhibiting or negating the material's performance potential.

Nanomaterial size, size distribution, mono-dispersity, morphology and surface functionalization can directly affect performance if it is not designed specifically to fit the application. If they are delivered via dispersions, the choice of surfactant and solvents can also play an outsized role in material performance.

Most nanomaterials are incorporated upstream into more complex systems. The process of incorporating them into a product could be fundamentally altering the particle's design or performance. Finally, the material could be interacting with other components of the product in unintended ways, creating a cascade of second and third order impacts.

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ACCESSING SUPPORT

The options for accessing nanomaterials from the market are varied, and the decisions made by product development teams will dictate the critical roadmap for commercialization. A foundational question that often comes up during product development is whether building nanomaterial expertise should be included in the scope of a product development programme. This decision is specific to each organization, their strategies and goals.

When developing nanomaterial competency in-house, it is critical to understand that this requires an organizational commitment financially larger than the scope of product development. Expect to make significant, on-going investments to build specialized nanomaterial design, scale-up and manufacturing expertise. This will include synthetic design, material characterization, quality assurance, quality control, engineering and significant capital investments in equipment.

These factors, risks and costs all need to be incorporated into the product development roadmap. Given the level of investment and the opportunity cost, most teams prefer to outsource their access to nanomaterial expertise. If so, it is important to understand your options.

LAB-SCALE PROVIDERS

Lab-scale materials can be sourced from catalogue companies like Sigma Aldrich, Alfa Aesar and Strem Chemicals. These will usually be a strong fit for basic research, where proving fundamental science is the goal. However, given the aforementioned nanomaterial design considerations, keep an open mind that these materials may not perform as desired.

If you are not achieving the results you expected at this stage in the lab, you could waste a lot of time finding out whether your experimental hypothesis or the design of the material is the problem. Typically, these materials are supplied to catalogue companies by small research organizations, who rarely have significant scale-up, manufacturing or QC capabilities.

Universities can be a cost-effective option for creating custom materials, though, again, they are usually best suited to blue-sky basic research. Due to the academic year and the use of student researchers, a more flexible timeline and approach works best here. This may or may not be aligned with your commercial priorities.

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Typically, lab-scale materials are made by researchers who do not have experience designing materials with scale-up, manufacturing or production costs in mind. This is perfectly fine for basic research, but you will need to find a commercial company later who can produce the material. Plan for additional investment in time and resources accordingly.

In the best-case scenario, the university researcher's process will require modifications to its formula and process conditions to make the material cost-effective for manufacturing. The median case scenario will require a completely new synthetic method to make scale-up and manufacturing possible. The worst-case scenario is that the transition from lab to manufacturing is neither practical nor cost-effective. These scenarios all can impact your product development roadmap timeline and budget.

COMMERCIAL PROVIDERS

There are two types of commercial nanomaterial providers who represent the fastest and least expensive pathway to sourcing your present and future needs. Your specific product development goals will inform which makes the most commercial sense.

Commercially off-the-shelf manufacturers are already making a specific nanomaterial in bulk either as a tolling service, or to solve a specific industrial challenge (e.g. nano-zinc oxide for sunscreen). In either case, these firms tend to want to 'sell a SKU' to the widest audience possible. Customizations are not usually a priority for them.

Custom nanomaterial manufacturers are fewer, but they typically represent your best opportunity to access the material you desire with the exact specifications required for your product. They will have some or all the technical, engineering

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and manufacturing expertise in-house to design and manufacture nanomaterials. The best will have a comprehensive and repeatable processes for meeting the ongoing needs of their customers.

WHAT TO LOOK FOR

The nanomaterials industry is still relatively young. While these materials have been explored for decades in the lab, their use in commercial products only began to accelerate within the last decade. Within the industry, this has resulted in a broad distribution of company models, technical and production sophistication as well as financial maturity.

Prior to selecting a nanomaterial provider, good due-diligence is required – typically with an eye for evaluating the breadth, depth and maturity of the provider. There are a few key things to consider, beginning with commercial relevance. A quick way to screen potential providers is to understand the companies they currently support and in what capacity (lab work, manufacturing or both).

Technical and production capability are also vital. Since commercialization is the goal, you will want to ensure that your provider can meet your current and future design, scale-up and manufacturing goals – as it will have a big impact on the critical path towards getting to market. Among the key practical issues here are:

- Experience with a specific material, class or classes of materials (e.g., metals, metal oxides, ceramics)
- The number of synthetic routes in-house to manufacture a material and their experience working with these routes
- Level of precision and degree of control over a variety of both size and non-size related material attributes
- Existing pilot, low-volume and high-volume manufacturing capability

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Finally, the firm should have financial maturity. Given the youthful nature of the industry, many companies currently run financial losses and depend on investor capital as they seek to monetize their technology. Product development is a multi-year effort and you need to be assured that your nanomaterial provider will be there to support you in the future.

Equally important is the provider having the capacity to invest to meet your future production demands. Does the production capability for the nanomaterial you require exist at the provider's facilities? At what scale? Does the provider need to raise capital for future expansion in order to meet your commercialization goals? Have they demonstrated experience scaling up to larger production volumes?

Characterization expertise is absolutely critical to all aspects of nanomaterial design and manufacturing. The absolute bare minimum capability for nanomaterial design and QC includes capabilities to evaluate size, size distribution and % solid (for dispersions). A more comprehensive analytical capability includes TEM, SEM-EDS, SLS, EDS, XRD, XRF, TGA, DTA, GC, ICP-MS, Zeta potential, BET and others.

Due to the high upfront cost of equipment and the on-going cost of dedicated analytical personnel, more youthful companies tend to under-invest in this area. Instead, they rely on third-party commercial labs or universities. This will increase the overall cost of product development. It will also increase the time required, since nanomaterial design relies on many rounds of analytical learnings created from prior experimental data.

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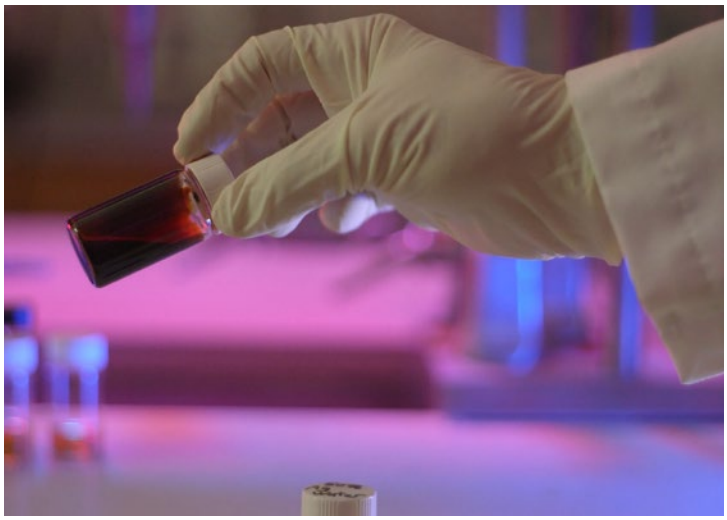

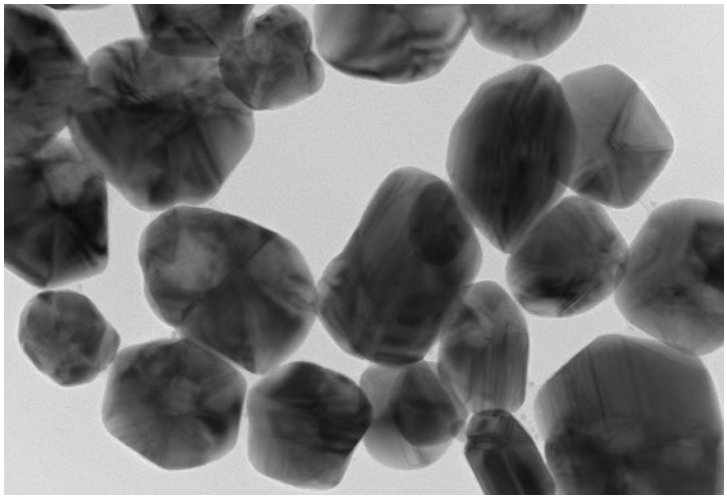

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IP

Intellectual property (IP) rights between companies can be a thorny issue to work through, though it does not have to be. Each nanomaterial provider will have different positions with respect to IP.

As a product development team, your goal is to create new innovations that provide a strategic competitive advantage in the marketplace. Protection of key IP is core to creating this advantage. You must look for providers with established IP positions. The best outcome will be one who is not looking to own or co-own the IP around the composition of the material for your intended field of use.

Typically, as the customer, you should not expect to own the manufacturing process for making the composition, which will rely heavily on the provider's IP. However, a good provider will be able to manufacture on your behalf or will provide a clear and concise means for you to use their process-based IP through a license.

Competition can be problematic. Be mindful of providers who are developing products enabled by nanomaterials and also selling design and manufacturing services. For many product developers, there is a risk (perceived or real) that their provider may try to monetize their confidential information in some way, shape or form.

To avoid this risk of competition, you are better off working with a firm who has a clear policy of focusing only on nanomaterial design and manufacturing and not product development; has years of operational history to prove it; and is willing back its policy up with straightforward contractual language.

Need consultation on a project? Contact us.

Chris Skipper, EVP Commercial Sales

+1.585.294.4958 | chris.skipper@cerionnano.com

Customers

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