Quotes from Participants during the Reception at the Nanomaterials and the Chemical Industry Roadmapping Workshop, October 1, 2002:

"One of the impressive aspects of this nanotech workshop process was that the different working groups have very similar concerns. There are still a lot of unknowns relative to the characteristics and performance of nanoparticles in production, assembly, scale-up, and so forth. There is a growing body of knowledge on nanoparticles that work for certain applications, but not a lot of knowledge on why they work or how they are made. The workshop participants have a high level of enthusiasm for the prospects for commercialization and use of nanoparticles, and I certainly believe the effort at this meeting has great merit in helping to focus the attention of government and other funding sources on where the funds for nanotechnology commercialization can be most effectively utilized."

"Attention to potential applications is very important. We need to accelerate applied research and development to get products into the real world where they can benefit humankind. That means funding practical work in areas that so far have not seemed to get much attention, handling, shipping, materials safety, knowing how material will react in different environments, etc. The practical exploitation of nanotechnology will take a lot of work and a lot of funding."
Bill Sanford, Chairman and CEO, NanoScale Materials, Inc.

"Commercialization is a huge hurdle. Nanotechnology is very exciting and interdisciplinary—it brings together engineers, physicists, chemists, and entrepreneurs. For years, funding has gone into exploring nanostructures and properties, but as we move to scale-up, processing, and other areas typical of manufacturing, there are still many unknowns: safety issues, materials handling, process monitoring and control, operations, and novel concepts. Another thing that makes it difficult is that many markets don't exist. You might serve some existing markets by producing the product at lower cost or with less material, but there are so many products that people imagine might be created, and there are no markets yet—so to break into that is even more difficult. This meeting has highlighted what we need to do."

"There are some hurdles to go over, but we're going to make it eventually—there are just too many good things that could come out of nanotechnology."
Kenneth Klabunde, Vice President and CTO, NanoScale Materials, Inc. and Professor of Chemistry, Kansas State University

"In addition to large corporations, different perspectives were brought in by smaller start-up firms and academia too. Although our group (Manufacturing) had a number of people who represent "mainstream" nanoparticle producers, others in the room were working on carbon nanotubes, which have very different scale-up issues, productivity, and applications. Still others were coming from the NEMs/MEMs point of view, and they don't think in terms of individual unit manufacturing operations typical of the chemical industry but more in terms of concerted manufacturing methodologies linked intimately to applications, or devices—it's kind of an integrated process coming from the electronics industry. At times we had to step back and say "Is this specific to one of these processes (nanoparticles, nanotubes, etc) or is it more generic? Where are the common denominators as far as the needs of the nanotechnology manufacturing community?" The point is that there is no nanotechnology manufacturing community. There are people doing vapor phase processes, others doing wet chemistry, and others doing totally unrelated processes."
Frank DiStefano, Manager of Product Research and Development, Air Products Polymers

“There is quite a diversity of products, but a lot of striking similarities in how you get to those final products. A large number of key steps are very similar. That was one of the reassuring things. Despite all the novel areas and the disparity, there are still some common approaches and themes that we're all up against. We need a collective way to tackle them.”
Frank Lipiecki, Director of Engineering Technical Center, Rohm and Haas Company

“The first thing is that Melissa did a superb job in the organization. A number of people have come up to me and said this is a wonderful workshop. The interactions were great, so I really want to acknowledge the work that she did. I'd also like to acknowledge the work that the Planning Committee as a whole did. We have about seven or eight people who really put in a lot of time, and I think it will show in the product.”

“I see that all the panels from the various workshop sessions say nearly the same thing. They're all interrelated. One cannot do manufacturing, for example, without considering the material that you're manufacturing; one cannot understand ordered nanostructures without having tools or without doing simulations. Every topic builds upon the other, and they're all interrelated. In order for us to have value in these products, we have to consider all of these elements. We can't break them apart. We can't go to NSF, for example, or to DOE or ARPA, and say we're going to focus on this one area and get you an application. We have to utilize all of the different skill bases and all the different disciplines as well, to get somewhere. The entire science has to be brought along--and there are gaps in every area. Even in areas that are closer to commercialization, we still have substantial gaps in our understanding and in our ability to manufacture. Each group has identified that as a common theme—these gaps.”

“No single entity type is going to be able to do all of the things that we need to do. It's going to require the skills of people in industry, people in academia, and people in government labs—researchers in each of those places. For example, if we want to think about manufacturing, we have to couple ourselves closely with some of the DOE labs that are now being built up as manufacturing sites. If we want to think about metrology, industrial people are going to have to interact with people at NIST. So no longer is this a single company doing work—it's collaborative in that aspect also.”

“There's an infusion of money to small companies through SBIR grants, but larger companies often have to develop these things on their own, and then the interest and willingness to share is not there—it's proprietary. So it becomes a balance between advancing the science and the technology or making a profit for a company.”
Judith Stein, Polymer and Specialty Chemical Technologies Laboratory, General Electric Company

“In general, it’s a great collection of industry people focused on the right problems. I think most of the participants are fairly confident that the output from this is going to be a big help in getting this thing moving in the direction that it needs to move.”

“My group had a good balance of small companies with innovative processes and a group of larger companies that are all making chemicals in large volumes. The challenge is how do you take what they know, in many cases, and take what we’re providing in terms of new technologies and bring it together. This whole roadmapping effort is about how you take that new nanotechnology and get it into the main stream as quickly as possible to get the benefits. There are huge benefits to come from it. It’s actually the people in this room that could pull this off if there were a way to get things organized and everyone working together. Some of the things that came out of this workshop speak to that.”

"Broader representation by small, venture-backed companies—companies that will have a huge impact on the future of this industry—might put a very different perspective on these time scales. A lot of key technology is being spun out of universities in the form of venture companies. Long term for a venture company is two months to two years, and long-term for any of the big companies can be five to ten years. It makes for very different perspectives. A 15-year development time frame before pulling in revenue is simply not an option for a small company!"
Randy Bell, Vice President, Sales and Marketing, Nanotechnologies, Inc.

"I've been very impressed with the layout of the whole workshop because these things are very difficult to do and that's obviously a key competency or skill set of your firm."

"One of the reasons we're interested in moving ahead with some of these issues is the lack of standards and the lack of understanding about nanoparticles. Nanoparticles themselves don't have any value until they've been incorporated into films, composites, or materials—and it's the understanding of that process that's needed. Each of these groups has addressed that in different ways: the need for better characterization, better modeling, better dispersion processes, and manufacturing. We need standards in all of those areas to create a common language and facilitate integration."
Denny Hamill, Vice President, Business Development, Nanotechnologies, Inc.

"I was really amazed at how the group came together. We worked really well together. What I thought was most interesting was that some of the ideas that people thought would be real stretches at the beginning of our discussions were seen as do-able by the end. One of those was the idea of having a tomography-type instrument that would be able to provide a 3-D image at the nanoscale. At the beginning, we thought that would be impossible, but then we thought we could see being able to do that in 10 to 15 years. We had physicists, engineers, and chemists from varied backgrounds, and the synergy of the group brought us a lot closer to understanding where we need to go."

"At one point, we did have to stop and benchmark the state-of-the-art for each tool. There was a lot learning that went on in a very condensed period to get everyone on the same page."
Catherine Hunt, Leader of Competency Networks and Technology Partnerships, Rohm and Haas Company

"I feel the session was very valuable. It was nice to be able to get together with peers from industry and express similar concerns in a pre-competitive way. Although we'll ultimately work on different products, we were able to see that we could connect and that on a root, scientific basis we have a lot in common. It's nice to see which industries are really interested in nanotechnology. Ten years ago this seemed like a laboratory curiosity and it's exciting to see how far things have come along."

"In the Simulation and Modeling group, the primary goal we came to pretty quickly is that we are looking to be able to predict the performance of nanomaterials across both time and length scales. A lot of simulation work is at femtosecond time scales, and we need to be able to understand the performance at long time and length scales that humans can perceive. Going from the atomic behavior to the nano-scale and then all the way up to a macro product, requires sophisticated analysis, and there are a lot of gaps in the knowledge."
Rajeev Gorowara, Senior Consulting Engineer, Particle Science & Technology, Dupont Engineering Technology

“We have tremendous enthusiasm and a very high level of technical knowledge here. The small companies are very pleased to be able to exchange viewpoints with people from the large companies, and I'm hearing the opposite comment from the large companies; they're very interested in hearing from the smaller companies. So we've got a good mix, which we worked hard to do.”

“From the standpoint of work output, we're at first base. But I think some really high-potential things have been identified. The Manufacturing group did an excellent job because, in many ways, manufacturing in nanomaterials is at a very primitive level and small scale. Figuring out what R&D to do from that standpoint is relatively difficult, but they did a great job.”

“We have a lot of interesting R&D that we're going to recommend. I think all the groups have had some struggles simply because the processes and products are less obvious than for more mature industries. The reward is relatively greater if you pick the winners, but it's harder to figure out. It's fun though—that's part of the challenge.”

“The Integration group identified two opportunities. In an early field like this, where the knowledge is not all in one place and it can be difficult to find references; one suggestion is to create a knowledge infrastructure. As these things get figured out, they can be placed in this infrastructure, which might be a database. A start-up company could then go to this knowledge infrastructure and figure out exactly how to do whatever they need to do. The other problem the Integration group identified is that nanomaterials as such are of no use—they're too small and will probably decompose or react. You have to take the nanomaterials and put them into something and structure them so they interact with the real world in an effective way. Our other recommendation is to have a concentrated R&D program that can develop the capability to take a nano-size material and incorporate it into something that’s real-world size so that it can be manipulated and used. This means develop the tools to incorporate nanomaterials into useful structures.”

Jack Solomon, Director of Technology Planning, Praxair, Inc. and Chair of the Chemical Industry Vision2020 Technology Partnership (Vision2020)