Project on Emerging Nanotechnologies – Consumer Product Inventory Evaluated

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Abstract

The Project on Emerging Nanotechnologies (PEN) product database began in 2005. The PEN Consumer Products Inventory (CPI) has been frequently cited in scholarly and popular articles as well as reports from government and industry. The CPI has been used to establish a baseline or benchmark on the pervasiveness of products produced by nanotechnology and/or incorporating nanoparticles. In this article, a team of researchers examine and validate a sample from the CPI involving four prominent categories of nanoparticles (carbon, gold, silver, and iron). The authors conclude that the CPI has substantive deficiencies that call the validity of claims associated with the CPI into question. Individuals and organizations citing the CPI should be wary of over-claiming the reliability and validity of the presence of nanotechnology in consumer products.

"Bis Repetita Placent."

("The things that please are those repeated.")

1. Introduction

The Project on Emerging Nanotechnologies (PEN) product database began in 2005 and was supported by The Woodrow Wilson International Center for scholars and the PEW Charitable Trusts. As part of this initiative to encourage information sharing and public engagement associated with the costs and benefits of nanotechnology, PEN supported nine categories of information regarding nanotechnology. These included nanotechnology and the environment, health and safety research, and nanotechnology medicine, among others. The Consumer Product

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Inventory (CPI) is one of their deliverables and is the focus of our research. The conclusions we've drawn about the CPI do not necessarily reflect on any of the other projects.

We conclude below that the CPI is not wholly reliable, and does not have sufficient validity to justify its prominence as evidence for claims associated with the pervasiveness of nanotechnology on the U.S. and global markets. In addition, we caution researchers to approach the CPI with care and due consideration because using the CPI as a rhetorical flourish to amplify concerns about market intrusions seems unjustified.

Consistent with the mission of North Carolina State University's (NCSU) Public Communication of Science and Technology project (PCOST) to improve public communication on science and technology and supported by a grant from the National Science Foundation[1] to better understand how the public decodes complicated data on risk, we dedicated a portion of our research agenda in 2010 to the CPI. We were motivated by the frequency that the CPI was cited in reports and articles discussing nanotechnology.

The CPI details over 1000 consumer products purportedly involving nanotechnology (read by most as nanoparticles). This database is described by PEN as "the best available look at the 800+ manufacturer-identified nanotechnology-based consumer products currently on the market."[2] The associated disclaimer page contextualizes some of our concerns on reliability. The disclaimer highlights the purpose of the database which is "to stimulate discussion and comment about the emergence of nanotechnology in commerce." Moreover, the website renounces all responsibility and liability for any safety issues associated with listed products, consequences resulting from the use of the information found on the inventory and linked websites, as well as "liability for, damages of any kind arising out of the use, reference to, reliance on, or performance of such information." In doing so, the project thus emphasizes complete disassociation from the information, products, and manufacturers mentioned in the database.

The PEN CPI website provides three criteria that should be met for product inclusion in the CPI database. These criteria include: products that can be readily purchased by consumers, products identified as nano-based by either the manufacturer or another source, and whether nano-based claims for the product appear reasonable.

Notably, a disclaimer in the product selection portion of the inventory admits that some products in the inventory may not actually use nanotechnology which is surprising. Furthermore, it confirms: "we have made no attempt to verify manufacturer claims about the use of nanotechnology in these products, nor have we conducted any independent testing of the products." Additionally, the project highlights that the inventory is solely based on information that can be readily found on the Internet. As such, non-Internet indexed products have not been included in the list consequently omitting all nanotechnology manufactured products without an online presence.

Major concerns have surfaced with regard to the reliability and validity of the product information provided within the CPI database. Are these products actually marketed? Is the database updated and if so, how? Do these products truly use nanotechnology? What does it mean when a product description mentions nanotechnology? Does it mean the product is composed of

[1] This work was supported by a grant from the National Science Foundation, NSF 06-595, Nanotechnology Interdisciplinary Research Team (NIRT): Intuitive Toxicology and Public Engagement. All opinions expressed within are the authors' and do not necessarily reflect those of the National Science Foundation or North Carolina State University.

[2] *See* Project on Emerging Nanotechnology, Consumer Products Inventory, http://www.nanotechproject.org/inventories (last visited April 16, 2010).

nanoparticles? How likely are those products to directly affect consumer health and safety? We examine these pertinent issues below.

2. The Ubiquitous Pen Inventory

The primary reason for analysis of this database is that it is widely used as a source of information regarding nanotechnology products by government, industry, non-government organizations, civic groups, media critics, and researchers. Without much forethought, researchers have referred to the tally of products on the consumer products listing as if it is valid. A Google Scholar search using the descriptors—PEN, CPI, consumer products, and nanotechnology—produced over 700 academic publications citing the PEN Consumer Products inventory. A standard Google search produced over 13,000 hits. While there are a high number of duplicate hits, it is safe to assert the PEN CPI has had a substantial effect on the discussion over the marketing of products using nanotechnology. Not all colleagues represent the CPI as definitive; some are cautious and refer to it as a sampling. Regardless, how the CPI is read within the context of an argument suggests that both the public and colleagues within the field use more guardedness.

3. Methods

Content analysis methodology was used to examine the information provided within the PEN database. A systematic random sample was used to examine the product inventory between 01/11/2010 and 01/28/2010.

The search feature within the CPI titled "words in product name, or description" was utilized to identify products to code using the search terms: carbon, gold, silver, and iron. The propensity for nanotechnology reporting to focus on these four prominent categories of elements led us to select them for our sample. After maintaining a set of blogs on developments in nanotechnology, we are secure in this choice.[3] We validated our selection and study of these four elemental categories with search data from the Internet. There are over two million Google hits for carbon and nanotechnology, one million search hits for gold and nanotechnology, nearly a half million for silver and nanotechnology, and over half a million for iron and nanotechnology.

All products in the CPI in these four categories were coded. We ran a second truncated set of ratings to demonstrate reliability. Inter-rater reliability was assessed using Cohen's Kappa for 10% of the sample in order to determine consistency among raters. Cohen's Kappa= .73 ($p<0.001$) indicating strong agreement between raters.[4]

Utilizing content analyses methodology the study incorporated and reviewed 82 products that referenced carbon, e.g., carbon black, fullerenes, and nanotubes), 27 products with gold, 258 products including the term for silver (e.g., ions, colloids, nanoparticles), and 24 products referencing iron.

Each product in the CPI was coded for the following variables: product name, company, product category, country of origin, availability (is the product available for purchase), countries where the product may be available, what elemental type of nanotechnology was employed or constituted in the product (e. g., carbon, gold, silver, iron, etc.), distribution channel, whether the source link was functional (source link is a term used by the CPI to indicate reference and it was often redundant with the product website), whether the product website was functional, whether it utilized

[3] *See* Nano News Update: Breakthroughs, Newsworthy, and Honorable Mentions, *at* http://nanonewsupdatehome.blogspot.com.

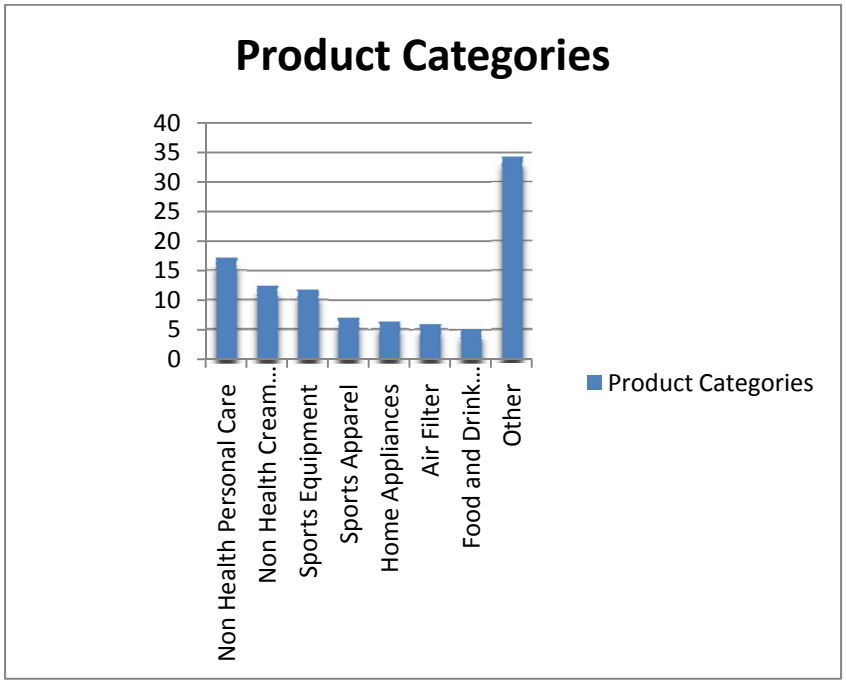
[4] *See* Jacob Cohen, *A Coefficient of Agreement for Nominal Scales,* 37 EDUCATIONAL AND PSYCHOLOGICAL MEASUREMENT 20 (1960).

nanotechnology (determined against claims from the website or source site), and if it was included on EC21. EC21 is a business to business (B2B) product listing website. The EC21 website was linked to 15% (N= 61) of the products. EC21 is the world's largest B2B marketplace to facilitate online trades between exporters and importers from all around the world.[5] EC21 further asserts that it covers over 240 countries and provides information to over 900,000 buyers.

The main purpose of coding these variables was to assess the reliability of the information provided by the CPI in order to discern whether this database represents an accurate inventory of nanotechnology based consumer products. We visited each of the websites linked to a product in the CPI in the sampled classes.

4. Results

We found that the largest product categories associated with carbon, gold, silver and iron represented in our sample was non-health personal care, which represented 17% (N=67) of the total number of products. Non-health personal care products include blow dryers, hair curlers, earplugs, brushes, denture cleaners, and other items.



The second largest product category consists of non-health products like creams and sunscreens, which accounted for 12% (N=49) of the total products analyzed. The third most prevalent product category was sports equipment at 12% (N= 46). This category included baseball bats, golf clubs, tennis rackets, shin guards, bicycles, etc. The fourth most frequent nanotech product category included sports apparel 7% (N= 27). Home appliances (vacuum cleaners, air conditioning units, washing machines, espresso machines, and shoe storage units) represented only 6% (N= 25) of the total sampled products. Air filters - 6%, (N=23) and food and drink packaging -

[5] *See* EC Website, *available at* http://www.ec21.com/html/ec/AU/AU_Overview.html (last visited April 12, 2010).

5% (N= 20) were among the most prevalent categories of nanotech products. The "OTHER" category was composed of a variety of products including: home cleaner and/or laundry related items - 4% (N= 16); non-sports apparel - 4% (N= 16); water filters - 4% (N= 16); industrial coatings, sealants, inks, and paints - 3% (N= 13); electronics and computers - 3% (N=12); drinks and food - 3% (N= 12); industrial materials - 2% (N= 9);home linens - 2% (N= 8); health supplies - 2% (N= 8); children related items and toys - 1% (N= 6); health vitamins and supplements - 1% (N= 5); miscellaneous - 1% (N= 5); automobile fuel - 1% (N= 4); industrial cleaners - 0.8% (N= 3); and home furnishings - 0.3%, (N= 1).

Next we analyzed the category of "propensity for human contact" with nanotechnology based products. We decided inhalation exposure may be possible in the production and fabrication of these nano based products, however, we excluded this category in our determination as every product would risk this exposure. Since consumers are meant to handle most of the products, it is not surprising that nanoparticles might slough off through consumer contact thereby accounting for the prominence of dermal exposure. We are using the most liberal interpretation of lifecycle data analysis assuming mere handling as an exposure route.

Human Contact		
Type of Exposure	**Frequency**	**Percent**
Dermal Only	287	73.4
Ingestion, Dermal	64	16.3
Inhalation, Dermal	23	5.9
Inhalation Only	12	3.1
Ingestion, Dermal, Inhalation	3	.8
Ingestion Only	2	.5
Total	391	100.0

These subcategories are highly speculative and absent exposure and dosage data, the information collected on the potential route of human contact provides minimally useful data on risk associated with product use.

Dermal only contact represented the most common exposure that humans would have to the products in our sample 73.4% (N= 287). Ingestion and dermal at 16.3% (N= 64), and inhalation and dermal at 5.9% (N= 23) are the second and third most common route of exposure indicating that dermal exposure may be the most prominent form of exposure. Once again, we are not suggesting any risk associated with these exposure pathways. Rather, data should be drawn from the multitude of environmental health and safety (EHS) studies completed, underway, and under consideration.

Several characteristics of the companies were also analyzed such as where the companies are located and what type of distribution channels they employ. The top five countries with companies that have products on the CPI list include: the USA with 48% (N= 187), Korea with 26% (N= 102), and China with 8% (N= 32). The remaining countries with 18% (N= 12) constituted "OTHER" (led by Taiwan with 4%, and the UK with 3%). The "OTHER" category also included unknown country of origin.

In relation to the individual product availability, we found that 49% (N= 193) of the products were available and that their availability was verifiable. Unavailable products represented 20% (N= 80) of the sample. For the remaining 30% (N=118) of products, we were "UNSURE" in terms of availability. This category of "UNSURE" was applied to products that were linked to nonfunctional websites and source links. Also, "UNSURE" was utilized if there was limited information on how and where to purchase the product (e.g. credit card information). Finding information from product websites and source links was challenging. Many of these sites were not functional. We found dysfunctional product websites 19% (N= 76) of the time and dysfunctional source links 18% (N= 71) of the time. Lastly, products indicated as "NEW" represented 11% (N= 44) of the total product sample under analysis.

The next set of categories involved the elemental types of nanoparticles and nanotechnology. If the CPI reported a product allegedly including one of these elements, it was included in the data set.

Carbon

The continued innovation of carbon nanotechnology has played a major role in shaping new nanotechnologies and has created a truly interdisciplinary field encompassing chemistry, physics, biology, medicine, material science, and engineering.[6]

Eighty-two products included the search term "carbon" and represents about 8% (N=82) of the total number of products in the database. In reference to availability, 47% (N=38) of the products found using the search term "carbon" were available, 26% (N= 21) were not available, and 28% (N= 23) of the availability of those products was unclear. Additionally, 80% (N= 66) of the source links to carbon products were functional. Similarly, the product website links of 75% (N= 62) of the carbon sample were operational.

Most often, carbon was reported in terms of single-walled and multi-walled nanotubes, fullerenes, and even some cellulosic derived nanotubes. In many applications, carbon nanotubes were integrated into a polymer.

We were surprised to learn of products which purportedly used carbon nanoparticles but were reported by the manufacturer as carbon nanoparticles free. The most noticeable was Babolet, who insisted their tennis rackets did not use carbon nanoparticles (email on file).

Gold[7]

Gold and nanoscience offer a host of applications in medicine and has received a lot of attention by researchers. Gold nanospheres, silica–gold nanoshells, and gold nanorods have been touted for their achievement of efficient contrast for biological and cell imaging applications, as well as for photothermal therapeutic applications.[8]

A total of 27 products included the search term "gold." These products represented about 3% (N=27) of the total number of products in the database. Within gold products, 55% (N= 15) were

[6] LIMING DAI, CARBON NANOTECHNOLOGY: RECENT DEVELOPMENTS IN CHEMISTRY, PHYSICS, MATERIAL SCIENCE, AND DEVICE APPLICATIONS (2006).

[7] *See* Travis Jennings andGeoffrey Strouse, *Past, Present, and Future of Gold Nanoparticles*, BIO-APPLICATION OF NANOPARTICLES, 34-47(Warren Chan, eds., 2007).

[8] *See* Prashant K. Jain et al., *Calculated Adsorption and Scattering Properties of Gold Nanoparticles of Different Size, Shape, and Composition: Applications in Biological Imaging and Biomedicine,* 7239 J. PHYSICAL CHEMISTRY 110 (2006).

identified as using nanotechnology. It was unclear as to whether 11% (N= 3) of the products used nanotechnology, while an additional 33% (N= 9) of the products did not use nanotechnology.

In terms of availability only 4 of the listed products could be confirmed as currently available. All 4 of these products were produced in the USA and are available within the USA. Overall, 55% (N= 14) of the products listed were classified as "UNSURE" in terms of availability. An additional 33% (N= 9) of the products were identified as currently not available.

For silver, only 66% (N= 18) of the source links were operational. Similarly, 66% (N= 18) of the products had operational organizational websites. These two figures were perfectly correlated since if a product website was operational its source links were also available.

Silver

Silver nanoparticles are emerging as one of the fastest growing product categories in the nanotechnology industry. "Silver nanoparticles may very well become the next 'it' product, much like antibacterial soaps took the consumer sector by storm a decade ago," said Marlene Bourne, principal analyst with Bourne Research. "Of course, some are concerned that being too clean is perpetuating the rise of allergies and autoimmune diseases, but there are many applications where its use makes perfect sense."[9]

Approximately 26% (N=258) of the products on the database were identified in the silver search. All products within this sample incorporated silver nanotechnology. A broad array of product types were represented such as: apparel; personal hygiene products (brushes, toothbrushes, razors, masks, soaps, lotions, etc.); hair care products (curling irons, blow dryers, and flat irons); baby products (pacifiers, strollers, and toys); home and industrial cleaning solutions; coatings; appliances (vacuums, washing machines, refrigerators, bidet, espresso machine); water and air filtration systems; food and beverage packaging; household items (detergent, paint, fabric softeners, pillows, towels); and, electronics.

The majority of the companies 56% (N= 145) with silver products listed were located in Asia representing China, Taiwan, Japan, Singapore, and Korea. Out of these Asian countries, Korea was the most prominent with 65% (N= 95) of the companies. Inadequate information was discernable on country product availability. The coders were compelled to indicate "UNSURE" 68% of the time due to inadequate information found on the CPI (N= 175).

In total, 18% (N= 47) of the silver products were not available for purchase. The coders were "UNSURE" of the availability of 28% (N= 72) of the silver products. The remaining 54% (N= 138), of the listed silver products were available.

The PEN list indicates if a product is listed as "NEW" by including a gold star in the product description. We tallied products listed as "NEW" and found that only 10% (N= 26) of silver products were actually listed as "NEW". Further, there is no data to confirm when the PEN list is updated nor is there information indicating when these products were added to the database, hence "newness" is unclear. Consequently, identifying "newness" is quite difficult.

Moreover, we examined whether the product website and the product source link existed in the product description. We found that the source link exists for 83% (N= 214) of the silver products and did not for the remaining 17% (N= 44). The source link and the product website link frequency were the same. With regard to the product website existing, 83% of the websites were functional

[9] *See* Nanotechwire, Use of Silver Nanoparticles Rapidly Expanding in the Consumer and Medical Markets – Report (2006), at http://www.nanotechwire.com/news.asp?nid=3201&ntid=190&pg=15 (last visited April 19, 2010).

while 17% were not in existence. The EC21 website accounted for 23% (N=59) of the products in the silver sample.

Iron

While iron's extreme reactivity has traditionally made iron nanoparticles difficult to study and inconvenient for practical applications, iron has a great deal to offer at the nanoscale, including very potent magnetic and catalytic properties. Recent work has begun to take advantage of iron's potential and work in this field appears to be blossoming. [10]

About 2% (N= 23) of the products in the four classes examined in the PEN inventory are identified as containing iron nanotechnology. The inventory included blow dryers, flat irons, and curling irons. The vast majority 87% (N=20) of the iron products did not seem to utilize iron nanotechnology at all. Thus, the sensitivity of the search is in question as well as the reliability of the list pertaining to iron.

Regarding product availability, 52% (N= 12) of the iron products were available, and 13% (N= 3) were unavailable. Availability could not be determined for the remaining 34% (N=8) of the iron products.

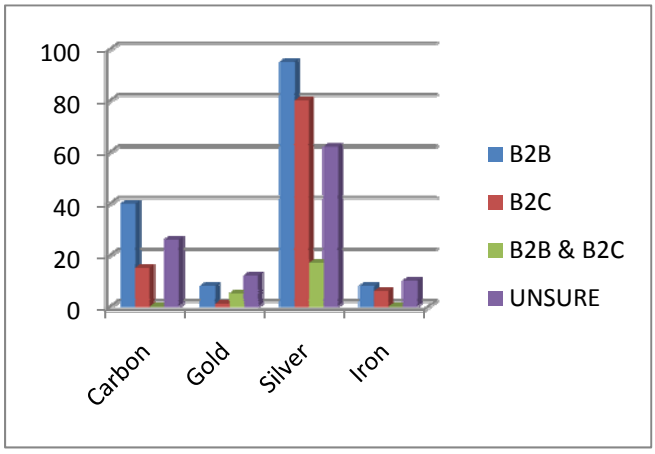
The majority of the iron products (83%, N= 19) were American with the UK, China, Korea, Japan, and one unknown country comprising the remainder of the sample.

Distribution channels

As part of this analysis, we examined the type of distribution channel for the products. This allows us to examine where nanotechnology was most prevalent.

The most prevalent distribution channel involved companies that were B2B (Business to Business) at 39% (N= 153). B2C (Business to Consumer) was 26% (N= 103). Companies that were both B2B as well as B2C consisted of 5% (N= 22) of the sample, and an additional 29% (N= 113) of the company channels were unknown (see below). Thus, most companies in the sample employed a B2B distribution channel.

Distribution Channels for Products



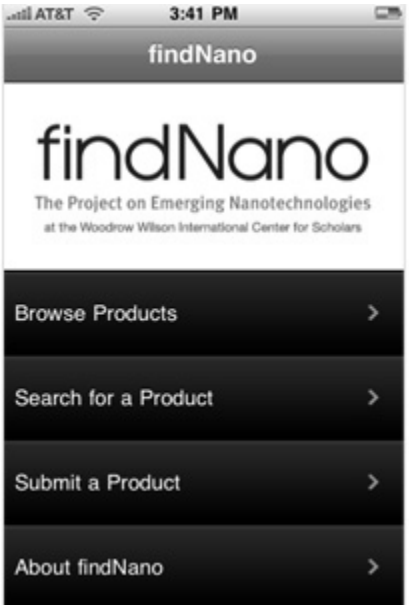
[10] *See* Dale Huber, *Synthesis, Properties, and Applications of Iron Nanoparticles,* 1 SMALL 482-501 (2005).

The distribution channel data may be particularly important because B2B distribution may have a less significant EHS footprint for consumer exposure. The CPI indicates under their selection criteria that a product must be readily purchasable by consumers as a condition for inclusion. However B2B products incorporating nanotechnology are not directly purchasable by consumers. Indeed, calling a site with such an extensive B2B data set a consumer product inventory is somewhat misleading.

Product distribution channel was also analyzed for silver. We found that 37% (N=95) of the silver products were from B2B companies. B2C companies accounted for 31% (N=81) of the silver products. Of the products, 6% (N=17) were from both B2B and B2C distribution channels and 25% (N= 65) of the silver products were coded as "UNSURE".

In addition, when looking at the type of product distribution channel for iron our research indicated that B2B business accounted for 35% (N=8) of the iron products. We were "UNSURE" of the distribution channel of 43% (N= 10) of the products. Although several iron products were categorized as B2B products, we did not see any iron products listed on the EC21 website. Moreover, the majority of the iron products were not listed as "NEW" products 83% of the time (N=19).

iPhone Application



In addition, we have noticed a recent cell phone application relating to the CPI. Any cell phone with built-in web capacity can download the "findNano" application to visit and view the CPI. However, consumers can not only search the database via the iPhone application but may also submit newly discovered nanotechnology items into the database by using their device's camera and connectivity.

"This innovative tool satisfies the needs of citizen scientists, tech-savvy consumers, and those who are merely curious about whether products contain nanomaterials," said Patrick Polischuk, a PEN research associate.[11] A submission only requires three pieces of information: the product name, company name, and a product photograph. Optional notes about the product can be added to the submission before it is listed. The ease of adding products to the inventory exasperates concerns about validity and reliability.

There is very little information found on the application.. It asks the user to "Submit a Product" and on the same screen asks: "Have you found a product that utilizes nanotechnology? Submit your entry and we'll review it for addition to our inventory." The reporting fields include: Product name, Company name, and Product photo (photo library). There are also three questions listed in the Notes section: Where did you see this product? What experiences did you have with it? Would you recommend it?

[11] *See* ConsumerReports.org, (2009) Finding nano—in sunscreen and other products, *Available at* http://blogs.consumerreports.org/safety/2009/12/findnano-iphone-application-ipod-touch-wilson-center.html, (last visited April 19, 2010).

Phantom Marketing

Another phenomenon worth considering is "phantom marketing." Phantom marketing is the ability to use word of mouth marketing without actually having a product to market. It is the buzz that starts as people suspect something will happen. The entire controversy over Apple's iPhone versus the GPhone is a smart example of phantom marketing. Google received an appreciable amount of publicity as journalists, consumers, and bloggers started writing, discussing, and debating about the slash in prices by Apple for the iPhone. As evidenced here, phantom marketing provided Google a lot of publicity even without having a product in the market.

On another level, phantom marketing involves demand prospecting. A company communicates the release of a product or service to test the level of demand. This is popular in the software industry. New software that is announced but never released is known as vapor ware.

Phantom marketing may have a darker visage. A company releases a product announcement to test the feedback from a set of stakeholders including regulators, non-governmental organization, media critics, and consumers. If inquiries and responses are limited, the business can frame the product not only in terms of demand but also EHS issues. Hence, the business realizes the product is not going to be a profitable long-term investment and the product never sees the light of day.

A number of other efficiencies result from conducting a phantom marketing strategy. Costs are reduced in a number of areas including new product development, market research, production process costs, and traditional marketing costs. An additional benefit of organizations conducting this type of demand prospecting is that it can be useful in demonstrating the investment potential for a product. For example, a large number of inquiries could lead to persuasive recruitment of venture capital funding.

As was illustrated within each product category, the main concern with the PEN database is the amount and accuracy of information available for each of the products. We have seen throughout each product category nonfunctional links for product websites and source listings. Efforts to purchase consumer articles (B2C) found on the list were stymied as well.

In addition, the CPI may function as a vehicle for phantom marketing and demand prospecting because it heightens exposure for products and offers a means of communication with potential buyers.

6. Implications

Producing nanoparticles that do not agglomerate is an expensive venture. High quality nanoparticles are being investigated for uses where agglomeration cannot be withstood given the application, such as aerospace/defense, electronics/semiconductor, and medical/healthcare industries. In an earlier article, Berube[12] posited this agglomeration helps explain why the findings of Consumer Reports on the protection of sunscreens using nanoparticles demonstrated no substantial protection against sunscreens using microparticles despite laboratory findings to the contrary. Nanoparticles may agglomerate once constituted into a final product. While there may be some end of life exposure involving disposal and recycling, that data is inconclusive.

We are not suggesting production of nanoparticles and manufacturing of products using nanotechnology is without risks to those individuals exposed to raw nanoparticles in powder or liquid form. That conclusion is beyond this data set and is being examined by teams of researchers

[12] *See* David Berube, *Rhetorical gamesmanship in the nano debates over sunscreens and nanoparticles,* 23 J. NANOPARTICLE RESEARCH 10 (2008).

in the USA and abroad. Nevertheless, it is highly questionable to suggest product availability is correlated to exposure and EHS risks.

The primary implications of our findings are associated with levels of care taken by those who cite the CPI. It is very important to note that while we suspect the reliability and validity of products on the CPI, we are not concluding the number of products employing nanotechnology to which consumers are exposed is insignificant. However, referencing the CPI for academic or professional purposes may delegitimize the credibility of both the referrer and the claims of the referrer.

In general, we have found several shortcomings with the CPI:

1. Almost anyone can post a product on the CPI. There is no check to verify that the products are legitimate (Are *actual* products available for purchase?) As such, the legitimacy, both its reliability and validity, of the list is questionable. Also, there is the ethical consideration of research responsibility in regard to data compilation and maintenance.

2. There is no indication when the CPI is updated. Many of the products are no longer available. An examination of the web and source links fails to clarify in many instances whether a product is available. Some of the products are delineated with a gold star and marked as "NEW", but the accuracy of product "newness" is dubious. For example, does "NEW" mean the product is new to the list (posted within the last week, month, 6 months, or year) or does it indicate that the product is new to the market? Not knowing when the list has been last updated raises further legitimacy concerns. Since many of the products are unavailable or their availability is questioned perhaps many of the products have been on the list for awhile. Continual maintenance of the list is necessary to combat this.

3. Also, the list does not delineate between B2B and B2C companies. This causes usability problems. The list is not well organized as it is an amalgamation of different types of products (some available to consumers and some available only for business use). It would be better for both usability and reference purposes if the list were better organized. Organization would also assist in the promotion of credibility and availability.

6. Conclusions

As a result of this analysis, it is evident standards for the identification of nanotechnology in consumer products may be needed. Thus, it might be prudent:

- To provide ongoing funding for the maintenance of the consumer product inventory by a third party, such as a university-based research team;

- To consider adding categories to characterize consumer products, such as products for children, green nanotechnology, labeled and unlabeled, etc.

- To develop protocols to determine when a product contains nanomaterials rather than having been produced using nanotechnology;

- To distinguish between products which may have problematic life cycle implications, especially associated with recycling and disposal;

- To incorporate a validation process. For example, a product might be added to the inventory provisionally with communication sent to the company to verify the entry within 48 hours; and,

- To remove products from the inventory under certain circumstances, such as a declaration of bankruptcy and liquidation or an announcement that a product or product line is no longer for sale.

Many challenges lay ahead in the field of nanotechnology. We must be able to identify the type of nanoparticle, as well as size, to determine whether a product actually contains nanotechnology. It is equally important to track product use to establish adverse effects and its EHS footprint. We must be able to track products from around the world. Given globalization and the role of contemporary international marketplaces, it is important to establish transnational data sets. For a data set on consumer products using nanotechnology to be wholly useful to all stakeholders, a detailed examination of existing databases like PEN's is required. A consensus regarding what variables need to be tracked for each product to maintain the highest levels of validity and reliability would need to be established. Finally, a commitment of resources at the governmental level to both produce and maintain a consumer product inventory is required.