Environmental Science & Technology

Viewpoint

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Translating the Materials Genome Into Safer Consumer Products

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Five years after legislation to establish the Green Chemistry Initiative (GCI), the landmark California Safer Consumer Products Law became effective on October 1st, 2013.[1] We argue here that the development of new regulatory policies to stimulate the convergence of materials development research and public health and environmental impact assessments provides evidence that these topics have traditionally addressed separate audiences, developed different values and measurement systems, and focused on incompatible goals. The United State's Materials Genome Initiative (MGI) provides an opportunity to use lessons learned from the California experience to reduce the temporal and scientific gaps that challenge initiatives to prevent disease and environmental pollution resulting from toxic chemicals in consumer products. The MGI aims to more rapidly meet societal needs in clean energy, national security, and human welfare by developing materials that are "at the heart of innovation, economic opportunities, and global competitiveness".[2] The MGI calls for accelerating the pace of research in computational and experimental tools, collaborative networks, and digital data processing—all represent a boost for the fledgling discipline of materials informatics. Two years after MGI started, the National Institute of Standards and Technology, DoE, and the White House's Office of Science called the first "Materials Genome Initiative Grand Challenges Summit" (June 25–26, 2013). The agenda focused on five traditional materials science themes.[3] The articulated MGI goals are laudable, but a crucial perspective is missing in its research foci: sustainable materials intended for use in mass-marketed products must not threaten environmental quality and human health through their production, use or disposal.

It is impossible to ignore the environmental pollution legacy of new materials that have revolutionized societal needs, including the accumulation of toxic waste from electronics products and plastics, which with and without phthalates, bisphenol A, or brominated flame-retardants, represented a remarkable commercial application of materials science and manufacturing, but now threaten to be the most highly contested products in legislation and environmental protection. Traditionally, the cost-benefit trade-offs inherent in selecting materials have not been transparent, leading to regrettable outcomes and policy reversals. This is because of incompatible metrics and weights that apply to different priorities such as energy conservation, economics, disease burden, and wildlife protection. To some extent, life cycle assessments (LCAs) can address trade-offs, but there are serious gaps in databases on which LCAs rely. For example, the poster on MGI features a fluorescent light bulb presumably to represent innovation in advanced materials for energy conservation. However, recent studies suggest that without developing appropriate waste management methods for bulbs, the savings in energy may not justify their potential detrimental impacts.[4]

The existing federal law to reduce exposure to chemicals used in commerce, the 1976 Toxic Substances Control Act, is widely considered a failure. Since its implementation, the U.S. EPA has restricted only five chemicals. Recent efforts in the U.S. congress to reconfigure ToSCA have stalled through opposition from the chemical industry. These efforts include the "Safe Chemicals Act of 2013" introduced in April 2013 by Senators Frank Lautenberg (D-NJ) and Kirsten Gillibrand (D-NY) that would require "safe-before-sell" evidence from manufacturers and a version introduced on May 22, 2013 as the "Chemical Safety Improvement Act of 2013" by Senators Lautenberg and David Viter (R-LA) to gain bipartisan support.[5]

The acceleration of materials discovery under MGI should be accompanied by increased support for other research disciplines that curb human and environmental exposures to dangerous chemicals will lead to costly and/or regrettable applications. The MGI "challenges researchers, policy makers, and business leaders to reduce the time and resources needed to bring new

Received: September 13, 2013
Revised: October 6, 2013
Accepted: October 11, 2013
Published: October 30, 2013

dx.doi.org/10.1021/es4040864 | Environ. Sci. Technol. 2013, 47, 12625–12627

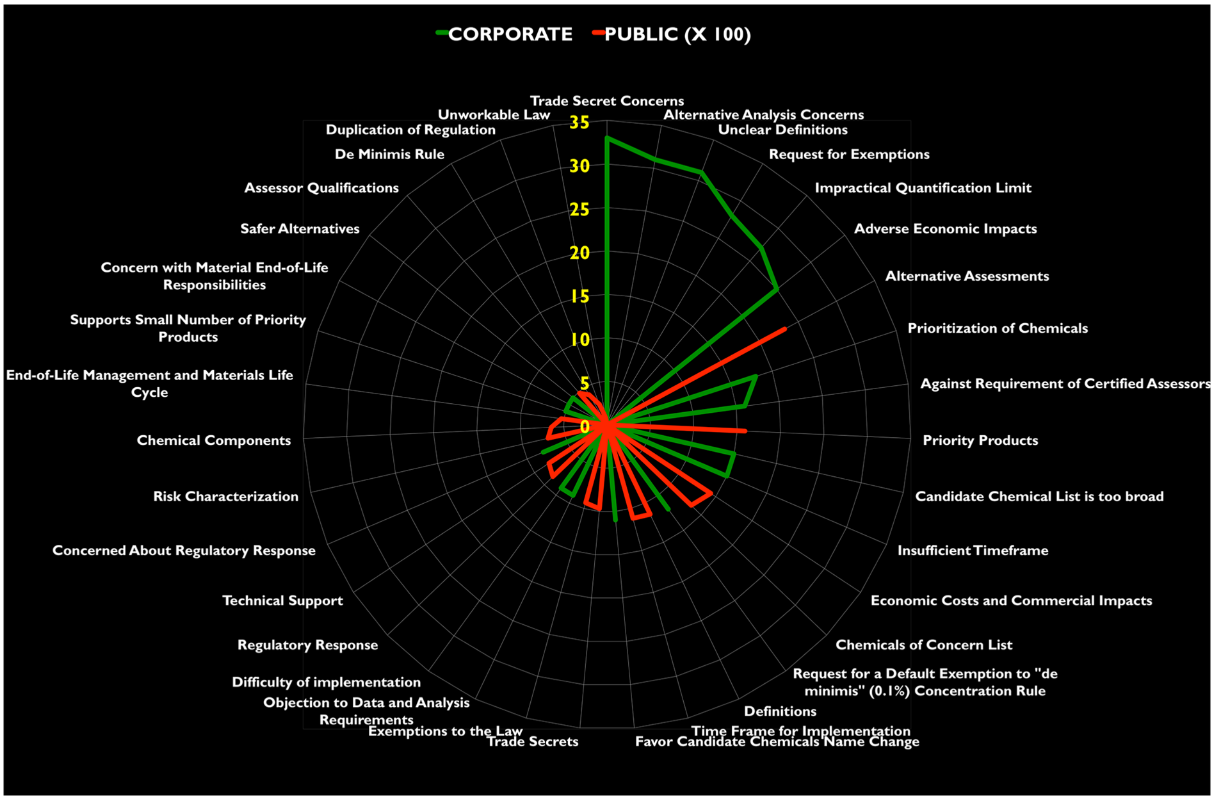

Figure 1. Content analysis of comments submitted about California's new Safer Consumer Products Law revealed marked differences in concerns raised by the general public and by manufacturers.

materials to market" but we view the temporal dimension as a symptom of systemic difficulties of integrating scientific disciplines to advance materials sustainability and decision-making. The complexity of material hazard and toxicity information needs to be better integrated with materials attributes into a user-friendly informatics tool designed to bridge discrepancies among preferences expressed by manufacturers and consumers. To illustrate this point, we examined the long-delayed California Green Chemistry Initiative (GCI or Safer Consumer Products Regulations, Health and Safety Code 25252.5) to understand reasons for the failure of existing policies to regulate toxic materials, and the regional, national and international challenges that must be overcome to change the course of research and development of new commercial materials.

The GCI called for the establishment of a "systematic scientific and engineering approach for reducing the use of hazardous chemicals in manufacturing of consumer products and the generation of toxic wastes by changing how society designs, manufactures, and uses chemicals in consumer products". The implementation of GCI as state law was delayed for two years because of various controversies. We conducted content analysis on public comments submitted on California's Safer Consumer Products Law by coding the frequency of concerns raised by stakeholders. The results presented in Figure 1 reveal some lessons for consideration under the federal MGI. For example, concern with "alternative assessments" is dominant presumably because of heightened public sensitivity to regrettable replacements. Manufacturers' concerns with protecting trade secrets also has major ramification for initiatives funded by taxpayers and the free flow of information. Information about science-based regulatory oversight of *de minimis* concentration of toxic chemicals in consumer products is one of the hottest areas of research at the intersection of exposure assessment, genomics and personalized medicine.

The MGI should stimulate translational research, including the development of a materials hazard and toxicity informatics tool designed to facilitate the screening, ranking, and selection of alternative materials in consumer products. The refinement of integrative models for evaluating complex materials such as alloys, mixtures, compounds and composites, and multimaterial components will become increasingly necessary as innovation in materials discovery progresses. Computational toxicology tools are also needed to supplement the dependable but slow protocols for assessing material toxicity and to fill the data gaps that have made ToSCA ineffective. Finally, the development of integrative risk analytic frameworks for dealing with uncertainty and combining multiple pieces of evidence in a systematic, transparent decision-making approach must be part of the MGI to facilitate comparative alternative assessments for safer consumer products.

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Notes

The authors declare no competing financial interest.

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