NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy
2018, Vol. 28(2) 179–201

DOI: 10.1177/1048291118765485
journals.sagepub.com/home/new
SAGE

The Production of Corporate Research to Manufacture Doubt About the Health Hazards of Products: An Overview of the Exponent Bakelite® Simulation Study

David Egilman[1]

Abstract

Although corporate sponsorship of research does not necessarily lead to biased results, in some industries it has resulted in the publication of inaccurate and misleading data. Some companies have hired scientific consulting firms to retrospectively calculate exposures during use to hazardous products that are no longer manufactured or sold. As an example, this paper reviews one such study—a litigation-generated study of Union Carbide Corporation's asbestos-containing product Bakelite®. This analysis is based on previously secret documents, produced as a result of litigation. The study generated asbestos fiber exposure measurements which resulted in underestimates of actual exposures to create doubt about the hazards associated with manufacture and manipulation of Bakelite®.

Keywords

asbestos, Bakelite, Cardno ChemRisk, dose reconstruction, junk science, litigation

[1]Brown University Warren Alpert Medical School, Providence, MA, USA

Corresponding Author:
David Egilman, Brown University Warren Alpert Medical School, 8 North Main Street, Suite 404, Providence, MA 02912, USA.
Email: degilman@egilman.com

Introduction

Corporate sponsorship of research does not necessarily lead to inaccurate findings. On the other hand, corporate sponsorship may result in the publication of false or misleading evidence that supports corporate economic interests. A body of corporate research has been generated in an effort to reduce liability in toxic tort litigation.[1–3] In an effort to determine dose-response relationships, companies have used historic dose reconstructions to estimate a range of potential product-related exposures experienced by workers and others. In defending themselves in tort suits stemming from asbestos exposure, some companies have attempted to apply dose reconstructions to estimate an individual plaintiff's historic exposures. Asbestos companies—or their lawyers—have hired experts to reconstruct historic exposures to asbestos-containing products that are no longer manufactured or sold in order to claim that these exposures were either in compliance with contemporaneous standards or too low to cause cancer or other injury.

In 2005, Exponent, an engineering and scientific consulting firm, published a study that purported to reformulate Union Carbide Corporation's (UCC's) Bakelite® and characterized exposures to this asbestos-containing plastic molding compound, the manufacture of which UCC discontinued in 1975.[4,5] After manufacturing Bakelite® powder "based on historical formulation information," Exponent molded and manipulated small "plaques" of this material (four inches by six inches by .23 inches).[a] Exponent claimed that the exposures produced by these plaques in laboratory simulations were representative of worker exposures to asbestos during manipulation of finished products made from Bakelite.[4] The studies were conducted to assist UCC's lawyers in defending against legal cases in which workers who had contracted mesothelioma after exposure to dust from Bakelite® molding compounds or finished Bakelite® products had sued the company for compensation. In their published paper, Exponent authors Mowat, Bono, Lee, Tamburello, and Paustenbach failed to cite more detailed results that they had provided the lawyer funders.[4,6,7]

This paper critically reviews the litigation-generated study of asbestos-containing Bakelite®, a plastic that was made by heating a mixture of asbestos and phenolic chemicals. The methodology that Exponent used inaccurately minimized asbestos exposures from Bakelite® and created doubt about the hazards associated with this product. Specifically, this paper reviews measures that Exponent took that give the impression that asbestos exposures to Bakelite® "would not, under any reasonably plausible scenario, be expected to produce airborne concentrations of asbestos above historical or current eight-hour time-weighted average (TWA) occupational exposure limits." (Current permissible exposure limit is 0.1 f/cc.) In fact, UCC's actual contemporaneous exposure estimates were much higher than these levels. In this review, I show why the study did not support this claim.

Part I: Dose-Reconstruction Studies

Legal Background

In its 1993 Daubert decision, the Supreme Court ruled regarding the question of the admissibility of evidence.[8,9] The court defined "scientific methodology" and provided a framework for trial judge decision-making to determine "validity" of scientific testimony. The court suggested, and many trial judges have adopted, five factors in evaluating whether or not a jury should decide whether a particular exposure caused or contributed to a particular disease:

a. *Whether the theory or technique is falsifiable, refutable, and/or testable*—a construct taken from Popper.
b. *Whether it has been peer reviewed and published*. The Appellate Court in Daubert itself relied heavily on a non-peer-reviewed polemic written by a lawyer who worked for the libertarian Manhattan Foundation.[10]
c. *Whether the method has a known or potential error rate*. This is not relevant for epidemiologic or animal studies since there is no way to evaluate the positive predictive value of a single or even many such studies.[8]
d. *Whether the study had controls*.
e. *Whether, and the degree to which, a theory or technique is generally accepted by a relevant scientific community*.

The courts have since determined that trial judges are required to act as gatekeepers to prevent "junk science" from entering the courtroom. As a result, judges have dismissed many cases by determining that juries should not even consider the scientific or other evidence. Prior to the Daubert and subsequent decisions, juries would have decided what weight to give this scientific evidence and would have made factual determinations of its reliability.

To capitalize on this decision, companies have funded research designed to undermine adverse scientific evidence and/or create a body of literature that supports their position that their product does not cause whichever disease plaintiffs or public health advocates allege.[b] Dose reconstruction is a major tool companies use to retrospectively argue that exposures to their product were too low to be considered a cause of the disease or injury for which the plaintiff or her family is seeking compensation.

The Role of Scientific Consulting Firms: Litigation

Scientific consulting firms have developed dose-reconstruction studies and policy arguments as part of a legal defense strategy and not as a scientific

endeavor. Exponent once described its business as follows:

> Exponent serves clients in automotive, aviation, chemical, construction, energy, government, health, insurance, manufacturing, technology and other sectors of the economy. Many of our engagements are initiated by lawyers or insurance companies, whose clients anticipate, or are engaged in, litigation over an alleged failure of their products, equipment or services.[2]

The current Exponent website is less explicit:

> Exponent is a leading engineering and scientific consulting firm providing solutions to complex technical problems. Our multidisciplinary team of scientists, physicians, engineers, and regulatory consultants will perform either in-depth scientific research and analysis, or very rapid-response evaluations, to provide our clients with the critical information that both day-to-day and strategic decisions can require.[11]

> Our multidisciplinary organization of scientists, physicians, engineers, and regulatory consultants performs in-depth investigations in more than 90 technical disciplines. We analyze failures and accidents to determine their causes and to understand how to prevent them. We evaluate complex human health and environmental issues to find cost-effective solutions. Our integrated approach offers a multifaceted perspective that leads to insight, revelation, and innovative solutions that produce bottom-line results. By introducing a new way of thinking about an existing situation, we assist clients to overcome seemingly insurmountable obstacles.[12]

ChemRisk, a similar firm founded by Dr. Paustenbach, has advertised in the past that its

> scientists and engineers have served as technical advisors to lawyers in all aspects of environmental, occupational, toxic tort, and product liability litigation, including technical strategy development, providing scientific advice, expert testimony, selection and preparation of expert witnesses, assistance in cross-examining opponent's expert witnesses.[2]

In 2005, ChemRisk claimed that:

> A distinguishing characteristic of our legal support work is our emphasis on conducting original, field research which fills data gaps. This work is usually an essential component in resolving disputes involving chemical, or radiological agents. We have provided support to litigants in some of the most publicized and complex major toxic tort law suits including silicone breast implants, developmental

> toxicants, beryllium, hexavalent chromium, benzene, asbestos, brake dust, dioxin, various pesticides, and many others.[2]

Now known (since 2012) as Cardno ChemRisk, the company's website states:

> [. . . .] The Cardno ChemRisk team has a long-standing reputation for thorough scientific analysis and project excellence, and many are sought-after advisors to the public and private sector. They drive new methodologies and stay at the forefront of current and emerging issues, enabling clients to make informed strategic decisions.
>
> Cardno ChemRisk professionals are deeply committed to collaboration as well, participating in many industry associations and panels, and publishing hundreds of papers that are frequently cited in both regulatory and litigation decision-making. Many Cardno ChemRisk professionals have participated on some of the most complex projects in the world, and have built international acclaim in specific areas of expertise, including more than 50 chemicals. [. . .][13]

Dr. Paustenbach, president of ChemRisk, explained in a 2006 presentation promoting the company's work why the Bakelite® and other dose-reconstruction studies are performed.[14] The presentation took place at a conference held by the Canadian Chrysotile Institute (formerly the Asbestos Institute)[c] to combat the European Union ban on asbestos-containing products and to assist companies in defending asbestos law suits filed by injured workers and their family members. Dr. Paustenbach used the opportunity to market his company's "simulation studies" as a method that companies could employ to defend law suits and block regulation:

> I'm going to talk today about simulation studies. I believe that they are a very important component of litigation and regulatory affairs, as well as in dealing with epidemiology studies. I happen to believe that epidemiology studies can be done better than categorizing exposure as low, medium, or high. There's not a single product that I can think of in the last hundred years that can't be reproduced in exposures simulated in the past.[14] (p. 2)

Dr. Paustenbach went on to describe the likely results:

> To the best of my knowledge in litigation that was traditionally lost in the United States, I'm not aware of a single case that has been lost when a high-quality simulation study was done, and of course the exposures were considered de minimis. And in those cases where they're not, then you can expect not to do very well. But when you go into these studies, quite usually you will know roughly what the

> degree of exposure's going to be; it's intuitive. Sometimes you're surprised, but quite often you're not.[14] (p. 2)

Of course, since the studies are performed for lawyers who represent corporations, unfavorable results do not have to be published or reported if nontestifying consultants performed them for the purpose of defending lawsuits.

Dr. Paustenbach used the Bakelite® simulation study as an example of how dose reconstruction could be used to cast doubt about the toxicity of an asbestos product. Paustenbach noted that the companies had often failed to measure exposures before or during the time the products were actually in the stream of commerce: "If you didn't collect the data contemporaneously, I think it can be done today."

In the same lecture, Paustenbach explained the monetary value of simulation studies in defending law suits:

> This is intuitive. It says – it would – it's a shame to have to have spent, let's say, $250,000 to do this study when it's really intuitive that there wouldn't be much exposure. But when there's – when it costs $4 million in the United States to work up and take a case to trial, that's just the expenses. That's not the outcome. A $250,000 or $500,000 study is – is a drop in the bucket. So when you heard the term yesterday – remember, we turned down a settlement of a $150 billion – that's with a B – $150 billion to settle the – the litigation crisis yesterday that was mentioned in the United States – these kinds of $250,000, $500,000 investments go a long way. If you've got a hundred cases and it takes $4 million for the lawyers and consultants to get ready for the case and to take it to trial, you can see this is a drop in the bucket. So when I hear people say, 'we can't afford it', I don't understand.[14] (p. 14)

He later went on, specifically in relation to Bakelite®:

> It is not easily done. The study cost over a million dollars, to find the product, to remanufacture it, to press it, and then cut it and drill and take all the samples. It – it was a massive project. But, again, I – the – the – in spite of the fact it cost upwards – I don't know if it was over a million, but it was very expensive, and it may well have approached a million. It – in potential benefit, it probably is going to save tens of millions of dollars in litigation costs, not settlements. So we reformulated it. We collected 150 personal and area samples by sawing, sanding, drilling, and cleaning up. Those are the three things that were alleged. That's the only three things, I think – or four things you can do with Bakelite®, and these are the results.
>
> You'll see even when you band-saw it, which is the highest possible concentration, it's still much below the .1 value. We look at one hour of work, two hours of work, half an hour of work, and then we can – we can scale up to eight hours if we want to. So I usually like to do it over a span of time; and, of course, you hope that those

> relationships are nearly linear, and they often are. So you see quite clearly the difference between cleanup, sanding, drilling, et cetera. So the studies on Bakelite® clearly show that the concentrations were very, very low. This does not even qualify – this doesn't even discuss the fact that the asbestos may not even pose a hazard when it's been soaked with a – with a resin and made into really a – a little piece of plastic fiber, rather, it may not have its asbestos characteristics anymore biologically. But that's another matter. We're just talking just about exposure . . . [14] (pp. 20–21)

> . . . In short, then, I believe that you can reproduce any of these exposure scenarios of the past 50 years. It is expensive, but I think it's well worth it, and I think they should be published for the scientific community to understand your views. We've looked at these five – or four that I've talked about today – or seven, depending on how you count them. We found that the exposures are very low. You need to consider the frequency, of course, and duration. And they're a wonderful add-on to the EPI studies.[14] (p. 26)

Dr. Paustenbach views himself as part of the company defense team. He took credit for victories, explaining in his lecture: "**We** took the first two results, I think, to trial, and **we** won hands down, again, based on this study"[14] (p. 17) (emphasis added).

While Dr. Paustenbach unequivocally states that the sole purpose of these studies is the defense of law suits, none of his papers explicitly explain this aim. And yet, " . . . we publish all of our work in peer-reviewed journals. That's kind of the – the – a distinguishing characteristic of our firm"[14] (p. 17).

The Role of Scientific Consulting Firms: Creation and Distribution of Inaccurate and Misleading "Science"

Many of Exponent/ChemRisk's studies are published in *Regulatory Toxicology and Pharmacology,* a journal edited by Gio Batta Gori, a former tobacco company consultant, and published by The International Society of Regulatory Toxicology and Pharmacology.[15–36] Jacobson has noted the problems with that journal:

> ISRTP publishes the scientific journal *Regulatory Toxicology and Pharmacology*. Its sponsors include Dow Agro-Sciences, Eastman Kodak, Gillette, Merck, Procter and Gamble, R. J. Reynolds Tobacco, and other corporations that have an interest in weakening government regulations of toxic chemicals. The Journal's editorial board is dominated by industry lawyers and scientists who consult for industry. In one egregious episode, the journal's editor was paid $30,000 by the tobacco industry to write a paper—which was published in the journal—downplaying the risks of second-hand smoke.[37]

Several journals have established ethical rules that bar publication of papers funded by tobacco companies, and many (e.g., *European Journal of Respiratory Disease*, *British Medical Journal* (*BMJ*), *BMJ Open*, *PLoS Medicine*, *PLoS One*, *PLoS Biology*, *Tobacco Control*, *Thorax*, *Heart*, journals published by the American Thoracic Society, and the *Journal of Health Psychology*) refuse to publish papers authored by researchers who received tobacco industry funding. Some ban authors who previously accepted tobacco funding, even if the researcher's work is unrelated to tobacco.[38–40]

In his 2006 presentation to the Chrysotile Institute, Dr. Paustenbach noted that institutional review boards should review this type of research:[d]

> The second [expectation] that is new [when conducting simulation studies today] is the use of an Institutional Review Board. Even though the exposures are often incredibly low and sometimes you're wearing respiratory protection, in the United States, at least, the bar has been raised that you may need to use institutional review board approval. [. . . .] I think the courts are going to be very sensitive to, at least, the institutional review board.[14] (p. 8)

Despite this acknowledgment, Mowat et al. did not seek institutional review board approval for the Bakelite® study.[4]

The protocol for Exponent's study called for the workers to wear Tyvek® suits and use respirators.[7] However, Exponent did not implement these worker protections in the Bakelite® study.[41]

Part II: The Bakelite® Simulation Study

In the following section, I deconstruct various components of the Bakelite® simulation study that are of scientific and ethical concern.

Ignoring Contemporaneous Exposures

Mowat et al. claimed they performed this dose reconstruction to determine the historical exposures to asbestos from working with finished Bakelite®. Mowat et al. state that:

> The test results from this study are useful in providing a sense of the possible exposures that historical workers may have experienced when they were engaged in sawing, sanding, or drilling of BMMA-5353 and other materials in this class of phenolic resins.

However, Mowat et al. ignored published and unpublished historical exposure data that UCC collected in its factories. In 1975, UCC's marketing manager, John Myers, published a paper and reported that users of Bakelite® compounds

had asbestos exposures that exceeded the 1972 Occupational Safety and Health Administration (OSHA) asbestos threshold limit value.[42] Peak exposures were 14 fibers/cc. Myers noted that the TWA exposure levels to various UCC products were " . . . in most cases . . . well below OSHA standards."[42] (The 1972 OSHA asbestos standard was a TWA of 5 f/cc and a peak of 10 f/cc.)

UCC conducted studies of asbestos exposures in its Bound Brook, New Jersey plant where Bakelite® was manufactured from 1968 to 1974. In 1972, an outside consultant who found asbestos exposures from phenolic-molding compounds to be as high as 10.2 f/cc recommended:

> Although you can manufacture and ship the product containing asbestos without Carbide personnel exposure, such products are becoming suspect in the hands of customers. To offset this fear, it is advisable to have independent studies conducted in your customer's plants whether or not such fears exist, and prior to OSHA inspections, if possible. You may recall that this Customer Service technique was undertaken prior to the sale of the toxic organic phosphate insecticides, in order to lessen the risk for both the seller and the customer. It was my suggestion to you that consideration be given to using a substitute in place of asbestos in your product.[43]

Although UCC never published these data, Paustenbach, a coauthor of the Mowat et al. paper who oversaw the Exponent study, testified that he was given access to and reviewed the historical UCC documents related to phenolic-molding compound in the repository at the offices of Mayer Brown (UCC's legal counsel) in Chicago.[44] He referenced, relative to that visit, UCC documents related to the company's 1969 air sampling, as well as to exposures while emptying bags of asbestos phenolic molding.[44]

A 1973 UCC slide presentation reporting "Typical Dust Counts" stated that asbestos ceiling concentrations while grinding phenolic compounds were 2 to 4 fibers/cc $>$ 5 micrometers in length.[45] In 1969, UCC discovered that the band sawing of Bakelite® resulted in asbestos exposures that exceeded the threshold limit value and "contaminated the room."[46,47] A UCC physician, Dr. McKinley, instructed local managers to require that workers who cut Bakelite® with a band saw use respirators.[46] Dr. McKinley noted that "this will not prevent room contamination from asbestos and other materials. To prevent this, it is further recommended that approved exhaust ventilation and dust collection be incorporated on the equipment as has been established for band saws."[46] In 1975, UCC published a study of asbestos exposures from use of thermosetting resin products.[48] In that study, Faulring et al. examined exposures to eight different thermosetting resins (containing .8 to 18 percent Calidria asbestos). Faulring et al. studied exposures during grinding, a usual use of the asbestos-containing resins that Mowat et al.[4] failed to study.[48] Faulring et al. stated that "the edge [of the panels] was ground for a period of 4–5 min." The four- to five-minute

duration of each grinding operation is much more realistic in the context of industrial use than Mowat et al.'s[4] "reconstruction" which did not include grinding. Faulring et al.[48] found asbestos exposures up to 1.2 fibers/cc during grinding (area sample) and 0.7 f/cc (breathing zone) in a 4 percent asbestos product, which was about 10-fold higher than Mowat et al.[4] reported with a recreated 31 percent asbestos "Bakelite®" product.

In 1973, UCC's industrial hygienist, Neal, tested exposure from manipulating formed Bakelite plastic and " . . . created dust clouds which showed that airborne concentrations well above the 10 fibers/cc ceiling exposure limit could, indeed be generated from products containing high amounts of regular (Carey) asbestos."[49] In 1973, Square D, a manufacturer of finished plastics made from UCC's and other suppliers' molding compounds, determined that long-fiber asbestos plastics (Durez 23639 and Rogers 368) are "basically not encapsulated" and noted that short-fiber asbestos plastics (Plenco 509 and UCC Bakelite 6935) potentially released asbestos fibers when "machined, filled or abraded in any way."[50]

In a study funded by plaintiff lawyers, Longo and Hatfield conducted a workplace simulation on an actual sample of Bakelite® made from the original BMMA-5353 formula.[51] They found exposures during sanding of 0.34., 0.38, 0.16, and 0.18 f/cc, which are several fold higher than the average .06 f/cc sanding exposures reported by Mowat et al.[4] The UCC lawyers who retained Mowat et al. to perform the "product reformulation and dose recreation" supplied this Bakelite® sample to Longo and Hatfield. Therefore, because the UCC lawyers already had a sample of actual BMMA-5353 formula Bakelite®, Mowat et al. could have used the same or similar specimens to examine exposures, rather than going through the process of product recreation.

Given this contemporaneous and current data, there was little reason to produce a dose reconstruction of exposures to Bakelite® molding compound or formed plastic.[e]

In 1973, UCC told their sales men that:

> [. . . .] Measurements made at Bound Brook on molding compound have indicated that it is unlikely that any free fibers in excess of the OSHA limit will be released during reasonable handling which might occur in a molding plant. However we cannot assume that this will always be so. Accordingly it has been decided to place the required caution label or marking on all packages used for compounds containing asbestos. The label will read:
>
> CAUTION
> CONTAINS ASBESTOS FIBERS
> AVOID CREATING DUST
> BREATHING ASBESTOS DUST MAY
> CAUSE SERIOUS BODILY HARM[52]

Inaccurate Description of the Product

In describing Bakelite®, Mowat et al.[4] went to great lengths to attempt to show that the product contained "encapsulated asbestos" (quotation marks in original):

> The term 'encapsulated asbestos' applies to fibers that are coated with a material or wetted with a binder, resin, or other medium, thereby containing the asbestos fibers within a solid matrix and limiting their potential to become airborne (e.g., asbestos in automotive brake pads, vinyl composite floor tiles, floor mastics, roofing tars). These fibers are considered to pose a negligible health hazard because of the inability of appreciable concentrations to become airborne and because the presence of the encapsulating medium inside and outside of the fiber may significantly reduce (or eliminate) its adverse effects.

Although the authors placed the words "encapsulated asbestos" within quotations, suggesting that OSHA gave these words a particular meaning that excluded such products from asbestos rulings, neither of the regulations that Exponent cites includes the word "encapsulated" nor do they make reference to any of the products that the authors mention. In fact, all references to "encapsulation" in the two cited regulations refer to products that can be *used* to reduce exposures to asbestos products when they are removed. For example, the 1994 OSHA standard's reference to encapsulation describes the use of an "encapsulant" during removal—not a product that comprises "encapsulated asbestos."[53,f]

Further, the cited OSHA regulations fail to support the authors' assertion that the listed products "pose a negligible health hazard." The cited regulations specifically name and regulate these products and include detailed mandatory workplace controls to avoid asbestos exposures while these products are used or removed:

> Class II asbestos work is defined as activities involving the removal of ACM or PACM which is not TSI or surfacing ACM. According to the definition, this includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, gaskets, joint compounds, roofing felts, roofing and siding shingles, and construction mastics.[54] (note: ACM = asbestos-containing materials, PACM = presumed asbestos-containing materials)

OSHA mandated workplace controls for asbestos-flooring and asbestos-roofing materials (see Appendix A). In addition, OSHA specifically included automotive repair workers (brake mechanics) as a subject of the asbestos regulation:

> "Automotive repair." The general automotive repair and service sector includes establishments involved in brake and clutch repair work and maintenance. The major source of asbestos exposure in this sector occurs when compressed air

> is used for blowing the residual dust from the brake lining assembly. In addition, minor exposures in brake repair can occur during spray applications and when handling cloths and other supplies contaminated with asbestos fibers. Replacement of clutch assemblies can also lead to fiber release. CONSAD [Research Corp.] estimates that approximately 329,000 automobile repair shops and garages, brake and clutch repair establishments, and motor vehicle dealers, employing 676,000 workers, will be affected by the revision to the asbestos standard. OSHA is mandating specific engineering controls and work practices that will affect this sector.[53]

The authors' description of asbestos-containing Bakelite® as products that "pose a negligible hazard" cannot be explained as "bias" or "error" in view of the internal Neal report and Longo and Hatfield's litigation study discussed above which revealed hazardous exposures during product use. While Exponent repeatedly represented Bakelite® as an "encapsulated product," in my estimation, they knew—or should have known—that this was inaccurate; their corporate sponsors (UCC and its law firm) who approved of their publication certainly should have known it.

Misstatement of the Law

Mowat et al. cited part of a sentence from the OSHA 1972 Asbestos Standard in support of their proposition that the Bakelite® products are safe:

> The low potential for release of fibers from these kinds of products is acknowledged in the federal regulations, wherein OSHA, in 1972, did not require asbestos caution labeling requirements for fibers that have been "modified by a bonding agent, coating, binder or other material."[g]

The authors misstated the 1972 OSHA standard by writing that the quotation ended with the word "material" and omitting an ellipsis, which would have indicated to the reader that the sentence was incomplete. In this case, the author's premature termination of the sentence misrepresented OSHA's intent:

> Caution labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos fibers, or to their containers, except that no label is required where asbestos fibers have been modified by a bonding agent, coating, binder, or other material **so that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section will be released.** (Mowat et al. omitted the part of the sentence in bold; see Appendix A).

The omission of the latter part of OSHA's language (which limits the definition of asbestos-containing "modified" products to products that do not release asbestos fibers during foreseeable use) in an effort to characterize Bakelite® as "safe" merchandise is particularly egregious given prior UCC research. As noted in the introduction, John Myers' 1975 published paper indicated that users of Bakelite® were exposed to asbestos at levels that exceeded the threshold limit value.

Inaccurate Presentation of the "Bakelite® Formula"

Mowat et al. claimed they were reproducing BMMA-5353; however, the actual product formula code on which they focused was BMMA-5353 BK-25 DC.[6] The code "DC" designated "dust controlled"—"products which are specially processed to remove extremely fine particles or 'smoke.'"[55] UCC had begun to develop low dust formulations after the American Conference of Governmental Industrial Hygienists (ACGIH) proposed that the asbestos threshold limit value be lowered in 1968. Earlier versions would not have been "dust controlled."

Exponent's report to the Bakelite® study funders (UCC's legal counsel) provided a more complete description of the reconstruction methodology than those described in the Methods section in their published paper, and included two different BMMA-5353 formulas.[6] One of these used a two-step resin; Exponent employed a one-step resin, which was used in another BMMA-5353 formulation. In the published paper, Mowat et al. did not disclose that there were many iterations of the formula for Bakelite®.

Failure to Disclose the Use of Different Raw Materials Than Those Called for in the Original Formula

Exponent substituted two key components in their Bakelite® formulation. UCC produced the original resin; however, Exponent never reviewed the recipe for this resin, and they did not use it. Instead, they purchased a one-part DURITE® FD-2170 Friction – Phenolic Powder Resin (a Borden Corporation product) which "was specifically developed as a general-purpose bond for **friction** elements"[6] (emphasis added). UCC's corporate representative testified that UCC never sold phenolic resins for friction products.[5] More importantly, Exponent used Johns-Manville chrysotile fiber from the Jeffrey Mine in Asbestos, Quebec.[6] Exponent thus used the third longest fiber size—7RF-3—while the original formulation called for RF-9 asbestos, from the Carey Mine in East Broughton (Québec, Canada), which was the shortest fiber type ever sold, and was tremolite-free.[56,57]

Use of a Different Manufacturing Process

The original Bakelite manufacturing process involved three sets of two rollers each. The Exponent process involved a single set of rollers, followed by manual manipulation of the material. After the dry mix was charged on the two-roll mill, it was worked manually with hot gloves and spatulas. Additionally, Exponent set the rollers to temperatures that did not match the original specifications. UCC's specifications called for temperatures of 60°F (front roller) and 100°F (second roller). Exponent kept the temperature of the front roller at approximately 200°F, and the second varied from approximately 60°F–100°F.

Additionally, Exponent discarded fibers smaller than sixty mesh. The original process did not discard any fiber size. This added process would have reduced the percentage of asbestos in the final Bakelite® product. Exponent also used a different mesh cutoff, which reduced the number of small fibers.[6]

Exponent's reformulated Bakelite® product specified the following mesh tests:

> The sieve set consisted of No. 6 (0.132 in.), No. 10 (0.0787 in.), No. 12 (0.0661 in.), and No. 60 (0.0098 in.) sieves. Granules that did not pass through the No. 6 sieve (oversized) were either reground or discarded.

Exponent discarded undersized particles.[6] This removal of small particles, which would have included small fibers, was not in the original UCC protocol.

Manipulation of the Time of the Work Simulation In Order To Reduce the TWA Exposure

The TWA is a simple formula, which divides the total exposure by the amount of time that a work process takes to perform. In a video taken as part of the Bakelite® study, Exponent increased the time denominator by starting the clock minutes before any activity commenced and by performing the work process at a farcically slow pace. For example, in the band sawing test, Dr. Paustenbach stood next to the band saw for two minutes and forty-five seconds before he picked up the reformulated Bakelite® plaque to begin cutting and stopped cutting two minutes and thirty-five seconds prior to the end of the taping. Thus, Paustenbach did not work for five minutes and twenty seconds of the fourteen-minute and twenty-nine-second "work simulation." To further reduce exposures and increase the denominator time, Paustenbach worked at an unrealistically slow pace while cutting; he took fourteen minutes and twenty-nine seconds to make five four-inch-long cuts in the reformulated Bakelite® pieces that were six-inches wide. No worker could work this slowly without risking job termination. Finally, Dr. Paustenbach only cut seven pieces[41]; however, the protocol called for seven cuts, resulting in eight pieces.[7]

Discussion: The Etiology of the Problem of Corporate Corruption of Science

Exponent's and ChemRisk's work for corporations involved in litigation is legal consulting and not science. In the case of Dr. Paustenbach's research, "filling data gaps" can mean producing science to specification. In such cases, instead of beginning with a question and seeking the most accurate possible answer, this research starts with the desired conclusions. For example, in 1990, Dr. Paustenbach developed a proposal for the American Petroleum Institute (API) and described it as follows:

> McLaren/ChemRisk is pleased to provide this proposal to develop an alternative cancer potency estimate for benzene. It is our understanding that API would like us to develop a succinct, yet scientifically compelling, integrated position statement to be used in comments to the state of North Carolina and as a possible springboard for future analyses that could be presented to US EPA [Environmental Protection Agency] and the State of California.[2]

Dr. Paustenbach explained some of their methods and assured the American Petroleum Institute that he would incorporate their comments into final published papers.

> . . . EPA and OSHA considered benzene to cause all types of leukemia in their development of cancer potency estimates for benzene. . . .The objective of this task is to develop a succinct, compelling position that presents evidence that AML is the only type of leukemia induced by benzene exposure (task 4.1). A meeting with Dr. Richard Irons will be needed in order to discuss the molecular basis for benzene-induced AML (task 4.2).
>
> *Deliverable to the API benzene task force*: Draft manuscript, suitable for publication in *Fundamental and Applied Toxicology*. Comments from the Task Force and Dr. Irons will be incorporated into a final document.[2]

Dr. Paustenbach published this work but failed to disclose that the research findings had been predetermined with a foregone conclusion and had been subject to editing by industry representatives.[2]

Exponent's production and simulation study of Bakelite® is typical of the type of service they provide industry in the form of fabricated historical reconstruction of product characteristics (i.e., "encapsulated") and exposure (i.e., "none," or "not enough to cause harm.").[58–63]

A 2002 letter from Exponent's Patrick Sheehan to Ford, General Motors, and Chrysler lawyers sheds light on the nature of the relationship that existed

between Exponent and ChemRisk, their staff, and the company's corporate clients.[h] This letter was designated as confidential attorney work product as follows:

> Document type: Confidential draft memoranda from expert consultant to legal staff attorneys memorializing scope of litigation strategy tasks, ongoing work and budgets related to defending ongoing, pending and potential litigation matters.
>
> Purpose: To set forth litigation strategy tasks to assist in ongoing, pending and prospective litigation.

Sheehan sent the letter to the legal representatives of the three automakers, and he stamped them "Attorney Work Product; Privileged & Confidential by Joint Defense Agreement."[64] Sheehan confirmed that the company lawyers, rather than the companies, hired Exponent, and later ChemRisk, under a "Joint Defense Agreement" for litigation research. In his deposition, Sheehan stated that he labeled the documents that he prepared as "attorney work product" per instructions from the company lawyers. The letter indicates that he was part of the legal defense team, and that Exponent's work was part of the legal defense—not independent research. Sheehan confirmed Exponent's strategy, understanding that the lawyers determined the nature of the research:

> . . . for litigation support work performed by Exponent **at the request of you and/or your designated representatives** from February 1, 2002 forward to the completion of this project or the severing of this agreement by these parties, each company will assume responsibility for payment of a one-third share of the cost of all tasks performed[64,i] (emphasis added).

When research is conducted pursuant to litigation, the company lawyers can block publication and disclosure even though the disclosure would prevent disease and death. In fact, in most states, the work of (or even the existence of) nontestifying consulting experts is not disclosed to the opposing party or to the court.[65]

Readers of corporate-funded studies must determine whether they are legitimate studies or camouflaged data manipulation masquerading as science.

Appendix A

Excerpted sections from U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1926.1101 – Asbestos. (available at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10862)

Asbestos containing flooring materials

1926.1101(g)(8)(i): For removing vinyl and asphalt flooring materials which contain ACM or for which in buildings constructed no later than 1980, the employer has not verified the absence of ACM pursuant to paragraph (g)(8)(i)(I) of this section. The employer shall ensure that employees comply with the following work practices and that employees are trained in these practices pursuant to paragraph (k)(9):

1926.1101(g)(8)(i)(A): Flooring or its backing shall not be sanded.

1926.1101(g)(8)(i)(B): Vacuums equipped with HEPA filter, disposable dust bag, and metal floor tool (no brush) shall be used to clean floors.

1926.1101(g)(8)(i)(C): Resilient sheeting shall be removed by cutting with wetting of the snip point and wetting during delamination. Rip-up of resilient sheet floor material is prohibited.

1926.1101(g)(8)(i)(D): All scraping of residual adhesive and/or backing shall be performed using wet methods.

1926.1101(g)(8)(i)(E): Dry sweeping is prohibited.

1926.1101(g)(8)(i)(F): Mechanical chipping is prohibited unless performed in a negative pressure enclosure which meets the requirements of paragraph (g)(5)(i) of this section.

1926.1101(g)(8)(i)(G): Tiles shall be removed intact, unless the employer demonstrates that intact removal is not possible.

1926.1101(g)(8)(i)(H): When tiles are heated and can be removed intact, wetting may be omitted.

1926.1101(g)(8)(i)(I): Resilient flooring material including associated mastic and backing shall be assumed to be asbestos-containing unless an industrial hygienist determines that it is asbestos-free using recognized analytical techniques.

Asbestos containing roofing materials

1926.1101(g)(8)(ii): For removing roofing material which contains ACM the employer shall ensure that the following work practices are followed:

1926.1101(g)(8)(ii)(A): Roofing material shall be removed in an intact state to the extent feasible.

1926.1101(g)(8)(ii)(B): Wet methods shall be used to remove roofing materials that are not intact, or that will be rendered not intact during removal, unless such wet methods are not feasible or will create safety hazards.

1926.1101(g)(8)(ii)(C): Cutting machines shall be continuously misted during use, unless a competent person determines that misting substantially decreases worker safety.

Author's and Editor's note

A previous version of this paper was peer reviewed, accepted, and published in January 2016 by the *International Journal of Occupational and Environmental Health*, of which Dr.

Egilman was the Editor. In April 2017, Taylor & Francis Publications, the publisher of *International Journal of Occupational and Environmental Health*, withdrew the paper stating that "due to an omission of oversight, the manuscript was not subject to our in-house review prior to its publication. Subsequently we have reviewed the content, and decided to withdraw it from publication." There is no description of any "in-house review procedure" in Taylor & Francis Publications's website or in any communication that Dr. Egilman had with them while serving as editor of the *International Journal of Occupational and Environmental Health*. Once submitted to *New Solutions*, the manuscript completed rigorous peer review, and revisions were made based on reviewer critiques. Dr. Egilman has made a website available (at http://egilmanbakelitedocuments.com) to readers of this article for access to referenced material made available through litigation or otherwise available as a matter of public record.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Dr. Egilman testifies as an expert witness in asbestos litigation at the request of injured parties and asbestos product manufacturing companies. He served as an expert witness at the request of Union Carbide in the Bhopal litigation.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

a. Exponent called the samples "plaques" in its first report to UCC's lawyers. They referred to the plaques as "test panels" in their second report to the company and in the published paper, apparently in an effort to imply that they reflected commercial sizes.
b. For several reasons, plaintiff lawyers almost never make Daubert motions to exclude defense evidence: plaintiffs have the burden of proof and must have preexisting evidence of some sort to bring a case in the first place. In addition, while plaintiff lawyers usually represent a single—or a few—clients, companies are often sued by many alleged victims (in the case of asbestos, tens of thousands) and thus can distribute research costs over many cases.
c. The name change was part of the strategy to convince juries and regulatory agencies that chrysotile asbestos was less harmful (or even nontoxic) compared to other asbestos forms.
d. Dr. Paustenbach presented this talk in 2006 as President of ChemRisk, the risk-assessment consulting firm that he founded during the 1990s and reestablished in June of 2003 after having served for a time as Vice President of Exponent. Dr. Paustenbach performed the Bakelite® study when he worked for Exponent.

e. It is important to note that worker exposures to the molding compounds used to manufacture Bakelite present a much higher risk of exposure. UCC measured these, and exposures were as high as 14.0 f/cc, taken when an operator was dumping five bags of powdered phenolic-molding compound.[43,52–55]
f. Additionally, in the Army Corps of Engineers' study cited by OSHA, three mechanical Certified Asbestos Consultants asbestos removal methods and a manual method were evaluated by monitoring during removal of the siding. The three methods were (1) super wet: the siding was thoroughly wetted with water on the outfacing and back side; (2) mist: a measured amount of water was applied to the outfacing side of the siding only; and (3) encapsulation: an EPA-approved commercially available encapsulant was applied at or above the recommended application rate. These removals took place inside enclosures, and the hand method was also evaluated.
g. The authors cite the 1994 OSHA standard; however, in the text, they correctly reference the 1972 OSHA standard, which is where this language appears.
h. This section relies on materials that relate to Exponent and ChemRisk work for companies involved in asbestos friction product litigation—not to that involving UCC.
i. GM's outside counsel issued the checks on behalf of GM.[64]

Supplemental Material

Supplementary material is available for this article online.

ORCID iD

David Egilman http://orcid.org/0000-0003-0280-163X

References

1. Egilman D, Ardolino E, Howe S, et al. Deconstructing a state-of-the-art review of the asbestos brake industry. *New Solut* 2011; 21: 545–571.
2. Bohme SR, Zorabedian J and Egilman DS. Maximizing profit and endangering health: corporate strategies to avoid litigation and regulation. *Int J Occup Env Heal* 2005; 11: 338–348.
3. Huff J. Industry influence on occupational and environmental public health. *Int J Occup Environ Health* 2007; 13: 107–117.
4. Mowat F, Bono M, Lee RJ, et al. Occupational exposure to airborne asbestos from phenolic molding material (Bakelite) during sanding, drilling, and related activities. *J Occup Environ Hyg* 2005; 2: 497–507.
5. Carrington S. Testimony in Abdalla vs. 84 Lumber Company et al., September 4, 2014, http://egilmanbakelitedocuments.com/Carrington_Testimony_in_Abdalla_vs_84_Lumber_September_ 4_2014.PDF (accessed 7 March 2018).
6. Scott C. Preparation of union carbide Bakelite product BMMA-5353 using historical information prepared for Mayer, Brown, Rowe & Maw Chicago, Illinois. Exponent 2003, http://egilmanbakelitedocuments.com/Scott_Preparation_of_Union_Carbide_Bakelite_Product_BMMA_5353_Using_Historical_Information_2003_May.pdf (accessed 7 March 2018).

7. Exponent, BMMA-5353 product testing prepared for Mayer, Brown, Rowe & Maw, http://egilmanbakelitedocuments.com//Exponent_BMMA_5353.pdf (2003, accessed 7 March 2018).
8. Egilman D, Kim J and Biklen M. Proving causation: the use and abuse of medical and scientific evidence inside the courtroom – an epidemiologist's critique of the judicial interpretation of the Daubert ruling. *Food Drug Law J* 2003; 58: 223–250.
9. Daubert v. Merrell Dow Pharmaceuticals, Inc. 509 US 579. Supreme Court, 1993.
10. Chesebro K. Galileo's retort: Peter Huber's junk scholarship. *Am Univ Law Rev* 1993; 42: 1637–1726.
11. Exponent, history, https://web.archive.org/web/20080605012055/ http://www.exponent.com/history/ (accessed 7 March 2018).
12. Exponent, Exponent capabilities, https://web.archive.org/web/20080605005858/ http://www.exponent.com:80/capabilities (accessed 7 March 2018).
13. Cardno ChemRisk, about us, http://www.cardnochemrisk.com/index.php?option=com_content&view=article&id=569&Itemid=10 (2017, accessed 7 March 2018).
14. Paustenbach D. The roles of dose reconstruction and simulation studies in understanding historical exposure to asbestos, http://www.chrysotile.com/en/conferences/speakers/Dennis_Paustenbach.aspx (2006, accessed 7 March 2018).
15. Calabrese EJ, Stanek EJ, Barnes R, et al. Methodology to estimate the amount and particle size of soil ingested by children: implications for exposure assessment at waste sites. *Regul Toxicol Pharmacol* 1996; 24: 264–268.
16. Copeland TL, Paustenbach DJ, Harris MA, et al. Comparing the results of a Monte Carlo analysis with EPA's reasonable maximum exposed individual (RMEI): a case study of a former wood treatment site. *Regul Toxicol Pharmacol* 1993; 18: 275–312.
17. Cowan DM, Dopart P, Ferracini T, et al. A cross-sectional analysis of reported corporate environmental sustainability practices. *Regul Toxicol Pharmacol* 2010; 58: 524–538.
18. Cowan DM, Kingsbury T, Perez AL, et al. Evaluation of the California Safer Consumer Products Regulation and the impact on consumers and product manufacturers. *Regul Toxicol Pharmacol* 2014; 68: 23–40.
19. Finley BL, Monnot AD, Paustenbach DJ, et al. Derivation of a chronic oral reference dose for cobalt. *Regul Toxicol Pharmacol* 2012; 64: 491–503.
20. Finley BL, Pierce JS, Paustenbach DJ, et al. Response to a letter to the editor by Dr. Murray M. Finkelstein regarding the article by Finley et al. (2012). *Regul Toxicol Pharmacol* 2013; 65: 180–181.
21. Finley BL, Pierce JS, Paustenbach DJ, et al. Malignant pleural mesothelioma in US automotive mechanics: reported vs expected number of cases from 1975 to 2007. *Regul Toxicol Pharmacol* 2012; 64: 104–116.
22. Finley BL, Proctor DM and Paustenbach DJ. An alternative to the USEPA's proposed inhalation reference concentrations for hexavalent and trivalent chromium. *Regul Toxicol Pharmacol* 1992; 16: 161–176.
23. Finley BL, Scott P and Paustenbach DJ. Evaluating the adequacy of maximum contaminant levels as health-protective cleanup goals: an analysis based on Monte Carlo techniques. *Regul Toxicol Pharmacol* 1993; 18: 438–455.
24. Jiang GC, Madl AK, Ingmundson KJ, et al. A study of airborne chrysotile concentrations associated with handling, unpacking, and repacking boxes of automobile clutch discs. *Regul Toxicol Pharmacol* 2008; 51: 87–97.

25. Kopelovich LM, Thuett KA, Chapman PS, et al. History and evolution of warning labels for automotive friction products. *Regul Toxicol Pharmacol* 2014; 68: 402–411.
26. Madl AK, Hollins DM, Devlin KD, et al. Airborne asbestos exposures associated with gasket and packing replacement: a simulation study and meta-analysis. *Regul Toxicol Pharmacol* 2014; 69: 304–319.
27. Paustenbach D and Galbraith D. Biomonitoring: is body burden relevant to public health? *Regul Toxicol Pharmacol* 2006; 44: 249–261.
28. Paustenbach DJ. Important recent advances in the practice of health risk assessment: implications for the 1990s. *Regul Toxicol Pharmacol* 1989; 10: 204–243.
29. Paustenbach DJ and EPA Science Advisory Board. The U.S. EPA Science Advisory Board Evaluation (2001) of the EPA dioxin reassessment. *Regul Toxicol Pharmacol* 2002; 36: 211–219.
30. Paustenbach DJ, Jernigan JD, Bass R, et al. A proposed approach to regulating contaminated soil: identify safe concentrations for seven of the most frequently encountered exposure scenarios. *Regul Toxicol Pharmacol* 1992; 16: 21–56.
31. Paustenbach DJ, Panko JM, Fredrick MM, et al. Urinary chromium as a biological marker of environmental exposure: what are the limitations? *Regul Toxicol Pharmacol* 1997; 26: S23–S34.
32. Paustenbach DJ, Rinehart WE and Sheehan PJ. The health hazards posed by chromium-contaminated soils in residential and industrial areas: conclusions of an expert panel. *Regul Toxicol Pharmacol* 1991; 13: 195–222.
33. Paustenbach DJ, Shu HP and Murray FJ. A critical examination of assumptions used in risk assessments of dioxin contaminated soil. *Regul Toxicol Pharmacol* 1986; 6: 284–307.
34. Proctor DM, Fredrick MM, Scott PK, et al. The prevalence of chromium allergy in the United States and its implications for setting soil cleanup: a cost-effectiveness case study. *Regul Toxicol Pharmacol* 1998; 28: 27–37.
35. Shu HP, Paustenbach DJ and Murray FJ. A critical evaluation of the use of mutagenesis, carcinogenesis, and tumor promotion data in a cancer risk assessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Regul Toxicol Pharmacol* 1987; 7: 57–88.
36. Teuschler L, Klaunig J, Carney E, et al. Support of science-based decisions concerning the evaluation of the toxicology of mixtures: a new beginning. *Regul Toxicol Pharmacol* 2002; 36: 34–39.
37. Jacobson MF. Lifting the veil of secrecy from industry funding of nonprofit health organizations. *Int J Occup Environ Health* 2005; 11: 349–355.
38. Rabe KF and Sterk PJ. Editing the ERJ: an observational study. *Eur Respir J* 2006; 27: 1–2.
39. McKee M and Allebeck P. Why the European Journal of Public Health will no longer publish tobacco industry-supported research. *Eur J Public Health* 2014; 24: 182.
40. EJR. European Respiratory Society research journals manuscript submission guidelines, http://erj.ersjournals.com/authors/ms-preparation (2017, accessed 7 March 2018).
41. Paustenbach D. Exponent Bakelite band sawing video, http://www.youtube.com/user/nacvids?feature=em-share_playlist_user (2014, accessed 7 March 2018).
42. Myers J. Handling asbestos chrysotile asbestos in plastics. *J Paint Technol* 1975; 47: 4.
43. Bradley W. Environmental health consultation for Bound Brook from William R. Bradley and Associates Environmental Health Consultants, http://egilmanbakelitedo

cuments.com/Bradley_Environ_Health_Consul_for_Bound_Brook_1972_Nov28_Report_No_UCASB00913256-7.pdf (1972, accessed 7 March 2018).
44. Paustenbach D. Testimony in Re: Baltimore City In The Asbestos Litigation Circuit Court For Baltimore City, Beeman, et al. Consolidated Case No. 24x04001106 V. AC&S et al. May 9, 2006 Trial Cluster, May 2, 2006, http://egilmanbakelitedocuments.com/Paustenbach_testimony_in_Beeman_vs_ACS_May_2006.pdf (accessed 7 March 2018).
45. Fusaro M. UCC slide show, http://egilmanbakelitedocuments.com/Fusaro_Slide_show_1973_UCC014269-014297.pdf (1973, accessed 7 March 2018).
46. McKinley C. Dust from Band Saw, Bldg. 95, http://egilmanbakelitedocuments.com/McKinley_Dust_from_Band_Saw_Bldg_95_1969.pdf (1969, accessed 7 March 2018).
47. Hagensli T. Memo to McKinley, CS., et al. Asbestos dust in Rooms 351 and 365, Building 95, Bound Brook, http://egilmanbakelitedocuments.com/Hagensli_to_McKinley_Asbestos_dust_in_rooms_351_and_365_Building_95_1969.pdf (1969, accessed 12 March 2018).
48. Faulring G, Forgeng W, Kleber E, et al. Detection of chrysotile asbestos in airborne dust from thermosetting resin grinding. *J Test Eval* 1975; 3: 482–490.
49. Swalm J. Memo to Krummel E. Swalm to Krummel, product labeling – asbestos, March 13, 1973, http://egilmanbakelitedocuments.com/Swalm_to_Krummel_Product_Labeling_Asbestos_1973_03-14.pdf (accessed 7 March 2018).
50. Hitchcock F. Memo to Denny C., emission standards for pollutants: asbestos, beryllium, and mercury, http://egilmanbakelitedocuments.com/Hitchcock_Memo_to_Denny_Emission_Standards_for%20Pollutants_1973.pdf (1973, accessed 7 March 2018).
51. Longo W and Hatfield R. Abrading of union carbide asbestos-containing Bakelite® fiber release study, August 2004, http://egilmanbakelitedocuments.com/Longo_Abrading_of_Union_Carbide_Asbestos_Containing_Bakelite_Fiber_Release_Study_August_2004.pdf (accessed 7 March 2018).
52. Potter PB. Letter to: all salesmen and customer service representatives, April 16, 1973, http://egilmanbakelitedocuments.com/Potter_Letter_to_All_Salesmen_and_Customer_Service_Representatives_April_1973.pdf (accessed 7 March 2018).
53. OSHA. Occupational exposures to asbestos; final rule federal register 59:153 pp. 40964–41158. August 10, 1994, https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=13404 (accessed 7 March 2018).
54. "Asbestos·containing materials in schools" Code of Federal Regulations Title 40 P, Subpart E. As cited in FR 52:41825–41905 October 30, 1987, http://www.law.cornell.edu/cfr/text/40/part-763/subpart-E (accessed 7 March 2018).
55. UCC, Bakelite phenolic molding materials guide, http://egilmanbakelitedocuments.com/Bakelite_Phenolic_molding_materials_guide_dust.pdf (1971, accessed 7 March 2018).
56. Virta R. *Asbestos: geology, mineralogy, mining, and uses. Open-File Report 02-149*. U.S. Department of the Interior, U.S. Geology Survey, 2002.
57. Gunter ME, Sanchez MS and Williams TJ. Characterization of chrysotile samples for the presence of amphiboles: The Carey Canadian deposit, Southeastern Quebec. *can Mineral* 2007; 45: 17.

58. Madl AK and Paustenbach DJ. Airborne concentrations of benzene and mineral spirits (stoddard solvent) during cleaning of a locomotive generator and traction motor. *J Toxicol Env Heal A* 2002; 65: 1965–1979.
59. Paustenbach DJ, Madl AK, Donovan E, et al. Chrysotile asbestos exposure associated with removal of automobile exhaust systems (ca. 1945-1975) by mechanics: results of a simulation study. *J Expo Sci Environ Epidemiol* 2006; 16: 156–171.
60. Gaffney S, Moody E, McKinley M, et al. Worker exposure to methanol vapors during cleaning of semiconductor wafers in a manufacturing setting. *J Occup Environ Hyg* 2008; 5: 313–324.
61. Paustenbach DJ, Knutsen JS, Hollins DM, et al. Comparison of modeled and measured concentrations of airborne benzene from the use of petroleum-based solvents spiked with low levels of benzene. *Chem-Biol Interact* 2010; 184: 296–298.
62. Kerger BD, Suder DR, Schmidt CE, et al. Airborne exposure to trihalomethanes from tap water in homes with refrigeration-type and evaporative cooling systems. *J Toxicol Env Heal A* 2005; 68: 401–429.
63. Madl AK, Scott LL, Murbach DM, et al. Exposure to chrysotile asbestos associated with unpacking and repacking boxes of automobile brake pads and shoes. *Ann Occup Hyg* 2008; 52: 463–479.
64. Sheehan PJ. Testimony in Allen vs 3M et al., Madison County Illinois Case No. 14 L 131, August 28, 2014, http://egilmanbakelitedocuments.com/Sheehan_Deposition_in_Allen_vs_3M_August_28_2014.pdf (accessed 7 March 2018).
65. Pielemeier JR. Discovery of non-testifying "in-house" experts under Federal Rule of Civil Procedure 26. *Indiana Law J* 1983; 58: 597, https://www.repository.law.indiana.edu/ilj/vol58/iss4/2 (accessed 7 March 2018).

Author Biography

David Egilman received his Bachelor of Science in Molecular Biology as well as his MD from Brown University. He is board certified in internal medicine and preventive occupational medicine and graduated from the NIH Epidemiology Training program. He received a Master's in Public Health from Harvard. He currently teaches at Brown and does research on the influence of corporations on science and health policy.