

October 11, 2007

The Honorable Jeff Haferman, Ph.D.  
Vice-Mayor of Monterey  
City Hall  
Monterey, CA 93940

Dear Dr. Haferman:

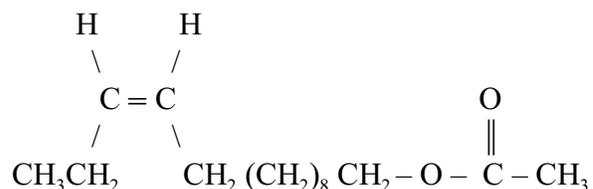
In our phone conversation this evening, you asked if I would provide you with a copy of the comments that I wrote regarding concerns with the aerial application of Checkmate products in and around Monterey County. I have since expanded and refined those comments somewhat. Thus, you should note that there are some differences relative to what you may have seen previously.

I had an opportunity to review an article in the Friday, September 28, 2007, issue of the *Santa Cruz Sentinel*, which allegedly lists several of the components (ingredients) in the Checkmate products manufactured by Suterra and proposed or used by the California Secretary of Agriculture for aerial spraying to control the light brown apple moth. For the sake of the discussion here, I have commented on that list as well as information publicly available through Suterra's website (specifically, the material data safety sheets or MSDSs and the technical data sheets for the Checkmate products). I am concerned that some of the materials reported by the *Sentinel* as components may in fact not be components, and I have noted this below. The discussion is obviously contingent upon the correctness of the reported formulation. Since the formulation is regarded as confidential business information, proprietary information, or a trade secret under various laws or regulations, I cannot be more specific.

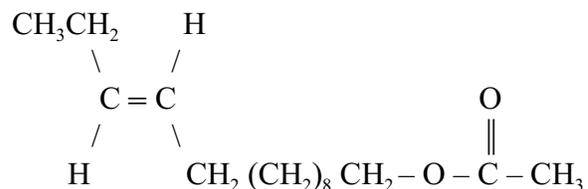
A summary of my credentials may be helpful. I have a B.S. in chemistry from Allegheny College and a Ph.D. in chemistry from Purdue University. I worked for the EPA's National Risk Management Research Laboratory for six years. My Ph.D. research was concerned with the equilibrium, kinetics, and mechanisms of chemical reactions. I have authored or coauthored about 40 papers in the peer-reviewed literature, mostly on the analysis of drinking water for trace and ultratrace contaminants and the fate and transformation of these contaminants in water and soil, including a number of review articles. In addition, I was formerly an associate editor of *Journal of Environmental Management* and a member of the International Advisory Board of *Journal of Environmental Monitoring*. My work on perchlorate chemistry is probably best known to most California environmental scientists, including editing a book, *Perchlorate in the Environment*. I have also served as a consultant to the State Attorney for the First Judicial Circuit in Florida.

I have represented the compounds with bold-face, unitalicized Arabic numerals, as is one of the conventions in the chemical literature. The first two compounds are reportedly the synthetic pheromones, which are the active principles.

- 1: (Z)-11-tetradecenyl acetate, this is an active ingredient; it is on the *Sentinel's* list and in the manufacturer's MSDS
- 2: (E)-11-tetradecenyl acetate, this is an active ingredient, but it is not represented correctly on the *Sentinel's* list; it is in the manufacturer's MSDS on its website



Compound 1 (could also be named as *cis* because the two hydrogens are together)



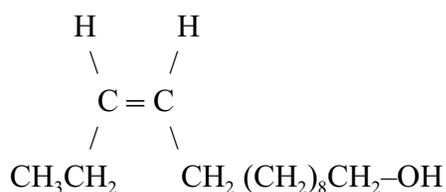
Compound 2 (could also be named as *trans* because the two hydrogens are across)

Compounds 1 and 2 are both on the manufacturer's MSDS as noted above, but compound 2 is missing from the *Sentinel's* list. The designations (*E*) and (*Z*) refer to the geometric isomers about the double bond that occurs at carbon 11 (hence, the locant 11). *E* stands for *entgegen* (German for opposite, meaning the higher priority groups are on the opposite sides of the double bond); *Z* stands for *zusammen* (German for together, meaning the higher priority groups are on the same side of the double bond). Carbon 1 is bonded to the acetate. Normally, only one of the geometric isomers has significant biological activity.

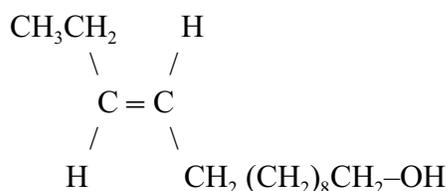
As a rule, we would not anticipate these types of esters to have significant biological activity. Esters are among the most physiologically benign functionalities. For example, glyceride fats are the esters of various fatty acids with the triol glycerine (also known as glycerol). It is called a triol because there are three –OH groups on it. Unfortunately, when esters hydrolyze, they are converted to the parent carboxylic acid and the parent alcohol. In this case, the parent carboxylic acid is acetic acid, which is also extremely benign. At the concentrations that would be encountered from hydrolysis, this acetic acid exposure would be less than a drop of vinegar in glass of water. The article does not list acetate explicitly, but I believe this may be an error due to the way that compound 4 is listed. I would anticipate some acetic acid or sodium acetate to be present from the manufacturing process. However, it may be that the concentration is below a reportable limit or has not been measured.

I suspect that the next two compounds (**3** and **4**) have very little effect on light brown apple moth mating behavior; these types of long-chain alcohols may even be repellent to some insects. The locant 1 is superfluous; if omitted (along with its hyphens), the name would represent the same compound. The isomeric designation is required, however. Both **3** and **4** are leftover starting materials or hydrolysis byproducts. They would be treated as inert ingredients because they do not contribute to the activity of the product for its intended use, not because they are biologically or chemically inert in a more general sense. I have some concern that these alcohols, especially because of the alkene functionality, may exert some irritant effects on the mucosae, but there have been no studies done to support such an assertion so far as I know. I would suggest avoiding aerosols of these materials because of their extremely low solubilities. There are no OSHA permissible exposure limits (PELs) or American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs), which makes it difficult to assess the physiological impacts of exposure. Also, risks from exposures are predicated on time-average values based on a combination of time and concentration. Therefore, it is difficult to extrapolate from the types of worker exposures for which the manufacturer recommends personal protective equipment to the types of exposures that would occur from the aerial spraying authorized by the Secretary. Whether compounds **3** and **4** are in fact present as leftover starting materials in the formulation when applied is largely irrelevant because they will form as the active principles (**1** and **2**) hydrolyze (react with water). These alcohols also probably offer some antifoaming activity.

- 3:** (*Z*)-11-tetradecen-1-ol, this would be expected as a leftover starting material, but it is not on the *Sentinel's* list
- 4:** (*E*)-11-tetradecen-1-ol, this should be a leftover starting material—However, it appears to be written incorrectly on the *Sentinel's* list as an acetate—the compound as named in the article cannot exist; I suspect the *Sentinel* may have reported commingled names of compounds **2** and **4**.



Compound **3** (also *cis*)

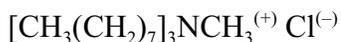


Compound **4** (also *trans*)

The active ingredients are most likely synthesized via an esterification reaction between either compound **1** or **2** and acetic acid,  $\text{CH}_3\text{CO}_2\text{H}$ :



**5:** tricaprylylmethyl ammonium chloride, a detergent or dispersant; this component is on the *Sentinel's* list, but not in the MSDS



Compound **5**

The caprylyl group is better known as the octyl group, but the trivial name is still used industrially. *Caprylyl* is a throwback trivial name; caprylic acid is naturally produced as goat's milk becomes rancid since the milk is rich in octyl glycerides. The name refers to this fact; *caper* means goat. All of the mid- to long-chain quaternary ammonium compounds can act as a cationic surfactants. This particular choice seems kind of odd in that it is not an especially good detergent, but it would be low-foaming, so that may be the main reason it was selected. Spraying tends to generate foam, which would reduce the efficiency of the process, so a low-foaming surfactant would be preferable.

Caprylic (*n*-octanoic) acid has an acrid smell and is somewhat irritating, but I can think of no obvious mechanism by which it could be produced here. On the other hand, 1-octanol (caprylol) would be produced by the hydrolysis of the quaternary ammonium cation. The reaction rate increases with increasing pH or temperature. At sufficient quantities, 1-octanol can be quite annoying. As with other alcohols with a chain length of 4–12 carbon atoms, the following can be stated: (1) it has an oily feel, (2) it is not especially soluble in water, (3) it has a somewhat sweet—but annoying—smell, and (4) it can exert tussive effects (promote coughing) at higher concentrations. Some people are far more sensitive to it than others.

Most cationic surfactants naturally have some level of antimicrobial properties. These properties vary among organisms, and can be devastating to populations of some organisms. For example, *Pseudomonas aeruginosa* is relatively immune to their effects, and this can lead to overgrowths of pseudomonads as the competing bacteria are suppressed or killed. In addition, minor changes in

surface tension brought about by surfactants can affect the more vulnerable crustacean zooplankton such as amphipods, copepods, or branchiopods (e.g., daphnids, brine shrimp). Although large scale fluctuations in population (major die-offs) are unlikely, localized disturbances could occur, especially in shallower estuarine waters or along shorelines (the neritic and benthic zones), where there is a potential for a greater exposure.

The significance depends partly on how much surfactant is present in the formulation. I have been told that foaming was evident after a rainfall. To cause foaming, the concentration of a surfactant has to be reasonably high (in terms of practices of surfactant usage)—usually high enough to expect impacts on vulnerable organisms, especially some types of aquatic or semi-aquatic life. As I will discuss below with phosphate, the watershed issue is one of total loading as well as the topography and hydrology that permit the rapid influx of stormwater run-off into surface waterways. Given the large regions proposed for spraying, the total surfactant loading appears to be significant and should be evaluated by persons with appropriate credentials in hydrology, soil attenuation, and watershed management.

**6:** sodium phosphate, a buffer to control pH, on the *Sentinel's* list, not in the MSDS

Although the name used is sodium phosphate, the actual speciation would be distributed among a mixture of the various conjugate acid-base pairs so as to serve as a buffer. One would expect the solution to be buffered to a slightly acidic pH (maybe 5–6) to avoid alkaline hydrolysis. In that case, the distribution would be dominated by  $\text{H}_2\text{PO}_4^-$  and  $\text{HPO}_4^{2-}$ , which would be present at much higher concentrations than either  $\text{H}_3\text{PO}_4$  or  $\text{PO}_4^{3-}$ . These materials are entirely harmless to humans at the exposure levels that could be reached via aerial spraying.

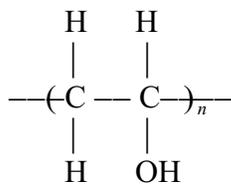
On the other hand, if the concentrations are sufficiently high, there could be ecological consequences for the watershed. I do not know what the phosphate concentrations are in the product, but it is important to remember that the amount of hard surface (parking lots, building roofs, roadways) that will be exposed is high. Even though the product is substantially diluted, vast areas of impermeable surface will be covered with phosphate. During a rain storm, this soluble phosphate is rapidly mobilized and carried into storm sewers and open waterways. I am unfamiliar with the civil engineering structures used to control, contain, and divert stormwater in the Monterey County region, so soil sorption and soil microbe consumption are possible mitigating factors. Nonetheless, I can say that it would be unfortunate if a significant phosphate bolus were delivered to any natural waterway because phosphate is associated with eutrophication. Certainly, the total loading and (hydrological) rate of loading of phosphate to the watershed must be carefully considered for possible impacts.

High available phosphate in a watershed can lead to severe algal blooms and sometimes to secondary adverse ecological effects (mainly die-offs of marine life, e.g., shrimp, bivalves, fish). In addition, these blooms create aesthetic and sanitary problems (e.g., algal mat wash-up and malodorous algal rot). In the 1960s and 1970s, problems with algae and foaming were associated largely with phosphate-laden municipal sewage effluents resulting from the use of laundry detergents containing phosphate builders. Agricultural run-off was implicated to a lesser degree. It is wise to remember

that phosphates have been almost completely eliminated from laundry detergent formulations for ecological reasons, thus putting a stop what was termed the “cultural eutrophication” of rivers and lakes in the United States.

Without knowing the formulation, it is possible to hazard rough guesses only. Monterey County has about 3320 square miles of land, which is 2.13 million acres. The Secretary’s plan is to apply on average a 15-gram portion of Checkmate to each acre. If we assume that (1) hard surfaces (parking lots, rooftops, and roads) make up 15% of this land and (2) the Checkmate phosphate concentration is 0.10% by mass, then we would expect about 10.5 lb of phosphate to be discharged to the bay by stormwater during a single storm after a single spraying. Overall, the Secretary intends to disperse perhaps 70 lb of phosphate with each aerial treatment. This may seem trivial in terms of horticultural or agricultural use, but it could be significant in terms of limnology if carried by rainwater run-off. However, I did not see any attempt by the Secretary to demonstrate that the phosphate would be negligible or even to account for phosphate release at all.

- 7: poly(vinyl alcohol), a rheological modifier or emulsifier (on the *Sentinel’s* list, not in the MSDS)



Compound 7

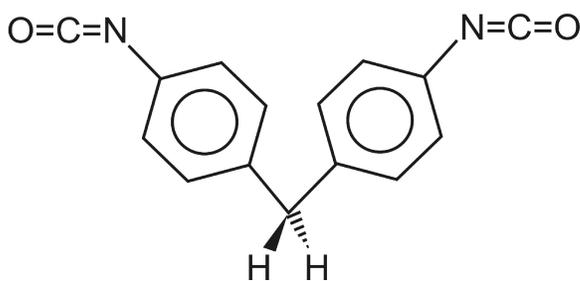
Depending on the size of the polymer, poly(vinyl alcohol) can serve a number of functions. Poly(vinyl alcohol) or PVA will modify the physical properties of a fluid. The various PVAs are well-known, widely used materials generally regarded as safe. The smaller ones are soluble in water, while the larger ones are not. My initial reaction to learning that there are PVAs is to think that they have been added to help keep the microcapsules suspended in the water. In low concentrations, PVAs are likely to have that effect. The polymers tend to stick to surfaces (which the microcapsules have in abundance); however, the benefit comes from the hydrophilicity of the –OH groups in the PVAs, which would help to increase the suspendability of the microcapsules. PVAs can serve as binders and promote foam formation. Without more information, however, this is not much more than a guess. Alone, these materials are harmless, but they could increase the risks associated with other agents by affecting dispersion, fluid dynamic properties, or bioavailability.

- 8: polymethylene polyphenyl isocyanate ,on the *Sentinel’s* list, not in the MSDS  
(no structure provided)

Everything I have read about Checkmate products up to now has suggested that the microcapsules are composed of urea-formaldehyde polymers, which is an industry standard for microencapsulation. Therefore, I am somewhat surprised to see PMPPI (**8**) listed among the components. I think this is suspect and needs to be verified directly with Suterra. Methylene polymers are often produced from formaldehyde (hence the name urea-formaldehyde); it is unsurprising to see polymethylene in the name. It is somewhat surprising to see polyphenyl isocyanate. For stiffness, phenyl groups are often incorporated into foaming polymers. They can also aid degradation by ultraviolet light. Normally, PMPPI is used to make foam insulation that is sprayed on and allowed to harden, but I suppose it could be used to generate the microcapsules. Patents exist for PMPPI-microencapsulation of the herbicide clomazone and the pesticide cadusafos, for example, so the report could be accurate. PMPPI would be more resistant to degradation than a typical urea-formaldehyde polymer, perhaps too resistant.

Aerial spraying of PMPPI microcapsules or PMPPI dust over areas where humans are likely to be exposed directly (that is, where humans may be outside) is ill-advised, in my opinion. I have concerns that particulates of this compound will have to be degraded physically. It may not be subject to reasonable rates of overall hydrolysis or oxidation. Although this is an oversimplification, imagine putting foam packing peanuts in your blender and then breathing in the dust. These kinds of fine dusts have been associated with a variety of adverse health effects. Exposures that are higher and chronic lead to various diseases, e.g., asbestosis, silicosis, and coal miner's lung. Fortunately, the types of exposures associated with these disabling diseases are substantially greater than the occasional, short-term exposure from the aerial spraying proposed by the Secretary. Nonetheless, it would be reasonable to expect vulnerable subpopulations (those predisposed to pulmonary or respiratory problems, e.g., asthmatics, emphysematics) to potentially suffer acute reactions.

I should note that the isocyanate group can be converted to a substituted urea or iminol by hydrolysis. Furthermore, the entire functionality probably will be eventually converted to a phenylamine and then perhaps a phenol. However, it is not clear that these types of transformations should make the polymer any less persistent in vivo overall. I am concerned that the polymer is insufficiently degradable. The closest chemical for which there are exposure guidelines is 4,4'-diphenylmethane diisocyanate (**9**), which has the Chemical Abstracts Service Registry No. [101-68-8]. However, we would expect the full polymer to have considerably lower acute toxicity, with acute toxicity falling as the molecular mass increases.



Compound **9**

The NIOSH recommended exposure limit (REL) for compound **9** is  $0.050 \text{ mg m}^{-3}$  as a time-weighted average or  $0.2 \text{ mg m}^{-3}$  for 10 minutes. The OSHA PEL is also  $0.2 \text{ mg m}^{-3}$ , using a 10-minute exposure. The immediately dangerous to life or health limit is  $75 \text{ mg m}^{-3}$ . I will draw your attention to some material from the OSHA webpage for PMPPI polymers with CAS Reg. No. [9016-87-9]. I have not had an opportunity to examine these references myself.

#### OSHA Notes:

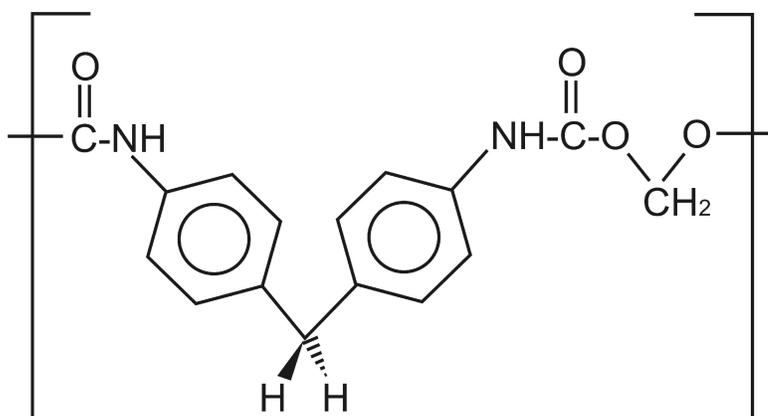
1. Although OSHA has a PEL for methylene bisphenyl diisocyanate (MDI) monomer (20 ppb ceiling), OSHA does not have a PEL for polymeric MDI (PAPI).
2. EPA's inhalation reference concentration (daily inhalational exposure likely to be without an appreciable risk of deleterious effects during a lifetime) is  $0.6 \mu\text{g m}^{-3}$ .
3. Because toxicity is likely related to the very reactive isocyanate ( $\text{N}=\text{C}=\text{O}$ ) group and commercial preparations often contain both MDI monomer and PAPI, exposure limit determination based upon the mass concentration of the  $\text{N}=\text{C}=\text{O}$  groups in polyisocyanates has been suggested.
4. The MDI metabolites, *N'*-acetyl-4,4'-methylenedianiline and 4,4'-methylene dianiline (MDA), have been measured in urine samples from employees involved in the manufacture of polyurethanes.
5. Acid hydrolysis to release MDA from plasma proteins was used to measure the half-lives of MDI-protein adducts in four employees exposed to thermal degradation products of MDI-based polyurethane. The half-lives of such adducts in plasma ranged from 10–22 days.
6. Chronic inhalation studies in rats with MDI (including PAPI) in concentrations up to  $6 \text{ mg m}^{-3}$  reported increased lung weight, interstitial fibrosis, broncho-alveolar hyperplasia and adenomas, and in one high-dose rat, lung adenocarcinoma. In contrast, chronic oral administration of the MDI metabolite, MDA, caused carcinomas in the thyroid (rats and mice), liver (female rats) and adrenals (male mice).

#### References:

1. U.S. EPA Integrated Risk Information System (IRIS). Methylene Diphenyl Diisocyanate (monomeric MDI) and polymeric MDI (PMDI) (CASRN 101-68-8, 9016-87-9).
2. Baur, X. Hypersensitivity pneumonitis (extrinsic allergic alveolitis) induced by isocyanates. *J. Allergy Clin. Immunol.* 95(5 Pt. 1): 1004-1010, 1995.

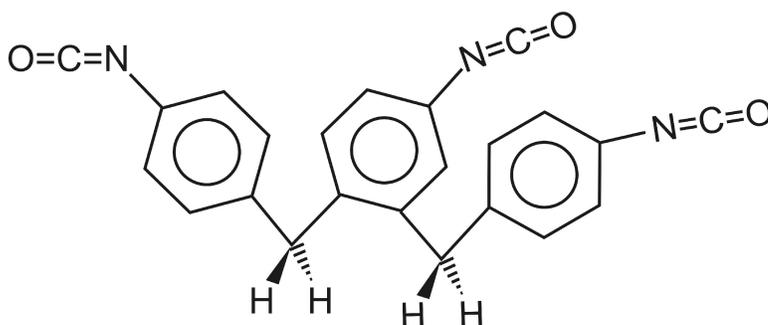
3. Bello, D., et al. Polyisocyanates in occupational environments: a critical review of exposure limits and metrics. *Am. J. Ind. Med.* 46(5): 480-491, 2004.
4. Bonauto, D.K., Sumner, A.D., Curwick, C.C., Whittaker, S.G. and Lofgren, D.J. Work-related asthma in the spray-on truck bed lining industry. *J. Occup. Environ. Med.* 47(5): 514-517, 2005.
5. Dalene, M., Skarping, G. and Lind, P. Workers exposed to thermal degradation products of TDI- and MDI-based polyurethane: biomonitoring of 2,4-TDA, 2,6-TDA, and 4,4'-MDA in hydrolyzed urine and plasma. *Am. Ind. Hyg. Assoc.* 58(8): 587-591, 1997.
6. Feron, V.J., et al. Chronic pulmonary effects of respirable methylene diphenyl diisocyanate (MDI) aerosol in rats: combination of findings from two bioassays. *Arch. Toxicol.* 75(3): 159-175, 2001.
7. Lamb, J.C., Huff, J.E., Haseman, J.K., Murthy, A.S. and Lilja, H.: Carcinogenesis studies of 4,4'-methylenedianiline dihydrochloride given in drinking water to F344/N rats and B6C3F1 mice. *J. Toxicol. Environ. Health* 18(3): 325-337, 1986.
8. No authors. 4,4'-Methylenediphenyl diisocyanate and polymeric 4,4'-methylenediphenyl diisocyanate. *IARC Monogr. Eval. Carcinog. Risks Hum.* 71(Pt. 3): 1049-1058, 1999.

I do want to point out that there is some variation in the techniques for polymerization of isocyanates. Isocyanate polymerization can lead to formation of polyurethanes when done with polyols, for example. Or it can lead to formation of polyureas when done with polyamines. On the other hand, there is no definitive evidence to suggest that a polyol or polyamine was included as an ingredient explicitly. Formaldehyde (methanal,  $\text{CH}_2\text{O}$ ) forms methanediol  $\text{CH}_2(\text{OH})_2$  in water, and could serve in the role of a polyol. Part of the problem stems from the way polymers are named, sometimes in terms of monomers (e.g., urea-formaldehyde) and sometimes in terms of the end result (e.g., polymethylene—you cannot buy a bottle of methylene; it does not exist). If the primary polymer in Checkmate is formed by the reaction between compound **9** and methanediol, which would yield primarily compound **10** as a reasonably accurate representation of the polymer, then it will be subject to degradation, except that its degradation products will be phenylamines, which are also called anilines (note studies above on anilines as degradates).



Compound 10

A complicating factor that arises is that there are other raw materials besides compound 9 that can be used in polymerization. Not all of these will be fully polymerized. Thus, there can be a mixture of partially polymerized starting material and even some completely unreacted starting material. In some cases, the reaction begins with what could appear to be a phenylmethylene polymer (11), even though it is not.



Compound 11

Finally, in addition to these various chemical issues, there is the matter of fine airborne particulate matter (PM). I have been told (but have been unable to verify) that Suterra claims the microcapsules are primarily in the size range of 100 to 150  $\mu\text{m}$ . While that may be true, there will always be a distribution, even if it tails off sharply. Accordingly, it would be critical to know the levels of fine particulate matter produced by spraying, specifically, PM<sub>2.5</sub> (airborne particles below 2.5  $\mu\text{m}$  in size) and PM<sub>10</sub> (airborne particles 2.5–10  $\mu\text{m}$  in size). Fine particulates can penetrate more deeply into the lungs, can interfere with white blood cell function in the lung tissues, and can lead to general irritation of the bronchial or alveolar mucosae. Most disturbing is that these particles could be there essentially forever and the effects of dusts of these polymers specifically are not well-studied. In addition to the microcapsules themselves, I note that polymer dusts can result from the normal manufacturing processes (e.g., from broken, abraded, or malformed microcapsules). I do not know if fine dusts are present at significant levels in these products (perhaps the manufacturing process

is well-controlled), but I would want to know this before I advocated dispersing an aerosolized mist of the products over populated areas where direct contact with humans would occur. Because the dusts would not contain the active principles, I note that such dusts ought to be classified as inert ingredients.

Please note that I find parts of the newspaper's report suspect. If you can verify that the material reported in the newspaper is accurate, then I would have reservations as I have explained above. If the material is a typical urea-formaldehyde polymer (or some very similar polymer), I would be less concerned because the dusts are rapidly biodegradable. No matter what, I am concerned about inhalation of surfactants, especially because there seems to have been no monitoring at ground level for them.

In conclusion, I would argue that an adequate, well-defined monitoring plan for all components (not just the active principles) is critically necessary for several reasons: (1) it ensures the active principles have been delivered in a sufficient dose to have the desired entomological effect, (2) it ensures that spraying is being done in a suitably systematic fashion so that distribution of the material is roughly uniform, (3) it ensures that overdoses and underdoses are not occurring, thereby wasting money and/or failing to have the desired impact, and (4) it ensures that human and ecological exposures of all components are within levels that are considered acceptable. From the information I have been able to review, I am unconvinced that the Secretary has instituted an adequate, well-defined monitoring plan, although there appears to be some sort of monitoring in terms of minimizing the carry-over to buffer zones and no-spray zones. The plan should be subjected to public and expert peer-review scrutiny prior to any further spraying.

In addition to the matter of proper environmental monitoring, I would argue for both (1) development of an information clearinghouse to handle complaints of suspected human or ecological adverse impacts *and* (2) a requirement to investigate and evaluate such claims by trained professionals who are skilled in the use of epidemiological, toxicological, and ecological methods in the development of public health and environmental policy. Moreover, I would argue that those investigators and evaluators must be granted the force of public health law to carry out their investigations and evaluations. Lastly, they must have sufficient trained clinical (medical) personnel at their disposal to interview persons and to assess histories, symptoms, laboratory findings, and clinical findings (or to order additional examination and testing if deemed prudent). This clearinghouse should be tasked to provide appropriate statistical reports and conclusions regarding impacts of spraying on wildlife, surface water quality, and human health. I believe that the California Office of Environmental Health Hazard Assessment (OEHHA) has much of the expertise necessary to carry out such a comprehensive program in-house, but an externally run program would work just as well and may be easier/faster to establish.

In addition to these matters, it would be nice to know what the lifetimes of the product and its degradates are in the soil or in the water. Suterra probably has some of these types of data on hand since it registered the product with the EPA as a pesticide (it meets the agency's definition even though it is technically not a pesticide in the sense of being a poison). Also, if the product's

components or their degradates are persistent (I suspect the tetradecenyl alcohols are somewhat persistent), then the next obvious question is whether the cumulative effect of multiple aerial applications can lead to accumulation in the surface soil, the water, or other environmental reservoirs. I would be most concerned about accumulation in small ponds, for example, and the impacts on phytoplankton and zooplankton. Fortunately, the compounds are mostly straight chains, which have the highest rates of biodegradation. Moreover, the presence of the alkene in both the alcohol and the ester offers a hope of regioselective oxidation or electrophilic addition.

I understand that a University of California study showed that mussel larvae were unaffected by the Checkmate dosage that would be expected from direct spraying of the marine sanctuary. I would caution against drawing strong conclusions about the impacts of spraying on the sanctuary's ecology. First, some mussels can be highly tolerant of chemical exposures. Other species may show distress that is reversible as conditions improve. It would be better to use traditional sentinel or bioindicator organisms, such as daphnids, fathead minnows, or rainbow trout for the purpose of comparison. Second, if the phytoplankton or zooplankton are adversely affected, mussels may show only secondary effects since they are filter-feeders. Third, hydrologic loading from storm events has not been considered. It is altogether possible that exposures will be higher than anticipated. Fourth, the surfactant or PVA may solubilize materials from parking lots, roads, and roofs and carry them into the waterways. The point here is that the real world is complicated and simple studies, while valuable and necessary, can be deceptive.

Overall, I am concerned that the Secretary has not considered all of the environmental, ecological, or toxicological effects of this aerial spraying activity. I suspect that the rush to stop the spread of the light brown apple moth has led to compartmentalization of hazard and risk. This compartmentalization has failed to take into account the big picture impacts of such activities in terms of accumulation and loading to surface waterways. Until all of these matters are satisfactorily addressed by the Secretary, I would discourage continued aerial spraying.

Although I am happy to provide you with this letter, please be aware that I cannot serve as an expert witness in court due to restrictions imposed by my current employer, who prefers not to be revealed.

Sincerely,

Edward Todd Urbansky, Ph.D.