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**Meeting the Challenge of Reducing VOC Product Emissions: A 10 Year Review.**

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**SUMMARY**

This paper provides a review of primary VOCs emissions from certain product types including office furniture, children's furniture, paints and coatings, insulations, adhesives, wall coverings, floor coverings, and electronic equipment. VOC data from specific product categories are grouped by frequency of detection and hazardous risk categories based on target VOC regulatory lists across years during which they were tested. The data demonstrate trends over time including a reduction the number of chemicals detected on key criteria lists and the change in emissions that occurs when moving from solvent based VOCs to water based, and other less toxic formulations and manufacturing processes.

**IMPLICATIONS**

Data from this study is informational to those developing programs and guidance for VOC source control- including policy makers, standard developers, manufacturers and laboratories - in identifying primary sources of indoor pollution, specific VOCs, their levels, and health significance. Data show that products tested generally emitted lower levels of chemicals over the years tested and that criteria lists used to assess indoor air quality generally became less relevant due to changes in raw materials and manufacturing processes.

**KEYWORDS**

VOCs, Certification, Standards, Products and Risk Management.

## INTRODUCTION

A large body of scientific evidence indicates that air within homes and buildings can be substantially more polluted than outdoor air even in the most industrialized cities.<sup>1</sup> Research also indicates that people spend 90 percent of their time indoors.<sup>2</sup> For certain sensitive populations like the elderly, chronically ill or infants, this number is greater.<sup>3</sup> These populations are the most susceptible to the effects of indoor air pollution and spend increased time indoors. Thus the health risks for sensitive populations are greater due to exposure to air pollution indoors than outdoors. There are many potential sources of indoor air pollution in homes and buildings. These include building materials, furnishings and other products used indoors. Considering that source control is the most effective means of preventing indoor air pollution, reducing volatile organic chemical emissions from products is a critical aspect of protecting human health.

Over the past 20 years, over 13,000 products have been studied for their VOC emissions using standardized test protocols and results have been compared to certain indoor air quality product guidelines. We selected a subset of this data and generated a database from which we pulled summary statistics and the frequency of detection for over 14,000 individual chemicals. We have summarized our findings in this paper.

## METHODS

All testing was conducted according to standardized measurement protocols that allow comparative emissions data and exposure concentrations across product types. Specifically, product emissions were measured following the testing requirements of GGTM.P066, “Standard Method for Measuring and Evaluating Chemical Emissions from Building Materials, Finishes, and Furnishings using Dynamic Environmental Chambers.” Emissions measured prior to 2000 were conducted using earlier versions of the test method. Chemical lists are based on published criteria lists as indicated by their name. Irritation lists include chemicals tested for irritation and with published RD50s,<sup>4</sup> and odor lists include chemicals from Wolkoff, Devos and AIHA odor threshold databases.<sup>5</sup> The IRIS list includes chemicals for which there is an IUR and the IRIS2 list includes chemicals for which there is an established Rfc.

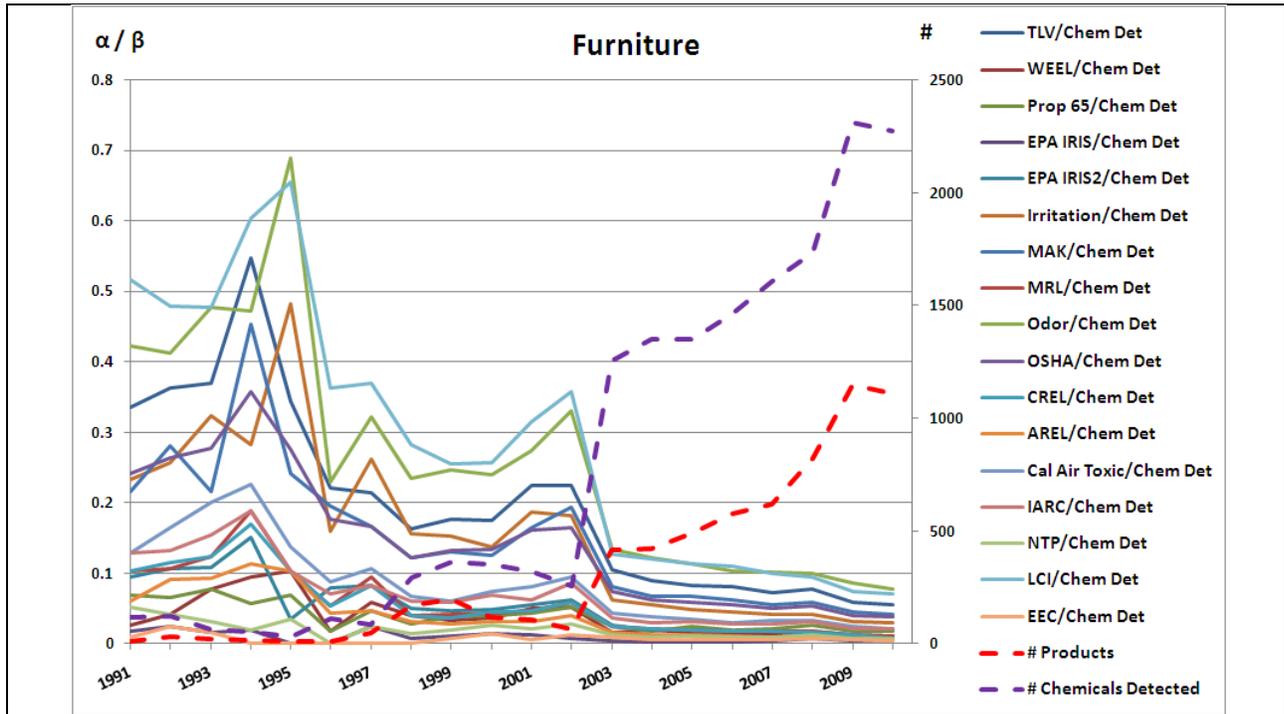
Analytical data was measured and compared to a mass spectral data base consisting of 10,000 compounds. The final measurement database was searched to produce a data set containing only those compounds which were detected in each individual product category. All data presented is as either emission factor in  $\mu\text{g}/\text{m}^2/\text{h}$  or  $\mu\text{g}/\text{unit}/\text{h}$  or frequency of detection based on chamber concentrations at 24 hours. Strict quality control programs entail replicate product tests and duplicate air measurements showing a 5.5% RSD for total VOCs and 2.5% RSD for formaldehyde.

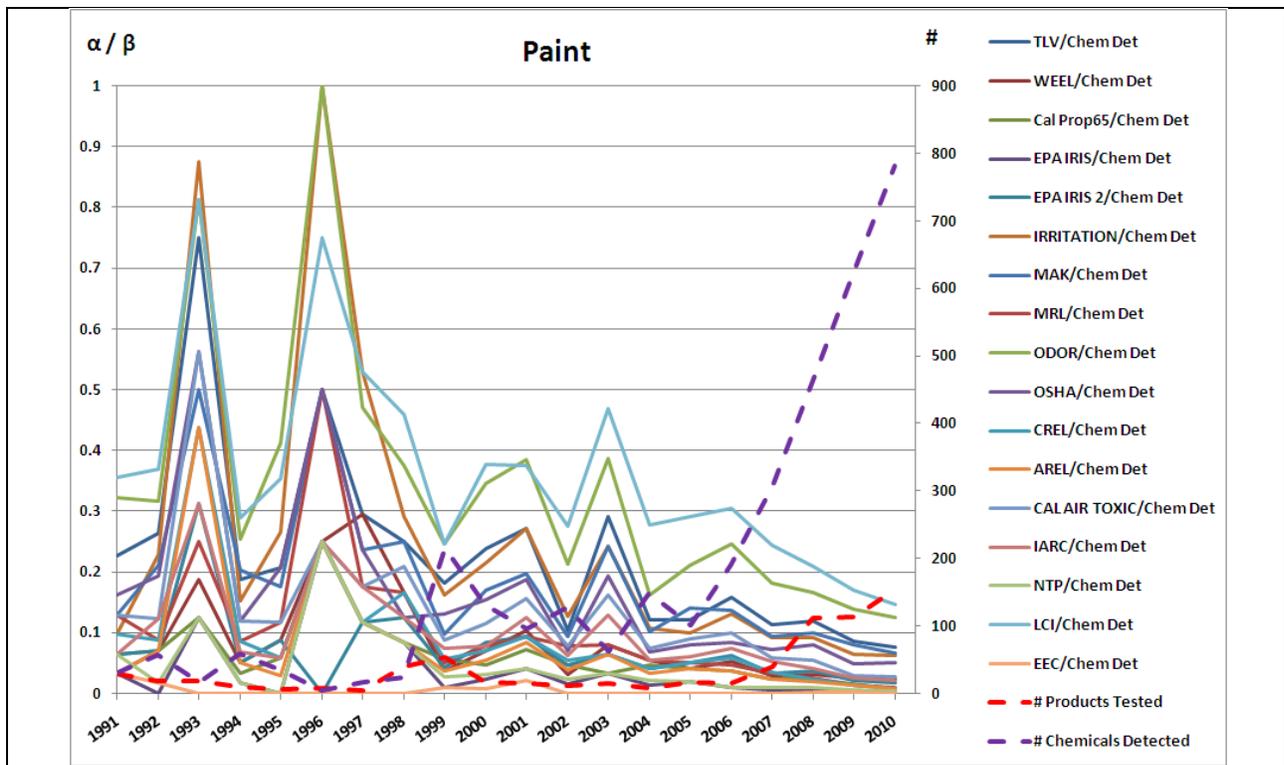
## RESULTS

Due to the large sample population examined, it was necessary to first determine the most efficient means by which to present this data. Simply displaying the frequency of detection by individual chemical is not manageable due to the large number of individual data points. Given that this data was collected over a twenty year period, and the ability to detect emissions from building products during that time has improved significantly. This is due to significant advancements in analytical technology and environmental chamber testing technology. Simply displaying the number of detected chemicals yields only marginally meaningful information.

Instead the number of chemicals on a given criteria list detected in the sample population ( $\alpha$ ), divided by the number of total chemicals detected ( $\beta$ ), provides more meaningful information.

**Figure 1a-c. Number of Detected Chemicals on Each Criteria List / Divided by the Number of Total Chemicals Detected ( $\alpha / \beta$ ), # Products Tested and # Chemicals Detected for Furniture, Paint and Insulation.**





## DISCUSSION

It can be seen for all criteria lists evaluated, that  $\alpha/\beta$  decreases for all criteria lists evaluated from 1991 to 2010. For furniture (Figure 1a), it can be seen that  $\alpha/\beta$  for LCI, Odor, TLV, Irritation and MAK lists decrease substantially for years after 2002, while  $\beta$  and the number of tested products increase significantly.

For paints (Figure 1b),  $\alpha/\beta$  approached 1 for Odor, Irritation, LCI and TLV chemicals during earlier years (namely for 1994, 1997 and 2000). This means that nearly all chemicals detected during those years appeared on those criteria lists. During those years the Average Total Emissions ( $\epsilon$ ) which includes emitted individual VOCs and aldehydes was significantly greater than for other years. Careful examination of the data reveals that a number of paint and adhesive products tested during those years emitted significant levels of a number of non-polar and polar solvents.

For insulation (not shown), all chemicals detected in 1997 were also on our Oder criteria lists (i.e.  $\alpha/\beta$  approached 1 in 1997). In several other years prior to 2000,  $\alpha/\beta$  increased dramatically for chemicals on Oder, Irritation and LCI lists but decreased for all lists in later years of testing.

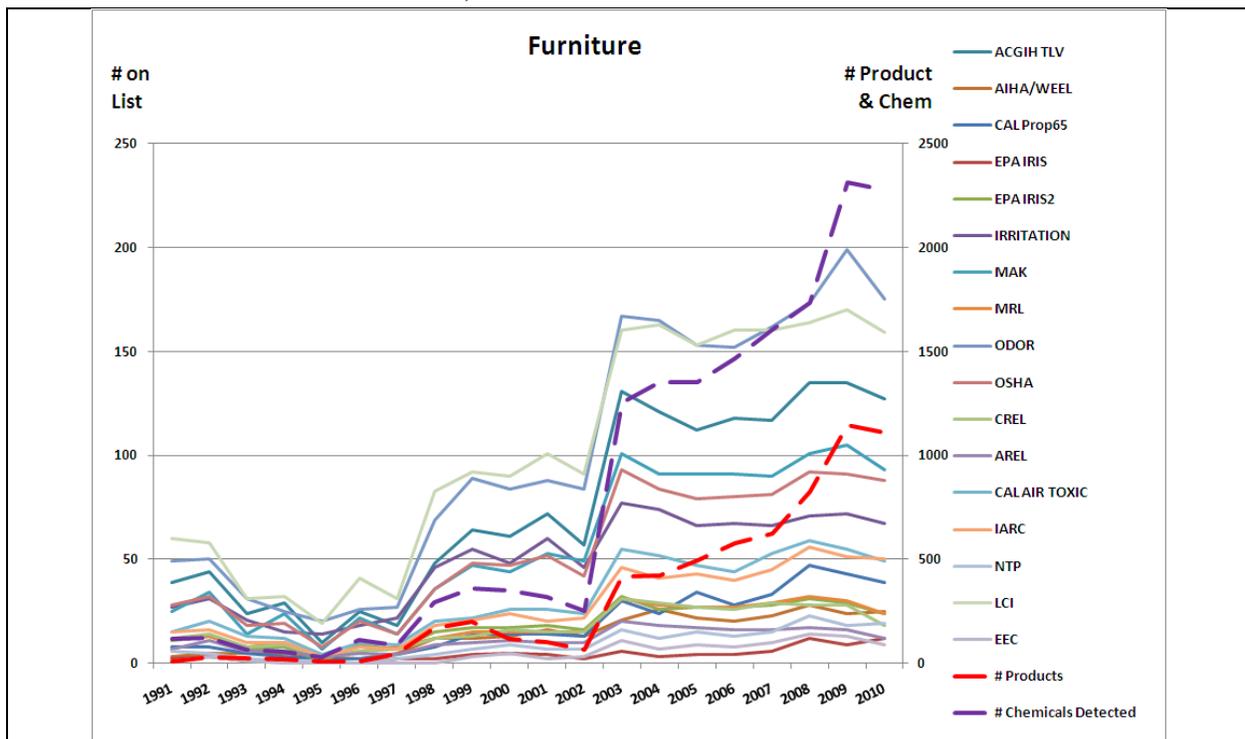
This information can be used to gauge to relevance of each criteria list to product emissions and exposure to chemicals in indoor environments. It can clearly be seen that some chemicals lists, such as the LCI list, include a number of chemicals that are more frequently detected in emissions from furniture, paint and insulation.

It is important to consider that the number of products tested or sample population ( $n$ ), is significantly smaller in earlier years than in later years, especially for furniture and insulation. While this would be expected to lead to a net increase in  $\alpha / \beta$ , it is noteworthy that for all three product categories,  $\alpha / \beta$  decreased, especially in later years. This data indicates that at present there are an insufficient number of criteria lists covering chemicals which are relevant to product emissions.

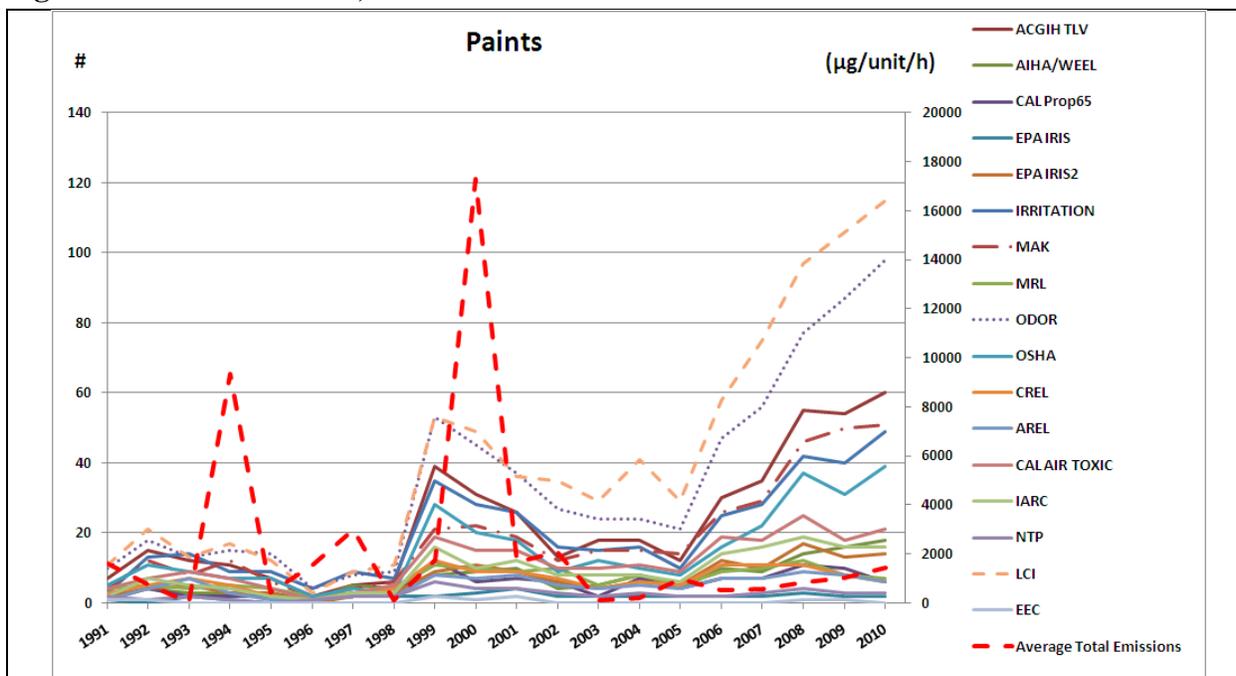
Figure 2a-c displays the number of detects on each criteria list, the number of products tested and the total number of chemicals detected overall years for furniture products. The number of chemicals detected on the LCI, MAK, Odor, TLV show the strongest correlation to the number of overall chemicals detected and products tested. A similar trend was observed for paint. For insulation, these same lists also show a strong correlation with the number of products tested and overall chemicals detected, however chemicals on our “irritation” list also show a strong correlation. This data supports the hypothesis that some of the criteria lists are more relevant to product emissions than others.

While considering that the ability to detect these chemicals has improved over the past twenty years, it is also worth mentioning that the average emission factor for detected chemicals in each of these product categories decreases over the years, while the number of chemicals detected has increased. The average emission factor, number of products tested and number of chemicals detected is shown in Figure 3 for Paint.

**Figure 2. Number of Detected Chemicals on Each Criteria List, # Products Tested and # Chemicals Detected for Furniture, Paint and Insulation.**



**Figure 3. Emission Factor, # Products Tested and # Chemicals Detected for Paint.**



## CONCLUSIONS

The data presented here shows that while the overall number of chemicals detected increases (due to decreased detection limits, increased sample size and improvements in analytical and chamber testing technology) the ratio of chemicals detected on individual criteria lists to the total number of detected chemicals decreases. Over the same period of time, the average emission factor decreases. This indicates that products tested generally emitted lower levels of chemicals over the years tested. Although not conclusive by itself, this data also supports the hypothesis that criteria lists used to assess indoor air quality may have become less relevant over the years possibly due to changes in raw materials and manufacturing processes. This supports a more aggressive approach to identifying chemicals being emitted from products and for routinely updating criteria lists.

## ACKNOWLEDGEMENT

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