Chemical Exposures Related to Upholstered Furniture and Other Consumer Products

Marilyn Black[1,*], Aika Davis[1], Stephen Kerber[1]

[1] Underwriters Laboratories, Inc. (ULI), Marietta, USA

[*] *Corresponding email: Marilyn.black@ul.com*

SUMMARY

With the increased awareness in product flammability and chemical exposure of flame retardants, current discussions are focused on processes for reducing both fire and exposure hazards. A preliminary study shows differences in flame retardant exposure and flammability performance from furniture made with and without flame retardants. The study also shows the presence of other chemicals that should be considered in evaluating chemical exposure risks.

PRACTICAL IMPLICATIONS

This study provides scientific data to assess chemical exposure risks and flammability from furniture. The results will contribute to policy discussion on flammability regulations and product safety.

KEYWORDS

Flame retardant, chemical exposure, flammability, furniture, TCPP

1 INTRODUCTION

In order to manage certain flammability requirements, chemical flame retardants are often added to furniture components. In some cases, flame retardant usage is being reduced through elimination or replacement with more benign alternatives. The health risks associated with flame retardants have been well documented. Studies have shown that exposure to some flame retardants can lead to health concerns such as cancer, thyroid disruption, delayed mental and physical development, advanced puberty, and reduced fertility. This study examined and compared both chemical exposure and flammability characteristics of similar furniture from the United States (US) and the United Kingdom (UK).

2 MATERIALS/METHODS

Two sets of a sofa and a chair were sourced from local furniture stores, one in the UK and the other in the US, with a total weight of 68.1 kg and 78.1 kg, respectively. Only the UK furniture complied with a specific flammability standard, the Furniture and Furnishings (Fire Safety) Regulations 1988. The chairs went through a week long environmental chamber experiment following the guidance of ASTM D6670 (ASTM 2013). Volatile organic compounds (VOCs) and semi volatile organic compounds were collected on Tenax absorbent tubes and measured using gas chromatography with mass spectrometric detection (GC/MS). Aldehydes were collected in 2, 4 dinitrophenylhydrazine (DNPH) cartridges, with measurement by high performance liquid chromatography (HPLC). The flammability experiments were performed in two rooms that were furnished with the sofa and chair set, with a total fuel weight of 280.5 kg for the UK room and 290.4 kg for the US room. Furniture was ignited following British Standards Institution’s EN 1021-2:2014 standard. The heat release rate was measured through the use of an oxygen consumption calorimeter.

3 RESULTS

VOC emissions measured from the US chair contained over 20 different chemicals including tetramethylbutanedinitrile, 1-methoxy-2-propanol, acetic acid, and 2-ethylhexanoic acid. The UK chair emitted fewer chemicals including 1-butanol and 2-ethylhexanoic acid. A large portion of the emissions from the UK chair was formaldehyde, with a predicted personal exposure level of 1018 $\mu g/m^3$. Predicted formaldehyde exposure for the US chair reached 175 $\mu g/m^3$. Several organophosphate flame retardants, tris(2-carboxyethyl)phosphine (TCEP) and tris(1-chloro-2-propyl)phosphate (TCPP), were detected in both foam and fabric materials of the UK chair (28.7 mg/g of TCPP in foam). TCPP emissions were continuously released to its surroundings at the rate of 82.6 μg/hr. These flame retardants were not found in the US furniture characterization. Both furniture sets ignited and sustained flaming until the contents were reduced to ashes. Figure 1 shows still images taken at 2 minutes past the start of the fire experiment, where the US room had already started to burn. Both rooms transitioned to flashover; the US room in 2:45 and the UK room in 6:35. At the end of the experiment, the US room released 12.4 MJ/kg of fuel while the UK room released 10.7 MJ/kg of fuel.

a)  b) 

Figure 1. Still images of flammability experiment at 2:00. a) US room, b) UK room.

4 DISCUSSION

Toxicity studies have been performed for various flame retardants, but a research gap exists between toxicity and human exposure. A more extensive study will address human exposure to semi-volatile flame retardants through inhalation, ingestion, and dermal exposure pathways. Gas phase radical quenching by TCPP may have been effective since flashover for the UK room was delayed by about 4 minutes. However, the question remains as to how crucial those extra few minutes are to escape from a fire. Further research is required for the safe use of flame retardants due to the many unknown factors relating to human toxicity from chemical exposure, flammability, and time required to respond to a fire.

5 CONCLUSIONS

Randomly purchased furniture from the US did not have flame retardants but similar furniture from the UK had significant levels of TCPP. Flame retardants are effective; however, there is a concern that some of them may be harmful when consumers are exposed to them. A flame retardant was released in the air surrounding the UK furniture, but the flashover was delayed relative to the US furniture possibly due to flame retardants. This data indicates the need to further evaluate the relationship between flammability and flame retardant usage, and to evaluate all parameters for harmonizing fire and chemical safety for users. Ongoing studies will evaluate a range of chemical emissions from furniture manufactured with different flame retardant technologies while also measuring the availability of different exposure routes. Investigated technologies will go through environmental chamber tests and flammability measures to further understand the relationship between flame retardant exposure and flammability.

ACKNOWLEDGEMENT

We would like to thank the non-profit company, UL Inc., for the funding of this project.

6 REFERENCES

ASTM. 2013. ASTM D6670-13, Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products. West Conshohocken, PA: American Society for Testing and Materials International.