Technical Brief

Methodologies for Studying Furniture Flame Retardant Exposure

Introduction

UL Chemical Safety and the group's University Research Partners conducted a three-year study on chemical exposure risk and flammability of upholstered furniture. The research report, "Human Health in the Built Environment: A Study of Chemical Exposure Risk and Flammability of Upholstered Furniture and Consumer Electronics," is available on UL Chemical Safety's website.

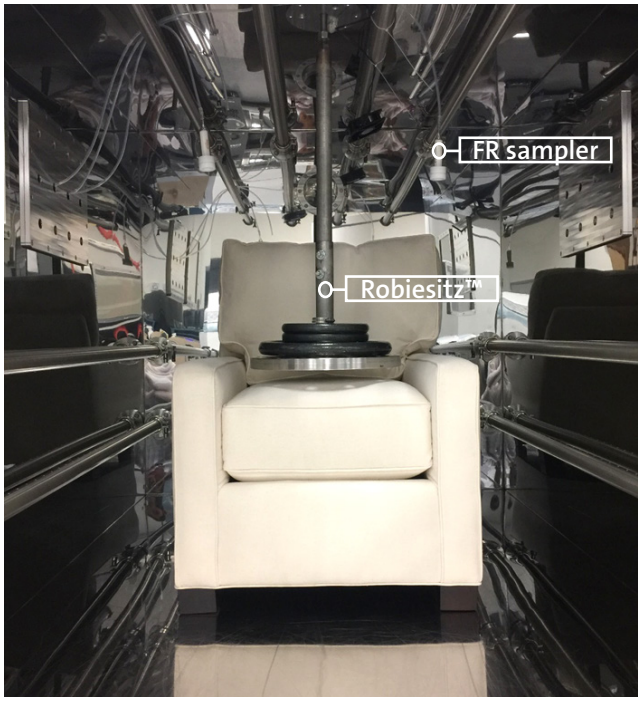
UL Chemical Safety's basic fact sheet, "Research on Chemical Exposure and Flammability Risks of Upholstered Furniture and Consumer Electronics," provides background and key facts.

The research was designed to understand how volatile chemical and flame retardant (FR) exposures occur during everyday use of upholstered furniture and to measure the effectiveness of different flammability control technologies applied to the furniture.

Two of the main objectives of the research were to develop methodologies for identifying FR exposure routes from upholstered furniture, and to study pathways and resulting levels of chemical exposure from furniture with different flammability control technologies.

Methodologies

• Initial exposure routes identified for study included inhalation, dermal, and ingestion (oral). These studies were conducted in a controlled environmental chamber with a clean air supply operating at one air exchange per hour. The chamber was constructed with stainless steel interior surfaces to minimize contaminant background and analyte loss via adsorption. Test chairs were placed in the chamber and agitated to simulate a person sitting up and down during chemical sampling. A specialized robot, Robiesitz™, was designed for this purpose, mimicking an average person sinking into the chair from a standing position.



An environmental chamber with Robiesitz™ and airborne FR sampler hanging from the top.

• Inhalation exposure was measured using an active air sampling process for volatile organic compounds (VOCs) and FRs. VOCs with the volatility range of n-pentane through n-heptadecane were collected onto a Tenax®

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sorbent tube and analyzed by gas chromatography mass spectrometer with thermal desorption unit (GC/MS/TD). Lower molecular weight aldehydes were collected on 2,4-dinitrophenylhydrazine (DNPH) cartridges and analyzed by high-performance liquid chromatography (HPLC) equipped with an ultraviolet detector. A quartz filter was used for capturing semi-volatile FRs in particulate phase, and a polyurethane foam (PUF) cartridge was used for capturing airborne FRs not collected on the quartz pre-filter.

• Dermal exposure potentials of FRs from the test chairs were evaluated using a filter paper patch saturated with an artificial sweat solution, 0.9% saline solution, placed on the seat of the test chair under a weight. The filter patch protocol mimicked an average person sitting on top of a specific surface area.

• Ingestion (oral) exposure was studied by measuring FRs in settled dust or dust that accumulated on the chamber floor during simulated use of the chair. Ingestion (oral) exposure was considered as hand-to-mouth transmission. A solvent-saturated gauze was used to collect dust using a template of a specific floor area.

• All FR samples collected on the various media were solvent extracted and analyzed by gas chromatography/mass spectrometry with electron impact ionization (GC/EI/MS).

• Detection and measurement of FRs provided confirmation of the various exposure routes. If FRs were measured, average daily doses were calculated for the respective exposure pathway for adults and children.

• An average daily dose (ADD) via inhalation was predicted based on human inhalation rates and the exposure air concentration determined from the measured emission rates inside the chamber.

• The ADD for dermal exposure was assumed to be sweat mediated and driven by contact surface area, contact time, and skin absorption rate.

• The ingestion (oral) exposure ADD was estimated using direct and oral contacts. Settled dust to hand to mouth, test product surface to hand to mouth, and test product surface to mouth contacts were combined for an ingestion ADD.

Full details of all methodologies and references can be obtained from the report and associated Appendix C, “Emory University Rollins School of Public Health Study Protocols for FR Collection and Measurement,” on UL Chemical Safety’s website.

FR dust wipe using gauze and a square template (top) and filter patch dermal transfer sampling with a weight on top of a filter (bottom).

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