2009 BFRL Project Description

Project Title: High Performance Barrier Materials for Mattresses and Furniture

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BFRL Program: Reduced Flammability of Materials

Objective: To develop the measurement science for predicting barrier fabric fire performance in mattress and furniture testing.

Problem:

What is the problem? Every year since 2002, an average of 7,630 home structure fires began with ignition of upholstered furniture.[i] These fires caused an annual average of 600 civilian deaths, 920 civilian fire injuries, and over $200 million in direct property damage. On average, 1 out of every 13 upholstered furniture fires resulted in death. Overall, fires beginning with upholstered furniture accounted for 2% of reported home fires, but 21% of home fire deaths. Including mattress flammability statistics, approximately 80% of the residential fires result in death as mattresses and upholstered furniture ignite quickly and are a large fuel source (polyurethane foams). Barrier fabrics are currently the only means used by industry to pass the new Consumer Product Safety Commission (CPSC) 1633 standard test for mattresses. There are two types of barriers, High Loft and Sheet. Sheet barriers are blends of virgin organic polymer fibers (polyacrilonitrile (PAN), cotton, rayon, novoloid) and organic polymer fibers coated with a flame retardant. Performance and cost is balanced by the amount of the superior performing and expensive FR-fibers in the product. In addition to expense, these barriers form a weak char and have poor resistance to water exposure. High Loft barriers form a carbonaceous char during pyrolysis; the char protects underlying flammable materials, such as foam and fibers. The char does not suffer from water exposure, but the char yields for the typically used inexpensive polymers are less than 100%. Due to low char yield and strength the charred fabric cracks, thus exposing the underlying foam and allowing ignition and fire growth. At high flux exposures this problem is more severe. Improving the char yield of low cost fabrics, using non-water soluble, sustainable, additives, in a cost effective manner is a difficult undertaking.

Why is it hard to solve? Developing a bench scale test to predict full scale performance is difficult as certain phenomenon may not translate well across the testing scales and the bench scale test may not "measure" the same parameters. Complicating the issue further is there is no consensus in what large scale tests (except CPSC 1633 for mattresses) we need to correlate with and what barrier fabric characteristics are important. If the solution technology for developing a superior performing barrier fabric is using an additive then additive must be water insoluble.

Regardless of the solution the char strength and shrinkage must be appropriate to provide adequate protection of the foam until the fire is extinguished.

How is it solved today, and by whom? There are no barrier fabrics with all of the above mentioned attributes. A similar study is being conducted at the USDA lead by D.V. Parikh. The project focuses on developing economic FR mattress pads using cotton combined with other FR fibers, such as Vasil™ (FR Rayon), Trevira™ (FR PET), Modacrylic™ and Basolfil™ (Melamine), and extending the flame resistance by treating the cotton fibers with chemicals, such as borax, phosphates, and intumescent layered silicates. These current solutions do not have the desirable characteristics described above as they are expensive and/or water soluble.

Why NIST? The goals of this project are aligned with the BFRL mission in terms of improving public safety and enhanced industry competitiveness, specifically for the fiber, chemical, flame retardant, foam and soft furnishings industries. This project is aligned with the BFRL strategic priority of Measurement Science for Sustainable Infrastructure Materials. It draws upon BFRL core competencies of fire protection and fire spread within buildings and communities, and the performance, durability and service life prediction of building materials.

Approach:

What is the new technical idea? The development of small scale barrier fabric tests (tool and method) which correlate with full fire testing to accelerate any project focused on evaluating new fabric technologies for mattresses or furniture applications. The Layer-By-Layer deposition coating process developed by Jamie Grunlan (awarded a FY09 BFRL Fire Grant) places unprecedented filler content on the surface of the fabric while maintaining, and often improving, the mechanical properties of the fabric. Steve Masia at Sappi Industries has offered to use his precipitation process to deposit high concentration of any fire retardant (FR) onto the fabric surface and to extend this study beyond cellulose fibers. These processes are perfectly suited for applying the appropriate FR additives at the right place (surface) and concentration to improve the defining characteristics of barrier fabrics.

Why can we succeed now? The recent development of new additives and small scale testing to predict full scale fire performance. The recent hiring of the PI to the BFRL staff also brings the necessary expertise and resource needed for this study. We are also working with D.V. Parikh (USDA), Jamie Grunlan (Texas A&M), Phil Wakelyn (National Cotton Council of America, NCC) and Bob Barker (American Fiber Manufacturers of America, AFMA) to form a consortium.

What is the research plan? Within the 1st quarter of the project we will, through workshops, literature reviews and attending conferences, determine what polymers and additives to study, what conventional tests to perform, the current status of any smaller scale testing tools and methods, and what potential obstacles may exist. During the 1st year the focus is on developing the small scale tests and correlating this test with the full scale testing analog. Initially the small scale may be simplified to only include fabric. However, the end test will likely need to be a barrier fabric over a foam in order to establish a firm link across the testing scale. The 2nd year

focus is on completing this correlation between small and full scale tests and, evaluating the different types and approaches to creating and testing the filled fibers/fabrics. During the 2nd year the "types" will only be commercially available barriers, and commercially available additives in polymers current used in these applications. The 3rd year will focus on a more extensive evaluation of the most promising application process, and materials. In addition, it is critical at the end of the 3rd year we formalize the technical knowledge in to a report/publication to help potential development of a national furniture flammability standard. Those potential interested in this report are CPSC, International Sleep Products Association (ISPA), ASTM, and the constituents for American Home Furnishing Association (AHFA), NCC, and AFMA.

Recent Results:

- Output - Jamie Grunlan (Texas A&M) and Satish Kumar (Georgia Tech) have prepared nanocomposite analog to the commercial barrier fabrics.
- Output - Rahatekar, S., Kumar, S., Gilman, JW; "Solution Spinning of Cellulose and Carbon Nanotube Composites using Room Temperature Ionic Liquids", MRS Conference – Spring 2008, San Francisco.

Standards and Codes: The success of this project could provide a technological solution for the industry that would foster closer work with CPSC on a national furniture flammability standard.

End notes:

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[i] Ahrens, M; "Home Fires that Began with Upholstered Furniture", NFPA One-Stop Data Shop Report, May 2008.