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Development of a Class I Fire Rated Industrial Resilient Floor Tile Made from Post-Consumer Carpet Waste

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The Chelsea Center for Recycling and Economic Development, a part of the University of Massachusetts' Center for Environmentally Appropriate Materials, was created by the Commonwealth of Massachusetts in 1995 to create jobs, support recycling efforts, and help the economy and the environment by increasing the use of recyclables by manufacturers. The mission of the Chelsea Center is to develop an infrastructure for a sustainable materials economy in Massachusetts, where businesses will thrive that rely on locally discarded goods as their feedstock and that minimize pressure on the environment by reducing waste, pollution, dependence on virgin materials, and dependence on disposal facilities. Further information can be obtained by writing the Chelsea Center for Recycling and Economic Development, 180 Second Street, Chelsea, MA 02150.

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1. Abstract

The purpose of this project was to modify a formulation of recycled PVC and post-consumer carpet so that it would produce a Class I fire-rated flooring product. Testing focused on varying both the concentrations of PVC and post-consumer carpeting to assess their effect on fire resistance. In addition, a recovered, post-industrial vinyl roofing material, which already has flame retardant additives, was tested as an additive to determine if it could enhance the fire rating of the final product. Finally, flame retardant agents were added to the mixture to determine their ability to enhance the fire resistance of the final product.

Testing showed that all the mixtures could be made into Class I rated flooring product and that changes in the concentration of post-consumer vinyl-backed tile had no real impact on the fire rating. Additions of flame retardant vinyl roofing membrane or even large amounts of flame-retardant agents did not significantly affect the final rating of the products.

2. Background

SelecTech has developed a patent-pending method for injection molding post-consumer, vinyl backed carpet waste in a way that leaves the various fibrous components of the carpet product (fiberglass, nylon, and polyester) intact as fibers that reinforce the finished product. The product made from this material is an interlocking, industrial floor tile knows as RepTile™. As an industrial flooring product, the RepTile must meet certain specifications and criteria to allow it to be used in interior spaces. One such criterion is its fire rating. This flame and smoke rating limits the uses and marketability of the product. A Class I fire rating allows for use of the product in any interior space. The RepTile is currently made with a mixture of post-consumer vinyl-backed carpet waste, post-industrial vinyl-coated roofing membrane, and post-industrial vinyl. It was found that varying the amounts of vinyl-coated roofing membrane and post-consumer carpet waste had no significant effect on the flame retardancy or smoke generation of the finished product. In all cases, the product met Class I fire rating classification. Even the addition of flame-retardants showed no improvement in the fire rating of the product.

2.1. Creating a Higher-Value Use for Waste Vinyl-Backed Carpet

The problem of disposing of old carpeting has become more of a public issue and has fueled the movement toward recycling this material. One type of carpeting, vinyl-backed carpet tiles, is not readily recycled and has become a problem for the companies that collect old carpeting. SelecTech's partner in this endeavor, DuPont Flooring Systems, collects all the old carpeting that is removed during a remodeling job and recycles most of what is collected. The vinyl-backed carpet, however, is a problem because it consists of a vinyl backing, a fiberglass reinforcing sheet, and nylon or polyester face fiber. These three materials are incompatible with each other and are too costly to separate.

SelecTech has developed a patent-pending method for reusing this mixed material in a way that leaves the fiberglass, nylon, and polyester intact as fibers that reinforce the finished product. These fibers will clog conventional plastics injection molding machinery and could even cause expensive damage. SelecTech's equipment is

specifically designed to handle solid contaminants and therefore and allows these fibers to be used in the product for added value.

Early testing of the RepTile has shown that it has a Class II fire rating. This fire rating limits the uses and marketability of the product. This project tested a variety of additives and formulations and determined a broad range of mixtures that provides a Class I Fire rating.

2.2. Potential use/diversion from waste stream

The market for resilient flooring is approximately 1.5 billion square feet per year. Resilient flooring is typically sold into commercial facilities such as factories, warehouses, hotels, hospitals, schools, municipalities, and office buildings. The RepTile, because of its quality, performance, and cost advantage has the potential to capture a significant share of this market. Moreover, because of its unique features, the RepTile has the potential of creating new applications to further expand the market. Each RepTile weighs 6.25 lbs and covers approximately 4 square feet (1.6 pounds per square foot). The potential market for this material is therefore 2.4 billion pounds per year. This represents a substantial outlet for a problem material.

The ability to compete in this market is based on quality and price. The RepTile has shown in tests to be superior in durability to competing resilient floor tiles made with virgin materials. Early tests showed, however, that the RepTile did not meet a Class I Fire Rating. Although many flooring applications do not require this classification, with a Class I Fire Rating, the RepTile is now capable of reaching a broader market and thereby consuming more post-consumer vinyl-backed carpet waste.

SelecTech introduced this product during the last quarter of 1998 and consumed approximately 64,000 pounds of post-consumer vinyl-backed carpeting. SelecTech's goal is to increase market penetration by attaining a Class I Fire Rating and through aggressive pricing.

2.3. Potential end markets

As mentioned above, the market for resilient flooring is very large. SelecTech markets this product through the existing DuPont Flooring Systems distribution channel, which includes nearly 85 offices located throughout the U.S. and Canada. These DuPont branches sell and install flooring to commercial customers. As recognized leaders in the industry, they are ideal outlets for this product.

3. Scope of Work

This project tested various mixtures of post-industrial PVC, post-industrial vinyl-coated roofing membrane, post-consumer vinyl-backed carpet waste and virgin fire-retardant additive to determine the effect of each on the fire retardancy and smoke generation of the final tile product.

4. Description of Approach

Fire retardancy was measured using critical radiant flux as determined by test method ASTM E648-97 and smoke density generated from a burning sample as measured by ASTM E662-95. The ultimate goal of the project was to create a formulation that would

produce a final product that would meet Class I Fire Rating specifications which include a critical radiant flux of 0.45 watts/cm^2 or greater and a maximum specific optical density not exceeding 450 under flaming exposure. All testing was completed by Testing Services, Inc, Dalton, Georgia.

In order to test the effect of the various mixture components, twelve formulations were created for the manufacture of tiles for testing for fire retardancy. In each case, 500 pounds of each formulation were mixed. The first 50 pounds of each mixture were used to purge the injection-molding machine. The remaining material was used to manufacture finished tile. In each case, approximately 75 tiles were made.

5. Results – Descriptive

The following table describes the 12 formulations tested and summarizes the test results. As shown, there was no significant change in critical radiant flux for the formulations tested. Eleven of the twelve samples measured between 1.00 and 1.02 watt/cm^2. The one sample that deviated from this result (30% post-consumer carpet, 70% post-industrial PVC) is not consistent with the other data of tests done with higher and lower amounts of post-consumer carpet waste.

Although there was more variation in smoke density between the different formulations, there was no correlation with changes in smoke density and post-consumer carpet content. Moreover, there was no correlation between smoke density and increases in additional fire retardant.

Sample Number	Post-Consumer Vinyl Backed Carpet	Post-Industrial Vinyl Coated Roofing Membrane	Post-Industrial PVC	Fire Retardant	Critical Radiant Flux Watt/cm^2	Smoke Density D_M
1	0%	0%	100%	0%	1.02	367
2	0%	0%	100%	0%	1.02	370
3	0%	0%	100%	0%	1.01	359
4	10%	0%	90%	0%	1.02	395
5	20%	0%	80%	0%	1.02	370
6	30%	0%	70%	0%	0.84	389
7	40%	0%	60%	0%	1.02	380
8	50%	0%	50%	0%	1.00	330
9	40%	15%	45%	0%	1.02	373
10*	10%			0%	1.02	386
11			95%	5%	1.02	349
12			90%	10%	1.02	389

* Sample 10 consisted of tiles made with pulverized (in powder form) carpet backing (primarily calcium carbonate and latex) rather than vinyl-backed carpet. This was tested to compare the fire retardancy of the tiles with post-consumer carpet material that contained nylon fibers and material that did not. In this way, we could determine if the nylon fibers had any impact (positive or negative) on the fire retardancy of the tiles.

6. Lessons Learned

In general, it was expected that the post-consumer carpet waste would make the final tile product more flame retardant due to the flame-retardants and fillers that are incorporated into the vinyl-backed carpet. However, it was found that increases in post-consumer carpet content had no statistically significant effect on critical radiant flux or smoke generation of the finished product.

Also, the vinyl coated roofing membrane material had no measurable effect on critical radiant flux or smoke generation. Moreover, (in other, unrelated testing) the roofing material reduced the durometer of the final product to an unacceptably low level. Thus, the post-industrial roofing membrane is not a desirable component of the RepTile.

Finally, even relatively large amounts of fire retardant added to the tile formulation had no measurable impact on critical radiant flux or smoke generation of the final product.

These results are, in fact quite helpful for the RepTile product. Feedstocks of post-industrial PVC and post-consumer vinyl-backed carpet waste are somewhat variable due to their recycled nature. These results show that the fire rating of the final RepTile products is fairly insensitive to changes in the recycled feedstock. Thus, natural variations in these materials will have no significant impact on the fire rating of the final product.

7. Transferability of the Research

This work is relevant for the recycling of post-industrial roofing materials and post-consumer vinyl-backed carpet materials in products that require fire retardant properties. In particular, products made for use in the building and construction industry.

8. Recommendations for Future Work

This project relied on a consistent source of post-industrial PVC that is sourced primarily from calendering operations. Other sources of post-industrial flexible PVC are available and may have different fire retardant characteristics. These materials would have to be tested in a similar protocol to determine if they are acceptable for the RepTile and/or other flooring products.

9. Conclusions

This work resulted in a variety of formulations for the RepTile that meets the requirements for Class I fire retardant flooring. It was found that the addition of varying amounts of post-consumer carpet waste did not significantly change the critical radiant flux or the smoke density of the final formulation. This result is important because of the varying nature of the recycled materials used in manufacturing the RepTile since these variations seem to have little to no effect on the fire rating on the final product.

10.References

American Society of Testing and Materials, “Test Method E648-97”
American Society of Testing and Materials, “Test Method E662-95

11.Appendices – Test Data