FIREBLOCK™

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FIREBLOCK™

Intumescent coatings have been known for years, but all attempts to market intumescent resins and gel coats failed in the past, since the products were very difficult to formulate and to apply. The composite's fiber reinforcement hampered the formation of the carbon field and the resin was too viscous to be easily used. In 2008, CCP Composites developed a breakthrough technical innovation called FIREBLOCK™, a stable and easily workable intumescent unsaturated polyester resin and gel coat.

Recent Milestones:

- January 2010: First customer completes their scale-up and approves FIREBLOCK™, marking the beginning of ongoing sales in U.S.

This technology is not eligible for either the small business award, or the academic award.

The nomination category is Focus Area 3 – design of greener chemicals

U.S. Component of Research and Development

The initial development of the FIREBLOCK™ concept was carried out in out laboratories in Drocourt, France. In early 2009 the technology was transferred to our laboratory in North Kansas City, Missouri with collaborative development thereafter. Work in the U.S. included the development of a bio-sourced unsaturated polyester resin to reduce the carbon footprint, development of a flexible unsaturated polyester resin to serve as the binder for the gel coat, and testing of gel coat/laminate combinations to develop composite structures that would pass the American standards.

Abstract

Composites that are used to manufacture interior and exterior parts for industry applications, including trains, tramways, subways and other rolling stock, must fulfill fire retardant specifications. The key raw material of these composites are unsaturated polyester resins possessing fire retardant properties, which when molded with glass fiber, are used to manufacture fire retardant parts. The standard method for making fire retardant composites, involves decabromodiphenyl ethers used in synergy with antimony trioxide. However, these materials are Carcinogenic, Mutagenic and Reprotoxic (CMR) compounds. The manufacturing of these fire retardant products requires handling highly toxic substances, and in the case of accidental combustion, they release bromine radicals and toxic fumes[1].
These important issues are avoided by the use of FIREBLOCK™ technology. FIREBLOCK™ uses an unsaturated polyester resin employing neither

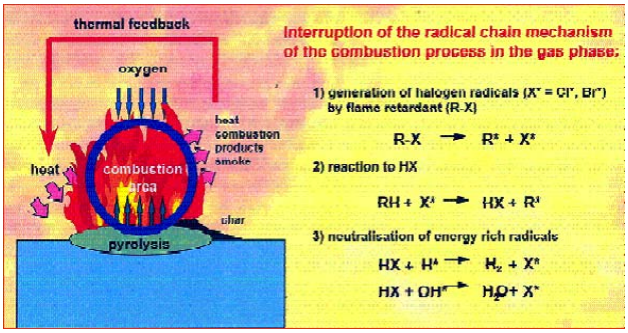
[1] U.S. Environmental Protection Agency, 2010
[2] United composites,, Bourbigot, S. et al, 2004; Camino, G., 1985, Strategic studies , 2009
[3] NF F16-101, NF P92-507, BS 476 Parts 6 and 7, UNE 23727, DIN 5510, ASTM E-162, E-662 and ASTM E-84, UL 94, SMP 800, AITM 2.002, 2.007 and 3.005, FAR 25853, TS EN 45545)
[4] Mouritz, A.P., 2006

decabromodiphenyl ethers nor antimony derivatives and operates through a different fire retardant mechanism[2]. FIREBLOCK™ technology functions through intumescence, which produces non-flammable and non-toxic gases when exposed to a flame. The FIREBLOCK™ intumescent resin meets a number of industry standard flammability tests[3], and has a lower density than standard unsaturated polyester resins, making it easier to handle.

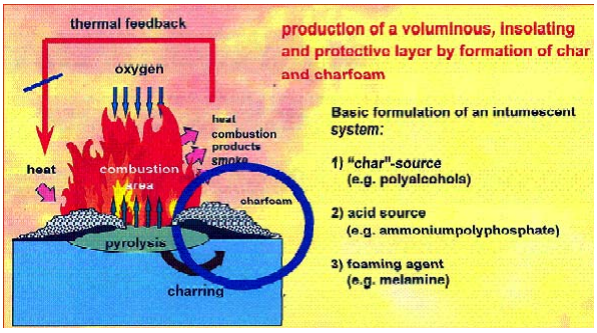
FIREBLOCK™ is a commercial product that is starting to be used in bus and architecture applications and is also approved for certain train applications. A significant portion of today's estimated 10 million pounds annual usage of brominated UPRs could be converted to FIREBLOCK™ technology in the next 5 years in the United States. Since the intumescence mechanism is based on the combination of three non-toxic elements: a polyalcohol, a source of gas and an inorganic acid source[4], hazardous decabromodiphenyl ethers and antimony trioxide fire retardant substances are completely replaced with non-hazardous chemicals, when using the FIREBLOCK™ system.

Chemistry

Fire retardant mechanisms are strongly linked to the composition of the resin. Brominated fire retardants operate differently from intumescent ones. In the brominated fire retardant mechanism, polybrominated aromatic compounds liberate free radicals, in synergy with antimony trioxide, which inhibits combustion. Aluminum Trihydrate (ATH) can be added to enhance fire retardant properties, by absorbing heat and releasing water, which cools the material. In the intumescence mechanism, high temperatures cause the ammonium polyphosphate to release an acid, which simultaneously reacts with melamine in the resin to liberate a gas that diffuses into small bubbles, and also carbonizes the carbon rich polyalcohol. These actions together form a foam that solidifies into a char. The char shields the material from oxygen and other volatile gases, stopping the combustion cycle. This method can also be combined with the alumina hydrate filler to enhance fire retardancy.



Usual mechanism implying bromide radicals and spreading toxic fumes (steps 2)



Intumescent mechanism showing the expansion of a char on the material.

[1] U.S. Environmental Protection Agency, 2010
[2] United composites,, Bourbigot, S. et al, 2004; Camino, G., 1985, Strategic studies , 2009
[3] NF F16-101, NF P92-507, BS 476 Parts 6 and 7, UNE 23727, DIN 5510, ASTM E-162, E-662 and ASTM E-84, UL 94, SMP 800, AITM 2.002, 2.007 and 3.005, FAR 25853, TS EN 45545)
[4] Mouritz, A.P., 2006

FIREBLOCK™ technology is an innovation which uses an intumescent fire retardant mechanism based on a new, non-toxic UPR (polyalcohol / acid / gas) system. It is designed to comply with numerous flammability standard requirements[3], while avoiding the use of hazardous substances. The FIREBLOCK™ innovation uses green chemistry in its fire retardant chemical design by replacing toxic chemicals (i.e. brominated fire retardant materials) with non-hazardous ones.

This technology also demonstrates green chemistry by reducing the amount of resources needed for the manufacture of each individual part. This weight reduction, leads to energy saving, thereby reducing green house gas emissions during the overall phase use of transportation products, including: trucks, trains, or rolling stock. This innovation will help the transportation sector deal with environmental issues.

Life Cycle Analysis

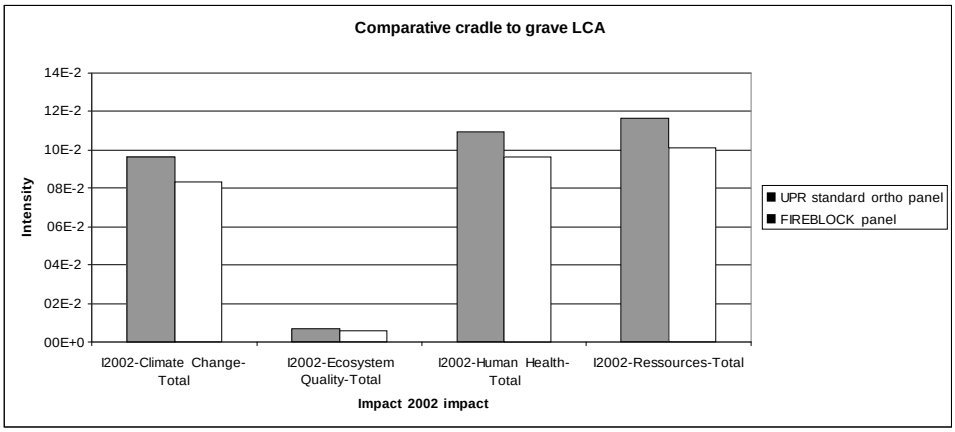
A life cycle analysis (LCA) was performed, comparing the FIREBLOCK™ product to the standard technology of the market, from the cradle to the grave. In line with industry practice, the LCA functional unit is prepared as a $1m^2$ surface area M1 fire retardant[i] panel of 4 mm thick, which is incorporated into a traveling material, i.e. a truck. The FIREBLOCK™ panels are compared to a UPR standard panel for LCA. Both resins are molded with fiberglass (25% and 30% respectively), producing FIREBLOCK™ and UPR panels.

Human Health Benefit:

By removing CMR chemicals, such as decabromodiphenyl and antimony trioxide halogens, the non-toxic FIREBLOCK™ substances provide health benefits in three stages of the life cycle. First, the manufacture of the resin and composite parts—workers are not exposed to risks related to these CMR substances. Then, in case of accidental combustion, when exposed to fire, the FIREBLOCK™ resin does not release toxic, corrosive brominated compounds which are the cause of death for passengers. And finally, as previously said, at the end of life, the absence of CMR compounds in FIREBLOCK™ technology will facilitate the management of waste, but this point was not quantified. A comparison of the environmental performance of the FIREBLOCK™ panel versus the UPR standard is shown below.

1 U.S. Environmental Protection Agency, 2010
2 United composites,, Bourbigot, S. et al, 2004; Camino, G., 1985, Strategic studies , 2009
3 NF F16-101, NF P92-507, BS 476 Parts 6 and 7, UNE 23727, DIN 5510, ASTM E-162, E-662 and ASTM E-84, UL 94, SMP 800, AITM 2.002, 2.007 and 3.005, FAR 25853, TS EN 45545)
4 Mouritz, A.P., 2006

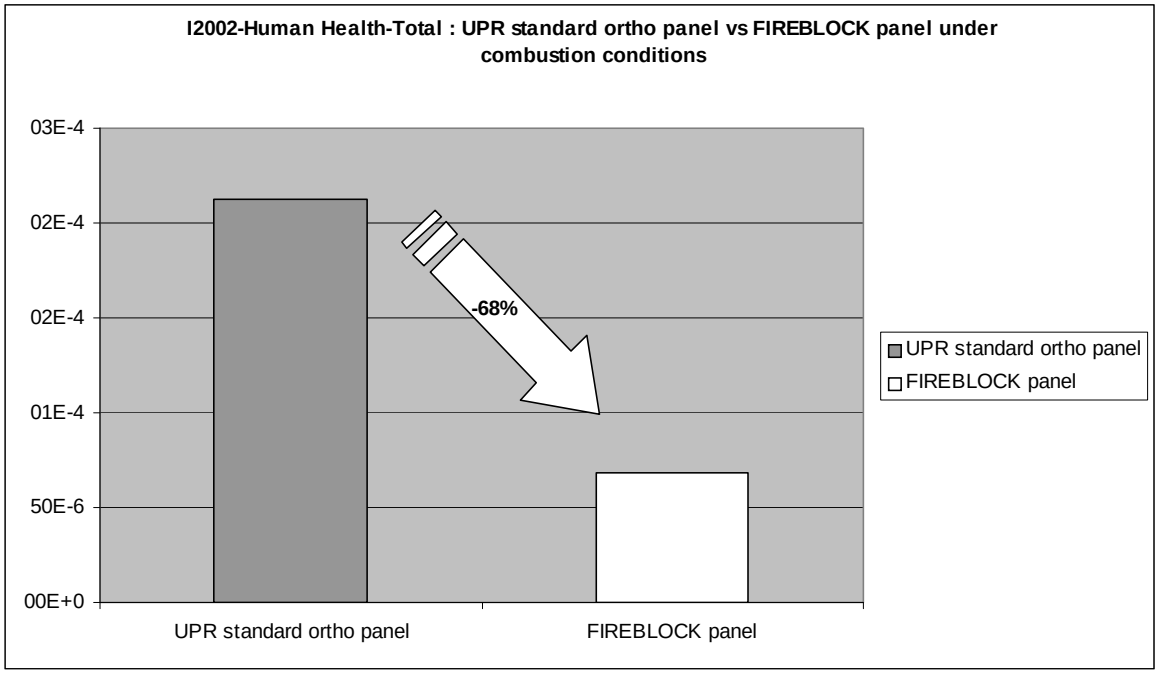
Comparative Environmental Performance Evaluation:



These results indicate that over the entire life cycle, the intumescent technology leads to green house gases savings of 13% with 852 kg eq. CO_2 / FU against 982 kg eq. CO_2 eq. / FU for *versus* the standard UPR technology. Energy savings are in the same range, a reduction of energy by 13%, between the panel B, 14620 MJ / FU, and the panel A, 16770 MJ / FU and others indicators show other environmental benefits with - 13% on the ecosystem quality, - 12% on the human health and –13% on resources consumptions. This LCA highlighted that no pollution transfer occurred.

Human Health Risk Decrease During the Combustion Phase:

The LCA of the accidental panel combustion showed that the UPR standard panel releases highly toxic substances compared to the FIREBLOCK™ panel. The significant amount of carbon monoxide (CO) and hydrobromic acid (HBr) released during combustion of the standard UPR panel seriously impairs respiratory function.



Significant Environmental Improvement:

The FIREBLOCK™ technology provides significant environmental improvement because no halogens or substances that are carcinogenic, mutagenic or toxic to reproduction (CMR) are present, an unquantifiable but real environmental and health benefit is delivered during production of raw materials, resin and composite parts, train life and the end-of-life of the composite part.

Conclusion

FIREBLOCK™ is a commercially viable alternative to bromine containing Unsaturated Polyester fire retardant resins used for a wide variety of composites applications. It is completely free of halogen and CMR substances. It has a low density (>10%) compared to standard fire retardant products and can be used in all composites processes in all market sectors where fire retardancy is required (train, construction, car, bus, etc.). It is environmentally friendly with a 13% reduction in CO2 emissions compared to standard Fire retardant in the railway industry and with a tremendous decrease in Toxicity for humans (-68%).

[i] In line with AFNOR standard F16-101.