

CSIRO Materials Flammability Research
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Overview

CSIRO has over 50 years experience in understanding and assessing the fire performance of materials. In this presentation, recent work on the following topics will be addressed:

- Fire resistant materials for construction
 - Ceramifiable polymers
 - Intumescent materials
- Fire retardant materials and issues
- Materials for use in bushfire-prone areas
- Assessing the fire performance of materials and building standards

Fire resistant materials for construction

Ceramifiable polymers

CSIRO has contributed its fire expertise to two projects run by the Cooperative Research for Polymers (CRC-P). Both involved the development of polymer products that undergo ceramification in a fire. In the ceramification process, as the polymer burns away, the carefully selected fillers form a porous ceramic.

Cables Of Improved Fire Performance

The partners in this project were CRC-P, CSIRO, Olex Cables, Monash University, RMIT and UNSW. The goal was to develop cables that would obtain a one-hour fire rating when tested to AS 3013, an electrical test that is carried out in the same fire resistance furnace that is used for fire rating building elements. The goal of the test is to determine whether power and communications cables continue to function during a fire.

CSIRO and Olex have continued this project once the CRC-P project came to an end. There are now both single-core and multi-core cables that have met the requirements of AS 3013.

Passive fire protection materials

The partners in this project are CRC-P, CSIRO, Ceram Polymerik, Monash University and RMIT. This project builds on the ceramifiable cable project, and applies the evolving technology to fire-stopping applications. The purpose of fire-stops is to 'fill holes' in fire-rated barriers whose purpose is to prevent fire spread between enclosures. Some applications developed or being developed are:

- Seals for fire doors
- Seals for windows in fire doors
- Seals for joints in concrete panel construction

The advantage of the ceramifiable polymers over existing systems is simplicity and ease of installation.

Intumescent materials

This project is CSIRO's research contribution to the CRC for Polymers project on passive fire protection materials. The goal is to understand the intumescent process in minute detail so that improved intumescent materials can be developed. Intumescence simply means swelling.

In the intumescent process, the polymer swells and chars. The expanded char layer provides a thermal barrier between the flame and the unburnt polymer. The reaction responsible for intumescence removes heat and cools the polymer. The char layer forms a barrier that impedes transfer of pyrolysis products to the outer surface and oxygen into the polymer. This both slows combustion of the polymer, and keeps the material being protected, often steel, cool, thus maintaining its structural strength. 'Engineered' intumescent materials will:

- Be invisible, i.e. appear like any normal coating
- Expand to as much as 40 times the original thickness
- Be stable over a greater temperature range
- Not burn
- Withstand blast/vibration (prevent a future WTC event?)

Current intumescent coatings have very little mechanical strength, and can be dislodged by impact or jet fires, such as might be expected in petrochemical plants. If ceramifiable intumescent coatings can be developed, they should provide far greater protection to lightweight steel structures, such as oil rigs and modern airport terminals.

Fire retardants

Why use fire retardants? Our modern style of life would not be possible without the wholesale use of polymeric materials, both synthetic and natural. All of these materials have a similar chemical backbone, and all are combustible. Whilst their fire properties vary enormously, many of the most popular materials burn readily and under relatively low imposition of heat. Therefore, steps have to be taken to reduce the chance of ignition of polymers, and the contribution that polymers might make to the early stages of a fire. This allows more time in the early stages of a fire for rapid extinguishment and escape.

Non-halogen fire retardants

The Montreal protocol was signed by almost every country in the world in 1987. It requires signatories to phase out the use and manufacture of ozone depleting substances, including halons or halogen containing organic substances. The protocol requires elimination of all listed substances by 2030. Most fire retardants (FRs) in polymers contain halogens such as bromine and chlorine. Therefore, there is a need to find alternative FRs for materials used in buildings and transport.

Halogens act primarily by quenching the combustion reactions taking place in the flame, a process commonly referred to as flame poisoning. Newer generation phosphorus,

nitrogen and nanoclay FR systems act to reduce the heat-flow back to the decomposing polymer by a combination of char formation and flame poisoning, though they are less effective at flame poisoning than halogens.

CSIRO is undertaking research on a number of avenues in relation to non-halogen fire retardants, including:

- The study of nanoclay fire retardant activity
- The study of catalysts for flame and fire inhibition
- The development of an understanding of fire retardant action
- The evaluation of new non-halogen fire retardants

Materials for bushfire-prone areas

Ultimately, requirements are set by state authorities. There are two issues – defining fire-prone areas, and setting requirements for materials in those areas. Both issues are contentious. The ‘bushfire standard’ (AS 3959) is currently under review.

FWPRDC project

The ‘bushfire standard’ (AS 3959) has a requirement for ‘fire-retarded’ timber in bushfire-prone areas. The Forest and Wood Products Research and Development Corporation (FWPRDC) funded a research program to determine feasibility of impregnating timber with fire retardants and preservatives in the one process. The properties required of FR-treated wood are:

- Fire-retarded to meet AS 3959
- Preservative treated in accordance with AS 1604.1. 2005
- Durability of both fire retardant and preservative

Outcomes of the FWPRDC project included:

1. It is possible to achieve fire retardancy and wood preservation in a single process
2. The weathering regime called for in AS 3959 is unrealistic
3. Some fire retardants have anti-termite and anti-fungal properties
4. There are currently no commercially available fire retardants that meet the weathering regime in AS 3959
5. There is now data on the fire performance of a range of wood preservatives, as well as data on the preservative performance of a range of fire retardants
6. There is now timber based fire performance data on fire retardants which are more commonly used in polymers

Assessing fire performance

In Australia, the requirements for fire performance of materials are set by various authorities and agencies:

- For buildings, there are the building regulations for life safety (BCA), and insurance companies for property protection
- In bushfire-prone areas, there are state government regulations
- For ships, there are IMO requirements
- For rail transport, requirements vary by state, and by project

- Specific industries and products have their own requirements, eg electrical, automotive, aeronautical

Ideally, all fire tests should reproduce the in-use situation. In practice, every fire is different, so standard 'fire scenarios' are used. Therefore, fire tests should be designed on the following principles:

- The test should be relevant to the end use of the product
- The test should not be material dependent
- The test should provide data that can be used in calculations of overall fire safety

Not all fire tests for materials are designed to measure fire hazard. Fire tests can be designated as follows:

- material characteristics (quality control)
- product performance (hazard assessment)
- scenario simulation (fire engineering)

The last two are of most interest for us today.

BCA fire tests

Prior to the implementation of the performance BCA, the main fire tests in the BCA were:

- Combustibility Test (AS 1530.1)
- Flammability Test (AS 1530.2)
- Early Fire Hazard Test (AS 1530.3)
- Fire Resistance Test (AS 1530.4)

These tests are all still in the deemed-to-satisfy provisions, but as a result of recommendations of the Fire Code reform Centre, changes were made to the requirements for wall and ceiling linings, and for flooring. These tests are:

- Room Corner Test (AS ISO 9705) – wall and ceiling linings
- Cone calorimeter (AS 3837) – some wall and ceiling linings
- Flooring Radiant Panel (AS ISO 9239.1) – floors and flooring

IMO fire tests

The following tests are required by the International Maritime Organisation:

- Room Corner Test (AS ISO 9705) – bulkhead linings
- LIFT apparatus (ISO 5658-2) – bulkhead linings
- Smoke and Toxicity Testing (NBS Smoke Chamber)

Simulation experiments

Simulation experiments have been designed to assess situations such as:

- Fires in trains
- Furniture fires (Sydney Olympics)
- Fire truck burn-overs
- Fire truck brake lines

- Bushfire exposure of building elements

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