In 2016 fire-related deaths and injuries in the UK and USA exceeded 28,000 incidents. As composite materials become ubiquitous across all manner of applications and sectors, so the fire safety of these materials increases in importance. Typically when exposed to high temperatures (300-500°C), most polymer composites tend to degrade over time and release heat, smoke, soot, and toxic volatiles. This is a major concern in industries such as aerospace; marine; rail; and; automotive, where the number of fire related deaths exceeded 7,000 incidents over the last few decades. In order for composites to continue to become a sustainable and standard alternative for metals and alloys, flame properties must be improved upon to be able to compete with these traditional materials in a reliable and low cost way compared to current available options.

### Aims

- Determine properties amid and post pyrolysis
- Develop simulation capability to predict fire behaviour

### Objectives

- Develop and test several commercial resin systems
- Perform regulatory flame retardancy testing
- Assess mechanical properties of tailored laminates
- Perform surface and property analysis

### Baseline Data – Toughened Epoxy Near-Infrared Spec.

![Fig 3 – Conversions for reaction components](image)

**Epoxy converted**

**Amines converted**

**Etherification**

### Rheology

**Tanδ = 1**

![Fig 4 – Complex viscosity and loss modulus of Toughened Epoxy](image)

**Eta* / Pas**

**G'' / Pa**

### Kinetic Study (DSC)

**Least cured**

**Post-cured**

![Fig 5 – Heat of reaction variation with degree of cure](image)

### Flame Retardancy – Cone Calorimetry

#### Heat Release

![Fig 6 – Total heat release rate for Toughened Epoxy](image)

#### Smoke Release

![Fig 7 – Total smoke release for Toughened Epoxy](image)

- 3 identical samples tested
- Good agreement between data sets
- Each test conducted over 600 seconds
- Experiment according to ISO regulations

### Further Work

- Obtain accurate thermal data for future blends
- Create laminates for mechanical testing
- Conduct flame retardancy tests on selected blends
- Analyse post pyrolysis samples
- Incorporate any flame retardant additives that might be suitable
- Repeat till suitable blend is created

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