CATALYSED PAVEMENT MARKING MATERIALS

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Note: *The views expressed in this paper are those of the author, and do not necessarily reflect those of the Department for Transport, Energy and Infrastructure.*

ABSTRACT

In terms of traffic engineering, pavement marking is predominantly a road safety related activity. Markings provide delineation and guidance and therefore have a role to play in minimising road crashes, and their value is often underestimated. As a result, there is pressure on network managers to reduce the cost of marking, and budget cuts often impact on pavement marking before other maintenance activities.

Pressure on preserving the bottom line has meant that the cheapest initial cost materials are used for the majority of pavement marking, even internationally. In other words, paint and drop-on glass beads. These materials provide excellent performance at a low cost, but are not always the right material for the job, either in terms of performance or lifetime cost.

Thermoplastic has been a popular choice as a high durability marking for more than 60 years in the United Kingdom, and has been widely used in Australasia for 30+ years; these materials will continue to provide excellent performance into the future. However, there are many pavement marking situations where performance beyond that of thermoplastic is required, and this void has been filled by catalysed or multi-component materials in recent years. Materials such as epoxy, polymethyl methacrylate (PMMA), polyurea and polyurethane have been used with varying degrees of success, and this paper looks at a number of materials and their applications.

1.0 INTRODUCTION

Most pavement marking programs, certainly in Australasia but also internationally, are based on the use of paint and drop-on glass beads. In some ways, this is a traditional approach to pavement marking with the only significant change in the last 50 years or so from solvent borne alkyd and chlorinated rubber paints to waterborne paint. For general marking use, these materials still represent the lowest initial and long term cost, whilst providing adequate performance for the road user.

Thermoplastic materials have been in general use for many years, and offer excellent durability at a reasonable initial cost. However, there are some applications where thermoplastic will not provide the required performance, and this is where multi-component materials have found a niche.

Performance characteristics such as wear resistance, skid resistance, wet retroreflectivity, rapid curing and colour retention are available with catalysed materials, and this paper explores some of the alternatives available.

2.0 DEFINITION

For the purposes of this paper, the term “catalysed” relates specifically to multi-component pavement marking materials. These will comprise two or more components which, when mixed together, cure to form a film.

3.0 APPLICATIONS

Multi-component materials offer a number of inherent performance advantages over thin film pavement markings:

- High resistance to wear
- Ability to build thick films
- Suitability for use with large glass beads
- Suitability for use with large aggregates
- Colourfastness

Multi-component materials incur a higher initial cost than paint or thermoplastic markings, and therefore tend to be a niche product, where higher performance is required. They are suited to high wear applications such as at intersections where regular maintenance is difficult.

The chemical reaction which takes place enhances abrasion resistance and toughness, and also allows higher film builds, which adds further to durability. These higher film builds mean that larger glass beads and aggregates can be retained, leading to potentially higher wet retroreflectivity and skid resistance.

Their colourfastness and skid resistance makes them particularly suited for use as exclusive bus or bicycle lanes. These characteristics plus enhanced slip resistance make these materials suitable for pedestrian use also.

4.0 COMMON BINDERS

4.1 Polymethyl Methacrylate

The most commonly used multi-component material is polymethyl methacrylate (PMMA).

The advantages offered by PMMA over thin film technologies are:

- Can be formulated for many different application methods.
- Are highly durable.
- Have excellent resistance to UV.
- Good colourfastness.
- Ability to retain glass beads and aggregate.
- Cure time can be tailored to suit application.

These materials have few disadvantages, but can contain high levels of Volatile Organic Compounds (VOC).

PMMA's are essentially 2 component materials, although some use additional components to modify curing characteristics. They can be applied by hand (trowel), spray, screed or extrusion. Formulations vary depending upon the method of application, with changes to viscosity, particle size and curing time to suit the equipment used. In the case of spray or extrusion application, the components are delivered separately to a mixing head, and mixed immediately prior to extrusion or spraying. Glass beads and aggregates are usually applied after application of the binder.

Hand applied, extruded and screeded markings are usually applied at thicknesses of 1.5 to 3mm, in a single coat, with aggregate and beads dropped on immediately after application of the binder.

Sprayable PMMA contains low-viscosity binders and fine fillers, and can therefore by mechanically sprayed, enabling higher application speed. They are generally applied in layer thicknesses of 0.4 – 1.00 mm, often with aggregate and beads applied to separate layers. Sprayable materials can also be applied by roller.

PMMA can be formulated for applications such as agglomerated or raised rib audio-tactile and wet night visible markings.

4.2 Epoxy

Epoxy resin based surface treatments have been around since the early 1970's, with materials such as Spraygrip® and Shellgrip® used in volume, particularly in the UK and Europe.

Epoxy coatings are 2 component products, with liquid epoxy resins converted through reactive epoxy sites into tough, insoluble, and infusible solids. Many commercial materials are suitable as reactive cross-linking agents for liquid epoxy resins. The most common types of curing agents are:

- primary and secondary polyamines and their adducts
- anhydrides
- polyamides
- catalytic

Epoxies are modified to provide the flexibility, adhesion and cure time required for the pavement marking application. Epoxies have been used in volume in Europe and the USA.

The advantages which epoxies offer over thin film markings are:

- High durability
- High film build capability
- Good glass bead retention
- Good aggregate retention
- Particularly suited to more rigid pavements, such as concrete.

As a generic group epoxies also have the following disadvantages:

- Slow cure at low temperatures.
- Often high in Volatile Organic Compounds (VOC).
- Health risks associated with amines.
- Tendency to chalk on exposure to UV, poor colour retention.
- Can lack flexibility if incorrectly formulated and under some exposure conditions.

4.3 Polyurethane

Polyurethane materials such as Flexigrip® and Gripflex PU® have been in use for many years in the UK and Europe.

Like epoxies, polyurethane's are available in a multitude of formulations, and are often modified by addition of other resins.

A polyurethane coating is comprised of two major components, part A, a co-reacting polyol or base resin, which can be acrylic, polyether or polyester, and part B, a polyisocyanate, sometimes referred to as a hardener, activator.

The paint film is formed when the A and B components chemically react and cross-link. Desired coating properties can be tailored depending upon the choice of resin raw materials and the other ingredients in a formulation such as the pigment, solvent, levelling agent, thickening agent, catalyst and other modifiers included to enhance performance.

The A and B components of a polyurethane formulation are usually proportioned by automatic metering equipment, with mixing just prior to the spray gun. The ingredients must be stored in dedicated vessels. Common materials utilized for storage vessels, piping, and related fittings are stainless steel and Teflon.

The advantages which polyurethane's offer are:

- High durability
- Good glass bead retention
- Good aggregate retention
- Excellent UV resistance.
- Excellent colourfastness.

As a generic group polyurethane's also have the following disadvantages:

- Slow cure.
- Usually low in volume solids.
- Low film building capability.
- Often high in Volatile Organic Compounds (VOC)
- Health risks associated with free isocyanates.
- Adhesion can be a problem over thermoplastic and over some detector loop sealant materials.
- A primer is required over concrete surfaces.

4.4 Polyurea

Polyurea appears to have found a niche in pavement marking only in the USA. A polyurea is an elastomer created by the chemical reaction between an isocyanate and an amine.
The isocyanate can be monomer, polymer, or any variant reaction of isocyanates, quasi-prepolymer or a prepolymer. Polyurea resin is comprised of polyether-amines or an amine terminated polyol. This polymer is very reactive and does not require a catalyst, which results in the relatively short set-up time associated with polyureas.

Polyurea has a number of advantages over other catalysed products:

- Very high film build capability of several mm.
- Very rapid cure.
- Surface moisture tolerant.
- Very high solids.
- High chemical resistance.
- Wide formulation capability.

The disadvantages are:

- Health risks associated with free isocyanate.
- Must be heated for application to ~70°C.

5. AGGREGATE

Aggregates are used to impart skid resistance and slip resistance to the markings. Thin film markings, such as those based on paint, tend to conform to the existing macrotexture and aggregates are only required to reinstate the microtexture of the pavement. In these applications, aggregates in a size range of 0.1 to 0.5mm are commonly used.

The binders discussed in this paper are capable of high film builds, and can therefore “fill in” the macrotexture of the pavement, creating a hazard for vehicles, in wet conditions. This higher film build does however allow the use of larger aggregates, with particle sizes commonly in the range of 1 to 3mm. The choice of aggregate is particularly important in these larger sizes, as the particles must be capable of withstanding traffic without crushing. Calcined bauxite is most commonly used in these applications because of its hardness and durability.

6. STANDARDS

The pavement marking industry had lobbied Standards Australia for development of a standard for cold-applied plastics, given that documents covering paint and thermoplastic had been in existence for many years. The committee felt that a continued development of generic materials-based standards could be a never-ending task. For example, what about hot-applied and other catalysed materials, pliant sheet etc.

With a growing trend towards performance-based contracting, the committee identified a need for a document which categorised the performance of materials rather than their generic chemistry. This resulted in AS 4049.4, High performance pavement marking systems, which will be published in the near future.

This standard focuses on what a marking system can do, rather than generic type. It therefore is useful for cold-applied and catalysed materials.

The standard addresses the following performance parameters:

Durability
Dry retroreflectivity
Wet retroreflectivity
Colour
Colourfastness
Luminance factor
Skid resistance
Slip resistance

Issues such as the level of VOC's are also addressed in the document.

Performance is determined from actual field performance rather than on the basis of formal test deck testing, so is therefore more relevant to real-world performance. The committee believes that the Standard will allow users to select a material which will deliver their performance requirements.

5 Conclusions

The conclusions are:

- Catalysed materials have the potential to provide higher performance than conventional paint and thermoplastic, in terms of durability, skid resistance and colour fastness.

- These materials tend to have a higher applied cost than conventional materials.

- The chemical constituents may have specific OHS&W risks which need to be managed by users of these materials.

- Materials need to be selected on the basis of the specific performance characteristics required.

- A new Standards Australia standard will provide users with information with regard to selection and use of catalysed pavement marking materials.