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Learnings

The choice of an adhesive for any mosaic is an important consideration if the mosaic is to remain stable over time. Today there is an ever increasing array of backing substrate[1] and tesserae being made available. Attendees to the presentation and readers of this paper will learn some simple approaches to screen adhesives for use on mosaics they wish to create.

Comment on the following Words, Tables and Charts

In the following are lists of adhesives and primers, and cross reference charts by manufacturer, for the products of adhesive classes.

A major point to remember in this competitive world is that many manufacturers make equivalent or same products. This presentation does not suggest that you should change the products that you use today to another manufacturer of the same type of product. By no means should anyone think this to be the case. The cross references are designed to allow you to understand where equivalence may occur, so that you are able to shop at various outlets, and obtain a product that will meet your needs, should your preferred material be unavailable.

The charts are also designed so that you can obtain and trial new products, for new assemblies and projects, should you wish to advance down this path.

Good luck with your projects and may all your bonds be strong.

Introduction

Making a successful mosaic is not just about the aesthetic design and appearance of the finished product. Every mosaic artist wants their work to look good, but also desires it to be enduring so that it can be appreciated for years to come.

Early mosaic artisans learnt the importance of understanding the best adhesive materials to use with their preferred substrates. Most mosaics today continue to use ceramic, porcelain, glass, stone or some other silicate based material as the tesserae to carry the design, colour and form to the admirer. However, mosaics can be made from a variety of facing materials including timber, plastic, rubber or metal.

In the past we have generally associated mosaics with backing materials based on stone, brick, concrete, cement render and cement rendered board and cement based fibre boards. Today there is an unparalleled variety of natural and manufactured backing substrates we can use, ranging from metal through engineered plastics to flexible materials such as rubber.

Similarly, tesserae are now available in ever expanding formats and materials. Older tile formats are being bolstered by metals, glass, plastics, manufactured stone, LED lights, in fact almost anything that can be bonded, secured and fixed to a chosen backing.

[1] Substrate is a material that is to be bonded. Can be the backing or the tesserae

At one alarming and intriguing, it is this variety of substrates that now challenge mosaic artists to understand the most appropriate adhesive systems for their applications. On the positive side is that adhesive and grouting systems have maintained pace with the new backing and tesserae combinations. On the negative side is that many of the new adhesives, sealants and grout systems are not promoted in a mosaic environment, and still many are not well known outside of their industrial applications.

It says a great deal about the inventiveness, and inquiry of mind, that some of the members of the mosaics fraternity have been able to "discover" and find ways of using new adhesive, sealant and grout products.

Unfortunately, as much proper adhesive and sealant selection is matched with partial and poor selection. None of the poor selection is deliberate, but is rather the result of individuals wanting to extend their art, and in the face of a lack of information, will trial available products.

The mosaic artists I have met are all familiar with conventional tile adhesive and grout products. These are systems based around premixed - ready for use (RFU) - add water and mix - cement and cement/polymer, and two part liquid/powder products, designed to service the residential and commercial bonding of tiles in the construction Industry. I have not seen use of epoxy or polyurethane tiling adhesive or grout products so far, but I am sure that there are people practicing mosaics using these materials. Manufacturers servicing this component of the construction market have the ability to support a large portion of most mosaic artist's requirements.

But what of the artist who wants to bond on engineered plastic – fibre reinforced polyester or epoxy, thermoplastic – glass, metal, rubber or other fully manufactured polymeric, metal or glass based substrate?

What of the artist that wants to achieve permanently clear bond-lines under clear glass tesserae on a glass backing so they can backlight their creation? What of the mosaic made with these substrates destined for full time water immersion or subjected to exterior environmental extremes of wind, hail and sun?

Cement and modified cement based products will not provide these artists with an ability to realise their dreams. They need to explore the realms of other types of adhesives and sealant technologies and this can be a significant challenge.

The aim of this paper is to assist in understanding how each of the general product families work and the needs for priming in certain instances.

At this point it is important to advise that Occupation Health and Safety (OH&S) and the use of Personal Protection Equipment (PPE) are absolute necessities when using any adhesive product.

In the case of powdered cement and gypsum products it is important to wear dust masks and gloves, in the case of liquid adhesives, rubber gloves and eye protection are important. When dealing with solvent based products good ventilation is extremely important.

When used on a construction site or a factory the requirement for safe use of products is mandated by legislation. That should give everyone a lead to taking care of their health by following the manufacturer's advice. As a purchaser, or user of a product, you have a right to obtain and read a copy of the Material Safety Data Sheet (MSDS) for that product.

My strong advice is that you do not use products where a MSDS or equivalent Safety Data package is not available. Protection of your health against unnecessary exposure to dangerous chemicals is a must.

Just because a material sits on the shelf at the supermarket, tile shop, hardware shop or other does not mean it is safe to us without appropriate precautions.

You wear sunscreen at the beach because you know the hazard from the sun. Please take the same approach to your health when dealing with your art.

Cement Based Adhesives

Porous natural backings and cement based products can generally be adhered using cement based adhesive systems, especially with modern day products containing a variety of additives to improve and enhance their adhesive performance.

It is also important to understand the limitations of adhesives in their end environments. We want to understand what can be used outdoors and what cannot; what can be used permanently underwater and what cannot; which adhesives can take movement and which cannot, etc. As important as understanding what an adhesive system can do, it is equally important to understand what they cannot do, so that the adhesive choice ensures that mosaic stays well bonded.

Cement Based Adhesive and Sealant products are classified by a coding system confirming their performance under internationally accepted criteria based around an International Standard ISO 13007.1 to .4. This Standard is recently adopted in Australia and replaces the previous AS 4992 series Standard.

Most competent manufacturers use the ISO 13007 coding system and reference it for each adhesive or grout on their literature or on their bags. (The ISO 13007 coding is the same as used in AS 4992)

A code outline is provided in Appendix 1.

A Cross Reference list of comparable cementitious products from the major Australian Manufacturers is provided in Appendix 2.

Cement based tile adhesives are complex mixtures of materials containing cement, aggregates and a number of other modifying additives of specific purpose.

Cement works by development of a hard crystalline network of hydrated silicates within the adhesive matrix. The development of these hydrated silicate crystals starts immediately after water addition to cement. The extent to which this reaction is completed influences the strength and durability of the adhesive or grout. Freshly mixed adhesive normally contains more water than is required for hydration of the cement; however, excessive loss of water by evaporation can delay or prevent adequate hydration. That is a reason to take great care on very hot days and to prime or to wet down absorbent surfaces at all times. Doing these things will assist you to retain moisture in the adhesive, until hydration of the cement is progressed.

The complexity of cement based adhesives due to the many competing demands of legislation, changes in types of tiles and stone used, and customer requirements wanting faster initial set but with extended pot life and open time.

Today cement based ceramic tile adhesives will have combinations of the following materials in their make-up. There are numerous other additives that are also used but this list will provide an understanding of the complexity of the end products. No longer are you buying a mix of sand cement and some colourant.

1. **Portland** or other blended **Cement**
2. **Fly ash**, blast-furnace slag, silica fume, natural pozzolans
3. **Blended sands**
4. **Calcium Carbonate** (rarely is silica flour used these days)
5. **Reclaimed rubber regrind** (weight reduction – NOT for flexibility)
6. **Bond and flexibility enhancers** (especially important on non-porous and difficult to bond substrates - re-dispersible powders – acrylic and others)
7. **Rheology enhancers** (viscosity control)
8. **Accelerators** (Accelerate setting and early strength development)
9. **Air-entrainers** (Workability – Creamy nature)
10. **Super-Plasticizers** (Water reduction)
11. **Retarders** (extended pot life)
12. **Corrosion inhibitors**
13. **Shrinkage reducers**
14. **Anti – fungal additives**

And the list goes on……

Understanding the work that goes into these adhesives is also to understand that each adhesive has its own character and attributes. Some of these are favourable to mosaics others are not.

Most manufacturers make ranges of cement based adhesives to cover the range of applications and use methods and speed of set requirements coming from the end user market. Whatever cement based product you decide to use please understand that it has been primarily targeted

to meet the demands of the commercial and residential tiling market. The result is a number of compromises that you may need to find means to accommodate, in your mosaic assembly.

The attributes and limitations are easily found in the manufacturer's literature so you can quickly determine suitability for your project of one product over another.

Extended open time is an attribute that lends itself to importance in mosaics. If that suits you then look for an adhesive with an "E" coding.

Wide bonding range (the number of different substrates an adhesive will successfully bond) is an important attribute for mosaics where a multitude of different tesserae may be used on a single job. If that is the case look for a product will increased flexibility (S1, S2 codes) as these materials will also contain higher levels of polymer necessary to extend bond range.

Alternatively, add a cement modifying emulsion based on acrylic resin technology to the cement based adhesive. This will do a similar job or extend the performance of the polymer modification in the dry mix.

If materials are to be used underwater then improved cement performance will be desired. Moving to a C2 class product will likely provide a better result.

There is a huge data base on cement based adhesives these days. The web is a wonderful open-pit of knowledge. Use it and you can screen adhesives before you buy them.

Dispersion based adhesives (ready mixed)

Dispersion Based Tile Adhesive products are classified by a coding system confirming their performance under internationally accepted criteria based around an International Standard ISO 13007.1 to .4. Most competent manufacturers use this coding system and reference it for each adhesive or grout on their literature or on their containers.

A code outline is provided in Appendix 3.

A Cross Reference list of comparable cementitious products from the major Australian Manufacturers is provided in Appendix 4

Dispersion based tile adhesives are invariably based on acrylic resin technology. In the past other emulsion systems including natural rubber (NR) and styrene butadiene (SBR) have been used. Acrylic technology has become so well developed and cost effective that it is now the emulsion of choice on which to make Tile Adhesives.

These products offer a fast easy no mix system for bonding tesserae. They bond reasonably well but will not achieve the same strength or environmental resistance as polymer modified cement based products.

As a result they can be used for internal works and works where timber and substrates affected by humidity change are used. Their naturally softer bond line allows them to provide an additional degree of movement not available in most cement based systems.

Commercial grade and project work mosaic artists should make vigorous consideration of using the best adhesives for their output. In doing so it is the view of the writer that dispersion grade tile adhesives should remain the domain of the hobbyist and not be used for saleable works.

Reactive resin adhesives

Epoxy

Epoxy systems are two pack products with extraordinary bonding capability. They are mostly hard stiff products suited to bonding stiff and hard substrates. This makes them suited to use with silicate based materials like tiles, stone and glass.

The general purpose grades available in the hardware store are basic products that have limited performance.

There have been great advances in Epoxy technology through their applications in multiple Industrial applications like automotive manufacture and in the aerospace industry.

The technologies used to make epoxies more useful in room temperature processing and allowing them to effectively bond more flexible substrates and resist vibration and movement are available in a limited manner for commercial sale.

Lord Chemical Products offer these products in Australia through limited outlets and from their local head office.

For some applications these hybrid epoxy products require primers but these primers simply extend the bonding range of the adhesives.

With correct primer selection many rubbery products can be combined to metals, plastics, glass, ceramic, stone, and cement based materials.

Epoxy adhesives should be protected from UV exposure.

Appendix 5 lists a number of epoxy products that can be used with mosaics.

Silicone

Silicone sealants are the most widely practiced chemistry in sealant production on a global basis. Their wide use and high volume production has ensured that they have become a relatively low cost engineering sealant. Much of the production of these silicone products and especially base prepolymer materials is now done in China. Unfortunately it is manufactured using a polluting production route. To make silicone precursors in countries with tight pollution controls is becoming very expensive.

Appendix 6 lists a number of Silicone products that can be used with mosaics.

Silicone sealants are also succumbing to the cost pressures of everything in this competitive world to the point that we now have a great variety of diluted silicone sealants being offered to market.

These diluted materials look okay today but within a short time – 6 months they will start to shrink, crack and increase in hardness and discolour (yellow). They may be low cost but it is for a reason.

The best options with these types of products are to stay with long term known brands or long term suppliers of silicone products. These company's generally have strong reputations to protect short and long term and if they market a diluted product they make this well known on the product literature.

Silicones sealants are generally classified according to the curing system that they use in order to cure. All single part systems use a reaction with atmospheric moisture to cross link and adhere to the substrates. During cure by-products of reaction are created and it is from these by-products that the Silicone will garner its classification.

Advantages of Silicone Sealants (Can be used as adhesives)

- Temperature range -65°C to +232°C Maximum (350°C for certain high performance products)
- Oxidation & UV stability
- Shock / stress absorbing (Flexible)
- Water repellent
- Broad adhesion characteristics
- Low toxicity
- Low chemical reactivity.
- One part, air cure (humidity)
- Tack free time = 6 -20 minutes
- Full cure = 24-48 hours (3mm thickness)

Limitations of Silicone Sealants

- Not paintable
- Potential reactivity with different substrates depending on cure type
- Can stain porous materials especially natural stone.

Of the Silicone products available to the general public there are three main grades to consider.

	ACETOXY*	NEUTRAL	ALCOXY
Features & Benefits	Quickly forms a tough skin Cures to a durable rubber Temperature resistance Chemical resistance Long shelf life	Non-corrosive cure Cures to a durable rubber Excellent adhesion Recommended for use on steel, glass and concrete	Least corrosive of silicones Extremely flexible Superior adhesion Suitable for high joint movement and structural applications Recommended for use on steel, glass and concrete
Limitations	Strong smell during cure Will cause corrosion on concrete and soft metal during cure Less adhesion and less flexibility Not recommended for underwater applications	Skin can crack if subjected to rapid movement at cure time Slow curing Medium shelf life Not recommended for underwater applications	 Slow curing Medium Shelf Life Not recommended for underwater applications

- Not suitable for cement based or acid reactive systems

Polyurethane

Polyurethane Adhesives and Sealants are generally supplied as single part moisture curing mastic materials in Cartridge or Sausage format. After silicone sealants, polyurethane sealants and adhesives are the second most used in the construction market.

The list in Appendix 7 provides a guide to Polyurethane materials suitable for bonding mosaics available in Australia.

These single part products are neutral cure with the by-product of reaction being carbon dioxide gas.

They are susceptible to bubbling on cure if the surface they are bonding:

- is moist
- contains significant moisture inside
- is in a hot humid location

Polyurethane materials, to be affective as adhesives, generally require priming of the surface they are to bond. They are well practiced materials in Industrial, Automotive and Construction applications. In Australia 100% of all fixed glass in a new car, windscreen and rear window glass is bonded using polyurethane adhesives. More than 60% of the replacement windscreens are bonded with polyurethane.

In the construction industry almost all of the concrete to concrete joints in tilt slab factory construction are sealed with polyurethane sealants.

These materials bond well to porous substrates like cement, as long as they are dry. They can be enabled to bond glass, and other silica based substrates (glazes etc.), metals and many other substrates with the appropriate primer selection.

Due to their toughness and flexibility, they allow the bonding of different materials without transfer of stress from one substrate to another due to differential thermal expansion, or moisture uptake.

They must however be used only for bonding and must be protected from UV light. This is a major downside, as UV light will degrade polyurethane materials rapidly.

Internationally there are people using polyurethane adhesives to bond tesserae to metals and other substrates.

The highlight features of Polyurethane one part adhesives and sealants ore outlined below.

Upside

- One part Mastic type
- Tougher than Silicone
- Bonds some porous surfaces without primer
- Readily available
- Fast Cure

Limitations

- Not Suitable for:
  - Chlorinated water immersion
  - Salt Water immersion
  - Cure below 5^{o}C
  - Glazing
  - Use on substrates contaminated with Bitumen.
- Require primers to gain good bonds to most surfaces

As with all reactive adhesives it is important to use appropriate Personal Protective Equipment during their use.

There are some issues around residues left in polyurethane adhesives from the manufacturing process. These have been highlighted under a new International Chemical labelling and classification scheme. Manufacturers wanting to avoid the onerous declarations involved are converting away to new Silyl Modified Polymer Technology.

As a result there is tremendous effort globally to manufacture products based around these Silyl Modified Polymers. These materials use a polyurethane backbone with its flexibility and strength, but utilise the same adhesion and cross linking chemistry that is found in certain silicone systems.

Silicones are generally too extensible, and far too low in tensile and tear resistance, to work as adhesives in most application. That is easily addressed by replacing the material backbone with tougher polyurethane like material.

Silyl Modified Polymers are now widely available in Australia and the next section will address some of these products.

Silyl Modified Polymer (MS Polymer)

SMP technology is amongst the easiest to use and most versatile adhesive and sealant technology platforms on the market today. This is a new class of adhesive that exhibits the combined properties of polyurethane and silicone systems. There are a growing number of these products on the market in Australia today. Appendix 8 references a range of SMP based products that are available in Australia today.

The highlight features of SMP Technology are listed below

- Moisture Cure
- One Part ready for use
- Supplied in optically clear grade or pre-pigmented grades
- Convenience packaging in Cartridge or Sausage
- Excellent primerless adhesion to most substrates
- Neutral cure so can be used on acid and alkali sensitive materials
- Highly Flexible
- Tough
- UV Stable
- Stable in use between -30°C and +90°C
- Will bond to moist surfaces
- Relatively cure independent of temperature above 5°C (They just need humid air)
- Non Bubbling
- Environmentally friendly (no solvents)
- Fast curing (>3mm / day)
- Can be over painted

Limitations

- Not suitable for:
  - Immersion in Chlorinated water (swimming pools)
  - Polypropylene,
  - Polyethylene,
  - Teflon
  - Surfaces contaminated with bitumen.

SMP cure and bonding chemistry is very versatile and allows use of reactive primer systems to gain chemical adhesion to an even wider variety of substrates. The adhesives can be used for applications where a mosaic is to be subjected to temperature ranges from -30°C through to +90°C.

As adhesives they can be used to bond almost any substrate combination even flexible materials to hard materials. e.g. Rubber to Tiles.

Other Adhesives - Water Based

Some of the opinions presented in this section are the writers own views and may differ from those of others. The writers concerns are expressed entirely as an alert to mosaic artists to ensure that product claims and performance are well tested prior to making saleable products using these materials. (Bruce Gascoigne)

There is a range of "other water based adhesives" that appear to find some use in the mosaic and associated markets.

Some of these products have found application where they appear to fulfil the bonding needs of the users, despite them not providing optimal adhesion characteristics. This is often the case with adhesives, where user needs are sometimes met by products that adhesive purists for want of risk reduction would not recommend.

The writer has been challenged on a couple of products fitting this description within the mosaic fraternity, and seen results that are impressive. There still exist reservations for the longer term performance but at 2-3 years the products appear to be working.

While water based adhesives are well proven on many porous materials. We only have to look at water based adhesives on porcelain tiles, on timber and concrete to understand what they are capable to deliver.

It is when they are used on glass, glazed china and other non-porous materials that the challenges begin. Water based adhesives will wet and adhere to non-porous substrates generally providing relatively low performance bonds. However with proper adhesive selection, substrate preparation and assembly techniques these adhesive products are capable of delivering results that meet user expectations in the mosaic world.

There is no doubt that these materials are entirely suited to use on porous mosaic materials.

The water based systems that I refer to are typically based on homopolymer or mixed polymer systems of the following materials

- PVA
- Acrylic/Styrene Acrylic
- Styrene Butadiene

Of these systems PVA (and copolymer) and Acrylic/Styrene Acrylic systems dominate the water based adhesives offered to the mosaics market.

These materials belong to families with extremely versatile chemistry that allows for production of products with a broad range of properties. They can be internally and externally plasticised

and will accept a wide range of additional modifiers including extenders, UV absorbers and antioxidants etc.

This ability to modify the base products allows them to be manipulated to meet the demands of particular applications.

Just think that members of the acrylic/styrene acrylic stream form the basis of all current dispersion based Tile Adhesives. The same is true of PVA's for many timber bonding applications.

There is a wide range of product available from the Acrylic and PVA families. This is possibly due to the inherent safety of the materials, the availability of base formulation advice, relative ease of manufacture and low capital cost of manufacturing equipment needed to make products based on these emulsions.

As a result there is a proliferation of products and brands existing in the marketplace. Due to this the writer has declined to list out products across this range of materials other than two materials that appear to have gained acceptance and use within certain sectors of the art.

PVA based - Weldbond™

Acrylic Based – MAC™ Glue

Other Adhesives – Solvent Based

Some of the opinions presented in this section are the writers own views and may differ from those of others. The writers concerns are expressed entirely as an alert to mosaic artists to ensure that product claims and performance are well tested prior to making saleable products using these materials. (Bruce Gascoigne)

Solvent based adhesives like water based systems provide adhesion through thorough wetting of the substrate surface. Whilst some of these products gain better adhesion than water based materials they are still lacking versus reactive resin and cementitious systems.

Solvent based adhesives are generally loosing favour these days. It is very important with products from this group that you ensure work is conducted in a well-ventilated area away from flames and sparks. Most solvents used have an effect on humans and they can build explosive concentrations in confined spaces.

Glue sniffing, VOC[2] construction site requirements, and community and trade acceptance of slower water based alternatives is having impact, and fewer and fewer solvent based systems are available, and even fewer new solvent based systems are making it into the market.

Typical of solvent based products is that base polymers and resins used are generally strongly coloured, non-UV resistant and because they normally create translucent or opaque dry films are not used in visible applications.

There are some exceptions that appear where specific properties, or where specialist additives, have been included in the adhesive to improve adhesion or other properties of the material.

Products like Selleys All-Clear™, Parchem supplied Lexel™ and Selleys Liquid Nails™ Clear fall into this category and are unique in that they have clarity and very good UV resistance.

An important feature of these products is that they are neutral cure and can be used to bond mirrors without concerns for damage to the mirror coating on the glass. Generally the mirror effect on glass is a layer of metal composed of layers of Tin (Ultra-thin tie-coat), Silver (Mirror effect) and Copper (antioxidant layer to protect the silver) then a couple of coats of paint to protect the metals.

Other solvent based adhesives do not necessarily exhibit this mirror compatibility.

Across the spectrum of solvent based adhesives are extended Neoprene adhesives like HB Fullers Fulaprene 303™. This is a capable adhesive for porous and non-porous applications but not UV stable. Neoprene solvent based systems are not suitable for use on expanded polystyrene (EPS) backing boards.

Selleys Liquid Nails™ and HB Fuller Maxbond™ are designed for similar applications to the Neoprene systems but are based on SBR Block Copolymer rubbers. These materials can be readily dissolved in solvents that will not dissolve expanded polystyrene. This is important if you are using polystyrene / cement composite backing substrate.

SBR and Neoprene materials must never be UV exposed as they will rapidly decompose and bonds will fail.

A major downside of all solvent based adhesives is that they shrink as the solvent evaporates. This either leaves voids in the adhesive bond line or that the shrinkage causes stress in the bonded assembly that could cause later failures.

[2] VOC = Volatile Organic Compound. There are now guidelines as to the volume of VOC products should release if they are to be used in commercial or construction site applications. Hence the development of many water based alternate systems.

Primers

Everyone wants that the adhesives they use bond well and be easy to use. In most cases they want to avoid the use of primer systems.

This is interesting when we consider the use of paints and adhesive in Industrial applications where the use of primers with adhesives and coatings is not mandatory but is still extremely widely practiced.

Appendix 9 lists a range of primers for various substrates that will work with reactive polyurethane and epoxy adhesives in particular.

Industrial users add steps and cost to their processes in this competitive world by using primer steps. The reasons for using primers are many and generally related to reducing risk of failure in the finished article.

Primers are also used to ensure improved compatibility of chosen adhesives with the substrates to be bonded. Well selected primers can allow a business to use a single adhesive system to bond a variety of substrates and know that they will not have field failures.

Likewise, as mosaic artists extend the boundaries of substrates and tesserae, it is important that they become familiar with the types of primers available in the market.

Many of the higher performing primer systems for use with reactive (resin) adhesives originate in the Industrial adhesives side of the market.

Use of correctly selected primers will allow bonding of substrates that without primers there would be little opportunity to use.

Many of the primers use reactive chemistry themselves or employ hazardous chemicals. Understanding the risks associated with each product and using them in safe environments with Personal Protection Equipment is mandatory.

Appendix 1

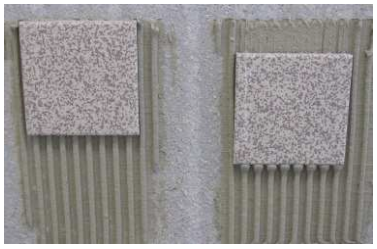
International Cementitious Adhesive Classification Coding.

CEMETITIOUS ADHESIVES (C)	
CLASSIFICATION	**REQUIREMENTS TO MEET CLASSIFICATION**
C1	Normal Setting Adhesive Fundamental Characteristics Tensile Strength measured after: • 28 days room temperature (RT) cure • 7 days RT cure + 21 days water soak • 14 days RT cure + 14 days cure at 70°C • Freeze thaw cycling ○ **All test protocols ≥ 0.5MPa** • Tensile strength after 20 minutes open time ○ **≥ 0.5MPa**
C2	Improved Setting Adhesive Tensile Strength measured after: • 28 days room temperature (RT) cure • 7 days RT cure + 21 days water soak • 14 days RT cure + 14 days cure at 70°C • Freeze thaw cycling ○ **All test protocols ≥ 1.0MPa**
S1	Flexibility **Transverse Deformation ≥ 2.5mm ≤ 5mm**
S2	Improved Flexibility **Transverse Deformation ≥ 5mm**
E	Extended Open Time **≥ 30 minutes open time**
F	Fast Setting **≥ 0.5MPa after 24 hours RT cure**
T	Slip Resistance **≤ 0.5mm**

For more information on testing visit - www.mastertilers.org/Adhesive-Testing.php

Test for Flexibility

Test for Slip Resistance



Appendix 2

Cross Reference chart Australian Cement Based Adhesive Manufacturers.

Class	Ardex			Bostik	Construction Chemicals	Construction Technologies		Davco	Laticrete	Mapei	RLA (ATLAS)
	Ardex	ABA	Dunlop			Prohesive	MCB				
C1	Fortiset			Fixall	Kemgrip std	Proset	A-10	Ceramacrete	280	Keraset	Tilebond
	Vitrobond							TTB		Keraflor	Tilebond Extra
	Supertileset									Adeflex R	
C1E	Super Fortiset			Superfixall Off White	Kemgrip super			SE-7		Tixobond Fine S1	
				Superfixall White	White Kemgrip super			Super TTB			
								Dribond off white			
C1FT	Quickbond										
C1S1	Fortiflex		Floor Tile Adhesive	Excelflex							
	Glue		Resaflex								
C1S1E								Ultraflex			
C1S1ET	X10			Maxiflex	Cemflex	EcoPro	A-62	Powdermastic	Latiflex gold/silver		
				Megafix	Gripflex			Econofix	Multiflex		
C1S1T						Megapro	A-74		Ultra X8		Moreflex

Class	Ardex			Bostik	Construction Chemicals	Construction Technologies		Davco	Laticrete	Mapei	RLA (ATLAS)
									4-XLT		Flexbond NS Tileflex
	Ardex	ABA	Dunlop			Prohesive	MCB				
C1S2	MPP								248		
C1S2E	Isoflex					Pro2Part (2K)		F1 Express			
	X56						A-40				
C1T	STS 8										
C2					Vitrigrip						
C2E								SMP 2010	290	Ultraflex 1	
C2EF				Prontofix	Fastflex			1-part rapid		Ultraflex 2	
C2ET						Proset super	A-20			Adesilex P9	
										Keraflex	
C2F										Adesilex P4	
										Ultraflex RS	
										Granirapid (2K)	
C2FT	S16										
C2T										Keracrete	
										Kerbond Plus	
C2S1	X52										Unibond
C2S1E				Conflex							
C2S1EF	X78				Rapidfix (2K)			2 Part Rapid (2K)			
C2S1EFT	X77								355 Rapid		

Class	Ardex			Bostik	Construction Chemicals	Construction Technologies		Davco	Laticrete	Mapei	RLA (ATLAS)
	Ardex	ABA	Dunlop			Prohesive	MCB				
C2S1ET			Wall and Floor Tile Adhesive	Ultra Mastik	Drymastic	Promaxstik	A-50		335		Techbond 14
			Floorfix		Duraflex	Ecoflex	A-65				
					Hydrabond	Proflex	A-66				
						Pro Premium	A-80		Glass Tile Adhesive		
					Ultima (2K)						
C2S1ETP									Sure Set		
C2S1FT									317	Keraquick	
C2S1T		Abaflex									Just 2 Ezy
C2S2					Acoustibond						Flex 1 part
C2S2E			Tile-All (2K)	Asaflex (2K)	Kemflex (2K)			Davcoflex / Tradeflex		Kerabond+Isolastic	Flex-2-Part
C2S2EF				Superglue							
C2S2EFT						Ultrapro	A-100				
C2S2ET				Landscape	Monoflex						
C2S2T	Optima (2K)										

Appendix 3

International Dispersion Adhesive Classification Coding.

DISPERSION ADHESIVES (D)	
CLASSIFICATION	**REQUIREMENTS TO MEET CLASSIFICATION**
D1	Normal Setting Adhesive Fundamental Characteristics Tensile Strength measured after: • 14 days room temperature (RT) cure • 14 days RT cure + 14 days cure at 70°C ○ **All test protocols ≥ 1.0 MPa** • Tensile strength after 20 minutes open time ○ **≥ 0.5MPa**
D2	Improved Setting Adhesive Tensile Strength measured after: • 21 days RT cure + 7 days water soak **≥ 0.5MPa** • 14 days RT cure + 14 days cure at 70°C **≥ 1.0MPa**
E	Extended Open Time **≥30 minutes open time**
F	Fast Setting • 7 days RT cure + 7 days water soak **≥ 0.5MPa** • 14 days RT cure + 14 days cure at 70°C **≥ 1.0MPa**
T	Slip Resistance **≤ 0.5mm**

Appendix 4

Cross Reference list of comparable Dispersion Based products

Class	Ardex			Bostik	Construction Chemicals	Construction Technologies		Davco	Laticrete	Mapei	RLA (ATLAS)
	ARDEX	ABA	Dunlop			Prohesive	MCB				
D1				Instant-pro Interior floor and Wall							
				Instant -Pro Mosaic Adhesive							
D1E	D11	Abafix	Wallfix	Multifix	Surefix			White one pot			
		Flexible Multipurpose	Resaflex Premixed					Flexible CTA			Multistick
								Glue Grout			
D1ET	D2		Wall Tile Adhesive	Mastik	Tilemastic	Progrip			Multimastic		
					Sureflex			Grey one pot		Ultramastic eco	Supreme NS
	D1	Abamastic		Tru Mastik	Trademastic			Supamastic		Ultramastic D1 Superwhite	
D1T								Litemastic*			
D2ET							M-1			Ultramastic III	
								*Powder mix with water			

Appendix 5

Epoxy Adhesives potentially suitable for mosaics

Supplier Name	Product Range / Name	Limitations
LORD Chemical	**LORD 310A/B, 320/322, 305/307**	Require primers on some surfaces
Selleys	**Araldite series**	Take care with 5 minute versions they are not so good. Require primers on some surfaces
Loctite (Henkel)	**EP 20HP, E-05CL**	Require primers on some surfaces
3M	**Scotchweld DP460, DP110**	Require primers on some surfaces
Vivacity	**Megabond, Megapoxy PM, Megapoxy 69**	Require primers on some surfaces
ARDEX	**Ardex Abapoxy, Ardex WA, Ardex WA100**	RG1 to R2T classes
Bostik	**Titan Bond Plus**	Will not bond olefin plastics, Teflon or Silicone
Chemical Technologies	**Eco Epoxy**	R2
Construction Chemicals	**Epi-Grout**	RG1
DAVCO	**Epoxy Grout**	RG1
Laticrete	**Latapoxy**	R2T
EPI-REZ	**Episet series**	Take care with selection due to variations in cure speed available across the range. Long cure tile and long open time best.
Mapei	**Kerapoxy**	R2T
RLA	**RT 1718**	RG1

Choice of Epoxy system is important. Traditional Tile Adhesive manufacturers and Construction Chemicals manufacturers (Vivacity, Epi-rez) will make products suited to bonding stiff porous substrates and tiles.

Araldite (Selleys), LORD and 3M will make much more capable industrial systems that may find easier and better use in bonding hard to bond substrates and offer greater flexibility and shock resistance.

LORD products are available through StorkAWD 6/ 2-4 Sarton Road Clayton 3168 Victoria.

Appendix 6

Mosaic suitable Silicone products available in Australia today.

Supplier Name	Product Range / Name
Admil	N-192, N-600, N-195, M1, Prosil 10, Prosil 41LM
ARDEX	Ardex ST series
Bostik	Roof n Gutter Premium, Bostik V-4, Bostik 5 CLM,
Construction Chemicals	No Neutral cure grades yet avaliable
Construction Technologies	No Neutral cure grades yet available
DAVCO	No Neutral cure grades yet available
Dunlop	No Neutral cure grades yet available
HB Fuller	660, 700, 705,720, 750, 760, 770, 780, 790, HBF 100, HBF 300
Laticrete	Latasil series
Macsim	Roof & Gutter, All Weather, Brick & Concrete, SN60, SN70
Roberts Designs	Maxisil N series, Maxisil P for underwater
Parchem	Construction Silicone, Hillastic 66, Hillastic 88
Selley's	Roof and Gutter, Wet Area, Kitchen and Bathroom, Paint Over.
Sika	Sikasil C, Sikasil AP, Sikasil Pool for underwater, SG20, SG500, WS305.
Soudis	Silrub 2, P, WS, Cleanroom
Tremco	Tremsil 600, 870

Note that the Silicone market is very competitive. There are a number of major global silicone manufacturers that supply base range silicone sealants that are then packed off under a variety of trademarks and names.

Importantly some companies have specialist products that they make for their own sales only. Some local companies have agreements with international manufacturers to ensure they have exclusivity to their products in Australia.

Parchem (DuluxGroup) the only one left standing!

Parchem is the only local manufacturer left making a range of silicone sealants in Australia. They make great products and should be supported. Parchem operate from branded distribution points located in most capital cities on mainland Australia and have further distribution through construction outlets.

Major global manufacturers of Silicone

- Dow Corning (Also known as Xiameter) (USA)
- General Electric (Also known as Momentive) (USA)
- Wacker (Europe)
- Shin-etsu (Japan)
- Bluestar (France and China) – Formerly Rhodia
- Bayun (China)

Specialist arrangements or own internal manufacture

- Bluestar (China) – Exclusive agreement
- Otto Chemie (Germany) – Exclusive agreement
- Sika (Europe) – Own manufacture

Dow, GE, Wacker and Shin-etsu market ranges of silicones under their own label but also supply to repackers and through private label agreements. Most leading silicone labels in Australia are repackaged products from the above listed major manufacturers.

Since China is now one of the largest markets for Silicone and there are many new Chinese manufacturers. We are starting to see silicone from these manufacturers enter Australia. Many grades from China, appearing in the market today are not 100% silicone materials, and have issues with time based discolouration, shrinkage, and hardening.

To avoid any quality issues it is advisable to pay a little more for a reputable and known brand. The owners of the brand are less likely to risk reputations by selling low grade products.

All suppliers listed above work with quality products.

Appendix 7

Polyurethane products available in Australia today.

Supplier Name	Product Range / Name	Limitations*
Selleys	**Proseries Flexiseal Range**	Require primers for best bonding on porous and non-porous surfaces
Parchem	**Emerseal PU range**	Require primers for best bonding on porous and non-porous surfaces
Sika	**Sikaflex series (PRO, 11FC etc.)**	Require primers for best bonding on porous and non-porous surfaces
Tremco	**Tremco PU540, Dymonic NT**	Require primers for best bonding on porous and non-porous surfaces
HB Fuller	**Superseal 101**	Require primers for best bonding on porous and non-porous surfaces
Bostik	**Seal N Flex 1, Seal n Flex FC**	Require primers for best bonding on porous and non-porous surfaces
Glass Assist (Dow)	**Betaseal range**	Require primers for best bonding on porous and non-porous surfaces

*See Appendix 9 for a list of primers

All the above manufacturers (except Dow) supply single component low modulus and high modulus polyurethane systems. Dow only supplies high modulus systems.

Adhesive properties are best in high modulus materials as they exhibit highest internal strength, limited extensibility and are generally higher in polymer content and as a result exhibit better adhesive strength than their low modulus counterparts.

Appendix 8

SMP products available in Australia today.

Supplier Name	Product Range / Name
Admil	Proflex 25, Proflex 50, Procon22
Bostik	Bostik Extreme, Simson 70-03, Simson 70-05, Clear Seal, Seal in the Wet
Dunlop	Tile-All Plus
Fixtech	Fixtech Range for Marine applications
Franklin International via Gutterguard	Titebond Weathermaster Sealant (Colour range)
HB Fuller	Toolbox, Superseal HPR, 720 Paintable Silicone, Liquid Glass
Henkel	OSI EP 1000
Macsim	MS-601, Clear Fix, High Tack
Parchem	Emerseal MS, Nitoseal
Powers	Powerstik
Selley's	Selley's 3 in 1 (White and Clear)
Sika	Sikaflex AT Range
Soudis	T-Rex, Fix-All, Fix-All Ultra, Soudaseal,
Tremco	Dymonic FC

Appendix 9

Primer products available in Australia today.

Supplier Name	Product Range / Name	Technology Platform	Primer for
LORD Chemical	**Chemlok 7701**	Solvated Chlorine Donor	Natural Rubber, Nitrile Rubber, PVC, SBR Rubber, Neoprene,
LORD Chemical	**Chemlok 607**	Solvated Silane adduct	Metals, Other non-porous silicaceous materials, porcelain, glazed ceramic tile, glass, fibreglass gel coat, UPVC, ABS
LORD Chemical	**Fusor 602EZ**	Solvated Chlorinated Rubber	Polyolefin rubbers, EPDM, Polypropylene
Sika	**Sika 205**	Solvated Silane adduct	Metals, Other non-porous silicaceous materials, porcelain, glazed ceramic tile, glass, fibreglass gel coat, UPVC, ABS
Sika	**Sika Primer 1**	Solvated Epoxy 2 part	Concrete, masonry, wood, porous surfaces
Bostik	**9210 Primer**	Solvated Chlorinated Rubber	Polyolefin rubbers, EPDM, Polypropylene
Bostik	**9300 A/B**	Solvated Chlorine Donor	Natural Rubber, Nitrile Rubber, PVC, SBR Rubber, Neoprene,
Bostik	**N40**	Solvated Silane adduct	Metals, Other non-porous silicaceous materials, porcelain, glazed ceramic tile, glass, fibreglass gel coat, UPVC, ABS
Bostik	**N49**	Solvated isocyanate adduct	Concrete, masonry, unglazed ceramic tiles
Bostik	**MVP525**	2- pack water based epoxy	Concrete, masonry, unglazed ceramic tiles
General	**Phosphate conversion primers**	Modified Phosphoric acid solution	Ferrous metals

Appendix 10

The following is the script written to accompany the power point presentation alongside which this paper was written.

Slide	Background Commentary
1.	This presentation has been prepared as an introduction to adhesives used for mosaic art. Mosaic artists by their very nature challenge everything about their mosaic world. Mostly they push the limits of form, colour, texture and substrate composition. This invokes challenges in assembling and ensuring that their pieces stay together and endure the test of time in the environments they are destined to operate. By far the majority of tesserae are of silicate background (tile, stone and glass) and base-substrate materials are generally of cement based material or variants thereof. However, the mosaic world does not stand still such is the very nature of its participants and today there are many different materials that are employed as tesserae and an equally large number of materials being investigated as base substrates. This presentation is a quick introduction to understanding some features about the variations of adhesive we can use to bond the various substrates and tesserae. At the outset I want to thank the following companies and individuals for input to this presentation, samples of materials used for demonstration and allowing me use of pictures of their products and from their files. • Bostik Australia • DuluxGroup – Selleys • Davco • Lord Corporation • Laurie Collins
2.	Safety is important for everything we do. A safety conscious attitude is important for all aspects of our lives. Mosaic art is no different. But it is important to put it into perspective. When it comes to adhesives my advice is to make sure that you try to understand the materials you are using and act accordingly. All adhesives present some form of hazard and adhesives are no different. Like many things – repeated or prolonged exposure should be avoided. Handled properly and in accordance with manufacturer's instructions and with use of proper Personal Protective Equipment you can reduce any hazards. Don't worry – it is very simple to avoid issues because the precautions are very easy and effective. For example – one of the common components in cement based adhesives is

Slide	Background Commentary
	sand. It is well known that the major component of sand (silica) has long term exposure effects. Simple dust masks protect against inhalation of silica dust. But we never wear such a mask when we go to the beach; we treat the sun as a bigger issue. Freshly mixed cement is highly alkaline, so over time it can dry out you skin and could cause dermatitis – but this is easily avoided – just by wearing gloves or use barrier cream. I encourage you to read the safety precautions on the packaging and the MSDS – but keep it all in perspective - they look more scary than they are – if there was an MSDS for going to the beach you would never go – both sand and water can be hazardous – but understanding the hazards (and how to avoid them) will make it a lot safer. The same applies here. So just like going to the beach, get into the habit of safe behaviour and the risk is very low.
3.	Before you choose an adhesive – you need to know what you are trying to bond. This applies to the tile and the surface to be tiled. As always, your job is only as good as the weakest link – so make sure everything is clean, compatible and suitable for the application. Next – try and understand your materials. One of the most important aspects to understanding the requirements of an adhesive for most mosaic applications is the porosity of the surfaces – especially the tesserae. As we all know – there are many of materials that tiles can be made of, - such as ceramic, porcelain, stone and glass (just to name a few). We could talk on this topic for hours – but they all have a few properties that we need to understand before we bond them. Probably the single most important property is porosity (or absorbency) of the materials. There is a very simple test you can do to check this. A drop of water will tell you a lot. If the water beads and is not absorbed or absorbs very slowly – then you have a non-porous surface. If it absorbs instantly then it is porous. Sometimes it can be difficult to tell the difference just by looking at a material – so if unsure, do the test. This knowledge can help make a better adhesive selection – and the test can be done on the tile as well as the base substrate surface.
4.	Mesh backed tiles can present a special challenge. All mesh backed tile systems need to be carefully checked for signs that they have excess adhesive applied. Excess adhesive on mess backed tiles is the single most troublesome reason for the bonding failures associated with use of mess backed tiles. In some cases adhesive will cover the entire window area between mesh strands. In such cases we will only ever bond to the adhesive and the adhesion using our preferred adhesive is entirely compromised.

Slide	Background Commentary
	Look closely at mesh backed tiles. A better option may be to use film faced tiles or paper faced tile systems. These materials should not exhibit issues with contaminated bonding surface conditions.
5.	The majorly used adhesives for mosaic works are derived from the realms of the tile adhesives made for residential and commercial tiling applications. These adhesives are generally made to meet standards or codes of performance that allow the user to identify key attributes within the adhesive that will meet their needs in a particular application. The standards for the testing and classification of tile adhesives have changed in the last few months. There is a period until January 2014 when two standards will be operable as manufacturer's transition. The standards vary little from each other so the same coding system for adhesive type and performance embedded in the old Standard AS 4992 and workmanship standard AS 3958 exists within the newly adopted international (ISO) standard. The global standard is ISO 13007 and the codes used in the Australian version are identical. These standards still reference • Paste adhesives (or ready to use) - Dispersion - D • Powder adhesives - Cement Based Adhesives - C and • Resin adhesives such as epoxy and polyurethane - R The Standards cover adhesives, grouts and workmanship and are based around testing, measuring and assigning codes of performance for each type of product around established laboratory determined attributes.
6.	There are also some additional classifications that you will see. The important ones are listed here. E - means there is at least 30 minutes open time under lab conditions, T - is more difficult to explain – but it basically means a 200x200mm tile on the wall does not slip down. Essentially a T class adhesive has better hold against gravity slip on a wall tile. This is not particularly important in mosaic work. F = Fast Cure. It does not mean that the material will lack open time or will have limited pot life. It refers to the speed of cure once the adhesive is set in place and provides a guide for adhesives to be used in applications requiring fast return to work. S - references the flexibility or suppleness of the adhesive. Flexibility of Cement based products is strongly related to the volume and type of "polymer" modification. Some modification allows products to meet a S1 classification and higher amounts allow products to meet S2 classification. Interestingly polymer addition to cement based products improves their adhesion to non-porous substrates across a multitude of different materials including some metals.

Slide	Background Commentary
7.	C, D and S codings are further separated into type 1 and 2 behaviour. 1 always references standard or unmodified or low modification behaviour as established through testing. 2 represents products that have been significantly modified. 1 = normal 2= Improved For example C2 is stronger than C1 D2 is stronger than D1 S2 is more flexible than S1 (In the paper written around this presentation there are cross reference lists of Australian manufactured adhesives set out against the classification established by the adhesive manufacturer.)
8.	Summary of the classification system for cement based products
9.	Although these terms seem technical – it is vital that you understand what they mean – they are important to selecting the right tile adhesive and gaining a good bond. **Pot life** is the time span over which an adhesive will stay usable after mixing. Dispersion adhesives have unlimited pot life as long as they do not dry out. Cement Based Adhesives are reactive. If a cement based adhesive becomes thick and crusty it is a clear indication that it has exceeded its pot life. Throw it away and make a new mix. **Open time** literally means – after you have applied the product – how long does it stay "open" for you to apply the tile? Remember also that the times quoted are at "ideal" conditions. Namely 22 degrees and 50% humidity. In real life the time you have will depend on ambient conditions. You can establish the open time of the adhesive on the job by placing a finger on the applied adhesive. If the adhesive does not immediately transfer to your finger then its open time has been exceeded and you should remove the material and apply new product. Lower performance (cheaper) adhesives will most often have shorter working times. So you may have a lot more wastage. So it can be more cost effective to buy a more expensive adhesive. As a general rule – make sure the adhesive transfers to the back of the tile. You should never see ridges, voids or "lines" and the entire back of the tile should have glue on it when you pull it up.
10.	All adhesives are complex mixtures of materials. The degree of complexity increases as more attributes (features) are offered or demanded of the adhesive Besides the ability to claim features in their products manufacturers of adhesives are also driven by cost, corporate governance, legislation, changed methods of assembly etc. etc.

Slide	Background Commentary
	Carbon tax drives mean cost impacts to materials like cement that use a large amount of energy in their manufacture. Changes in customer demand toward large format and stone based tile systems mean improved adhesive products need to be offered. Tilers want products that can do all jobs in all environmental conditions equally well and they want them to do these jobs quickly so they can grout and finish the job for the next trades to get on with their jobs. Although this is not particularly relevant to a mosaic artist it does have an impact since the adhesives you want to use will be designed around applications and processes that are not necessarily sympathetic to your requirements. Any system that you use will be from a selection of materials designed for other purposes. I hear you say that there are specific mosaic adhesives and you hear me say they are mostly repacks of other products that you may pay more for because they say suitable for mosaics.
11.	**To provide you with a small snippet of the complexity of modern day adhesives let's look quickly at the sorts of materials that might be used in a cement based tile adhesive system** 15. **Portland** or other blended **Cement** 16. **Fly ash**, blast-furnace slag, silica fume, natural pozzolans 17. **Blended sands** 18. **Calcium Carbonate** (rarely is silica flour used these days) 19. **Reclaimed rubber regrind** (weight reduction – NOT for flexibility) 20. **Bond and flexibility enhancers** (especially important on non-porous and difficult to bond substrates - re-dispersible powders – acrylic and others) 21. **Rheology enhancers** (viscosity control) 22. **Accelerators** (Accelerate setting and early strength development) 23. **Air-entrainers** (Workability – Creamy nature) 24. **Super-Plasticizers** (Water reduction) 25. **Retarders** (extended pot life) 26. **Corrosion inhibitors** 27. **Shrinkage reducers** 28. **Anti – fungal additives** 29. **And the list goes on……**
12.	Since cement based adhesives make up by far the majority of adhesives that you will choose to use it is important to understand a couple of features of these materials. Cement does undergo a very complex series of reactions over a lengthy period of time. Initially it will set and then it will proceed to build strength. No matter whether it is accelerated or not it will undergo a series of changes as

Slide	Background Commentary
	long as there is water available to allow the reactions to occur. These reactions happen in the presence of moisture and relate to the formation of alkaline oxide and silicate hydrate materials. The silica hydrates are the materials that give concrete its strength. These materials in a concrete structure form a dense fibrous crystalline network over time and it is the growth of these crystals into porous substrates and their interlocking nature that allows them to be such good adhesives on porous materials. Such crystalline material is generally brittle so not so good for high movement applications or impact or vibrating substrates are involved. They are compromised by use on non-porous surfaces. In is on non-porous surfaces where polymers added to the adhesive come into their own and provide flexible high adhesion levels to non-porous and porous substrates alike. The growth of crystals in cement based systems starts immediately on water addition. Once a cement based adhesive is set in place do not move it. If you do you will disturb the forming crystals in their gel state and they will never recover – no matter what you do.
13.	Ok, so let's talk about each type and work out the advantages and disadvantages of each: First – The ready to use or Paste adhesives
14.	**Tips:** Drying: Paste adhesives need to dry by evaporation, so to speed things up make sure there is good ventilation and low humidity. For example – open the windows, get a cross breeze, switch on a fan or dehumidify the room. Avoid drying in direct sun as this can cause crusting and uneven drying. The glue will dry out through the gaps between the tiles. So it is a good idea to leave the project ungrouted for longer than you think – just to make sure the glue has dried out as much as possible. **Use:** To preserve the product in the pail, take out some material and close the lid (or cover with glad wrap). This will help prevent the material skinning in the pail. This will happen quickest on the sides. If it does, you will have to fish pick out "blobs" of hard glue. Suitability: As a general rule – use on porous surfaces with porous tiles. If using with low porosity tiles make sure the surface is porous, and leave ungrouted for longer than usual. If not allowed to dry out properly the glue can dry around the edges of the tile and remain soft in the middle. Although this is rare – and happens most often with bigger tiles, just be aware of the limitations of this type of adhesive
15.	This table references the sorts of codes that you will see on the cans or pails of dispersion grade adhesive from a quality adhesives manufacturer. If you are into starting out in mosaics or early level teaching of mosaics then dispersion grade products may be okay.

Slide	Background Commentary
	For the serious mosaic artist I do not recommend their use. Properly selected cement based products offer a great deal more security and longer bond performance.
16.	**UPSIDE** • Generally higher performance than pastes • Wide selection (price and performance) • External and fully immersible variants easy to obtain • Cures chemically • Options for every tile type **DOWNSIDE** • Needs to be mixed before use • Finite pot life • Unused product should not be stored in open containers • Reaction time will be affected by ambient conditions (faster in warm, slower in cold) • Correct mixing is important • Most grades only available in large packs **Tips:** Drying: Cement based adhesives dry through reaction of the water into the hydrate structure previously discussed and through migration of moisture into the substrates or dehydration of water through evaporation into the air. Avoid placing mosaics in direct sun as this can cause rapid removal of moisture and will result in much lower strength in a cement based adhesive. If there is insufficient moisture present the reaction will take new pathways and later addition of moisture will not reactivate the system. Prime porous substrates to reduce porosity and reduce the migration path into the substrate. Primers will generally enhance adhesion and on less stable substrates and will potentially improve the stability and strength of poorly bound surface structures on some cement based substrates.
17.	Cement based adhesives require a bit more effort to mix and prepare – but they are easily the better choice when it comes to performance. There are a few tips that will make things easier. Firstly – make sure you use the right water ratio. It is very tempting to use more water to make mixing easier. But think of it like making bread. The correct ratios of components are very important. **"Powder to water is what you oughta"** Unlike bread, the order of mixing is critical. Always mix powder to water. If added the other way the mixture will require too much water and you will have performance and consistency issues.

Slide	Background Commentary
	Buy high performance products. Cement based materials starting with C1S1E are a good start. Store excess material in airtight containers (zip-lock plus sealed bucket / Tupperware) Use cool water in warm weather (will give you longer working time but product will still cure quickly) Use products with "E" designation Will give you longer working and adjustment times Always use the minimum amount of water Mix for longer than you think (especially before adding more water) Too much water will kill performance Cement based systems will seem dry and stiff when first mixed but will "wet" out during mixing
18.	All-purpose adhesives for mosaics will start with the C1S1E type products through to C2S2E type products. These will have improved open times and maximum substrate adhesion capability. They will also have the best ability to handle movement from thermal or moisture expansion and contraction of the substrate. Special products may be needed for constant water immersion situations. When making ponds, birdbaths and the like you may need to review the manufacturer's product literature to confirm suitability for constant immersion. Generally C2 classed systems will be okay. Two part systems are generally effective as the emulsion component will rely on the alkaline materials in the cement to make it react and become water proof.
19.	Addition of high performance emulsions. In all cases you can improve the flexibility, adhesion and water proof properties of C1 or higher adhesives by the addition of competent emulsion additives. These allow the system to talk on the character of two part systems. Emulsions can be added to S1 rated products but there is little to be gained adding them to a C2 rated system Use primers to seal porous surfaces to reduce dehydration rates As stated previously the priming of porous substrates is advised to assist with slowing moisture escape from cement based systems and assisting with open time and ultimate adhesion.
20.	Resin based systems are generally used for high performance applications in the tiling industry. These products provide special features not available from cement based products. Epoxy systems are often used for exterior cladding applications and

Slide	Background Commentary
	Polyurethane systems are often used in conjunction with noise control applications. Interestingly epoxy based systems are used in dairy applications where lactic acid can overtime react with and destroy cement based adhesives. You can use them if you like but I hardly think that you are going to place mosaics into a milk bath. Epoxies are also used in cleanrooms where there is need to ensure that there is no chance of dust creation or porosity that can lead to mould or spore growth and where there is need for adhesives and grouts to withstand harsh cleaning regimes.
21.	**SILICONES** We generally think of silicone sealants as just that - sealants. They can also be used as adhesives. They have excellent bonding capability, flexibility and environmental resistance. Importantly they should have one surface that is porous if the area to be bonded is more than 10mm in width. Otherwise cure is too slow and cracking can occur. We classify Silicones according to the by-product of the reaction they undertake with water. Today there are two main types we see in the stores and marketed by the tile adhesive manufacturers. **ACETOXY** - Releases acetic acid as it cures making it unsuitable for use on cement based substrates. - It is okay for use on glass, tiles and some corrosion resistant metal surfaces. **NEUTRAL** - Often known as oxime cure this system releases Methyl Ketoxime a solvent like material. - Although classed as neutral cure the ketoxime materials are mildly corrosive to metals and as a result care should be taken if bonding mirror tiles etc. - These are the most commonly available Silicones today. **ALCOXY** - These systems are more difficult to find and are the best for mirror bonding as the reaction by product is methanol and this is not corrosive. - These materials are very soft (low modulus) and can accept large amounts of movement When using Silicones it is important to understand that they restrict you using

Slide	Background Commentary
	any other adhesives on the same piece. New silicone will bond to old but nothing else will bond to silicone. Most Silicones are no recommended for underwater immersion or for immersion in chlorinated or salt water. SIKA (Sikapool) and a couple of specialty silicone manufacturers offer specific silicone products for these applications Although they appear milky in mass translucent silicone becomes reasonably transparent and colourless in thin layers. This enables these materials to be considered for some glass bonding applications.
22.	One part Polyurethane sealants and adhesives have been around for years. They are very common and bond porous surfaces reasonably well. Unless specifically designed for primerless application most Polyurethane materials will require a primer (epoxy, isocyanate or silane adduct) to gain adhesion to non-porous substrates. Most polyurethane materials that you can find in the store will not be UVC stable so they should only be used to bond opaque materials. Some people have used Automotive grade polyurethane based windscreen sealers to create mosaics on metal and other substrates. Whilst this is great from a challenge perspective these creations may not do so well long term if not properly primed. Where polyurethane systems do excel in a primerless mode is on scuffed fibreglass resin, scuffed glass reinforced nylon and scuffed acrylic resin substrates. For most applications Fast Cure FC grades of polyurethane sealants will provide sufficient bond performance for mosaics. The added expense of the automotive reglaze materials is hard to justify. Just remember that on most surfaces it is important to prime.
23.	And now for my current favourite chemistry in adhesives and sealants. *Silyl Modified Polymers.* Even the name sounds good. (well to me anyway.) Almost the best of both worlds. Polyurethane toughness combined with the safety of silicone chemistry (OHS) and the extraordinarily wide range of materials that silicone can bond without priming.

Slide	Background Commentary
	These materials as a family are on a rapid rise in popularity globally. They constitute almost 4% of the global sealants and adhesives market but are growing in a slow global economy faster than other types of product. Largely at the expense of polyurethane. These products work with all PU primers and will bond to cured polyurethane and cured SMP. The products are neutral cure and offer a range of properties challenging both Polyurethane and Silicone systems.
24.	Now this area interests me enormously. I make a comment with care but knowing it will potentially cause me a wealth of requests for recommendation and advice. If you use the right primer(s) then you have an ability to bond almost anything to anything else and have it stay bonded under almost any natural ambient conditions. Many of these primers are made from reactive and hazardous chemicals but as I said at the start we can minimise risk to acceptable levels using the right approach and PPE. I will show some examples of what I mean in a moment. These primers will not always be in the supermarket or hardware store. They are more likely in a specialist industrial adhesives outlet or from an automotive refinish paint outlet. I have provided a couple of products for you to take a lead in the associated paper.
25.	Water based adhesives are an interesting conundrum. These are generally unmodified or simply modified systems but I note with interest people extending their use beyond what I would consider generally acceptable for products that are potentially on-sold to others. The adhesive properties of these materials are possibly okay for porous products but their use with non-porous glass and similar materials has me somewhat concerned. Mostly they will be suitable for internal mosaic applications on timber and other porous surfaces. PVA and EVA based materials will yellow in time with exposure to UV and as they degrade they will create acetic acid that with moisture has potential to

Slide	Background Commentary
	attack other components of the assemblies composing the mosaics. Styrene Butadiene (SBR) based systems are used for primers and not so much for as direct adhesives. Even so long term exposure of these materials in relatively unmodified format will see them susceptible to the effects of moisture in a process we call hydrolytic degradation. They will simply become soft and sticky and fail. Acrylics and Styrene acrylics are the stand out products within this group. The range of emulsions is simply staggering and most pure acrylic emulsions are UV stable. They range from soft sticky pressure sensitive materials through to hard brittle materials requiring heat to allow them to film form. These materials form the basis of most water based exterior and interior paints so their environmental performance is undeniably good. They are also the materials used to make water based acrylic sealants and construction adhesives. My concern is that products I have seen offered into the market by small entrepreneurial businesses have not been fully tested against some of the claims that are made of the products.
26.	Solvent based adhesives are generally out of favour these days. Glue sniffing, VOC construction site requirements, and community and trade acceptance of slower water based alternatives is having impact and fewer and fewer solvent based systems are available and even fewer new systems are making it into the market. That said we still have products like Selleys All-Clear (Lexel), Selleys Liquid Nails and neoprene based sealant/adhesive like HB Fuller 303 on the market. Clear sealants are made to be UV resistant but still yellow and surface craze in time. SBR and Neoprene materials must never be UV exposed as they will rapidly decompose.
27.	The materials on this and the next slide are interesting industrial grade materials. I class cyanoacrylates as temporary fixing agents on all but certain rubber materials due to the fact that they break down over time with exposure to moisture. You do need to take care with super glues as they will bond well to skin and eyes and do it very quickly. They will also cure on contact with slightly moist fabrics with the evolution of substantial amounts of heat. The 2 part acrylics and the new hybrid epoxy systems are in a league of their own for strength, bonding range, versatility and relative ease of use. These materials are being used in the auto repair markets as competent weld replacement materials in body repair. The acrylics are best used with non-porous materials while the epoxies are equally at home on porous and non-porous materials. The epoxies I refer to here are not the General Purpose grades on the

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	supermarket shelf or the 5 minute grades that I detest on performance and odour grounds. These are true engineering grades some of which are listed in the background paper.
28.	The epoxies I refer to here are not the General Purpose grades on the supermarket shelf or the 5 minute grades that I detest on performance and odour grounds. These are true engineering grades some of which are listed in the background paper. Depending on the nature of the substrate and use of appropriate primers these materials will bond almost anything except the polyolefin plastics, teflon and silicone based materials
29.	Imagine is what you all do every day. You challenge the paradigms of texture, form, colour Imagine if there are no boundaries to what you can bond The answers are out there in the Industrial and Construction Adhesive Markets. You simply need to think beyond the conventional. We replace welding in cars with adhesives, we bond windscreens, aircraft would not fly if they were not bonded together. How hard is it then to bond tesserae to a substrate and have it stay there for years?

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