

The True Polyurea Spray Elastomer Story: Chemistry, Advances and Applications

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ABSTRACT:

The *polyurea* elastomer coating / lining technology has shown some very significant inroads since the introduction of the technology back in the late 1980's and has grown in use by significant volumes since the initial start in the early 1990's. As "polyurea" is a description of a complete technology area, there are a variety of systems / formulations / chemistry available and this has become very confusing. Recent technical developments have pushed the technology into new use areas including concrete coatings / linings, steel coatings, traffic deck systems and specialty coating uses. This paper will take a look at the *polyurea* technology, formulation basics and chemical advancements as well as application and performance.

INTRODUCTION

The future of the polyurea technology is very promising. Current market sales are approximately 18 – 20 million gallons of system world wide. This is significant considering the world market sales was less than 1,000 gallons in 1990.^{1,2} The advantages of the polyurea technology are well known and published, as compared to other coating / lining technologies.

Two-component polyurea elastomeric coating / lining systems are the newest technology to the protective coating / lining industry. Polyurea systems have sometimes been characterized as modified two-component polyurethane systems. While they both may have some characteristics in common, polyurea systems are actually a unique technology in itself.³

Two-component polyurea systems are typically known for a very rapid dry time (typically less than 30 seconds), achieved without the use of a catalyst as in the two-component polyurethane systems. This rapid dry time is very consistent / uniform over a very broad ambient temperature range. While the fast reaction / rapid dry time is virtually unaffected by ambient moisture, the presence of moisture on a substrate must be considered when achieving adhesion to that substrate. This is all made possible by a unique chemistry of raw materials used to develop the two-component polyurea systems.

Two-component fast set polyurea systems typically do not contain any solvent or Volatile Organic Compounds (VOC). They are normally processed by specialized plural component equipment, which develops high pressure and high temperature for spray application. The two components are mixed inside the impingement mix spray gun, as there typically is not any pre-mixing or hot potting.

Since the introduction of the two-component polyurea technology, a wide variety of applications are seen. These include coating / lining applications over concrete, geotextile membranes, various metals for corrosion and decorative areas as well as some plastics. For all of these, the rapid dry time of the technology means that the area of application can be returned to service rather quickly.

In 2000, the Polyurea Development Association prepared and published a definition for polyurea systems. That is identified as follows:

“A *polyurea* coating / elastomer is that derived from the reaction product of an isocyanate component and a resin blend component. The isocyanate can be aromatic or aliphatic in nature. It can be monomer, polymer, or any variant reaction of isocyanates, quasi-prepolymer or a prepolymer. The prepolymer, or quasi-prepolymer, can be made of an amine-terminated polymer resin, or a hydroxyl-terminated polymer resin.

The resin blend must be made up of amine-terminated polymer resins, and/or amine-terminated chain extenders. The amine-terminated polymer resins will not have any intentional hydroxyl moieties. Any hydroxyls are the result of incomplete conversion to the amine-terminated polymer resins. The resin blend may also contain additives, or non-primary components. These additives may contain hydroxyls, such as pre-dispersed pigments in a polyol carrier. Normally, the resin blend will not contain a catalyst(s).”

So contrary to what some have then noted in the industry in the past, polyurea systems are not those systems that contain 70% amine in the resin blend, but based solely on amine terminated resins.

To date, the largest market use for the polyurea technology is in concrete coating areas. This includes secondary exposure areas as well as constant immersion applications. The use in steel coating areas is starting to grow, primarily due to the understanding that proper surface preparation is also required for the polyurea technology.

However, the continued growth and success is highly dependant on successful application work. This is enhanced by the presence of credible polyurea system suppliers with complete knowledge of their products and research, development and application support. There is a large investment on the part of the contractor to apply the systems, so one should not skimp on the choice of polyurea system suppliers.⁴

The first thing to remember is that not all polyurea systems are created equal. One must select the proper formulation for the specific type of application work to be completed. You can't just use “any old polyurea system.” The polyurea system supplier should be able to guide you to the proper system, as well as the application parameters. In doing so, this will insure a successful completion of the project. The system supplier provides the liquid components of the system; the contractor actually prepares the polyurea elastomer in the field via the application equipment.⁵

A BRIEF HISTORY of POLYUREA DEVELOPMENT:

The first actual reference to polyurea came in 1948 when some researchers were evaluating thermal properties / melting points of various polymer systems.⁶ They were comparing polyesters, linear polyethylene, polyurethanes, polyamides and polyureas; and, found that the polyureas had far superior thermal properties and an extremely high

melting point. Keep in mind that these polymers were manufactured in a laboratory environment and were not very conducive to coating / lining applications.

The two-component polyurea elastomeric coating / lining technology is a derivation of the polyurea Reaction Injection Molding (RIM) technology developed in the early 1980's.⁷ Polyurea RIM was used to produce a variety of automotive exterior body panel and fascia (bumper covers) parts. The most noted use was in the Pontiac Fiero, which employed the space frame concept. Other parts included fascia for the Camaro, Firebird / TransAm, Corvette, Pontiac Bonneville and GrandAm, and rear quarter panels / fenders for the dually trucks, like Ford, Dodge and GM.

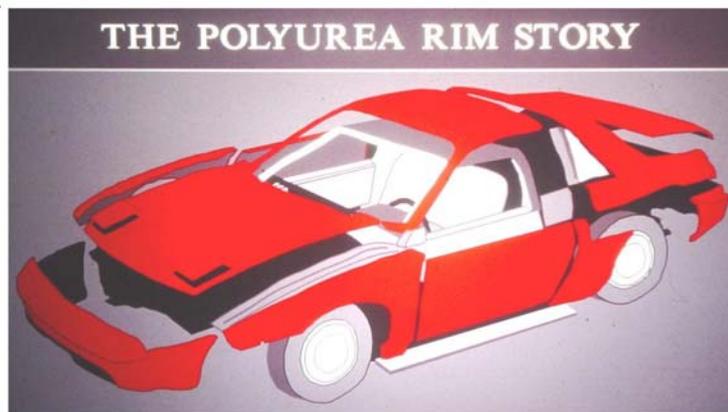


Figure 2: Polyurea RIM

The advantages or unique characteristics of polyurea over polyurethane and polyurethane/polyurea hybrid system in RIM applications included rapid molding / cure time which was typically 2 – 3 second set or gel times with a dry time of less than 10 seconds. Also realized were reduced part scrap rate and most importantly, the ability to paint the parts using the online Electrophoretic Paint Deposition (ELPO) process. This process involved heating the parts to almost 400°F (205°C), a temperature that was very detrimental to polyurethane and most hybrid systems. Polyurea systems are noted for their high thermal stability.

The two-component fast set polyurea coating / lining technology was first introduced to the industry in 1988, following the development in 1986.^{8,9} This technology evolved from the need to develop a more stable, durable and 100% solids polymer system for coating rigid, spray applied polyurethane foam used in roofing and other insulation applications. Some of the first plural component spray applied polyurea formulations had get times of 1 – 2 secs, with tack free of < 10 secs. The actual first commercial application of the polyurea elastomeric coating / lining technology was as a roofing system in 1989.

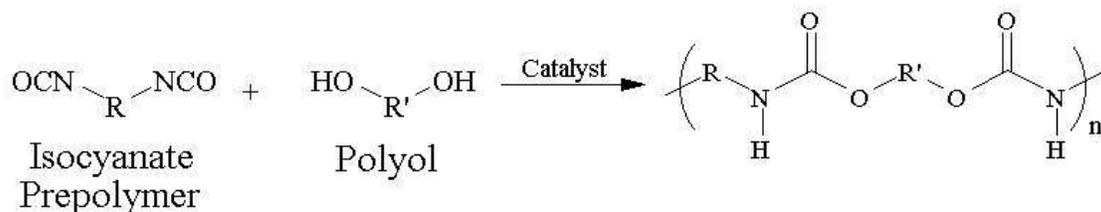


Figure 4: Polyurethane Formation Reaction

It should be noted that “polyurea” is a description of a technology and it in itself is not a coating / lining system. There are a variety of formulation possibilities to achieve desired performance, as well as various additives that may be used. This is made possible by the selection of various raw materials in the formulation, much like that for polyurethane chemistry. The selection of proper raw materials for the system can be a very complex procedure.

Based on reactive equivalents between the polyisocyanate component and the resin blend component for the 2-part systems, the following Table I can be established:

Table I
Formulation Basics vs Technology Type

<u>Resin Part</u>	<u>Chain Extender</u>	<u>System Type</u>
Polyetheramine	Amine Terminated	Polyurea
Polyether Polyol	Amine Terminated	Polyurea/Polyurethane
Polyetheramine	Glycol	Polyurethane/Polyurea
Polyether Polyol	Glycol	Polyurethane

To understand Table I and the derived system type, one must assume for the above chart that we are processing a 2-part system, where the volume ratio is 1:1, or very close to that. The isocyanate content of the polyisocyanate component would be 8 to 16%.

To illustrate the reactive equivalents in a system and a distinction of whether a polyurea/polyurethane or polyurethane/polyurea, the following example is shown in Table II. The isocyanate portion of the system is based on an isocyanate quasi-prepolymer with a total isocyanate (NCO) content of 15.5% (equivalent weight of 271; reactive milli-equivalents or MEQ's is 369). The resin was formulated to achieve an INDEX, ratio of isocyanate equivalents to reactive hydrogen equivalents, of 1.05

Table II
Formulation Basics / Reactive Equivalent Contribution

<u>Resin type</u>	<u>pbw</u>	<u>equivalent weight</u>	<u>Reactive MEQ's</u>
PEA, Di	65	1041	62.4
PEA, Tri	10	1889	5.3
Amine Chain Extender	25	89	281
Total	100		349

* based on a 1:1 by volume, 1.05 INDEX, 15.5% NCO content isocyanate

From Table II, one can see that for the resin blend portion of this 2-part fast set polyurea elastomer system, the chain extender contributes the most part of the reactive hydrogen equivalents with the isocyanate reactive equivalents. In this case, over 80%. The chain extender is really the determining factor on what makes a polyurea. There are no polyols, or hydroxyl terminated materials, used as the main reactive resin in the resin blend portion of a two-component polyurea elastomer system. If so, then these would be classified as a polyurea/polyurethane hybrid system.

Now compare that to the following aromatic formulation given in Table III. This formulation is based upon a blend of amine terminated resins and a relatively small amount by weight of a tetra-functional polyol chain extender of low equivalent weight.

Table III
Formulation Basics / Reactive Equivalent Contribution: Hybrid System

<u>Resin type</u>	<u>pbw</u>	<u>equivalent weight</u>	<u>Reactive MEQ's</u>
PEA, Di	77.5	1041	77
Amine Chain Extender	15	89	168
Tetrol polyol	7.5	73	103
Total	100		348

* based on a 1:1 by volume, 1.05 INDEX, 15.5% NCO content isocyanate

Based on this calculation in Table III, the polyol chain extender used (at 7.5 %) is contributing about 30% of the reaction in the polymer formation. Thus, this system would be considered a HYBRID, as per the PDA definition, since it is a polyol, regardless of whether or not this is a good elastomer system. It will react in, though not as fast as the primary amines used.

One might then also point to the reaction of moisture with the polyisocyanate component. When moisture enters into the reaction mechanism, the moisture would react with the isocyanate to form a carbamate. This will very quickly dissociate into an amine-terminated molecule, which would then very rapidly react with an isocyanate specie / moiety to form a urea linkage. Hence forth, a single component moisture cured urethane system could be considered a polyurea system, but not a two-part system. The moisture reaction is the curing mechanism to reaction.

There is also some interest and work in the 2-part systems where part of one component is blocked, both parts are mixed and reaction / curing occurs when another factor is introduced. This other factor may be heat, as is the case of blocking the isocyanate component (using oximes and phenols). The other would be moisture, as in the case of blocked amine resin blends (formation of aldimines).

Aromatic Based Polyurea:

Aromatic based two-component polyurea systems have been the workhorse of the two-component polyurea technology. Aromatic refers to the nature of the chemical backbone of the polymer system. The two-component systems are comprised of an isocyanate part and a resin blend component. The isocyanate component is typically an isocyanate quasi-prepolymer, prepared from methylene diisocyanate (MDI) (Figure 5).

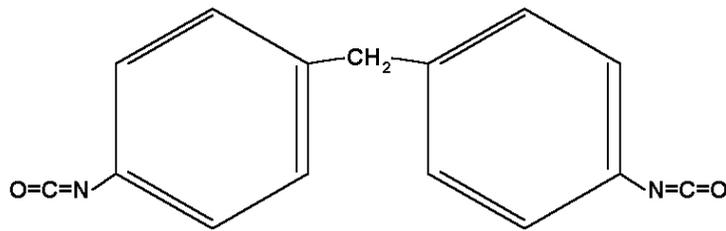


Figure 5: Methylene Diisocyanate Structure

The quasi-prepolymer is based on the MDI and a polyether polyol. By changing the type / structure of the MDI and the polyol, a wide variety of elastomer physical properties, performance and reactivities can be achieved. Reactive diluents may also be employed to lower the viscosity of the isocyanate component.

The MDI is partially polymerized with a polyol in order to reduce the overall isocyanate content and allow for application processing at a 1:1 volume ratio with the resin blend component. It should be noted that toluene diisocyanate (TDI) has typically not been used in two-component, fast set spray polyurea elastomer systems. There are some results that do show some unique viability in certain applications and some recent use has been noted.

The resin blend portion of an aromatic based polyurea system is the more complex portion of the system. The resin blend utilizes soft-block and hard-block segments for the reactive constituents. The soft-block segments are the high molecular weight resins, referred to as polyetheramines or amine terminated polyethers. These polyetheramines are either di-functional or tri-functional with blends of the two providing for certain elastomer physical properties and performance. Figure 6 is an illustration of the diamine and Figure 7 is an illustration of the triamine.

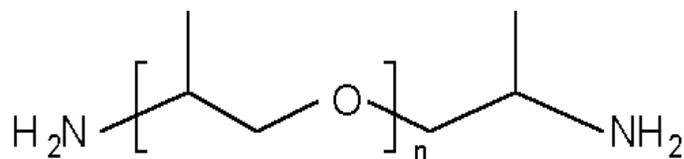


Figure 6: Polyoxypropylene Diamine Structure
Polyether Diamine

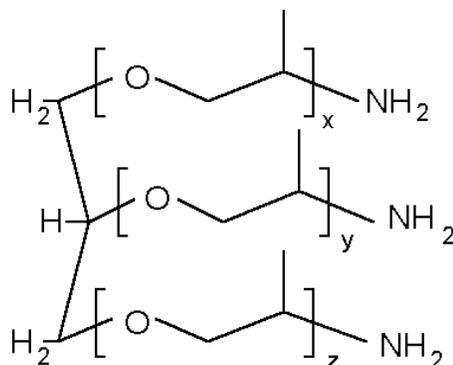


Figure 7: Polyoxypropylene Triamine Structure
Polyether Triamine

The polyoxypropylene diamine is typically in the 2000 molecular weight range while the polyoxypropylene triamine is in the 5000 molecular weight range. These resins provide the flexibility in the resulting polyurea polymer system. They also provide for that initial reaction or set in the polymer system when the isocyanate and resin blend components are mixed.

There are other high molecular weight amine terminated resins that are making recent inroads in polyurea applications. These are based on aromatic or linear hydrocarbon chains, as well as silicone resin backbones. This paper is designed merely to touch on / hi-light the overall polyurea technology and concept and cannot address all specific types.

The other portion of the resin blend component is the hard-block, or more commonly called the chain extender. A chain extender is the low molecular weight amine terminated resin that completes the polymer chain and extends / controls the overall system dry time. The most common chain extender used in two-component polyurea elastomer systems is diethyltoluene diamine (DETDA). It is available as an 80,20 isomer of the 2,4 -diamine to 2,6 -diamine. Figure 8 is an illustration of DETDA.

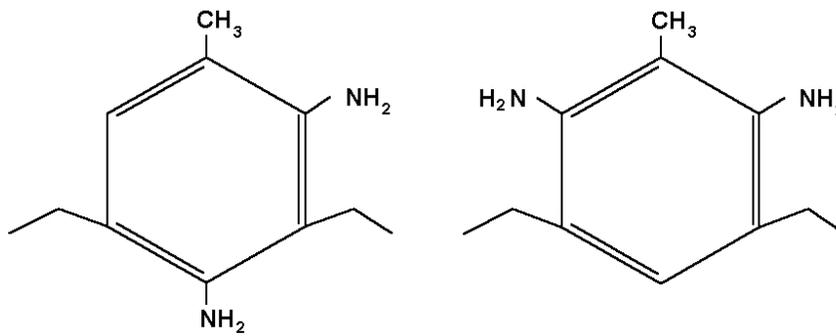


Figure 8: DETDA; 80,20 Isomer Structure

To assist in controlling the dry time of the two-component polyurea systems, a co-chain extender will be used with the DETDA. This co-chain extender is also an amine terminated material, but is generally a secondary / hindered amine. Figure 9 is an illustration of a common hindered amine chain extender based on methylene dianiline.

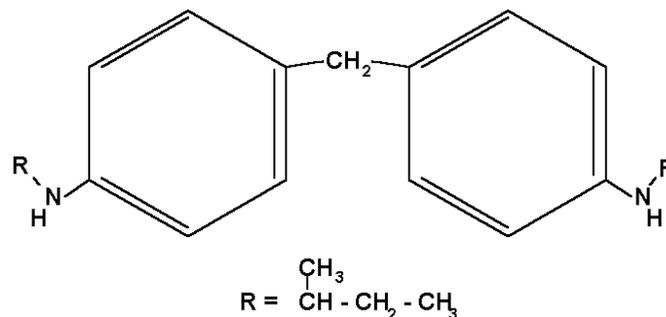


Figure 9: N,N'-Dialkyl Methylene Dianiline

For non-polyurea type systems, low molecular weight glycol type chain extenders are used. They are hydroxyl terminated and the reaction with the isocyanate portion yields the urethane linkage. Examples are ethylene glycol and 1,4-butylene glycol, two commonly used hydroxyl-terminated chain extenders for reference.

To get a better understanding of the effect of the secondary or hindered amine co-chain extender, Table IV illustrates the effect on the two-component polyurea dry time as these chain extenders are adjusted. It should be noted that the isocyanate component remained the same composition, and the overall systems were adjusted to achieve the 1:1 volume ratio processing.

Table IV
Effect of Secondary / Hindered Amines on Dry Time

Resin	pbw					
Polyether Diamine, 2000 mw	40	40	39	39	38	38
Polyether Triamine, 5000 mw	27	27	26	26	25	25
DETDA	30	25	17	9	4	0
Secondary Amine, Figure 9	3	8	18	26	33	37
Gel time, secs	2	2.5	3.5	5.0	12	23
Dry time, secs	2.5	3.0	4.0	10	70	130

These are not the only two types of chain extenders that may or are currently used; there are others that can provide the same effect. Many of these are solids at room temperature and may be hard to blend into the resin blend portion by the manufacturer of the system. The secondary or hindered diamines extend the reactivity of the rapid dry two-component aromatic polyurea elastomer technology to allow for improved processing and better substrate wetout / adhesion.

In most cases, pigment dispersions are used to pigment the elastomer systems. These dispersions are solid pigments in a carrier media such as a polyetheramine or polyether or polyester polyol. Use here would be in typical additive type amounts and would have no bearing on the classification of the system. The resin blend portion may also contain various additives such as adhesion promoters, UV stabilizers and antioxidants. This would also apply to the aliphatic-based systems described later.

The main limitation of the aromatic two-component polyurea system is overall color stability of the resulting polymer. While pigmentation will help, all aromatic based two-component polyurea elastomer systems will fade or change color when exposed to ultraviolet light. It should be noted that this is only a surface effect on the polymer.

Aliphatic Based Polyurea:

Following the introduction of the aromatic based two-component polyurea elastomer systems; the fast dry aliphatic-based materials were developed.^{13,14} For these systems, you also have an isocyanate component and a resin blend portion. The isocyanate is also a quasi-prepolymer, like with the aromatic based two-component polyurea systems. However, the isocyanate used is a light stable monomer and the “polyol” may actually be the polyoxypropylene diamine. The common isocyanate used is isophorone diisocyanate (IPDI) (Figure 10).

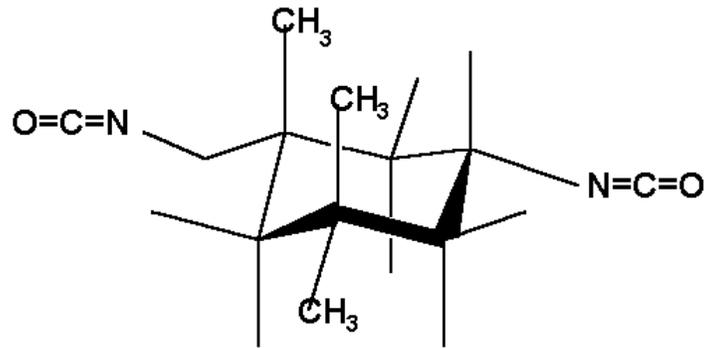


Figure 10: Isophorone Diisocyanate Structure

The resin blend of the aliphatic-based two-component polyurea systems is very similar to the aromatic based system. Blends of the high molecular weight polyoxypropylene amines (Figures 6 and 7) are used to develop flexibility and initial set in the polymer system.

The chain extender portion of the two-component fast dry aliphatic polyurea elastomer system is different than the aromatic based system. Here, the chain extender may actually be a “soft” hard-block or a conventional “hard” hard-block. For the “soft” hard-block segment, chain extenders of a low molecular weight (typically less than 400) are used based on the polyoxypropylene amines as shown in Figures 6 and 7. These provide for an aliphatic polyurea elastomer that has a limited thermal resistance, typically less than 176°F (80°C).

The more common form of chain extender for the two-component fast dry aliphatic polyurea technology is the cycloaliphatic diamines. The most common of those would be isophorone diamine (IPDA) (Figure 11).

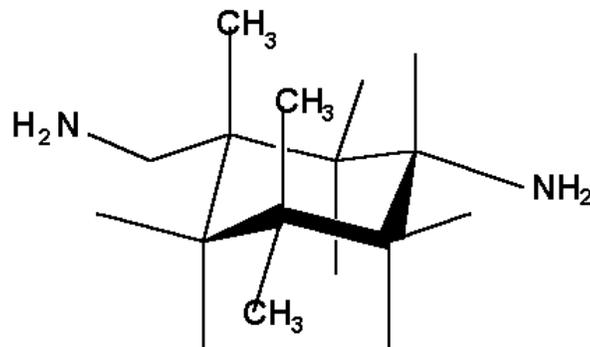


Figure 11: Isophorone Diamine Structure

There are other cycloaliphatic diamines that may be used as well; these include various isomers of cyclohexane diamine, hydrogenated versions of methylene dianiline's, or tetramethyl xylene diamine.

There will also be a co-chain extender used with the IPDA to control overall polyurea elastomer system dry time, very similar to that with the aromatic based two-component polyurea elastomers. These co-chain extenders will either be secondary or hindered aliphatic amines. They are typically derivatives of IPDA, hydrogenated methylene dianiline (HMDA) or other cycloaliphatic diamines.¹⁵⁻²¹ These to provide for extending the dry time of the rapid dry two-component aliphatic polyurea systems and to aid in processing and improved substrate wetout.

The fast dry two-component aliphatic polyurea systems will utilize some of the same additives found in the aromatic based systems.

Polyaspartic Ester Based Polyurea:

In the early 1990's a new technology of two-component aliphatic polyurea was introduced to the industry.^{22,23} This technology was introduced primarily for thin film applications where high gloss and excellent color stability are important. The polyaspartic ester polyurea technology is considered a slow dry technology, with dry times of up to 120 minutes.

This technology primarily uses isocyanate components based on either trimers or dimers of hexamethylene diisocyanate. Rather than the somewhat complex reactive resin selections as with the rapid dry two-component polyurea systems, the resin choice for the slow dry polyaspartic esters is somewhat simpler than conventional two-component fast set polyurea systems. The resin blend is composed primarily of the polyaspartic ester amine resins (Figure 12).

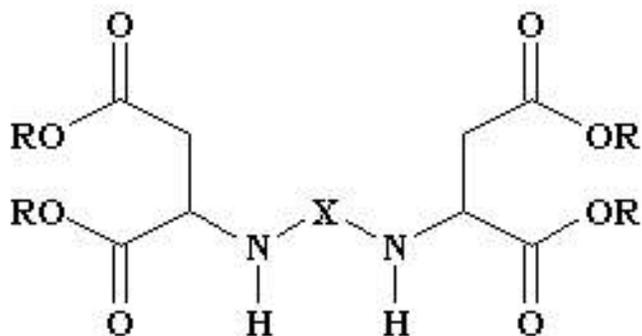


Figure 12: Polyaspartic Ester Amine Resin

The polyaspartic ester amine resins are relatively low in viscosity and molecular weight. The primary backbone structure (X from Figure 12) is cycloaliphatic, but can be a linear diamine. This technology can be easily applied by brush, roller or by pre-mixing and application through airless spray techniques. Solvents may be used in small amounts to assist in mix viscosity control and application.

The polyaspartic ester amine resins may also be used as co-chain extenders in the rapid dry, two-component aromatic and aliphatic polyurea elastomer systems. These will have an effect of extending out the dry time of the systems and allow for improved wetout of the substrate. The total aliphatic polyurea spray elastomer technology has been shown to have excellent performance characteristics in coating / lining applications.²⁴

PERFORMANCE ISSUES:

In general, the basic fast set polyurea spray technology is comparable to physical properties of polyurethane/polyurea hybrids and polyurethane systems. In other words, these technologies of coatings / lining systems can be formulated to achieve a variety of elastomer physical properties.

The truly big advantage of the polyurea technology is the speed of reaction and the ability to put the structure or facility back into service very quickly. One has to be very careful here though because polyurea systems may set and give an initial cure very quickly that will allow this “return to service” very quickly, but not develop ultimate elastomer physical properties for 24 hours or more. This all depends on the exact polyurea system formulation.

The polyurea systems do tend to have better flexibility at lower temperatures than to the corresponding polyurethane/polyurea hybrid or polyurethane system. The technology also performs very well with regard to thermal shock resistance.

Moisture and Temperature Sensitivity:

One of the major advantages of the polyurea technology is the relative insensitivity to moisture during processing / application. As the amine – isocyanate reaction tends to be preferential over the hydroxyl – isocyanate reaction, foaming of polyurea systems is almost impossible. However, it can occur, especially if a catalyst is present. For polyurethane/polyurea hybrids and polyurethane systems, catalysts are used to control the reaction. If moisture is present, they may exhibit some foaming which leads to lower density, porosity and poor performance.

While polyurea systems may show insensitivity to moisture, that does not mean they can be applied over a wet substrate. The polyurea will react over the water, but the applied system will not bond to the substrate in that area.

The ambient temperature and substrate temperature may have little affect on the reaction and cure of a polyurea system as compared to the others. But, the real important issue is substrate temperature and dew point. Industry standard coating practices must also be followed with polyurea systems and application in that the substrate temperature must be 5°F above dew point and rising. If not, moisture will condense on that substrate and cause adhesion issues with the polyurea technology, as with other coating / lining systems.

Chemical Resistance:

Polyurea systems in general exhibit similar chemical resistance properties as that of comparable formulated polyurethane / polyurea hybrids and polyurethanes. This is due primarily to the fact that all have the polyether backbone in the elastomer. The urea linkage found in the polyurea as well as the hybrid system is more resistant to hydrolysis than the urethane linkage. Polyurea systems do tend to have better resistance to alkali, high pH, than the hybrids or polyurethane systems. Aromatic polyurea systems are subject to chemical oxidation.

There are some newer technologies of polyurea systems that are showing significantly higher chemical resistance with respect to highly acidic environments. Keep in mind that chemical resistance / performance can be directly related to processing conditions of the polyurea systems. Those that do not achieve complete mix and contain porosity will have lower chemical resistance performance than those processed at the optimum conditions. This would include proper processing temperatures and pressures as well as the proper mix configuration in the spray gun.

These newer technologies of polyurea systems have different polymer backbones in the chain. These can be polyester, epoxy, silicone, polyBD or polysulfide or a combination of proprietary modifications to the polymer chain.²⁵

The following Figure 13 shows the affect of various acids and solvent on the Shore Hardness of three polyurea systems as 1 week immersion exposure. The HXP ISO 12 is a new isocyanate quasi-prepolymer based on a PolyDB backbone. It is compared to two conventional isocyanate quasi-prepolymers using a conventional polyether backbone. Note that the same type resin blend component was used for each.

Further improvement to the chemical resistance has been noted using resin blends containing phenolic, polyBD or polysulfide modifications as noted above.

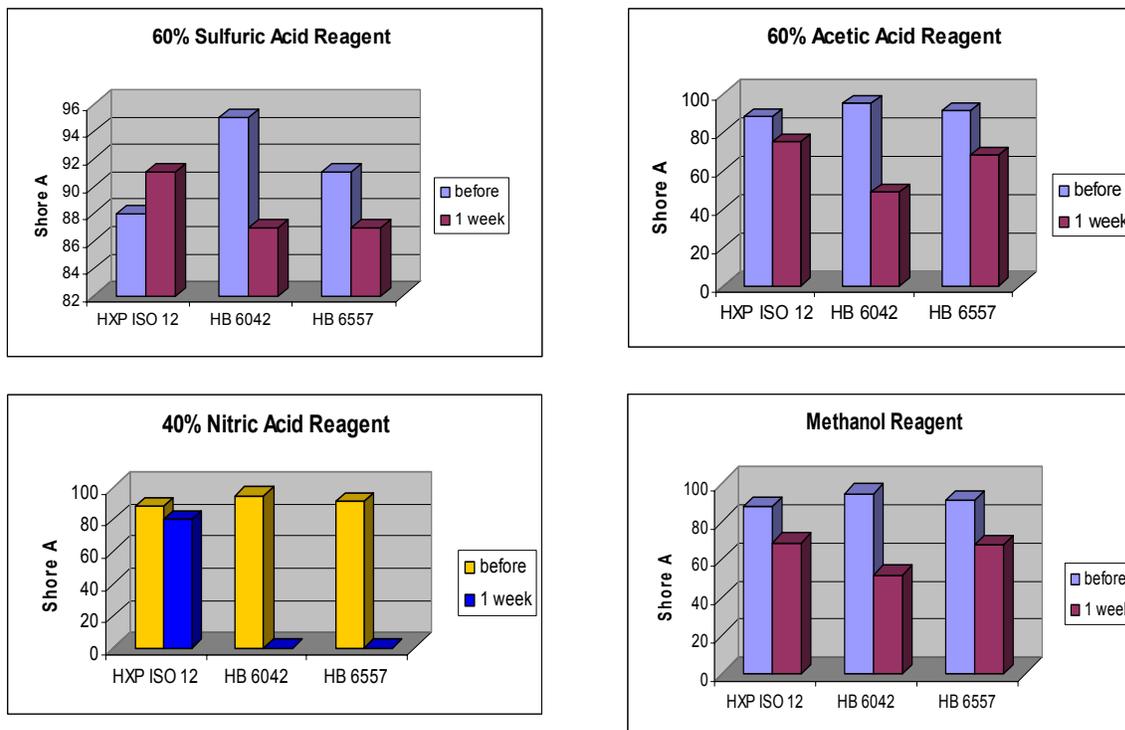


Figure 13: Improved Chemical Resistance Studies

Weatherability Properties:

The Aromatic polyurea systems have good resistance to ultraviolet light from an overall performance standpoint. Even with the use of UV Stabilizers / Antioxidants, they will however become discolored and fade over time when used in light colors for exterior exposure environments.

Aliphatic polyurea systems have excellent resistance to degradation by ultraviolet light and are used for a variety of exterior and interior atmospheric services. By modifying the aromatic based systems with inclusion of aliphatic isocyanates or chain extenders, some color stability enhancement may be noted. However, these still have aromatic specie in the polymer backbone and are not color stable.

APPLICATIONS

Based on the variety of application and performance advantages of the polyurea elastomer technology, numerous applications area can be targeted. This would include areas commonly served by polyurethane, epoxy, and polyester technologies as well as polyethylene and polypropylene sheet goods.

For many coating applications, the desire to return the facility back into service shortly after the application is complete is extremely advantageous. Polymer systems based on polyurethane, epoxy and acrylics usually require at least a 12-hour cure period, and in some case 24 hours, before the coated area can be put into service. Due to the fast, consistent reactivity and cure times of polyurea systems, coating applications can easily be returned to service in a 1- to 3-hour time period. This technology can even be applied at -20°C ambient temperature and reach service cure within 1 hour.

Another very important feature of the polyurea technology is the 100% solids nature with no volatile organic compounds (VOC's). During and after application, no vapors, fumes or chemicals are released when properly processed. This makes the polyurea technology attractive for confined space application as well as for use in food processing/handling applications.

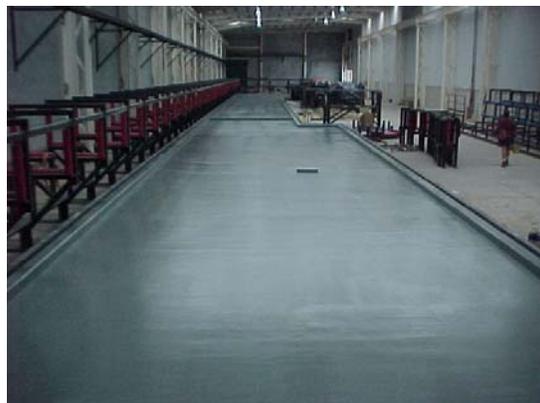
CONCRETE COATINGS:

The largest use of the polyurea spray technology is in concrete coating applications. This ranges from secondary containment to flooring to water proofing methods. The fast reactivity and cure of the polyurea spray technology allows for rapid application and minimum downtime for the facility where the coating is being applied. For the application work, the concrete surface is abrasive blasted, cleaned and vacuumed followed by application of a primer system.

The most prominent concrete coating application is secondary containment. Here the polyurea system can be easily applied around protrusion and adheres well to tank footings and pipes through the concrete. For highly chemical resistant application, a topcoating can be applied. An example can be seen in Figure 14.



Polyurea elastomer base coat



with chemical resistant topcoat

Figure 14: Secondary Containment Area

Polyurea spray elastomer systems are also being touted as a new system for parking deck,

traffic areas and flooring. The application technique is the same as that for secondary containment except that a slower system may be required. This will allow the introduction of a non-skid type aggregate material for traction purposes. Types of aggregate commonly used would be metal slag and quartz or sand. In addition, slow cure polyurea plural component caulk/sealant systems are used for the expansion joints. These are applied by means of 2-part caulk tubes or proportioning equipment.

In addition to introduction of aggregate into the spray, the non-skid appearance can be done by spray technique. The fast reactivity of the polyurea technology will give a uniform stipple effect to the surface of the coating. This texture is acceptable for normal foot traffic type flooring applications.

For either highly corrosive environments or a more aesthetic appeal, the polyurea technology can be used as a base coat system and then top coated with an epoxy or aliphatic polyurethane system. The polyurea system has the flexibility to absorb normal movements in the substrate that would typically crack the more rigid top coating system.

Concrete surfaces can also be coated for corrosion protection, not necessarily secondary containment applications. This would be areas where salt spray or road film has had a detrimental affect on the concrete causing spalling and deterioration. Normal thermal expansion and contraction has also played a key role in the failures of the concrete.

TANK LININGS:

Another major use for the polyurea spray technology is in direct immersion application such as tank and pond linings. Here, the performance of the polyurea elastomer system must be optimum so as to hold up to these environments. The largest application area would be the wastewater / process water industry. For concrete tankage, the surface is prepared in a manner much similar to that as in the secondary containment. Figure 15 is an example of a concrete wastewater storage tank lining application.



Figure 15: Concrete tank lining

In another concrete tank lining application, polyurea systems have been found to show no adverse effect on aquatic marine life, and there are some ANSI/NSF-61 approved systems for potable water application areas. The properly formulated systems have no off-gassing. The polyurea is used due to the fast processing time of the system and the durable, flexible properties of the film. This allows for expansion and contraction of the tanks during extreme temperature variations and loading and unloading without cracking of the lining.

Polyurea systems also perform well as lining systems for non-aqueous environments. In the case of steel tankage used for fuel type storage application, a minimum 3-mil blast profile is specified and a high solids epoxy primer is used to insure optimum performance. Speed of application and being able to return the tank back into service was the main reason for using polyurea. The elastomer system also performs well in the application.

While not a direct concrete coating tank lining application, applying the polyurea spray elastomer system to geotextile has been used in secondary containment applications as well as primary containment / pond liners. The geotextile fabric, both woven and non-woven, provides a nice uniform surface for application of the polyurea elastomer system. The fabric also enhances the tear and puncture resistance of the system, Figure 16.



Figure 16: Coated Geotextile Application, CANADA

While these applications highlight the most significant application areas for the polyurea spray technology, there are several other interesting uses. Exterior coating to metal pipe for corrosion protection is a growing area. The polyurea technology allows for pipe to be re-coated in field environments without the use of expensive coating cure equipment. It has been reported that a polyurea system has been approved for use on the Alaska pipeline for repair applications. There are also several in-house new pipe-coating applications involving polyurea spray elastomer systems.

Polyurea spray elastomer systems are also finding significant use in OEM truck bed lining applications. Here the adhesion to the substrate, durability of the system, high thermal properties, rapid application and the ability to produce uniform textured surfaces are the advantages over polyurethane based systems.

Another area is the use in in-mold coating applications, i.e. the composite industry, to replace the unsaturated vinyl esters for open mold spray part production. This would be for the production of marine based items, such as boats hulls and accessories, RV moldings as well as shower and vanity type items. The fast set of the aliphatic based polyurea technology allows for faster part production, higher impact strength, non-porous finish and no emissions or VOC's.

CONCLUSION

The development of the polyurea spray elastomer technology now provides for an extremely good cost and time-effective solution to a variety of coating problems. The fast, consistent reactivity, coupled with a good performance record, is pushing the polyurea technology to levels like that of polyurethane and epoxy systems. With the extreme efforts for industrial rehabilitation and increasing need to comply with environmental, economic and time constraints, the speed and durability of the polyurea elastomer technology holds great promise.

Well, what does the future hold for the polyurea spray technology? Efforts will continue with the aromatic polyurea technology to fine-tune the formulations for specific end use application areas. This may mean designing a formulation specifically for coating fresh impacted mortar concrete pipe, or a system that would be applied by way of a centrifugal spinner for lining the interior of pipe.

Work is currently in progress to modify the aliphatic polyurea systems such that reaction rates will allow application of an aesthetically smooth film yet maintain the fast processing characteristics. The possibility also exists for development of a single-component applied polyurea elastomer system that is not moisture cured.

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