Department of Environmental Protection

2600 Blair Stone Road ♦ Tallahassee, Florida 32399-2400

DEP Form: 62-761.900(9)
Form Title: Storage Tank Equipment Registration Form
Effective Date: July 2019
Incorporated in Rule 62-761.850, F.A.C.

Storage Tank System Equipment Registration Form

Fill out completely

General Information

Company Name: MatLor LLC
Contact Name: Mike Whitener
Company Address: 12901 McGregor Blvd.
City, State: FT. Myers Zip: 33919
E-mail: mike@roboliners.com
Contact Number: 239-410-1522
Product Name: TCS-380 CL TCS-25
Model Number(s): _____
Product Type: _____
Rule(s) citation that registration is being requested within Chapter 62-761 (UST), and/or 62-762 (AST), _____

F.A.C.: Write a brief description of equipment registration request including product limitations:

Information Checklist (Choose Yes, No, or N/A - Not Applicable):	**Yes**	**No**	**N/A**
1. Third-party Certification by a Nationally Recognized Testing Laboratory? (Required)	☐	✔	
2. Documentation of third-party evaluation that the equipment meets DEP Rules?	✔	☐	☐
3. Documents included about the qualifications of the Nationally Recognized Testing Laboratory?	☐	☐	✔
4. Technical information and drawings included?	✔	☐	☐
5. Installation instructions included?	☐	✔	☐
6. Annual Operability Testing Requirements (Rules 62-761.500, 62-762.501, & 62-762.502 F.A.C.)?	✔	☐	☐
7. Integrity Testing Requirements (Rules 62-761.700, 62-762.701, & 62-762.702, F.A.C.)?	☐	☐	✔
8. Compatible with fuel blends containing >10% ethanol or >20% biodiesel?	✔	☐	☐
9. Has the product been approved or registered in other countries or states? (If so provide list)	☐	✔	☐
10. Any requirements for company-certified installers or trainers?	✔	☐	☐
11. Was this product(s) previously approved or registered by the Department? If yes, EQ- **846**	✔	☐	☐
12. Any changes or modifications to the equipment since the last submittal to DEP?	☐	✔	☐

Document Information: Provide supporting documents indicated as "Yes" above including this form via email to Tanknotify@floridadep.gov, or documents can be sent to FDEP, Division of Waste Management, 2600 Blair Stone Road, MS 4560, Tallahassee, FL 32399.

Write a brief description of equipment installation and performance in the U.S.:

Equipment Registration Certification:

To the best of my knowledge and belief, all information submitted on this form is true, accurate and complete.

Mike Whitener Manager
Printed Name and Title

Mike Whitener Digitally signed by Mike Whitener Date: 2022.08.29 13:06:11 -04'00'
Signature (right click to sign)

08/29/2022
Date

For Department Use Only:

Date Application Received: 08/30/2022 Application complete: Yes: ✔ No: ☐

EQ- 846 Date of complete or incomplete letter sent: 09/08/2022 Date Equipment Requires Renewal: **09/08/2027**

Storage tank system equipment requires renewal every 5 years in accordance with subsection 62-761.850(2), F.A.C.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

RICK SCOTT
GOVERNOR

CARLOS LOPEZ-CANTERA
LT. GOVERNOR

JONATHAN P. STEVERSON
SECRETARY

VIA ELECTRONIC MAIL
sherry@tcsliners.com

Ms. Sherry Currie
Total Containment Solutions, Inc.
11000 Metro Parkway, Suite 20
Fort Myers, FL 33966

Subject: Approval of the Total Containment Solutions, Inc. TCS 380-25 and TCS 380-CL Polyurea Spray Elastomer Systems for Secondary Containment Coating. File No. EQ-846

Dear Ms. Sherry Currie:

The Office of District and Business Support has concluded its review of the Equipment Approval request dated February 9, 2015, that was submitted for the Total Containment Solutions, Inc.'s TCS 380-25 and TCS 380-CL Polyurea Spray Elastomer Systems for Secondary Containment Coating, pursuant to Rules 62-762.501(1)(e)3.b., and 62-762.851(2), Florida Administrative Code (F.A.C.). The Total Containment Solutions, Inc.'s TCS 380-25 and TCS 380-CL Polyurea Spray Elastomer Systems for Secondary Containment Coating are protective coatings for the exterior surfaces of secondary containment systems.

Based on the information provided by Total Containment Solutions, Inc., the above referenced coatings provide environmental protection substantially equivalent to that provided by compliance with the requirements established in Rule 62-762.501(1)(e)3.b., F.A.C. The Total Containment Solutions, Inc.'s TCS 380-25 and TCS 380-CL Polyurea Spray Elastomer Systems for Secondary Containment Coating may be used as protective coatings for secondary containment systems.

Pursuant to Rule 62-762.851(2), F.A.C., the request for the use of the Total Containment Solutions, Inc.'s TCS 380-25 and TCS 380-CL Polyurea Spray Elastomer Systems for Secondary Containment Coating is approved in the State of Florida as a coating for secondary containment systems. The coating must be installed in accordance with the manufacturer recommendations for surface preparation, application, and maintenance.

Please be advised that the above referenced DEP rules are subject to change. If the above rule standards are modified in the future, this order may be modified or rescinded for future upgrades and installations. Additionally, if the product(s) show a consistent pattern of failure(s), and therefore does not provide substantially equivalent environmental protection, the Department may rescind this order.
The Department's Order shall become final unless a timely petition for an administrative hearing is filed under sections 120.569 and 120.57, F.S., within **21** days of receipt of this Order. Persons who have filed such a petition may seek to mediate the dispute and choosing mediation will not adversely affect the right to a hearing if mediation does not result in a settlement. The procedures for petitioning a hearing and pursuing mediation are set forth below.

Persons affected by this Order have the following options:

A. If you choose to accept the Department's decision regarding the Order, you do not have to do anything. This Order is final and effective as of the date it is clerked and filed (see page 4).
B. If you choose to challenge the decision, you may do the following:
    1. File a request for an extension of time to file a petition for hearing with the Department's Agency Clerk in the Office of General Counsel within **21** days of receipt of this Order. This request should be made if you wish to meet with the Department in an attempt to resolve any disputes without first filing a petition for hearing or negotiate an agreement to mediate; or
    2. File a petition for administrative hearing with the Department's Agency Clerk in the Office of General Counsel within **21** days of receipt of this Order.

In addition to requesting an administrative hearing, any petitioner may elect to pursue mediation under Section 120.573, F.S., and must negotiate an agreement to mediate within **10** days after the deadline for filing a petition.

How to Request an Extension of Time to File a Petition for Hearing

For good cause shown, pursuant to Rule 62-110.106(4), F.A.C., the Department may grant a request for an extension of time to file a petition for hearing. Such a request must be filed (received) by the Agency Clerk in the Office of General Counsel of the Department at 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida, 32399-3000, within **21** days of receipt of this Order. Petitioner, if different from the applicant, shall mail a copy of the request to the applicant at the time of filing. Failure to file a petition within this time period shall waive the right of anyone who may request an administrative hearing under Sections 120.569 and 120.57, F.S.

How to File a Petition for Administrative Hearing

A person whose substantial interests are affected by this Order may petition for an administrative proceeding (hearing) under Sections 120.569 and 120.57, F.S. The petition must contain the information set forth below and must be filed (received) by the Agency Clerk in the Office of General Counsel of the Department at 3900 Commonwealth Boulevard, MS 35, Tallahassee, Florida, 32399-3000, within **21** days of receipt of this Order. Petitioner, if different from the applicant shall mail a copy of the petition to the applicant at the time of filing. Failure to file a petition within this time period shall waive the right of anyone who may request an administrative hearing under Sections 120.569 and 120.57, F.S.

Pursuant to Subsection 120.569(2), F.S., and Rule 28-106.201, F.A.C., a petition for administrative hearing shall contain the following information.

a) The name, address, and telephone number of each petitioner; the name, address, and telephone number of the petitioner's representative, if any, the site owner's name and address, if different from the petitioner, the DEP facility number, and the name and address of the facility;
b) A statement of when and how the petitioner received notice of the Department's action or proposed action;
c) An explanation of how each petitioner's substantial interests are or will be affected by the Department's action or proposed action;
d) A statement of the disputed issues of material fact, or a statement that there are no disputed facts;

e) A concise statement of the ultimate facts alleged, including a statement of the specific facts the petitioner contends warrant reversal or modification of the Department's action or proposed action;
f) A statement of the specific rules or statutes the petitioner contends requires reversal or modification of the Department's action or proposed action; and
g) A statement of the relief sought by the petitioner, stating precisely the action petitioner wishes the Department to take with respect to the Department's action or proposed action.

How to Pursue Mediation

In addition to requesting an administrative hearing, any petitioner may elect to pursue mediation. The election may be accomplished by filing with the Department a mediation agreement with all parties to the proceeding (i.e., the applicant, the Department, and any person who has filed a timely and sufficient petition for hearing). The agreement must contain all the information required by Rule 28-106.404, F.A.C. The agreement, signed by all parties, must be received by the Agency Clerk in the Office of General Counsel of the Department at 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida, 32399-3000 within **10** days after the deadline for filing a petition, as set forth above. Choosing mediation will not adversely affect the right to a hearing if mediation does not result in a settlement.

Pursuant to Rule 28-106.404, F.A.C., an agreement to mediate must include the following.

(i) The name, address, and telephone number of the persons who may attend the mediation, (also the DEP facility number, the name and address of the facility if applicable);
(ii) The name, address, and telephone number of the mediator agreed to by the parties;
(iii) How the costs and fees associated with the mediation will be allocated (the Department will not pay any of the costs of mediation);
(iv) The agreement of the parties regarding the confidentiality of discussions and documents introduced during mediation to the extent authorized by law;
(v) The date, time, and place of the first mediation session;
(vi) The name of the party's representative who shall have authority to settle or recommend settlement; and
(vii) The signature of the parties.

As provided in Section 120.573, F.S., the timely agreement of all parties to mediate will toll the time limitations imposed by Sections 120.569 and 120.57, F.S., for holding an administrative hearing and issuing a final order. Unless otherwise agreed by the parties, the mediation must be concluded within sixty days of the execution of the agreement. If mediation results in settlement of the administrative dispute, the Department must enter a final order incorporating the agreement of the parties. Persons seeking to protect their substantial interests that would be affected by such a modified final decision must file their petitions within **21** days of receipt of this notice, or they shall be deemed to have waived their right to a proceeding under Sections 120.569 and 120.57, F.S. If mediation terminates without settlement of the dispute, the Department shall notify all parties in writing that the administrative hearing processes under Sections 120.569 and 120.57, F.S., are resumed.

This Order is final and effective as of the date it is clerked and filed (see page 4). Timely filing a petition for administrative hearing postpones the date this Order takes effect until the Department issues either a final order pursuant to an administrative hearing or mediation settlement.

Judicial Review

Any party to this Order has the right to seek judicial review of it under Section 120.68, F.S., by filing a notice of appeal under Rule 9.110 of the Florida Rules of Appellate Procedure with the Agency Clerk of the Department in the Office of General Counsel, Mail Station 35, 3900 Commonwealth Boulevard, Tallahassee, Florida 32399-3000, and by filing a copy of the notice of appeal accompanied by the applicable filing fees with the appropriate district court of appeal. The notice of appeal must be filed within thirty days after this order is filed with the clerk of the Department (see below).

Questions

Any questions regarding the Department's review of your equipment approval should be directed to John Svec at (850)245-8845. Questions regarding legal issues should be referred to Rebecca Robinette, Office of General Counsel, at (850)245-2242. Contact with any of the above does not constitute a petition for administrative hearing, a request for a time extension to file a petition for hearing or an agreement to mediate.

Sincerely,

John A. Coates, PE, Assistant Division Director
Division of Waste Management

JAC/js

FILING AND ACKNOWLEDGMENT FILED,
on this date, pursuant to §120.52 Florida Statutes,
with the designated Department Clerk, receipt of
which is hereby acknowledged.

5/15/2015

X

Judith Pennington

Signed by: Penningto_JA

Clerk (or Deputy Clerk) Date

Total Containment Solutions, Inc.

Manufacturer of RoboLiner™

February 4, 2015

John Svec
FL Department of Environmental Protection
2600 Blair Stone Road
District and Business Support Section; MS 4535
Tallahassee, FL 32399-2400

RE: DEP Approval of Polyurea Spray Elastomer Systems for Secondary Containment Coating
Rule 62-761.500(1)(d) and Rule 62-761-850(2) F.A.C.
Products: TCS 380-25 and TCS 380-CL

Dear Mr. Svec,

Total Containment Solutions, Inc. has completed ASTM D5322 testing on our TCS 380-25 & TCS 380-CL products. We submit the results of that testing to aid you in the evaluation of our request for approval under the above references rule.

Should you require further information for your evaluation please contact me. We look forward to your approval, and will gratefully accept invoicing from you on the application process.

Thank you,

Sherry Currie
Office Manager
Total Containment Solutions, Inc.

Office of District &

FEB 09 2015

Business Support

239-275-6235 Office • 11000 Metro Parkway • Suite 20 • Fort Myers, FL 33966 • 239-275-6412 Fax

The Hanson Group, LLC

900 McFarland 400 Blvd, Duluth, GA 30097

Telephone 770-495-9554/Fax 770-495-9449
E-mail: sales@hansonco.net
www.hansonco.net

TCS 380-25 Film Fluid Immersion Testing Report

This work was requested by Total Containment Solutions and was done to compare the resistance to several solvents of the TCS 380-25 product.

Summary

- TCS380-25 films were completely immersed in several fluids and tested according to ASTM D5322. The films were immersed 7and 28days in kerosene, diesel, gasoline and fuel methanol M85 at ambient temperature. The changes in mass, volume and hardness were determined immediately after removal from the test solvents and after 7days air drying.

1. Materials

TCS 380-25 films were allowed to cure for more than 2 weeks at ambient conditions before fluid immersion testing.

Four fluids were used:

1) Kerosene, which is replaced to Commercial Jet A Fuel
2) Diesel Fuel
3) Gasoline (Premium Grade)
4) Fuel methanol M85 (85% by volume methanol and 15% by volume gasoline)

2. Results

The results for TCS 380-25 are summarized in Tables 1-4. Measurable swelling and softening were observed in all samples. The change percent in mass, volume and hardness were not much different between 7 days and 28 days immersion. These results suggest that prolonged immersion for 28 days does not significantly worsen the performance. After drying, only slight swelling and weight gain were seen in kerosene, gasoline and fuel methanol M85. This is probably due to their relatively low boiling points.

Table 1. TCS 380-25 Kerosene Immersion Testing

		Mass	Volume	Hardness	Percent Change (%)		
		(g)	(cm3)	(A)	Mass	Volume	Hardness
1	Initial	17.2568	4.92	77	%	%	%
	After 7days immersion	19.9441	6.11	71	16	24	-8
2	Initial	17.2818	4.92	77			
	7days immersion, 7days drying	17.9331	5.12	72	4	4	-6
3	Initial	8.8848	4.92	77			
	After 28 days immersion	10.5048	6.08	67	18	24	-13
4	Initial	7.2172	4.92	77			
	After 28 days immersion, 7 days drying	7.3324	4.92	71	2	0	-8

Table 2. TCS 380-25 Film Diesel Fuel Immersion Testing

		Mass	Volume	Hardness	Percent Change (%)		
		(g)	(cm3)	(A)	Mass	Volume	Hardness
1	Initial	15.6699	4.92	77			
	After 7days immersion	18.1692	5.76	69	16	17	-10
2	Initial	16.5532	4.92	77			
	7days immersion, 7days drying	18.6004	5.48	69	12	11	-10
3	Initial	7.3504	4.92	77			
	After 28 days immersion	8.7874	6.08	67	20	24	-13
4	Initial	8.8949	4.92	77			
	After 28 days immersion, 7 days drying	9.9847	5.64	65	12	15	-16

Table 3. TCS 380-25 Film Gasoline Premium Immersion Testing

		Mass	Volume	Hardness	Percent Change (%)		
		(g)	(cm3)	(A)	Mass	Volume	Hardness
1	Initial	15.6208	4.92	77			
	After 7days immersion	22.1631	7.48	45	42	52	-42
2	Initial	16.3971	4.92	77			
	7days immersion, 7days drying	16.8787	4.82	65	3	-2	-16
3	Initial	8.9669	4.92	77			
	After 28 days immersion	13.8511	8.31	41	54	69	-47
4	Initial	7.1779	4.92	77			
	After 28 days immersion, 7 days drying	7.0937	4.68	63	-1	-5	-18

Table 4. TCS 380-25 Film Fuel Methanol M85 Immersion Testing

		Mass	Volume	Hardness	Percent Change (%)		
		(g)	(cm3)	(A)	Mass	Volume	Hardness
1	Initial	n/a	4.92	77			
	After 7days immersion	n/a	8.36	35	n/a	70	-55
2	Initial	n/a	4.92	77			
	7days immersion, 7days drying	n/a	4.87	65	n/a	-1	-16
3	Initial						
	After 28 days immersion	available next month					
4	Initial						
	After 28 days immersion, 7days drying						

RoboLiner TCS 380-CL Evaluation

Report Title:	RoboLiner TCS 380-CL Evaluation
Report Number:	MQ-14-002
Revision No.	0
Author:	Michael Quinn
Date:	July 24, 2014
Reference	N/A

RoboLiner TCS 380-CL Evaluation

1.Purpose:

Evaluate the RoboLiner TCS 380-CL product and describe its place in the general area of polyurea coatings.

2.Summary:

- Roboliner TCS 380-CL was tested and found to be an excellent product
  - ✓ Good tensile strength properties.
  - ✓ An example of Green Chemistry
  - ✓ Shows good retention of tensile properties after exposure to UV radiation.
  - ✓ Shows resistance to solvents
  - ✓ Water and moisture vapor permeability
    - Passed D5385-93 (2006) Standard Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes
    - Meets moisture vapor permeability standard
- Total Containment Solutions and The Hanson Group have formed a strategic alliance to service the needs of several markets combining knowledge of customer's needs with technical expertise

3.Background:

The most common method to make a polyurea is through by the reaction between an isocyanate and an amine. The isocyanate and the amine can be aromatic or aliphatic. The isocyanate can be a low molecular weight monomer species or it can be pre-reacted to increase its molecular weight to form a pre-polymer which is end-capped with isocyanate functional groups. The amine component can be a low molecular weight monomeric species but it can also be pre-reacted to form a pre-polymer which is end-capped with amine functional groups.

Polyureas differ from polyurethanes whereby the latter are formed by the reaction of an isocyanate and a hydroxyl group. The urethane formation reaction is often catalyzed to obtain reaction rates that are sufficiently rapid for commercial use.

A common method of using polyureas is with a hybrid system whereby the system contains both urea and urethane components. This helps develop systems that combine the lower cost of polyurethanes and the improved properties of polyureas.

Reactions to form polyureas proceed rapidly and are not greatly influenced by ambient temperature. Because these reactions are so rapid, they are relatively insensitive to ambient relative humidity.

Polyurethanes have been in commercial use for decades and their properties are extensively documented. Properties can vary considerably since there is a wide variety of starting materials. The isocyanate can be monomeric and/or polymeric. The monomeric isocyanate is usually

selected from various commercially available materials. Polymeric isocyanates can be made by increasing the molecular weight of the monomeric isocyanate or by reacting them with hydroxyl terminated polymers. The ingredient ratios are selected to maintain the isocyanate functionality on the resultant pre-polymer. Furthermore, the molecular weight of the isocyanate terminated pre-polymer can be varied. Pre-polymers of differing types can be blended to make the polyurethane.

4.Polyurea Physical Properties:

As with polyurethanes, the ability to tailor properties of polyureas is very broad. This becomes even wider when hybrid systems are used. In general, polyureas are used when systems require:

- Rapid curing speed
- Very good abrasion resistance
- High impermeability to liquids and gasses
- Thick layers
- Chemical resistance

Polyureas can also be tailored to perform at temperatures as low as -50^{O} C.

Hanson tests the physical properties of polyurea materials using the following methods:

- ASTM D412; Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
- ASTM D624-C; Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
- Hardness is tested with Hanson Standard Test Method 124

Hanson usually tests polyurea physical properties within 1 – 2 hours after spraying a test sample and thereafter periodically for about seven days since physical properties of polyureas generally take this time to reach their ultimate values. In addition, the rate at which ultimate physical build is used as one quality control test to ensure that formulas are manufactured consistently.

Specific uses of polyureas generally require specific physical properties. For example, a climbing hold will have relatively high Shore D hardness and tensile strength values and low elongation values. A polyurea used for a flexible coating will have low Shore D and tensile and high elongation values. This variation in customer requirements has guided Hanson to also add toughness value to physical property testing.

Hanson calculates toughness by integrating the area encompassed by the stress-strain curve. It relates to the ability of a material to absorb energy without being destroyed. Toughness is a useful method to help define what formulation will perform in specific tasks and as a marker for quality testing.

The tensile properties of the RoboLiner TCS 380-CL are given in Table 4.1. These are excellent tensile strength properties.

Conclusion:

- RoboLiner TCS 380-CL has excellent tensile strength properties.

Table 4.1

Tensile Properties of TCS 380

Tensile (psi)	Elongation (%)	Tear (pli)	Toughness (psi)
2290	470	430	6720

5.Green Chemistry:

The polyureas supplied by Total Containment Solutions Inc. are examples of Green Chemistry as evaluated by the Green Chemistry Guide published by the American Chemical Society, Fig. 5.1.

The specific criteria for Green Chemistry are:

- Prevent waste – Polyureas are applied as two-part systems either by spraying or brushing. There is no waste of raw materials. Overspray is completely converted to cured, inert product which is easily and safely disposed.
- Atom economy - Synthetic methods are designed to maximize the incorporation of all materials used in the process into the final product. Polyureas are 100 % solids or sometimes incorporate a non-volatile diluent. What you start with is what you get in the final product.
- Less hazardous synthesis - Chemistry should be designed to use and generate substances that possess little or no toxicity to human health and the environment. The final product of polyurea application is a cured product and all starting materials are incorporated into the final product or entrapped in the polymer matrix.
- Design Benign Chemicals - Chemical products should be designed to affect their desired function while minimizing their toxicity. Pre-polymers are usually used rather than volatile monomers and they are cured with non-volatile curatives.
- Benign Solvents and Auxiliaries - Auxiliary substances (e.g., solvents, additives, etc.) should be made unnecessary wherever possible and innocuous when used. All additives in cured polyureas are non-volatile and trapped within the polymer matrix.
- Design for Energy Efficiency - Energy requirements of chemical processes should be minimized. If possible, synthetic methods should be conducted at ambient temperature

and pressure. Reactions to form polyureas proceed at room temperature and do not require heating to cure the product.

- Use of Renewable Feedstocks – The polyureas formulated for Total Containment Systems contain a plant-based renewable raw material.
- Reduce Derivatives - Unnecessary derivatization (use of blocking groups, protection/ de-protection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste. No blocking groups and hence no activation steps are needed to form polyureas.
- Catalysts vs. Stoichiometric - Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. Hybrid systems commonly contain a catalyst. However, the formation of polyureas proceeds so rapidly that a catalyst in not needed. Although a catalyst is not used in pure polyurea systems, this criterion is followed in the spirit of Green Chemistry with polyureas.
- Design for Degradation - Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment. Polyureas are extremely stable and remain so throughout an extended lifetime. This encompasses a Green Chemistry because polyureas do not need to be re-applied as frequently as competitive products.
- Real-time Analysis for Pollution Prevention - Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances. This is a moot point because of the rapid, 100 % completion the reaction to form polyureas.
- Inherently Benign Chemistry for Accident Prevention - Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires. The components of a two-part polyurea are inherently stable when stored properly. They react 100 % with each other when mixed properly.

Conclusion:

- RoboLiner TCS 380-CL coatings are an example of Green Chemistry

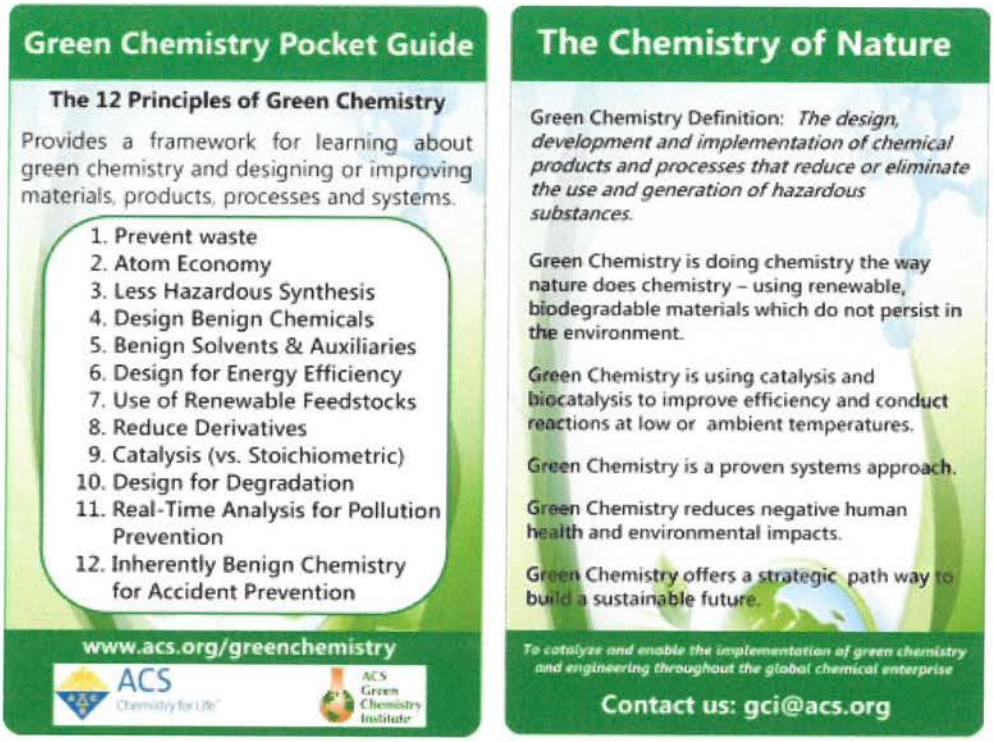

Fig. 5.1. Green Chemistry Pocket Guide from the American Chemical Society.

6.Resistance to UV Radiation:

All materials that are used outdoors are susceptible to degradation from exposure to sunlight with most of this damage coming from the UV component of sunlight. The UV component of sunlight is modified by the time it reaches the Earth's surface. For example, much of the most energetic and hazardous UV radiation from the sun is filtered by ozone, oxygen and nitrogen well before it reaches the Earth's surface. In addition, the amount of UV radiation reaching the Earth's surface varies with time, season, solar activity, altitude, ozone level and cloud conditions[1]. In general, UV radiation between 290 and 400 nm reaches the Earth's surface[2]. This is often divided into UVB (290-315 nm) and UVA (315 – 400 nm).

Ultraviolet radiation that does reach the Earth's surface varies in its ability to damage substances exposed to it. This is illustrated in Fig 5.1 which shows the amount of UV (Irradiance) reaching the Earth's surface and compares it to its ability to cause damage(photon energy). Radiation with higher photon energies is more likely to cause damage to a system than those of lower energies. As Fig. 6.1 shows, UVA is the most prevalent UV radiation reaching the Earth's surface and is also the least energetic[3].

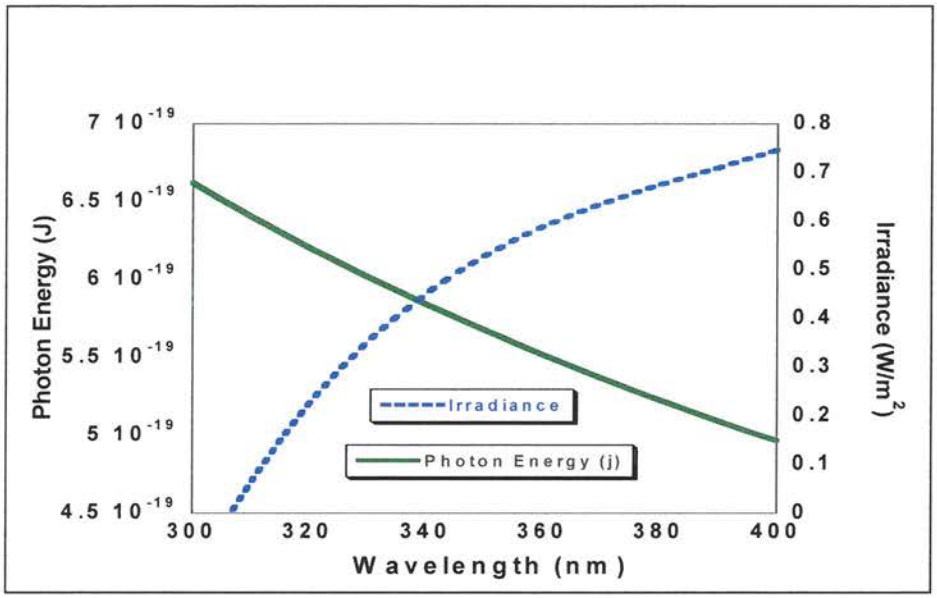

Fig. 6.1. Photon Energy (Plank's constant X Speed of light)/wavelength of photons at various wavelengths and Irradiance (at the Earth's surface) plotted from Pitts[3]

The energy of UVB radiation at 300 nm is about 6.6 J photon^{-1} (399 kJ mole^{-1}) which is sufficiently strong to break C-H and N-H bonds[4]. These bonds are prevalent in polyureas and breaking enough of them would lead to polymer degradation. Fortunately, there are fewer 300 nm photons that of the lower energy, higher wavelength photons reaching the Earth's surface. The higher wavelength photons do not have enough energy to directly break important C-H and N-H bonds. However, if there is prior photo-degradation, these areas may be susceptible to additional damage from UVA. In addition, the chronic effect of extended exposure to lower energy photons is not well understood and a prudent approach would be to minimize the effects of all UV radiation.

The best approach to avoid UV degradation is to prevent the chemical bonds in the system from absorbing UV radiation. This is sometimes termed blocking. This is expressed by the first law of photo-chemistry which states that a system will not undergo a photochemical reaction if light (radiation) is not absorbed[5]. Preventing or blocking the absorption of UV radiation is a good starting point to protect a system. However, even a system containing a good UV blocker can eventually undergo some degree of photo-induced damage given sufficient exposure. Once some degree of photo-induced degradation occurs, a pathway has been opened whereby the relatively small amount of degraded material can help accelerate further degradation. When this occurs, a good next line of defense for a system is to also contain a UV additive that interferes with the mechanism of photochemical degradation.

Benzotriazoles such as HXA UV-328, Fig. 6.2, are common UV blocking additives. The UV/Visible spectrum of HXA UV – 328 is shown in Fig. 6.3. This was run at a lower concentration than is usually present in a stabilized system in order to illustrate details. Even at this low concentration the spectrum shows very low transmission (good protection) in the UVA

and UVB ranges. The ability to protect a system would increase significantly as the concentration of HXA UV-328 increases. The UV energy absorbed by this molecule is expected to be dissipated by non-destructive heat loss rather than polymer degradation[1]. Other UV absorbing materials may also be used but benzotriazoles have excellent absorbance in the entire UVA and UVB regions.

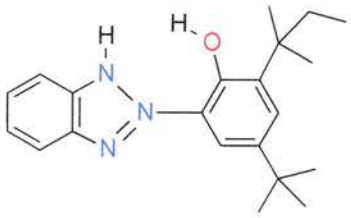

Fig. 6.2. The benzotriazole UV absorber HXA UV 328, 2-(3'5'-di-t-amyl-2'-hydroxyphenyl) benzotriazole.

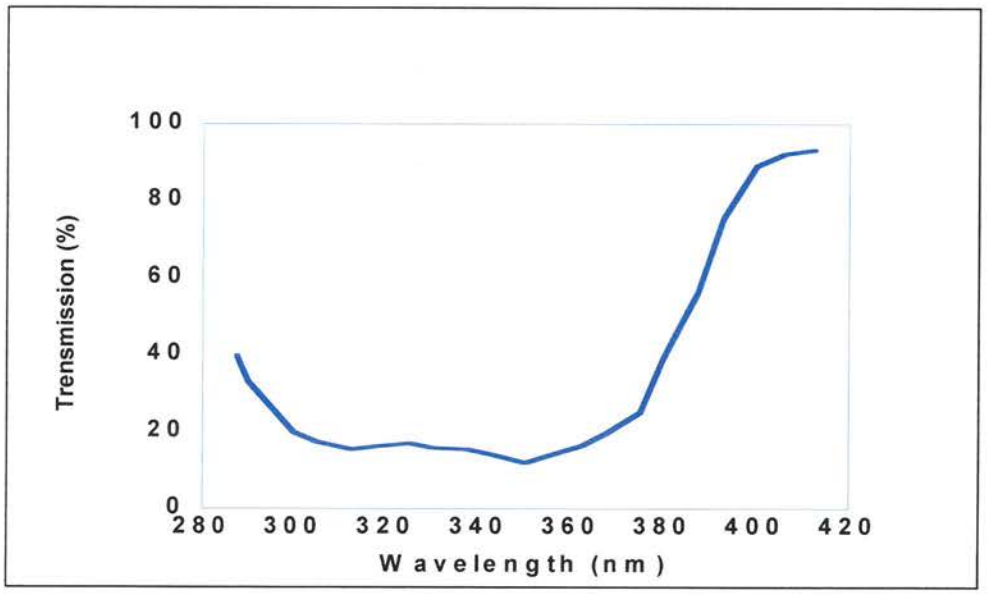

Fig. 6.3. UV/Visible spectrum of HXA UV 328 2-(3'5'-di-t-amyl-2'-hydroxyphenyl) benzotriazole.

A common next-line-of-defense after the UV blocking stage to protect a polyurea is to also include an additive that interferes with photo-induced chemical reactions. Materials such as HALS (Hindered Amine Light Stabilizer) as illustrated by HXA UV-944, Fig. 6.4, are common additives which act by interfering with the degradation process[6,7,8].

HALS additives are not good absorbers of UV radiation but are useful because they are readily susceptible to attack by radicals derived from photo-oxidized species. The HALS molecule reacts with any photo-oxidized species before they can react with the polyurea to cause further

polymer degradation. The HALS molecule which has reacted with photo-degradation products interfere with the degradation chain reaction because they are converted to a less reactive, less destructive species that is less likely to degrade the polyurea.

The key to UV stability of polyureas is to add a package of a UV absorber and a HALS additive.

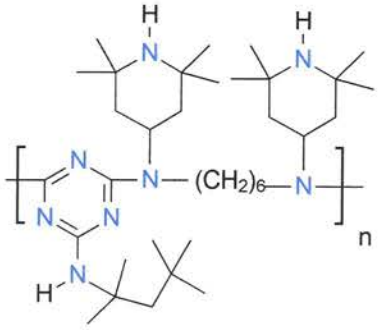

Fig. 6.4. HXA UV-944; N,N'-bis(2,2,6,6-tetramethyl-4-piperidinyl)-1,6-hexanediamine, polymer with 1,3,5-triazine based polymer

Aromatic systems are often associated with diminished UV stability. In order to determine if the RoboLiner TCS 380-CL system fits within this general statement, it was exposed to UV radiation for several weeks. The percent of retained properties are shown in Table 6.4 and the same information is presented as a bar graph in Fig. 6.5. The properly stabilized RoboLiner TCS 380-CL system retains significant amounts of physical properties after exposure to UV radiation.

Conclusions

- Polymers can be degraded by UV radiation in sunlight
- The RoboLiner TCS 380-CL system with proper UV stabilization shows excellent retention of tensile properties after exposure to UV radiation.

	Table 6.4		
	Percent Retained		
Weeks Exposure	**Tensile**	**Elongation**	**Tear**
2	90	102	88
4	97	105	96
12	99	95	99

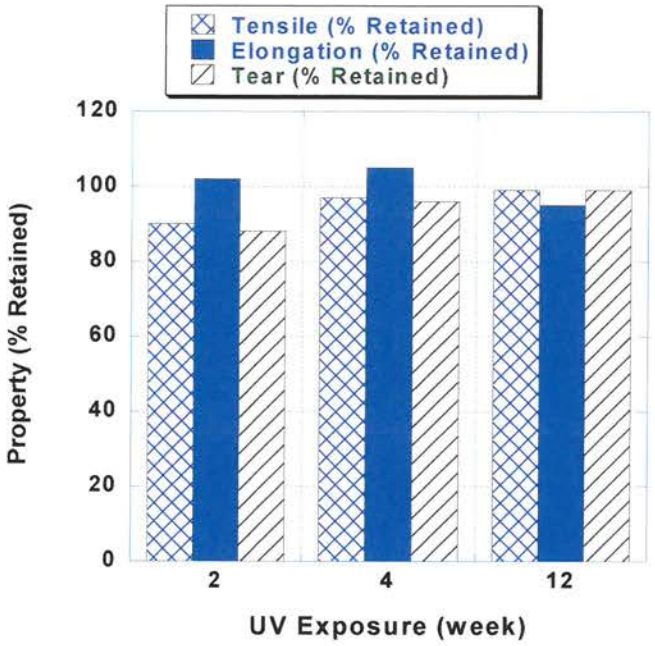

Fig. 6.5. Bar graph showing the precent retentionof properties of RoboLiner TCS 380-CL after various times exposed to UV radiation.

7.Resistance to Solvents:

Polyureas are capable of retaining key physical properties after exposure to solvents. Table 7.1 lists the percent retention of several physical properties after exposure to various solvents by one polyurea. The samples were exposed on both sides for one week at room temperature to solvents making this test more severe than would be expected for a coating which would only be exposed on one side. Polyureas show the ability to retain a significant amount of physical properties after exposure to solvent.

Using the remarkable ability to custom formulate polureas, resistance to specific solvents can be enhanced. For example, properties of a custom formulated polyurea are shown in Table 7.2. The retention of properties for a narrower range of solvents is significant.

Conclusions

- Polyureas generally show resistance to solvents
- Specific polyureas can be formulated to enhance resistance to selected solvents

Table 7.1			
Percent Retention of Properties			
Solvent	**Tensile (psi)**	**Elongation (%)**	**Tear (pli)**
Acetic acid 100 %	33	134	20
Hydrochloric acid25 %	27	45	78
Sodium hydroxide 10%	111	109	95
Acetone	59	133	60
Diesel	59	133	60
Gasoline	89	115	80
Toluene	73	128	65
Water	107	110	97

Table 7.2			
Percent Retention of Properties			
	Tensile (psi)	**Elongation (%)**	**Tear (pli)**
Diesel	132	125	102
Hydrochloric acid 25 %	152	213	128
Toluene	124	463	48
Sodium hydroxide 10 %	157	275	96
Gasoline	100	450	63

8.Water and Moisture Vapor Permeability:

The RoboLiner TCS 380-CL product can be in contact with the ground and moisture and moisture vapor permeability can be important. Moisture permeability was tested according to ASTM D5385-93 (2006) Standard Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes. Test specimens were mounted and sealed using rubber gaskets. The apparatus was filled with water with a colored dye and an airline was attached. Air pressure was increased in 15 psi step increments each hour until reaching a maximum of 100 psi. The maximum pressure was held for 1 hour. At the completion of the testing samples were further examined for leaks prior to disassembly. A summary of the test data is shown in Table 8.1. The material passed the hydrostatic pressure testing performance test.

Permeability to moisture vapor was tested according to ASTM E96 Standard Test Methods for Vapor Transmission of Materials using the water method. Specimens were tested in the orientation that the coating was sprayed. Test containers were filled with water to within 0.5 inches of the container rim. Specimens were sealed to the test containers using a mixture of paraffin and bee's wax and stored at a temperature of 73.4 ± 2°F and a relative humidity of 50 ± 2%

The average sample measurement was 3.56 X 10^{-8} grams/Pa.s.m^2. This can be compared to the maximum allowable vapor permeance of a wall assembly in Canada under the National Building Code of Canada and the Ontario Provincial Building Code which is noted as 6.0 X 10^{-8} grams/Pa.s.m^2. The polyurea material is well within this standard.

Conclusions

- Polyurea
  - ✓ Passed D5385-93 (2006) Standard Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes
  - ✓ Meets moisture vapor permeability standard

Table 8.1

Elapsed Time (hr)	Applied Pressure (psi)	Result
60	15	Pass
240	60	Pass
300	75	Pass

9. References:

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