



INNOVATIVE AND SUSTAINABLE SOLUTIONS FOR FLOOR CARE

THEODORE TYSAK, Ph.D.

Technology Manager

ALVIM JORGE – AJORGE@DOW.COM

Fabric and Surface Care Latin America

The Dow Chemical Company

INTRODUCTION

Zinc-cross linked acrylic polymers provide the unique structure needed to significantly improve removability and other performance characteristics of floor finishes (Figure 1 and Figure 2). They have been the material of choice for the production of all high performance, commercial grade floor polishes for nearly 40 years. No other binder chemistry has offered the same combination of toughness, durability, detergent resistance, and removability.¹

Today, however, zinc-containing acrylic polymers no longer stand alone at the top of the technology mound. They have been joined by notable polymers that carry the DURAGREEN™ designation. These new DURAGREEN™ binders are based on unique, patented and patent pending acrylic emulsion based chemistries that enable them to match and, in some cases surpass the performance of leading conventional zinc-containing polymers and formulations.

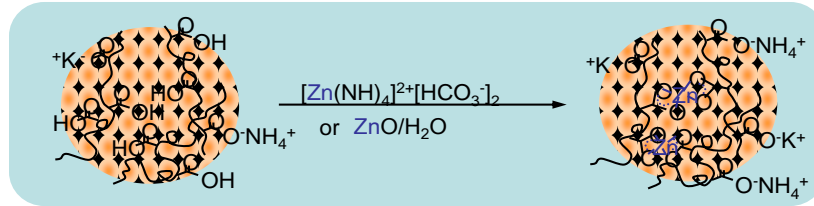
The DURAGREEN™ binders provide the same exceptional film toughness and durability associated with conventional zinc-crosslinking polymers. However, the novel chemistries of the new emulsions also give them important advantages over their conventional counterparts.

First, because the DURAGREEN™ polymers contain no zinc, they moderate potential environmental concerns for both formulators and end users. Second, unlike conventional floor finish polymers, detergent resistance and removability are not inversely related properties in the DURAGREEN™ polymers, so there is no need to compromise this critical balance of properties. Third, the new polymers contain comparatively little ammonia, so polishes based on them have a less noticeable odor and allow recoating to occur with fewer issues. Fourth, the DURAGREEN™ polymers provide better gloss retention in highly trafficked and maintained conditions. Fifth, despite their innovative chemistry, the DURAGREEN™ polymers can be formulated essentially the same way as conventional zinc-crosslinked polymers while meeting the demands for volatile organic compound emission requirements and other environmentally preferred needs including phthalate free and alkylphenoxy ethoxylate free formulation capability².

Figure 1: Depiction of Floor Finish Polymer Chemistry

Conventional Floor Finish Polymer Chemistry

- Polymers manufactured by emulsion polymerization
- Acrylic & styrene/acrylic, high Tg polymers



- **Metal crosslinking provides:**
 - A fast dry time
 - High durability
 - A method of removal with amine-based strippers

Figure 2: Depiction of floor finish polymer and formulation technology.

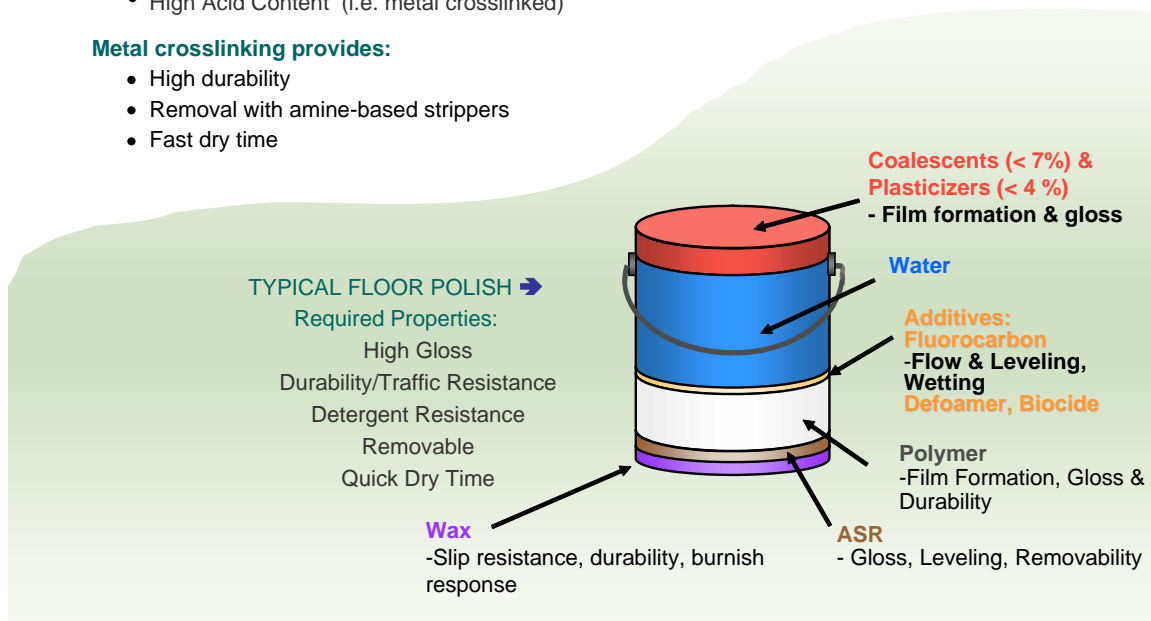
Floor Polish Technology

➔ **Polymers**

- Acrylic & Styrene/Acrylic
- High Tg Polymers
- High Acid Content (i.e. metal crosslinked)

Metal crosslinking provides:

- High durability
- Removal with amine-based strippers
- Fast dry time





NEW CHEMICAL APPROACHES TO FILM TOUGHNESS AND DURABILITY

The key to the unexpected properties of the DURAGREEN™ polymers lies in their approach to crosslinking.

With conventional floor polish vehicles, cross-linking results from the reaction of zinc ions with carboxyl groups on the acrylic backbones of the polymers.³ The use of zinc provides three benefits. First, zinc cross-linking contributes a measure of durability to the polymer itself. Second, the zinc permits the polymer manufacturer to incorporate high levels of acid in a vehicle without detracting from detergent resistance; more acid results in better polish durability. Third and most important, zinc cross-linking provides a way of achieving a good balance between alkaline detergent resistance and polish removability. This last phenomenon occurs because the zinc crosslink has the dual effect of making the polymeric acid insensitive to alkaline materials such as cleaner solutions but making the polish sensitive to amines in stripper solutions.⁴

By designing the DURAGREEN™ polymers with inherent sensitivity to amines present in typical floor polish stripping compositions, Dow chemists have achieved the effect of reversible cross-linking without the use of zinc ions. Exactly how this is accomplished remains proprietary; however, in broad terms, Dow scientists have developed patent and patent pending chemistries that enable them to manipulate the synthesis of the emulsion polymer in novel ways.

The ability to control the polymerization and emulsion process in this fashion permits Dow to create vehicles that develop film properties through the interaction of their constituent monomers, polymer segments and other cross-linking technologies introduced to the vehicles. Since these polymers do not rely on heavy metal ion crosslinking, they contain no zinc. Despite the absence of zinc in these vehicles, the films they form are at least as tough and durable as the films produced by conventional zinc cross-linked polymers.

GENERAL BENEFITS OF THE NEW CHEMISTRIES

The fact that the DURAGREEN™ vehicles can provide the superb film properties associated with conventional zinc ion cross-linking chemistry is a remarkable achievement in and of itself. However, the new polymers do much more than simply match the performance of vehicles. As noted, the DURAGREEN™ polymers actually furnish some attributes that conventional floor finish chemistry does not provide; these new traits spring directly from the unique nature of the innovative chemistries.

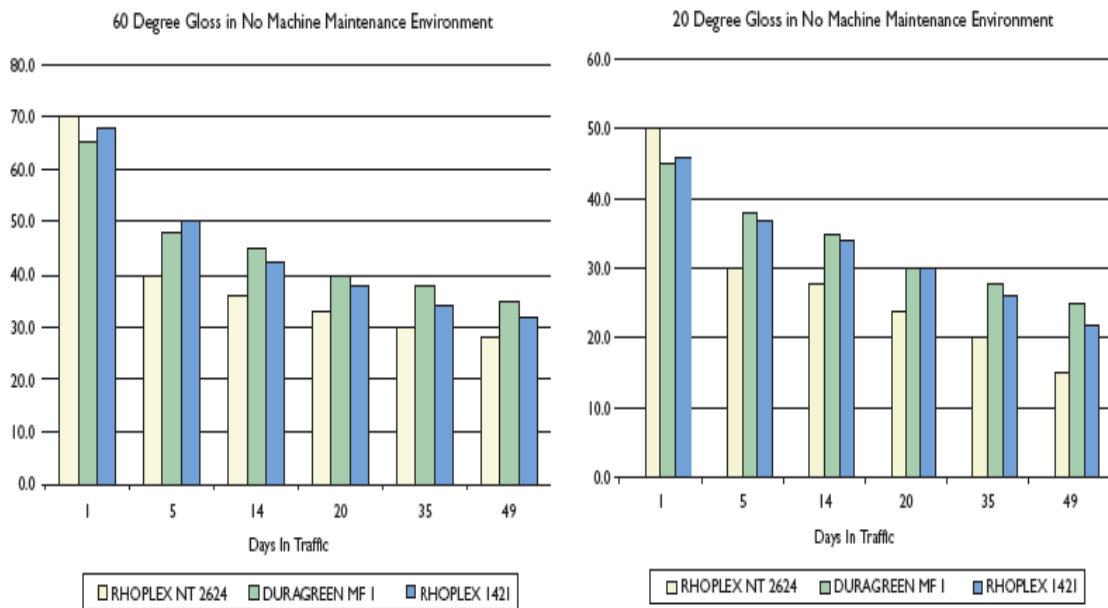
All of the DURAGREEN™ polymers provide high levels of both detergent resistance and removability to a polish formulation. This is in sharp contrast to zinc-cross-linking vehicles, in which these two attributes are inversely related. Thus, with conventional floor finishes, maximizing detergent resistance requires some sacrifice in removability and vice versa. However, with the DURAGREEN™ chemistries, there are almost no connections between the two properties.

As noted previously, the DURAGREEN™ polymers are designed to be inherently sensitive to amines but not to alkaline materials in general. Consequently, Dow is able to produce vehicles that offer high levels of performance in both alkaline detergent resistance and removability.



The new chemistries deliver another benefit in the form of superior gloss retention. Although the dried-film properties of the DURAGREEN™ technology and conventional zinc chemistries are comparable on balance, finishes formulated with the new polymers display a significant edge in their ability to retain gloss after repeated floor maintenance operations. This superiority springs from the long-range cross-linking that occurs as well the association of ionic components in the new polymers.

Most significant, despite the innovative nature of the new chemistries, it has proven to be wholly compatible with the chemical materials now used by polish manufacturers in formulating and by floor care personnel in maintaining, cleaning, and stripping conventional floor finishes.



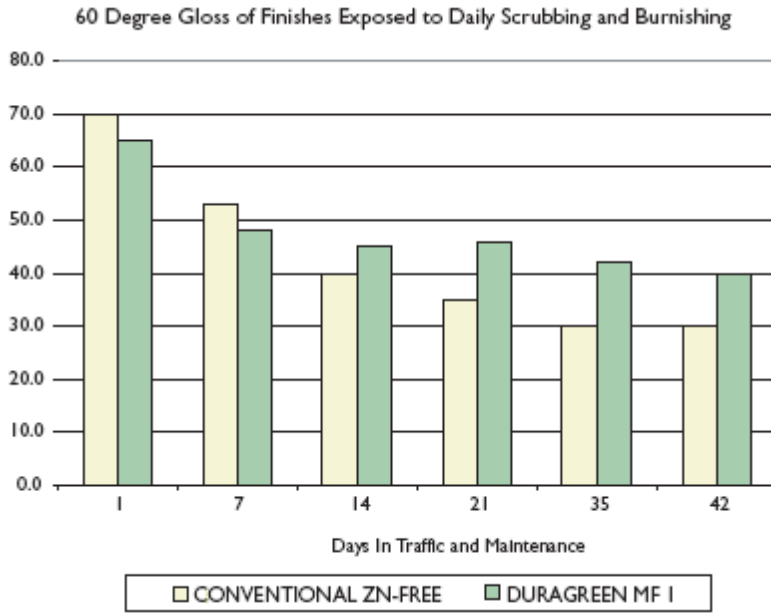


Figure 3: Performance data from floor wear tests showing gloss retention properties of DURAGREEN™ MF-1 versus conventional zinc and zinc-free polishes.

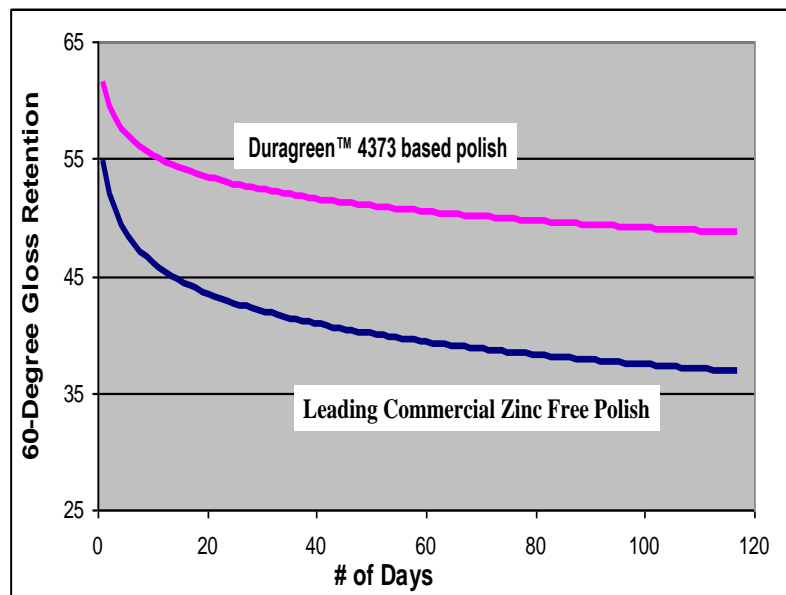
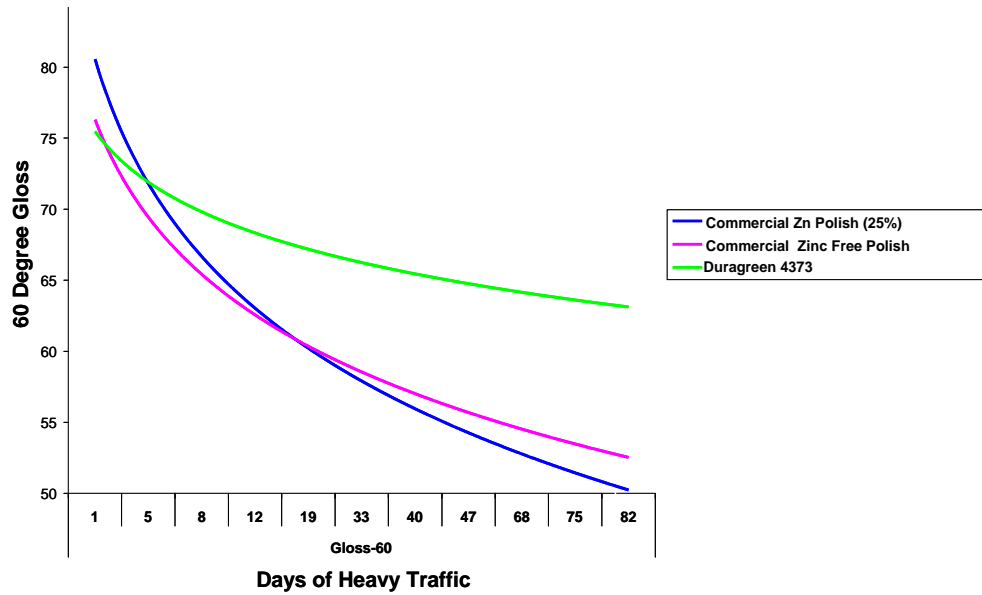




Figure 4 – Performance data from floor wear test showing gloss retention properties of DURAGREEN™ 4373 versus a leading commercial zinc free polish in a low maintenance environment. The 60° gloss measurements through the course of the floor test underscore the superior performance of polishes based on DURAGREEN™ 4373 emulsion. To make this kind of comparison, Dow chemists applied two floor finishes based respectively on DURAGREEN™ 4373 and a commercial zinc free polymer to a section of floor in a local grocery store where maintenance practices involved scrubbing with neutral cleaner followed by propane burnishing two times per week and evaluated them on a weekly basis for gloss.



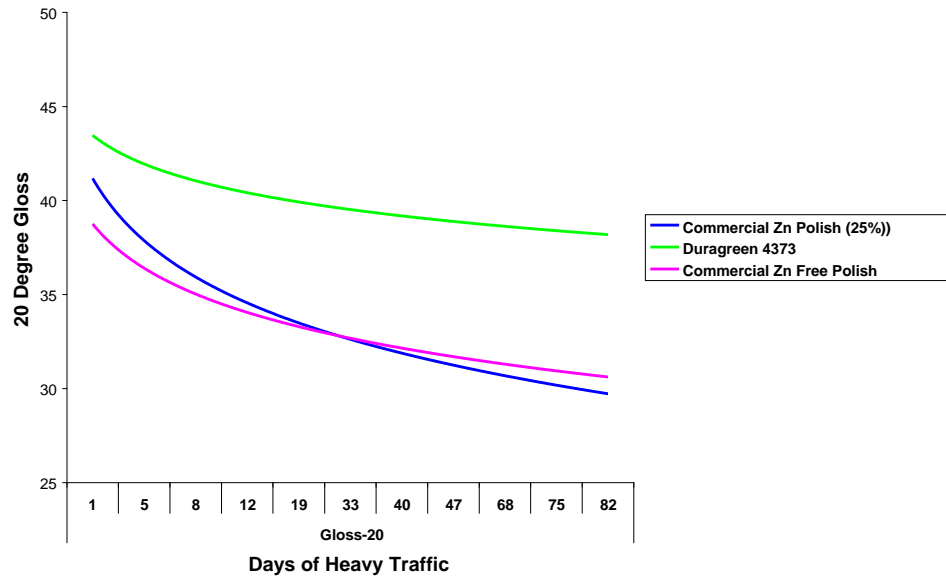


Figure 5 – Performance data (60° and 20° gloss) from floor wear test showing gloss retention properties of DURAGREEN™ 4373 in a medium to high maintenance environment. The gloss measurements through the course of the floor test underscore the exceptional performance of polishes based on DURAGREEN™ 4373 emulsion. To make this kind of comparison, Dow chemists applied three floor finishes based respectively on DURAGREEN™ 4373, a leading brand commercial zinc free polish, and leading brand commercial zinc crosslinking polish to a section of floor in a local food retail store where maintenance practices involved scrubbing with neutral cleaner followed by propane burnishing five times per week and evaluated them on a weekly basis for gloss.

THE ADVANTAGES OF ZINC-FREE VEHICLES

The remaining benefits of the DURAGREEN™ polymers come from their lack of zinc. The Regulatory Environment – the absence of zinc is a benefit in and of itself for reasons relating to environmental concerns². Although an essential element in the diets of most animal organisms, zinc is bacteriostatic.⁵ Consequently, it can deactivate the bacteria employed to digest chemical and biological waste in municipal water/sewage treatment systems, severely reducing the systems' ability to maintain water purity. To prevent this from happening, local authorities levy substantial fines on anyone introducing high levels zinc into publicly treated waste streams or natural waterways.⁶

The restrictions on the use of zinc have important ramifications for both the manufacturers and consumers of floor polishes. Virtually all formulators know that zinc waste is an all but unavoidable by-product of formulating polishes based on conventional polymers. Since regulations do not permit this material to be discharged as effluent, formulators face additional costs for process changes and industrial hygiene practices aimed at isolating or recycling their zinc-containing waste streams.

At present, end users are not impacted by zinc regulations because it is nearly impossible to monitor every building where high-performance polishes may be used. However, the fact that finish use cannot be tracked does not change the fact that virtually all zinc-containing polish applied by an end user will ultimately find its way into waste drains. Of even greater concern to end users is the possibility, however

remote, that regulatory agencies could ultimately ban all industrial chemical products containing zinc-cross-linking floor polishes.

Given the climate of environmentally preferred products being desired, the DURAGREEN™ polymers represent a particularly appealing alternative to conventional zinc cross-linking chemistry.¹⁰ Not only are the DURAGREEN™ polymers completely devoid of zinc, they contain none of the other metals that have come under scrutiny as potential health and safety hazards. Consequently, they are in an excellent position to comply with any regulatory restrictions and requirements by the various nongovernment ecological label organizations that have been or may be established in the near future on the use of various metals.⁷

Ammonia Reduction – Environmentally friendly finishes are by no means the only benefit of eliminating zinc in the DURAGREEN™ polymers. Conventional vehicles require polish manufacturers to include moderate levels of amine in their formulations. The amine, usually ammonium hydroxide, forms a complex with zinc to prevent the metal ions from agglomerating or precipitating the polymer emulsion particles, or cross-linking with the polymer side chains when the finish is in the liquid state before polish film formation. However, since the DURAGREEN™ polymers contain no zinc that must be complexed, formulators can employ much lower levels of amine. They need only enough to maintain the formulation pH in the range of 7.0 – 8.5.

Reducing the amount of amine or ammonium hydroxide in floor polishes yields two major benefits: 1) it virtually eliminates the odor of ammonia present in conventional polishes; and 2) it dramatically improves recoatability.

Odor Aesthetics-Reducing polishes of the ammonia odor enhances their aesthetic appeal to end users and also facilitates compositions passing the screens for some environmental programs. Many consumers-particularly those living outside North America, consider the smell of ammonia to be highly objectionable. In Europe, conventional floor polishes are commonly perfumed to mask the ammonia odor. Eastern and Far Eastern cultures have even greater sensitivity to and antipathy for the smell of ammonia. For this reason, floor polishes based on conventional zinc-cross-linked polymers have always faced a highly subjective barrier to their acceptance in markets outside the United States and Canada despite clearly superior performance. Although ammonia odor has not been as great a drawback in North American marketplace, polish users in that region have also been less than enthusiastic about high levels of ammonia in high-performance industrial polishes.

In some instances, the ammonia odor is more than simply an aesthetic problem. High performance commercial polishes are frequently used in institutional residences occupied by people who are often elderly, infirm, or both. Some of these individuals have sensitive respiratory systems, and the odor of ammonia can be irritating.

The low ammonia levels of polishes based on the DURAGREEN™ polymers makes them particularly appealing alternatives to zinc-cross-linking formulations in any sort of application where the smell of ammonia is unacceptable for any reason.

Recoatability – For most end users the exceptional recoatability of polishes based on the new Dow polymers is even more desirable than the lack of odor. To ensure the most attractive appearance and the



highest degree of protection, most modern floor care programs require the maintenance professional to lay down a minimum of four coats of polish. And this number applies only to conventional floor care programs. The popular high-speed machine maintenance practices typically require more coats of polish. High-speed burnishing programs may actually require as many as six or more applications. Yet even with the additional coats of polish in these programs, no more time is allocated for applying the polish.

With a conventional formulation, one coat must dry and crosslink thoroughly before another coat can be applied. If the interval between the coats is too short, the combination of ammonia, water, and coalescing solvents in the fresh coat will act as a stripper and attack the zinc ion crosslinks in the still-fragile underlying coat. This process causes the polish to swell, soften, and become viscous and sticky. In some instances, the polish may actually begin to redisperse. As the dry polish film weakens, its surface can become tacky and irregular, causing the applicator tool (typically a string mop) to drag and the new polish to level poorly. To prevent these problems, the user must usually wait until the previous coat is completely dry to the touch and tack free before putting down the next coat. This may mean an interval of approximately 45 – 60 minutes between these coats and much longer if applications are heavy, the floor is cool, or the humidity is high.

Custodians and maintenance contractors do not have to wait nearly as long between multiple coats of formulations based on DURAGREEN™ polymers, especially for formulations based on DURAGREEN™ 4373. Since polishes made with the new DOW floor care polymer, DURAGREEN™ 4373 contains reduced ammonia levels compared to conventional formulations, they do not act as a stripper. As a result, even if a previous coat retains water and solvents, a fresh application of polish will not attack and damage it. A new coat can be applied even while the underlying material is still tacky. Polishes based on DURAGREEN™ 4373 polymer do not actually dry any faster, but they develop sufficient film integrity characteristics to the low-ammonia wet polish such that they can be recoated without haze or film damage. Theoretically, this feature could reduce actual application time significantly. Figure 6 shows a picture of a tile containing four coats of test finishes where a coat of polish had been applied once every 20 minutes. The DURAGREEN™ 4373 based polish showed the best resistance to hazing and film appearance issues as compared to the other polish. Users will benefit from the excellent recoatability that the DURAGREEN™ polymers provide. In environments where the humidity is high, air circulation is poor, or the floor is chilled, a custodian can inadvertently recoat a conventional polish before it has cured sufficiently to withstand the stripping action of the amine (ammonia) in the wet coat. However, the improved recoatability of polishes based on the DURAGREEN™ polymers dramatically reduces the opportunities for marginal application conditions to cause problems.

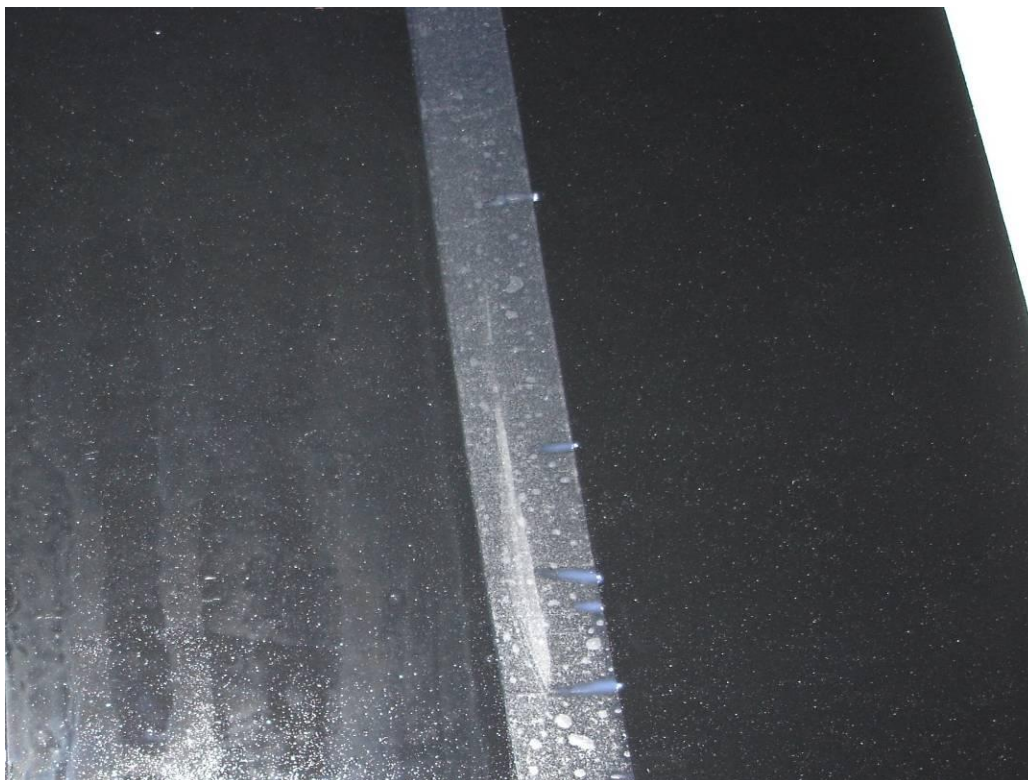


Figure 6 – The zinc-free chemistry of the DURAGREEN™ 4373 polymer provides excellent recoatability. Four coats each of two different floor finishes were applied at relatively short intervals (20 minutes) to either half of the vinyl composition floor tile pictured. Multiple applications of the DURAGREEN™ 4373 finish (right) went on without any problem, but each coat of a conventional zinc-crosslinking finish (left) attacked the underlying polish, causing streaking and hazing.

Versatile Vehicles

Although the new floor polish polymer chemistries and the traditional zinc ion crosslinking technology differ in a number of key aspects, it possesses one important trait in common: versatility. Both chemistries can produce an array of vehicles with varying combinations of properties.

The value of this feature should not be underestimated. As with zinc-ion cross-linking polymers, no one single polymer vehicle is able to satisfy all the end users' polish needs: gloss, durability, and cost. Long experience has shown polymer suppliers they can deliver any two of these properties, but never all three.

For instance, all-acrylic copolymers produce highly durable floor finishes at low to moderate cost, but moderate gloss is inherent in the all-acrylic polymer chemistry. Modifying acrylic copolymers with styrene will dramatically upgrade their gloss without any increase in cost, but their durability will suffer. It is possible to create polymers that combine both the durability of the all-acrylic vehicles with the gloss of the styrenated products. However, the polymer processing and formulating techniques necessary to obtain both features can be expensive.



Since no one vehicle can suit all needs, polish formulators need a several polymers that collectively will enable them to develop the different formulations their customers demand. One of the great strengths of traditional zinc-ion crosslinking polymer chemistry has its ability to produce the full range of vehicles the formulator requires. The DURAGREEN™ chemistry can offer the same capability.

**Table 1: Formulation DG-73-1 based on DURAGREEN™ 4373**

Material Name	Weight Percent	Lbs/100 US GAL	Gallons/ 100 US Gallons
Water	43.20	368.33	44.12
KATHON™ CG/ICP (1.5%)	0.05	0.43	0.05
Silfoam® SE21	0.02	0.17	0.02
MaSurf® FS-230 (1% active) ¹	0.96	8.16	0.98
CARBITOL™ Solvent-low gravity (Diethylene Glycol Monoethyl Ether)	4.79	40.78	4.93
DOWANOL™ DPnP (Dipropylene Glycol n-Propyl Ether)	0.40	3.43	0.45
Eastman TXIB®	0.95	8.07	1.03
Tributoxy Ethyl Phosphate	2.12	18.03	2.13
DURAGREEN™ 4373 (38%)	38.49	327.97	37.27
SMA® 17352 (25%) ²	3.79	32.25	3.67
Michem® Dispersion 89235DE (35%) ³	3.79	32.25	3.88
Michem® Dispersion 89640DE (40%) ³	1.44	12.24	1.47
Totals	100.00	852.11	100.00

Formulation Constants for DG-73-1 based on DURAGREEN™ 4373

Polymer/ASR/Wax ratio	84/5/11
Theoretical Non-volatile Solids	20%
Theoretical Density, Lbs/U.S. Gal	8.52
pH	~8.0

¹Masurf FS-230 Fluorochemical Wetting Aid (Mason Chemical) has been found to provide the best polish flow and leveling characteristics and should be considered for optimum polish appearance properties.

² SMA® 17352 (25%) Alkali Soluble Resin manufactured by Sartomer Company

³ Nonionic wax emulsions manufactured by Michelman®

**Table 2: Formulation DURAGREEN™ MF-1-2 based on DURAGREEN™ MF-1**

Material Name	Weight Percent	Lbs/100 US GAL	Gallons/ 100 US Gallons
Water	46.53	397.32	47.69
KATHON™ CG/ICP (1.5%)	0.07	0.60	0.07
Silfoam® SE21	0.05	0.43	0.05
MaSurf® FS-230 (1% active) ¹	0.95	8.11	0.97
Solution ASR (30%) ²	3.14	26.81	3.23
CARBITOL™ Solvent-low gravity (Diethylene Glycol Monoethyl Ether)	4.00	34.15	4.14
Tributoxy Ethyl Phosphate	1.50	12.81	1.51
DURAGREEN™ MF-1 (40.5%)	38.20	326.18	36.65
A-C® 325 N (35%) ³	2.70	23.03	2.77
Epolene® E43N (40%) ⁴	2.36	20.17	2.42
Totals	100.00	853.88	100.00

Formulation Constants for DURAGREEN™ MF-1-2

Polymer/ASR/Wax ratio	85/5/10
Theoretical Non-Volatile Solids	20%
Theoretical Density, Lb./U.S. Gal.	~8.53

¹Fluorochemical Wetting Aid (Mason Chemical)

²Michem® Dispersion MD-91530, Chemrez 30, and Resinall 802 (30%) can be substituted.

³Commercial Trade Names: Chemcor 325G35, Michem Emulsion 932535

⁴Commercial Trade Names: Chemcor 43G40SP, Michem Emulsion 94340



Table 3 – Bench Performance Properties of DURAGREEN™ 4373 and a Comparable Conventional Vehicle

Polymer	DURAGREEN™ 4373	Conventional Zinc- Crosslinked Vehicle
Total Solids (%)	20	20
pH	8.0	8.5
Viscosity (cps)	5.2	4.9
Film Formation @ 10 °C	Excellent	Excellent
Leveling	Excellent	Excellent
Gloss, 1 coat		
Visual	Very Good	Very Good
60° Gloss	40	38
20° Gloss	15	15
Recoat Gloss		
Visual	VG-EXC	VG-EXC
60° Gloss	75	72
20° Gloss	38	35
Average Tack Rate of Dry (min.)	18	18
Water Resistance		
1 hour	VG-EXC	VG-EXC
24 hours	Excellent	Excellent
Detergent resistance		
1 day (1/20 Forward ¹)	VG-Exc	VG-Exc
7 Days (1/20 Forward)	VG-Exc	VG-Exc
Removability		
7 Days (1/20 Forward +1% NH ₃)	Exc/100%	Exc/100%
Black Heel Mark Resistance	Very Good	Very Good
Scuff Mark Resistance	Very Good	Very Good
James Static Coefficient of Friction O.V.C.T. ²	0.55	0.52
Soil Resistance	Very Good	Good
Powdering	Nil	Nil
Thermal Stability @50° C		
30 Days – pH	7.5	8.3
30 Days – viscosity (cps)	6.8	7.5
Freeze thaw stability @ 3 cycles	Pass	Pass

¹Detergent²Official Vinyl Composition Tile



Table 4 – Bench Performance Properties of DURAGREEN™ MF-1 and a Comparable Conventional Vehicle

Polymer	DURAGREEN™ MF-1	Conventional Zinc-Crosslinked Vehicle
Total Solids (%)	20%	20%
pH	7.3	8.4
Viscosity (cps)	3.8	3.7
Film Formation @ 10 °C	Exc	Exc
Leveling	VG-Exc	VG-Exc
Gloss, 1 coat		
Visual	Good	VG
60° Gloss	32	35
20° Gloss	12	15
Recoat Gloss		
Visual	VG	VG-Exc
60° Gloss	65	70
20° Gloss	28	30
Water Resistance		
1 hour	VG	VG-Exc
24 hours	Exc	Exc
Detergent resistance		
1 day (1/20 Forward ¹)	VG-Exc	VG-Exc
7 Days (1/20 Forward)	Exc	VG-Exc
Removability		
7 Days (1/20 Forward +1% NH ₃)	Exc/100%	G/50%
Black Heel Mark Resistance	G-VG	VG
Scuff Mark Resistance	Very Good	Very Good
James Static Coefficient of Friction O.V.C.T. ²	0.5	0.6
Soil resistance	Very Good	Good
Powdering	Nil	Nil
Thermal Stability @50° C		
30 Days – pH	7.0	8.2
30 Days – viscosity (cps)	6.3	6.3
Freeze thaw stability @ 3 cycles	Pass	Pass

¹Detergent²Official Vinyl Composition Tile

Dow has utilized the new technology to produce polymers that will meet most floor maintenance requirements carrying the following designations for the global floor care market place: DURAGREEN™ 4373 and DURAGREEN™ MF-1. Each of these vehicles provides a different set of properties for the floor polish producer.

DURAGREEN™ 4373

This new polymer is a modified-acrylic polymer developed specifically for periodic to high maintenance environments that can be formulated into a high gloss durable floor finish. Formulations based on DURAGREEN™ 4373 emulsion provide features typically expected of zinc-crosslinked coatings designed for high and medium maintenance environments (Figure 8). Although this polymer has been modified with styrene to give it gloss, it has a very sophisticated design enabling it to deliver the durability and gloss retention normally associated with all-acrylic polymers.

DURAGREEN™ 4373 offers a very high level of gloss (Figure 7) and very good durability. Along with high gloss and durability, DURAGREEN™ 4373 offers versatility; it can be formulated into many different types of finishes. Formulators can produce polishes for high speed burnishing, and for “scrub” and “recoat” maintenance programs. In addition, this vehicle possesses the combination of excellent resistance to alkaline detergent scrubs and the easy removability that characterize all Dow floor finish polymers.

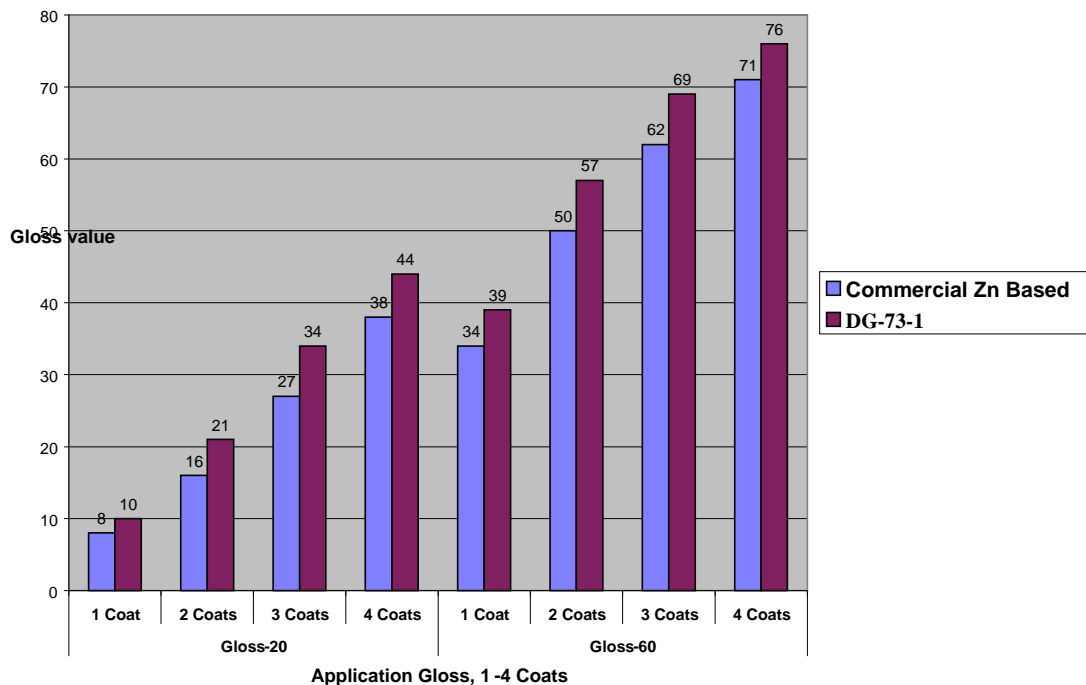


Figure 7 - Initial application gloss of DURAGREEN™ 4373 based polish versus conventional polish. The zinc-free chemistry of the DURAGREEN™ 4373 polymer provides excellent recoatability. Four coats each of two different floor finishes were applied at intervals of 45 minutes to vinyl composition floor tile. The 60° and 20° gloss was recorded for each coat.

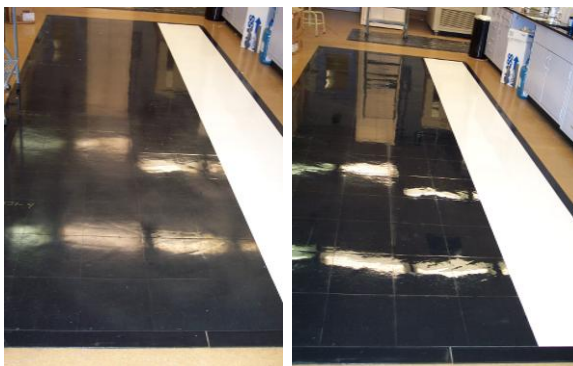


Figure 8 - Polishes based on DURAGREEN™ 4373 exhibit very good response to high speed burnishing. An ordinary polish exposed to high speed burnishing at 2000 rpm appears flat and dull (left). However, a formulation based on the new polymer, DURAGREEN™ 4373, high speed burnished at the same speed has a gloss level that would be acceptable for finishes typically designed for these types of maintenance practices (right).

The properties of DURAGREEN™ 4373 make it an excellent all-purpose vehicle. Formulations based on this polymer perform well in any situation where a floor must retain an attractive appearance despite heavy traffic. This attribute makes finishes based on DURAGREEN™ 4373 especially appropriate for high-visibility floors that go long intervals between maintenance or experience very heavy traffic. These conditions typically prevail in such buildings as supermarkets, schools, and hospitals. The especially high degree of resistance to quaternary ammonium based cleaners makes DURAGREEN™ 4373 ideal for hospital and health care facilities, Figures 9 - 10.

DURAGREEN™ MF-1

This unique polymer is noteworthy for the exceptional durability it provides. Polishes based on DURAGREEN™ MF-1 demonstrate superb gloss retention and exceptional resistance to soiling in highly trafficked, low maintenance conditions.

In addition to durability, DURAGREEN™ MF-1 furnishes a moderate level of gloss and in combination with the characteristic it shares with DURAGREEN™ 4373 and other Dow floor care polymers of having an excellent balance of scrub resistance and removability, offers a very good polish that complements the labor savings initiatives desired from end-users for their floor care maintenance systems.

These attributes make finishes based on DURAGREEN™ MF-1 an excellent choice in very heavy traffic sites where aesthetic requirements do not mandate the highest gloss. Finishes based on this unique air-oxidative cure crosslinking technology would be most appropriate in corridors for schools and hospitals and in the entryways and passageways of busy offices.

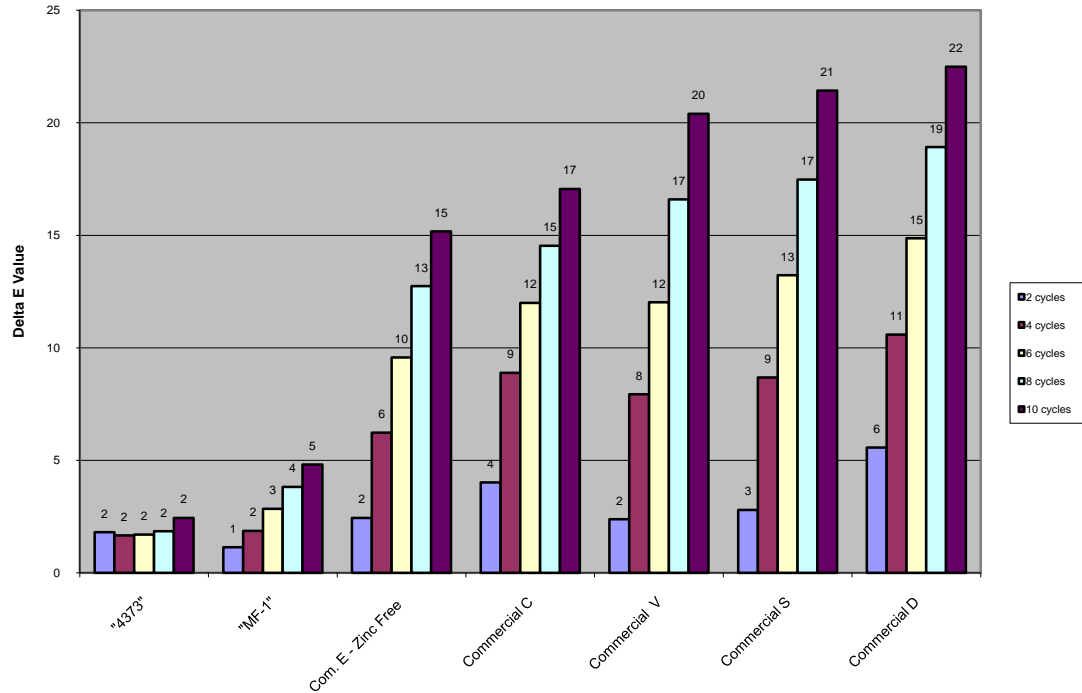


Figure 9 - Polish Soiling After Cleaning with Quaternary Amine Based Floor Cleaner. Laboratory trials performed with a new testing device known to Dow chemists as the Accelerated Wear Tester⁹ confirms the excellent resistance of DURAGREEN™ polishes to quaternary ammonium based cleaners. Quaternary ammonium based cleaners are known to “soften” floor polishes with repeated cleaning operations resulting in soil impregnation with time. Colorimetric measurements (ΔE) were made on polishes coated over white vinyl composition tiles coated with four coats of each finish. Low ΔE values indicate low soil pickup (better resistance to quaternary ammonium based cleaners) and high ΔE values indicate moderate to high soil pickup (poor resistance to quaternary ammonium based cleaners).



Commercial “S” DURAGREEN™ 4373 Commercial “C”

Figure 10 - Visual Color change after repeated exposure to commercial quaternary ammonium based cleaning solution and soil. Data was collected using a new testing device developed by Dow chemists to assess coating performance properties.⁹ The device known to Dow chemists as the Accelerated Wear Tester was used to assess the quaternary ammonium cleaner resistance properties of a DURAGREEN™ 4373 based finish. The procedure used was similar to that disclosed in reference 9 except that the coated tiles were repeatedly exposed to the “quat”-based cleaner and soiling steps. The visual differences are dramatic: The DURAGREEN™ 4373 based finish shows exceptional soil resistance (better quaternary ammonium cleaner resistance) as compared to the leading commercial zinc containing finishes.

Performance Documentation

Despite the relative newness of the DURAGREEN™ polymers, especially in the case of DURAGREEN™ 4373, Dow chemists have managed to compile an extensive amount of evidence documenting the performance properties. The majority of the performance data was generated by bench test and wear trials conducted in a manner consistent with formulations and methods used in the floor care industry.⁸ In every test procedure polish based on a DURAGREEN™ polymer was matched against a polish with a zinc-crosslinking vehicle designed to provide the same general level of performance as the zinc-free polymer. In many instances, the studies included commercial polishes with well-defined performance profiles and established end-users of those commercial finishes.

Despite very different test conditions, the patterns of the results from the different trials were remarkably similar. In every comparison, the formulation based on the DURAGREEN™ polymer matched the overall toughness and durability of the conventional zinc-cross-linked control polish. Nevertheless, as expected, the DURAGREEN based finishes showed significant advantages over its conventional counterpart on the areas of gloss retention, durability and soil resistance.

In the interest of brevity, this article does not present the results from every trial conducted on the DURAGREEN™ polymers. However, Figures 3 - 5 and Tables 3 - 4 show representative information produced in several different bench and wear test conditions for the DURAGREEN™ polymers. Tables 1 - 2 show the starting point formulations used to generate the performance data. As indicated, the data represented in these tables and figures closely mirror the relative performance results collected from all other trials, regardless of which DURAGREEN™ polymer was being evaluated.

Formulating Considerations

One of the most appealing attributes of the DURAGREEN™ polymers is that they do not require major adjustments to traditional formulating techniques. Polish manufacturers can employ essentially the same ingredients they use in conventional finishes, especially those designed with environmentally preferred attributes (ape-free, low vapor pressure solvents, etc). And these materials function in virtually the same way in formulations based on the DURAGREEN™ polymers.

The only departure from conventional formulating procedures is a need for control of formulation pH. The pH of formulations based on zinc-crosslinking polymers generally runs in the neighborhood of 9.0 due to ammonia used to complex the zinc cross-linker. However, the unique acrylic polymer architecture and cross-linking technology built into the DURAGREEN™ vehicles, pH greater than 9.0 will result in a polish that may experience recoat issues resulting in hazy, low gloss coatings. Maintaining a formulation pH not exceeding 8.5 and not dropping below 7.0 would maintain conditions optimal for recoat, wetting and leveling. Using emulsion ASR's that require ammonia to be effective (solubilization) would necessitate pre-neutralization of the emulsion ASR or pH adjustment.

This excess ammonia in the formulations can be used to solubilize alkali-soluble resins and allow the wetting agents typically used in the formulations to act accordingly. With the unique compositions of the DURAGREEN™ polymers, maintaining a pH between 8.5 and 7.0, provides the optimal coating properties.



SUMMARY AND CONCLUSION

The development of the DURAGREEN™ polymers represents an innovative and sustainable advance in floor polish vehicle technology. The fruit of unique approaches to polymer design, the DURAGREEN™ polymers constitute true alternatives to the zinc-crosslinking vehicles that have dominated the high-performance commercial floor finish market for the past 40 years.

The Dow DURAGREEN™ polymers not only match the performance of the conventional zinc cross-linking products, they actually exceed it in some key aspects. Equally significant, they deliver this performance without relying on zinc ion cross-linking.

Finishes formulated with the DURAGREEN™ polymers have all of the toughness and durability for which conventional high performance polishes are acclaimed. However, the new vehicles also have several advantages over their conventional, metalized counterparts. Most important there is no inverse relationship between detergent resistance and removability with the DURAGREEN™ polymers. Unlike conventional vehicles, in which these two performance attributes must be balanced against each other, the new polymers furnish high levels of performance in both areas. The DURAGREEN™ emulsions also supply better gloss retention than their traditional counterparts.

The absence of zinc in these products is beneficial for two reasons. First, eliminating zinc from a polymer reduces environmental compliance problems. Second, with no zinc in the vehicle, the need for amine to complex the metal or for process reasons is reduced. Less amine in turn means lower odor and better recoatability.

The DURAGREEN™ polymers and formulations can be formulated to meet the various certification programs available to the floor care industry.⁷



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About the author:

Theodore Tysak received a B.A. in Chemistry from LaSalle College (Philadelphia, PA, U.S.A.) and a Ph.D. in inorganic chemistry from the University of Pennsylvania (Philadelphia, PA, U.S.A.) before joining the Dow Advanced Materials division in 1984. His present position is Technology Manager for the Floor Care business of Dow's Home & Personal Care business.

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