and MBS impact modifiers are not suitable for weatherable applications. This extends to use in both topcoat and substrate layers of coextruded products. In the substrate, while the impact modifier is protected from direct UV exposure by a weatherable cap layer, it is not protected from exposure to heat build up through the panel. This thermal exposure causes degradation of the impact modifier and erodes the impact performance.

In summary, a combination of weatherable ingredients in adequate amounts and efficient processing that minimizes heat history of the compounds leads to excellent weatherability of a finished building product.

Durastrength 200 is one such ingredient with excellent weatherability. This unsurpassed weatherability can be easily explained by its chemical nature. Durastrength 200 is a butadiene-modified acrylic impact modifier. Acrylic polymers have long been considered to have superb weatherability and therefore find application in a number of outdoor applications. The small amount of butadiene contained in Durastrength 200 does not affect weatherability, but acts to help properties such as cold temperature impact and processability (which ultimately helps weatherability).

To explain further, Diagram A shows the weathering process of a pure butadiene polymer. UV radiation is absorbed by the polymer which contains many double bonds. Free radicals are generated and the double bonds become conjugated, causing a color change.

Diagram A

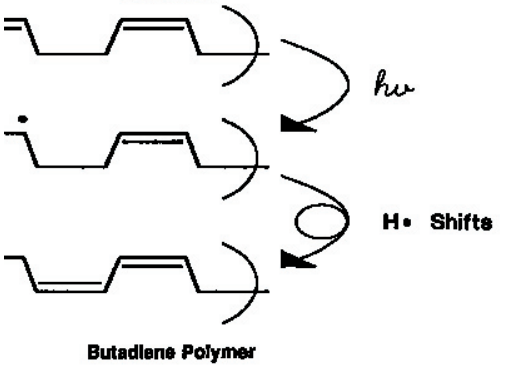
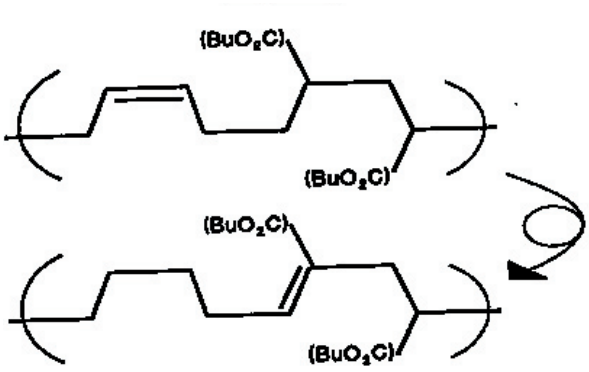


Diagram B, on the other hand shows a Durastrength 200 molecule. When UV radiation is absorbed by the butadiene portion of the Durastrength 200 molecule, it can also cause a shift. However, since the amount of butadiene in Durastrength 200 is so low, there is essentially no chance that two butadiene molecules are close enough to each other to form conjugation. Further, the presence of the butyl acrylate portion of the molecule acts to stabilize the butadiene portion.

Diagram B



The preceeding study demonstrates the excellent long-term weatherability of Durastrength 200, and explains the chemical theory behind its performance. It is not our intent to make outrageous statements about the superior impact and color hold of Durastrength 200 in comparison to other commercial impact modifiers, but to point out some of the aspects that affect weatherability of a vinyl compound so that the manufacturer can make a rational, educated choice in formulating a weatherable vinyl compound.

The claim that Durastrength 200 is one of the best weatherable impact modifiers on the market today is supported by the data here and over 25 years of commercial weathering testing by numerous compounders, manufacturers and industry associations.

DURASTRENGTH® 200

ACRYLIC IMPACT MODIFIER

In Siding Topcoat and Window Profile Yields Maximum Impact and Color Retention

PLASTIC ADDITIVES

More Technical Information Available

Ask your Arkema Account Manager for further information about other high quality Arkema additives for use in PVC resins, PVC alloys, and other polymer systems. Arkema produces a full line of heat stabilizers, impact modifiers, process aids and epoxidized vegetable oils.

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Plastistrength process aids offer producers of rigid and flexible PVC greater product uniformity by improving compound fusion and flow during extrusion, injection molding and thermoforming. Variances in wall thickness and surging can be greatly minimized or eliminated with Plastistrength process aids.

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Visit us at our Website

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Note: The "Material Safety Data Sheet" on this product is available on request from the Safety and Environmental Services Department of Arkema Inc., 2000 Market Street, Philadelphia, PA 19103.

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DURASTRENGTH® 200

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ACRYLIC IMPACT MODIFIER

In Siding Topcoat and Window Profile Yields Maximum Impact and Color Retention

Introduction

Durastrength 200 modified acrylic impact modifier has historically withstood harsh weathering conditions in all types of climates and come out on top in impact and color retention in both siding and profile applications. With more than 25 years of excellent commercial performance in both vinyl siding and window profiles, Durastrength 200 has stood the test of time in weatherable building product applications. The reasons for this excellent showing in vinyl building products can be traced back to the unsurpassed processing latitude this product gives the fabricator.

For the early monoextruded vinyl siding of the past, and the more sophisticated high output coextruded siding of the present, Durastrength 200 is the impact modifier of choice for excellent impact resistance, easy processability and unsurpassed weatherability and impact retention.

In the following study, Durastrength 200 was compared to a commercial all-acrylic impact modifier in both a white and a pigmented typical siding topcoat formulation to assess the effect of the different impact modifiers on weatherability. Both accelerated weathering studies (QUV) and outdoor weathering studies in three locations were done on the formulations. The locations chosen for the weathering studies were New Jersey (northern industrial climate), Florida (hot, humid climate) and Arizona (hot, dry climate). Color change and impact retention were both measured over time.

For the weatherability study, the following formulations were used:

Ingredients	white	almond
PVC Resin (K65)	100.00	100.00
Thermolite® 340	1.0	1.0
Calcium Stearate	1.5	1.5
Paraffin Wax (165°F mp)	1.0	1.0
Calcium Carbonate (0.8µm)	5.0	5.0
Titanium Dioxide	10.0	10.0
Plastistrength® 501	0.5	0.5
Impact Modifier	5.0	5.0
Almond Pigment System	–	3.5

Compounds were mixed in a Henschel high shear mixer and then extruded into strips on a Krauss Maffei KMDL 25 twin screw laboratory extruder. Samples were read for L, a, b values and yellowness index using a MacBeth colorimeter. Initial dart drop impact resistance values of the samples were tested and recorded.

Weathering Mechanisms

PVC weathering is the result of both thermal degradation during processing and photochemical degradation during exposure to solar radiation. Heat history acquired during processing generates double bonds in the PVC molecules that absorb wavelengths from the solar spectrum when the finished product is exposed outdoors. Several processes successively occur:

- Dehydrochlorination of PVC leads to formation of conjugated double bonds. When more than eight form, the double bonds absorb the visible light which produces yellowing.
- Oxidation of double bonds interrupts the polyene sequences, leading to a reduction and even disappearance of the yellowing. Water sensitive molecules are formed and easily removed from the surface. Chain scission also occurs.
- Crosslinking causes high stresses on the surface and leads to microcracking and separation of the surface layer from the matrix. The disintegration of the surface leads to a loss in gloss. The microcracks act as fracture initiators which, accompanied by chain scission, lead to a reduction in the mechanical properties.
- Microcracking reduces the adhesion of the surface layer to the undegraded PVC matrix. Eventually, the degraded surface layer is removed (by erosion or cleaning) and an undegraded PVC layer is again visible whose color approaches the one of initial product.

Gloss is still low due to the unevenness of the surface. The same degradation cycle then starts on the new layer. Removal of the microcracked layer allows partial recovery of the mechanical properties.

QUV Testing

Two short-term QUV weathering tests were performed on the white samples using both UVA-340 and UVB-313 bulbs. QUV conditions were 4 hours of light and 4 hours of condensation. QUV temperature was set at 50°C. Samples were read for yellowness index prior to QUV exposure. Subsequent readings were taken every two weeks for a period of 12 weeks.

One frequently asked question about QUV weathering data is “how many hours in the QUV weathering tester equals one year of outdoor exposure?” Unfortunately, there is no simple answer to this question. The biggest problem is variability and complexity of outdoor exposure situations.

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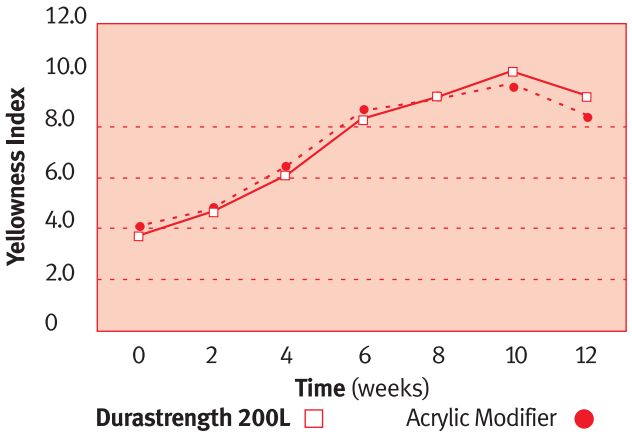
Therefore, it is important to realize that while QUV data is valuable in making a decision about the weatherability of a compound, it is only relative data. The most that should be expected of laboratory generated weathering data is a reliable relative ranking of a material's weatherability compared to other materials.

In the following study, Durastrength 200 was compared to an all acrylic impact modifier to get some idea of the relative weatherability of the two impact modifiers. Under the conditions from two different bulb types, the weathering of Durastrength 200 and the all acrylic impact modifier are essentially identical. This conclusion has been substantiated by years of outdoor commercial exposure of both types of impact modifiers.

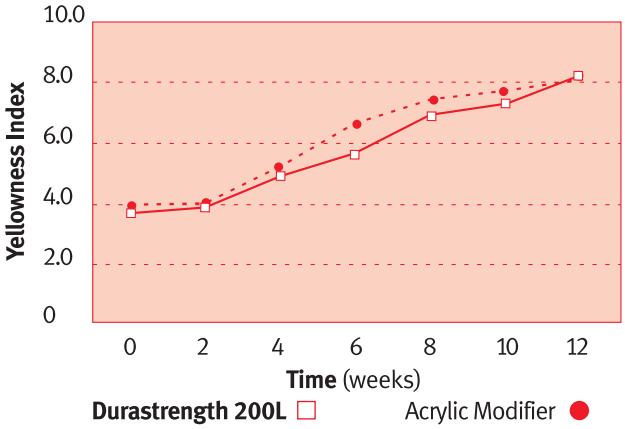
QUV Weathering Results

Durastrength 200 vs. Acrylic Impact Modifier
Q-Panel UVB-313 Weathering



QUV Weathering Index Results

Durastrength 200 vs. Acrylic Impact Modifier
Q-Panel UVA-340 Weathering



Outdoor Weathering Tests

The best indication of outdoor weathering performance is actual long-term outdoor testing. The following outdoor weathering tests were done in three locations – New Jersey (northern industrial climate), Florida (hot, humid climate) and Arizona (hot, dry climate). Samples were read for color and tested for impact prior to being mounted at a test site at each of the three different locations at 45° south exposure. Color readings and impact values were determined at 3, 6, 9, 12, 18 and 24 months.

As seen from the test results, Durastrength 200 weathered essentially identically to the all-acrylic impact modifier tested, a fact which has been known for years by vinyl siding and profile manufacturers. In all three locations, both color hold and impact resistance of both white and almond samples were the same.

DURASTRENGTH® 200

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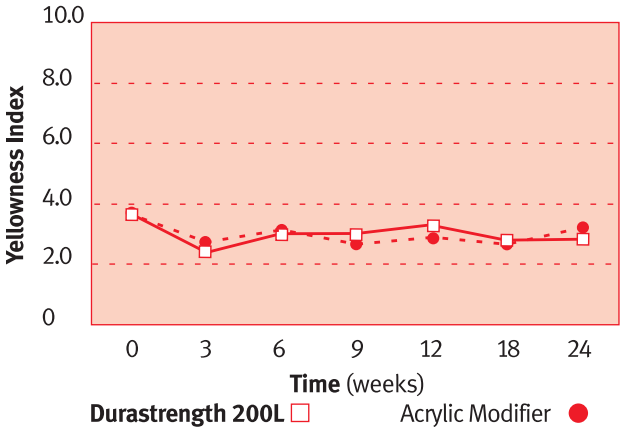
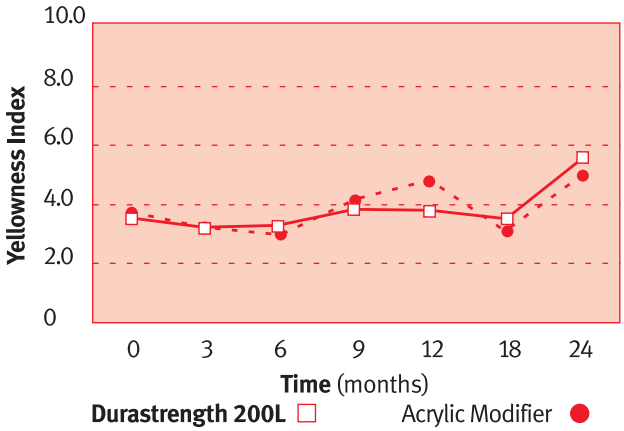
Outdoor Weathering Studies – White

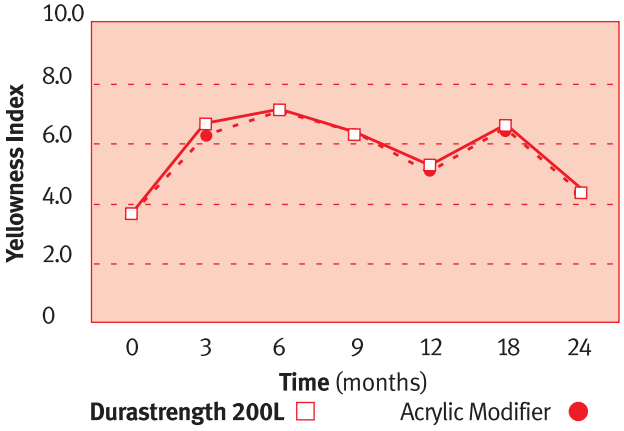
New Jersey Weathering



Florida Weathering

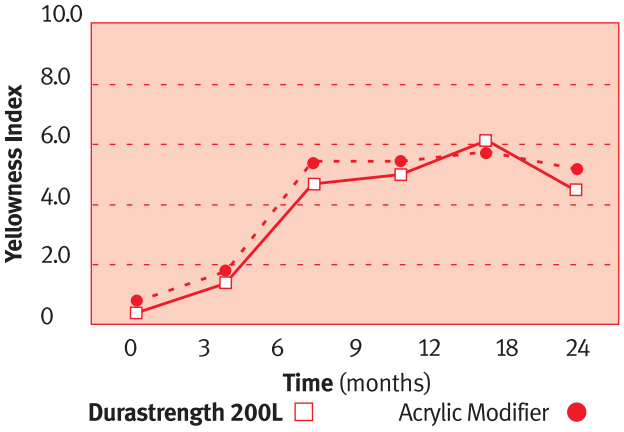


Arizona Weathering

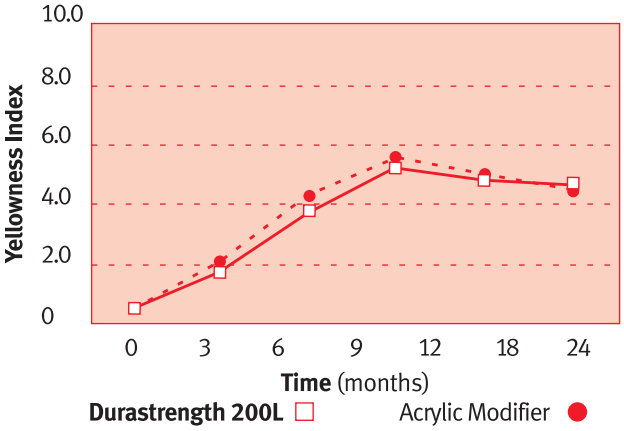


Outdoor Weathering Studies – Almond

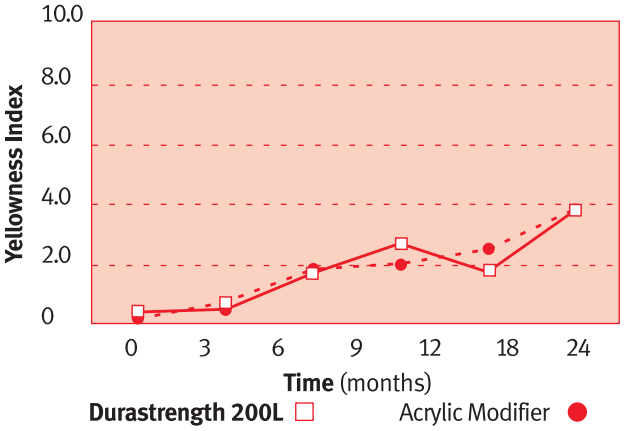
New Jersey Weathering



Florid a Weathering



Arizona Weathering



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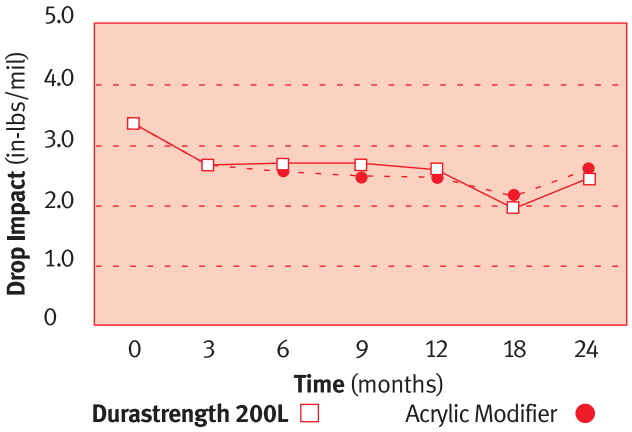
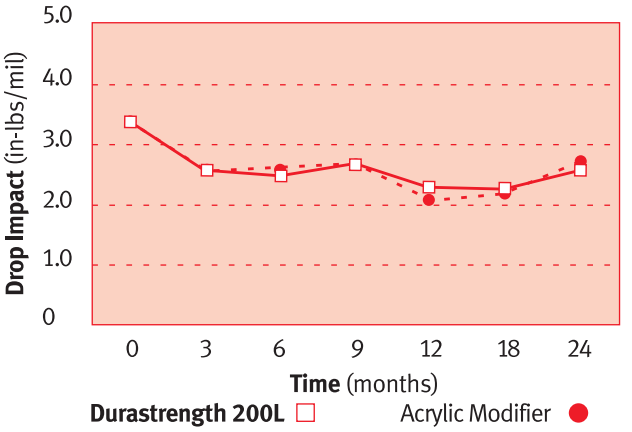
Outdoor Weathering Studies – Impacts

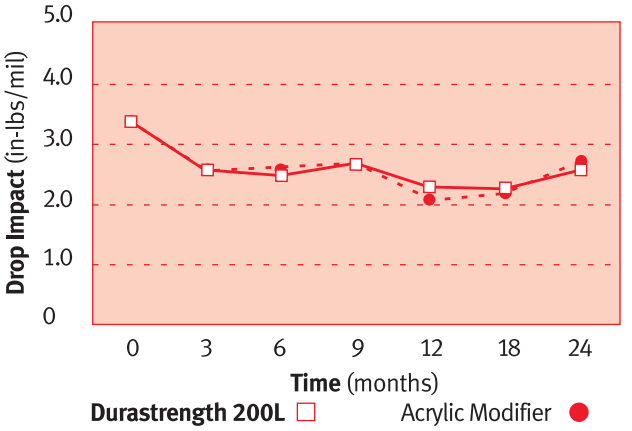
New Jersey Weathering Impacts



Florida Weathering Impacts



Arizona Weathering Impacts



PVC Compound Weathering Theory

Many of the ingredients contained in a typical PVC profile or siding topcoat formulation can affect the weatherability of the compound. In fact, some ingredients have "weatherable" and "non-weatherable" grades. Many of the ingredients found in a typical formulation have the potential to affect the weatherability more than an acrylic impact modifier. For example...

PVC resin

Every PVC article undergoes a certain amount of thermal degradation on the way to becoming a finished product. The amount of thermal degradation depends on the total heat history of the resin, from manufacture to formulation in the extruder. When thermally degraded PVC is exposed to weathering, UV light has enough energy to break chemical bonds, generate free radical structures and continue the "unzipping" process which results in color changes and impact loss. Therefore, it is possible to significantly accelerate the weathering of a vinyl profile just by processing at temperatures which are too high.

PVC heat stabilizers

Tin mercaptide heat stabilizers are the most typical heat stabilizers used for PVC building products in North America today. However, it is well documented that the mercaptide portion of the stabilizer is detrimental to long-term weathering of vinyl compounds. Therefore, while it is important to have enough stabilizer present to prevent the thermal decomposition of the PVC resin, an excess should be avoided so that the weathering of the finished product is not affected by an excess of sulfur. Stabilizers with a low level of mercaptide are best for this application.

Pigments

Most pigments are defined as "weatherable" or "non-weatherable." For example, in the siding industry, non-weatherable pigments are typically used in substrate compounds due to the fact that they are usually much less expensive than "weatherable" pigments. Titanium dioxide, the most widely used pigment, functions also as an opacifier and, most importantly, a UV stabilizer.

Impact Modifiers

Impact modifiers are also classified as "weatherable" or "non-weatherable." In the "weatherable" category are acrylics, modified acrylics and chlorinated polyethylene (CPE). In the "non-weatherable" category are methyl acrylate-butadiene-styrene (MBS) and acrylonitrile-butadiene-styrene (ABS) impact modifiers. The three "weatherable" types have a long commercial history of acceptable weatherability, whereas it is generally known that ABS