# Coatings for Exterior Cladding

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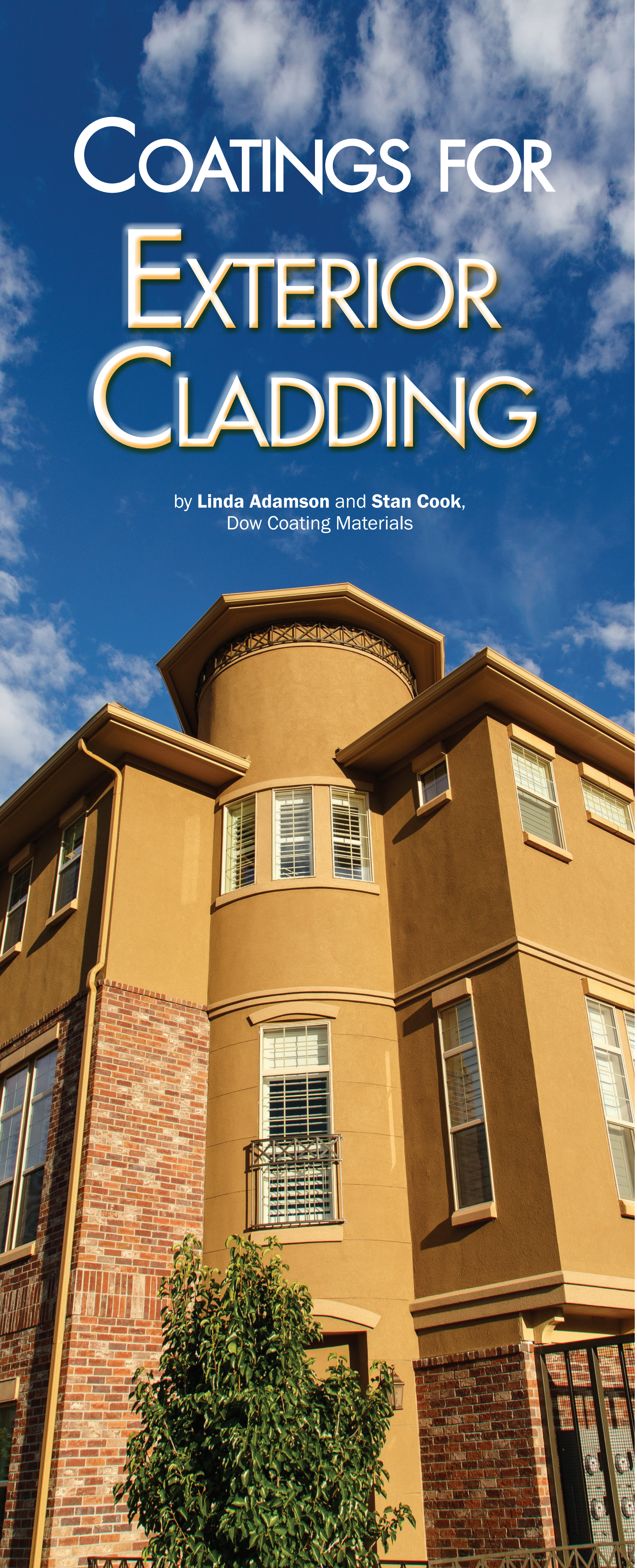


*Diversity in exterior cladding substrates is driving the need for architectural coatings that adhere to multiple substrates and combine the properties of high performance wood coatings with the properties needed for high performance on a variety of cementitious substrates, particularly stucco and fiber cement siding. A new 100% acrylic binder was developed to accommodate the increasingly broad range of exterior new build and repaint substrates and to be delivered with high solids to offer the paint formulator added flexibility without losing $TiO_2$ efficiency. Compared to commercial high-solids binders, the new binder technology offers notable improvements in cracking and flaking resistance on wood, as well as outstanding alkali and efflorescence resistance on cementitious substrates, with an overall performance profile that is comparable to a leading commercial binder that offers high performance but low solids.*

## EXTERIOR CLADDING TRENDS

Like a Cadillac in the driveway, a home clad in brick was considered a sign of prosperity throughout the early years of waterborne latex house paints. As reported by the U.S. Census Bureau Survey of Construction (SOC) (*Table* 1), brick was the most popular primary cladding for new home construction in 1970, accounting for 39% of new home exteriors. By 1980, however, wood had replaced brick in the number one spot and remained there until 1990. Wood and brick accounted for 42% and 38% of new home facades, respectively. By 2000, wood lost its number one spot to vinyl and the new millennium saw steady growth in fiber cement cladding. A relative newcomer to the cementitious category, fiber cement cladding, in combination with stucco, gave non-brick masonry facades a 27% share of new home exteriors in 2000 and accounted for a 36% share by 2010. As demonstrated in a 2005 regional breakout of new home construction facades (*Figure* 1), the current landscape of exterior wall cladding is a mosaic of substrate materials, including vinyl siding, aluminum siding, brick and brick veneer, fiber cement siding and shingles, wood and wood products, and stone and concrete block. As can be seen, the choice of exterior wall cladding used is very regional in nature.

Driven by a rise in new housing starts and its ripple effect on the entire economy, robust demand for exterior architectural coatings is generating renewed interest in a versatile binder chemistry that meets low-VOC targets, offers formulation flexibility, and performs across the broad spectrum of substrates that comprise today's residential new build and repaint markets.

## ADAPTING COATING PROPERTIES TO CLADDING SUBSTRATE

From repainting wood shingles on older homes to priming and painting fiber cement siding on newer homes, few binder chemistries match the exterior durability properties offered by 100% acrylics; however, the critical performance properties required for these substrates vary considerably. On primed or painted wood, for example, chalk adhesion is a critical performance property that influences resistance to cracking, peeling, and blistering. Highly resinous woods like cedar require excellent tannin stain blocking. Also, wood facades of all kinds require binders that impart excellent grain–crack resistance.

To a certain extent, masonry surfaces such as brick, stucco, fiber cement, and cinder block are like any exterior substrate. They need a finish with good adhesion properties, especially under wet conditions, along with the ability to provide decorative durability properties, such as tint retention, chalk resistance, and dirt pick-up resistance. In addition to these properties, a unique need for masonry coatings not shared by wood substrates is efflorescence resistance. As demonstrated in

**Table 1**—Exterior Wall Materials Used in Residential New Construction, United States (Source: U.S. Census Bureau SOC)

| Substrate | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|
| Brick | 39% | 26% | 15% | 20% | 25% |
| Stucco | 12% | 15% | 20% | 18% | 20% |
| Fiber Cement | — | — | 3% | 9% | 16% |
| Wood | 30% | 42% | 38% | 15% | 9% |
| Vinyl | --- | — | 22% | 40% | 37% |
| Aluminum | 14% | 8% | 5% | 2% | — |

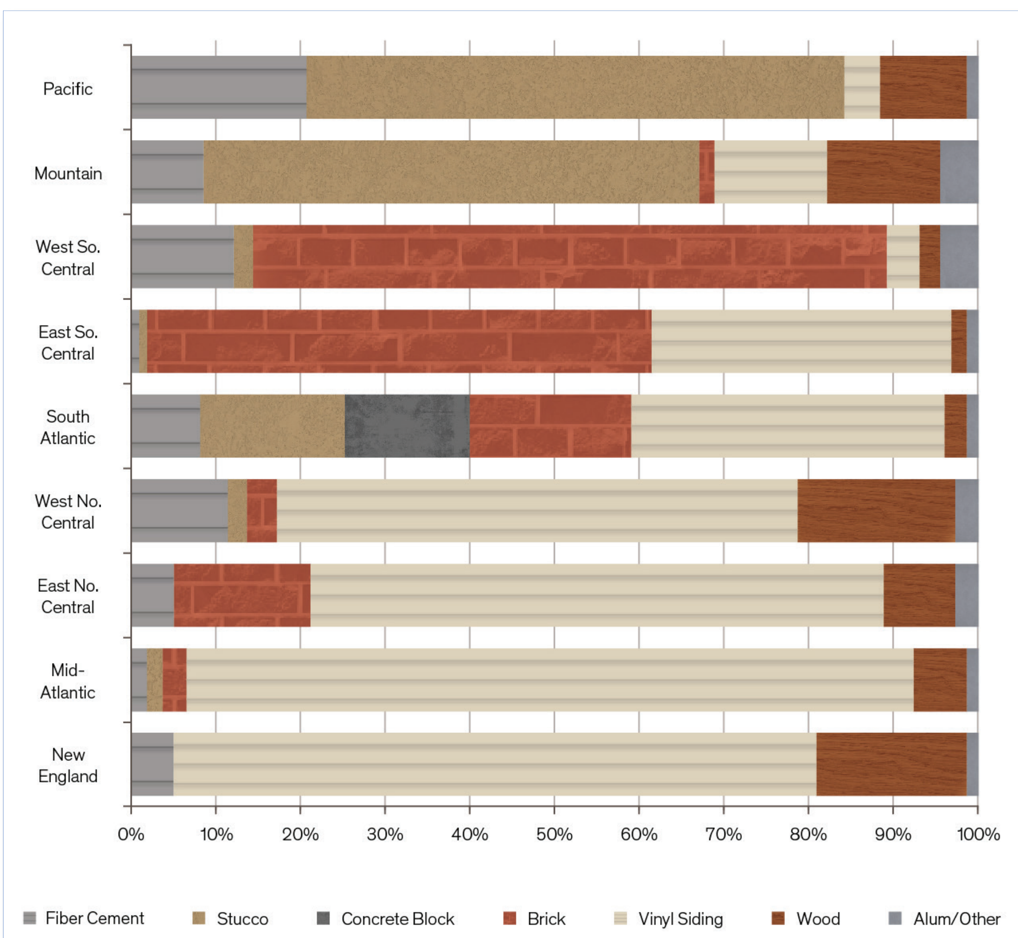



**Figure 1**—Principal type of exterior wall material by region in 2005. (Source: U.S. Census Bureau SOC)

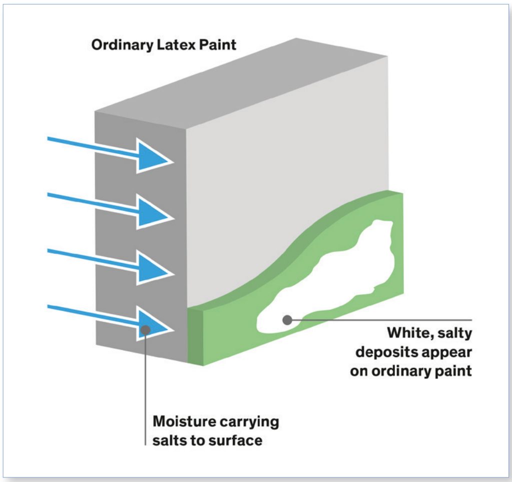



**Figure 2**—Illustration of exterior coating failure over stucco due to efflorescence. (Source: Paint Quality Institute).

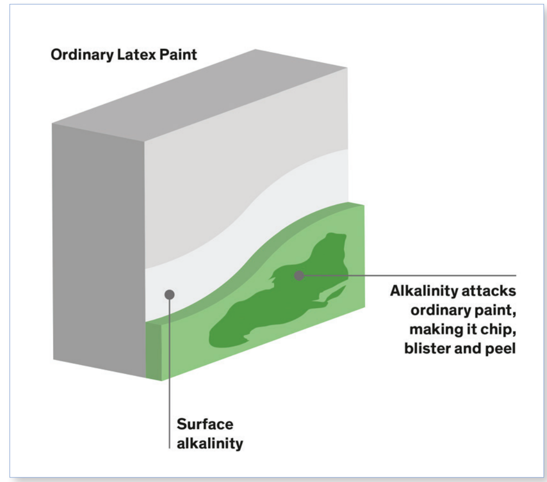



**Figure 3**—Illustration of exterior coating failure over stucco due to alkali degradation. (Source: Paint Quality Institute).

*Figure* 2, efflorescence occurs when moisture carries salts to the coating's surface, resulting in white deposits over the paint film. Because masonry surfaces are highly alkaline when fresh (pH 9.0–10.0) and often porous, they are routinely prone to efflorescence. In addition, the surface alkalinity unique to masonry substrates may cause coating failures from alkali degradation, leading to chipping, blistering, and peeling, as demonstrated in *Figure* 3.

## IMPACT OF VOC REDUCTION

Advances in binder chemistries validated by exposure testing have led to significant improvements in adhesion to a wide variety of exterior substrates, including chalky substrates without the use of alkyd modifiers that detract from durability. These advances, coupled with improvements in tint retention and dirt pick-up resistance, have significantly raised the bar on exterior coating performance and consumer expectations, but have been complicated by the drive to low- and no-VOC-capable binders.

In traditional binder chemistries, film formation and dirt pick-up resistance are mutually exclusive properties: the softer a binder, the better its film formation characteristics and the poorer its dirt pick-up resistance. If an emulsion is hard enough to provide satisfactory dirt resistance, it usually requires at least 7% to 10% of coalescent—too much to satisfy the requirements of <50 g/l VOC or lower.

In response to these new VOC limitations, a novel binder was developed a decade ago that alters the traditional balance between softness and dirt pick-up resistance. Used in premium 100% acrylic exterior paint, this binder offers a performance profile that is very similar to exterior flat binders with higher solvent loads and surpasses other low-VOC binder technologies with regard to durability. *Figure* 4 graphs the overall performance of this novel low-VOC binder after 48 months of exposure testing relative to another commercial low-VOC binder. While both systems performed well for adhesion and grain crack resistance, the novel low-VOC binder excelled in dirt pick-up resistance (DPUR) and efflorescence and alkali resistance, along with providing better tint retention.

Introduced in 2006, this novel low-VOC binder is widely considered to be the benchmark for high performance exterior binders across a range of substrates. Because it is supplied with low solids, however, it lacks the formulation latitude afforded by higher-solids binders. Binder solids can be critical for coating manufacturers, particularly when using $TiO_2$ supplied in slurry form, as this can limit the amount of total water, or other liquids, in a formulation. The higher the binder solids, the more flexibility the manufacturer has in its plants for making paints of different qualities across various sheens.

## NEXT STEP: RAISING SOLIDS TO INCREASE FLEXIBILITY WITHOUT LOWERING PERFORMANCE

After years of compositional, processing, and morphology studies, including two years of exposure testing, a new low-VOC-capable binder has been developed that performs as well as the leading low-VOC, low-solids commercial binder when used in paints across a range of exterior substrates. The new high-solids binder is solvent-free-capable with the use of a low-VOC coalescent, and it offers the additional feature of formulation flexibility due to much higher binder solids.

*Figure* 5 presents a comparison of performance properties based on laboratory testing of an identical-quality, flat exterior formulation made with the leading high performance, low-solids binder; a competitive high-solids binder; and the new high performance, high-solids binder. While the new high-solids binder required slightly more thickener, it was very comparable to the commercial low-solids binder in all other properties. When compared to the competitive high-solids binder, the new high-solids offering had better freeze/thaw capability along with much better efflorescence resistance and DPUR. The latter results are based on "accelerated" benchmark testing conducted in the laboratory to help predict what can be expected on test fence exposures over time. Dow protocol for accelerated testing employs substrates that mimic conditions found on exposure. For efflorescence testing, unglazed ceramic tiles are used in the lab to correlate with the actual stucco panels used on exposure fences, as both contain the materials that make the test substrate alkaline and are very porous. In laboratory DPUR testing, paints are applied to metal panels, weathered on exposure for one week, and then treated with a dirt slurry to test how well the paint "repels" the dirt when rinsed off.

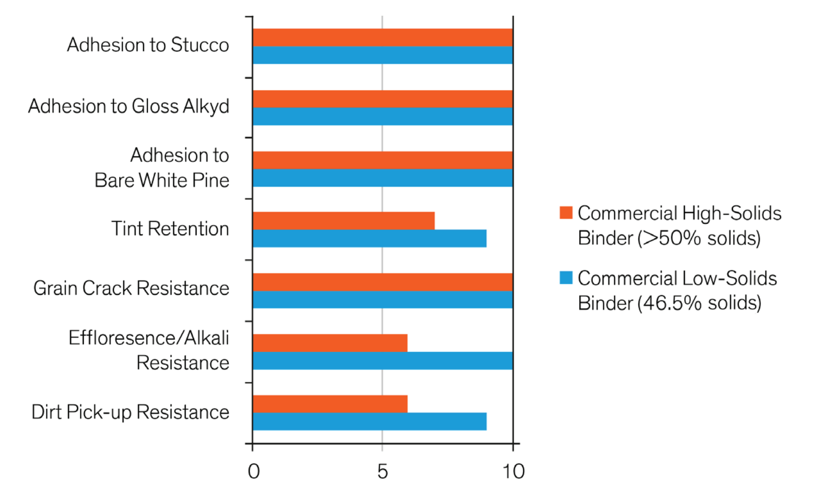
## EXTERIOR DURABILITY SUMMARY

The three test paints presented in *Figure* 5, along with similar paints based on older high-solids binder technologies, were exposed to real world weathering at the Dow Exposure Station in Spring House, PA. Two coats were applied to weathered pine (no primer) and put on South 45° exposure in December 2012. Notable differences in performance were evident within six months under these conditions. As demonstrated in the test panel photos presented in *Figure* 6, taken after 13 months of exposure, the new high-solids binder offered excellent crack resistance, with a performance level that was comparable to the leading commercial low-solids binder and visibly better than the competitive high-solids binder and several other older high-solids binder technologies from Dow. The new high-solids binder technology continues to demonstrate great durability after two years of exposure testing over a range of substrates.

## $TIO_2$ EFFICIENCY

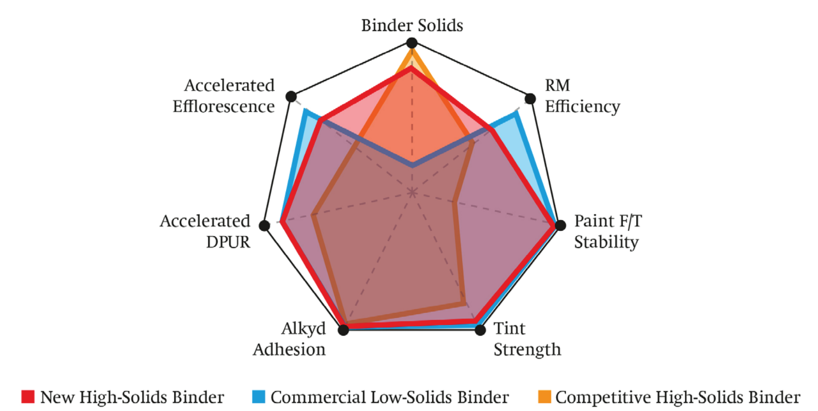
In addition to an outstanding performance profile, this new high-solids binder technology offers an added benefit of improved $TiO_2$ efficiency, which facilitates higher hiding paints or $TiO_2$ reduction with equal hiding. This feature is particularly significant because $TiO_2$ efficiency is not normally associated with high-solids binders; in fact, high-solids binders often result in reduced $TiO_2$ efficiency, primarily due to the larger particle size or morphology changes needed to deliver solids greater than 50%. The unique polymer morphology of this new binder not only enables the higher solids, but also contributes to better hiding than other traditional high-solids binders, almost equaling the hiding efficiency of the lower-solids commercial binder used as the benchmark, as seen in *Figure* 7.

In any discussion of hiding, it is important to consider the crowding effect of $TiO_2$ in the



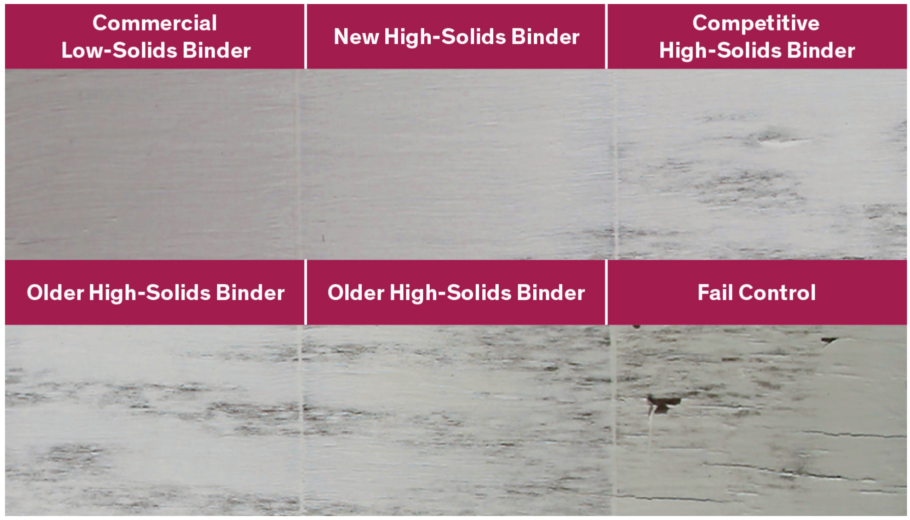

(a) High quality flat paint (50% PVC/37% VS) formulated with universal grade $TiO_2$, 25 lb of ZnO, and thickened with HEC/HEUR. Data represents 48 months' exposure at Dow Exposure Station, Spring House, PA.

**Figure 4**—Exterior durability of commercial low-VOC binders after 48 months' exposure.[a] (Source: Dow Coating Materials)



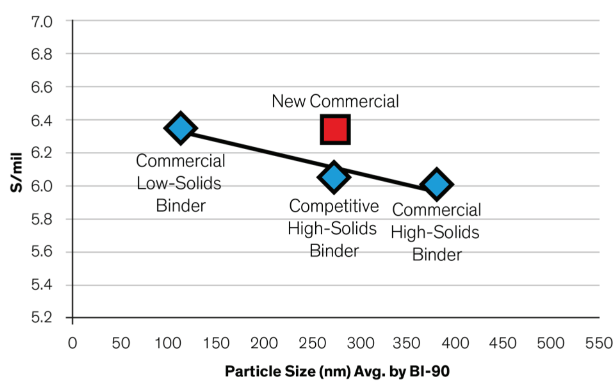

(a) High quality exterior flat paint (48% PVC/36% VS) formulated with universal grade $TiO_2$, 25 lb of ZnO, and thickened with HEC/HEUR.

**Figure 5**—Performance profile of new high-solids binder compared to commercial low-solids binder and competitive high-solids binder.[a] (Source: Dow Coating Materials)



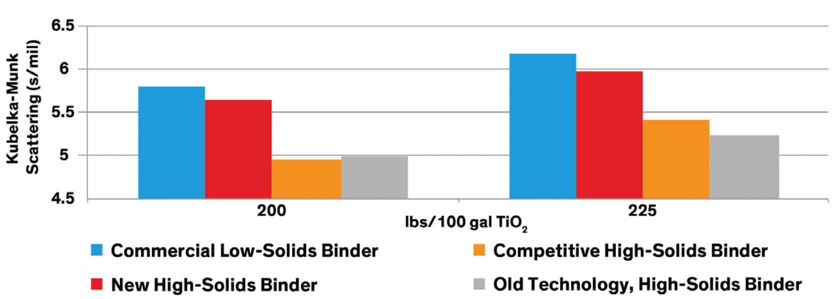

(a) High quality exterior flat paint (48% PVC/36% VS) formulated with universal grade TiO2 and 25 lb of ZnO and thickened with HEC/HEUR. Two coats on weathered pine (no primer). South 45° exposure after 13 months in Spring House, PA.

**Figure 6**—Comparison of binder technologies on exposure for 13 months.[a] (Source: Dow Coating Materials)




(a) High quality exterior flat formulation (50% PVC/35% VS) formulated with 200 lb/100 gal of universal grade $TiO_2$ and thickened with HEC/HEUR.

**Figure 7**—Scattering coefficient (S/mil) vs particle size of new high-solids binder vs commercial high-solids and low-solids offerings.[a]




(a) High quality exterior flat formulation (50%PVC/35% VS) thickened with HEC/HEUR.

**Figure 8**—Binder effect on scattering (S/mil) at two levels of $TiO_2$.[a]

paint formulation. One way of describing the crowding effect is by dependent scattering.* This theory describes the effective scattering diameter, or scattering zones, of $TiO_2$ particles as being greater than their actual diameter. These scattering zones overlap as the concentration of $TiO_2$ increases, reducing scattering efficiency and resulting in the crowding effect. When you consider that latex binders are also particles, they too can crowd $TiO_2$ and reduce its scattering efficiency.

For further examination of the $TiO_2$ efficiency of the new high-solids binder, experiments were conducted to measure the scattering (S/mil) of quality flat formulations with 200 and 225 lb of $TiO_2$ per 100 gal of paint. As demonstrated in *Figure* 8, the new high-solids binder provides comparable light scattering (S/mil) to the low-solids commercial offering at a similar $TiO_2$ level, and both are much better than the older and competitive high-solids binders. Additionally, the improved $TiO_2$ efficiency of the new high-solids binder could enable a paint manufacturer to reduce the level of $TiO_2$ in the formulation by up to 20 lb/100 gal, which could then provide a cost savings opportunity of 30 cents/gal (considering the price of $TiO_2$ of $1.50 per pound).

## CONCLUSION

From a predominance of wood and brick in 1970 to a diversity of substrates in 2010, exterior

*Steig, F., *J. Coat. Technol.*, 53 (680) 75-91 (1981).

cladding trends for new residential construction have changed significantly over the past 40 years. Current trends include steady growth in stucco and fiberboard cement.

A new low-VOC-capable, high-solids binder meets a longstanding need for adhesion and durability across multiple substrates; offers a performance profile that is similar to the highest performing low-VOC-capable, low-solids commercial binder; and offers enhanced performance compared to other high-solids binders in the marketplace with regard to exterior durability. The new low-VOC-capable, high-solids binder is made without APEO-containing surfactant and can be formulated < 50 g/L VOC (or lower with the use of a low-VOC coalescent).

In addition to a robust balance of exterior properties, this new binder technology may offer some formulators the ability to reduce $TiO_2$ in their formulations without sacrificing performance and offer the capability to improve the hiding power of the paint. These properties are offered across a range of substrates, making this new binder technology adaptable to changing trends in exterior cladding. CT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