

# Efflorescence 101

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## 1. What is efflorescence?

In the plastering industry, the word “efflorescence” refers to the crystalline deposit, usually white, that may develop on the surface of Portland cement plaster walls. Efflorescence is the end result of water dissolving the salts that are naturally present within cement-based products. This salt solution migrates to the finished surface and a salt deposit remains after the water evaporates. Efflorescence often occurs during periods of wet, cold weather and can occur on the surface of any cement-based product such as masonry, concrete, brick, and stucco. Typically, efflorescence occurs shortly after the completion of the building project, but this is not a definite rule as efflorescence can occur and reoccur at anytime as long as the conditions for its cause are not eliminated or reduced from the wall.

Although this white residue is aesthetically unpleasing, it does no harm to the wall assembly or compromise the integrity of the wall. In fact, efflorescence is a common, natural occurrence and should not be considered a product or application defect. Rather, it is an unfortunate result of a combination of various factors and events that take place at the same time despite efforts to contain/prevent it.

## 2. What are the causes of efflorescence?

Efflorescence has been studied and reported on for more than 100 years. A technical bulletin by T. Rishie, issued by the Division of Building Research of the National Research Council in Ottawa, Canada states that the following compounds can be found in efflorescence: sodium sulfate, sodium carbonate, sodium silicate, sodium bicarbonate, potassium sulfate, calcium sulfate, calcium carbonate, and magnesium sulfate. There can also be chlorides, nitrates, and other salts in addition to the listed compounds above.

For the process of efflorescence to occur, four things must be present: a) salts, b) physical forces, c) moisture, and d) an opening (no matter how microscopic).

a) **Salts:** Quantities of water-soluble salts as small as a few tenths of one percent are sufficient to cause efflorescence. The primary source of salts is the calcium hydroxide ( $\text{Ca}(\text{OH})_2$ ) from hydrated cement. The calcium hydroxide is a by-product of the cement curing process. It can dissolve in water and migrate to the surface of the wall where it remains when the water evaporates. The calcium hydroxide crystals then react with carbon dioxide ( $\text{CO}_2$ ) in the air to form calcium carbonates ( $\text{CaCO}_3$ ). Eventually, the likelihood of calcium carbonate efflorescence will taper off as soluble calcium hydroxide reacts with carbon dioxide from air or dissolves in water to form calcium carbonate inside the stucco matrix. Since calcium carbonate is insoluble, it will remain in the wall and not contribute to future efflorescence.



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Other water-soluble salts may contribute to efflorescence also. A major source for water-soluble salts in stucco is the raw materials themselves. Salts are very common minerals that occur naturally in many of the materials used in cement-based products. For instance, the sand and lime can contain various types and quantities of soluble salts despite the manufacturer's effort to eliminate them from their products. Another source of soluble salts is the soil in contact with basement and retaining walls. Additionally, salts may be deposited on the wall's surface from seawater exposure or previous attempts at cleaning that did not completely remove contaminants from the surface.

**b) Physical Forces:** Efflorescence is particularly affected by temperature, humidity, and wind. These physical forces, as well as others, can increase the absorption of water that leads to efflorescence. For example, wind can force water into a building substrate and its movement over the surface of a building can create pressure differentials that cause the water to move upward. Also, capillary action can cause water to move upward and laterally within a substrate. Hydrostatic pressure present under below-grade slabs and behind below-grade retaining walls can also cause water and/or water vapor movement. Additionally, temperature gradients across the wall can drive moisture into or out of the wall.

**c) Moisture:** Water is the vehicle that dissolves and transports the salts to the surface. Possible sources of moisture may include precipitation, water vapor from the interior, poorly aligned sprinklers, or ground water migration.

**d) Openings:** Cement based products, such as stucco, are naturally porous and thus have numerous capillaries or pathways for water and/or water vapor to move through them. Other obvious pathways include hairline cracks, voids caused by shrinkage, bug holes, and improper building designs.

Together these four factors result in efflorescence appearing on the surface of a wall. Efflorescence can be generally categorized as either primary or secondary. They are distinguished by the point in time at which they occur in relation to the curing process. The two forms of efflorescence and how they manifest explains why most efflorescence occurs immediately upon the completion of a building project, while other efflorescence can develop much later.

Primary efflorescence occurs during the curing process. Excess water in the wet plaster matrix bleeds to the surface where it eventually evaporates, leaving behind crystal deposits. Primary efflorescence is mostly calcium carbonate based and is often responsible for the "white bloom" or the "new building bloom" observed in newly constructed buildings with fresh stucco walls. Typically, primary efflorescence covers larger areas and is more difficult to clean than secondary efflorescence. As mentioned earlier, the calcium carbonate will eventually be locked into the stucco as it cures, so this type of efflorescence becomes less likely over time.

Secondary efflorescence occurs in cured stucco walls that are subjected to cycles of re-wetting and drying. In this case, the incident moisture penetrates into and leaches from the matrix, dissolving remaining soluble salts. Upon subsequent drying and wetting cycles, the water can migrate back to the surface and carry with it the dissolved salts, as described below. The water will then evaporate and leave behind unsightly deposits on the surface of walls.

Both primary and secondary efflorescence most often appear on buildings after long periods of precipitation during cool

weather. During such periods, walls become increasingly saturated from the outside to inside. As the weather clears, the walls begin to dry. Drying, caused by evaporation, occurs from the outside in and at the same time gravity is pulling the water downward. As the water is drawn outward and downward, the water-soluble salts are transported to the surface. The water follows the path of least resistance, which explains why efflorescence is concentrated in some areas.

Additionally, freeze-thaw cycles can contribute to efflorescence. During freeze-thaw cycles, ice may thaw from the side closest to the interior due to warming and water will be absorbed deep into the substrate and remain trapped by the outer skin of ice. Upon melting, water migrating back to the surface may be extremely saturated with salts, which are heavily deposited on the surface due to a very slow rate of evaporation.

Condensation is another major source of moisture in the field. Increased thermal resistance of a wall will make the outside components colder. Moisture laden air, moving through the building envelope, is cooled and becomes more saturated. When it reaches total saturation at its dew point, water vapor condenses. This condensation may occur inside the wall cavity or on the exterior wall surface. Therefore, the apparent absence of moisture does not necessarily eliminate the chance of efflorescence.

For all the reasons above, efflorescence sometimes is classified as a seasonal problem. In the summer, even after long rainy periods, moisture evaporates so quickly that comparatively small amounts of salts are brought to the surface. Usually, efflorescence is observed to be more common in the winter when a slower rate of evaporation, combined with cold and damp nights, allows successful migration of salts to the surface to cause efflorescence.



### 3. Suggested prevention and remedies

Since many factors influence the formation of efflorescence, it is difficult to predict if and when any will appear. We can only try to control to some degree factors such as moisture and salts that contribute to the efflorescence. Other factors such as weather are out of our control.

Given the characteristics of construction raw materials, it is virtually impossible to: eliminate all the soluble salts, construct walls containing no free moisture, or completely eliminate paths of moisture migration. However, steps can be taken to minimize the extent of these important contributing factors to efflorescence. For example, good workmanship is one of the most effective means of limiting the potential for efflorescence. Efforts should be taken whenever possible to ensure proper curing (protect the walls from cold temperatures, premature drying, or improper use of admixtures), provide for good drainage (properly design and install waterstops, flashing, rain gutters, weepholes, eaves, etc.), and to limit water entry as much as possible from all sides and sources of the structure. In general, low water absorption is the best insurance against efflorescence. Properly graded aggregates, low water-cement ratios, and proper curing techniques will help assure Portland cement products maximize density and minimize water absorption.

Once efflorescence appears on the surface, a variety of methods have been suggested for effective removal. The final method used to eliminate the efflorescence will depend on the type and severity of the stains. The simplest method is to try cleaning the stains off the wall by dry brushing followed by flushing with clean water.

If brushing is not successful, then the stain is probably calcium carbonate efflorescence, which is a more difficult to remove. It usually appears as a white "bloom" and in worst cases forms a hard white crust. To remove calcium carbonate try saturating the wall as thoroughly as possible with water then wash with a diluted acid solution followed immediately with an alkaline wash. The acid recommended is two to five (2-5) parts hydrochloric to one hundred (100) parts water or twenty (20) parts vinegar to one hundred (100) parts water. A diluted solution of household ammonia is the recommend alkaline wash.

Care should be taken to assure that the cleaning solution and technique do not physically damage the surface of the walls. Improper cleaning procedures can significantly change the appearance of the wall and/or contribute to additional efflorescence in the future.

If cleaning is not effective in removing the efflorescence, then the wall needs to be fog coated. Fogging is a common process used to even out the color on most new stucco applications today. In fact, there is a good chance the home or building has already been fogged. Omega Products International's fog coat product is called Omega Coat, which is a blend of cement, water, and dry pigment. Omega Coat

is manufactured using the same pigments and cement as the stucco finish originally applied to the home or building. Omega Coat is sprayed onto the wall, but, unlike paint, it will not chip, peel, or fade. The fog coat becomes an integral and permanent part of the original stucco finish, restoring the home or building to its original color.

Proper scheduling is critical to a successful fog coat application. As previously stated, efflorescence is a condition that usually occurs in freshly applied stucco during cold, wet weather. Therefore, it is recommended to schedule the repairs after the rainy season is over. This will greatly reduce the chance of the efflorescence returning during the next big rain and requiring additional repairs.

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