Kalcor University

2K Coatings: Mixing it Up

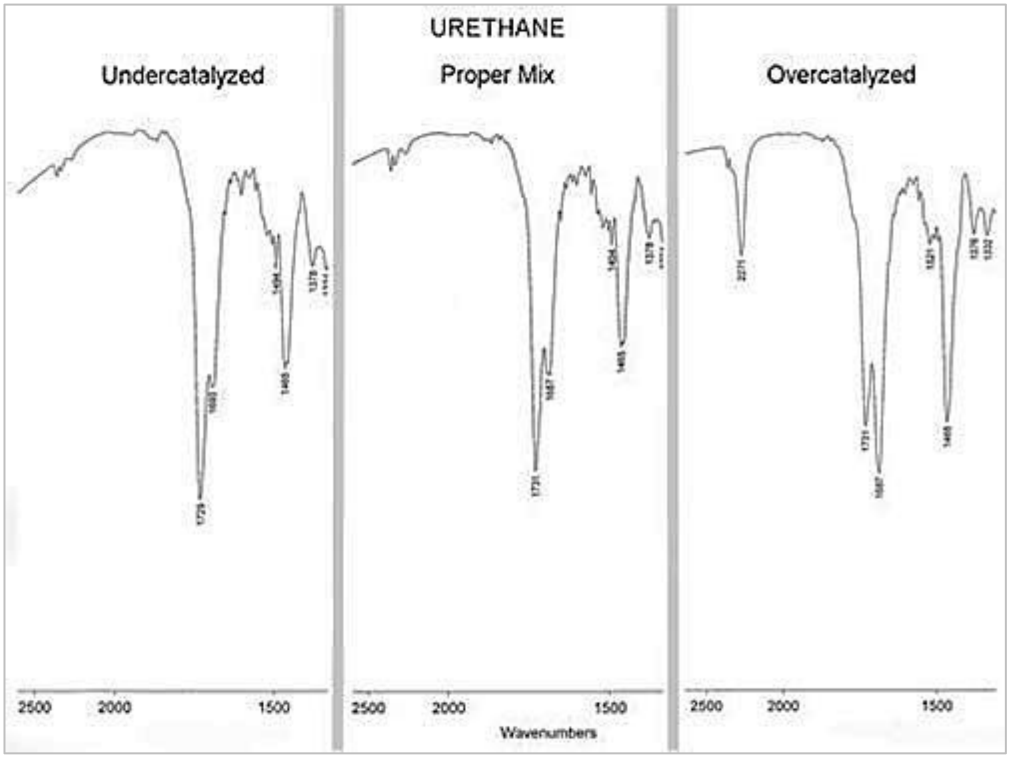
The performance of the best coating formula can be jeopardized by an inexperienced applicator. This is particularly true when it comes to working with so called 2-component, or “2K” coatings (the “K” comes from the German word, ‘Komponente’). These coatings are often selected for applications that require especially scratch or mar resistant surfaces, or when high chemical resistance is needed. 2K coatings achieve these performance properties by combining a resin with a second component, often referred to either as a catalyst, hardener, or activator. You are probably familiar with this principle from the 2part epoxy adhesives sold in hardware stores. These fast curing adhesives consist of two liquid gels that are often dispensed using connected, side-by-side, plastic needle-looking injector nozzles. The plungers are connected to assure that the two components are effortlessly dispensed in a proper, preset ratio.

In 2K coatings, the ratio of hardener to resin is determined by the ratio of molecules that need to react to form the cured coating and is called Indexing. Unfortunately, the large volumes applied in production make it impossible to dispense them as effortlessly as the hardware store adhesive. However, delivering too much, or too little hardener for a given volume of resin will compromise a number of coating properties. Only when the proper amount of the base and activator are mixed (or indexed) will the optimal results be obtained. The coating supplier’s product data sheet for the coating should provide the correct mixing ratio of the two components.

The coating formulator prescribes the correct mixing ratio of coating components for a 2K product. While minor variations in the mixing ratio might not have a disastrous impact on performance for all 2K coatings, the rapid-cure 2K coatings commonly using plural-component spray equipment can be very sensitive to mixing ratio variation, and so the performance of the final coating can vary greatly even with relatively small errors in proportioning. The amount of variation from the proper mixing ratio for a given coating thus depends on the type of coating system, the chemical formulation, and the desired performance properties.

The optimal mixing ratio is determined by the chemical composition of the coating, called the stoichiometry of the two components needed to produce a complete and chemically efficient reaction. Each molecule of the two components has a certain number of chemically reactive sites that must bond with molecules of the other component in order to achieve the final coating film. When there is exactly the same number of available sites on each component, the chemical reaction is balanced. In other words, the right stoichiometry has been achieved which ensures that all of the reactive molecules are consumed with no shortage or excess of either the base or activator. Depending on its chemistry, one of the components may have more reactive sites per unit volume than the other and so the corresponding mix ratio needed to balance the reaction may not be one-part base to one-part activator, or any convenient ratio for that matter.

The figure below (Source: KTA-Tator Inc.) illustrates the chemical differences between a 2K coating that is properly cured (center panel) with under-catalyzed (left panel) and over-catalyzed (right panel) versions of the same material using IR spectroscopy. The IR bands at 1,730 cm^{-1} (from the resin) and 1,690 cm^{-1} (from the catalyst) show the dramatic effects of improper mixing ratios. As the amount of catalyst increases, so does the 1,690 cm^{-1} band relative to the 1,730 cm^{-1} band.



The chemical consequences of improper mix ratios can be observed using IR spectral analysis

Changes in the final film properties can result if the two components are not mixed in the ratio (or index) specified by the coating manufacturer. Frequently these changes are not apparent when the coating is applied, but shows up after the product has shipped.

When the coating components are improperly mixed, the chemical curing reaction is not well balanced, and an excess of a reactant can cause a visual and tactile changes in the coating. The most obvious cases result in a coating that does not cure. This material remains unreacted and wet, leading to sags and runs, and excess dirt and contamination sticking to the soft, sticky uncured surface. Another visual symptom of poor mixing is cracking, which occurs when the coating cures too quickly, forming a film that is more rigid and brittle than normal. Sometimes, there is no visible change in the appearance of improperly mixed 2K coatings. Off-ratio mixes may appear similar to properly mixed material, but probing the surface reveals that the off-ratio mix has much softer composition than a properly cured coating. Remember that when there is an excess of reactant, this excess remains in the film, and while the residual reactant may or may not cause a change in appearance, and the film may perform initially, the performance may deteriorate over time

Formulators can use some chemical tricks to provide materials that require reasonable mixing ratios for use in the plant, but still there is always a chance that human error will create off-mixes. To help prevent these mistakes, different techniques and high tech plural component metering systems have been developed to minimize the sources of these costly errors.

Accurately mixing 2K materials can be difficult to do on the plant floor.

In small quantities, a coating manufacturer could provide the materials in separate, premeasured containers each containing the correct proportion (ratio) of each component.

The process of mixing multi-component paints by hand or with a mixer in an open container prior to application is referred to as “hot potting” because mixing the components triggers a chemical reaction that generates heat in the container.

While hot potting is simple, and requires little investment in equipment, there are some decided risks and drawbacks to the technique. First, hot potting is more prone to human error, since it requires careful measurement of the components both in their amounts and in the mix ratio. Hot potting also requires thorough and often continuous blending. Since once mixed, the reactive materials begin curing, application must be done quickly, before the material hardens. If the process stops, material can harden in the spray equipment and fluid delivery lines creating a maintenance nightmare. Thus, due to shelf life issues, hot potting is often practical only for low volumes applications, and using small, portable equipment. Finally, since hot potting often takes place on the plant floor, temperature and humidity can cause problems of maintaining the proper consistency.

For larger spray applications, plural component mixing systems are used that employ either mechanical metering systems, or electronically programmable metering devices that allow the applicator to set the proper ratio remotely. The two components are delivered separately, and mixed in a closed system at, or near, the spray gun. Thus, there are also no pot-life issues since only a small amount of material is mixed as it is being sprayed. These systems provide a high degree of accuracy and repeatability. This is particularly important for odd mix rations (such as 15:1) where small manual errors can have more dire effects on performance.

In summary, mixing a two-component coating in a ratio different from the ratio specified by the manufacturer can result in a wide range of defects. Some of these defects can cause coating failure. The likelihood and severity of defects depends on the nature of the materials being mixed, the amount of deviation from the correct ratio, and the environmental conditions during mixing. Clues of a bad mix ratio may or may not be visible to the eye, and if improper mixing is suspected, analytical tests can be performed to evaluate the coating and provide evidence of an improper ratio of the two components.

.