## **Ceramic Pigments**

by Richard A. Eppler<sup>1</sup>

CERAMIC PIGMENTS ARE COMPLEX MIXTURES of oxygen-containing materials that have been calcined at high temperatures to form specific crystalline phases [1]. In most cases, oxide raw materials are carefully mixed and then calcined in either batch kilns or continuous calciners [2]. After calcination, they are ground to the necessary fineness in mills. Micronizers and/or jet mills are used to break agglomerates. The final production step involves careful control of the color tone by adjustment with toners.

Because these pigments are formed at high temperatures, they generally offer superb thermal stability and are relatively inert. This results in excellent weathering and light fastness properties. Most of these pigments have superior acid and alkali resistance. They are nonmigrating and nonbleeding in nature and do not interact with polymer systems [3].

The principal disadvantage of ceramic pigment as theil low tinting strength. In addition, some are that it dri high in cost. This is particularly true of cell locataning pigments. Some of these pigments areld freelt to disperse. Howe clark recent development are easily dispersed ceraric rigations should elimin to this problem, at least for witer-based systems. A final concern is the inherent hardness of these pigments. Their hardness can lead to processing system damage through abrasion. When using ceramic pigments, processing system components designed for use with abrasive materials should be considered.

The major use of ceramic pigments is for applications such as vinyl siding and automotive paints where the product is thermally cured and then placed in an outdoor setting.

## CERAMIC PIGMENTS USED IN ORGANIC PAINTS

The major criterion used in selecting ceramic pigments for organic paints is hardness. The pigments listed in Table 1 and discussed below are those that can be used in paint processing equipment without causing excessive wear. Property attributes of the pigments are given in Table 2. All are compatible with most polymer systems, with manganese-doped rutile especially useful when it is necessary to avoid iron.

Nickel-doped rutile, which is often called Sun Yellow, is produced from a mixture of various amounts of titanium (IV) oxide, nickel (II) oxide, and antimony (V) oxide by high-

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temperature calcination [1]. The result is formation of a crystalline matrix of rutile that has the basic chemical formula  $(Ti,Ni,Sb)O_2$ . The pigment is used for coloring high-performance industrial coatings, wire coatings, vinyl sidings, automotive and other exterior paints, as well as for roofing, granules, porcelain enamels, and ceramic bodies.

Chrome-doped rutile is prepared from a mixture of varying amounts of titanium (IV) oxide, chrome (III) oxide, and antimony (V) oxide by high-temperature calcination [1]. The resultant crystalline rutile matrix has the basic chemical formula (Ti,Cr,Sb)O<sub>2</sub>. The orang yer or highment is used for coloring the same system s as nockel-doped rutile. Manganese or provide is prepared from a mixture of varicuration of the system (W) or ide means the system of the system of the system (W) or ide means the system of th

Manganese on the fittle is prepared from a mixture of various a name of uttanium (IV) oxide, manganese (II) oxide, at it manmony (V) oxide by high-temperature calcination [1]. The resulting drystalline rutile matrix has the basic chemical formulae Ii, Mr Sb)O<sub>2</sub>. The brown pigment is used for coloring the same systems as nickel-doped rutile.

Spinel brown pigments are an example of the 2-4 inverse spinels [4]. The basic pigment is prepared by a high-temperature calcination of titanium (IV) oxide and iron (II) oxide [1]. The resulting crystalline matrix of spinel is brown in color and has the basic chemical formula  $Fe_2TiO_4$ . The spinel phase permits extensive substitution, within defined limits, with other compounds to provide a variety of shades of brown. Modifiers used for substitution include  $Al_2O_3$ , CoO,  $Cr_2O_3$ ,  $Fe_2O_3$ , MnO, and ZnO. The pigments are used for coloring high-performance industrial coatings, wire coatings, vinyl sidings, and automotive and other high-quality exterior paints.

Titanate green and blue-green pigments are also produced by high-temperature calcination of mixtures of titanium (IV) oxide, cobalt (II) oxide, nickel (II) oxide, and zinc (II) oxide to form a crystalline matrix of inverse spinel [1]. The pigments have the basic chemical formula  $(Co,Ni,Zn)_2TiO_4$ . The pigments are used for coloring the same systems as the spinel brown pigments.

Cobalt blue pigments are crystalline spinels formed by high-temperature calcination of cobalt (II) oxide and aluminum (III) oxide in varying amounts [1]. The basic cobalt blue pigment (CAS 68186-86-7) has the chemical structure  $CoAl_2O_4$ . The lighter-colored cobalt blue is prepared by addition of zinc (II) oxide to the ingredients used for the basic pigment. The chemical structure of the resultant material (CAS 68186-87-8) is (Co,Zn)Al\_2O\_4. Blue-green shades are produced by introduction of chromium (III) oxide, partially replacing aluminum (III) oxide in the basic cobalt blue system. It has the chemical formula  $Co(Al,Cr)_2O_4$ . In addition to being

