Nanocomposites and nanomaterials

Study of the blue Zn-doped cobalt aluminate nanopigments

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In this study, Zn-doped cobalt aluminate spinel compounds have been explored for blue pigment application. Meanwhile, they may cause some environmental issues since cobalt is considered to be a human carcinogen. Spinel-based Zn-doped cobalt aluminate blue pigments were obtained with a low Co content. The aim of our research is to design cost-effective and environmentally benign pigments with intense blue color comparable to $CoAl_2O_4$. The particle size of commonly used pigments ranges from 1 μm to 10 μm. However, nanopigments are gaining attention due to their high surface area, which provides higher surface coverage and enhanced optical reflectance.

Typical methods used for the preparation of $Zn_xCo_{1-x}Al_2O_4$ includes ceramic, co-precipitation, Pechini, sol-gel, hydrothermal, flame spray-pyrolysis. The present work is devoted to new synthesis and characterization of Zn-containing spinel solid solutions with the general formula $Zn_xCo_{1-x}Al_2O_4$ ($0 \le x < 1.0$ with step 0.2). The studied compositions display a range of blue colors. The preparation of blue Zn^{2+}-doped $CoAl_2O_4$ pigments with low cobalt content using a co-precipitation method from $Zn(NH_4)_2(SO_4)_2{\cdot}6H_2O$, $Co(NH_4)_2(SO_4)_2{\cdot}6H_2O$, $Al(NH_4)(SO_4)_2{\cdot}12H_2O$ and $NaHCO_3$ as precipitant is described. The precursors were calcined at 800°C for 4 hours. Then the powders were characterized using thermal analysis (TG/DTA/DTG), XRD, SEM and EDX, which reveal that single-phase compounds are formed. Structure refinements of powder diffraction data reveal that Zn^{2+} preferably occupies the tetrahedral site in $CoAl_2O_4$ spinel structure, while the crystallite size varies in the range 10-13 nm. FT-IR characterization was used to observe the chemical species present in the $Zn_xCo_{1-x}Al_2O_4$ system.

The color and the properties of the pigment are discussed in relation to the synthesis procedure. The values of color coordinates CIE L*a*b* was estimated: L* gives the brightness from 42 to 88; the value of a* shows colors from green to red (from -7,2 to -11) and b* from blue to yellow (from -11 to -13). The as-fabricated pigments were found to be very adequate for ceramic decoration.