Solid-state synthesis of NIR-reflective black pigment: Effect of raw material on pigment's property

Sitthisuntorn Supothina[a,*], Nuchjarin Sangwong[a], Mantana Suwan[a], Chalita Tangon[a], Teerasak Tangkittimasak[a], Bundit Buddhahai[b], Pattana Rakkwamsuk[b]

[a]National Metal and Materials Technology Center, National Science and Technology Development Agency (NSTDA), 114 Thailand Science Park Paholyothin Rd., Klong Luang, Pathumthani, 12120, Thailand.
[b]School of Energy, Environment and Materials, King Mongkut's University of Technology Thonburi, 126 Pracha-Uthit Rd., Thung khru, Bangkok, 10140, Thailand.
*sitthis@mtec.or.th

Keywords: Iron chromium oxide, NIR-reflective pigment, Near-infrared reflectance, Black pigment, Solid-state reaction

It has been reported that energy utilization in the buildings accounts for a substantial portion of total energy consumption. As high as 60% of solar radiation can be absorbed and transferred into the building via roof and ceiling, resulting in accumulated heat during a daytime. A novel approach of using solar-reflective coating has been adopted to reflect solar radiation, particularly in the near-infrared (NIR) region to reduce heat buildup at building surfaces. Thus, exterior surface temperature can be reduced and the heat to be transferred into the building can be reduced. It has been reported that by replacing the traditional pigment in with the NIR-reflective pigment, total solar reflectance of the formulated paint increased from 5% to 30%. It is well realized that bright pigments exhibit high NIR reflectance. However, for some applications such as roof coating, they are not satisfied by the consumer because white roofing can be easily stained by dirt and pollutants. Therefore, non-white roofing products with dark color shade are more preferable for aesthetic reason. This article describes the development of high NIR-reflective black pigments based on a Fe_2O_3-Cr_2O_3 composition doped with TiO_2 synthesized by solid-state reaction at 1100°C. Reagent and industrial-graded raw materials were used to investigate their effects on properties of the synthesized pigments. The study revealed that, by using reagent-grade raw material, black pigments with NIR reflectance in a range of 31.8-33.6% were obtained. On the other hand, the NIR reflectance as high as 52.5% was obtained from the pigment synthesized from the industrial-graded raw material. The increased reflectance was ascribed to the presence of $(Cr_{0.88}Ti_{0.22})_2O_3$ phase in addition to $Cr_{1.3}Fe_{0.7}O_3$ which is the major phase. The impurities such as quartz (SiO_2) and Kaolinite ($Al_2Si_2O_5(OH)_4$) was found to be related to the formation of the $(Cr_{0.88}Ti_{0.22})_2O_3$. An artificial intelligent has been employed to find correlation between the NIR reflectance and chemical composition of raw materials obtained from different sources.